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ARTICLE

Impacts of technological and organizational changes on working conditions in Brazilian sugarcane: an analysis on 2000-2019

Impactos de mudanças tecnológicas e organizacionais nas condições de trabalho no setor canavieiro brasileiro: uma análise de 2000 a 2019

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Abstract: This article analyses changes in working conditions in sugarcane in the light of Brazilian legislation in the 20 years, when the sector expanded and adopted new technological solutions and management paths. A central theme is understanding the effects of harvesting mechanization, which reached 90% of the national production on average. In total, 15,488 notices of violation were analysed, issued between 2000 and 2019 against the 280 business groups authorized by the ANP (National Agency for Petroleum, Natural Gas and Biofuels) to produce fuel ethanol from sugarcane, both in their agricultural and industrial operations. For comparisons purposes, the country was divided into three major producing regions – São Paulo, Northeast and Other States. The most common irregularities refer to workers' health and safety, mandatory rest, working hours, and pay. Notices of violation saw an upward trend until 2013, given the expansion of sugarcane throughout the country and authorities' strategy to pressure the sector and improve Brazilian ethanol's international reputation. The number of fines began to fall in 2014. Among the causes, intensification of mechanized harvesting reduced the number of workers in manual cutting – where irregularities were concentrated – and reduction in the impulse towards enforcement, given the Brazilian government's fiscal crisis.

Keywords: labour fines, inspection, sustainability.

Resumo: Este artigo analisa as transformações nas condições de trabalho na atividade canavieira à luz da legislação brasileira nas últimas duas décadas, período em que o setor se expandiu e adotou novas soluções tecnológicas e caminhos gerenciais. Um tema central é compreender os efeitos da mecanização do corte da cana, que chegou a 90% da safra nacional, em média. Foram catalogados 15.488 autos de infração trabalhistas, emitidos pelos fiscais do governo federal entre 2000 e 2019, contra os 280 grupos empresariais autorizados pela ANP, tanto em suas operações agrícolas quanto industriais. Para permitir comparações, dividiu-se o país em três regiões – São Paulo, Nordeste e Demais UFs. O artigo demonstra que as irregularidades mais comuns se referem a saúde e segurança do trabalhador, descanso obrigatório, jornada e remuneração. A emissão de autos registrou tendência de alta até 2013, diante da expansão canavieira e da estratégia das autoridades em pressionar o setor e melhorar a imagem do etanol brasileiro. A aplicação de multas passou a cair em 2014. Entre as principais causas, intensificação da colheita mecanizada, que reduziu a quantidade de trabalhadores no corte manual, etapa na qual se concentravam irregularidades, e redução do ímpeto da fiscalização, diante da crise fiscal do país.

Palavras-chave: autos de infração, fiscalização, sustentabilidade.

Introduction

The sugarcane industry experienced a period of strong expansion and change in the first two decades of the 21st century. The area planted in Brazil more than doubled in 2000-2019,

mainly to meet the higher domestic demand for ethanol. Areas in the Centre-South of the country were occupied by new enterprises, as mills built from scratch were supplied by plantations using mechanized cutting. Foreign groups arrived in the country to invest in the industry, encouraging mergers and acquisitions.

The new sugarcane boom – comparable only to that seen after the government's programme to promote fuel ethanol known as Proálcool was launched in the 1970s – took place under the framework of a stronger global debate on sustainability. In 1992, in Rio de Janeiro, the world's main nations had signed a treaty to stabilize greenhouse gases concentrations in the atmosphere – the United Nations Framework Convention on Climate Change. It served as the basis for the Kyoto Protocol signed in 1997, which required signatories to reduce their own emissions.

The Brazilian government and business leaders saw ethanol's potential in that new scenario. The fact that it was renewable and had a production base located far from the Amazon should help the fuel enter countries that needed options to replace petroleum derivatives. However, several obstacles emerged in the first decade of this century, regarding not only ethanol produced in Brazil but also biofuels in general, under the argument that the sustainability equation has not been solved. Some of the risks pointed out included deforestation, changes in land use, competition with food crops, scarcity of water resources, and poor conditions provided to workers.

As for labour issues in Brazilian sugarcane production, some studies have approached it from the point of view of the productive system and organizational structure (Scopinho et al. 1999; Alves, 2006), of the interaction with the legal system (Oliveira, 2003; Mendes 2007) or based on its historical roots (Santos, 2015; Campos, 2019). In research conducted under the theoretical framework of labour economics, the discussion is supported by official information on the evolution of wages and job offers by companies (Hoffmann & Oliveira, 2007; Baccarin 2017). Working conditions issues also appear in case studies (Guanais, 2010; Favoretto, 2014) that may be far from the midpoint of the problem as they portray extreme situations.

Some studies have also used information produced by federal government labour inspectors to analyse working conditions (Figueira & Prado, 2009; Almeida, 2011; Rodrigues, 2014), but without further expanding upon the types of violation and the dynamics for applying fines (Capitani et al., 2021 is an exception). While it is a public database, it is not organized so as to allow analysing specific economic segments. In this case, the so-called notices of labour violations have to be consulted one by one and then be catalogued. However, the material provides a comprehensive overview of what happens to workers in an agricultural or manufacturing industry.

To contribute to the discussion on the evolution of working conditions in sugarcane, this article describes results obtained from the analysis of notices of violation (fines) issued against the sugar-energy industry over 20 years (2000-2019). More specifically, the aim was to understand the changes in working conditions in view of the production changes seen in the period, in particular mechanization of sugarcane cutting.

1. Theoretical framework

Changes in labour relations and conditions in the sugarcane industry have been studied under different theoretical references. In this research, the main references are the reflections

developed under the framework of labour economics and the role of institutions in economic-social relations.

Labour economics investigates how labour markets work, how they respond to variations in supply and demand, and which factors exogenous to wages may influence whether a worker accepts a job or not (Borjas, 2012). In the case of sugarcane, the expansion of the activity has attracted contingents of migrants to producing areas for decades, in search of jobs, even if temporary. In the state of São Paulo, the advance of sugarcane monoculture in the 1970s increased the seasonal nature of agricultural work and imposed an industrial pace to work, with a direct impact on working conditions (Graziano da Silva, 1980).

Work became more intense, and sugarcane cutting began to be controlled by the pace of raw material processing at the mill. At that time, businesses chose the so-called multitask farm worker because it valued their capital compared to more expensive options such as partners, settlers or permanent waged workers (Gonzales & Bastos, 1977). Mechanization of sugarcane cutting, which has recently become more widespread, eliminated jobs in manual cutting but maintained the trend towards increasing productivity and intensifying work (Scopinho & Valarelli, 1995).

This process of social and economic changes was influenced by the institutional environment. By defining laws, financing the private sector with its resources, taxing businesses or imposing criminal sentences, the State is able to make companies progress or regress, including the sugarcane sector, which has a long tradition of being dependent on and intervened by government agencies (Vian & Belik 2003). Employment relationships and working conditions are determined by the Consolidation of Labour Laws (CLT, for its Portuguese acronym) and a series of regulatory standards issued by the federal government. Any violations can be taken to Labour Courts, which regulate relations between the State, companies and workers (Mendes, 2007).

Despite this historical relationship with the State, the sugarcane industry began to depend more on private governance from the second half of the 1980s onwards. While Brazilian politics saw a process of democratization and increased transparency, the economy was marked by the fiscal crisis and the end of forms of regulation based on central power, generating a logic in which stronger groups imposed their interests. While such liberalization created new competitive structures and opened new frontiers for sugarcane, it proved unable to solve problems related to working conditions (Vian & Belik, 2003).

Mechanization of sugarcane cutting made little progress in Brazil in the last two decades of the 20th century. Estimates showed that, in the State of São Paulo, it did not exceed 5% in the 1980s (Graziano da Silva, 1980) and 20% in the 1990s (Veiga Filho, 1998). Among the reasons, the lower cost of manual harvest, the need to adapt the fields, with wider corridors between plantations to receive machines, and the still insufficient technological development of harvesting machines (Veiga Filho, 1998; Baccarin, 2017).

Mechanization only gained ground in the early years of the new millennium, when these challenges began to be overcome. The adoption of machines was possible because cane fields began to be prepared for them. There were organizational changes both in the occupation of land areas with irregular topography and in the operating logistics of the agricultural production process and its interfaces with sugarcane's loading, transportation and reception. With more credit available, the result was a market for agricultural machinery developed in a context of stronger pressure for positive environmental results (Maeda, 2012; Baccarin, 2017).

There was also pressure from the state. Since the 1990s, sugarcane mills had been facing a series of lawsuits filed by the Public Prosecution Service because of fires, with unfavourable

decisions in some of them. In July 1998, the Presidency published Executive Order 2661, determining the end of sugarcane burning for 20 years in mechanized areas – that is, by 2018. Given the new rule, companies started to sign the Agro-environmental Protocol for the Sugar-Energy Sector with the State of São Paulo, in 2007 (Instituto de Economia Agrícola, 2014). The agreement determined the end of sugarcane harvesting using fire in mechanized areas in 2014 and in non-mechanized areas in 2017. Versions of the Protocol were signed in other States, e.g. as Minas Gerais.

The movement advocating the use of machines also advanced, driven by the favourable conditions in the ethanol market at that time. In 2003, flex-fuel cars were launched in the country, powered by gasoline and ethanol, helping to attract more investments to the sugar-energy sector. Brazil, too, started to export part of its ethanol output, and the sector wanted to make the product into a new commodity – more sustainable than and alternative to gasoline.

Therefore, mechanization of sugarcane cutting became the main vector for labour changes in sugarcane. Since 2016, the proportion of mechanized cutting has remained above 89% of the country's total harvest, according to the National Supply Company (Conab) (Figure 1). Considering an estimated production of 592 million tons in 2020/21, this means that around 527 million were harvested by machines, and only 65 million depended on machetes. In the 2007/2008 harvest season, when Conab started to measure the country's mechanization rate, it accounted for only 24% of the cutting.

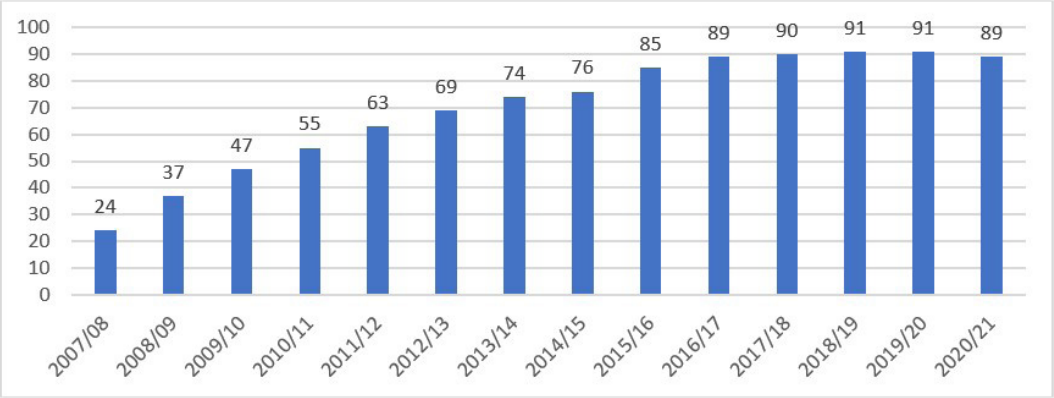

Figure 1: Mechanized sugarcane cutting in Brazil (% of the harvest). Source: Conab's Bulletin on the sugarcane harvest (August 2021)

With one harvesting machine doing the jobs of several workers, the impact on employment was brutal (Table 1). Between 2006 and 2019,[1] the number of formal sugarcane workers dropped from 291,600 to 156,100 – a loss of 135,000 jobs (– 46.5%). The number of jobs in machine operation increased but not to the point of compensating for the decline in manual labour: it went from 32,700 people in 2006 to 64,500 in 2019 (+97.1%). There was also a significant increase in so-called administrative and support activities, with 54,400 new jobs (+42.5%). But the final balance is that, despite having increased production, agriculture and the sugarcane industry lost 41,100 jobs between 2006 and 2019 (–7.9%).

[1] The new methodology adopted by Rais and Caged from 2006 on recommends that the initial date for comparisons within the time series begin in that same year.

Table 1:[2] Number and variation of people employed in sugarcane companies in Brazil, by professional groups and subgroups, 2006-2019

Worker categories	Occupation by year														2006-2019 variation	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Absolute	%
Farming workers	**335,303**	**357,916**	**373,095**	**381,947**	**360,084**	**359,030**	**337,243**	**322,339**	**288,453**	**265,714**	**256,868**	**252,997**	**243,073**	**235,817**	**-99,486**	**-29.7**
Sugarcane workers	291,616	306,862	316,141	320,048	291,463	284,386	253,457	231,732	202,897	180,837	173,887	170,386	161,606	156,131	-135,485	-46.5
Workers in mechanized activities	32,751	38,502	43,368	47,739	53,720	58,565	67,594	73,751	69,617	69,078	67,888	67,537	66,291	64,560	31,809	97.1
Other farming workers	10,936	12,552	13,586	14,160	14,901	16,079	16,192	16,856	15,939	15,799	15,093	15,074	15,176	15,126	4,190	38.3
Workers in the manufacturing industry	**41,561**	**46,640**	**54,830**	**60,108**	**58,946**	**61,081**	**59,348**	**58,950**	**55,025**	**55,180**	**53,945**	**53,955**	**52,754**	**51,565**	**10,004**	**24.1**
Management and support	**128,223**	**144,756**	**157,719**	**172,175**	**181,061**	**200,736**	**211,326**	**216,686**	**213,204**	**204,948**	**197,369**	**192,192**	**183,754**	**182,654**	**54,431**	**42.5**
Non-sugar-alcohol	**15,362**	**15,589**	**12,789**	**14,970**	**13,509**	**14,286**	**15,230**	**11,911**	**11,006**	**10,407**	**9,877**	**10,008**	**9,643**	**9,256**	**-6,106**	**-39.7**
Total workers	**520,449**	**564,901**	**598,433**	**629,200**	**613,600**	**635,133**	**623,147**	**609,886**	**567,688**	**536,249**	**518,059**	**509,152**	**489,224**	**479,292**	**-41,157**	**-7.9**

Source: Ministry of Labour and Welfare

[2] Table based on the methodology of the bulletin *Formal occupation in the sugar and alcohol sector in São Paulo*, an extension project of Unesp at Jaboticabal (Universidade Estadual Paulista, 2021).

In addition to its effect on jobs, mechanization had an impact on aspects related to the quality of employment in the sugarcane industry. The new scenario opened up opportunities for more skilled professionals – not only on farms and mills themselves, but also in the input and service industries (Moraes, 2007). Harvester operators usually have to attend several training courses to do their job. The effect of this whole process is that wages in the sector increased above inflation in 2006-2019 (Table 2).

In this period, the industry's average monthly wage in Brazil jumped to R$ 2,480 in values corrected for inflation (+32.7%). The highest increases were seen among workers hired by sugarcane companies who did not work directly in core activities, such as teachers and telephone operators, who are also hired by mills. In this case, the monthly wage reached R$ 2,174 (+35.9%). The wage of an employee in mechanized farming is 78.9% higher, on average, than that paid to a worker involved in manual cutting – R$ 2,396 compared to R$ 1,339, according to data from RAIS and CAGED.

In addition to income, other aspects related to employment quality must be considered, such as workers' health and safety, daily working hours and the right to weekly rest. With fewer employees exposed to manual cutting, these conditions – from the requirement of working in an open location to payment based on daily production – would be expected to improve with the advancement of the mechanized system.

But several investigations warned that problems would not cease to occur and would be nothing more than a 'myth' spread by the industry, insofar as the mechanisms of worker exploitation still exist, albeit in a new guise, now as targets and profit sharing. According to this view, risks and hard work have barely changed. In mechanized areas, there would be problems related to long working hours, accumulation of functions, indiscriminate use of hour banks, just-in-time production, and night work (Barreto, 2018).

As for the trucks that transport the sugarcane harvested, mills adopt what is called a back-and-forth operation – tractor trucks allow containers to be attached to receive the sugarcane from transhipment. This strategy optimizes the use of resources by saving time, transportation costs and equipment wear. Harvesting machines work almost uninterruptedly, and workers are subjected to an intense work pace of (Eid, 1996; Scopinho et al., 1999) even at the risk of suffering fatal accidents (Rodrigues, 2014).

Thus, with machines and a new type of management for sugarcane cutting, mills would have managed to regain control over workers, intervening in the logic of payment on a piece-rate basis, in which the cutting pace depended on each individual's effort (Baccarin, 2017). There are many testimonies from workers involved with mechanized cutting that highlight everyday life's stress and the frustration with promises that the hardships of manual cutting would be left behind (Cover & Menezes, 2015).

2. Methodology

This research started (i) from the analysis of the literature on working conditions in the sugarcane industry, in particular concerning the impacts of mechanization. It was based specifically (ii) on understanding the context, with knowledge of facts observed and recorded in the course of interviews and field investigations, and (iii) evaluation of notices of labour violations issued by federal government inspectors.

From the literature, we sought to understand the history of recent changes in labour in sugarcane production, with a special interest in cause-and-effect mechanisms. Our hypotheses are formulated after these reflections and then tested by quantitative and qualitative analyses.

Table 2: Real average income in worker groups and subgroups in sugarcane companies, 2006-2019 (in R$)

Worker categories	Real average monthly wage / year														2006-2019 variation	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Absolute	%
Farming workers	**2,282**	**2,477**	**2,586**	**2,589**	**2,754**	**2,814**	**3,018**	**3,144**	**3,070**	**2,936**	**3,034**	**3,080**	**2,977**	**2,741**	**459**	**20.1**
Sugarcane workers	1,205	1,260	1,284	1,286	1,365	1,412	1,495	1,527	1,477	1,437	1,502	1,515	1,489	1,339	134	11.1
Workers in mechanized activities	2,145	2,316	2,474	2,439	2,565	2,601	2,822	2,912	2,805	2,701	2,715	2,755	2,623	2,396	252	11.7
Other farming workers	3,497	3,855	4,001	4,042	4,332	4,428	4,737	4,993	4,927	4,669	4,885	4,969	4,818	4,489	991	28.3
Workers in the manufacturing industry	**2,922**	**3,062**	**3,119**	**2,962**	**3,136**	**3,149**	**3,365**	**3,476**	**3,517**	**3,295**	**3,408**	**3,483**	**3,423**	**3,257**	**335**	**11.5**
Management and support	**2,858**	**3,003**	**3,162**	**3,106**	**3,216**	**3,305**	**3,454**	**3,569**	**3,515**	**3,375**	**3,445**	**3,483**	**3,324**	**3,115**	**257**	**9.0**
Non-sugar-alcohol	**1,600**	**1,723**	**1,947**	**1,949**	**2,055**	**2,158**	**2,156**	**2,414**	**2,382**	**2,272**	**2,293**	**2,363**	**2,362**	**2,174**	**575**	**35.9**
Average of total workers	**1,868**	**1,998**	**2,109**	**2,109**	**2,274**	**2,380**	**2,582**	**2,721**	**2,718**	**2,643**	**2,713**	**2,750**	**2,661**	**2,480**	**612**	**32.7**

Source: Ministry of Labour and Welfare. Values updated for December 2019 by INPC/IBGE

This causal study strategy (Gil, 2008) is of great value to systematize complex phenomena in which the process of change may have different origins.

Methodologically, a descriptive approach was also employed (Richardson, 2017). Usually adopted in human science investigations, it is useful in efforts to observe specific groups and social and economic phenomena (Prodanov & Freitas, 2013). The results can be generalized when supported by data sets and information collected.

For a better understanding of reality and to answer the doubts, interviews were carried out with representatives of the sugarcane industry, such as workers, union members and industry leaders. Public authorities involved with rural inspection were also heard, in particular inspectors in charge of field operations and labour prosecutors who filed lawsuits against companies in the sector.[3]

The interviews were conducted in an unstructured manner, following previously defined discussion topics. The approach was adopted because the intention was not to generate quantitative data from the results but rather to focus on interpreting information on working conditions that had already been obtained from government agencies (Richardson, 2017). All respondents mentioned here requested anonymity, which is why information sources are not cited.

Records on notices of violation were obtained from a website (Brasil, 2020b), of the Labour Inspection Department of the current Ministry of Labour and Welfare, intended for companies seeking information on notices issued against them. Data were obtained on 15,488 notices issued against the 280 business groups authorized by the ANP to process sugarcane in the country. Authorization records from 2020 were used to select business groups. Notices of violation correspond to irregularities observed both in their agricultural and industrial operations. The resulting database covers 2000-2019.

Processing the information as it is provided was relatively hard, and the authors did it using computer methods. The information was organized depending on the legal justification for the violation, based on the year they were issued and allocated among three regions representing the country's sugarcane activity, according to the location of the sanctioned production unit: the largest hub, in São Paulo; the oldest one, in the Northeast; and the most recent expansion region, which we called Other States.

As an example, Raízen, the largest sugar-energy group in the country, has production units in São Paulo, Goiás and Mato Grosso do Sul. Notices of violation issued for units in São Paulo were allocated in the state. Those related to the company's units in Goiás and Mato Grosso do Sul, in turn, were placed under the region called Other States.

A notice of labour violation is a document issued by a labour inspector – a public servant position exclusively controlled by the federal administration. The document provides a description of the violation of labour legislation found in the company. It can be issued either on the spot or later, if there is any risk to inspectors. Each notice sets a fine to be paid by the company involved, which has deadlines to appeal in administrative proceedings under the Ministry itself.

The federal government does not grant full access to the information contained in a notice of violation, only to some of its key information. For example, in a notice issued against Biosev SA in 2018, it is possible to identify the CNPJ (company taxpayers' number) of the sanctioned unit (15.527.906/0007-21), the case number (46300.002812/2017-62), the violation (lack of

[3] Interviews were conducted in partnership with journalist Poliana Dallabrida.

registration and working documents), and the legal provision violated (Art. 41, Head of CLT). Procedural progress can also be consulted but not the value of the fine imposed.

The federal government does not provide access to older data either, for example from the 1990s, when much of the information was not yet digitized. In a previous research work that also investigated notices of violation in sugarcane, part of the information on the documents had to be collected directly from inspection book records kept in offices of the then Ministry of Labour and Employment in São Paulo (Capitani et al., 2021).

Furthermore, the federal government's search system does not aggregate records of companies that were acquired by other groups or that participated in merger processes or other corporate changes that altered their corporate information. Therefore, there is not as much data as one would expect on São Paulo for the 2000s, when this process of mergers and acquisitions was intense.

Despite not understanding independent sugarcane producers, who can also be inspected and punished with fines, the sample analysed in this research is relevant because it includes the sugarcane plantations owned and cultivated by mills and also the land they lease, covering an area that comprises most of the production in the country. Still about the sample, it is worth mentioning that statistics prior to 2000 and after 2019 were not available on the government system on the date they were collected (April 9, 2020).

In addition to the notices of violation, this research also used records from the Ministry of Employment and Welfare's Annual List of Social Information (RAIS, for its Portuguese acronym) and from the General Register of Employed and Unemployed People (CAGED). The two bases provide socioeconomic data on occupation and income in the sugarcane sector, which were used to contextualize the analysis on the evolution of working conditions. However, no deeper analyses were made on the subject, since that has already been done in other academic studies.

3. Results and discussion

3.1 Labour law enforcement in sugarcane

As mentioned earlier, 15,488 notices of labour violations were issued for the sample of 280 sugarcane business groups in Brazil in the 20 years between 2000 and 2019. Companies in the sector are exposed to a strong regulatory framework that seeks to regulate working conditions. In the period under analysis, 57 different types of notices were issued, based both on the CLT itself and regulatory standards (known as NRs for *normas regulamentadoras*), which set rules on various issues, such as machine operation, ergonomics, work at height or outdoors.

The most common violation in the period under study referred to NR-31, with 3,470 notices – 22% of the total (Figure 2). This regulatory standard came into effect in 2005, as a longstanding demand[4] of the National Confederation of Agricultural Workers (CONTAG) for specific safety and health regulations in the timber and sugar-energy sectors, due to the high number of fatal accidents seen in these activities.

[4] The full standard can be accessed at Brasil (2020a).

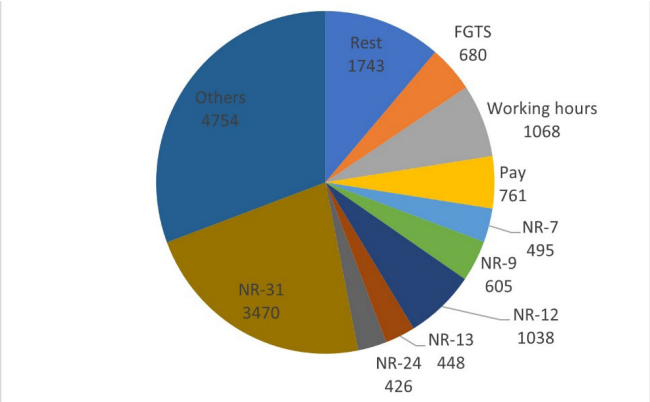

Figure 2: Total number of notices of violation// issued in 2000-2019 – by type of violation. Source: Secretary of Labour Inspection of the Ministry of Labour and Welfare

In addition to NR-31, 27 other regulatory standards were used by inspectors as a basis to issue notices of violation. The most commonly used were NR-7 (obligation to maintain permanent risk assessment about work accidents); NR-9 (exposure of workers to risks from chemical, physical and biological agents); NR-12 (risk in machine operation, including harvesters); NR-13 (operation of boilers, tanks and pipe areas); and NR-24 (facilities for workers' safety and comfort, complementing NR-31).

Notices of violation based directly on CLT include violations of the right to weekly rest (Art. 71, which provides for at least 24 consecutive hours of rest) and maximum workdays (Art. 59, Head and Art. 61, on overtime pay). Also worthy of mention are the recurring notices of violation related to irregularities in worker's pay. In 2013, 294 violations were recorded regarding wages paid by companies in the sample (Article 459, Section 1 of CLT, on payment rules), an annual figure only surpassed by fines related to NR-31. There are also recurring violations of FGTS collection (Art. 23, Section 1, I of Law 8036/90).

Notices of violation saw an upward trend until 2013, when the number started to fall (Figure 3). In the first part of this cycle (2000-2013), the increase in fines followed the increase in the area planted with sugarcane in the country (+109%; Figure 4), and also responded to a strategy by the federal government to act on the problem to improve the image of Brazilian ethanol abroad, since it saw the asset as a central product in its economic and environmental diplomacy – as explained by a diplomat involved with the subject at Brazil's Ministry of Foreign Affairs who granted an interview but requested anonymity. For this, the government created new rules and encouraged enforcement actions.

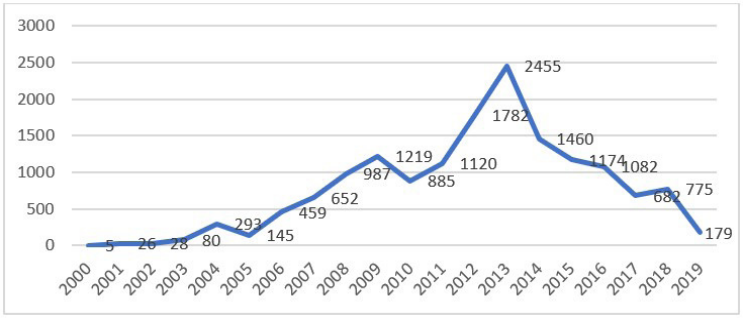

Figure 3: Notices of violation issued, by year, against companies in the sample. Source: Secretary of Labour Inspection of the Ministry of Labour and Welfare

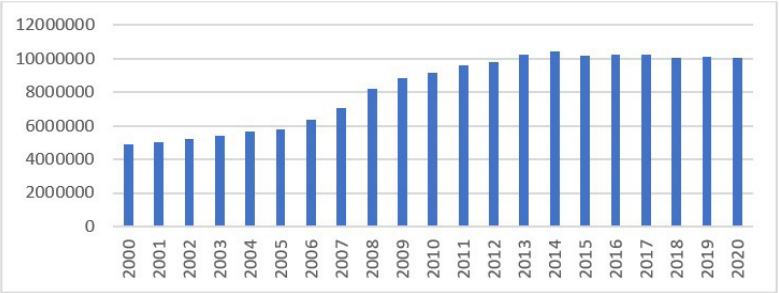

Figure 4: Sugarcane plantation area (in hectares) in 2000-2020. Source: IBGE Municipal Agricultural Production (Instituto Brasileiro de Geografia e Estatística, 2020)

When NR-31 came into force in 2005, it also helped to raise the official levels of non-compliance in Brazil's sugarcane industry, as labour inspectors began to systematically assess situations of risk to workers' health and safety, such as lack of drinking water, toilets or dining areas in the work environment. According to labour inspectors interviewed during the research, NR-31 was intended to increase pressure on companies so that they avoid serious violations of workers' dignity that could even amount to modern slavery. In 2007, 419 notices of violation were issued based on NR-31 (Figure 5) or 42% of all 987 notices issued against the 280 economic groups analysed in this research.

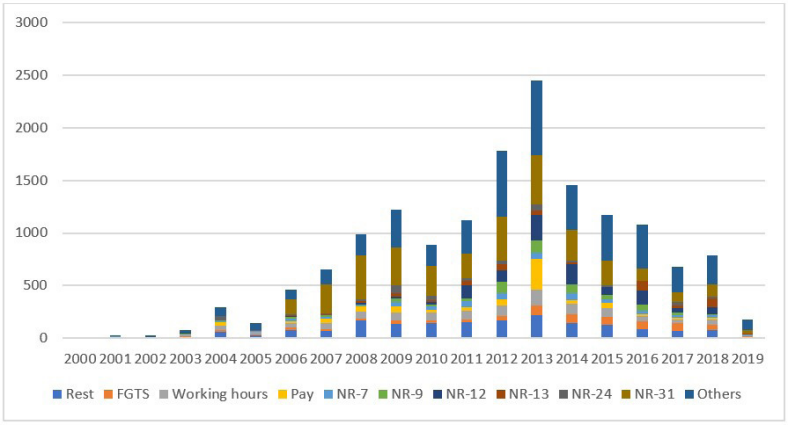

Figure 5: Main violations recorded against companies in the sample, by year. Source: Based on data from the Secretary of Labour Inspection/Ministry of Labour and Social Security

In the second cycle (2014-2019), the number of notices of violation in the sugarcane industry dropped. The trend is consistent with the stabilization of the plantation area (Figure 4), which occurred concomitantly with the intense advance of mechanized cutting. It is worth remembering that this process eliminated 135,000 rural jobs in sugarcane between 2006 and 2019, most of them linked to manual cutting (Table 1), exactly where irregularities were concentrated.

This second cycle was also marked by lower impulse towards enforcement of labour laws.[5] The fiscal crisis experienced by the country after 2015 reduced funds available for enforcement to the point that operations were suspended due to lack of fuel as reported in a 2018 interview by a head of inspections based in the state of São Paulo. Between 2016 and 2018, there were

[5] More information on how the fiscal crisis hit labour law enforcement is available at Sindicato Nacional dos Auditores Fiscais do Trabalho (2018).

episodes in which inspectors depended on money from the Public Prosecution Service to carry out operations or had to use their own money to pay travel expenses.

According to data from the National Union of Labour Inspectors (Sinait), as a result of retirements and leaves, in January 2020, only 2,154 of the 6,276 existing positions were filled. There has been no selection process since 2013. The situation became even more difficult when inspectors went on strikes and campaigns between 2015 and 2017, demanding better wages and working conditions, which further undermined the results of their work. In 2020, as explained by another inspector based in Brasília, the pandemic created by the novel coronavirus led many of them to work remotely and temporarily abandon field operations, since they are public servants and many are of advanced age.

To better understand the evolution in the number of notices of violation, two indicators were estimated. The first one – here called Index A – indicates the total number of cases per sugarcane area throughout Brazil, per year. The aim is to understand if the number of notices increased or decreased proportionally to the advance of the planted area or if it had a particular dynamic. As can be seen in Figure 6, until 2013 the number of notices of violation grew more than the plantation area, which also increased in that period. As of 2014, even with the stabilization of the area, the number of notices began to fall almost continuously.

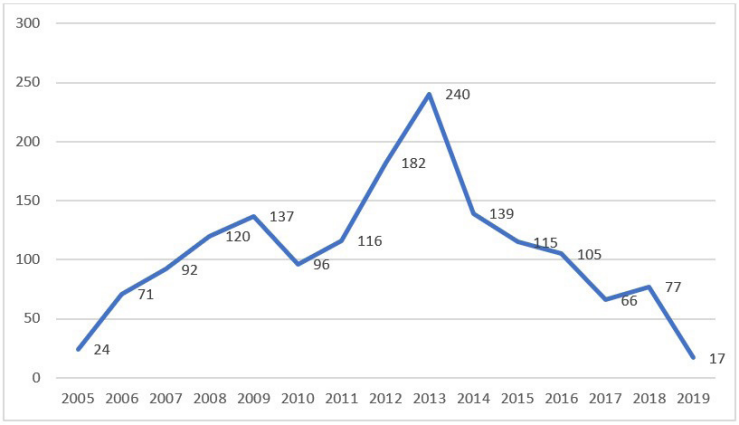

Figure 6: Index A: notices of violation per sugarcane plantation area (violations per million hectares) throughout Brazil. Source: Based on data from the Department of Labour Inspection/ Ministry of Labour and Welfare and IBGE's Municipal Agricultural Production (Instituto Brasileiro de Geografia e Estatística, 2020)

The so-called Index B is the ratio between the number of notices of violation issued and the area with mechanized sugarcane cutting across the country. The results presented in Figure 7 indicate that, until 2010, with the increase in the mechanized area (see Figure 1), the number of notices issued by inspectors compared to that area saw an average downward trend. In 2010-2013, the number of notices increased, even with the country's area of mechanized sugarcane jumping from 55.1% to 74.0%. This result suggests that mechanization alone was not able to reduce noncompliance with labour laws in sugarcane.

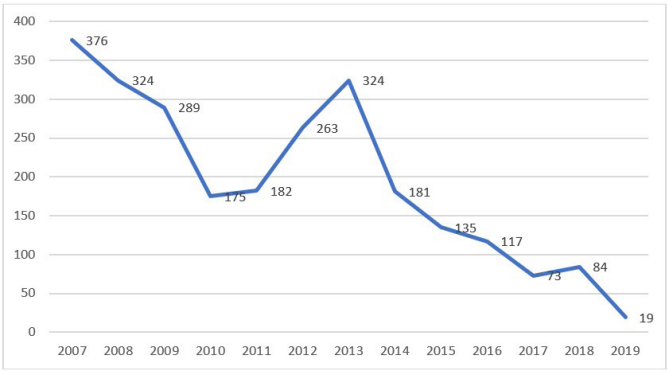

Figure 7: Index B: total number of notices of violation per sugarcane area with mechanized harvesting in Brazil (violations per million hectares), in 2007-2019. Source: Based on data from the Labour Inspection Department/Ministry of Labour and Social Security, and Conab

The literature on the topic has reflected this idea that mechanization alone is not capable of improving compliance rates and increasing workers' satisfaction with their jobs. While Scopinho et al. (1999) details the risks faced by workers, Guanais (2010) explains that machines that cut sugarcane gave control over the workforce back to mill owners, as productivity started to respond to the rhythm of mechanical harvesters rather than to workrs doing manual cutting. This intensification of the work pace not only caused workers' dissatisfaction, as concluded by Favoretto (2014) from a series of field interviews, but also generated, according to Rodrigues (2014), more serious and even fatal accidents in agricultural operation.

Three sugarcane workers involved in machine operation in the region of Bebedouro (SP) and a union leader from Guariba (SP), interviewed for this research, highlighted the dismay caused to them and their colleagues by the reduction in the number of jobs in sugar-energy companies. While companies and the government provided retraining courses, many workers were not able to take them, given their low education and the need to keep working and supporting their families. They also complained that wage increases that may have occurred in mechanized areas did little to compensate for the fact that, in manual cutting, earning more was also an option if workers voluntarily increased the work pace.

In order to analyse the profile and the dynamics of notices of violation in more detail, the 280 business groups in the sample were divided into three large areas based on their places of operation: São Paulo, the largest producer hub in the country, with 101 groups; the Northeast region, the most traditional hub, with 57 groups; and Other States, which is the main expansion area for greenfield mills, with 122 groups. The groups located in São Paulo received 2,838 notices of violation between 2000 and 2019, both for their agricultural and industrial operations. North-eastern groups got 4,328 notices. Finally, the groups in Other States had 8322 cases, always in the same period.

3.2 Inspection results in São Paulo

The state of São Paulo is Brazil's largest sugarcane producer. In 2020, its planted area reached 5.51 million hectares, accounting for 62% of the state's cropland, and 431.52 million tons were harvested (+128% in 2000-2020). In the last two decades, São Paulo has undergone strong transformation in its sugar-energy park, with mechanization of 98% of its plantations. This process led to a huge loss of rural jobs, with 53,900 positions closed in 2006-2019 (56.9% of the total in 2006, Table 3), according to data from RAIS and CAGED.

Another intense movement seen in São Paulo was the arrival of foreign companies to the sector. Among the biggest deals closed, Louis Dreyfus Commodities (LDC) bought a series of mills in the state in the 2000s – the biggest one being Santelisa Vale, in Sertãozinho, which had its name changed to Biosev and became one of the largest in the country. In 2011, it was Cosan's turn to create a joint venture with Shell, giving rise to Raízen, currently the largest Brazilian manufacturer of sugarcane ethanol and the world's largest individual exporter of cane sugar. Alongside these groups, many others made investments in the sugarcane industry in São Paulo, such as BP, Cofco, Tereos, Bunge and Cargill. In 2021, Raízen absorbed Biosev's operations.

The fact that there have been so many corporate changes in São Paulo companies has 'washed' the history of labour violations of many operations. As they are formally new groups, only 108 notices were found between 2000 and 2010. Since 2011, however, when the mergers and acquisitions market was more stable, the number of notices of violation has increased – 2,730 in 2011-2019 (Figure 8). Due to intense corporate changes, São Paulo has a low number of violations compared to other regions: 28.1 cases per business group in 20 years – much less than that seen in the Northeast (75.9) and in Other States (68.2).

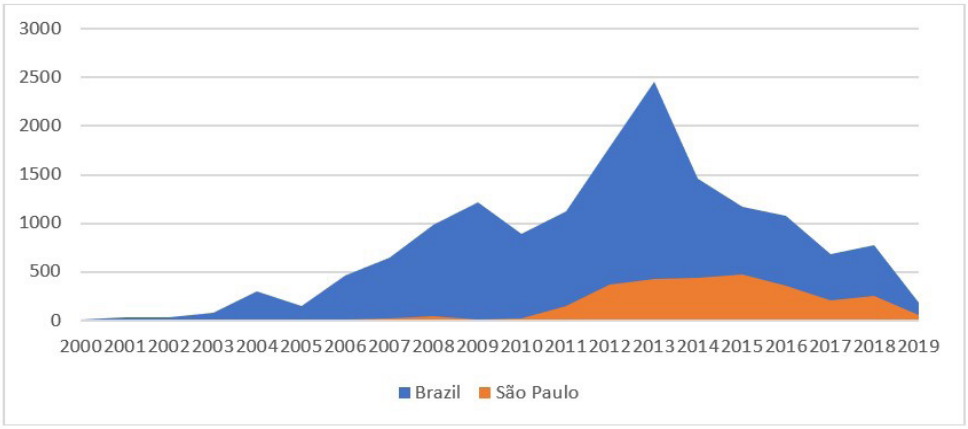

Figure 8: Notices of violation issued in São Paulo and in Brazil, 2000-2019. Source: Based on data from the Secretary of Labour Inspection/Ministry of Labour and Social Security

As in the rest of the country, the most commonly issued notice of violations in São Paulo are related to NR-31: 1,205 fines were associated to it between 2000 and 2019, or 21.6% of the total number. The inspectors punished companies that did not provide drinking water, toilets or living areas to their workers, including those using mechanized cutting. Transportation of workers in tractors, especially during planting season, and irregular exposure to pesticides were also common issues.

In the specific case of workers involved with mechanized operation, there were many notices of violations based on NR-12 – 249 in total. However, this standard has been used not only because of the risks found in harvesters but also in the machines existing in mills' labs to measure the sucrose content in sugarcane, such as shredders, chippers, and mixers.

Finally, two other cases related to working hours stood out. There were 423 notices related to lack of rest periods for workers and another 255 related to irregularities in working hours. A trade unionist in the Ribeirão Preto area explained that mills often force workers to finish cutting certain plots before they can go home, even if bad weather or other problems interfere.

Table 3: Number and variation of employed persons in professional groups and subgroups in sugar-energy companies, São Paulo, 2006-2019

Worker categories	Occupation by year														2006-2019 variation	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Absolute	%
Farming workers	**119,856**	**120,317**	**123,174**	**126,837**	**121,727**	**114,795**	**114,881**	**110,255**	**95,513**	**92,421**	**88,501**	**86,771**	**84,547**	**84,688**	**-35,168**	**-29.3**
Sugarcane workers	94,791	92,133	92,144	93,002	84,823	76,236	70,339	62,444	52,288	48,056	45,405	42,187	40,964	40,883	-53,908	-56.9
Workers in mechanized activities	19,612	22,184	24,526	27,087	30,110	31,129	36,937	39,634	35,614	36,907	36,215	37,481	36,293	36,365	16,753	85.4
Other farming workers	5,453	6,000	6,504	6,748	6,794	7,430	7,605	8,177	7,611	7,458	6,881	7,103	7,290	7,440	1,987	36.4
Workers in the manufacturing industry	**22,151**	**23,674**	**27,646**	**29,398**	**28,457**	**29,221**	**28,931**	**29,232**	**25,762**	**26,378**	**25,767**	**25,829**	**24,984**	**24,924**	**2,773**	**12.5**
Management and support	**60,925**	**67,796**	**74,275**	**80,215**	**83,367**	**90,340**	**97,132**	**101,204**	**99,324**	**99,498**	**97,048**	**95,837**	**88,756**	**89,563**	**28,638**	**47.0**
Non-sugar-alcohol	**4,206**	**3,948**	**4,217**	**5,046**	**3,603**	**5,109**	**5,620**	**3,656**	**3,630**	**3,489**	**3,377**	**3,353**	**3,274**	**3,274**	**-932**	**-22.2**
Total workers	**207,138**	**215,735**	**229,312**	**241,496**	**237,154**	**239,465**	**246,564**	**244,347**	**224,229**	**221,786**	**214,693**	**211,790**	**201,561**	**202,449**	**-4,689**	**-2.3**

Source: Ministry of Labour and Welfare

3.3 Results related to inspections in Northeast Brazil

The Northeast region stands out in number of notices based on NR-31, when compared to the rest of Brazil. There were 1,205 such fines between 2000 and 2019, equivalent to 27.8% of the total number of notices issued in the region. This number was 19.8% in the Other States group; 21.6% in São Paulo; and 22.4% in the national average. The region has lower mechanization rates and, therefore, more workers involved in manual cutting, where health and safety irregularities are concentrated. According to Companhia Nacional de Abastecimento (2021), in the 2019-2020 season, less than 25% of the sugarcane in the Northeast was harvested by machines, while the national average was 89.2% (almost 98% in São Paulo).

According to official data (Table 4), the number of workers doing mechanized tasks rose by only 3.4% in the region between 2006 and 2019, while the increase was 102.4% nationwide. The number of employees involved in sugarcane operations, such as manual harvesting, fell by 39.5%, below the national decline of 44.6%.

The Northeast is Brazil's oldest sugarcane producing region, where the industry dates back to early Portuguese colonization in the 16th century (Lima, 2021). Leading producer states include Alagoas and Pernambuco, where the activity, despite responding with difficulties to the modernizing pressures of the 21st century, remains an important local source of employment and income.

In Alagoas, the planted area was 270,530 hectares in 2020 for a harvest of 15.29 million tons (a 45% drop compared to 2000). There, mechanized harvesting was 22.2% of the total in the 2020/2021 season (Companhia Nacional de Abastecimento, 2021). In Pernambuco, the planted area reached 261,080 hectares in 2020, with 14.82 million tons (2% less than in 2000). Mechanization is very low, being estimated at 1.2% in 2020/21. Factors contributing to this scenario are the availability of cheap labour, economic difficulties faced by mills to invest in machines, and the irregular topography of the areas where most of the sugarcane plantations are established (Lima, 2021).

In addition to NR-31, the most common reasons for notices of violations in the Northeast in 2000-2019, against the 57 groups identified in the region, were a combination of issues of rest periods (439 fines), FGTS (338), working hours (251), and pay (227). The trend is similar to that recorded for Brazil as a whole, with an increase until 2013 (although with a substantial decrease in 2010 and 2011) and a decrease in 2014-2019 (Figure 9).

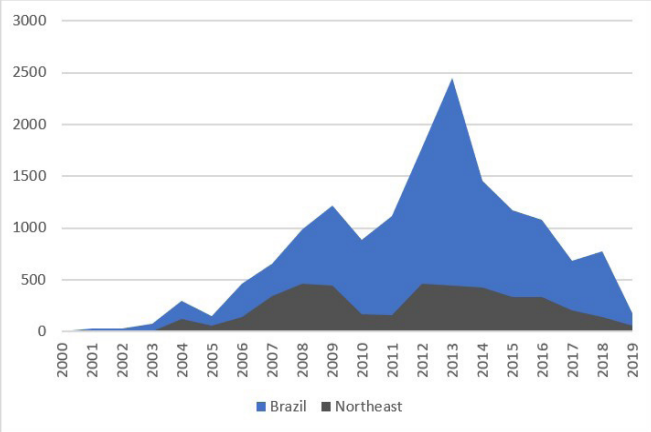

Figure 9: Notices of violation issued in the Northeast and in Brazil as a whole in 2000-2019.
Source: Secretary of Labour Inspection/Ministry of Labour and Social Security.

Table 4: Number of and variation in persons employed in professional groups and subgroups in sugar-energy companies; Northeast Brazil, 2006-2019

Worker categories	Occupation by year														2006-2019 variation	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Absolute	%
Farming workers	**150,395**	**157,862**	**167,422**	**168,311**	**163,138**	**159,496**	**142,242**	**131,091**	**119,557**	**108,985**	**107,251**	**106,000**	**96,134**	**94,210**	**-56,185**	**-37.4**
Sugarcane workers	141,956	149,288	157,752	158,595	152,905	148,970	131,987	120,707	109,462	99,119	97,440	96,745	87,486	85,861	-56,095	-39.5
Workers in mechanized activities	5,517	5,643	6,460	6,469	6,583	7,191	6,992	7,288	7,150	6,870	6,831	6,310	5,838	5,707	190	3.4
Other farming workers	2,922	2,931	3,210	3,247	3,650	3,335	3,263	3,096	2,945	2,996	2,980	2,945	2,810	2,642	-280	-9.6
Workers in the manufacturing industry	**8,444**	**8,827**	**10,192**	**10,370**	**10,042**	**10,265**	**9,351**	**9,091**	**9,067**	**9,125**	**8,909**	**8,820**	**8,548**	**8,030**	**-414**	**-4.9**
Management and support	**34,014**	**34,217**	**38,297**	**38,748**	**38,944**	**41,570**	**40,717**	**38,173**	**37,172**	**34,702**	**32,974**	**30,970**	**29,467**	**28,938**	**-5,076**	**-14.9**
Non-sugar-alcohol	**6,559**	**6,959**	**4,125**	**4,548**	**4,605**	**5,040**	**5,112**	**3,953**	**3,828**	**3,713**	**3,464**	**3,377**	**2,987**	**3,120**	**-3,439**	**-52.4**
Total workers	**199,412**	**207,865**	**220,036**	**221,977**	**216,729**	**216,371**	**197,422**	**182,308**	**169,624**	**156,525**	**152,598**	**149,167**	**137,136**	**134,298**	**-65,114**	**-32.7**

3.4 Inspection results in Other States

In the region defined in this research as Other States – which includes all Brazilian states but São Paulo and the Northeast region – Minas Gerais appears as the largest sugarcane producer, with emphasis on regions of expansion of the crop in the so-called Triângulo Mineiro area, on the border with northern São Paulo. Minas Gerais had 1 million hectares planted in 2020, for a production of 78.38 million tons (+318% in 2000-2020).

The second largest producer in the group is Goiás, with 937.63 million hectares cultivated in 2020 and a harvest of 76.48 million tons of sugarcane (+656% in 2000-2020). In third place comes Mato Grosso do Sul with 666.44 million hectares of planted area and 47.89 million tons harvested (+724% in 2000-2020).

As a hub of sugarcane expansion, especially in the flatter Cerrado areas of Minas Gerais and the Centre-West states, the Other States region received many investments for building new mills with agricultural operations already mechanized. In Rio Brilhante, Mato Grosso do Sul, LCD built a new Biosev unit, now owned by Raízen. British Petroleum (BP), along with Brazilian partners, bought the Tropical mill in Edeia, Goiás, and would later expand its market share by acquiring the CNAA group in 2011, which had mills in Minas Gerais and Goiás.

Due to the latest expansion of sugarcane, often implemented in mechanized operations since its inception, the activity did not depend on large numbers of rural workers and encouraged less migration than that seen in São Paulo. In 2006-2019, the region increased the number of jobs in the sector by 25.2% (Table 5) and, in states such as Mato Grosso do Sul, the number of employees registered in mechanized tasks is even higher than in sugarcane activities (4,256 compared to 2,679 in 2019, respectively).

As for notices of violation (Figure 10), most business groups (122) among the three blocks selected for this research operate in the Other States region and received the largest number of notices of violation (8,322). The high level of mechanization in sugarcane cutting did not prevent the most recurrent violations – those related to NR-31. There were 1,652 such fines in 2000-2019, or 19.8% of the total number of cases – just below the level found in São Paulo (21.6%) and Brazil (22.4%).

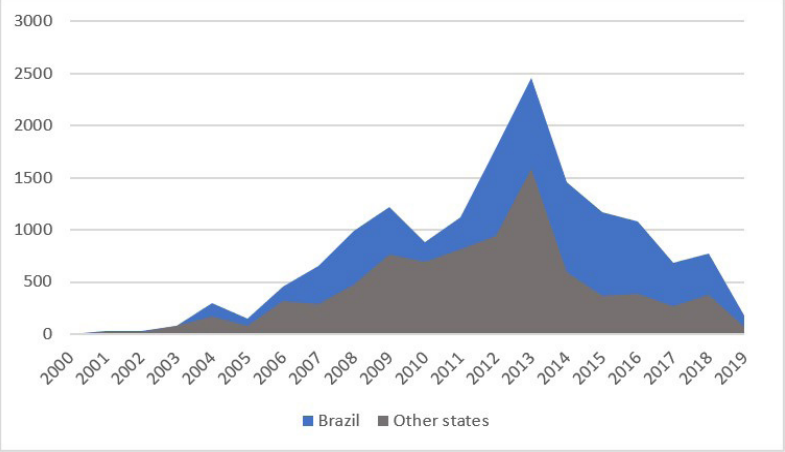

Figure 10: Notices of violation issued in Other States and in Brazil in 2000-2019. Source: Secretary of Labour Inspection of the Ministry of Labor and Welfare.

In addition to NR-31, the regulatory standards most commonly related to violations issued in the Other States region are NR-7 (336 times), NR-9 (467), NR-12 (695), NR-13 (285) and NR 24 (275). Among the notices based directly on the Consolidation of Labour Laws, there

Table 5: Number and variation of people employed in professional groups and subgroups in sugar-energy companies, in Other States, 2006-2019

Worker categories	Occupation by year														2006-2019 variation	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Absolute	%
Farming workers	**65,052**	**79,737**	**82,499**	**86,799**	**75,219**	**84,739**	**80,120**	**80,993**	**73,383**	**64,308**	**61,116**	**60,226**	**62,392**	**56,919**	**-8,133**	**-12.5**
Sugarcane workers	54,869	65,441	66,245	68,451	53,735	59,180	51,131	48,581	41,147	33,662	31,042	31,454	33,156	29,387	-25,482	-46.4
Workers in mechanized activities	7,622	10,675	12,382	14,183	17,027	20,245	23,665	26,829	26,853	25,301	24,842	23,746	24,160	22,488	14,866	195.0
Other farming workers	2,561	3,621	3,872	4,165	4,457	5,314	5,324	5,583	5,383	5,345	5,232	5,026	5,076	5,044	2,483	97.0
Workers in the manufacturing industry	**10,966**	**14,139**	**16,992**	**20,340**	**20,447**	**21,595**	**21,066**	**20,627**	**20,196**	**19,677**	**19,269**	**19,306**	**19,222**	**18,611**	**7,645**	**69.7**
Management and support	**33,284**	**42,743**	**45,147**	**53,212**	**58,750**	**68,826**	**73,477**	**77,309**	**76,708**	**70,748**	**67,347**	**65,385**	**65,531**	**64,153**	**30,869**	**92.7**
Non-sugar-alcohol	**4,597**	**4,682**	**4,447**	**5,376**	**5,301**	**4,137**	**4,498**	**4,302**	**3,548**	**3,205**	**3,036**	**3,278**	**3,382**	**2,862**	**-1,735**	**-37.7**
Total workers	**113,899**	**141,301**	**149,085**	**165,727**	**159,717**	**179,297**	**179,161**	**183,231**	**173,835**	**157,938**	**150,768**	**148,195**	**150,527**	**142,545**	**28,646**	**25.2**

Source: Ministry of Labour and Welfare

are violations of the right to weekly rest (881 times) and daily working hours (562). Violations related to irregularities in worker's pay are also worth mentioning, including frequent fines for issues with wages themselves (425) and FGTS (228).

The fact the region was occupied more recently, largely with operations mechanized from the start, did not prevent business groups based in Other States from committing a substantial number of labour law violations. As shown above, that is where the most irregularities are in the three regions studied and where the peak number of violations occurred in 2013.

In 2011, inspectors rescued 39 people who operated harvesting machines[6] from modern slavery on a farm in Goiatuba (GO). They used to work 24 hours in a row, which, added to the three hours of travel to the site, totalled 27 hours. The group interspersed the long journeys with 21 hours of rest. The farm supplied raw material for a mill belonging to the Vital Renewable Energy Company (VREC) group.

Proportionally, the higher number of cases in Other States ends up defining more clearly the upward trend observed in the country as a whole until 2013 and their decrease from then on. In 2014-2019, the most common notices of violation were still related to NR-31, with 281 fines – very close to the 271 violations under NR-12. As mentioned above, NR-12 regulates machine operation and is used to identify irregularities in mechanized operations.

In Other States, the 172 notices of violations issued under NR-9 in 2014-2019 stand out. This standard gives engineers or occupational safety technicians the task of preparing action plans to preserve workers' health and integrity – the Environmental Risk Prevention Programs (PPRA). Fined mills either did not comply with such plans or did not even have one. In the same period, 91 fines were found under NR-7, which addresses employee health. Companies must keep so-called Occupational Health and Medical Control Programs (PCMSO) updated, carrying out periodic medical examinations. In case of inconsistencies, they can also be notified by labour inspectors.

Conclusions

This article is based on the inventory of labour fines issued in 2000-2019 against the 280 business groups authorized by the ANP to operate sugarcane mills in Brazil. Two distinct periods were identified: the first one – 2000-2013 – saw an increase in the number of notices of violation of labour laws, while that number began to fall from 2014 onwards.

A general conclusion based on the analysis of notices of labour violations issued against the sugar-energy industry indicates that harvest mechanization helped to reduce irregularities related to the health and safety of sugarcane workers.

One of the factors explaining the upward trend in notices of violation in the former period is the expansion of sugarcane plantations and the number of workers in the sector. In 2006-2011 alone, the total number of formal employees in sugar-energy companies grew by 22%, but in a slightly longer period – 2006-2013 – the number of rural workers dropped by 20.5%. However, while the total number of notices of violation increased in 2000-2013, it proportionally fell in association with health and safety irregularities, a topic covered by NR-31. Such notices dropped from a peak of 42% of total fines applied in 2007 to 19% in 2013.

This occurred when the mechanization of sugarcane cutting was already advancing significantly in the country. It can be assumed, therefore, that this process helped to avoid an even greater increase in the number of violations in the first period.

From 2014 on, the absolute number of notices began to fall for all types of violations: rest periods, working hours, pay, health and safety, machine operation, among others. The advance

[6] More information at Pyl (2011).

of mechanization, which reached 91% in the national average for the 2019/20 harvest season, is once again one of the factors explaining this trend, especially in the context of stabilization of the sugarcane area in the country. In 2013-2018, more than 70,000 jobs in the sugarcane subgroup (rural work) disappeared in the sector, or 30% of the number recorded in 2013.

In addition to the advance of mechanization, the sudden fall in the number of fines is also explained by actors in the industry as a result of the government's fiscal crisis that undermined rural labour inspection in the country. Inspections faced material and human restrictions, indicating that violations may have occurred, albeit to a lesser extent than in the past, but there were no inspectors to record them. It should be noted that violations of legislation still exist even in mechanized areas, as has been pointed out in the literature, or in activities – such as sugarcane planting – and places – industries and offices – that are not directly affected by harvesting machines.

The research results presented here are limited by the publicly available database, which is incomplete in terms of information on violations and eliminates notices issued to companies that underwent mergers and acquisitions. To get around the problem, it would be necessary to reconstruct the labour database by identifying all the business groups that resulted in the one under analysis. Even with limitations, by providing details on the type and prevalence of irregularities, the data allow better understanding of the effects of recent changes in the sugar-energy sector, helping the debate on social sustainability to be carried out on more solid foundations.

References

Almeida, A. A. (2011). *Marcados pela desigualdade: o trabalho escravo na cana-de-açúcar no Estado de São Paulo (1995-2010)* (Tese de doutorado). Pontifícia Universidade Católica de São Paulo, São Paulo.

Alves, F. (2006). Por que morrem os cortadores de cana? *Saúde e Sociedade*, *15*(3), 90-98.

Baccarin, J. G. (2017). Mudanças administrativas e tecnológicas de empresas sucroalcooleiras e os impactos na ocupação canavieira no estado de São Paulo, Brasil. In *55º Congresso da Sober*. Santa Maria.

Barreto, M. J. (2018). *Novas e velhas formas de degradação do trabalho no agrohidronegócio canavieiro nas Regiões Administrativas de Presidente Prudente e Ribeirão Preto (SP)* (Tese de doutorado). Universidade Estadual Paulista, Presidente Prudente.

Borjas, G. J. (2012). *Economia do trabalho* (5ª ed.). Nova Iorque: AMGH Editora.

Brasil. Ministério do Trabalho e Previdência. (2020a). *Norma regulamentadora nº 31 (NR-31).* Brasília. Recuperado em 3 de novembro de 2021, de https://www.gov.br/trabalho-e-previdencia/pt-br/composicao/orgaos-especificos/secretaria-de-trabalho/inspecao/seguranca-e-saude-no-trabalho/ctpp-nrs/norma-regulamentadora-no-31-nr-31

Brasil. Ministério do Trabalho e Previdência. Subsecretaria de Inspeção do Trabalho – SIT. (2020b). *Banco de dados de autos de infração.* Brasília. Recuperado em 9 de abril de 2020, de http://cdcit.mte.gov.br/inter/cdcit/emitir.seam

Campos, M. R. (2019). *Formas contemporâneas de trabalho escravo no cultivo da cana-de-açúcar no Brasil* (Dissertação de mestrado). Universidade Estadual Paulista, Franca.

Capitani, D. H. D., Gomes, M. S., Walter, A. C. S., & Leal, M. R. L. V. (2021). Condições de trabalho na atividade canavieira brasileira. *Revista de Política Agrícola*, *2*, 64-77.

Companhia Nacional de Abastecimento – Conab. (2021). *Boletim da safra de cana-de-açúcar.* Recuperado em 3 de novembro de 2021, de https://www.conab.gov.br/info-agro/safras/cana

Cover, M., & Menezes, M. A. (2015). Trabalhadores migrantes nos canaviais do Estado de São Paulo: formas de resistências e movimentos espontâneos. In A. Riella & P. Mascheroni (Eds.), *Asalariados rurales en América Latina* (pp. 213-235). Buenos Aires: Clacso.

Eid, F. (1996). Progresso técnico na indústria sucroalcooleira. *Informações Econômicas*, *26*(5), 29-38.

Favoretto, T. M. (2014). *Máquinas de empobrecimento: impactos da mecanização do corte da cana sobre trabalhadores canavieiros em Barrinha-SP* (Dissertação de mestrado). Universidade Estadual de Campinas, Campinas.

Figueira, R. R., & Prado, A. A. (2009). O trabalho escravo por dívida: discussões e persistência. In M. H. Versiani, I. Maciel & N. M. Santos (Eds.), *Ciclo cidadania em debate*. Rio de Janeiro: Jauá.

Gil, A. C. (2008). *Como elaborar projetos de pesquisa* (5ª ed.). São Paulo: Atlas.

Gonzales, E. N., & Bastos, M. I. (1977). *O trabalho volante na agricultura brasileira: capital e trabalho no campo*. São Paulo: Hucitec.

Graziano da Silva, J. (1980). *Progresso técnico e relações de trabalho na agricultura paulista* (Tese de doutorado). Universidade Estadual de Campinas, Campinas.

Guanais, J. B. (2010). *No eito da cana, a quadra é fechada: estratégias de dominação e resistência entre patrões e cortadores de cana em Cosmópolis (SP)* (Dissertação de mestrado). Universidade Estadual de Campinas, Campinas.

Hoffmann, R., & Oliveira, F. C. R. (2007). *Remuneração e características das pessoas ocupadas na agroindústria canavieira no Brasil, de 2002 a 2006*. Piracicaba: Gemt Esalq-USP.

Instituto Brasileiro de Geografia e Estatística – IBGE. (2020). *Produção agrícola municipal 1974-2020.* Rio de Janeiro. Recuperado em 3 de novembro de 2021, de https://sidra.ibge.gov.br/pesquisa/pam/tabelas

Instituto de Economia Agrícola – IEA. (2014). *Protocolo agroambiental do setor sucroenérgetico paulista: dados consolidados das safras 2007/08 a 2013/14.* São Paulo. Recuperado em 3 de novembro de 2021, de http://www.iea.sp.gov.br/Relat%C3%B3rioConsolidado1512.pdf

Lima, J. R. T. (2021). Colheita mecanizada da cana-de-açúcar: o que nos revelam os especialistas do setor sobre as motivações e impeditivos da sua adoção na realidade canavieira de Alagoas? *Estudos Sociedade e Agricultura*, *29*(1), 219-245.

Maeda, F. (2012). *Influências do Protocolo Ambiental do setor sucroalcooleiro na produção de açúcar, álcool e energia: estudo de caso em uma usina no interior de São Paulo* (Dissertação de mestrado). Universidade Estadual Paulista, Botucatu.

Mendes, M. M. B. (2007). *Justiça do trabalho e mercado de trabalho: trajetória e interação judiciário e a regulação do trabalho no Brasil* (Dissertação de mestrado). Universidade Estadual de Campinas, Campinas.

Moraes, M. A. F. D. (2007). O mercado de trabalho da agroindústria canavieira: desafios e oportunidades. *Economia Aplicada*, *11*(4), 605-619.

Oliveira, M. A. (2003). Tendências recentes da negociação coletiva no Brasil. In M. W. Proni & W. Henrique (Eds.), *Trabalho, mercado e sociedade*. Campinas: Unesp.

Prodanov, C. C., & Freitas, E. C. (2013). *Metodologia do trabalho científico: métodos e técnicas de pesquisa e do trabalho acadêmico* (2ª ed.). Novo Hamburgo: Feevale.

Pyl, B. (2011, dezembro 20). Operação inédita flagra escravidão em colheita mecanizada. *Repórter Brasil*. Recuperado em 3 de novembro de 2021, de https://reporterbrasil.org.br/2011/12/operacao-inedita-flagra-escravidao-em-colheita-mecanizada/

Richardson, R. J. (2017). *Pesquisa social: métodos e técnicas* (3ª ed.). São Paulo: Atlas.

Rodrigues, D. A. (2014). *Acidentes graves fatais no trabalho de corte mecanizado de cana-de-açúcar: o olhar através do método mapa* (Dissertação de mestrado). Universidade Estadual Paulista, Botucatu.

Santos, A. M. F. T. (2015). *Cana doce, trabalho amargo: o trabalho escravo na expansão territorial do agronegócio sucroenergético no estado de Goiás* (Dissertação de mestrado). Universidade Federal de Goiás, Goiânia.

Scopinho, R. A., & Valarelli, L. L. (1995). *Modernização e impactos sociais: o caso da agroindústria sucroalcooleira da região de Ribeirão Preto (SP*). Rio de Janeiro: Fase.

Scopinho, R. A., Eid, F., Vian, C. E. F., & Silva, P. R. C. (1999). Novas tecnologias e saúde do trabalhador: a mecanização do corte da cana-de-açúcar. *Cadernos de Saude Publica*, *15*(1), 147-161.

Sindicato Nacional dos Auditores Fiscais do Trabalho – SINAIT. (2018). *Número de ações contra trabalho escravo cai 23,5% em 1 ano; total de resgatados é o menor desde 1998.* Brasília. Recuperado em 3 de novembro de 2021, de https://www.sinait.org.br/site/noticia-view?id=15286%2Fnumero+de+acoes+contra+trabalho+escravo+cai+23%2C5%25+em+1+ano%3B+total+de+resgatados+e+o+menor+desde+1998

Universidade Estadual Paulista – Unesp. (2021). *Boletim ocupação formal no setor sucroalcooleiro em São Paulo, projeto de extensão da Unesp Jaboticabal.* Recuperado em 3 de novembro de 2021, de https://www.fcav.unesp.br/#!/departamentos/economia-rural/docentes/jose-giacomo-baccarin/boletim-ocupacao-sucroalcooleira-em-sao-paulo/

Veiga Filho, A. A. (1998). *Mecanização da colheita da cana-de-açúcar no Estado de São Paulo: uma fronteira de modernização tecnológica da lavoura* (Dissertação de mestrado). Universidade Estadual de Campinas, Campinas.

Vian, C. E. F., & Belik, W. (2003). Os desafios para a reestruturação do complexo agroindustrial canavieiro do Centro-Sul. *Economía*, *4*(1), 153-194.

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