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FUELING DEVELOPMENT:
SUGARCANE EXPANSION
IMPACTS IN BRAZIL

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Fueling Development: Sugarcane Expansion Impacts in Brazil

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Abstract

With the growing effort to decrease greenhouse gas emissions and the inevitable shift towards renewable energy, sugarcane and ethanol production are forecast to expand worldwide. This paper studies the multiple local impacts of the sugar, ethanol and bioelectricity producing mills in the Brazilian state of Mato Grosso do Sul, where the industry grew almost threefold in an eight-year period. We find a myriad of positive impacts related to the entry of sugarcane mills with investments accounting for 130% of the average municipal GDP. Three years after a mill is built, a typical municipality has a 30% increase in GDP; population increases by 10%; employment shoots up by 40%; wages go up 49%; and tax revenues jump 31%. Land use shifts primarily from pastures to sugarcane and there is a decrease in deforestation. There are positive spillovers on agriculture, leading to an increase in the productivity of other crops. Channels contributing to these spillovers include a larger and more educated labor force combined with better financial services, transportation, agricultural equipment and support activities. These results are important to the contentious debate on how different energy sources affect the producing areas.

Key-words: Local economic development, spillovers, biofuels, land use.

JEL-Codes: R11, R14, Q16

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1 Introduction

With the growing effort to slow carbon emissions by shifting towards renewable energy, sugarcane and ethanol production are forecast to expand worldwide.[1] Given the contentious debate on how different energy sources (such as shale gas and nuclear energy) affect producing areas, understanding the impacts of the sugar, ethanol, and bioelectricity producing mills on the hosting localities becomes fundamental. The deployment of these mills implies large private investments that bring considerable economic, social and spatial changes. These changes are even more substantial in rural, sparsely populated and poor areas, where a variety of spillover channels rapidly develop.

This paper studies the multiple local impacts of the mills in the Brazilian state of Mato Grosso do Sul (henceforth, MS), an industry that grew almost threefold in an eight-year period and where investments accounted for 130% of the average municipality GDP.[2] We analyze the various impacts, spillovers and transmission mechanisms involving agricultural land, deforestation, economic activities, demography, labor market and financial services.

During the 2005-2012 period, sugarcane area increased almost 70% in Brazil and more than 300% in MS, a new frontier for sugarcane. A typical new sugarcane mill involves capital expenditures around 280 million reais[3], has a sugarcane crushing capacity of 2 million tons per year[4] and employs 1,500 to 2,500 workers. This boom was the result of the surge in ethanol demand caused by the introduction of flex fuel vehicles (FFVs) in 2003 (Pessoa et al. (2013); Salvo and Huse (2013)) paired with a credit reform that boosted loans for automobile purchases in 2004 (Assuncao et al. (2013)). Currently, Brazil is the world's first producer of sugarcane, the first sugar producer and exporter, and the second ethanol producer and exporter (US Department of Agriculture, 2015). Moreover, the sugarcane

[1]Global ethanol production increased from 28 billion liters in 2004 to 94 billion liters in 2014. In the same 10-year period, global bio-power generation increased from 227 TWh in 2004 to 433 TWh in 2014. In 2015, 164 countries have renewable energy targets and 145 countries have renewable energy support policies (REN21, 2015).

[2]MS is similar in area to Germany.

[3]Approximately USD 130 million in 2006 figures.

[4]One ton of sugarcane has approximately the same energy content as one barrel of oil.

industry is forecast to grow in the country, with land use dedicated to sugarcane predicted to undergo the largest percentage growth (37%) among all crops in the next 10 years (OECD/FAO (2015)).

We use panel data on 78 municipalities for the years 1999-2012 to estimate the impact of the mills on a series of outcomes. We use data from several sources to investigate the events through different dimensions. Data on agricultural land use and output comes from the Municipal Agricultural Survey (PAM) and the Municipal Livestock Survey (PPM) from the Brazilian Institute of Geography and Statistics (IBGE).[5] Data on municipal GDP and population also comes from IBGE. We use administrative data on labor market, income and education for all employers and employees in all economic sectors, which are mandatorily collected on the Annual Social Information Report (RAIS) of the Ministry of Labor and Employment.[6] We also use financial data from Banking Statistics per Municipality (ESTBAN) from the Brazilian Central Bank.[7] We use georeferenced data on municipal area and agricultural suitability from IBGE, river extension from the Brazilian Electricity Regulatory Agency (ANEEL), distance to Paraná river waterway from the National Water Agency (ANA) and average temperature and rainfall from the Climatic Research Unit at the University of East Anglia (New et al. (2002)). Finally, we use Landsat satellite data at approximately 30-meter spatial resolution to characterize deforestation from the University of Maryland Global Forest Change 2000–2014 dataset (Hansen et al. (2013)).

We use two empirical strategies: fixed-effects panel estimation and the synthetic control method (Abadie et al. (2010); Abadie and Gardeazabal (2003)). For the panel estimation, we use municipal and time fixed-effects to control for time-invariant municipal characteristics and year variations. Our specification includes leads and lags in order to capture outcomes prior and after the mill's entry. We find no differences in trends more than two years before a mill's entry, showing that the difference-in-difference's parallel trend assumption holds in this interval. In contrast, in the two years preceding the mill's entry, plant construction and sugarcane fields preparation are already taking place and important outcomes start to re-

[5]PAM is Pesquisa Agrícola Municipal. PPM is Pesquisa Pecuária Municipal. IBGE is the Instituto Brasileiro de Geografia e Estatística.

[6]RAIS is Relação Anual de Informações.

[7]ESTBAN is Estatística Bancária por Município.

spond. We also implement the synthetic control method for causal inference for the main outcomes of interest. Since we have several treatments, we use the methodology in (Cavallo et al. (2013)) and (Quistorff and Galiani. (2016)) to run multiple synthetic controls estimations, to generate placebo tests and to conduct inference. We compare the estimates of the panel regressions to the synthetic control method and find very similar results.

We estimate that each operating mill demands about 25 thousand hectares[8] to produce 1.7 million tons of sugarcane.[9] We find that sugarcane production starts two years before the mill becomes operational. A similar pattern is observed with sugarcane harvested area. Therefore, these initial results replicate real agriculture conditions.

Spillovers are far-reaching. Cattle herd in municipalities with sugarcane mills is reduced on average by 27 thousand heads, out of a sample average of 285 thousand heads. This result suggests that mills produced a land use shift from pastures to sugarcane.

Regarding other main crops, soybean harvested area is reduced, while production is kept constant; in fact, it goes up in the short run. For corn, there is an increase in production and harvested area. There is evidence that the sugarcane expansion creates positive spillovers and increases grain productivity as measured in yield per hectare.

Three years after a mill is built, a typical treated municipality has a 30% increase in GDP. The GDP, when broken down into its main components, shows an increase of 65% for agriculture, 45% for industry, 13% for services and 10% for public administration. Tax revenues go up by 31%. Population and GDP per capita also increase 10% and 20%, respectively.

Besides the mill, there are 186 additional business openings. Employment shoots up by 40% with 3,542 vacancies opening (mainly for skilled workers) and aggregate wages go up by 49%.

The industrial sector benefits the most in terms of job creation and wage increases (sugarcane mills and their employees, including those working in cultivation activities, are classified as manufacturing industry in RAIS). Detailed data shows that manufacturing; wholesale and retail trade and maintenance; hotels and restaurants; and transport, storage, and communications are the most positively affected sectors.

[8]The sample average municipality area is 453 thousand hectares.

[9]This output figure corresponds to a typical mill operating at almost full capacity.

Impacts keep unfolding. Employment in soybean and corn production increases while it decreases in cattle ranching, confirming our previous agricultural outcomes. Other positively affected sectors are agriculture service activities; cattle slaughtering; manufacture of fertilizers and nitrogen compounds; maintenance of tractors and agricultural equipment; road freight; wholesale of agricultural machinery and equipment; wholesale of fertilizers and pesticides; and renting of agricultural machinery and equipment.

Finally, we observe increased financial intermediation. Private deposits increase by 4.8 million reais (sample mean of 4.6 million reais). Agricultural credit goes up by 18.5 million reais (sample mean of 24.2 million reais) both for investments and operational expenses and for output commercialization.

Therefore, a mill demands a broad range of ancillary activities, attracting suppliers of agricultural inputs and services, which results in improved access to better technologies and farming practices for all agricultural producers in those municipalities. It also improves transportation, storage and communications which may benefit non-sugarcane producers. Finally, the sugarcane business brings capital and boosts access to credit that can relieve financially constrained farmers, allowing them to use better inputs and increase yields. These three transmission channels can potentially explain positive spillover effects to soybean and corn productivity, which possibly extend to other agricultural sectors.

Our results are relevant to the contentious debate on the impact of different energy sources on producing areas (Allcott and Keniston (2014); Black et al. (2005); Muehlenbachs et al. (2014)).

This study contributes to a recent literature on the existence of spillover effects across sectors (Bleakley and Lin (2012); Greenstone et al. (2010); Kline and Moretti (2013); Redding et al. (2011); Severnini (2012)) and the related policy implications discussed in (Glaeser and Gottlieb (2008)). Our results point to spillovers and their transmission mechanisms within agriculture and other economic sectors.

The displacement effect of sugarcane cultivation on cattle ranching has a parallel in (Jia (2008)). The study describes how economies of scale related to large retail chain openings turn smaller stores unprofitable and ultimately drive them off market.

If we interpret municipalities as small open economies, the investment in sugarcane mills construction is analogous to foreign direct investments.

In this case, our results are related to those found by (Barry and Bradley (1997)), where foreign direct investments led to industrial growth and diversification in Ireland.

Our study has implications for policies that promote bioenergy production and climate change mitigation strategies. In places where land allocation and agricultural production are still inefficient, as in many developing countries, positive spillovers generated by bioenergy production can potentially outweigh increased competition for land. This result is similar to those found in (Negash and Swinnen (2013)) for small households in Ethiopia, except ours apply to large scale agriculture. The findings in this paper are also relevant for local governments making decisions about fiscal incentives to attract private investments.

The remaining of the paper is organized as follows. The next section presents the institutional and geographical context. Section 3 describes our dataset. The identification strategy is laid down in section 4 and results are reported in section 5. Concluding remarks are in section 6.

2 Sugarcane Context: The Revitalization of the 2000s

A technological breakthrough sparked a boom in the sugarcane industry in the early 2000s. Brazilian car manufacturers developed FFVs that could not only run on any arbitrary blend of hydrated ethanol and gasoline, but also had a lower production cost than previously available flexible fuel engines.[10] When FFVs were commercially introduced in 2003, market penetration was fast. In 2005, Brazilian sales of FFVs surpassed that of petrol-only vehicles. By 2012, the bulk (87%) of light-duty vehicles sold ran on flexible fuel engines.[11] As consumers could respond to market prices of different fuels, FFVs became the main reason behind recent sugarcane industry growth.

[10] Two types of ethanol with different water content are produced; anhydrous and hydrated ethanol. Anhydrous ethanol can have at most 0.5% of water volume while hydrated ethanol can have up to 5%. Anhydrous ethanol is blended into petrol while hydrated ethanol is sold at the pump for automobiles with ethanol or flexible fuel engines.

[11] Data from Anfavea - Associação Nacional dos Fabricantes de Veículos Automotores. (`www.anfavea.com.br`)

Important government policies also gave a major thrust to ethanol.[12] First, federal law requires gasoline for automobile use to have ethanol added to its composition. The proportion of ethanol that must be mixed with petrol has been above 20% since 1992 and reached 27% in 2015.[13] Second, ethanol and petrol have different taxation schemes in which the latter faces a higher burden. Finally, FFVs face lower taxation than their petrol counterparts.

Therefore, FFV innovation and government policies combined to trigger an investment boom in sugarcane plantations and greenfield mills. This expansion was carried on not only by incumbents but also by domestic and foreign entrants. Besides attracting investments from the sugar and ethanol industry itself, companies that operated in sectors such as food processing, agricultural commodities trading, civil construction, oil and gas and banking have also stepped in (BNDES and CGEE, 2008).[14]

Brazilian sugar and ethanol industry is concentrated in the Center-South region, mainly in State of São Paulo. But further expansion opportunities in this state were becoming limited as sugarcane crop area increased from 12.4% to 20.7% of total state area from 2005 to 2012. This led mills to compete intensely for land, raising its cost (Adami et al. (2012b); BNDES and CGEE (2008)). Therefore, investments in greenfield mills and new sugarcane fields spread to neighboring states. MS was the state with the largest percentage increase in sugarcane harvested area from 2005 to 2012.

Multiple factors attracted investors to MS, such as fiscal incentives, low priced land, adequate soil and climate conditions, infrastructure to outflow sugar and ethanol production coupled with proximity to main domestic fuel markets and the Santos port, the main sugar export route (Pereira et al., 2007).

From 1979 to 1982, eight mills started operating in MS within the Pró-Álcool program (which started in 1975), followed by an interim of stagnation, from 1983 to 2004, when no entries occurred.

[12]See Goldemberg and Moreira (1999) for an analysis of the early years of the Brazilian ethanol industry and the Pró-Álcool program. See Hira and de Oliveira (2009) for a broader history of Brazilian ethanol.

[13]Federal Law number 8,723 from 1993 established a countrywide blending mandate of 22% of anhydrous ethanol into petrol. This law was modified by Federal Law numbers 10,203 from 2001, 12,490 from 2011 and 13,033 from 2014, widening the blending mandate range from 20% to 24%, 18% to 25% and 18% to 27.5%, respectively.

[14]This follows a global trend identified by (Chan and Reiner (2011)).

A second expansion started in 2005 with the entry of 14 greenfield mills until 2012. During this period, the number of mills increased almost three-fold from 8 to 22 while sugarcane cultivation area increased fourfold from 136,803 to 558,664 hectares.[15] This represents less than 2% of the State's territory.

Figure 1 details the mills' locations, municipalities boundaries and sugarcane crops as of 2005 and 2012. The satellite images were provided by the National Institute for Space Research (INPE) - Canasat Project (Adami et al., 2012a; Rudorff et al., 2010). It also shows the Pantanal biome and Upper Paraguay hydrographical basin. Federal Decree 6,961 from 2009 prohibited new sugarcane plantations and greenfield mills in these areas. However, this particular legislation has not forbidden other agricultural activities in the same region.

The aforementioned Federal Decree also enforced the sugarcane agroecological zoning or ZAE Cana (EMBRAPA, 2008), which identifies potential areas for sustainable sugarcane production (excluding all regions with native vegetation).[16]

In particular, ZAE Cana (EMBRAPA, 2008) pinpointed MS as having a significant expansion potential of highly suitable areas for sugarcane crops, currently used as pastureland, of up to 5.4 million hectares, equivalent to 15.2% of the State's area (almost the same area currently used for sugarcane crops in São Paulo State).

In 2006, Brazil had more than 330 operative sugar and ethanol mills with sugarcane crushing capacities ranging from 600 thousand to 7 million tons per year (BNDES and CGEE, 2008).[17]

A standard mill with sugarcane crushing capacity of 2 million tons per year has a capital expenditure of approximately 280 million reais, in 2006 figures, which is comprised of approximately 205 million reais for the industrial site and 75 million reais for the agricultural site (CGEE, 2009). For the industrial site only, capital expenditures amounted to approximately 50 USD per ton of installed capacity according to (CGEE, 2009) or 48.5 USD per ton as reported by (BNDES and CGEE, 2008). These numbers

[15] The average area of a mill increased from 17,100 to 25,394 hectares reflecting new mills larger sugarcane crushing capacities.

[16] The study was conducted by the Ministry of Agriculture, Livestock and Food Supply (MAPA) and Ministry of the Environment (MMA).

[17] An ethanol mill with 7 million tons per year of sugarcane crushing capacity compares in output to a 35.000 barrels per day oil refinery (BNDES and CGEE, 2008).

are considerable especially when compared to the average municipality GDP of 214.6 million reais (excluding the State capital (Campo Grande)). Therefore, such an investment represents 30.5% more than average GDP.

This standard mill employs from 1,500 to 2,500 workers depending on technological choices and degree of sugarcane harvest mechanization (BNDES and CGEE, 2008).[18] The average mill gives employment opportunities for 7.5% of the population.

3 Data

We construct a panel of 78 municipalities in MS for the period 1999-2012 since we are interested in the impact of the sugarcane mills that started operating between 2006 and 2011. We use several data sources to analyze the events through different dimensions.

Descriptive statistics comparing hosting municipalities (treated) and non-hosting municipalities (untreated) in 2005 and 2012 are presented in table 1 with variables name, number of observations, means, and standard deviations.

Data on the mills' geolocation and operation period was provided by the Mato Grosso do Sul Bioenergy Producers Association (BioSul).[19]

We use the Municipal Agricultural Production survey (PAM) from the Brazilian Institute of Geography and Statistics (IBGE) for data on harvested area, agricultural output and production value.[20,21] We use the Municipal Livestock Production survey (PPM), also from IBGE, for data on cattle heads and livestock production value.[22] Both PAM and PPM are annual surveys for all Brazilian municipalities.

We use Landsat satellite data at approximately 30-meter spatial resolution to characterize deforestation from the University of Maryland Global Forest Change 2000–2014 dataset (Hansen et al. (2013)).

[18]According to CONAB (CONAB, 2008), one worker can harvest 15.2 hectares per season against 1,246.82 hectares of a harvester. Thus each harvester replaces 82 workers.

[19]BioSul is Associação dos Produtores de Bioenergia de Mato Grosso do Sul.

[20]PAM is Produção Agrícola Municipal.

[21]IBGE is Instituto Brasileiro de Geografia e Estatística.

[22]PPM is Produção Pecuária Municipal.

Data on the gross domestic product per municipality and its breakdown into agriculture, industry and services, as well as tax revenues and public administration, were obtained from IBGE's regional accounts. Data on municipal population per year was also obtained from IBGE. This is estimated using information on population growth trends from the two previous Censuses at the municipal and state levels.[23]

Labor market data comes from the Annual Social Information Report (RAIS), an administrative record with detailed information on all formal employers and employees in Brazil, which is collected by the Ministry of Labor and Employment.[24,25] The data includes information on firms, employment, wages and labor force education for more than 1,300 economic sectors. We are particularly interested in the labor market outcomes for agriculture, livestock, forestry, manufacturing, construction, wholesale, retail, maintenance, lodging and restaurants, transportation, warehousing, communications, financial services and education.

Data on financial services were obtained from the Banking Statistics per Municipality dataset (EstBan) of the Brazilian Central Bank.[26] It contains the balance sheet per bank branch and provides data on bank assets, private deposits (of both households and firms) and rural credit (for both agriculture and cattle ranching by credit purpose).

Finally, we have several geographic data: 1) municipal area was taken from IBGE; 2) agricultural suitability (topography, fertility, soil type and agricultural limitations) was also taken from IBGE; 3) river extension was taken from the Brazilian Electricity Regulatory Agency (ANEEL); 4) distance to Paraná river waterway was taken from the National Water Agency (ANA); and 5) average temperature and rainfall data were taken from the Climatic Research Unit at the University of East Anglia (New et al. (2002)).

All nominal values were deflated to 2005 Brazilian Reais (BRL) using the Broad Consumer Price Index (IPCA) from IBGE.[27]

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[23]For 2007, population has been counted by IBGE and data for 2010 comes from the National Census.

[24]RAIS is Relação Anual de Informações Sociais.

[25]Every year, each firm in Brazil is required to provide detailed information about its employees to the Ministry of Labor and Employment.

[26]EstBan is Estatística Bancária por Município from the Banco Central do Brasil.

[27]IPCA is Índice Nacional de Preços ao Consumidor Amplo. It is used by the Brazilian Central Bank for inflation targeting.

4 Empirical Strategy

Our goal is to estimate the impacts of new sugarcane mills on municipal outcomes. We use two different strategies: fixed-effects panel estimation and the synthetic control method (Abadie et al. (2010); Abadie and Gardeazabal (2003)). We compare the estimates of both methods for our main outcomes of interest and, as seen in Section 5, find very similar results.

We consider that some of the impacts of a mill's entry may spring up before the mill starts operating and others may continue for several years after that. We use leads and lags dummy variables indicating the deployment of new sugarcane mills, controlling for municipality and time fixed effects.

The dummy variable indicating the year (τ) in which the mill started operating in municipality (m) is denoted by $(\text{new mill}_{m,\tau})$. Dummies that capture anticipated effects range from $(\tau - 5)$ to $(\tau - 1)$, while dummies that capture lasting effects range from $(\tau + 1)$ to $(\tau + 6)$. Hence, the coefficient of $(\text{new mill}_{m,\tau-1})$ indicates the impact one year before the mill starts operating. Accordingly, the coefficient of $(\text{new mill}_{m,\tau+1})$ indicates the impact one year after the mill is operating. The inclusion of $(\tau - 5)$ to $(\tau - 1)$ allow the analysis of pre-trends while the inclusion of $(\tau + 1)$ to $(\tau + 6)$ allows the analysis of whether the treatment effect changes over time after treatment.

Equation 1 presents our main specification for the panel estimation.

$$y_{m,t} = \alpha_m + \phi_t + \sum_{k=\tau-5}^{k=\tau+6} \beta_k \times \text{new mill}_{m,k} + \epsilon_{m,t} \tag{1}$$

where $y_{m,t}$ is an outcome variable in municipality m and year t, α_m and ϕ_t are the municipality and year fixed effects, respectively. The β coefficients represent the impact of a new sugarcane mill on the outcome variable. Due to the sugarcane mills' investment profile detailed in section (2), statistically significant impacts should trace back at most two years before the mill starts operation. We expect $\beta_k = 0$ for all $(k < \tau - 2)$ since impacts trace back at most to two years before the mill is operational.

Our 8-year panel data and the timing of entry of new sugarcane mills constrains estimation to 9 parameters per regression.[28] As a result, starting

[28] Including more than 9 parameters leads to collinearity.

at $(\tau - 5)$ we can include impacts until $(\tau + 3)$ and starting at $(\tau - 2)$ we can include impacts up to $(\tau + 6)$.

We use two approaches to estimate specification 1. For main municipal outcomes (e.g., GDP and population) we present four regressions with different initial lags, starting in $(\tau - 5)$, $(\tau - 4)$, $(\tau - 3)$ and $(\tau - 2)$. For main municipal outcomes, we use a rolling window with at most four different time intervals to estimate equation 1.

Additionally, for each lead included one year of information is lost. To reduce data loss when estimating lead coefficients in equation 1, we also used data on two new sugarcane mills entry in 2013, and zero mills in 2014.

Therefore, the only time interval that uses the whole sample is from $(\tau - 2)$ to $(\tau + 6)$, with only two lead dummies measuring the impacts at $(\tau - 2)$ and $(\tau - 1)$. For all other municipal outcomes we use only this period to estimate equation 1 to avoid data loss.

Coefficients β_k from equation 1 can be interpreted as the cumulative impact of a new mill at k, compared to a baseline in which a new mill is absent in the period before the regression leads starts. If the regression starts at $(\tau - 2)$, impacts at k are being measured cumulatively to the baseline at $(\tau - 3)$.

The impacts can be either on changes in outcome variables levels or growth rates, depending whether outcome variables are employed in their original measurement units or in logarithms, respectively. To interpret results we use the year of 2005 as the baseline.

In our tables we present only results until $(\tau + 3)$ because there are 12 mills to estimate this parameter. We also consider this as the long run impact from the new mill. At $(\tau + 4)$ there are only 5 mills to estimate the parameter and in $(\tau + 5)$ and $(\tau + 6)$ there are only 2 mills. Thus, there are not enough observations to rely on the estimations. Nevertheless, these variables are included in the regression as controls because otherwise it would lead to biased estimates of the remainder parameters.

For the panel fixed effects regressions, we focus on the period between 2005 and 2012. New municipalities were created in 2005 and in 2013 taking part of the territories of other municipalities. As most of our data is available at the municipal level, expanding the sample period would imply undesirable data loss.[29]

[29] Expanding the period would require merging divided municipalities into single en-

We have 15 different treated municipalities (out of 77) and 16 mills.[30],[31] Their treatment year also is different. Municipalities with pre-existing mills and without new mills were assigned to the control group.

We also estimate the mill's effects using the synthetic control method (Abadie et al. (2010); Abadie and Gardeazabal (2003)). This method takes a weighted average of untreated municipalities as a synthetic control. Weights $W = (w_1, ..., w_J)'$ of each municipality are chosen so that the synthetic municipality most closely resembles the treated municipality before the new mill. The vector of weights W^* is chosen to minimize:

$$(X_1 - X_0 W) V (X_1 - X_0 W) \tag{2}$$

where X_1 is a $(Kx1)$ vector of K pre-mill outcome predictors in the treated municipality, X_0 is a (KxJ) matrix of the values of the same variables for the J controls and V is the diagonal matrix with nonnegative components reflecting the relative importance of the different predictors. Matrix V is chosen such that the real outcome path for the treated municipality before the mill is best reproduced by the resulting synthetic municipality.

The evolution of the outcome for the resulting synthetic control group is an estimate of the counterfactual (it is an estimate of what would have been observed for the affected municipality in the absence of the mill). Then counterfactual outcome (in the absence of the mill) is $Y_1^* = Y_0 W^*$, where Y_1 is the $(Tx1)$ vector with the values of outcome values for T years in the treated municipality and Y_0 is the (TxJ) matrix whose elements are the values of the outcome variable for T years in the control municipalities.

The average effect over all treatments is $\overline{\alpha} = \frac{\sum_{j=1}^{G} \widehat{\alpha_g}}{G}$, where $g \in [1, ..., G]$ index treated units. For each treatment, we generate a set of placebo effects $\widehat{\alpha_g^{PL}}$. We construct all possible averages were a single placebo is taken from

tities throughout the whole period in order to have comparable data. The Figueirão municipality was created in 2005 from the area previously belonging to other two municipalities. The Paraíso das Águas municipality was created in 2013 from the area of three other municipalities.

[30]Throughout this period, MS had 78 municipalities. We exclude the state capital, Campo Grande, because of its dissimilarities with the other municipalities: In 2005, Campo Grande had 32% of the state GDP, 33% of the population, 0.7% of the agricultural land use and 2.7% of the cattle. Moreover, Campo Grande has no sugarcane mills.

[31]The municipality of Rio Brilhante, received two new mills.

each $\widehat{\alpha_g^{PL}}$. For inference, we have:

$$p - value = Pr(|\overline{\alpha^{PL}}| \geq |\overline{\alpha}|) = \frac{\sum_{i=1}^{N_{\overline{PL}}} 1(|\overline{\alpha^{PL(i)}}| \geq |\overline{\alpha}|)}{N_{\overline{PL}}} \quad (3)$$

5 Results

5.1 Land Use and Deforestation Impacts

5.1.1 Sugarcane

Each new mill demands sugarcane, which requires land for its production. Sugarcane fields have to be sowed from 18 to 12 months prior to the start of the mill's operation, in order to be ready for the first harvest.[32] Therefore, we expect to observe impacts tracing back to $(\tau - 2)$.

We start by estimating, using equation 1, the size of the expansion of sugarcane harvested area and output in hosting municipalities, from four years before the mill begins operating $(\tau - 4)$ up to three years after $(\tau + 3)$.

We also use the synthetic control method to estimate sugarcane area and output expansion from $(\tau - 3)$ to $(\tau + 3)$.[33]

Table 2 shows that in all time frames considered and using both empirical strategies (columns 1-5 and 7-11), agricultural impacts are triggered at $(\tau - 2)$ as sugarcane harvested area and output start expanding, as expected.

Since no impacts are observed before $(\tau - 2)$, we focus on results from $(\tau - 2)$ to $(\tau + 3)$ in columns 3, 5, 9 and 11.

According to the fixed effects panel regressions (columns 3 and 9), sugarcane area and production ramps up at $(\tau - 2)$. Three years after the mill is operational $(\tau + 3)$, it has claimed 24.54 thousand hectares[34] to produce

[32]Sugarcane is a semi-perennial crop that has to be renewed in 5 to 7 years cycles as productivity declines.

[33]We employed as predictors for sugarcane area and output the pre-treatment average of the outcomes in 1999 and 2001 for three leads (table 2 - columns 4 and 10) and 1999, 2001 and 2003 for two leads and one lead (table 2 - columns 5-6 and 11-12), total municipal area, average temperature, average rainfall, total river length in Km by municipality and distance from Paraná river, a waterway in the border of MS and São Paulo state.

[34]1 hectare = 10,000 m^2 = 0.01 km^2.

1.73 million tons of sugarcane (both statistically significant at the 1% level), with a yield of 70.50 tons per hectare.

The synthetic control method produces similar estimates (columns 5 and 11). At $(\tau + 3)$ the mill demands 23.81 thousand hectares to produce 1.98 million tons of sugarcane (both statistically significant at the 1% level), which results in a productivity of 83.16 tons per hectare.

The set of results in table 2 is consistent with the magnitude of investments, considering as a baseline a standard mill with 2 million tons per year of sugarcane crushing capacity and with sugarcane crop productivity, measured in tons per hectare.

5.1.2 Agricultural Spillovers

We proceed by analyzing sugarcane production expansion spillovers on other agricultural sectors. Table 3 presents the resulting effects on other crops' harvested areas, output and cattle herd when a mill starts operating.

Sugarcane crop expansion triggered by the arriving mill sets in motion a profound restructuring of the local agricultural sector. Promptly, at $(\tau - 2)$, there is a reduction of 4.65 thousand hectares in soybean harvested area (statistically significant at the 1% level), an increase of 6.82 thousand hectares in corn harvested area, mainly led by an increase of 6.70 thousand hectares in the second corn crop (both statistically significant at the 5% level). As a result, annual crops harvested area goes up initially by 3.37 thousand hectares (not statistically significant). Concurrently, the number of cattle heads starts decreasing but the estimate is also not statistically significant.

In the long run, $(\tau + 3)$, soybean harvested area is reduced by 10.16 thousand hectares (statistically significant at the 1% level), from a baseline mean of 26.08 thousand hectares - a 39% reduction. Total corn harvested area increases by 20.88 thousand hectares (statistically significant at the 10% level), from a baseline mean of 6.15 thousand hectares, as a result of two counteracting effects. The first corn crop is almost terminated. It is reduced by 1.02 thousand hectares, statistically significant at the 5% level, from almost the same baseline mean (1.04 thousand hectares). The second corn crop harvested area shoots up fivefold, increasing by 21.90 thousand hectares (statistically significant at the 5% level), from a baseline mean of 5.11 thousand hectares.

Consequently, land use for annual crops increased by 80% or 30.9 thousand hectares (statistically significant at the 5% level). Annual crops harvested area increased 6.35 thousand hectares more than the area required to supply the sugarcane mill.

The number of cattle decreases by 27.2 thousand heads (statistically significant at the 5% level, from a baseline of 309.6 thousand heads). If we consider a productivity ratio of one cattle per hectare (1:1), this translates into 27.2 hectares of displaced pastureland.[35]

Results from table 3 indicate that sugarcane crops have predominantly displaced cattle herd, i.e. pastureland, followed by soybean area.

Despite the decrease in soybean harvested area, our estimations do not show a long run decrease in soybean output as presented in panel (ii) in table 3. On the contrary, in the short run $(\tau - 1)$, $(\tau + 1)$ and $(\tau + 2)$ soybean output increases, statistically significant at the 5% level.

If we measure productivity as yield per hectare, this indicates an enduring increase in soybean productivity in hosting municipalities. Soybean harvested area has decreased while output level was preserved. This productivity gain is confirmed if we compare soybean baseline yield per hectare (1.84 tons/hectare) with long run post treatment yield per hectare (2.87 tons/hectare).[36]

At $(\tau + 3)$, total corn production rises by 143.36 thousand tons, statistically significant at the 5% level, from a baseline mean of 16.67 thousand tons, as a result of two opposite effects of different magnitudes.

The first corn crop output is reduced almost completely by 5.57 thousand tons, from a baseline mean of 5.54 thousand tons. This estimate barely misses being statistically significant, with a p-value of 0.122. In the short run, $(\tau + 1)$ and $(\tau + 2)$ first corn crop output decreases, statistically significant at the 10% and 5% level respectively. Baseline yield per hectare of the first corn crop is 5.33 tons/hectare.[37]

The end of the first corn crop is more than compensated by a large increase in the second corn crop production. Second corn crop output expansion starts at $(\tau - 2)$ alongside with sugarcane fields, increasing by 33.07

[35] According to the 2006 Agricultural Census, Mato Grosso do Sul pastureland had 0.98 cattle heads per hectare. Under the same assumption, varying point estimate by one standard deviation, pastureland displacement ranges from 15.3 to 39.1 thousand hectares.

[36] Soybean baseline productivity $= 47.91/26.08 = 1.84$ and long-run post-treatment productivity $= (47.91 - 2.24)/(26.08 - 10.16) = 2.87$.

[37] First corn crop baseline productivity $= 5.54/1.04 = 5.33$.

thousand tons (statistically significant at the 5% level). At $(\tau + 3)$ it has increased by 148.94 thousand tons, statistically significant at the 5% level, from a baseline mean of 11.14 thousand tons. This represents an increase of 1,337% compared to the baseline mean or 6.37 standard deviations. Baseline yield per hectare of the second corn crop is 2.18 tons/hectare and jumps to 5.93 tons/hectare after treatment in the long run.[38]

Total corn harvested area and output increases. Overall, total corn yield per hectare increases from a baseline mean of 2.71 tons/hectare to 5.92 tons/hectare in hosting municipalities.[39]

These results indicate a lasting overall increase in agricultural productivity for soybean and corn crops in hosting municipalities.

We speculate that this increase in agricultural productivity stems from an increased income for farmers renting land or selling output to the mill, which is further reinvested in increasing productivity of other crops. It is possible as well that there are technological spillovers from sugarcane production to other agricultural sectors.

Moreover, these productivity gains in cereal production are land sparing, assuming that cattle ranching productivity does not plummet, because soybean and the second corn crops are produced on the same land plots.

Therefore, a new sugarcane mill results in an estimated land sparing of 13.83 thousand hectares as depicted in figure 2.

At $(\tau + 3)$ sugarcane area increases by 24.54 thousand hectares, soybean area is reduced in 10.16 thousand hectares and first corn crop area decreases by 1.02 hectares. Summing these changes, the new mill has increased land use by 13.36 thousand hectares, the net result 1 shown in figure 2.[40]

This increase is offset by a decrease in pastureland of 27.19 thousand hectares, assuming that the productivity ratio remains one cattle head per hectare (1:1), resulting in a calculated decrease in land use of 13.83 thousand hectares (Net Result 2).[41]

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[38]Second corn crop baseline productivity $= 11.14/5.11 = 2.18$ and long-run post-treatment productivity $= (11.14 + 148.94)/(5.11 + 21.90) = 5.93$.

[39]Total corn crop baseline productivity $16.67/6.15 = 2.71$ and long-run post-treatment productivity $= (16.67 + 143.36) = (6.15 + 20.88) = 5.92$

[40]Net result 1 = 24.45 - 10.16 - 1.02 = 13.36.

[41]Net result 2 = 13.36 - 27.19 = - 13.83.

The mill displaces less productive farmers and cattle ranchers and generates positive productivity spillovers to grain production.

5.1.3 Deforestation

We move forward by analyzing new mills' impact on tree cover area and deforestation using the Global Forest Change Dataset version 1.1 (Hansen et al. (2013)).

We employ two measures of remaining forest cover. The first measure considers the initial tree canopy cover area for the year 2000 and subtracts, for each following year, the area with gross forest cover loss. We obtain a municipality per year panel of the remaining tree cover area in pixels and convert it to hectares.[42] This measure captures deforested area disregarding the initial tree canopy cover percentage in each pixel.

The second measure takes into account the initial percentage of tree canopy cover in each pixel for the year 2000. For each subsequent year, we subtract pixels which had gross forest cover loss using information on their initial percentage vegetation cover. We obtain a municipality per year panel of the remaining forest cover area with their corresponding initial tree canopy cover percentage. We then compute a full tree canopy cover equivalent area, where each pixel has 100% vegetation cover.[43]

Figure 3 shows the initial forest cover in 2000 and cumulative deforestation from 2001 to 2012.

Regression results for both measures of remaining tree cover area and their percentage change in logarithm are presented in tables 4 and 5.[44]

In the long run $(\tau + 3)$, treated municipalities have 4.34 to 7.42 thousand hectares more of tree cover, statistically significant at the 1% level (tables 4 and 5 - columns 1-4). Hence, new mills implied a decrease in deforestation.

[42] We consider each pixel a 29m x 29m square = 841 m^2 = 0.0841 hectares. In the Global Forest Cover Change Dataset each pixel has "a spatial resolution of 1 arc-second per pixel, or approximately 30 meters per pixel at the equator."

[43] We sum the value of all remaining tree canopy cover in each pixel (from 0 to 100), divide it by 100 and convert it to hectares. For example, if two pixels have 50% tree canopy cover each, they are converted into one pixel of full tree cover equivalent area, which is then converted to 0.0841 hectares.

[44] It is possible to employ the logarithm because all tree cover values in all municipalities for every year are greater than zero, in contrast to other types of land use.

We find a mild decrease in deforestation before $(\tau - 2)$ when we use the variables in levels, but it is not robust. In fact, using the logarithm of the two tree cover measures we find that municipalities with new mills reduce deforestation one or two years before the mill starts operation, depending on the measure used.

Considering tree cover area only, it begins to fall less rapidly (deforestation decreases) at $(\tau - 1)$, statistically significant at the 10% level (table 4 - columns 6 and 8). Taking into account the initial vegetation cover of deforested pixels, deforestation decreases at $(\tau - 2)$, in parallel to changes in land use caused by the mills' entry, statistically significant at the 10% level (table 5 - columns 6-8).

In the long run $(\tau + 3)$, municipalities with new mills have 1.48% more tree cover area or 1.93% more in full tree cover area equivalent, (tables 4 and 5 - column 8).

This change in deforestation pattern caused by the mills may be due to stronger environmental scrutiny of large enterprises by investors and the media. Also, as municipalities gain more economic visibility with the mills' entry, this may lead to more stringent law enforcement. Both factors should result in higher compliance with environmental laws by local agricultural producers.

5.2 Economic and Demographic Impacts

In this section we describe the mills' impacts on total GDP, the composition of GDP by economic sector and population.

The effects on GDP and population growth rates using specification 1 and the synthetic control method are presented in table 6.

There is no evidence of different trends in GDP and population growth before the mills start operating (up to τ-1).

Our full sample regression in column 3 indicates that GDP starts increasing by 9% the year the mill starts operating (τ), statistically significant at the 5% level. Considering different leads and lags (columns 1-3) point estimates at (τ) are very similar, between 7 and 9%. The synthetic control method produces similar estimates at (τ) with impacts ranging from 8 to 10% (columns 4-6).[45]

[45] We used as predictors for the logarithm of GDP, the pre-treatment period average of the logarithm of GDP, population, cattle herd, total area, annual crops harvested area,

Our long run estimate, at $(\tau + 3)$, indicates that each mill generates a 30% growth in GDP, statistically significant at the 1% level (column 3). Taking the baseline GDP of 190.98 million reais, this amounts to an additional 57.29 million reais to the hosting municipalities.

The synthetic control method estimates a 28% increase in GDP in the long run $(\tau + 3)$, statistically significant at the 1% level (columns 4-5). Our full sample synthetic control estimates (column 6) are within the range of parameters estimated previously (columns 1-5).

Population has grown by 10% at $(\tau + 3)$, statistically significant at the 5% level (column 9). Taking as baseline an average population of 19.67 thousand dwellers, this represents an inbound migration of 1.97 thousand inhabitants to hosting municipalities.

Using the synthetic control method, population increases by 12% in the long run $(\tau + 3)$ with a p-value of 0.17 (columns 10-11).[46] The full sample synthetic control estimates (column 12) are inside the range of other estimated parameters for population growth (columns 7-11).

Yet, private investments in a greenfield mill affect each economic sector differently. In table 7 we analyze impacts on GDP growth broken down by economic sector according to the production approach, that is, agriculture, industry, services, public administration and taxes less subsidies on products. We also present impacts on GDP per capita growth.

As expected, along with changes in land use, agricultural GDP starts growing by 15% at $(\tau - 2)$, statistically significant at the 10% level, and continues growing steadily as far as our analysis goes, three years after the mill is built. By $(\tau + 3)$ agricultural GDP has increased 65%, statistically significant at the 1% level (column 1). Taking the baseline agricultural GDP of 36.02 million reais, this represents an increase of 23.41 million reais.

Industry GDP begins to rise one year after the mills' entry $(\tau + 1)$ by 23%, statistically significant at the 10% level (column 2).[47] This result can

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permanent crops harvested area and agricultural suitability.

[46]We employed as predictors for the logarithm of population, the pre-treatment average of the logarithm of population in 1999 and 2002 for three leads (column 10) and 1999, 2001 and 2003 for two leads and one lead (column 11-12), the logarithm of industry GDP, total area, cattle herd and distance from Paraná river, a waterway in the border of MS and São Paulo state.

[47]Sugarcane mills are classified as manufacturing industries and therefore their added value is computed as industry GDP.

probably be attributed to the fact that only in the second year the mill is able to operate throughout the entire harvesting season. In the long run $(\tau+3)$, industry GDP has grown by 45%, statistically significant at the 1% level. This implies a growth of 12.49 million reais from a baseline of 27.75 million reais.

Services GDP starts increasing by 6% at (τ), statistically significant at the 5% level (column 3). By $(\tau+3)$ services GDP has gone up 13%, statistically significant at the 1% level. From the 101.27 million reais GDP baseline, services GDP increases by 13.17 million reais.

These different growth rates lead to a structural change in hosting municipalities, with an increase in agriculture and industry GDP shares.

Tax revenues increase at $(\tau-1)$ by 13%, statistically significant at the 10% level (column 5). At $(\tau+3)$ fiscal revenues have increased by 31%, statistically significant at the 1% level. Compared to the 25.94 million reais baseline, this represents an increase of 8.04 millions reais in fiscal revenues.

This allows public administration GDP, proxied by its payroll expenditure, to increase in the long run by 10%, statistically significant at the 5% level (column 4). Public expenditure goes up by 3.03 million reais compared to the 30.27 million reais baseline.

Finally, as a result of the combined effects of GDP and population growth, GDP per capita starts increasing one year after the mill is installed $(\tau+1)$ and grows by 20% in the long run $(\tau+3)$, statistically significant at the 1% level (column 6). This represents an increase of 1.87 thousand reais compared to a baseline GDP per capita of 9.35 thousand reais.

These results highlight that positive spillovers extend beyond the agricultural and industrial sectors, where initial investments are allocated.

5.3 Labor Market Impacts

In this section we report the mills' impact on labor market outcomes with increasing detail on economic sectors, industries and economic activities. We analyze changes on the number of firms, employment, aggregate wages, and labor force education.

First we present the overall impacts of the mills' operation on municipal labor market in table 8. On aggregate, the impact on the number of firms is significant starting from one year before a mill's arrival. At $(\tau+3)$, we observe an accumulated increase of 82% in the number of firms due to

186 new businesses opened. Employment, measured by the number of labor contracts at the end of each year, starts to increase significantly in the same year the mills begin operating, and it more than doubles by three years after with 3,542 new job contracts. A similar pattern is observed in the number of labor contracts of skilled workers, which increases by 4,717 in the same time span, from a baseline mean of 3,368. Impacts on aggregate year end wages are observed concurrent to the mill's entry and add up to a 3.7 million reais increase at $(\tau + 2)$. At $(\tau + 3)$ point estimate amounts to a 4,4 million reais increase in wages, with a 0.113 p-value.

Table 9 depicts the effects on municipal labor market split by economic sector. There are an additional 4.37 firms in agriculture three years after the arrival of a new mill $(\tau + 3)$. Overall effects in agriculture are small for three reasons. First, the mill is classified into the industry sector, including its employees working on sugarcane crops. Second, inside the agriculture sector there are positive and negative changes that cancel each other. Third, the RAIS dataset includes only changes within formal firms, and, consequently, there may be some informal labor on agricultural production that is not being captured in our dataset.

The number of workers employed in the industry sector increases by almost fourfold in the long run $(\tau + 3)$ compared to the baseline mean, with the creation of 1,563 vacancies, while aggregate year end wages increase by 1.9 million reais. Impact on labor contracts of skilled workers are significant starting at (τ) and lasting through $(\tau + 3)$, with an increase of 1,778 labor contracts from a baseline mean of 880.

In the services sector there is a significant impact on the number of firms, which increases by 80% or 152 businesses in the long run. Employment goes up by 2,060 places although not statistically significant at the 10% level (p-value of 0.174). Aggregate year end wages rise by 2.6 million reais at $(\tau + 3)$ also not statistically significant at the 10% level (p-value of 0.204).

A further disaggregation of the long run effects of the mill on labor market outcomes is provided in table 10, which presents results split by industry.

For agriculture, livestock and forestry, a 42% rise in the number of firms is observed at $(\tau + 3)$. The manufacturing industry, in which the mills are included, experiences significant rises in aggregate wages, in the size of the labor force, and in the number of skilled worker labor contracts. Wages go up by 1.9 million reais, while the number of total workers rises by 1.5 thousand, and labor contracts for skilled workers increase by 1.7 thousand. These three results are statistically significant at the 1% level.

For the wholesale and retail trade and maintenance industry, we observe a 60% rise in the number of firms as well as an over 100% increase in the number of workers and labor contracts for skilled workers.

Hotels and restaurants' labor force triples in the long run and aggregate wages rise by 97 thousand reais.

The transport, storage and communications industry experiences strong labor market effects. The number of firms more than doubles and the number of workers almost triples, while aggregate wages go up by 221 thousand reais (from a 63 thousand reais baseline mean) and labor contracts for skilled workers rise by 354 (from a 121.55 baseline mean).

For the financial intermediation sector there is a 43% increase in the number of firms. These results are consistent with the overall increase in income.

The number of firms in the education sector increases by 4.10 in the long run $(\tau + 3)$, statistically significant at the 10% level. It more than doubles from the 3.97 baseline mean.

Finally, no major long-run effects are observed for five industries analyzed: i) mining and quarrying, ii) electricity, gas and water supply, iii) construction, iv) real estate, renting and business activities, and v) health and social work.

In table 11 we analyze detailed labor market outcomes for specific sectors that confirm our previous results and add information on the spillovers transmission mechanisms.

The number of firms growing sugarcane increases by 0.84, statistically significant at the 1% level. Although it is less than a firm, this represents a fivefold increase from the baseline mean.[48] Moreover, there may be some informal labor on agricultural production.

In the long run, 119 additional workers are hired for growing of soybean and their aggregate wages also go up (both statistically significant at the 5% level).

Growing of corn also expands employment, wages and labor force skill (all statistically significant at the 5% level).

These three agricultural related outcomes confirm that there are spillovers

[48]Sugarcane mills' employees who work with sugarcane are not classified as agricultural workers.

to corn and soybean production.

The number of firms in agricultural service activities goes up by 3.96, statistically significant at the 1% level. These firms supply support activities for farm operations that may benefit any agricultural producer located on that municipality.[49]

As expected, employment, wages and labor force education in raising of cattle decreases although no statistically significant changes in animal husbandry service activities are observed.

Two manufacturing activities related to cattle ranching are impacted differently. Employment, wages and labor force education in tanning and dressing of leather decreases. Cattle slaughtering employment increases by 148 workers, mainly with skilled workers. We speculate that cattle slaughtering activity may be accelerated as pasturelands are displaced by sugarcane fields.

There is evidence of increased supply of fertilizers. The number of firms in mining of chemical and fertilizer minerals; and in manufacture of fertilizers and nitrogen compounds goes up by 0.02 and 0.25, respectively. Also, wholesale of fertilizers and agrochemical compounds is positively affected.

Agricultural machinery and equipment become more available to local producers. There are positive labor market outcomes for wholesale of agricultural machinery and equipment; repair and maintenance of tractors and agricultural machinery; repair and maintenance of electrical equipment; and repair and maintenance of motor vehicles. Also, the number of firms, employment, wages and labor force education increase in renting of agricultural machinery and equipment.

Freight transportation by road and warehousing and storage are also improved.

The mill and its sugarcane fields demand a broad range of agricultural inputs and ancillary services such as fertilizers, machinery and equipment, repair and maintenance, transportation and warehousing, attracting multiple suppliers that can potentially benefit all agricultural producers in the hosting municipalities.

[49] Activities include preparation of fields, establishing and treating a crop, harvesting and provision of agricultural machinery with operators and crew.

5.4 Financial Services Impacts

In this section we describe the mills' impacts on the provision of financial services - the banking business, measured by the number of bank branches, aggregate bank assets, total private deposits (narrowing down to households and firms deposits), and banks' total rural credit portfolios, separated into credit for agriculture and cattle ranching and further split into credit for investment and operational expenses and for output commercialization.

Using specification number 1, each mill increases the provision of financial services in hosting municipalities as described in tables 12 and 13.

Paired with an increase in annual crops production value at $(\tau - 2)$ and a contemporaneous rise in wages (although not yet statistically significant), total private deposits also start mounting at $(\tau - 2)$ at the 5% significance level (table 12 - columns 1-4).

Rural credit starts expanding at $(\tau - 2)$ at the 5% significance level (table 12 - column 8) simultaneously with all changes triggered by sugarcane expansion in treated municipalities at $(\tau - 2)$, mainly with those in agriculture, and coupled with increases in private deposits.

In the long run $(\tau + 3)$, private deposits double from baseline mean, rising by 4.76 million reais (0.57 standard deviations) at the 10% significance level. Rural credit goes up by 18.53 million reais (0.47 standard deviations) at the 5% significance level. Both long run results are robust - statistically significant - in regressions with different starting lead variables (table 12 - columns 1-8).

In table 13 we show the impacts on the number of bank branches, on total bank assets, and on disaggregated outcomes for private deposits and rural credit.

The number of bank branches in hosting municipalities does not increase, although at $(\tau + 3)$ the point estimate is 0.36 (with a p-value of 0.157).[50] Total bank assets do not change significantly.

The bulk of private deposits belongs to households or firms.[51]

Household deposits start increasing at $(\tau - 2)$ by 1.33 million reais, statistically significant at the 5% level. At $(\tau + 3)$, household deposits have

[50]In the labor market impacts section, the number of firms in financial intermediation increase by 1.28 in the long run at the 5% significance level.

[51]There are residual classes of private deposits such as judicial deposits and other deposits.

increased by 3.31 million reais at the 10% significance level, an increase of 121% from baseline mean or 0.82 standard deviations.

Firm deposits start increasing at $(\tau - 1)$ synchronous to the surge in the number of firms.[52] At (τ) firm deposits have already almost doubled compared to the baseline mean. In the long run, $(\tau + 3)$, firm deposits go up by 1.43 million reais, although this coefficient is not statistically significant (with a p-value of 0.108). This amounts to an 87% increase from baseline mean or 0.38 standard deviations.

The initial growth in total rural credit at $(\tau - 2)$ is driven by a surge in agricultural credit for investments and operational expenses, which goes up by 6.72 million reais at the 10% significance level, more than one third of baseline mean. This credit line is targeted to procurement of durable goods, services and expenses related to the crop productive cycle, from input acquisition to harvesting. It includes credit for sugarcane fields preparation, harvesting and renewal.[53] At $(\tau + 3)$ agricultural credit for investments and operational expenses almost doubles from baseline mean, increasing by 15.40 million reais at the 10% significance level.

Agricultural credit for output commercialization steps up at $(\tau + 2)$. At $(\tau + 3)$ it has multiplied more than 16-fold from baseline mean, a 2.82 million reais increase, statistically significant at the 5% level.[54]

There is a short-run increase in credit for cattle ranching output commercialization at $(\tau - 1)$, doubling from baseline mean, that can be due to the displacement effect of sugarcane crops on pastureland resulting in momentarily faster slaughter rates. In the long run, both categories of credit for cattle ranching do not increase nor decrease. As the number of cattle heads decreases, this implies that remaining producers are more leveraged on a cattle head basis.

Therefore, each mill results in an increased demand for and supply of financial services that can benefit all agricultural producers and non-agricultural businesses in hosting municipalities.

[52] At $(\tau - 1)$ the number of firms increases by 46.

[53] Investments also include improvements in buildings and facilities, purchase and maintenance of machinery and equipment, irrigation and drainage systems, rural electrification and telecommunications, soil protection and correction, vehicles, preparation of permanent crops, among others.

[54] It includes credit for post-harvest activities such as output storage and transportation to markets.

5.5 Robustness to Spillovers in Neighboring Municipalities

In this section, we perform a robustness check to assess if our results may have been biased by municipalities neighboring new mills that could also have been impacted by them.[55]

To test this, we use the synthetic control method setting a sample restriction on the donor pool. We excluded untreated municipalities within 50 km from new mills that had sugarcane fields in 2012, reducing the donor pool from 61 to 49 municipalities. If spillovers to neighboring municipalities are nonexistent or small our synthetic counterfactual, constructed from the restricted donor pool, should produce similar results to those found previously. Hence, by excluding from the donor pool municipalities that could potentially have been affected by new mills, we ascertain our estimates are unbiased.

We focus the robustness check on four main outcomes: sugarcane harvested area and output, GDP and population growth. Results are presented in table 14.[56]

As before, sugarcane area and output ramp up at $(\tau - 2)$. In the long run $(\tau + 3)$, sugarcane area increases between 24.78 to 26.12 hectares, statistically significant at the 1% level (columns 1-2). Sugarcane output rises to between 1.90 and 2.03 million tons per year, statistically significant at the 1% level (columns 3-4). These results are within the range of point estimates in table 2 and are also consistent with an investment in a standard mill with 2 thousand tons of sugarcane crushing capacity. Estimates result in a sugarcane productivity at $(\tau + 3)$ of 76.67 and 77.72 tons per hectare, respectively.

GDP exhibits a similar pattern when using the restricted donor pool. It starts increasing at $(\tau + 1)$ as in table 6 (columns 1-2 and 4-6), statistically significant at the 1% level. By $(\tau + 3)$ GDP has increased between 28 and 29%, statistically significant at the 1% level, which coincides with previous GDP growth point estimates for this period in table 6 (columns 2, 4-5).

Population growth estimates (columns 7-8) indicate a long run increase reaching 13% at $(\tau + 3)$, statistically significant at the 5% level. Point estimates at the same period in table 6 (columns 7-11) range from 4 to 12%.

[55]Spillover effects to neighboring municipalities can include, for example, higher GDP growth and population gain or drain.

[56]For each outcome, the same set of predictors used previously was employed.

The 13% point estimate is inside the 90% confidence interval of statistically significant panel regression coefficients at $(\tau + 3)$ in table 6 (columns 8-9).

Our robustness check indicates that spillovers in neighboring municipalities, if any, do not change our main results.

6 Final Comments

We analyzed the impacts of private investments in 14 greenfield sugar and ethanol mills on the municipalities of Mato Grosso do Sul. The mills' arrival has direct impact on land use, mainly displacing livestock. These investments generate productivity gains to other agricultural sectors, particularly in grain production (soybean and corn), that can be potentially explained by technological or financial spillovers. The mills also reduce deforestation in municipalities where they are located.

Because these investments are sizable when compared to figures from a typical municipality, they trigger economic and population growth in hosting municipalities. Hosting municipalities also undergo a structural change with agriculture and industry sectors growing faster than the services sector.

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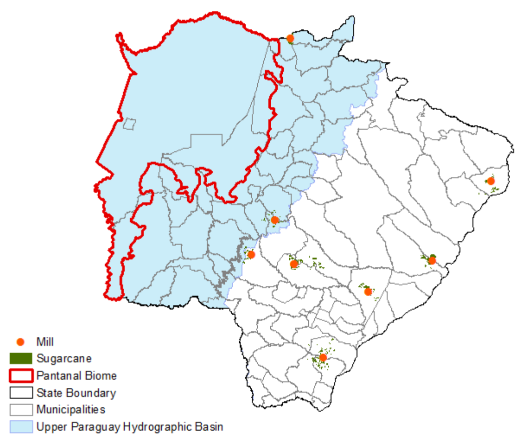
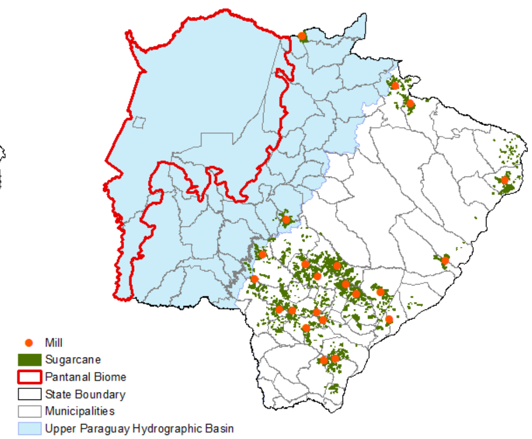
Figure 1: Mills and Sugarcane Crops

(a) Year 2005 - 8 Mills



(b) Year 2012 - 22 Mills



Source: Mills' locations and entry timeline from BioSul - Associação dos Produtores de Bioenergia de Mato Grosso do Sul. Sugarcane satellite images from CANASat project, from the National Institute for Space Research (INPE - Instituto Nacional de Pesquisa Espacial).

Figure 2: Estimated Net Land Use Change (Hectares)

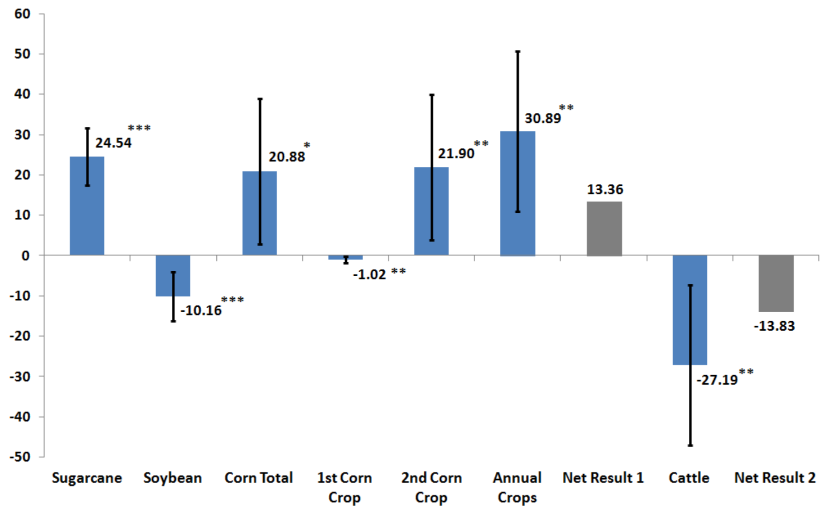
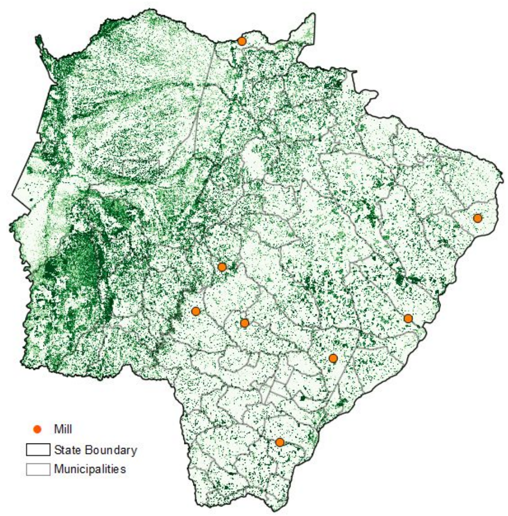
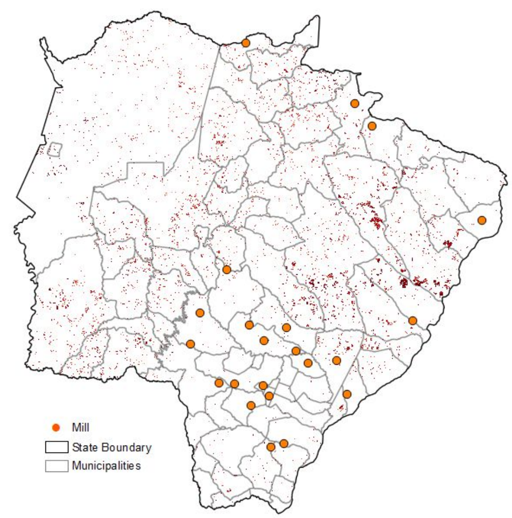


Figure 3: Initial Forest Cover in 2000 and Cumulative Deforestation

(a) Initial Forest Cover in 2000



(b) Cumulative Deforestation*



Note: Maps constructed using data from the Global Forest Change Dataset version 1.1 (Hansen et al. (2013)). * The map on cumulative deforestation shows areas deforested between 2001 and 2012 that had forest cover greater than 50% in 2000.

Table 1: Treated and Untreated Municipalities Descriptive Statistics

	2005			2012		
Variable	All	Treated	Untreated	All	Treated	Untreated
Panel (i): Agriculture						
Sugarcane Harvested Area	1.78	3.06	1.47	7.25	25.12	2.93
	(4.25)	(6.09)	(3.68)	(14.25)	(22.69)	(6.11)
Sugarcane Output	0.12	0.29	0.08	0.49	1.76	0.18
	(0.33)	(0.59)	(0.22)	(0.98)	(1.55)	(0.39)
Soybean Harvested Area	26.08	69.42	15.60	23.36	57.76	15.04
	(42.93)	(68.46)	(25.44)	(41.33)	(65.46)	(27.99)
Soybean Output	47.91	124.12	29.47	59.18	146.58	38.03
	(80.29)	(122.61)	(52.98)	(110.58)	(177.04)	(75.56)
Corn Harvested Area	6.15	17.28	3.45	16.03	41.90	9.77
	(11.22)	(18.28)	(6.51)	(32.16)	(53.98)	(20.39)
Corn Output	16.67	44.33	9.98	83.62	220.29	50.55
	(29.89)	(45.81)	(19.95)	(168.46)	(275.42)	(110.65)
Corn 1st Harvested Area	1.04	2.68	0.65	0.90	2.05	0.62
	(2.31)	(4.78)	(0.75)	(2.04)	(3.76)	(1.25)
Corn 1st Harvested Output	5.54	16.96	2.77	6.01	16.00	3.60
	(16.13)	(34.09)	(4.18)	(18.49)	(35.24)	(10.50)
Corn 2nd Harvested Area	5.11	14.60	2.81	15.14	39.85	9.16
	(10.75)	(18.56)	(6.11)	(31.40)	(53.66)	(19.52)
Corn 2nd Harvested Output	11.14	27.37	7.21	77.60	204.29	46.95
	(23.37)	(36.71)	(17.06)	(162.79)	(274.53)	(104.01)
Annual Crops Harvested Area	38.71	102.31	23.33	49.15	132.07	29.09
	(61.30)	(95.43)	(36.83)	(84.57)	(133.14)	(52.37)
Cattle	309.55	224.36	330.15	271.49	174.07	295.06
	(299.14)	(103.12)	(326.86)	(263.50)	(84.15)	(286.33)
Sugarcane Production Value	5.24	13.59	3.22	20.38	73.82	7.45
	(14.79)	(28.10)	(8.36)	(41.72)	(66.50)	(16.79)
Soybean Production Value	27.76	70.30	17.46	31.29	77.39	20.14
	(45.92)	(68.85)	(31.41)	(57.86)	(92.52)	(39.47)
Corn Production Value	4.73	12.60	2.83	21.95	58.38	13.13
	(8.45)	(13.07)	(5.55)	(43.87)	(72.28)	(28.17)
Annual Crop Production Value	45.19	118.39	27.48	79.49	227.72	43.63
	(71.91)	(113.12)	(43.24)	(134.65)	(208.37)	(76.89)
Observations	77	15	62	77	15	62

Table 1: Treated and Untreated Municipalities Descriptive Statistics, Continued

	2005			2012		
Variable	All	Treated	Untreated	All	Treated	Untreated
Panel (ii): Forest Cover						
Tree Cover Area	185.55	74.38	212.45	177.63	72.37	203.10
	(433.11)	(51.77)	(478.87)	(420.86)	(50.58)	(465.52)
Weighted Tree Cover Area	108.05	41.77	124.09	102.91	40.64	117.98
	(246.30)	(29.55)	(272.10)	(238.78)	(28.85)	(263.94)
Panel (iii): GDP and Population						
Real GDP	190.98	310.24	162.12	342.77	618.86	275.97
	(284.61)	(439.72)	(228.47)	(556.12)	(844.65)	(445.30)
Agriculture GDP	36.02	42.48	34.45	65.20	125.06	50.72
	(27.19)	(26.83)	(27.26)	(62.16)	(93.94)	(41.17)
Industry GDP	27.75	41.30	24.47	66.23	106.90	56.38
	(52.52)	(69.61)	(47.63)	(145.32)	(163.03)	(140.38)
Services GDP	101.27	179.30	82.40	169.80	307.44	136.49
	(174.00)	(291.74)	(127.77)	(306.11)	(502.91)	(230.02)
Public Administration GDP	30.27	46.37	26.37	54.93	86.89	47.20
	(38.36)	(69.13)	(25.63)	(68.48)	(118.42)	(48.09)
Taxes GDP	25.94	47.16	20.81	41.55	79.46	32.37
	(50.60)	(70.78)	(43.63)	(87.54)	(127.78)	(73.22)
Population	19.67	30.19	17.13	22.07	35.25	18.89
	(25.26)	(44.82)	(17.32)	(28.21)	(49.23)	(19.54)
GDP per Capita	9.35	10.43	9.09	13.83	17.48	12.95
	(3.98)	(4.56)	(3.83)	(5.33)	(6.48)	(4.65)
Observations	77	15	62	77	15	62

Table 1: Treated and Untreated Municipalities Descriptive Statistics, Continued

	2005			2012		
Variable	All	Treated	Untreated	All	Treated	Untreated
Panel (iv):Labor Market						
Employment	2,277.21	3,895.80	1,885.61	3,784.86	7,727.33	2,831.03
	(3,855.08)	(6,921.66)	(2,592.39)	(7,378.77)	(12,855.22)	(5,015.98)
Number of Firms	227.27	399.40	185.63	339.86	628.07	270.13
	(364.28)	(668.78)	(231.60)	(545.14)	(993.60)	(343.96)
Aggregate Year End Real Wages	1,527.57	2,748.20	1,232.25	3,840.68	7,948.11	2,846.94
	(2,725.49)	(4,984.04)	(1,760.33)	(8,466.67)	(13,289.06)	(6,605.19)
Skilled Labor Contracts	3,367.74	5,784.87	2,782.95	5,880.00	11,369.53	4,551.89
	(5,934.51)	(10,484.87)	(4,106.57)	(12,047.33)	(18,924.93)	(5,880.00)
Panel (v): Financial Services						
Total Private Deposits	4.62	9.68	3.39	7.36	15.50	5.39
	(8.32)	(15.74)	(4.65)	(12.74)	(23.45)	(7.47)
Total Rural Credit	24.21	54.56	16.87	30.51	73.83	20.03
	(39.23)	(67.98)	(24.00)	(50.08)	(93.61)	(23.26)
Number of Bank Branches	1.94	3.13	1.65	2.30	3.74	1.95
	(2.15)	(3.27)	(1.70)	(2.37)	(3.89)	(1.70)
Total Bank Asset	401.04	754.96	315.41	162.21	384.69	108.39
	(1,045.80)	(1,307.73)	(965.35)	(347.65)	(678.04)	(173.06)
Household Deposits	2.74	5.29	2.12	4.85	9.51	3.72
	(4.03)	(6.95)	(2.69)	(7.33)	(12.65)	(4.85)
Firm Deposits	1.64	3.81	1.12	2.26	5.38	1.50
	(3.75)	(7.54)	(1.74)	(4.91)	(9.69)	(2.34)
Agriculture Credit - Investments	15.64	43.46	8.91	15.67	54.15	6.37
and Operational Expenses	(31.69)	(55.94)	(17.23)	(39.30)	(75.21)	(13.19)
Agriculture Credit - Output	0.17	0.45	0.10	0.83	2.94	0.32
Commercialization	(0.64)	(0.86)	(0.56)	(2.10)	(3.95)	(0.76)
Cattle Ranching Credit - Investments	8.32	10.42	7.81	13.99	16.70	13.34
and Operational Expenses	(11.07)	(13.06)	(10.59)	(17.28)	(20.43)	(16.55)
Cattle ranching - Output	0.08	0.22	0.05	0.01	0.05	0.00
Commercialization	(0.29)	(0.63)	(0.09)	(0.06)	(0.13)	(0.01)
Observations	77	15	62	77	15	62

Table 2: Mills' Impact on Sugarcane Harvested Area and Output

	Sugarcane Harvested Area (Thousand Hectares)						Sugarcane Output (Million Tons)					
	Panel Regression			Synthetic Control			Panel Regression			Synthetic Control		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\tau - 4$	2.18						0.19					
	(1.85)						(0.17)					
$\tau - 3$	2.81	1.67		0.39			0.24	0.11		0.08		
	(2.37)	(1.56)		0.28			(0.22)	(0.13)		0.10		
$\tau - 2$	3.70*	3.06*	2.49*	1.61*	1.59**		0.35*	0.24*	0.19*	0.18***	0.19***	
	(2.14)	(1.71)	(1.32)	0.06	0.03		(0.20)	(0.13)	(0.10)	0.01	0.01	
$\tau - 1$	4.22*	2.93*	3.06*	1.91*	1.75*	1.58*	0.38*	0.21	0.20	0.24***	0.26***	0.23***
	(2.22)	(1.73)	(1.78)	0.06	0.06	0.09	(0.21)	(0.15)	(0.14)	0.00	0.00	0.00
τ	9.62***	8.13***	7.70***	6.30***	5.80***	5.30***	0.93***	0.75***	0.70***	0.62***	0.67***	0.58***
	(2.59)	(2.00)	(1.81)	0.00	0.00	0.00	(0.25)	(0.18)	(0.16)	0.00	0.00	0.00
$\tau + 1$	14.32***	13.09***	12.24***	11.43***	10.28***	9.44***	1.34***	1.19***	1.07***	1.07***	1.16***	1.00***
	(2.69)	(1.96)	(2.15)	0.00	0.00	0.00	(0.25)	(0.16)	(0.17)	0.00	0.00	0.00
$\tau + 2$	22.63***	20.77***	20.20***	20.76***	18.97***		2.11***	1.61***	1.57***	1.57***	1.69***	
	(7.09)	(3.64)	(3.48)	0.00	0.00		(0.70)	(0.32)	(0.33)	0.00	0.00	
$\tau + 3$	26.20***	23.01***	24.54***	26.06***	23.81***		2.31***	1.71***	1.73***	1.83***	1.98***	
	(8.97)	(5.55)	(4.30)	0.00	0.00		(0.85)	(0.44)	(0.29)	0.00	0.00	
Adjusted R^2	0.62	0.65	0.65				0.61	0.60	0.60			
Observations	462	539	616	1,008	1,008	1,022	462	539	616	1,008	1,008	1,022
Number of Municipalities	77	77	77	72	72	73	77	77	77	72	72	73
Number of Years	6	7	8	14	14	14	6	7	8	14	14	14
Municipality FE	Yes	Yes	Yes				Yes	Yes	Yes			
Time FE	Yes	Yes	Yes				Yes	Yes	Yes			
Treated Units				11	11	12				11	11	12
Donor Pool				61	61	61				61	61	61
Baseline Mean	1.78						0.12					
Baseline Std. Dev.	(4.25)						(0.33)					

Notes: Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10. Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls. For synthetic control method, p-values are underneath parameters.

Table 3: Agricultural Spillovers

Panel (i): Mills' Impact on Other Crops Harvested Area (Thousand Hectares)	Soybean (1)	Corn Total (2)	1st Corn Crop (3)	2nd Corn Crop (4)	Annual Crops[a] (5)	Cattle[a] (6)
$\tau - 2$	-4.65***	6.82**	0.12	6.70**	3.37	n/a
	(1.56)	(3.22)	(0.23)	(3.23)	(3.33)	
$\tau - 1$	-3.23*	10.75**	-0.90	11.64**	8.67*	
	(1.87)	(5.05)	(0.75)	(5.13)	(4.82)	
τ	-5.82**	11.07**	-1.17	12.24**	11.39**	
	(2.23)	(5.35)	(0.88)	(5.20)	(5.21)	
$\tau + 1$	-7.81***	8.17	-1.40*	9.57*	10.03	
	(2.23)	(5.63)	(0.72)	(5.57)	(6.05)	
$\tau + 2$	-9.46***	14.58*	-1.62*	16.21**	20.68**	
	(3.05)	(7.82)	(0.85)	(7.78)	(8.82)	
$\tau + 3$	-10.16***	20.88*	-1.02**	21.90**	30.89**	
	(3.65)	(10.83)	(0.50)	(10.80)	(11.94)	
Adjusted R^2	0.25	0.21	0.16	0.24	0.23	
Baseline Mean	26.08	6.15	1.04	5.11	38.71	
Baseline Std. Dev.	(42.93)	(11.22)	(2.31)	(10.75)	(61.30)	

Panel (ii): Mills' Impact on Other Crops Output (Thousand Tons) and Livestock (Thousand Heads)	Soybean (7)	Corn Total (8)	1st Corn Crop (9)	2nd Corn Crop (10)	Annual Crops[b] (11)	Cattle (12)
$\tau - 2$	20.45	32.80**	-0.26	33.07**	n/a	-0.27
	(12.88)	(15.21)	(1.61)	(15.46)		(6.37)
$\tau - 1$	27.14**	44.98*	-5.19	50.16**		-5.29
	(11.02)	(22.69)	(5.75)	(23.26)		(8.27)
τ	6.12	16.25	-8.34	24.60		-13.52
	(10.19)	(18.09)	(6.33)	(17.12)		(9.44)
$\tau + 1$	41.15**	44.55	-8.54*	53.09*		-17.64*
	(15.94)	(27.93)	(4.45)	(27.94)		(9.17)
$\tau + 2$	44.88**	68.90*	-10.01**	78.91**		-20.03*
	(21.76)	(34.92)	(4.83)	(34.66)		(10.08)
$\tau + 3$	-2.24	143.36**	-5.57	148.94**		-27.19**
	(19.71)	(65.76)	(3.56)	(66.16)		(11.90)
Adjusted R^2	0.17	0.27	0.09	0.28		0.21
Baseline Mean	47.91	16.67	5.54	11.14		309.55
Baseline Std. Dev.	(80.29)	(29.89)	(16.13)	(23.37)		(299.14)

Panel (iii): Observations and Fixed Effects Settings for All Regressions						
Observations	616	616	616	616	616	616
Number of Municipalities	77	77	77	77	77	77
Number of Years	8	8	8	8	8	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10. (a) Data on hectares of pastureland is not available. (b) Annual crops total output is incalculable. Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls.

Table 4: Mills' Impact on Tree Cover Area

	Tree Cover Area (Thousand Hectares)				Log Tree Cover Area (Log Thousand Hectares)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau - 5$	1.61***				0.0026			
	(0.57)				(0.0034)			
$\tau - 4$	2.25**	1.73**			0.0048	0.0041		
	(0.96)	(0.81)			(0.0049)	(0.0040)		
$\tau - 3$	3.03**	2.58**	1.61**		0.0061	0.0052	0.0029	
	(1.24)	(1.03)	(0.64)		(0.0055)	(0.0040)	(0.0023)	
$\tau - 2$	3.97***	3.43***	2.59***	1.94***	0.0082	0.0073	0.0049	0.0037
	(1.48)	(1.29)	(0.88)	(0.66)	(0.0062)	(0.0049)	(0.0032)	(0.0023)
$\tau - 1$	4.90***	4.32***	3.31***	2.96***	0.0097	0.0093*	0.0068	0.0060*
	(1.69)	(1.51)	(1.09)	(0.95)	(0.0069)	(0.0056)	(0.0045)	(0.0035)
τ	5.74***	5.17***	4.10***	3.47***	0.0116	0.0107*	0.0087*	0.0076*
	(1.90)	(1.70)	(1.31)	(1.08)	(0.0072)	(0.0059)	(0.0050)	(0.0041)
$\tau + 1$	6.56***	6.01***	4.89***	4.28***	0.0154**	0.0128**	0.0099*	0.0097**
	(2.07)	(1.92)	(1.50)	(1.33)	(0.0070)	(0.0062)	(0.0053)	(0.0045)
$\tau + 2$	6.87***	6.70***	5.91***	5.17***	0.0160**	0.0169***	0.0131**	0.0116**
	(2.26)	(2.10)	(1.76)	(1.54)	(0.0070)	(0.0061)	(0.0062)	(0.0053)
$\tau + 3$	7.42***	6.95***	6.67***	6.28***	0.0173**	0.0174***	0.0182***	0.0148**
	(2.49)	(2.29)	(2.00)	(1.87)	(0.0076)	(0.0062)	(0.0060)	(0.0062)
Adjusted R^2	0.25	0.24	0.24	0.23	0.61	0.61	0.55	0.50
Observations	385	462	539	616	385	462	539	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	5	6	7	8	5	6	7	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean	185.55				4.3834			
Baseline Std. Dev.	(433.11)				(1.2589)			

Notes: Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table 5: Mills' Impact on Full Tree Cover Equivalent Area

	Full Tree Cover Equivalent Area (Thousand Hectares)				Log Full Tree Cover Equivalent Area (Log Thousand Hectares)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau - 5$	1.03***				0.0033			
	(0.38)				(0.0042)			
$\tau - 4$	1.45**	1.13**			0.0059	0.0053		
	(0.64)	(0.54)			(0.0058)	(0.0047)		
$\tau - 3$	2.02**	1.74**	1.12***		0.0079	0.0073	0.0045	
	(0.82)	(0.68)	(0.42)		(0.0064)	(0.0048)	(0.0028)	
$\tau - 2$	2.66***	2.33***	1.79***	1.33***	0.0104	0.0096*	0.0072*	0.0053*
	(0.97)	(0.84)	(0.57)	(0.43)	(0.0073)	(0.0057)	(0.0040)	(0.0029)
$\tau - 1$	3.30***	2.94***	2.29***	2.01***	0.0122	0.0120*	0.0091*	0.0079*
	(1.10)	(0.98)	(0.70)	(0.61)	(0.0082)	(0.0065)	(0.0054)	(0.0042)
τ	3.89***	3.55***	2.84***	2.38***	0.0147*	0.0140**	0.0117*	0.0097**
	(1.23)	(1.11)	(0.85)	(0.70)	(0.0086)	(0.0070)	(0.0060)	(0.0048)
$\tau + 1$	4.43***	4.14***	3.41***	2.95***	0.0193**	0.0167**	0.0135**	0.0124**
	(1.35)	(1.25)	(0.97)	(0.86)	(0.0083)	(0.0074)	(0.0064)	(0.0053)
$\tau + 2$	4.66***	4.60***	4.13***	3.60***	0.0215**	0.0220***	0.0179**	0.0157**
	(1.46)	(1.36)	(1.14)	(1.00)	(0.0084)	(0.0073)	(0.0075)	(0.0063)
$\tau + 3$	5.07***	4.79***	4.60***	4.34***	0.0234**	0.0236***	0.0239***	0.0193***
	(1.61)	(1.49)	(1.30)	(1.20)	(0.0093)	(0.0075)	(0.0074)	(0.0073)
Adjusted R^2	0.26	0.25	0.24	0.24	0.55	0.54	0.48	0.48
Observations	385	462	539	616	385	462	539	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	5	6	7	8	5	6	7	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean	108.05				3.8039			
Baseline Std. Dev.	(246.30)				(1.3319)			

Notes: Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table 6: Mills’ Impact on GDP and Population Growth

	Log of GDP (2005 Million Reais)						Log of Population (Thousand Inhabitants)					
	Panel Regression			Synthetic Control			Panel Regression			Synthetic Control		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\tau - 4$	0.06**						0.03					
	(0.03)						(0.03)					
$\tau - 3$	0.00	-0.04		0.03			0.03	0.01		0.00		
	(0.04)	(0.04)		0.49			(0.03)	(0.01)		0.94		
$\tau - 2$	0.06	0.02	0.03	0.10	0.09		0.03	0.01	-0.00	0.02	0.02	
	(0.05)	(0.04)	(0.03)	0.16	0.16		(0.04)	(0.03)	(0.02)	0.70	0.70	
$\tau - 1$	0.08	0.04	0.05	0.10	0.10	0.06	0.06	0.04	0.02	0.05	0.05	0.04
	(0.06)	(0.05)	(0.05)	0.14	0.15	0.28	(0.04)	(0.03)	(0.03)	0.41	0.37	0.48
τ	0.08	0.07	0.09**	0.10	0.10	0.08	0.07	0.04	0.03	0.05	0.05	0.04
	(0.05)	(0.04)	(0.04)	0.16	0.17	0.23	(0.04)	(0.03)	(0.03)	0.40	0.37	0.47
$\tau + 1$	0.20***	0.14***	0.16***	0.22**	0.21**	0.17**	0.10*	0.07	0.06	0.09	0.09	0.07
	(0.06)	(0.05)	(0.05)	0.02	0.02	0.03	(0.05)	(0.05)	(0.04)	0.22	0.23	0.29
$\tau + 2$	0.36***	0.27***	0.27***	0.29***	0.29***		0.12**	0.11**	0.09**	0.12	0.11	
	(0.11)	(0.06)	(0.06)	0.00	0.00		(0.06)	(0.05)	(0.05)	0.18	0.18	
$\tau + 3$	0.14	0.29***	0.30***	0.28***	0.28***		0.04	0.10*	0.10**	0.12	0.12	
	(0.10)	(0.10)	(0.06)	0.01	0.01		(0.05)	(0.05)	(0.05)	0.17	0.17	
Adjusted R^2	0.75	0.75	0.77				0.21	0.25	0.28			
Observations	462	539	616	1,008	1,008	1,022	462	539	616	1,008	1,008	1,022
Number of Municipalities	77	77	77	72	72	73	77	77	77	72	72	73
Number of Years	6	7	8	14	14	14	6	7	8	14	14	14
Municipality FE	Yes	Yes	Yes				Yes	Yes	Yes			
Time FE	Yes	Yes	Yes				Yes	Yes	Yes			
Treated Units				11	11	12				11	11	12
Donor Pool				61	61	61				61	61	61
Baseline Mean (Log)			4.74						2.58			
Baseline Std. Dev. (Log)			(0.93)						(0.83)			
Baseline Mean (Reais)			190.98						19.67			
Baseline Std. Dev. (Reais)			(284.61)						(25.26)			

Notes: Robust standard errors clustered by municipality for panel regressions and p-values for synthetic control estimates. Significance: *** p<0.01, ** p<0.05, * p<0.10. Additional leads ($\tau + 4$), ($\tau + 5$) and ($\tau + 6$) included in regressions as controls.

Table 7: Mills' Impact on GDP Growth by Economic Sector and GDP per Capita (Log of 2005 Million Reais)

	Agriculture	Industry	Services	Public Administration (Payroll Proxied)[a]	Taxes on Products (Net of Subsidies)	GDP per Capita[b]
	(1)	(2)	(3)	(4)	(5)	(6)
$\tau - 2$	0.15*	-0.09	0.03	0.01	0.06	0.03
	(0.08)	(0.09)	(0.02)	(0.02)	(0.04)	(0.04)
$\tau - 1$	0.16**	-0.03	0.05	0.02	0.13*	0.03
	(0.07)	(0.12)	(0.03)	(0.02)	(0.07)	(0.05)
τ	0.24***	-0.01	0.06**	0.03	0.18***	0.05
	(0.06)	(0.11)	(0.03)	(0.02)	(0.06)	(0.04)
$\tau + 1$	0.37***	0.23*	0.07*	0.04	0.24***	0.10*
	(0.06)	(0.13)	(0.04)	(0.03)	(0.08)	(0.06)
$\tau + 2$	0.56***	0.41***	0.11***	0.10***	0.32***	0.18***
	(0.10)	(0.14)	(0.04)	(0.03)	(0.09)	(0.06)
$\tau + 3$	0.65***	0.45***	0.13***	0.10**	0.31***	0.20***
	(0.10)	(0.13)	(0.04)	(0.04)	(0.09)	(0.05)
Adjusted R^2	0.63	0.66	0.80	0.92	0.39	0.63
Observations	616	616	616	616	616	616
Number of Municipalities	77	77	77	77	77	77
Number of Years	8	8	8	8	8	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean (Log)	3.30	2.35	4.02	3.05	2.48	2.15
Baseline Std. Dev. (log)	(0.80)	(1.36)	(0.99)	(0.77)	(1.14)	(0.40)
Baseline Mean (Reais)[b]	36.02	27.75	101.27	30.27	25.94	9.35
Baseline Std. Dev. (Reais)[b]	(27.19)	(52.52)	(174.00)	(38.36)	(50.60)	(3.98)

Notes: Robust standard errors clustered by municipality. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls. (a) Value added by public administration, public healthcare and education and social security at State Level, assigned to each municipality according to the sum of their payroll expenditures on these services. (b) GDP per capita measured in thousand Reais.

Table 8: Mills' Impact on Municipal Labor Market

	Number of Firms				Employment (Year End)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau - 5$	1.83				28.64			
	(6.15)				(73.93)			
$\tau - 4$	-4.72	-12.63			-86.60	-232.92		
	(10.20)	(14.60)			(175.20)	(234.67)		
$\tau - 3$	15.49	9.02	17.24		237.95	82.82	217.01	
	(14.31)	(12.61)	(14.64)		(216.26)	(168.88)	(194.65)	
$\tau - 2$	25.59	20.72	24.92	16.90	420.65	292.82	375.58	248.28
	(17.32)	(15.10)	(18.53)	(12.50)	(298.24)	(241.49)	(276.14)	(198.81)
$\tau - 1$	59.39*	46.89*	58.41*	45.88*	1,079.04	843.12	1,035.61	822.82
	(29.99)	(23.65)	(30.91)	(25.75)	(719.62)	(544.79)	(690.11)	(595.41)
τ	86.61**	82.33**	82.53**	75.80**	2,003.51**	1,845.07**	1,753.49**	1,660.06**
	(43.13)	(39.56)	(40.22)	(36.71)	(902.29)	(807.92)	(817.13)	(779.37)
$\tau + 1$	63.35**	110.57*	122.15*	100.10**	1,815.49***	2,314.71**	2,487.90**	2,036.98**
	(31.25)	(56.12)	(63.31)	(48.37)	(616.87)	(951.83)	(1,084.38)	(870.86)
$\tau + 2$	65.90**	68.30**	154.28*	145.86*	1,133.02*	1,626.07**	3,168.61*	2,979.43*
	(25.74)	(32.08)	(82.82)	(77.37)	(666.89)	(635.66)	(1,635.93)	(1,572.28)
$\tau + 3$	102.30***	84.96***	96.18**	185.59*	1,935.14***	1,763.98***	2,015.32**	3,541.88*
	(38.13)	(23.36)	(43.09)	(101.99)	(648.56)	(474.74)	(791.61)	(1,938.31)
Adjusted R^2	0.38	0.39	0.39	0.36	0.26	0.29	0.27	0.24
Observations	385	462	539	616	385	462	539	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	5	6	7	8	5	6	7	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean	227.27				2,277.21			
Baseline Std. Dev.	(364.28)				(3,855.08)			

Notes: Additional leads ($\tau + 4$), ($\tau + 5$) and ($\tau + 6$) included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table 8: Mills' Impact on Municipal Labor Market, Continued

	Aggregate Year End Real Wages (2005 Thousand BRL)				Number of Labor Contracts (Skilled Workers)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau-5$	-156.37				-58.41			
	(145.55)				(249.22)			
$\tau-4$	-319.21	-372.35			-242.86	-455.20		
	(221.31)	(296.88)			(344.67)	(390.30)		
$\tau-3$	-102.38	-119.05	86.91		311.01	59.59	327.78	
	(367.28)	(253.42)	(323.72)		(475.97)	(354.74)	(334.35)	
$\tau-2$	619.69	656.88	715.35	639.43	826.30	581.27	731.96	518.33
	(437.53)	(408.03)	(452.68)	(405.83)	(602.31)	(479.10)	(478.03)	(359.33)
$\tau-1$	840.69	837.54	1,157.91	959.94	2,225.24	1,690.84	2,072.88*	1,653.47
	(890.79)	(671.69)	(857.79)	(759.92)	(1,387.79)	(1,034.98)	(1,214.29)	(1,073.86)
τ	2,386.84**	2,431.52**	2,417.82**	2,420.75**	2,808.54*	2,507.27*	2,580.55**	2,398.55*
	(1,172.57)	(1,062.64)	(1,057.64)	(1,025.17)	(1,540.28)	(1,334.86)	(1,294.73)	(1,229.34)
$\tau+1$	1,575.59**	2,756.63**	2,994.08**	2,541.46**	3,138.10**	3,349.67**	3,672.67**	2,978.32**
	(778.73)	(1,319.05)	(1,498.02)	(1,193.71)	(1,408.07)	(1,427.82)	(1,580.97)	(1,274.50)
$\tau+2$	359.74	1,456.71	3,811.78*	3,657.22*	3,144.13**	2,600.16**	4,893.32*	4,564.29*
	(1,118.41)	(879.81)	(2,184.99)	(2,095.00)	(1,252.45)	(1,039.72)	(2,561.40)	(2,458.77)
$\tau+3$	734.17	765.33	1,998.38*	4,366.54	2,032.08	1,473.29	2,562.61**	4,717.36*
	(1,027.21)	(1,032.60)	(1,157.47)	(2,725.17)	(1,273.16)	(993.05)	(1,276.95)	(2,806.52)
Adjusted R^2	0.20	0.23	0.22	0.17	0.15	0.19	0.20	0.17
Observations	385	462	539	616	385	462	539	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	5	6	7	8	5	6	7	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean	1,527.57				3,367.74			
Baseline Std. Dev.	(2,725.49)				(5,934.51)			

Notes: Additional leads $(\tau+4)$, $(\tau+5)$ and $(\tau+6)$ included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table 9: Mills' Impact on Municipal Labor Market by Economic Sector

	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Labor Contracts (Skilled Workers)
	Panel (i): Agriculture			
	(1)	(2)	(3)	(4)
$\tau - 2$	1.76	38.05	375.84	119.70
	(1.44)	(99.72)	(356.44)	(110.55)
$\tau - 1$	2.54*	21.64	10.99	126.43
	(1.46)	(92.30)	(130.10)	(186.96)
τ	2.13**	130.79	468.33	165.26
	(1.06)	(157.12)	(315.91)	(241.08)
$\tau + 1$	2.77**	0.13	65.52	48.13
	(1.17)	(194.21)	(298.91)	(242.71)
$\tau + 2$	4.92***	-104.71	-198.11	-203.02
	(1.50)	(192.90)	(335.68)	(258.37)
$\tau + 3$	4.37***	-81.00	-153.92	-235.05
	(1.46)	(161.01)	(262.22)	(262.60)
Adjusted R^2	0.15	0.07	0.13	0.07
Baseline Mean	10.45	664.27	425.38	896.58
Baseline Std. Dev.	(11.59)	(620.93)	(436.64)	(968.57)
	Panel (ii): Industry			
	(5)	(6)	(7)	(8)
$\tau - 2$	1.69	59.88	87.19	91.54
	(1.87)	(125.22)	(170.01)	(192.84)
$\tau - 1$	6.31	326.67	415.22	693.35
	(4.33)	(257.27)	(331.19)	(468.90)
τ	10.85*	828.69**	1,132.40***	1,099.12**
	(6.04)	(332.92)	(395.51)	(485.39)
$\tau + 1$	11.59	1,030.09***	1,323.51***	1,272.42***
	(7.24)	(335.57)	(483.78)	(460.88)
$\tau + 2$	18.68	1,350.04***	1,807.85***	1,740.82***
	(12.36)	(432.84)	(596.31)	(568.73)
$\tau + 3$	28.85	1,562.88***	1,888.36**	1,778.26**
	(18.59)	(491.80)	(723.62)	(709.38)
Adjusted R^2	0.25	0.26	0.15	0.11
Baseline Mean	27.08	556.62	396.87	879.90
Baseline Std. Dev.	(42.93)	(1,109.72)	(764.27)	(1,768.54)

Notes: Additional leads $(\tau + 4)$, $(\tau + 5)$ and $(\tau + 6)$ included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Table 9: Mills' Impact on Municipal Labor Market by Economic Sector, Continued

	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Labor Contracts (Skilled Workers)
Panel (iii): Services				
	(9)	(10)	(11)	(12)
$\tau-2$	13.46	150.35	176.40	307.09
	(9.74)	(133.04)	(170.24)	(251.29)
$\tau-1$	37.03*	474.51	533.73	833.69
	(20.43)	(355.94)	(460.06)	(629.13)
τ	62.81**	700.58	820.02	1,134.16
	(30.56)	(489.82)	(657.36)	(761.99)
$\tau+1$	85.75**	1,006.76	1,152.43	1,657.78*
	(40.78)	(615.95)	(791.11)	(947.85)
$\tau+2$	122.25*	1,734.10	2,047.48	3,026.49
	(65.30)	(1,169.22)	(1,511.16)	(1,978.34)
$\tau+3$	152.38*	2,059.99	2,632.10	3,174.15
	(83.80)	(1,502.25)	(2,054.73)	(2,139.52)
Adjusted R^2	0.37	0.18	0.15	0.18
Baseline Mean	189.74	1,056.31	705.32	1,591.26
Baseline Std. Dev.	(316.06)	(2,469.41)	(1,798.45)	(3,779.91)
Observations and Fixed Effects Settings for All Regressions				
Observations	616	616	616	616
Number of Municipalities	77	77	77	77
Number of Years	8	8	8	8
Municipality FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Notes: Additional leads $(\tau+4)$, $(\tau+5)$ and $(\tau+6)$ included in regressions as controls. Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10.

Table 10: Mills' Impact on Municipal Labor Market by Industry at $\tau + 3$

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Skilled Workers
	(1)	(2)	(3)	(4)
Agriculture, Livestock and Forestry	4.30***	-84.82	-157.45	-239.03
	(1.47)	(162.09)	(263.44)	(264.14)
Baseline Mean	10.12	662.90	424.50	894.99
Baseline Std. Dev.	(11.44)	(620.71)	(436.72)	(968.39)
Mining and Quarrying	0.01	-15.41	-38.57	-26.32
	(0.33)	(12.41)	(35.97)	(21.28)
Baseline Mean	1.09	15.99	20.00	20.18
Baseline Std. Dev.	(1.53)	(84.33)	(139.43)	(93.74)
Manufacturing	15.11	1,495.29***	1,893.60***	1,735.56***
	(9.20)	(392.17)	(594.26)	(521.58)
Baseline Mean	21.27	490.47	330.37	764.52
Baseline Std. Dev.	(34.42)	(1,001.34)	(657.23)	(1,525.55)
Electricity, Gas and Water Supply	0.32	0.23	-4.92	-0.45
	(0.34)	(4.68)	(17.43)	(6.46)
Baseline Mean	0.94	5.95	15.08	6.68
Baseline Std. Dev.	(0.61)	(14.50)	(37.61)	(15.98)
Construction	13.40	82.77	38.25	69.47
	(9.42)	(119.31)	(151.90)	(221.61)
Baseline Mean	3.78	44.22	31.41	88.52
Baseline Std. Dev.	(8.40)	(116.78)	(82.20)	(280.58)
Wholesale and Retail Trade and Maintenance	74.21*	652.75*	869.02	1,202.00*
	(37.63)	(340.43)	(548.28)	(661.94)
Baseline Mean	124.30	573.91	332.59	856.32
Baseline Std. Dev.	(204.84)	(1,229.57)	(781.77)	(1,856.95)
Hotels and Restaurants	13.99	117.03*	97.08*	259.57
	(9.47)	(70.06)	(57.88)	(157.35)
Baseline Mean	11.91	59.19	26.13	100.10
Baseline Std. Dev.	(20.69)	(119.25)	(53.85)	(209.74)

Notes: (a) UN ISIC - International Standard Industrial Classification of All Economic Activities, Rev. 3.1. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 10: Mills' Impact on Municipal Labor Market by Industry at $\tau + 3$, Continued

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Skilled Workers
	(1)	(2)	(3)	(4)
Transport, Storage and Communications	19.67**	157.37**	221.39**	354.05***
	(8.47)	(64.82)	(90.26)	(129.78)
Baseline Mean	12.78	81.26	63.48	121.55
Baseline Std. Dev.	(20.72)	(197.57)	(157.21)	(294.54)
Financial Intermediation	1.28**	16.02	60.59	27.28
	(0.63)	(14.18)	(46.37)	(27.63)
Baseline Mean	3.01	27.86	72.28	33.38
Baseline Std. Dev.	(5.17)	(64.65)	(171.64)	(77.27)
Real estate, Renting and Business Activities	26.61	282.87	276.70	388.82
	(17.63)	(288.93)	(298.16)	(380.88)
Baseline Mean	13.10	95.71	69.76	207.78
Baseline Std. Dev.	(30.14)	(305.62)	(238.98)	(761.08)
Public administration, defense and compulsory social security	-0.06	-1.93	-5.47*	-2.26
	(0.14)	(1.49)	(2.83)	(1.80)
Baseline Mean	0.18	0.69	0.43	0.81
Baseline Std. Dev.	(0.45)	(2.70)	(1.72)	(3.16)
Education	4.10*	68.36	81.90	110.71
	(2.39)	(68.66)	(89.59)	(103.44)
Baseline Mean	3.97	53.77	43.27	70.96
Baseline Std. Dev.	(6.31)	(143.72)	(138.68)	(184.58)
Health and Social Work	6.30	113.72	117.53	151.06
	(4.44)	(105.56)	(111.98)	(146.23)
Baseline Mean	5.62	67.82	45.23	82.95
Baseline Std. Dev.	(10.99)	(202.04)	(139.78)	(253.02)
Observations and Fixed Effects Settings for All Regressions				
Observations	616	616	616	616
Number of Municipalities	77	77	77	77
Number of Years	8	8	8	8
Municipality FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Notes: (a) UN ISIC - International Standard Industrial Classification of All Economic Activities, Rev. 3.1. Significance: *** p<0.01, ** p<0.05, * p<0.10

Table 11: Mills' Impact on Labor Market by Economic Activity ($\tau + 3$)

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Labor Contracts (Skilled Workers)
	(1)	(2)	(3)	(4)
Panel (i): Agriculture, Livestock and Forestry				
Growing of sugarcane	0.84***	-86.39	-170.78	-196.48
	(0.26)	(167.53)	(258.70)	(291.88)
Baseline Mean	0.21	44.45	47.92	135.77
Baseline Std. Dev.	(0.59)	(178.30)	(192.66)	(486.59)
Growing of soybean	0.13	119.11**	129.77**	89.95
	(0.24)	(55.45)	(51.77)	(64.54)
Baseline Mean	0.92	42.82	31.00	60.26
Baseline Std. Dev.	(0.76)	(105.17)	(88.24)	(150.14)
Growing of corn[b]	0.07	10.03**	7.67**	11.99**
	(0.17)	(4.70)	(3.48)	(5.68)
Baseline Mean	0.18	0.65	0.32	0.79
Baseline Std. Dev.	(0.39)	(2.40)	(1.33)	(2.72)
Raising of Cattle	-0.30	-69.71***	-57.35**	-116.99***
	(0.49)	(21.43)	(25.09)	(34.88)
Baseline Mean	5.25	414.88	240.00	461.75
Baseline Std. Dev.	(5.01)	(360.23)	(215.03)	(403.04)
Agricultural service activities	3.96***	-7.78	4.06	16.33
	(0.99)	(16.02)	(12.20)	(19.44)
Baseline Mean	2.66	25.06	19.16	38.79
Baseline Std. Dev.	(3.43)	(63.13)	(53.36)	(98.27)
Animal husbandry service activities, except veterinary	0.47	6.16	13.47	7.77
	(0.38)	(6.89)	(10.54)	(8.90)
Baseline Mean	1.26	22.30	13.66	31.75
Baseline Std. Dev.	(1.03)	(49.22)	(32.12)	(72.56)

Notes: (a) Classificação Nacional de Atividades Econômicas - CNAE 1.0 based on UN ISIC - International Standard Industrial Classification of All Economic Activities, Rev. 3.1 (b) CNAE 2.0 based on UN ISIC, Rev. 4 - Data unavailable for 2005. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 11: Mills' Impact on Labor Market by Economic Activity ($\tau + 3$), Continued

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Labor Contracts (Skilled Workers)
	(1)	(2)	(3)	(4)
Panel (ii): Mining and Quarrying				
Mining of chemical and fertilizer minerals	0.02*	0.13	0.09	0.11
	(0.01)	(0.10)	(0.08)	(0.10)
Baseline Mean	0.03	0.18	0.14	0.17
Baseline Std. Dev.	(0.16)	(1.38)	(1.06)	(1.37)
Panel (iii): Manufacturing				
Manufacture of sugar	0.14	415.93**	547.01**	363.62*
	(0.10)	(187.77)	(266.55)	(191.25)
Baseline Mean	0.03	13.05	10.64	16.39
Baseline Std. Dev.	(0.16)	(80.46)	(65.81)	(101.02)
Manufacture of other chemical products[c]	1.27***	825.49***	1,115.27***	1,004.11***
	(0.31)	(273.98)	(386.75)	(286.61)
Baseline Mean	0.77	27.19	30.52	59.47
Baseline Std. Dev.	(1.89)	(87.73)	(105.64)	(223.86)
Cattle Slaughtering[b]	-0.13	147.68**	110.99**	105.50*
	(0.23)	(58.32)	(48.88)	(62.38)
Baseline Mean	0.83	158.53	109.93	211.48
Baseline Std. Dev.	(1.07)	(440.68)	(322.88)	(535.30)
Tanning and dressing of leather	-0.23	-29.75**	-20.80*	-56.42***
	(0.18)	(11.31)	(11.33)	(20.37)
Baseline Mean	0.53	19.70	10.08	36.09
Baseline Std. Dev.	(1.75)	(97.29)	(47.24)	(162.40)
Manufacture of fertilizers and nitrogen compounds	0.25**	22.14	26.76	34.27
	(0.12)	(15.20)	(19.70)	(22.24)
Baseline Mean	0.14	0.82	0.52	1.31
Baseline Std. Dev.	(0.64)	(5.64)	(3.04)	(9.19)
Repair and maintenance of tractors and agricultural machinery	2.05**	21.16**	21.58**	34.51*
	(0.97)	(9.41)	(9.02)	(18.06)
Baseline Mean	0.08	0.29	0.24	0.36
Baseline Std. Dev.	(0.31)	(1.26)	(1.28)	(1.62)
Repair and maintenance of electrical equipment	0.41**	9.18	7.12	12.93
	(0.19)	(8.38)	(6.53)	(11.59)
Baseline Mean	0.00	0.00	0.00	0.00
Baseline Std. Dev.	(0.00)	(0.00)	(0.00)	(0.00)

Notes: (c) This sector includes ethanol production. Significance: *** p<0.01, ** p<0.05, * p<0.10

Table 11: Mills' Impact on Labor Market by Economic Activity ($\tau + 3$), Continued

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Skilled Workers
	(1)	(2)	(3)	(4)
Panel (iv): Electricity, Gas and Water Supply				
Production and Distribution of Electricity	0.41*	2.75	-3.78	3.25
	(0.24)	(3.55)	(17.22)	(4.74)
Baseline Mean	0.90	5.74	14.97	6.25
Baseline Std. Dev.	(0.55)	(14.12)	(37.49)	(15.35)
Panel (v): Wholesale and Retail Trade and Maintenance				
Repair and maintenance of motor vehicles	7.54*	15.93*	25.32	25.82**
	(3.93)	(8.97)	(17.05)	(12.18)
Baseline Mean	5.13	17.27	8.64	25.34
Baseline Std. Dev.	(9.40)	(41.47)	(20.61)	(64.81)
Wholesale of agricultural raw materials	0.89**	42.62*	36.82*	45.36
	(0.41)	(24.73)	(19.14)	(27.49)
Baseline Mean	0.95	5.70	5.81	8.49
Baseline Std. Dev.	(2.06)	(14.28)	(15.92)	(21.20)
Wholesale of agricultural machinery and equipment	0.69**	14.87**	36.12**	21.22**
	(0.31)	(6.77)	(16.95)	(9.70)
Baseline Mean	0.44	3.04	3.44	4.32
Baseline Std. Dev.	(1.30)	(8.87)	(10.88)	(12.46)
Wholesale of fertilizers and agrochemical products[b]	1.17***	20.80**	26.56**	29.30**
	(0.44)	(7.91)	(11.01)	(11.21)
Baseline Mean	0.61	2.58	2.82	3.96
Baseline Std. Dev.	(1.63)	(6.01)	(7.03)	(11.13)
Panel (vi): Hotels and Restaurants				
Restaurants, bars and canteens	13.17	100.21*	84.25*	222.14*
	(9.17)	(59.40)	(47.99)	(129.25)
Baseline Mean	7.27	35.35	15.10	62.53
Baseline Std. Dev.	(13.45)	(71.50)	(31.54)	(133.51)

Notes: (a) Classificação Nacional de Atividades Econômicas - CNAE 1.0 based on UN ISIC - International Standard Industrial Classification of All Economic Activities, Rev. 3.1 (b) CNAE 2.0 based on UN ISIC, Rev. 4 - Data unavailable for 2005. Significance: *** p<0.01, ** p<0.05, * p<0.10

Table 11: Mills' Impact on Labor Market by Economic Activity ($\tau + 3$), Continued

Industry Name[a]	Labor Force Size		Income	Education
	Number of Firms	Number of Workers (Year End)	Aggregate Year End Real Wages (1,000 Reais)	Number of Skilled Workers
	(1)	(2)	(3)	(4)
Panel (vii): Transport Storage and Communications				
Freight transport by road	16.67**	119.10***	147.67**	272.07***
	(6.57)	(43.85)	(58.57)	(91.13)
Baseline Mean	5.27	29.17	22.86	43.35
Baseline Std. Dev.	(11.25)	(83.53)	(72.02)	(122.77)
Warehousing and Storage	0.52	10.47	29.43*	20.77*
	(0.50)	(7.18)	(15.28)	(10.52)
Baseline Mean	0.84	5.66	4.30	9.58
Baseline Std. Dev.	(1.89)	(15.37)	(11.12)	(25.54)
Panel (viii): Real estate, renting and business activities				
Renting of agricultural machinery and equipment	1.77**	11.74*	11.60**	32.16**
	(0.75)	(6.50)	(5.69)	(15.63)
Baseline Mean	0.10	0.48	0.24	0.70
Baseline Std. Dev.	(0.35)	(2.02)	(1.05)	(2.64)

Notes: (a) Classificação Nacional de Atividades Econômicas - CNAE 1.0 based on UN ISIC - International Standard Industrial Classification of All Economic Activities, Rev. 3.1 (b) CNAE 2.0 based on UN ISIC, Rev. 4 - Data unavailable for 2005. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 12: Mills' Impact on Private Deposits and Rural Credit

	Total Private Deposits (2005 Million reais)				Total Rural Credit (2005 Million reais)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau-5$	0.31				1.11			
	(0.61)				(2.24)			
$\tau-4$	-0.11	-0.82			-2.29	-4.47		
	(0.60)	(0.71)			(6.10)	(7.33)		
$\tau-3$	0.98	0.36	0.68		6.30	4.78	6.31	
	(0.69)	(0.66)	(0.54)		(7.14)	(6.32)	(4.85)	
$\tau-2$	2.67**	2.02**	2.14**	1.66**	12.99	10.39	12.39*	9.04**
	(1.06)	(0.93)	(0.93)	(0.75)	(9.05)	(7.85)	(6.64)	(4.23)
$\tau-1$	5.78***	4.21**	4.56**	3.61**	25.38*	18.48*	19.86*	15.59**
	(2.12)	(1.74)	(1.89)	(1.62)	(13.07)	(10.97)	(11.09)	(7.77)
τ	5.63***	4.92**	4.80**	4.19**	29.01**	25.18**	22.41*	18.54*
	(2.08)	(1.88)	(1.84)	(1.70)	(14.22)	(12.14)	(12.67)	(9.92)
$\tau+1$	3.90**	5.86**	6.16**	4.92**	22.50**	21.52**	22.45**	15.44*
	(1.48)	(2.66)	(2.81)	(2.38)	(10.59)	(10.35)	(10.63)	(8.04)
$\tau+2$	6.12***	4.30**	5.85**	5.15*	18.40	15.86	18.03**	13.60**
	(2.06)	(1.82)	(2.74)	(2.59)	(11.74)	(9.67)	(8.62)	(6.78)
$\tau+3$	5.39***	3.50**	3.97**	4.76*	22.24*	17.24*	16.11*	18.53**
	(2.01)	(1.40)	(1.65)	(2.55)	(11.99)	(10.04)	(9.50)	(9.14)
Adjusted R^2	0.36	0.34	0.32	0.30	0.26	0.20	0.14	0.12
Observations	385	462	539	616	385	462	539	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	5	6	7	8	5	6	7	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Mean	4.62				24.21			
Baseline Std. Dev.	(8.32)				(39.23)			

Notes: Robust standard errors clustered by municipality. Significance: *** p<0.01, ** p<0.05, * p<0.10. Additional leads $(\tau+4)$, $(\tau+5)$ and $(\tau+6)$ included in regressions as controls.

Table 13: Mills' Impact on Financial Services (2005 Million Reais)

	Number of Branches	Total Bank Assets	Private Deposits		Credit for Agriculture		Credit for Cattle Ranching	
			Households	Firms	Investments and Operational Expenses	Output Commercialization	Investments and Operational Expenses	Output Commercialization
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau - 2$	-0.00	-394.94	1.33**	0.23	6.72*	-0.05	2.32	0.04
	(0.05)	(261.05)	(0.59)	(0.22)	(3.42)	(0.24)	(1.57)	(0.04)
$\tau - 1$	0.10	-363.79	2.06**	1.40**	12.51*	0.70	2.29	0.09*
	(0.12)	(312.59)	(0.96)	(0.64)	(6.46)	(0.74)	(1.70)	(0.05)
τ	0.31	-397.26	2.56**	1.60**	16.08*	1.06	1.40	-0.00
	(0.19)	(327.39)	(1.05)	(0.70)	(8.36)	(1.05)	(1.52)	(0.03)
$\tau + 1$	0.37	-317.50	2.88*	1.98**	13.40*	1.02	1.13	-0.11
	(0.25)	(329.01)	(1.47)	(0.97)	(6.74)	(0.84)	(1.70)	(0.14)
$\tau + 2$	0.40	-255.77	3.45*	1.59*	12.56**	1.15*	0.06	-0.17
	(0.26)	(349.03)	(1.76)	(0.86)	(5.91)	0.67)	1.68)	(0.34)
$\tau + 3$	0.36	-246.41	3.31*	1.43	15.40*	2.82**	0.56	-0.25
	(0.25)	(346.36)	(1.77)	(0.88)	(7.79)	(1.15)	(2.21)	(0.30)
Adjusted R^2	0.28	0.08	0.34	0.18	0.12	0.14	0.17	0.05
Baseline Mean	1.94	401.04	2.74	1.64	15.64	0.17	8.32	0.08
Baseline Std. Dev.	(2.15)	(1,045.80)	(4.03)	(3.75)	(31.69)	(0.64)	(11.07)	(0.29)
Observations	616	616	616	616	616	616	616	616
Number of Municipalities	77	77	77	77	77	77	77	77
Number of Years	8	8	8	8	8	8	8	8
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors clustered by municipality. Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. All values refer to yearly averaged monthly data.

Table 14: Controlling for Spillovers from Neighboring Municipalities - Restricted Donor Pool

	Sugarcane Harvested Area (Thousand Hectares)		Sugarcane Output (Million Tons)		Log of GDP (2005 Million Reais)		Log of Population (Thousand Inhabitants)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau - 3$	0.46		0.08		-0.01		0.01	
	0.27		0.12		0.86		0.84	
$\tau - 2$	1.53*	1.55*	0.18*	0.19***	0.07	0.07	0.03	0.03
	0.10	0.04	0.01	0.01	0.11	0.11	0.46	0.37
$\tau - 1$	1.83	1.64	0.25***	0.27***	0.04	0.05	0.07	0.07*
	0.11	0.11	0.01	0.00	0.39	0.30	0.12	0.06
τ	5.99***	6.18***	0.63***	0.68***	0.06	0.06	0.07	0.08*
	0.00	0.00	0.00	0.00	0.27	0.22	0.12	0.08
$\tau + 1$	11.10***	11.38***	1.14***	1.22***	0.19***	0.19***	0.10**	0.11**
	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02
$\tau + 2$	19.71***	20.64***	1.63***	1.73***	0.29***	0.29***	0.12**	0.13**
	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
$\tau + 3$	24.78***	26.12***	1.90***	2.03***	0.28***	0.29***	0.13**	0.13**
	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Observations	840	840	840	840	840	840	840	840
Number of Municipalities	60	60	60	60	60	60	60	60
Number of Years	14	14	14	14	14	14	14	14
Treated Units	11	11	11	11	11	11	11	11
Donor Pool	49	49	49	49	49	49	49	49
Baseline Mean	1.78		0.12		4.74		2.58	
Baseline Std. Dev.	(4.25)		(0.33)		(0.93)		(0.83)	

Notes: Significance: *** p<0.01, ** p<0.05, * p<0.10. For synthetic control method, p-values are underneath parameters.