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Research paper

Accelerated growth of the sugarcane, sugar, and ethanol sectors in Brazil (2000–2008): Effects on municipal gross domestic product per capita in the south-central region

Márcia Azanha Ferraz Dias de Moraes [a, *], Mírian Rumenos Piedade Bacchi [a], Carlos Eduardo Caldarelli [b]

[a] Escola Superior de Agricultura "Luiz de Queiroz" – ESALQ/USP, University of São Paulo, Piracicaba, São Paulo, Brazil
[b] Department of Economics, Londrina State University – UEL, Londrina, Paraná, Brazil

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ABSTRACT

During the 2000–2008 period, there was a marked acceleration in the growth of the sugarcane, sugar, and ethanol sectors of Brazil, which are most active in the south-central region of the country. Therefore, the objective of this study was to evaluate the effects of those sectors on the municipal gross domestic product (GDP) per capita in the south-central region of Brazil during that period. To that end, we constructed a theoretical model, estimating its parameters with a generalized method of moments system estimator and using spatial dynamic panel data to estimate the direct (municipal) effects and indirect (regional) effects. The cumulative direct and indirect effects increased the real municipal GDP per capita by 1028 $ in the host municipalities and by 324 $ in each of their 15 closest neighboring municipalities. On the basis of our findings, we can infer that the effects of establishing a sugar mill or ethanol plant are most significant for the host municipality and persist for at least 10 years after operations begin. Our results also indicate that sugarcane production has a significant, positive impact on municipal GDP per capita, not only in the municipalities where that production takes place but also in neighboring municipalities.

1. Introduction

The objective of this study was to quantify and evaluate the effects that the sugarcane, sugar, and ethanol sectors (hereafter collectively referred to as the sugarcane industry) have on the municipal gross domestic product (GDP) per capita in the south-central region of Brazil between 2000 and 2008, a period during which there was considerable growth of those sectors. We focused on the south-central region, which comprises the states of São Paulo, Paraná, Minas Gerais, Mato Grosso do Sul, Mato Grosso, and Goiás, as well as the Federal District of Brasília, because it surpasses all other regions of the country in terms of the production of sugarcane, sugar, and ethanol.

Because Brazil is a country of continental dimensions, the economic structure and socioeconomic conditions vary considerably among its geographic regions. Most previous studies of the effects of the sugarcane industry have focused on the state of São Paulo [1–3]. For a more comprehensive evaluation, it is essential to expand that analysis to the other regions of the country. So, in face of this heterogeneity, the objective of this paper was to increase the current knowledge of the effects of that industry in the Brazilian states that are less industrialized and present socioeconomic conditions different than those in the state of São Paulo.

Beginning in the year 2000, there was marked acceleration in the rate of growth of the sugarcane industry in Brazil. The most rapid growth occurred in the 2000–2008 period, during which the production of sugarcane grew by 124.6% and the amount of land devoted to its cultivation grew by 68.2% [4]. That led to the construction of new mills and consequent increases in exports, as reported in an ever-increasing number of studies on the topic. Foreign trade figures indicate that, from 2000 to 2008, exports of sugar and ethanol increased by 199.4% and 2152.3%, respectively [5]. However, it should be borne in mind that the ethanol market is now considerably less vigorous.

The initial expansion of the sugarcane industry in Brazil

* Corresponding author.
E-mail address: mafdmora@usp.br (M.A.F.D. Moraes).

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occurred in the early 2000s and was mainly due to an increase in ethanol production, driven by the growing prospects for ethanol demand in domestic and foreign markets. At that time, companies invested in plants designed to produce only ethanol. Over the years, the vast majority of those plants incorporated a sugar mill, in order to increase production flexibility and to optimize profitability during periods of unfavorable ethanol pricing. In this paper, we estimate the impacts of the expansion of sugarcane production, as well as those of the expansion of the sugar and ethanol sectors considered jointly.

In a review of the sugarcane industry, Gilio [6] stated that there has also been strong post-2000 growth in the number of studies related to the industry, which the author found to correlate directly with the degree of expansion of the industry itself. The author noted that most such studies have been regionalized, underscoring the need for studies evaluating the broader effects of the growth of this industry. Given the efforts to understand the dynamics and interactions of these sectors with the Brazilian economy, together with the lack of comprehensive studies, the present study seeks to investigate the relationship between accelerated growth of the sugarcane industry and production/income—the GDP per capita—at the municipal level, for the south-central region of Brazil.

Evaluating the direct and indirect effects of sugarcane, sugar, and ethanol production is of paramount importance for quantifying the contribution of this industry to the regional and national economy, which could facilitate the selection of targets for future research and inform the decisions of policy makers. According to Barros et al. [7], studies aimed at singling out the determinants of per capita income and capturing the economic aspect also evaluate economic welfare.

In view of the aforementioned lack of comprehensive studies of the sugarcane industry of Brazil, we used econometric tools for the analysis of panel data, in order to model the relationship between municipal GDP per capita and expansion of the industry in the south-central region of the country.

The estimated models include spatial dynamic panel data, estimated with a generalized method of moments system estimator (GMM-SYS), which allows the effects to be quantified, not only for the host municipalities but also for those in the surrounding area (i.e., the regional effects) [8,9]. Dynamic panel data models that accommodate spatial dependence have recently attracted considerable attention. Therefore, there has been increasing development of new theoretical and empirical models focusing on externalities and spillover effects, with a special focus on regional effects [10].

2. Overview of the sugarcane industry in Brazil, 2000–2008

In the late 1990s, the sugarcane industry of Brazil began to undergo a profound transformation. The observed changes were not restricted to the ethanol market. There were also institutional changes related to various factors, including the cessation of government intervention, the advent of flex-fuel vehicles, mergers/acquisitions, and the rapid internationalization of assets, exemplifying the profound, comprehensive character of the changes [11]. There were external factors as well. Countries seeking to mitigate greenhouse gas emissions by introducing ethanol into their energy mix began to pay close attention to the emergence of renewable energy sources and biofuel derived from sugarcane [1]. This new structure ensured a dynamic of accelerated growth in the industry, in terms of production, processing (production units), and exports. Fig. 1 shows the evolution of sugarcane production between the harvests of 1990–91 and 2013–14.

As can be seen, the expansion was most pronounced between the 2000–01 and 2008–09 harvests. In addition, in the 2009–10 and 2010–11 harvests, there was a marked slowdown in the rate of growth, followed by a transitory downward trend. According to data obtained from the Brazilian Sugarcane Industry Association and the Western São Paulo Association of Ethanol Plants [5,12], the downward trend observed between the harvest of 2010–11 and that of 2012–13 constituted the so-called Brazilian sugarcane industry crisis, characterized by reduced production and the closing of many production facilities, as is also currently the case.

Another important aspect of the sugarcane industry of Brazil during the period evaluated was the regional distribution of sugarcane production, the south-central region accounting for approximately 84% of the total production of the country. By the harvests of 2012–13 and 2013–14, that proportion had increased to a mean of 91%. Conversely, there has been a relative stagnation of sugarcane production in the northern and northeastern regions.

Table 1 summarizes the data related to the production of sugarcane, sugar, and ethanol for the harvests of 2000–01, 2008–09, and 2013–14.

Foreign trade figures for the period in question confirm the importance of the sugarcane industry for generating foreign exchange gains and therefore for the Brazilian economy in general. As can be seen in Fig. 2, Brazilian sugar exports increased from approximately 6.5 Mt in 2000 to 19.4 Mt in 2008, a 199.46% increase. Likewise, exports of ethanol increased from approximately 0.22 hm^3 to 5.11 hm^3, an increase of 2152.30%, between 2000 and 2008.

In the 2000–2008 period, the foreign exchange gains from the export of sugar and ethanol (in free on board values) were 31 billion dollars and 7.18 billion dollars, respectively. Of all Brazilian agribusiness exports in that period, sugar and ethanol collectively accounted for 10.4% (8.5% for sugar and 1.9% for ethanol).

Despite the post-2009 crisis, exports of sugar and ethanol are still relevant for Brazilian agribusiness. According to the Brazilian Ministry of Agriculture, Animal Husbandry, and Supply [13], agribusiness exports in 2013 totaled 99.97 billion dollars, of which the sugarcane industry accounted for 13.70%, comprising sugar exports of 11.84 billion dollars (11.8%) and ethanol exports of 1.86 billion dollars (1.8%).

Within the period studied, there were also certain phases during which processing (as quantified by number of production units) was more vigorous. Fig. 3 shows the distribution of sugarcane processing facilities, distinguishing between those already operating in 2000 and those coming online between 2000 and 2008, in the 2363 municipalities within the south-central region. According to Moraes and Zilberman [11], the year of greatest expansion in the sugarcane processing capacity of Brazil was 2008, during which operations began at 30 new facilities—all located in the south-central region. Those authors also showed that there was a post-2009 slowdown, describing it as a period of crisis and of greater caution in terms of the level of investment in the sugarcane industry.

In addition to altering the agricultural landscape, the activities of the sugarcane industry have had various socioeconomic effects on sugarcane producing regions, which has raised a number of questions about this process. Efforts to understand the changes underlying the accelerated growth of this industry have intensified in recent years. Various studies, with different objectives and employing diverse methodological approaches, have addressed this topic. In a systematic review of the literature on this topic, focusing on the socioeconomic impact, Gilio [6] identified a multitude of studies.

According to Shikida and Souza [2], the presence of a sugarcane processing facility drives economic growth in municipalities in Brazil. In support of that assertion, various other authors have demonstrated that such facilities not only create jobs directly but