Factors influencing ethanol mill location in a new sugarcane producing region in Brazil

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ARTICLE INFO

Keywords:
- Ethanol mill
- Expansion
- Location
- Spatial dependence
- Sugarcane
- Brazil

ABSTRACT

The rise in global demand for ethanol has caused an expansion of ethanol mills into new areas to increase supply. Ethanol mills are supply-oriented firms; thus, they seek locations near agricultural feedstocks to ensure access and to reduce transaction costs. In Brazil, the rise of ethanol production has been more significant in the states of Goiás and Mato Grosso do Sul. Expansion of the sugarcane ethanol industry into this new frontier is a challenge because sugarcane is not a traditional crop in this region. The purpose of this paper is to understand the factors determining the location decision of ethanol mills in new producing areas. For the analysis, we focus on the new sugarcane ethanol plants in Goiás and Mato Grosso do Sul, we developed a probit and a spatial autoregressive probit model that incorporates agricultural conditions, distance to markets, infrastructure, and policy. The results indicate that counties with agricultural tradition have a higher probability of a mill locating there (0.0918). The presence of rural syndicates in a county increases the likelihood of a mill deciding to locate in that county by 0.083. The county’s distance to an operating mill in 2002 decreases in 0.00006 the probability of a new mill locating in that county. Policymakers should focus on policies that promote the institutional organization of producers, development of the transportation infrastructure, and utilize the agricultural tradition to attract new mills.

1. Introduction

Global demand for biofuels has sharply increased since the 2000s because of higher oil prices and the impact of fossil fuels on the environment [1–3]. This expanding market has attracted investments into the production of biofuels, resulting in an increase from 49 hm³ in 2007 to > 90 hm³ in 2012 [4]. The top two producing countries, the United States and Brazil, witnessed the construction of 114 and 80 new ethanol plants between 2006 and 2012, respectively. The location decision of an ethanol plant has an important role in the successful operation of the enterprise [5–7]. Ethanol plants are supply-oriented firms that need to be located near agricultural feedstocks to ensure access and reduced costs of acquisition [8]. This strategy becomes more important in the sugarcane ethanol industry because sugarcane, the main input in ethanol production, requires immediate processing after harvest to avoid the loss of the sugar content.

Brazil has a history of successfully adopting ethanol fuel in the transportation sector. Brazilian consumers have been using sugarcane ethanol blended with gasoline in their vehicles since the 1930s. Cars that ran solely on ethanol became available in the 1980s [9]. More recently, with the introduction of flex-fuel cars technology in 2003, consumers can decide the proportion of ethanol and gasoline to use at the pump; with ethanol being selected when its price is 30% cheaper than gasoline considering ethanol’s efficiency [10]. This technology, together with competitive ethanol prices, has stimulated the consumption of ethanol in Brazil. Under these circumstances, the Brazilian sugarcane ethanol industry has increased its production capacity to meet the rising demand for ethanol [11]. To achieve this growth, the industry has expanded into the Brazilian cerrado, especially in the states of Goiás and Mato Grosso do Sul [12–14]. Expansion of the sugarcane ethanol industry into the new frontier is a challenge because sugarcane is not a traditional crop in this region. Nevertheless, these two states produced 6 hm³ in 2014, representing 23% of all Brazilian ethanol for that year [15].

Previous research on the rapid development of the ethanol industry focused on the case of corn ethanol produced in the USA. These studies...
show that the presence of corn is a major factor in the location decision process \[8,16,17\]. Additionally, infrastructure (i.e., railroads and navigable rivers) and governmental policies (i.e., ethanol subsidies, zoning guidelines) are also considered relevant factors for this process \[5–7\]. The location of ethanol plants has been associated with economic development in the host counties as well \[5,8,18\]. However, which factors influence the location decision of ethanol plants in new areas is not well established, especially areas with no tradition in growing the required feedstock \[19\]. Indeed, this is the case of the sugarcane industry expansion to the Brazilian Cerrado. The location decision of ethanol plants (sugarcane mills) in the states of Goiás and Mato Grosso do Sul may differ from previous studies on ethanol plant location because of the necessity to develop sugarcane fields and to identify suppliers within a 50-km radius of the mill \[20\]. Knowledge about the location decision process is important for policymakers and county governments interested in the continuous expansion of ethanol industry to new regions \[19,21,22\].

The purpose of this paper is to understand the factors explaining the location decision of ethanol mills in new producing areas. For this analysis, we focus on the new sugarcane ethanol plants in the states of Goiás and Mato Grosso do Sul, two relevant ethanol-producing states that constitute the new frontier for sugarcane ethanol production in Brazil. To achieve this goal, a spatial autoregressive probit (SAR probit) and a probit regression model are estimated. The dependent variable is the mill’s location in a given municipality. Explanatory variables are derived from location theory, including county distance to a mill, distance to major market, transportation, and institutional factors. Moreover, factors related to agricultural production are also considered as explanatory variables, such as the area in agricultural production before the sugarcane expansion and areas suitable for further expansion. This paper contributes to the development of the literature on ethanol plant location in several novel ways: (i) by examining an integrated decision over industrial and agricultural aspects; (ii) considering infrastructure, agriculture, and institutional characteristics of counties that influence location decisions; and (iii) providing local and regional recommendations for policymakers for assisting in the development of a new ethanol-producing region that can be generalized to other countries.

2. Brazilian sugarcane ethanol industry

Brazil has a long and successful history of ethanol production and consumption \[23\]. The ethanol industry had been investing in São Paulo State because of: lower transportation and agricultural production costs; a favorable sugarcane growing environment; and the availability of sugarcane varieties suitable for production in São Paulo along with the production know-how \[10\]. Governmental intervention in the sector was substantially reduced in the 1990s when the government began the process of deregulation of the sugarcane sector \[24\]. After deregulation, the sugarcane industry concentrated even more in São Paulo, leading to the consolidation of the industry followed by strong competition for sugarcane areas \[12,13\]. Consequently, sugarcane ethanol mills were forced to expand elsewhere.

The sugarcane expansion into the states of Goiás and Mato Grosso do Sul, initiated in the mid-2000s, transformed these two states into the second largest producing areas for ethanol and sugar after São Paulo. Fig. 1 illustrates the expansion for the period of 2005–2013. In this time, 32 new mills started operations in these states promoting an expansion in the total area planted with sugarcane from 3000 km² in 2005 to over 14,000 km² in 2013, representing 17% of the total sugarcane area in Brazil.

The production profile of the new frontier is remarkably concentrated in the hydrous ethanol market where these states accounted for 30% of Brazil’s hydrous ethanol production in 2015–2016 \[15\]. The production of hydrous ethanol is advancing fast in Goiás and Mato Grosso do Sul, already representing 68% of São Paulo’s production – the current main producing state in Brazil. Nevertheless, when we consider the sugar market, Goiás and Mato Grosso do Sul have been unable to increase their share as fast as they have in the ethanol market. These states represent 15% and 10% of sugar production in São Paulo and Brazil, respectively \[15\]. The preponderance of ethanol over sugar production in the new frontier is an outcome of the business orientation of the mills. The new mills were built to supply hydrous ethanol to meet demand in Brazil, resulting in a larger proportion of ethanol mills in the region when compared to the consolidated sector in São Paulo: 49% vs. 21%, respectively \[12,25\].

With the withdrawal of government intervention, the relationship between the industry and farmers has become an area of contention \[26\]. The ethanol industry had become increasingly more vertically integrated. The decision to vertically integrate is a strategy to reduce transaction costs and guarantee feedstock for the mill \[27\]. In the crop year of 2011–2012, the industry produced 64% of the sugarcane it has processed, the remaining 36% was acquired from nearby farmers \[25\]. This industrial model has been implemented in the expansion of the new frontier \[13,28\]. Industry-controlled sugarcane production in Goiás and in Mato Grosso do Sul accounts for 76.8% and 73.4% of the sugarcane crushed by the mills in each state, respectively \[25\]. Industry participation in agricultural production is more intense in the new frontier because farmers in this region lack experience in growing sugarcane.

Following the fast expansion of the sugarcane industry in the beginning of the 2000s, the Brazilian government issued a Sugarcane Agroecological Zoning policy to ensure the sustainability of sugarcane expansion. The zoning mapped areas suitable for sugarcane expansion in the country using the following criteria: areas with a slope smaller than 12° to facilitate harvest mechanization; areas with adequate soil; areas suitable for sugarcane production without irrigation; areas outside of the Amazon and the Pantanal biomes; and areas without native vegetation. Conversion of areas under pasture is preferred to the conversion of cropland in order to reduce impacts on food production \[14,29\]. Goiás and Mato Grosso do Sul have the largest areas classified as suitable for sugarcane expansion. Together, they account for 230 000 km² of suitable areas representing 35% of all the zoning areas for expansion in Brazil \[29\].

Another contribution to this positive scenario for the location of ethanol mills into the center-west region was the development of a transportation network connecting the region to the Brazilian and global markets. Although most of the agricultural production of the area is transported by trucks, there are new projects aiming to diversify the current transportation system. The goal is to have a more cost-efficient transportation solution for the bulk products that the region exports by offering new railroads, waterways, and pipelines sponsored by the government and the private sector \[30\]. The main example is the ethanol pipeline project connecting the southern portion of Goiás to São Paulo (domestic market) and to the Santos’ port to export ethanol with more than 1300 km of pipeline. The first phase of the pipeline construction finished in 2013, connecting the main producing region in São Paulo to the main distribution center. However, the next construction phase is facing a major financial challenge, and the extension to Goiás has not started \[31\].

3. Methods and data

3.1. Location theory model

Location is a fundamental decision for ethanol mills because they are supply-oriented firms; hence input acquisition dominates a firm’s cost structure \[8\]. This, in turn, means that mills are likely to be located close to their input sources to minimize the costs associated with obtaining feedstock \[32\]. Apart from evaluating the potential for a new location based on revenue factors, such as market penetration and access to the transportation network, a firm also considers factors that
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