# The economic growth impacts of sugarcane expansion in Brazil:

## An inter-regional analysis

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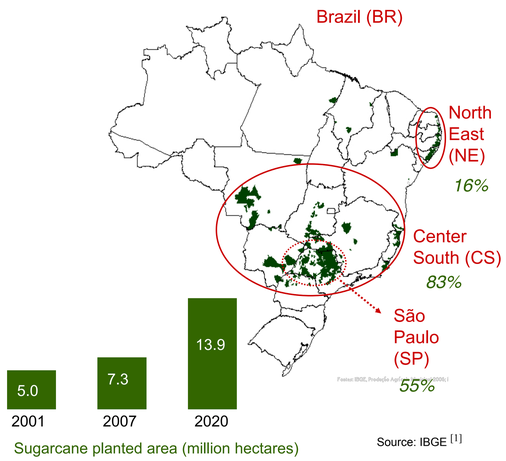
## Motivation

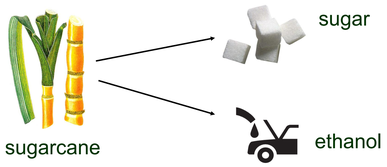
Since 2001, Brazil experienced a sharp expansion in sugarcane production. Over 60% of this expansion occurred in São Paulo state (SP). By 2020, the country is planning to double the amount of sugarcane plantations. Most of these expansions will take place in the region of the Center-South excluding São Paulo (CSexclSP).

Map: Concentration of sugarcane plantations in Brazil (2007)




Source: IBGE [1]

The drivers behind this expansion were the increased demand for sugar and ethanol. In Brazil, both sugar and ethanol are entirely derived from sugarcane.




This expansion can have both positive and negative impacts on local economies:

*Positive*: creation of income and employment in sugar and ethanol sector [2]

*Negative*: sugarcane monopolizes land use and economic activities [3]

Moreover, economic impacts of sugarcane expansion might *depend on the region* where sugarcane is grown.

## Research questions

**Question 1**: What was the impact of sugarcane expansion on economic growth in the sugarcane-expanding municipalities in Brazil and in the main sugarcane-growing regions?

**Question 2**: What are the potential economic growth impacts of the planned sugarcane expansions in the municipalities in the Center-South excluding São Paulo (CSexclSP)?

## Methodology

Classify municipalities into Treatment (T=1) and Control (T=0) groups. A municipality is treated if its average annual growth rate in sugarcane production between 2001 and 2007 was equal to or above the regional average.

Classification of municipalities according to average annual growth in sugarcane production (SUGR) between 2001-2007

| Region | Region's average (RA) | # muni in treated SUGR ≥ RA | # muni in control SUGR ≤ 0 | # muni excluded 0<SUGR<RA |
|---|---|---|---|---|
| BR | 6.5% | 1428 | 3158 | 975 |
| NE | 1.5% | 539 | 1336 | 56 |
| CS | 7.7% | 910 | 1634 | 775 |
| SP | 7.4% | 255 | 213 | 177 |
| CSexclSP | 8.1% | 635 | 1421 | 618 |

Source: IBGE [1]

**Question 1**: Estimate the Average Treatment Effect on the Treated (**ATT**) for the various regions using the propensity score ρ(X) [4] :

$$ATT = E(Y_1 | T=1, \rho(X)) - E(Y_0 | T=1, \rho(X))$$

**Question 2**: Estimate the Average Treatment Effect on the Untreated (**ATU**) for CSexclSP using the propensity score ρ(X) [4]:

$$ATU = E(Y_1 | T=0, \rho(X)) - E(Y_0 | T=0, \rho(X))$$

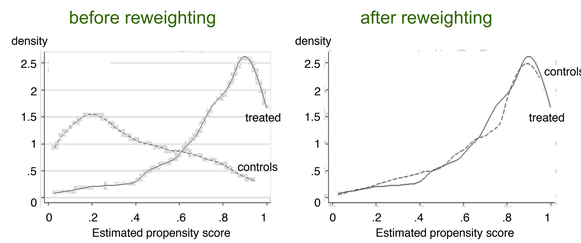
$Y_i$ = average annual GDP per capita growth, 2001-07 (i=0,1)

ρ(X) = prob(T=1 | X), i.e. the "propensity score" or the conditional probability that a municipality increased sugarcane production given a set of observable characteristics *X*. One of these observable characteristics is a municipality's suitability to grow sugarcane, data recently published by EMBRAPA [5].

Applied four types of estimators based on the estimated ρ(X) to estimate ATT and ATU.

## Results

Kernel densities of estimated propensity scores before and after reweighting – illustration for SP




**Question 1**: ATT and standard errors[1]

| region | | blocking | reweighting | mixed blocking | mixed reweighting |
|---|---|---|---|---|---|
| BR | ATT | 0.500 | 0.537 | 0.452 | 0.491 |
| | std.err. | (0.231)** | (0.263)** | (0.239)* | (0.217)** |
| NE | ATT | 0.818 | 0.959 | 0.933 | 0.923 |
| | std.err. | (0.335)** | (0.440)** | (0.330)*** | (0.370)** |
| CS | ATT | 0.020 | 0.099 | 0.136 | 0.143 |
| | std.err. | (0.323) | (0.312) | (0.314) | (0.292) |
| SP | ATT | 0.250 | 0.666 | 0.407 | 0.617 |
| | std.err. | (1.270) | (1.325) | (1.010) | (1.062) |
| CSex clSP | ATT | 0.498 | 0.494 | 0.550 | 0.508 |
| | std.err. | (0.258)* | (0.255)* | (0.320)* | (0.262)* |

**Question 2**: ATU and standard errors[1]

| | blocking | reweighting | mixed blocking | mixed reweighting |
|---|---|---|---|---|
| *Scenario 1: sugarcane expansion ≥ 1%* | | | | |
| ATU | 0.712 | 0.610 | 0.733 | 0.609 |
| std.err. | (0.324)** | (0.334)* | (0.334)** | (0.328)* |
| *Scenario 2: sugarcane expansion ≥ 5%* | | | | |
| ATU | 0.597 | 0.588 | 0.611 | 0.606 |
| std.err. | (0.334)* | (0.348)* | (0.320)* | (0.332)* |
| *Scenario 3: sugarcane expansion ≥ 10%* | | | | |
| ATU | 0.676 | 0.651 | 0.639 | 0.632 |
| std.err. | (0.404)* | (0.415) | (0.415) | (0.403) |

[1] Note: values for bias, standard errors, t-values, and MSE are obtained using bootstrap procedures with 10,000 replications. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

## Conclusions

**Question 1**:

- Sugarcane-expanding municipalities in BR, NE and CSexclSP experienced a higher economic growth due to sugarcane expansion.
  - → In BR and CSexclSP: 0.5 percent higher average annual economic growth.
  - → In NE: 0.9 percent higher average annual economic growth
- Sugarcane-expanding municipalities in CS and SP did not experience a higher economic growth due to sugarcane expansion.

**Question 2**: Sugarcane non-expanding municipalities in CSexclSP would have experienced a 0.6 percent higher average annual economic growth if they had expanded sugarcane production.

## Literature and data cited

[1] IBGE (Instituto Brasileiro de Geografia e Estatística). 2010. Online database.
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[3] Ramos, P. 2008. "Os impactos da expansão do lavoura canaviera na estrutura fundiária e as manifestações de sua concentração no Brasil." Paper presented at the "Workshop sobre os impactos da evolução do setor sucroalcooleiro", UNICAMP, Campinas, Brazil, 16 May.
[4] Rosenbaum, P.R. and D.B. Rubin. 1983a. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70:41-55
[5] EMBRAPA. 2009. Zoneamento agroecológico da cana-de-açucar.

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