

# The Dynamics in the Structure of Sugarcane Job Market in Brazil

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## **Resumo:**

Esta pesquisa teve como propósito averiguar a estrutura do mercado de trabalho na atividade de cultivo de cana-de-açúcar, à luz das mudanças recentes ocorridas no setor sucroalcooleiro, levando-se em conta os principais estados produtores de cana. Para tanto, realizou-se uma análise estatística descritiva e uma análise de regressão linear simples, com base nos dados da PNAD, de 1997 a 2009. Como corolário, constatou-se que houve uma redução da informalidade no mercado de trabalho em questão, sendo que esta redução foi mais expressiva em Alagoas. Confirmou-se, também, mudanças recentes nas ocupações do setor, com acréscimos nas atividades técnicas, representadas por tratoristas e operadores de máquinas. Evidenciou-se que o mercado de trabalho do setor em questão tem sua dinâmica diretamente ligada aos fatores que ocorrem na cadeia produtiva do setor sucroalcooleiro como um todo.

**Palavras Chave:** Mercado de Trabalho, Tecnologia, Agronegócios e Produção de cana-de-açúcar

## **Sumario:**

Esta investigación tuvo como objetivo investigar la estructura del mercado de trabajo en la actividad del cultivo de la caña de azúcar a la luz de los cambios recientes en el sector del azúcar y el alcohol, teniendo en cuenta los principales estados productores de caña de azúcar. Para ello, se realizó un análisis estadístico descriptivo y un análisis de regresión lineal simple basado en datos de la Encuesta Nacional de Hogares de 1997 a 2009. Como corolario, se encontró que hubo una reducción de la informalidad en el mercado laboral de que se trate, y esta reducción fue más significativa en Alagoas. Se confirmó, también, los cambios recientes en las ocupaciones de la industria, con actividades técnicas superiores, representados por los conductores de tractores y operadores de máquinas. Era evidente que el sector del mercado de trabajo en cuestión ha su dinámica directamente relacionada con factores que se producen en la cadena de producción de este sector en su conjunto.

**Palabras clave:** mercado de trabajo, tecnología, los Negocios Agrícolas y la caña de azúcar de producción

## **Abstract:**

This research aims to verify the structure of sugarcane cultivation's job market, considering the recent changes in this sector and the states with the major production. For that, descriptive and statistical analysis were made, as well as a simplified line regression analysis, based on the *Pesquisa Nacional por Amostra de Domicílios - PNAD* data, for the 1997-2009 period. As corollary, it was stated that there was a reduction in the informal jobs in the

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sugarcane production market, showing more expressivity in the state of Alagoas. Recent changes in the sector occupation were confirmed, as an increase in technical activities, represented by tractors and machinery operators. It was evidenced that this sector's job market has its dynamics closely linked to the sugarcane production chain as a whole.

**Keywords:** Job Market, Agribusiness, Technology, Sugarcane production.

## 1. INTRODUCTION

The articulation in the production chains are influenced by a horizon of possibilities, which are dictated by technology, workforce and the strategies of the agents in production to reach their objectives. The primary production, one of the most important links in the chain, is pushed to increase productivity, quality raw material supply, job market rules, environment care and to other exigencies. These issues have driven the agribusiness into modernization, having technology as its main resource to increase productivity and quality while changing the job market relations.

From the sugarcane agribusiness viewpoint, Shikida (1998a) asserts that the sector embraces the agricultural segments – including rural producers – and the industrial segment, which processes the sugarcane, represented by factories. The sector progresses as the changes imposed by the institutional system, which involves the environmental and laborite matters, have driven the workers to resizing and setting new dimensions in the job market.

Brazil is seen as a big producer of sugarcane, having produced 569 million tons of sugarcane and 27.5 million cubic meters of ethanol in the 2008/2009 crop (UNICA, 2012). Concerning the sugar exportation, only in July, 2011, Brazil exported 2.29 million tons of raw sugar, representing an increase of 11.09%, in comparison to the same period in 2010 (CEPEA, 2012).

However, the recent increase in the sector took place after a period of deregulation. According to Vian (2003), in this case, the state changed its status from intervener to coordinator of the sugarcane market. Moreover, the institutional changes have reflected the actions of the sector's agents, so the modernization of production is a necessary condition to surviving in this market. Thus, the insertion of new production techniques increased the productivity in the sugarcane sector, reaching all of the links of the chain.

Regarding the environmental matters, the public sector presents an essential role because, according to Moraes (2007a), the legislation that forbids burns as detrash technique has affected the number of workers in the sugarcane crop.

On the other hand, the advance in of formality in the sector's job market sets another important change in this market. This advance is closely related to the insertion of sugarcane sector in the foreign market, as since 1941 the sector may only demand workforce by direct hiring, in factory or rural activities. Thereby, the job formality characterizes a market strategy in relation to the external market competition (DEDECA e MENDES, 2009).

Considering the presented information, this research has as purpose to investigate whether there were changes in the composition of the sugarcane cultivation job market. In this case, it is supposed that the sugarcane complex's recent dynamics has influenced the occupations' distribution in the sector. In other words, the implantation of new technology that happened at the same moment as the institutional changes had a contribution to reduce informal jobs, increasing the formality since the informal workers are occupy jobs that do not have technological demands. Furthermore, it is believed that there was a redistribution of the

sector's occupations, from the increase of people that manipulate the agribusiness mechanization machinery and the reduction of workers in manual sugarcane crop.

In order to reach the scope of this research, a descriptive-statistical analysis was developed, as a simplified linear regression of National Research of Domicile Sample (PNAD) data from 1997 to 2009. The PNAD database is national research realized by the Brazilian Institute of Geography and Statistics (IBGE) and it is part of a probabilistic sample of homes, which aims to elicit the socioeconomic condition of the country.

Regarding the database characteristics, it is noteworthy that it studies the market on the point view of labor supply because the PNAD data are collected from individual questioning.

## 2. THE TECHNOLOGY AND THE JOB MARKET IN THE SUGARCANE CULTIVATION

According to Shikida and Bacha (1998), the sugarcane derivatives had as propulsions to the technology modernization: the machinery innovation and agricultural implements; the physical-chemical innovation through new alcoholic brew techniques and the vinasse as fertilizing; new production methods and work organization strategies; the reuse of sugarcane bagasse for generating energy and straw, among other sub products.

Shikida et al. (2007) affirm that the whole sugarcane sector is characterized by a recent expansion that was pushed by the increase of the alcohol demand, inside and outside the country. Thus, the biggest participation on Brazil in the international market, for sugar and/or ethanol, has brought significant changes in the competitiveness of this sector. As an example, there is the growth of planted sugarcane area, the entrance of new mills in the market, the search for increasing productivity and the adoption of new production techniques.

Such factors created favorable conditions to the equipment industry to develop a whole line of products, including pioneer technology, using a minimum amount of importation. The consequence of this expansion was the accelerated increase of sugarcane processing from less than 100 million tons to over 700 million tons per year and medium yield of 50 ton/ha to over 71 ton/ha between the decades of 1975-2011 (IBGE, 2011b).

Because of this, new occupations in the work technique division of the sugarcane sector were implemented, demanding workers with higher qualification and promoting important changes in the work process. The required qualification shows the increase of workers stability by the reduction of the turnover and the increase of life quality, generating a positive impact over the economy in the places of production/beneficiation.

Nevertheless, it is known that the job offering in this segment is, in its major part, represented by workers with limited qualification and the demand, in general, is represented by the sector's enterprises or big landowners. Meanwhile, this workforce demand is changing due to the institutional and competitive environments' modifications. Regarding to the institutional one, it is caused by Environmental Legislation. About that, Moraes (2007b) points out that the gradual reduction of the sugarcane burn, contained in the Federal Decree n° 2.661 of 7<sup>th</sup> July 1998, which has different settings for some Brazilian states:

[...] The sugarcane burn is still commonly adopted in Brazil, since the sugarcane crop is, in its majority, manually made by temporary workers and, after the detrash, the cropping and transportation take place. [...] The previous burn of the sugarcane increases the workers' productivity because it

avoids the sugarcane straw removal. As the worker gains per productivity, their on corporate conventions stipulate that the cropping must be of burned sugarcane. To harvest the raw sugarcane manually is anti-economical, driving to the mechanization of harvesting. (MORAES, 2007b, p.8 – translated by authors).

However, such practice guarantees thousands of job, according to the ones who defend the method. When the sugarcane straw is not burned, the crop has to be made mechanically, and each harvest machine substitutes around 100 workers (RAMOS, 2007; BACCARIN, *et al.*, 2008).

With that said, we point out that, with the advance of the sugarcane sector in the foreign market, the enterprises, in order to make it on the market, start working on developing new technologies and invest in new researches and developing, aiming to trespass their competitors and having technology as their main strategy.

It is noteworthy that these settings adopted by the enterprises reflect directly in the work market composition, mainly the one regarding the sugarcane crop and harvest. The reduction of informal jobs is clear in every link of the chain, considering that the competition standards in the foreign market require a production that follow the environmental and laborite rules. This new standards drive to the reduction of informality, since the country may be charged with nontariff barriers (MORAES, 2007a; DEDECCA & MENDES, 2009).

Ulyssea (2005) reinforces that the problem of informality has been eased in Brasil due to the legislation that requires from every salaried worker to have an Employment Record Book.

In addition, Moraes (2007b) affirms that as the technical evolutions as the changes in the institutional environment have effects over the jobs. For that, Ricci et al. (1994) point out three important technological innovations effecting over the job market: (i) the introduction of the machine that intensifies the work journey; (ii) the physical-chemical innovations that change the natural characteristics of the soil, increasing the productivity; (iii) biological innovations that affects the rotation process between capital and work.

As corollary, the main impacts of mechanization are: the reduction of time to execute tasks, the reduction of labor force demand and the qualitative changes in the demand, since other activities, such as machinery operators and more specialized workers are now demanded by enterprises (RICCI et al., 1994).

It is noteworthy that several elements set and change the structure of job market. In the case of sugarcane sector, the law's changes and the advance of the sector in the foreign market are crucial, so that the sector start to restructure itself to be kept in the market. It is believed that this restructure affected the job work in this sector, specially concerning to jobs inserted in the sugarcane cultivation. Taking that in consideration, the methodology and results contained in the next sections of this paper were elaborated.

### 3. METHODOLOGY AND DATA

In order to reach the proposed goals in this research, a statistic-descriptive analysis was made, as a simplified linear regressive analysis, of historical series obtained through PNAD, from 1997 to 2009. The statistic-descriptive analysis aims to synthesize a series of values of same nature, allowing having a global view of these values' variation. The descriptive statistics describes data in three ways: tables, graphics and descriptive measures. In this case, the descriptive statistics was used to analyze the number and percentage of

formal and informal workers in this period. Through this method it was also analyzed the participation of main occupations regarding the total of workers in the time. Such analyses were split by state.

Furthermore, the results presented in this research are composed by seasonal series that may show tendencies, to growth or crash. In order to notice this behavior, it was used the linear trend model, in which the variable  $t$  is known as *trend variable*. In this case, the simplified linear regression follows the equation below:

$$y_t = \beta_0 + \beta_1.t + \varepsilon_t \quad t = 1, 2, \dots, 12 \quad (1)$$

Where:

$y_t$  => Number of workers with formal or informal jobs, working in the cropping/harvesting of sugarcane, or working as tractor/machinery operator;

$t$  => Regressive “time” indicator, assuming values 1, 2, ..., 12;

$\beta_0$  e  $\beta_1$  => Regression parameters, in which  $\beta_1$  measures a change in  $y_t$ , from a period of time to the next one, motivated by passing time (as the other values remain still and when  $\Delta\varepsilon_t = 0$ );

$\varepsilon_t$  => Estimated error, supposing that  $E(\varepsilon_t) = 0$ ;  $\text{Var}(\varepsilon_t) = \sigma^2$ <sup>4</sup>.

In this paper, among the PNADs<sup>2</sup> information from 1997 to 2009 were selected people aged between 10 and 80 years old that declared themselves as workers in the week of the PNAD research. Out of those were selected only the ones identified as workers in the sugarcane cultivation, living in the states of Pernambuco, Alagoas, Minas Gerais, São Paulo, Paraná, Mato Grosso do Sul, Mato Grosso and Goiás. From this selection, these workers occupations<sup>5</sup> were identified, just as the number and percentage of people in formal or informal jobs.

Regarding the chosen states to the sample, it is noteworthy that, recently, the agricultural exploration of sugarcane grows in Brazil in states that did not have this activity before. In those states, the number of workers and their condition in job market present significant oscillations from a year to another. Table A1 (attached) shows the Brazilian sugarcane production, split in states. It is possible to see that the participation of the Northern states is still small, whereas the Center-West region states have their productivity systematically growing. This way, it was chosen to include in the analyses the states that overcame the production of 10 million tons, in the 2008/2009 harvest.

Another point to be noted concerns to the concept of informality, to which Ulysea (2005) affirms not to exist a consensus in the job market literature, since there are a big variety of definitions, as for theoretical workers as for the empirical ones. Thus, since Brazilian legislation requires that workers have a signed an Employment Record Book, the definition here is associated to its possession. The Brazilian Institute for Statistical Geography (IBGE) includes the possession of Employment Record Book in its researches over workers’ characteristics. Also, the self-employers are identified, just as the employers and the ones who work for self-consume and construction for self-use. Since over 90% of the employers and the

<sup>4</sup> The PNADs’ data were extracted using the *SAS for Windows V8* software.

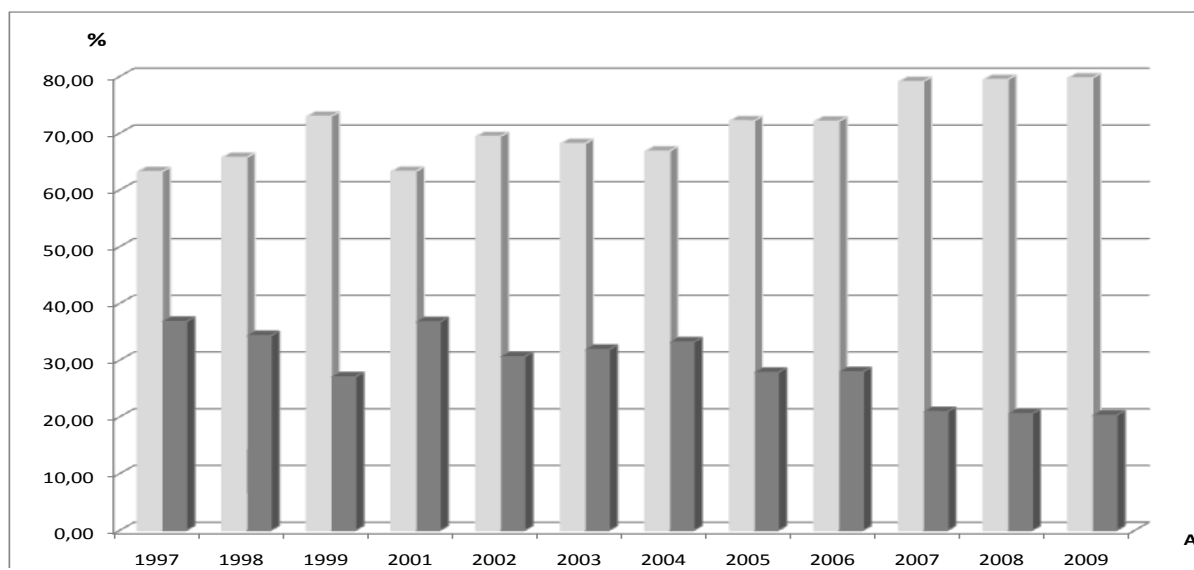
<sup>5</sup> According to the methodological notes of PNADs, it is defined as occupation the job, position, craft or profession of people, in the referred period.

totality of employees that have signed Employment Record Book pay social insurance, this research included them in the formal workers group. Likewise, the ones with no Employment Record and in construction/production for self-consume were considered informal workers.

#### 4. 4. RESULTS AND DISCUSSIONS

Image 1 shows that in 1997, about 37% of workers inside the sugarcane cultivation are informal. This percentage reduced gradually between 1998 and 1999, increasing again in 2001. From 2002 on there was another reduction of this percentage and an increase of formal workers participation, reaching 20.27% and 79.73% respectively in 2009.

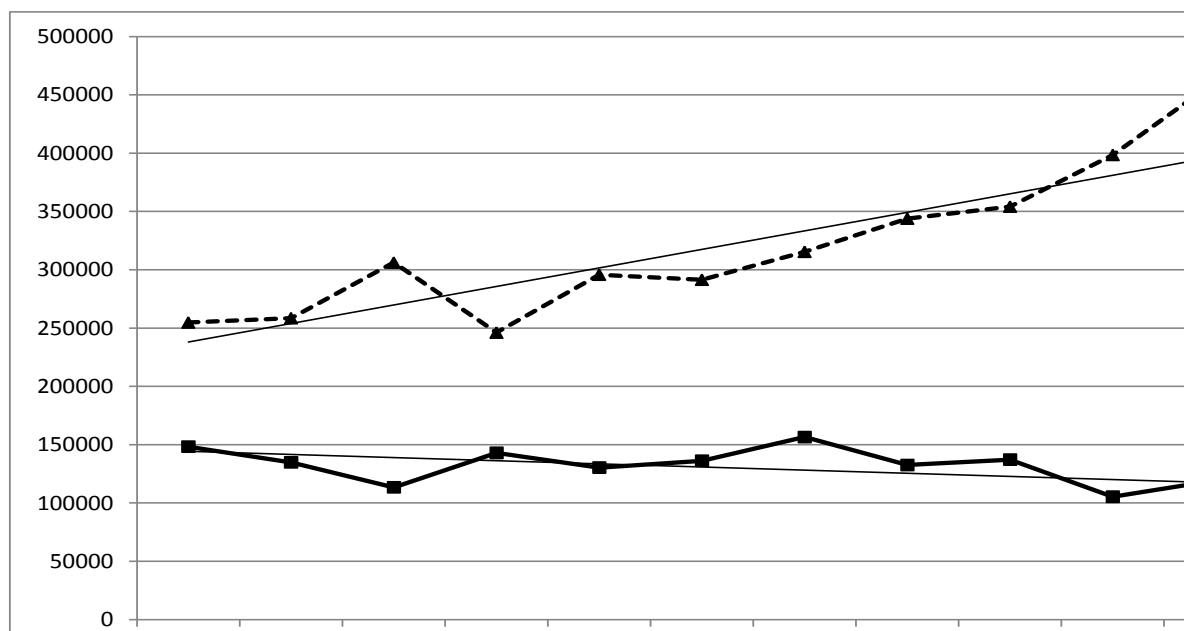
Image 1 – Percentage of formal and informal workers in the sugarcane cultivation – Selected states – 1997 to 2009.



Source: Elaborated by authors based on PNADs 1997-2009.

In addition to the graphic above, Image 2 shows the evolution of the total number of workers, in formal and informal job markets.

Image 2 – Total of formal and informal workers in the sugarcane cultivation – Selected states – 1997 to 2009.



Source: Elaborated by authors, based on PNADs 1997-2009.

The image above shows a clear trend in formality increase and informality decrease. The number of formal workers, which was 254,788 people in 1997, increased 48.7%, reaching 378,872 people in 2009. In the informal job work there was a decrease of 35.01%, being a reduction of the total of workers from 148,231 to 96,333 people. However, it is to be clarified if this trend is statistically meaningful.

In table 1, just as the percentage of formal and informal market participation as the growth of the total number of workers is separated by states. Alagoas is detached as the state with the biggest decrease of informal market number, regarding the total number of workers, from 68.6% to 19.33%, between the years of 1997 and 2009. In Minas Gerais the decrease was of 21.08% and about 15% in Paraná and Mato Grosso do Sul. Even though the decrease was small in São Paulo (about 8%), it is noteworthy that the index of informality was the lowest along the period. In the other states, the number of workers (formal and informal) oscillated in the period of time.

Regarding to the evolution of number of workers, Goiás was the most highlighted state, showing frequent growing indexes, as for the formal jobs as for the informal ones. In this state, there was an increase from 1,602 workers to 22,893. This evolution was the most significant for formal workers, growing 1,109% from 1997 to 2009. Going back to Table A1, Goiás also presents a singular behavior, since 2008/2009 production was 3.6 times bigger than 1996/1997 harvest.

São Paulo, Alagoas e Mato Grosso do Sul had the most regular growth in formal jobs and in informal job decrease. Comparing 1997 and 2009, the number of formal workers in Alagoas grew 70.89%, as the informality felt 81.26%. Also in this period, the informality decreased 38.11% in São Paulo, in contrast to the formal work, that grew 50.95%. In Mato Grosso do Sul, the positive growth was 114.51% for formal jobs and the decrease of 67.96% for informal jobs.

In opposition to the other states, the informal jobs in Pernambuco grew more than the formal ones. Mato Grosso and Minas Gerais had a positive growth, in which both markets presented a positive increase, with a slight difference in Mato Grosso's percentage.

Regarding the job Market structure in Latin America, Cerqueira (2015) points out to

the fact that in such region there is a very peculiar and long lasting form of hierarchical capitalism, in which the biggest part of workers have low qualification and the market is segmented.

In this case, even though the Latin-American economies present a high level of job regulations, the rules do not seem to reach the majority of workers in informal conditions. In comparison to developed regions, Latin America also presents low levels of education and working qualification.

Brazil is not an exception when it comes to low-qualification, which becomes clear by analyzing the sugarcane production sector, which presents a high level of informality amongst workers. This reality has surrounded the discussions about the production mechanization, because the workers would not be prepared to follow up the technological evolution, and therefore would be unemployed. However, considering that the work in sugarcane fields also brings damage to the workers' health, we believe that the way to solve this problem lays on the qualification of such workers, in order to prepare them to occupy new spots created along with the arrival of new technologies.



Table 1: Total number and percentage of formal and informal workers in sugarcane cultivation in the selected states – from 1997 to 2009.

Year	Alagoas		Pernambuco		Goiás		Mato Grosso do Sul		Mato Grosso		Paraná		Minas Gerais		São Paulo	
	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal
<b>1997</b>	31.40	68.60	61.70	38.30	100.00	0.00	81.26	18.74	81.84	18.16	76.35	23.65	46.43	53.57	84.81	15.19
<b>1998</b>	41.57	58.43	59.64	40.36	74.97	25.03	49.96	50.04	78.58	21.42	77.38	22.62	44.82	55.18	85.19	14.81
<b>1999</b>	45.16	54.84	63.47	36.53	68.75	31.25	89.99	10.01	75.02	24.98	92.63	7.37	58.30	41.70	88.36	11.64
<b>2001</b>	43.07	56.93	51.42	48.58	63.13	36.87	92.87	7.13	70.97	29.03	94.11	5.89	36.30	63.70	87.98	12.02
<b>2002</b>	52.89	47.11	59.20	40.80	78.95	21.05	94.46	5.54	52.92	47.08	75.01	24.99	50.26	49.74	92.18	7.82
<b>2003</b>	67.02	32.98	54.31	45.69	62.86	37.14	66.60	33.40	88.47	11.53	71.99	28.01	46.67	53.33	88.74	11.26
<b>2004</b>	58.27	41.73	52.67	47.33	85.71	14.29	80.00	20.00	65.01	34.99	86.35	13.65	35.91	64.09	86.26	13.74
<b>2005</b>	66.22	33.78	55.93	44.07	75.00	25.00	83.88	16.12	65.00	35.00	78.05	21.95	56.86	43.14	93.48	6.52
<b>2006</b>	59.52	40.48	63.69	36.31	82.36	17.64	85.71	14.29	52.49	47.51	73.90	26.10	49.00	51.00	90.45	9.55
<b>2007</b>	80.00	20.00	57.72	42.28	75.93	24.07	94.23	5.77	97.05	2.95	97.29	2.71	57.31	42.69	93.59	6.41
<b>2008</b>	77.12	22.88	65.70	34.30	92.59	7.41	85.00	15.00	92.00	8.00	81.46	18.54	60.19	39.81	92.07	7.93
<b>2009</b>	80.67	19.33	59.07	40.93	84.61	15.39	96.67	3.33	84.01	15.99	91.43	8.57	67.51	32.49	93.16	6.84
<b>1997</b>	30095	65762	48333	30003	1602	0	4142	955	3023	671	42137	13054	15710	18129	109746	19657
<b>1998</b>	38600	54260	40921	27693	1965	656	637	638	3939	1074	40294	11780	14927	18375	117189	20379
<b>1999</b>	39504	47973	35875	20645	3641	1655	5787	644	1021	340	52362	4165	27199	19455	140770	18542
<b>2001</b>	28071	37110	61122	57739	3854	2251	4152	319	7565	3095	9416	589	14714	25819	117237	16024
<b>2002</b>	54387	48445	64604	44520	4937	1316	5250	308	2932	2608	5406	1801	19818	19613	138439	11746
<b>2003</b>	57691	28388	77544	65232	7324	4328	640	321	7180	936	10814	4207	16007	18291	114298	14501
<b>2004</b>	39979	28628	79593	71514	6210	1035	3703	926	4290	2309	11353	1794	14279	25483	156011	24859
<b>2005</b>	45757	23343	84835	66854	6081	2027	8022	1542	4304	2318	18976	5337	27345	20748	148535	10367
<b>2006</b>	47816	32515	86873	49527	9714	2081	11004	1835	6768	6126	10124	3575	23829	24806	158035	16681
<b>2007</b>	45503	11377	70043	51317	14457	4582	15418	944	11985	364	22256	619	31259	23288	187568	12845
<b>2008</b>	51020	15140	97838	51088	26480	2119	10588	1869	8882	772	10379	2363	41586	27508	214798	18488
<b>2009</b>	51428	12325	66307	45943	19370	3523	8885	306	8299	1580	20288	1902	38632	18588	165663	12166

Source: Elaborated by authors based on PNADs from 1997 to 2009.

In Minas Gerais, the formal job market growth 145.91%, as the number of informal workers had an increase of only 2.53%. Finally, it is noteworthy that the changes initially observed in the selected states might be statistically relevant or not. This relevancy will be measured through simplified linear regression.

Thus, table 2 shows the total number and the percentage of workers in selected states, according to the occupation stated by each of them. The line that identifies the occupation of these workers has a group of information for the 1997-2001 period and another relation for the years between 2002 and 2009, because of a change in the naming adopted by IBGE for the PNADs occupation. But, in both cases, it is possible to clearly identify the workers whose function was tractor/machinery operator or a similar function. The participation of this occupation in relation to the total number of workers grew annually, starting with an increase of 4.76% in 1997 and reaching 14.43% in 2009. Moreover, the growth of the total number of workers was expressive (257.22%, comparing 1997 and 2009).

In the job defined as sugarcane cropper/harvester the variation of workers number was small and its participation percentage has a slight decrease. In this case, there was a persistent decrease of workers number until 2003, which reached 30.7% in comparison to 1997. However, this number started growing again after 2004, reaching, in 2008, a percentage higher than in 1997 and a lower percentage (4.62%) in 2009.

Regarding the other occupations, the number and percentage of employers and self-employers after 2002 is important. Between 1997 and 2001, reach the maximum of 25.671 putting the values of the second and third rows together, a participation of 6.6%. In 2002, the number of workers in this category grew 418.29% in relation to 2001, having the participation percentage increased from 1.27% to 18.13%. Such participation kept expressive until 2006, reducing again in 4.4% in 2009. It is important to notice that the employers and self-employers are, in general, the land owners that cultivate some kinds of farming by themselves or with the help of family/others. In the case of sugarcane cultivation, apparently there was an increase in the number of producers interested in this kind of farming between 2002 and 2006, which was soon discouraged by some external factor that was not identified in this research.

Table 2: Number and percentage of workers in the sugarcane cultivation, according to occupation's identification – Selected states

Year	Occupation Identification <sup>6,7</sup>												Total
	Agribusiness/agricultural employer; Cultivator; Farmer/Land Owner; Plowman, Grower; Rural worker, hoe worker.		Agribusiness/agricultural manager, farming manager; Agribusiness/agricultural enterprise manager.		Self-employer: Farmer, Farm Renter, Cultivator, Plowman, Grower, Sharecropper; Hoe worker.		Fertilizer/cropper machinery operator; Agricultural machinery operator; Sower operator; Tractor operator.		Sugarcane harvester; Sugarcane cropper; Employees: Farmer, plowman, harvester, cropper; Diarist worker.		Other occupations – less than 1%		
	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	
<b>1997</b>	5.090	1.26	6.236	1.55	9.815	2.44	19.199	4.76	350.880	87.06	11.799	2.93	403.019
<b>1998</b>	3.219	0.82	6.104	1.55	10.374	2.64	24.576	6.25	335.950	85.41	13.104	3.33	393.327
<b>1999</b>	6.443	1.54	3.315	0.79	16.565	3.95	19.080	4.55	353.533	84.26	20.642	4.92	419.578
<b>2001</b>	4.923	1.27	1.319	0.34	20.748	5.33	17.699	4.55	327.312	84.13	17.076	4.39	389.077
	Self-employer/Employer: Farmer. Farm Renter. Diarist worker. producer, cropper, harvester.		Rural work manager; Work fiscal; Farm caretaker; Planter; Planter chief.		Rural worker; Rural worker assistant; Diarist rural worker; Cultivator; Planter; Cropper; Land owner; Land partner.		Fertilizer/cropper machinery operator; Agricultural machinery operator. Machinery operator assistant.		Sugarcane harvester; Sugarcane cropper; Employees: Farmer, plowman, harvester, cropper; Diarist worker. Detrasher; Agribusiness entrepreneur.		Other occupations – less than 1%		Total
<b>2002</b>	77.251	18.13	10.534	2.47	23.359	5.48	17.964	4.22	284.054	66.66	12.968	3.04	
<b>2003</b>	102.819	24.04	3.676	0.86	28.447	6.65	21.928	5.13	243.150	56.85	27.682	6.47	427.702
<b>2004</b>	72.246	15.31	9.357	1.98	23.638	5.01	21.192	4.49	309.253	65.52	36.280	7.69	471.966
<b>2005</b>	39.402	8.27	6.620	1.39	23.272	4.89	32.254	6.77	334.280	70.17	40.563	8.51	476.391
<b>2006</b>	52.923	10.77	5.388	1.10	23.714	4.83	42.748	8.70	335.177	68.22	31.359	6.38	491.309
<b>2007</b>	32.924	6.53	7.322	1.45	22.225	4.41	35.593	7.06	372.047	73.84	33.714	6.69	503.825
<b>2008</b>	43.888	7.55	12.744	2.19	32.416	5.58	76.204	13.12	374.427	64.45	41.239	7.1	580.918
<b>2009</b>	20.901	4.4	8.004	1.68	21.033	4.43	68.582	14.43	334.675	70.43	22.010	4.63	475.205

Source: Elaborated by authors based on PNADs from 1997 to 2009.

<sup>6</sup> In order to identify the each worker occupation, the PNADs from 1997 to 2001 were based in the Brazilian Classification for Occupations (CBO), while PNADs from 2002 to 2009 took in consideration the Brazilian Classification for Domiciliary Occupation (CBO-Domiciliar), which is an adaptation of CBO to domiciliary occupations. Thus, PNAD regroups some occupational families in subgroups and main subgroups, considering the difficulties of its accurate capitation in domiciliary researches. In this work, the information regarding the occupation of each worker in sugarcane cultivation considered this variations, so some similarities and differences are noticeable in the two mentioned periods analysis.

<sup>7</sup> Translator's note: This article was originally written in Portuguese. Some of the occupation's names in the table do not have a translation, so analog words were used but it does not affect the results presented in the translated version.

It is also noteworthy that in the occupations presented in Table 2, only from two of them will be analyzed the temporal trend, once the information of only two of them is enough to test the pertinent hypothesis in this research.

#### 4.1 Linear trend model estimative of workers inserted in the sugarcane cultivation

Table 3 shows the linear trend of the number of workers (formal and informal) in the sugarcane cultivation, in Brazil and in selected states. It is possible to verify that the results for Brazil were significant and according to the expected. This because the positive sign for estimative parameters  $\beta_1$  reveals an increasing trend to formal workers in job market, while the total of workers increases, in average, to the maximum of 15,900 workers in the period from 1997 to 2009. In informal job market, it is statistically proved the decreasing trend, reaching the maximum of 2,689 workers in the meantime.

Regarding the selected states, the results were, in majority, in according to the expected estimated models for formal job market. On the other hand, many estimative results for informal job market were not relevant or differentiated from the expected. Observing the two states with higher number of hires, the statistics were relevant in Alagoas in both models, while there is an increasing trend for formal job market and decreasing for informal market. In the state of São Paulo, the formal market trends to grow, in an absolute rate of 7,333 people. In this state, the estimated parameter of inclination in informal job market model was not statistically significant, but the negative sign indicates the possibility of an even bigger decrease in the State's index of informality.

It is important to highlight the increasing tendency to formality in state of Goiás. This is state has shown a recent growth in the sugarcane production and the growing number of formal jobs points a positive participation of sugar and ethanol production complex in the local economy.

In the state of Parana, the results for the formal job market were relevant, but negative, indicating a tendency to the informality. However, an accurate view over the results on Table 2 reveals an expressive decrease in the total number of workers between 2002 and 2003. Such result is a reflex of the leaving of producers out of the sugarcane production, due to climatic issues and the lack of government support. Recently, the new demand of ethanol has increased the interest of producers in some parts of the state, which leads to a regain in the number of jobs in the sector. Nevertheless, these changes are still not evident, but they may be more expressive in a longer period. Shikida et al. (2010) explains that the recent production of flex fuel vehicles has increased the consume of ethanol in Brazil, which heated the sugarcane agribusiness and consequently the expansion of sugarcane planted area.

Table 3: Model of linear trend for formal and informal workers in the sugarcane cultivation – Brazil and Selected States (1997 to 2009).

Geographical Unity	Condition	Intercepto $\beta_0$	Inclination $\beta_1$	R <sup>2</sup>
Brazil	Formal	222,081 (11.41)*	15,900 (6.01)*	0,78
	Informal	146,919 (15.36)*	-2,689 (-2.07)***	0,30

Geographical Unity	Condition	Intercepto $\beta_0$	Inclination $\beta_1$	R <sup>2</sup>
Alagoas	Formal	34,073 (7.22)*	1,551 (2.42)**	0,37
	Informal	63,183 (15.88)*	-4,525 (-8.37)*	0,87
Pernambuco	Formal	41,900 (5.22)*	3,988 (3.66)*	0,57
	Informal	34,124 (3.81)*	2,213 (1.82)***	0,25
Goiás	Formal	-3,093 (-1.26)	1,830 (5.49)*	0,75
	Informal	531 (0.76)	246 (2.59)**	0,40
Mato Grosso do Sul	Formal	728 (0.37)	891 (3.36)*	0,53
	Informal	476 (1.37)	63 (1.33)	0,15
Mato Grosso	Formal	1,837 (1.31)	617 (3.23)*	0,51
	Informal	1,324 (1.27)	81 (0.57)	0,03
Paraná	Formal	36,503 (4.40)*	-2,362 (-2.09)***	0,30
	Informal	9,018 (4.48)*	-731 (-2.67)**	0,42
Minas Gerais	Formal	10,436 (2.66)**	2,052 (3.84)*	0,60
	Informal	18,957 (9.39)*	418 (1.52)	0,19
São Paulo	Formal	99,695 (8.72)*	7,333 (4.72)*	0,69
	Informal	19,304 (7.61)*	-454 (-1.32)	0,15

Source: Research results.

Note: Values in parenthesis refer to *t-student* statistics; \*Indicates significance level of 1%; \*\*Indicates significance level of 5%; \*\*\*Indicates significance level of 10%.

To analyze the sugarcane cultivation jobs from the occupations in a linear trend model, it was chosen the two occupations that better relate to this research's hypotheses. Table 4 shows a growing trend for tractor operator occupation, reaching the absolute index of 4,513 workers. Thus, one of the hypotheses was confirmed: the technological advance in the sugarcane sector increased the opportunities for jobs that demand higher technical knowledge. About this point, it is important to note that:

[...] There is a constant growing in the number of workers in the mechanized harvest. The total of workers was 15,500 in the 2006/07 harvest and it must reach 59,500 in 2015/16 and 70,800 in 2020/21. [...] the new job offers will demand better qualified workers, but will also offer better payments (UNICA, 2012b – translated by authors).

Sorda, Banse e Kemfert (2010) point out to the importance of the growth in the supply demand in the sugar and alcohol sector. Between 2000 and 2009, the world production of ethanol went to an increase of 16.9 to 72 billion of liters, especially amongst the biggest producers in the world: Brazil, Canada, the United States, Argentina and Colombia. To those authors, Brazil has the most developed and professionalized biofuel sector in the world, since the other countries still need government support, which usually occurs through tax discounts, as well as subsidies and other incentives to assure the production growth.

Maiero e Lopes (2008) have shown that Latin-American countries are potential ethanol and biofuel suppliers for a possible new alternative energies market. Brazil and the United States detach as the world's biggest producers, mas the Latin-American governments have searched for infrastructure in regulations and finances, in order to figure in such emergent industry. In Colombia, the agriculture made in a diversified way, creating work spots in the fields due to the substitution of coke plantations by the ones destined to biofuel production. In Paraguay, the interest in the biofuel industry lays on the complete dependence on petroleum, and in the economy majorly rural. In other American countries, the production of biofuels is faced as an important tool for social and economic development, but investments and incentives are necessary.

There is a debate, in Brazil, regarding the deploy of cultivable lands. As in the country sugarcane is the main raw material for ethanol, there a discussion around the dichotomy Food X Fuel, in which one of the arguments is that the biofuel production would lead to decrease the amount of land used for food production. Chaddad (2010) affirms that such debate is overcome in Brazil, since the sugar and ethanol sector has shown fast growth and a meaningful structure change, especially regarding the culture of sugarcane. Thus, the use of new technologies, such as the mechanization of seeding and harvest, has contributed to the vertical growth in the production, which spares other lands to be used for ethanol culture.

It is important to mention that the mechanized harvest in sugarcane culture sets an important change in the work, considering that handwork in such activity can be extremely tiring and damaging for the worker's health. According to Rodrigues (2006), the sugarcane harvest worker labors from 8 to 12 hours per day in hostile environment, with smoke and dust from the burn process. Besides, the sugarcane culture locations and the facilities that host the croppers do not have minimum structure to do so, such as potable water, restrooms or food storage features (MARTINELLI and FILOSO, 2008).

Also, as brought by Baccarin et al. (2008), the work is done outdoors, usually in high temperatures, which make the croppers sweat in excess, causing dehydration and cramps. Plus, workers often present pain all over the body, leading to absenteeism.

Table 4: Linear trend model for workers in the sugarcane cultivation, regarding the two selected occupations – Brazil (1997 to 2009).

Occupation	Intercepto $\beta_0$	Inclination $\beta_1$	R <sup>2</sup>
Tractor/Harvest Machinery	3,748	4,513	0,66

Operator	(0.50)	(4.41)*	
Sugarcane	316,976	1,936	
Harvester/Cropper	(13.58)*	(0.61)	0,04

Source: Research results.

Note: Values in parenthesis refer to *t-student* statistics; \*Indicates significance level of 1%.

Unlike the expected, the inclination of the coefficient in the linear trend model to Sugarcane Harvester/Cropper occupation presented a positive sign, which was not significant in the level of 10%. However, Table 2 shows that the number of jobs in this occupation reduced a priori, growing again after 2004. Wooldridge (2006) states that some seasonal series are better approximated by an exponential trend or a polynomial trend, thus, it was estimated for these occupations the equation 2, supposing that the series might have a quadratic trend. In this second model, all the parameters were significant at the 10% level. There is, thus, two parameters representing the inclination. The negative sign for the  $\beta_1$  estimative (-22,942) followed by a positive sign for  $\beta_2$  estimative (1,914) confirms that the sugarcane harvester/cropper job had a decreasing trend and in sequence an increasing trend. It is possible that this result is associated to the recent growth in the sugarcane production in Brazil, as it is shown in Table A1. If this growth is associated to the entrance of new produced in the market, it is possible that they start their activities prioritizing the manual harvest and, in a later moment, invest in rural and harvesting equipment. Thereto, there are some areas that are not appropriate for mechanic harvest, requiring manual work. According Veiga Filho et al. (2003), about 50% of sugarcane plantation area in São Paulo, the state with biggest production, have irregular terrain, inappropriate for mechanic cropping and harvesting.

$$Total\_job\_harvester = 375025 - 22942.t + 1914.t^2 \quad (2)$$

$t\text{-student} = (11.17) \quad (-1.93) \quad (2.15)$   
 $Significance\ level = \quad 1\% \quad 10\% \quad 10\%$

## 5. CONCLUSIONS

This research aimed to verify the composition of sugarcane cultivation/harvest job market considering the recent changes in the sugarcane sector. For that, a statistic-descriptive analysis was made, as a simplified linear regression, based in PNAD's data, from 1997 to 2009.

This way, this work points the evolution in the job market in the main producer states of sugarcane. Regarding the informality in the sector, it was noticed a reduction of 35.01% in the period of the analysis while the formal job grew 48.7%. From the states approached by this research, Alagoas presented the highest decrease in informal job, right before Minas Gerais, Paraná, Mato Grosso do Sul and São Paulo. Meantime, it is noteworthy that São Paulo already presented the lowest indexes of informality so its decrease was less expressive.

Among the selected states, São Paulo, Alagoas and Mato Grosso do Sul presented more regularity in the formal job increase and informal job decrease. On the other hand, Pernambuco, Mato Grosso and Minas Gerais presented and addition in informal workers.

However, Minas Gerais and Mato Grosso had also additions in formal workers, unlike Pernambuco.

Formality is a requirement in Brazil since 1940, but its evolution was only expressive in the last years. Thereby, it is possible to state that the changes in the labor market were moved not only by legislation but also by the insertion of the sector in new markets. These changes can be seen as competition strategies of the enterprises, once the new concurrence patterns demand the producers to follow the laws around environment and labor. Thus, other than the institutional environment, the competitive environment affects the job market in the sector, setting changes in its composition.

Another factor took in consideration in this work was the occupation issues. About that, the conclusions were that the activities that require higher capacitation gained more space in the sector. Thereby, in 1997, the jobs regarding tractor and other machinery operators represented 4.76% of the workers, while in 2009 this index reached 14.43%. Otherwise, the number of people working as harvester or cropper fell 30.7% by 2003.

Furthermore, it was highlighted that the federal legislation that forbids the burns in the sugarcane production made the raw sugarcane harvest less viable for producers, turning mechanization into the easiest solution for them, which increased the number of workers in functions that require higher qualification, like equipment operators. In general, the alterations in the institutional and competitive dynamics also changed the job market composition for the sugarcane producing and processing.

Considering the scenario trend, it is important to notice that the mechanization process brought some resets in sugarcane crop work, since the handwork in this sector causes serious damages to the workers, which can be diminished with the use of machines.

Another relevant aspect is the great number of workers dismissed with the mechanization process, which deserves attention in order to develop sector measures to qualify and reintegrate such manpower.

The linear regressive analysis revealed that there is an ascending trend to the formal job market as a descending trend to the informal job market in Brazil. Otherwise, the analysis separated by states pointed significant parameters for Alagoas, São Paulo and Goiás, showing increase in formal jobs and decrease in informal jobs, except for São Paulo that did not have a significant parameter for informal job market, but the negative sign indicate a reduction of informality in the state. Moreover, Paraná presented significant parameter to informal job market reduction, with some particularities, which are noteworthy: at first, there was a reduction in the total number of workers in 2002 and 2003, because some producers left the market, due to the lack of government support and climatic issues. In a second moment, the raise of ethanol demand took the market by surprise, affecting its offering. These recent perturbation will probably cause later changes in the state's job market, but they will only be noticeable over the time.

Regarding the occupations, it was verified a tendency of increasing the technical functions, characterized in this work as tractor/machinery operators. This result confirms the hypothesis that the mechanization in the sugarcane production raises the number of workers with higher qualification. At the same time, the occupations of harvester/cropper presented a decreasing tendency at first and then an increasing trend. It is explained by the recent (and fast) growth in the sugarcane production and new plantation areas. This expansion may cause



turbulences in the sector's job market. Also, some producing regions have inappropriate terrains for mechanization, which contributes to the hiring of harvesters and croppers.

Finally, it is noteworthy that the results presented in this research confirm that the job market in the sugarcane production sector has been influenced by the recent dynamics in the sugar and ethanol complex. It is suggested, then, that the analyses over an economic sector always take in consideration the interconnection among the production chain's links considering that a decision took in a certain link may lead to changes in the whole chain.

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**ATTACHMENT A1 – BRAZILIAN PRODUCTION OF SUGARCANE**

STATE/HARVEST	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09
ACRE	0	0	0	0	0							
RONDONIA	0	0	0	0	0							106292
AMAZONAS	0	0	0	0	201036	255852	250881	267767	252672	224700	318141	303350
PARÁ	247045	307650	521339	527383	283406	311492	419514	580999	510086	697400	575525	626865
TOCANTINS	184761	20962	0	0	0				95314	179300		55456
MARANHÃO	898988	1118330	938174	799490	1094115	1105114	1303509	1275119	1797490	1660300	2134604	2280160
PIAÚÍ	337032	312580	218022	248289	273691	284180	322802	349329	492369	706000	689130	900181
CEARÁ	325613	367684	131166	65671	73637	88954	63907	79444	40709	27400	8250	122355
RIO GRANDE DO NORTE	2645204	2807772	1892617	2388270	2064515	2681857	2614068	2917677	2356268	2397400	2047750	3186768
PARAIBA	5329824	3888104	3418496	3594320	4001051	4335516	5017263	5474229	4291473	5107700	5653047	5885978
PERNAMBUCO	16970789	15588250	13320164	14366994	14351050	14891497	17003192	16684867	13858319	15293700	19844415	18949518
ALAGOAS	23698079	17345105	19315230	25198251	23124558	22645220	29536815	26029770	22532291	23635100	29444208	27309285
SERGIPE	1063417	1037538	1163285	1413639	1316925	1429746	1526270	1465185	1109052	1136100	1371683	1831714
BAHIA	2581225	2347217	2098231	1920653	2048475	2213955	2136747	2268369	2391415	2185600	2522923	2541816
MINAS GERAIS	11971312	13483617	13599488	10634653	12204821	15599511	18915977	21649744	24543456	29034195	35723246	42480968
ESPIRITO SANTO	2465729	1942022	2126902	2554166	2010903	3292724	2952895	3900307	3804231	2894421	3938757	4373248
RIO DE JANEIRO	4926275	5191421	4953176	3934844	3072603	4478142	4577007	5638063	4799351	3445154	3831652	4018840
SÃO PAULO	180596909	199521253	194234474	148256436	176574250	192486643	207810964	230280444	243767347	263870142	296242813	346292969
PARANÁ	24874691	24177859	24351048	19320856	23075623	23892645	28485775	28997547	24808908	31994581	40369063	44829652
SANTA CATARINA	0	0	0	0	0	0	0	0	0	0	0	0
RIO GRANDE DO SUL	45459	32493	0	0	80262	102999	93836	77997	57976	91919	128980	107184
MATO GROSSO	9786054	10306270	10110766	8669533	10673433	12384480	14349933	14447155	12335471	13179510	14928015	15283134
MATO GROSSO DO SUL	5916046	6589965	7410240	6520923	7743914	8247056	8892972	9700048	9037918	11635096	14869066	18090388
GOIÁS	8192963	8536430	7162805	7207646	8782275	9922493	13041232	14006057	14559760	16140043	21082011	29486508
<b>REGIÃO CENTRO-SUL</b>	<b>248775438</b>	<b>269781330</b>	<b>263948899</b>	<b>207099057</b>	<b>244218084</b>	<b>270406693</b>	<b>299120591</b>	<b>328697362</b>	<b>337714418</b>	<b>372285061</b>	<b>431113603</b>	<b>504962891</b>
<b>REGIÃO NORTE-NORDESTE</b>	<b>54281977</b>	<b>45141192</b>	<b>43016724</b>	<b>50522960</b>	<b>48832459</b>	<b>50243383</b>	<b>60194968</b>	<b>57392755</b>	<b>49727458</b>	<b>53250700</b>	<b>64609676</b>	<b>64099738</b>
<b>BRASIL</b>	<b>303057415</b>	<b>314922522</b>	<b>306965623</b>	<b>257622017</b>	<b>293050543</b>	<b>320650076</b>	<b>359315559</b>	<b>386090117</b>	<b>387441876</b>	<b>425535761</b>	<b>495723279</b>	<b>569062629</b>

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