Mechanization process of the sugar cane harvest and its direct and indirect impact over the employment in Brazil and in its 5 macro regions

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Mechanization Process of the Sugar Cane Harvest and Its Direct and Indirect Impact over the Employment in Brazil and in Its 5 Macro Regions

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Abstract

One of the main concerns about the mechanization process of the sugar cane harvest is its direct and indirect impact over the employment. To study such an impact, it was: a) constructed an interregional input-output model, for the Brazilian economy for 1997, at the level of its 5 macro regions, with specific details for the sugar cane, alcohol, and sugar sectors; b) estimated the employment level, for the sectors in the model, by the qualification level of the workforce, i.e., by years of study (less than 1 year, 1 to 3 years, 4 to 7 years, 8 to 10 years, 11 to 14 years, and greater than 15 years); c) construct 3 possible scenarios for the mechanization process. The results are rather stressing, from the estimated 510,651 people working in the sugar cane harvest in 1997, one has that, depending on the scenario being considered, the total workforce will be reduced somewhere between 243,211 to 316,288 people, mainly in the lower qualification levels and in the Northeast and Southeast regions. This also has an impact over the employment generate indirectly, which is estimated through the use of the interregional input-output model constructed.

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1. Introduction

The goal of the work being presented here is to analyze which would be the impact, of the increase in productivity and the mechanization process that is taking place in the harvest of the sugar cane, over the employment in Brazil and in its 5 macro regions.

The burn of the sugar cane before it is harvest is a common practice in Brazil. However, through federal and state laws, it is determined that the year of 2020 should be the deadline for the end of this process. As a consequence of that, this practically fixes this year as the end of the manual harvest, giving that it is unfeasible to have a manual harvest without the burn of the sugar cane.

Giving the above, the producers have been increasing the use of machinery in the harvest of the sugar cane. On one hand this has a positive impact over the environment, giving that less pollution is generated in process of harvesting the sugar cane, on the other hand it reduces the level of employment in the sector. It is over this last aspect that this paper is concerned, i.e., what is the direct and indirect impact over the employment.

To do so, it was: a) constructed an interregional input-output model, for the Brazilian economy for 1997, at the level of its 5 macro regions, with specific details for the sugar cane, alcohol, and sugar sectors; b) estimated the employment level, for the sectors in the model, by the qualification level of the workforce, i.e., by years of study (less than 1 year, 1 to 3 years, 4 to 7 years, 8 to 10 years, 11 to 14 years, and greater than 15 years); c) construct 3 possible scenarios for the productivity and the mechanization process.

The discussion of the impacts over the employment becomes important, on one hand by the number of people being employed directly in the sugar cane production, around 510,000 in 1997 (table 1), and on the other hand by the importance that the sugar cane complex has for the Brazilian economy and specially for the Northeast region, see Moraes (2000) and Shikida (1997).

This work is organized in the following way, the next section presents the theoretical background, the hypotheses used in the paper are presented in the third section, in the fourth section the results are discussed, while in the last section some final comments are made.

2. Theoretical Background

The intersectoral flows in a given economy can be given by the following system

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

where X is a (nx1) vector with the value of the total production in each sector, Y is a (nx1) vector with values for the final demand, and A is a (nxn) matrix with the technical coefficients of production (Leontief, 1951). In this model, the final demand vector can be treated as exogenous to the system, such that the level of total production can be determined by the final demand, i.e.,

$$X = BY \qquad (2)$$

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

where B is a (nxn) matrix of the Leontief inverse.

From equation (2) it is possible to evaluate the impact of the final demand over total production, and from there, over employment, imports, wages, etc.

To estimate the induced effect, i.e., how much the increase in employment would generate, for example, of production in the economy given the consumption of the newly employed people, one can make the family consumption endogenous in the model, such that one has

$$\overline{A} = \begin{bmatrix} A & H_c \\ H_r & 0 \end{bmatrix} \qquad (4)$$

where $\overline{A}$ is the new matrix of technical coefficients with size (n+1)x(n+1), and H_r is a (1xn) vector with the income coefficient in each sector and H_c is a (nx1) vector with the families consumption coefficients.

As so, the new vectors of production and final demand would be given, respectively, by ($\overline{X}$, (n+1)x1), and by ($\overline{Y}$, (n+1)x1). They would be represented as

$$\overline{X} = \begin{bmatrix} X \\ X_{n+1} \end{bmatrix} \qquad (5) \qquad \text{and}$$

$$\overline{Y} = \begin{bmatrix} Y^* \\ Y^*_{n+1} \end{bmatrix} \qquad (6)$$

The Leontief system would them be represented by:

$$\overline{X} = \overline{B}\,\overline{Y} \qquad (7)$$

$$\overline{B} = \left(I - \overline{A}\right)^{-1} \qquad (8)$$

To coefficients of employment, are given by

$$w_j = \frac{e_j}{x_j} \qquad (9)$$

where w_j is the coefficient of employment in sector j, e_j is the total employment in sector j, and x_j is the level of production in sector j.

The employment multipliers of type I (E_j) and type II ($\overline{E}_j$), that take into consideration the in induced effect, are giving by

$$E_j = \sum_{i=1}^{n} w_i b_{ij} \qquad (10)$$

$$\overline{E}_j = \sum_{i=1}^{n} w_i \overline{b}_{ij} \qquad (11)$$

where b_{ij} and $\overline{b}_{ij}$ are elements of the matrices B and $\overline{B}$ described above.

The estimation of how much employment is generated in the economy for each person employed in a given sector can be obtained by the use of equations (12) and (13) below, for the cases of the type I (W_j) and type II ($\overline{W}_j$) multipliers

$$W_j = \frac{E_j}{w_j} \qquad (12)$$

$$\overline{W}_j = \frac{\overline{E}_j}{w_j} \qquad (13)$$

3. Hypothesis and Scenarios for the Mechanization of the Sugar Cane Harvest

Using the data from the input-output matrices constructed for an interregional system of the 5 Brazilian macro regions (North, Northeast, Central West, Southeast, and South), for the year of 1997, with specific details for the sugar cane, the alcohol and the sugar sector, see Guilhoto et al (2001), together with information from the works of Caron and Romanach (1999), Romanach (1998) and Veiga Filho (1998) it was estimated that the level of mechanization in the sugar cane harvest for the main Brazilian producers regions was, in 1997, of 5% for the Northeast region and 20% for the southeast region.

Using this initial estimation it is possible to estimate that: a) the Southeast region has an average productivity, per day, per worker, of 8.5 tons of kilograms in the manual harvest, and 40.0 tons of kilograms in the mechanical harvest, with a total of 142,324 people employed in the manual harvest and 5,710 employed in the mechanical harvest; b) the Northeast region has an average productivity, per day, per worker, of 1.98 tons of kilograms in the manual harvest, and 32.0 tons of kilograms in the mechanical harvest, with a total of 196,134 people employed in the manual harvest and 482 employed in the mechanical harvest.

Using this initial structure of production, three scenarios where constructed to considerer the impact of a mechanization process together with an increase of productivity in the manual and mechanical harvest.

The scenarios are as follow:

- **Scenario I: Increase in the mechanization of the harvest with no increase in productivity**
  - **a.** mechanization of 50% in the harvest of the sugar cane in the Northeast region;
  - **b.** mechanization of 80% in the harvest of the sugar cane in the other Brazilian regions, with the structure of production, for the sugar cane, in the South, Central West, and North regions becoming similar to the one for the Southeast region;
  - **c.** there would be no changes in the productivity of the manual and mechanical harvest.
- **Scenario II: Increase in the mechanization of the harvest with the same rate of productivity increase for all regions**

a. mechanization of 50% in the harvest of the sugar cane in the Northeast region;

b. mechanization of 80% in the harvest of the sugar cane in the other Brazilian regions, with the structure of production, for the sugar cane, in the South, Central West, and North regions becoming similar to the one for the Southeast region;

c. there would be a 20% increase in the productivity of the manual and mechanical harvest in all the 5 Brazilian macro regions.

- **Scenario III: Increase in the mechanization of the harvest with different rates of productivity increase for the regions**

a. mechanization of 50% in the harvest of the sugar cane in the Northeast region;

b. mechanization of 80% in the harvest of the sugar cane in the other Brazilian regions, with the structure of production, for the sugar cane, in the South, Central West, and North regions becoming similar to the one for the Southeast region;

c. for the Southeast, North, Central West, and South regions there would be a 20% increase in the productivity of the manual and mechanical harvest. For the Northeast region there would be an increase of 140% in the manual harvest and of 20% in the mechanical harvest.

The results obtained from the above scenarios are presented in the next section.

4. Impact of Mechanization and Productivity Changes on the Sugar Cane Harvest over Employment

From the above scenarios concerning the changes in the mechanization and productivity in the harvest of the sugar cane, tables 1 to 3 show the impacts on direct employment for the 5 Brazilian macro regions.

As can be observed in tables 1 to 3, the number o people direct employed in the sugar cane harvest would be reduced by 243,211 in scenario I, by 273,276 in scenario II, and by 316,288 in scenario III. In the case of scenario III the total number of people employed would go from 510,651 to 194,363.

In scenario I, where there is only changes in mechanization, the Southeast region would be the one to loose the most in the number of people employed, 89,613, followed by the Northeast (88,570), South (39,622), Central West (23,582), and North (1,824) regions.

When there is a mechanization processes with changes in productivity, as presented in scenarios II and III, the biggest changes in employment occur in the Northeast region.

For scenario II, the employment in the Northeast region would be reduced by 106,578 workers, while the reduction of employment in the North, Central West, Southeast, and South regions would be, respectively, of 1,844, 24,709, 99,350, and 40,795 workers. Considering only the impact of productivity changes, i.e., excluding the mechanization process, the reduction in employment in the regions would be: a) 9,737 for the Southeast; b) 18,008 for the Northeast; c) 20 for the North; d) 1,173 for the South; and e) 1,127 for the Central West.

Table 1

Scenario I – Direct Employment in the Sugar Cane Production

Region	Observed in 1997	Mechanization Process	Reduction in Workers
North	2,043	218	1,824
Northeast	225,911	137,341	88,570
Central West	35,746	12,164	23,582
Southeast	194,669	105,057	89,613
South	52,282	12,661	39,622
Brazil	510,651	267,440	243,211

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 2

Scenario II – Direct Employment in the Sugar Cane Production

Region	Observed in 1997	Mechanization and Productivity Changes	Reduction in Workers
North	2,043	198	1,844
Northeast	225,911	119,334	106,578
Central West	35,746	11,036	24,709
Southeast	194,669	95,320	99,350
South	52,282	11,487	40,795
Brazil	510,651	237,375	273,276

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 3

Scenario III – Direct Employment in the Sugar Cane Production

Region	Observed in 1997	Mechanization and Productivity Changes	Reduction in Workers
North	2,043	198	1,844
Northeast	225,911	76,322	149,589
Central West	35,746	11,036	24,709
Southeast	194,669	95,320	99,350
South	52,282	11,487	40,795
Brazil	510,651	194,363	316,288

Source: Research Data

Note.: The totals may not add due to rounding problems.

The difference between scenarios II and III refers mainly to the increase in the productivity of the manual harvest in the Northeast region. As a result, it can be observed that in scenario III the only region that reduces the number of people employed is the Northeast region, now with a reduction of 149,589 workers compared to 106,578 workers in scenario II.

Table 4 presents the number of people, by years of study, employed in the sugar cane harvest in each one of the macro Brazilian regions for the year of 1997. Tables 5 to 6 present the same results for scenarios I to III, respectively.

Table 4

Employment Structure, by Years of Study, in the Sugar Cane Harvest
Brazil and Macro Regions, 1997

Region	Years of Study						
	< 1	1 to 3	4 to 7	8 to 10	11 to 14	³ 15	Total
				People Employed			
Brazil	**189,643**	**157,671**	**133,108**	**21,266**	**6,703**	**2,260**	**510,651**
North	1,170	618	213	25	9	8	2,043
Northeast	129,357	68,373	23,570	2,724	964	923	225,911
Central West	6,948	10,766	14,889	3,143	0	0	35,746
Southeast	39,970	66,361	70,719	12,004	4,287	1,328	194,669
South	12,198	11,553	23,717	3,371	1,444	0	52,283
				Share (%)			
Brazil	**37.14**	**30.88**	**26.07**	**4.16**	**1.31**	**0.44**	**100.00**
North	57.26	30.27	10.43	1.21	0.43	0.41	100.00
Northeast	57.26	30.27	10.43	1.21	0.43	0.41	100.00
Central West	19.44	30.12	41.65	8.79	0.00	0.00	100.00
Southeast	20.53	34.09	36.33	6.17	2.20	0.68	100.00
South	23.33	22.10	45.36	6.45	2.76	0.00	100.00
				Share (%)			
Brazil	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
North	0.62	0.39	0.16	0.12	0.13	0.35	0.40
Northeast	68.21	43.36	17.71	12.81	14.38	40.84	44.24
Central West	3.66	6.83	11.19	14.78	0.00	0.00	7.00
Southeast	21.08	42.09	53.13	56.45	63.96	58.76	38.12
South	6.43	7.33	17.82	15.85	21.54	0.00	10.24

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 5

Scenario I
Employment Structure, by Years of Study, in the Sugar Cane Harvest
Brazil and Macro Regions, 1997

Region	Years of Study						
	< 1	1 to 3	4 to 7	8 to 10	11 to 14	³ 15	Total
				People Employed			
Brazil	**80,808**	**56,553**	**98,113**	**20,787**	**7,931**	**3,248**	**267,440**
North	21	34	119	30	11	4	219
Northeast	68,577	36,247	27,262	3,151	1,137	967	137,341
Central West	1,143	1,899	6,624	1,649	635	213	12,163
Southeast	9,876	16,397	57,213	14,241	5,486	1,842	105,055
South	1,190	1,976	6,895	1,716	661	222	12,660
				Share (%)			
Brazil	**30.22**	**21.15**	**36.69**	**7.77**	**2.97**	**1.21**	**100.00**
North	9.40	15.61	54.46	13.56	5.22	1.75	100.00
Northeast	49.93	26.39	19.85	2.29	0.83	0.70	100.00
Central West	9.40	15.61	54.46	13.56	5.22	1.75	100.00
Southeast	9.40	15.61	54.46	13.56	5.22	1.75	100.00
South	9.40	15.61	54.46	13.56	5.22	1.75	100.00
				Reduction in Number of People Being Employed			
Brazil	**108,835**	**101,118**	**34,995**	**479**	**-1,228**	**-988**	**243,211**
North	1,149	584	94	-5	-3	5	1,824
Northeast	60,780	32,126	-3,692	-427	-173	-43	88,571
Central West	5,805	8,867	8,265	1,494	-635	-213	23,583
Southeast	30,094	49,964	13,506	-2,237	-1,199	-514	89,614
South	11,008	9,577	16,822	1,654	782	-222	39,621

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 6

Scenario II
Employment Structure, by Years of Study, in the Sugar Cane Harvest
Brazil and Macro Regions, 1997

Region	Years of Study						
	< 1	1 to 3	4 to 7	8 to 10	11 to 14	³ 15	Total
				People Employed			
Brazil	**67,482**	**47,166**	**91,966**	**20,092**	**7,569**	**3,099**	**237,375**
North	17	28	110	29	11	4	198
Northeast	57,322	30,298	26,579	3,072	1,105	959	119,334
Central West	950	1,577	6,113	1,591	604	200	11,036
Southeast	8,204	13,622	52,801	13,744	5,220	1,728	95,320
South	989	1,642	6,363	1,656	629	208	11,487
				Share (%)			
Brazil	**28.43**	**19.87**	**38.74**	**8.46**	**3.19**	**1.31**	**100.00**
North	8.61	14.29	55.39	14.42	5.48	1.81	100.00
Northeast	48.03	25.39	22.27	2.57	0.93	0.80	100.00
Central West	8.61	14.29	55.39	14.42	5.48	1.81	100.00
Southeast	8.61	14.29	55.39	14.42	5.48	1.81	100.00
South	8.61	14.29	55.39	14.42	5.48	1.81	100.00
				Reduction in Number of People Being Employed			
Brazil	**122,161**	**110,505**	**41,142**	**1,174**	**-866**	**-839**	**273,276**
North	1,153	590	103	-4	-2	5	1,844
Northeast	72,035	38,075	-3,008	-348	-141	-35	106,578
Central West	5,998	9,189	8,775	1,551	-604	-200	24,709
Southeast	31,766	52,739	17,917	-1,740	-933	-400	99,350
South	11,209	9,912	17,354	1,714	815	-208	40,795

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 7

Scenario III
Employment Structure, by Years of Study, in the Sugar Cane Harvest
Brazil and Macro Regions, 1997

Region	Years of Study						
	< 1	1 to 3	4 to 7	8 to 10	11 to 14	³ 15	Total
				People Employed			
Brazil	**39,343**	**32,293**	**91,966**	**20,092**	**7,569**	**3,099**	**194,363**
North	17	28	110	29	11	4	198
Northeast	29,183	15,425	26,579	3,072	1,105	959	76,322
Central West	950	1,577	6,113	1,591	604	200	11,036
Southeast	8,204	13,622	52,801	13,744	5,220	1,728	95,320
South	989	1,642	6,363	1,656	629	208	11,487
				Share (%)			
Brazil	**20.24**	**16.62**	**47.32**	**10.34**	**3.89**	**1.59**	**100.00**
North	8.61	14.29	55.39	14.42	5.48	1.81	100.00
Northeast	38.24	20.21	34.82	4.02	1.45	1.26	100.00
Central West	8.61	14.29	55.39	14.42	5.48	1.81	100.00
Southeast	8.61	14.29	55.39	14.42	5.48	1.81	100.00
South	8.61	14.29	55.39	14.42	5.48	1.81	100.00
				Reduction in Number of People Being Employed			
Brazil	**150,300**	**125,378**	**41,142**	**1,174**	**-866**	**-839**	**316,288**
North	1,153	590	103	-4	-2	5	1,844
Northeast	100,174	52,948	-3,008	-348	-141	-35	149,589
Central West	5,998	9,189	8,775	1,551	-604	-200	24,709
Southeast	31,766	52,739	17,917	-1,740	-933	-400	99,350
South	11,209	9,912	17,354	1,714	815	-208	40,795

Source: Research Data

Note.: The totals may not add due to rounding problems.

An analysis of tables 4 to 7 clearly shows a reduction in the share of the people employed with low level of education.

For Brazil, the reduction of employment, depending on the scenario, was between 44% to 48% for the workers with less than 1 year of study, from 40% to 42% in the workers between 1 and 3 years of study, from 13% to 15% in the workers with 4 to 7 years of study, and from 0,2% to 0,4% in the workers with 8 to 10 years of study. Also, there is a little increase in the number of workers with 11 to 14 years of study and with more than 15 years of study.

In the three scenarios, for the Northeast region, there is a decrease in the number of workers with less than 3 years of study and an increase in the other levels of qualification. For the Southeast region, the reduction occurs in workers that have up to 7 years of study, there is an increase of employment in the other levels of education. The changes that take place in the North, Central West, and South regions occur in a way that such regions, as assumed above, change their productive structure such that it becomes equal to structure of the Southeast region.

For the Northeast region, in scenario I, 49.93% of the workers have less than one year of study, against 9.40% for the other regions, in scenario II, the number become 48.03% for the Northeast region and 8.61% for the other regions, while for scenario III the change occurs only in the Northeast region with its share reducing to 38.24%. In the next level of qualification, 1 to 3 years of study, for the Northeast, the share of this qualification in the scenarios I, II, and III, is respectively of 26.39%, 25.39% and 20.21%, in the other Brazilian regions, the share of this qualification is of 15.61% for scenario I, and of 14.29% for scenarios II and III.

It is observed that before the mechanization process, 68.01% of the sugar cane labor force, for Brazil, had less than 3 years of study, after this process, this number is reduced to 51.36% in scenario I, 48.30% in scenario II, and 36.86% in scenario III. The level of qualification that concentrates the most of the work force in the sugar cane harvest is the one by the workers that have between 4 and 7 years of study, with a share of 36.69% in scenario I, 38.74% in scenario II, and 47.32% in scenario III. In this way, it is possible to observe a general increase in the level of qualification of the people being employed in this sector.

4.1. Direct, Indirect and Induced Employment in the Sugar Cane Harvest

Concerning the impact of the mechanization of the sugar cane harvest over the employment generated direct, indirect, and induced for every R$ 1 million produced of sugar cane, it can be observed, by the results presented into tables 8 to 10, a decrease in the employment generated directly, indirectly, and induced. [5]

For Brazil, for every R$ 1 million produced of sugar cane, the total employment reduces from 178.5 to 127.6 jobs in scenario I, 121.3 in scenario II, and 113.4 in scenario III. This means a decrease from 28.5% to 36.5% depending on the scenario that has been considered. For the North, Northeast, Central West, Southeast, and South regions the range of decrease are, respectively, of 68.0% to 68.8%, 26.5% to 45.2%, 43.1% to 45.2%, 23.0% to 25.6%, and 45.0% to 46.4%

In absolute numbers the biggest decrease in the employment generated for every R$ 1 million produced occurs in the direct employment, for Brazil as a whole and for each one of its macro regions. And as observed before, the greatest decrease occur in the workers with a low level of education.

Of the total employment generated, the direct jobs that had a share of 43.20% for Brazil, decreased its share to 31.65% in scenario I, 29.52% in scenario II, and 25.89% in scenario III, due to the mechanization process and the change in productivity. At the same time the indirect jobs had an increase of its share from 9.29% to 11.73%, 12.12% and 12.63%, respectively for scenarios I, II, and III, and the induced jobs grew from 47.52% to 56.62%, 58.32% and 61.48% in the scenarios being considered here.

The total employment generated in each one of the regions, as well as the qualification of the labor force differs among the regions and the employment being considered (direct, indirect, and induced).

In the case of the total generated employment, while the Southeast region generates a total of 103.1 jobs in scenario I, and 99.5 jobs in scenarios II and III, for every R$ 1 million produced, in the Northeast region these number are of 270.5 for scenario I, 250.2 for scenario II and of 201.7 for scenario III. For the other regions, the numbers are as follow, respectively, for scenarios I, II, and III: a) North, 112.2, 109.5 and 109.5; b) Central West, 84.2, 81.1 and 81.1; c) South, 135.7, 132.2 and 132.2; and d) Brazil, 127.6, 121.3 and 113.4.

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[5] Despite that in this section, and in sections 4.2 and 4.3, the results for all the Brazilian macro regions are discussed, due to a space limitation, the tables presented here are only for Brazil as a whole and for the Northeast and Southeast regions, which are the main producing regions of sugar cane.

As the hypothesis related to productivity in scenarios II and III differ only for the Northeast region, this makes that the results for the other regions identical in scenarios II and III. In this way, there will be only differences, in scenario III, for the Northeast region and for Brazil as a whole.

4.2. Direct, Indirect and Induced Employment in Alcohol Production

Tables 11 to 13 show the results of the impact of the mechanization process of the sugar cane harvest over the employment generated directly, indirectly, and induced by every R$ 1 million produced of Alcohol.

As it was made no hypothesis concerning technological changes in the Alcohol production, there is no changes in the direct employment generated in this sector. The differences occur in the indirect and induced employment. The decrease in the indirect employment is the result of the decrease in the amount of the labor force needed to produce sugar cane, that is the main input in the alcohol production. As there is less people employed, the total wages received by them, also is reduced, and as a consequence, less money is spend by the families, which causes a reduction in the induced employment.

For Brazil, for every R$ 1 million produced of alcohol, the total employment reduces from 127.0 to 106.8 jobs in scenario I, 104.3 in scenario II, and 101.1 in scenario III. This means a decrease from 15.9% to 20.3% depending on the scenario that has been considered. For the North, Northeast, Central West, Southeast, and South regions the range of decrease are, respectively, of 41.5% to 42.0%, 15.1% to 25.7%, 18.7% to 19.6%, 12.2% to 13.7%, and 24.3% to 25.1%.

In absolute numbers the biggest decrease in the employment generated for every R$ 1 million produced occurs in the indirect employment, for Brazil as a whole and for each one of its macro regions. And as observed before, the greatest decrease occur in the workers with a low level of education.

Of the total employment generated, due to the decrease in the indirect jobs, the direct jobs increased its share from 4.76%, for Brazil, to 5.66% in scenario I, 5.8% in scenario II, and 5.98% in scenario III, due to the mechanization process and the change in productivity. At the same time the indirect jobs had a decrease of its share from 36.13% to 28.81%, 27.69% and 25.87%, respectively for scenarios I, II, and III, and the induced jobs grew from 59.10% to 65.53%, 66.51% and 68.15% in the scenarios being considered here.

The total employment generated in each one of the regions, as well as the qualification of the labor force differs among the regions and the employment being considered (direct, indirect, and induced).

In the case of the total generated employment, while the Southeast region generates a total of 88.3 jobs in scenario I, and 86.8 jobs in scenarios II and III, for every R$ 1 million produced, in the Northeast region these number are of 235.1 for scenario I, 226.5 for scenario II and of 205.7 for scenario III. For the other regions, the numbers are as follow, respectively, for scenarios I, II, and III: a) North, 116.1, 115.1 and 115.1; b) Central West, 82.9, 81.9 and 81.9; c) South, 135.4, 133.9 and 133.9; and d) Brazil, 106.8, 104.3 and 101.1.

As observed before, the hypothesis related to productivity in scenarios II and III differ only for the Northeast region, this makes that the results for the other regions identical in scenarios II and III. In this way, there will be only differences, in scenario III, for the Northeast region and for Brazil as a whole.

4.3. Direct, Indirect and Induced Employment in Sugar Production

Tables 14 to 16 show the results of the impact of the mechanization process of the sugar cane harvest over the employment generated directly, indirectly, and induced by every R$ 1 million produced of Sugar.

As in the case of the Alcohol production, it was made no hypothesis concerning technological changes in the Sugar production, such that there is no changes in the direct employment generated in this sector. The differences, as explained above, occur in the indirect and induced employment.

For Brazil, for every R$ 1 million produced of sugar, the total employment reduces from 149.9 to 128.2 jobs in scenario I, 125.5 in scenario II, and 122.1 in scenario III. This means a decrease from 14.5% to 18.5% depending on the scenario that has been considered. For the North, Northeast, Central West, Southeast, and South regions the range of decrease are, respectively, of 34.7% to 35.2%, 14.4% to 24.5%, 19.8% to 20.8%, 10.8% to 12,.%, and 23.9% to 24.8%. In terms of relative changes, of the tree sectors being analyzed here, the Sugar sector is the one that shows the biggest relative change in total employment.

In absolute numbers the biggest decrease in the employment generated for every R$ 1 million produced occurs in the indirect employment, for Brazil as a whole and for each one of its macro regions. And as observed before, the greatest decrease occur in the workers with a low level of education.

Of the total employment generated, due to the decrease in the indirect jobs, the direct jobs increased its share from 8.50%, for Brazil, to 9.94% in scenario I, 10.14% in scenario II, and 10.43% in scenario III. At the same time the indirect jobs had a decrease of its share from 38.90% to 32.84%, 31.92% and 30.42%, respectively for scenarios I, II, and III, and the induced jobs grew from 52.60% to 57.23%, 57.93% and 59.15% in the scenarios being considered here.

The total employment generated in each one of the regions, as well as the qualification of the labor force differs among the regions and the employment being considered (direct, indirect, and induced).

In the case of the total generated employment, while the Southeast region generates a total of 103.7 jobs in scenario I, and 102.2 jobs in scenarios II and III, for every R$ 1 million produced, in the Northeast region these number are of 267.5 for scenario I, 258.2 for scenario II and of 236.0 for scenario III. For the other regions, the numbers are as follow, respectively, for scenarios I, II, and III: a) North, 154.2, 152.9 and 152.9; b) Central West, 105.7, 104.4 and 104.4; c) South, 140.9, 139.3 and 139.3; and d) Brazil, 128.2, 125.5 and 122.1.

As observed before, the hypothesis related to productivity in scenarios II and III differ only for the Northeast region, this makes that the results for the other regions are identical in scenarios II and III. In this way, there will be only differences, in scenario III, for the Northeast region and for Brazil as a whole.

An additional information is that as the number of people directly employed in the sugar cane harvest decreases in all the macro regions, this causes an increase in the share of the Southeast region in the direct and induced employment generated by the direct employment in other regions.

Table 8
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar Cane: Observed in 1997 and Scenarios I, II, and III - Brazil

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	77.1	40.4	35.9	29.4
	Indirect	16.6	15.0	14.7	14.3
	Induced	84.8	72.3	70.7	69.7
	Total	178.5	127.6	121.3	113.4
< 1	Direct	28.6	12.2	10.2	5.9
	Indirect	2.7	1.8	1.7	1.4
	Induced	12.6	10.6	10.4	10.2
	Total	44.0	24.6	22.3	17.6
1 to 3	Direct	23.8	8.5	7.1	4.9
	Indirect	2.9	2.1	2.0	1.9
	Induced	14.4	12.2	12.0	11.8
	Total	41.2	22.8	21.1	18.5
4 to 7	Direct	20.1	14.8	13.9	13.9
	Indirect	5.1	4.9	4.9	4.9
	Induced	26.4	22.6	22.1	21.8
	Total	51.6	42.3	40.8	40.5
8 to 10	Direct	3.2	3.1	3.0	3.0
	Indirect	2.4	2.5	2.5	2.5
	Induced	12.1	10.3	10.1	10.0
	Total	17.7	15.9	15.6	15.5
11 to 14	Direct	1.0	1.2	1.1	1.1
	Indirect	2.7	2.8	2.8	2.8
	Induced	14.1	12.1	11.9	11.7
	Total	17.9	16.1	15.8	15.7
≥ 15	Direct	0.3	0.5	0.5	0.5
	Indirect	0.8	0.9	0.9	0.9
	Induced	5.1	4.4	4.3	4.3
	Total	6.3	5.8	5.6	5.6

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 9
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar Cane: Observed in 1997 and Scenarios I, II, and III - Northeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	182.1	110.7	96.2	61.5
	Indirect	28.3	23.8	22.7	20.3
	Induced	157.7	136.0	131.2	119.9
	Total	368.1	270.5	250.2	201.7
< 1	Direct	104.3	55.3	46.2	23.5
	Indirect	9.6	6.2	5.6	4.0
	Induced	43.4	36.9	35.5	32.3
	Total	157.2	98.4	87.3	59.8
1 to 3	Direct	55.1	29.2	24.4	12.4
	Indirect	6.4	4.7	4.3	3.5
	Induced	36.0	30.8	29.7	27.1
	Total	97.5	64.7	58.4	43.0
4 to 7	Direct	19.0	22.0	21.4	21.4
	Indirect	5.9	6.2	6.2	6.2
	Induced	39.0	34.0	32.8	30.1
	Total	63.9	62.1	60.4	57.7
8 to 10	Direct	2.2	2.5	2.5	2.5
	Indirect	2.4	2.5	2.5	2.5
	Induced	14.8	12.9	12.5	11.5
	Total	19.4	18.0	17.5	16.5
11 to 14	Direct	0.8	0.9	0.9	0.9
	Indirect	3.2	3.3	3.3	3.3
	Induced	19.1	16.6	16.1	14.7
	Total	23.0	20.9	20.3	19.0
≥ 15	Direct	0.7	0.8	0.8	0.8
	Indirect	0.8	0.8	0.8	0.8
	Induced	5.5	4.8	4.7	4.3
	Total	7.0	6.4	6.3	5.9

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 10
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar Cane: Observed in 1997 and Scenarios I, II, and III - Southeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	44.8	24.2	21.9	21.9
	Indirect	13.4	13.0	12.9	12.9
	Induced	75.6	65.9	64.6	64.6
	Total	133.8	103.1	99.5	99.5
< 1	Direct	9.2	2.3	1.9	1.9
	Indirect	1.1	0.9	0.9	0.9
	Induced	8.3	7.3	7.1	7.1
	Total	18.7	10.4	9.9	9.9
1 to 3	Direct	15.3	3.8	3.1	3.1
	Indirect	1.9	1.5	1.5	1.5
	Induced	11.5	10.0	9.8	9.8
	Total	28.7	15.3	14.4	14.4
4 to 7	Direct	16.3	13.2	12.2	12.2
	Indirect	4.4	4.4	4.4	4.4
	Induced	24.7	21.5	21.1	21.1
	Total	45.4	39.1	37.7	37.7
8 to 10	Direct	2.8	3.3	3.2	3.2
	Indirect	2.4	2.5	2.5	2.5
	Induced	12.0	10.5	10.3	10.3
	Total	17.2	16.2	15.9	15.9
11 to 14	Direct	1.0	1.3	1.2	1.2
	Indirect	2.7	2.8	2.8	2.8
	Induced	13.7	12.0	11.8	11.8
	Total	17.4	16.0	15.7	15.7
≥ 15	Direct	0.3	0.4	0.4	0.4
	Indirect	0.9	0.9	0.9	0.9
	Induced	5.3	4.6	4.5	4.5
	Total	6.5	6.0	5.9	5.9

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 11
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Alcohol: Observed in 1997 and Scenarios I, II, and III - Brazil

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	6.0	6.0	6.0	6.0
	Indirect	45.9	30.8	28.9	26.2
	Induced	75.0	70.0	69.4	68.9
	Total	127.0	106.8	104.3	101.1
< 1	Direct	0.7	0.7	0.7	0.7
	Indirect	13.2	6.4	5.6	3.8
	Induced	11.2	10.3	10.2	10.1
	Total	25.1	17.5	16.5	14.7
1 to 3	Direct	0.7	0.7	0.7	0.7
	Indirect	11.8	5.4	4.8	3.9
	Induced	12.8	11.8	11.7	11.6
	Total	25.2	17.9	17.2	16.2
4 to 7	Direct	2.0	2.0	2.0	2.0
	Indirect	12.8	10.7	10.3	10.3
	Induced	23.4	21.8	21.7	21.5
	Total	38.2	34.5	33.9	33.8
8 to 10	Direct	0.8	0.8	0.8	0.8
	Indirect	3.8	3.8	3.7	3.7
	Induced	10.7	10.0	9.9	9.8
	Total	15.2	14.6	14.4	14.4
11 to 14	Direct	1.4	1.4	1.4	1.4
	Indirect	3.3	3.4	3.4	3.4
	Induced	12.5	11.7	11.6	11.6
	Total	17.2	16.5	16.4	16.3
≥ 15	Direct	0.5	0.5	0.5	0.5
	Indirect	1.0	1.1	1.1	1.1
	Induced	4.6	4.3	4.2	4.2
	Total	6.1	5.8	5.8	5.8

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 12
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Alcohol: Observed in 1997 and Scenarios I, II, and III - Northeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	18.1	18.1	18.1	18.1
	Indirect	106.1	73.9	67.3	51.5
	Induced	152.7	143.2	141.1	136.1
	Total	277.0	235.1	226.5	205.7
< 1	Direct	3.6	3.6	3.6	3.6
	Indirect	51.1	28.9	24.8	14.5
	Induced	42.3	39.2	38.6	37.1
	Total	97.0	71.7	67.0	55.1
1 to 3	Direct	2.4	2.4	2.4	2.4
	Indirect	29.1	17.4	15.2	9.7
	Induced	35.0	32.6	32.1	30.9
	Total	66.4	52.4	49.7	43.1
4 to 7	Direct	5.6	5.6	5.6	5.6
	Indirect	15.2	16.6	16.3	16.3
	Induced	37.6	35.5	35.0	33.9
	Total	58.4	57.7	57.0	55.8
8 to 10	Direct	1.9	1.9	1.9	1.9
	Indirect	4.2	4.4	4.3	4.3
	Induced	14.2	13.4	13.2	12.8
	Total	20.3	19.7	19.5	19.1
11 to 14	Direct	3.9	3.9	3.9	3.9
	Indirect	5.0	5.1	5.1	5.1
	Induced	18.4	17.3	17.1	16.5
	Total	27.3	26.4	26.1	25.6
≥ 15	Direct	0.7	0.7	0.7	0.7
	Indirect	1.5	1.5	1.5	1.5
	Induced	5.3	5.0	4.9	4.8
	Total	7.5	7.3	7.2	7.0

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 13
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Alcohol: Observed in 1997 and Scenarios I, II, and III - Southeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	3.4	3.4	3.4	3.4
	Indirect	30.4	22.0	21.1	21.1
	Induced	66.8	62.8	62.3	62.3
	Total	100.6	88.3	86.9	86.8
< 1	Direct	0.2	0.2	0.2	0.2
	Indirect	4.6	1.8	1.6	1.6
	Induced	7.3	6.8	6.8	6.8
	Total	12.1	8.8	8.6	8.6
1 to 3	Direct	0.3	0.3	0.3	0.3
	Indirect	7.7	3.0	2.7	2.7
	Induced	10.2	9.5	9.4	9.4
	Total	18.2	12.8	12.5	12.5
4 to 7	Direct	1.0	1.0	1.0	1.0
	Indirect	10.7	9.5	9.0	9.0
	Induced	21.8	20.6	20.4	20.4
	Total	33.5	31.0	30.4	30.4
8 to 10	Direct	0.6	0.6	0.6	0.6
	Indirect	3.4	3.7	3.6	3.6
	Induced	10.6	10.0	10.0	10.0
	Total	14.7	14.3	14.2	14.2
11 to 14	Direct	0.8	0.8	0.8	0.8
	Indirect	3.0	3.1	3.1	3.1
	Induced	12.1	11.5	11.4	11.4
	Total	16.0	15.4	15.3	15.3
≥ 15	Direct	0.4	0.4	0.4	0.4
	Indirect	1.0	1.0	1.0	1.0
	Induced	4.7	4.4	4.4	4.4
	Total	6.1	5.9	5.9	5.9

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 14
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar: Observed in 1997 and Scenarios I, II, and III - Brazil

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	12.7	12.7	12.7	12.7
	Indirect	58.3	42.1	40.1	37.2
	Induced	78.9	73.4	72.7	72.2
	Total	149.9	128.2	125.5	122.1
< 1	Direct	1.4	1.4	1.4	1.4
	Indirect	15.0	7.6	6.7	4.8
	Induced	11.7	10.8	10.7	10.6
	Total	28.1	19.8	18.8	16.8
1 to 3	Direct	2.1	2.1	2.1	2.1
	Indirect	13.8	6.9	6.3	5.3
	Induced	13.4	12.4	12.3	12.2
	Total	29.3	21.5	20.7	19.6
4 to 7	Direct	4.6	4.6	4.6	4.6
	Indirect	16.8	14.5	14.1	14.1
	Induced	24.6	22.9	22.7	22.6
	Total	46.0	42.0	41.4	41.3
8 to 10	Direct	2.1	2.1	2.1	2.1
	Indirect	5.8	5.8	5.8	5.8
	Induced	11.2	10.5	10.4	10.3
	Total	19.1	18.4	18.3	18.2
11 to 14	Direct	2.1	2.1	2.1	2.1
	Indirect	5.4	5.5	5.5	5.5
	Induced	13.2	12.3	12.2	12.1
	Total	20.6	19.9	19.8	19.7
≥ 15	Direct	0.4	0.4	0.4	0.4
	Indirect	1.6	1.7	1.7	1.7
	Induced	4.8	4.5	4.4	4.4
	Total	6.8	6.6	6.5	6.5

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 15
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar: Observed in 1997 and Scenarios I, II, and III - Northeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	24.1	24.1	24.1	24.1
	Indirect	122.4	87.9	80.9	64.0
	Induced	165.9	155.5	153.2	147.8
	Total	312.4	267.5	258.2	236.0
< 1	Direct	4.4	4.4	4.4	4.4
	Indirect	56.7	32.9	28.5	17.5
	Induced	45.8	42.5	41.8	40.2
	Total	106.9	79.8	74.7	62.1
1 to 3	Direct	5.1	5.1	5.1	5.1
	Indirect	33.0	20.4	18.1	12.2
	Induced	37.9	35.4	34.8	33.5
	Total	76.0	60.9	58.0	50.9
4 to 7	Direct	7.0	7.0	7.0	7.0
	Indirect	18.6	20.1	19.8	19.8
	Induced	40.9	38.7	38.1	36.9
	Total	66.5	65.7	64.9	63.7
8 to 10	Direct	3.3	3.3	3.3	3.3
	Indirect	5.6	5.8	5.7	5.7
	Induced	15.5	14.6	14.4	14.0
	Total	24.3	23.7	23.4	23.0
11 to 14	Direct	3.6	3.6	3.6	3.6
	Indirect	6.8	6.9	6.9	6.9
	Induced	20.0	18.9	18.6	18.0
	Total	30.4	29.4	29.1	28.5
≥ 15	Direct	0.7	0.7	0.7	0.7
	Indirect	1.8	1.9	1.9	1.9
	Induced	5.8	5.5	5.4	5.2
	Total	8.3	8.1	8.0	7.8

Source: Research Data

Note.: The totals may not add due to rounding problems.

Table 16
Direct, Indirect and Induced Employment for every R$ 1 Million Produced of Sugar: Observed in 1997 and Scenarios I, II, and III - Southeast

Years of Study	Type of Employment	Observed in 1997	Scenario I	Scenario II	Scenario III
Total	Direct	7.5	7.5	7.5	7.5
	Indirect	41.7	33.2	32.3	32.2
	Induced	67.0	63.0	62.5	62.4
	Total	116.3	103.7	102.2	102.2
< 1	Direct	0.3	0.3	0.3	0.3
	Indirect	5.4	2.5	2.4	2.4
	Induced	7.6	7.1	7.0	7.0
	Total	13.4	10.0	9.7	9.7
1 to 3	Direct	0.9	0.9	0.9	0.9
	Indirect	9.0	4.2	3.9	3.9
	Induced	10.3	9.6	9.6	9.5
	Total	20.3	14.8	14.4	14.4
4 to 7	Direct	3.1	3.1	3.1	3.1
	Indirect	14.6	13.3	12.9	12.9
	Induced	21.8	20.5	20.3	20.3
	Total	39.5	36.9	36.3	36.3
8 to 10	Direct	1.5	1.5	1.5	1.5
	Indirect	5.7	5.9	5.9	5.9
	Induced	10.6	9.9	9.9	9.9
	Total	17.8	17.4	17.3	17.3
11 to 14	Direct	1.3	1.3	1.3	1.3
	Indirect	5.3	5.5	5.5	5.5
	Induced	12.1	11.4	11.3	11.3
	Total	18.7	18.2	18.1	18.1
≥ 15	Direct	0.3	0.3	0.3	0.3
	Indirect	1.7	1.7	1.7	1.7
	Induced	4.6	4.4	4.3	4.3
	Total	6.6	6.4	6.3	6.3

Source: Research Data

Note.: The totals may not add due to rounding problems.

5. Final Comments

This paper makes an analysis of the possible impacts that the mechanization process and the changes in productivity on the harvest of the sugar cane will have on employment - direct, indirect, and induced – generated in the sectors producing Sugar Cane, Alcohol, and Sugar. This analysis is made for Brazil and for its five macro regions – North, Northeast, Central West, Southeast and South. To do so, it was construct three scenarios where it was considered different hypothesis about mechanization and productivity.

The hypothesis of the scenarios are as follow: a) scenario I, the mechanization would be of 50% in the Northeast region and of 80% in the other regions, with no changes in productivity; b) scenario II, the same as I for mechanization, for productivity there would be an increase of 20% in the mechanical as well as manual harvest for all the regions; and c) scenario III, the same as II for the North, Central West, Southeast and South regions, for the Northeast region there would be and increase of 140% in productivity for the manual harvest, and of 20% for the mechanical harvest.

It was estimated the employment generated directly, indirectly, and induced, by different levels of study of the labor force, i.e.: a) less than one year of study; b) between 1 and 3 years of study; c) between 4 and 7 years of study; d) between 8 and 10 years of study; e) between 11 and 14 years of study; and f) 15 or more years of study.

The results show that for the above scenarios the number of people directly employed in the sugar cane production would be reduced by 243,211 workers in scenario I, by 273,276 in scenario II, and by 316,288 in scenario III, this means a reduction between 52% to 64% in the number of the labor force being employed directly in the sugar cane production.

This reduction in direct employment in the sugar cane harvest occurs mainly in the workers with a low level of qualification, i.e., workers with 3 or less years of study, and mainly in the Northeast region. In the Northeast region it is found the labor force with the lowest level of qualification, and as a consequence, this is the region where there is the greatest loss of job positions due to the mechanization process and the changes in productivity.

As a consequence of the reduction in the direct employment in the sugar cane harvest, there is a decrease in the indirect and induced employment in the sectors producing sugar cane, alcohol, and sugar.

By the above it is clear that for the sectors producing sugar cane, alcohol, and sugar, the trend is that theses sectors will loose importance in generating direct, indirect and induced

employment. At the same time there is a tendency for an increase in qualification of labor force in these sectors.

The trend observed in these sectors is similar to the one observed in more modern economies, where, on one hand there is an increase in the level of qualification in the people being employed and, on the other hand, there is a decrease in the number of jobs in the primary and secondary sectors with an increasing role of the tertiary sector for employment generation.

However, this reduction in employment calls for an immediate action from the government, giving that the most affected population would be the one with low level of study and with a low probability of being absorbed by the labor market. This would create a social problem that need to be addressed by public policies before it happens.

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