RELATIONSHIP BETWEEN PERFORMANCE AND CAPITAL STRUCTURE: EVIDENCE FROM THE SUGAR-ENERGY INDUSTRY IN BRAZIL

Haroldo José Torres da Silva[1]; Pedro Valentim Marques[2]

[1] Ph.D. in Applied Economics from Universiy of São Paulo. E-mail: haroldo@pecege.com
[2] Senior Professor at Universiy of São Paulo, "Luiz de Queiroz" College of Agriculture (ESALQ/USP). E-mail: pvmarque@usp.br

Resumo

Este artigo investiga a relação entre performance e estrutura de capital das empresas de açúcar e etanol no Brasil. Em particular, abordam-se as seguintes questões: *i)* a maior alavancagem leva a um melhor desempenho da empresa? e *ii)* a eficiência exerce um efeito significativo sobre a alavancagem, além das métricas financeiras tradicionais? De forma a responder ambas as questões, o artigo se ampara em duas hipóteses, *i)* uma maior alavancagem reduz os custos de agência, bem como a ineficiência e, assim, leva a uma melhoria no desempenho da empresa, como preconizado por Jensen e Meckling (1976) (H_0) e *ii)* em sentido reverso, as empresas com melhor desempenho optam por menores níveis de alavancagem - hipótese eficiência-risco (*efficiency-risk hypothesis*) (H_2), conforme proposição de Berger e Bonaccorsi di Patti (2006). Utilizando-se dados anuais de uma amostra de usinas de açúcar e etanol, localizadas no Brasil, entre 2006 e 2015, não se descarta a hipótese do custo de agência dos acionistas externos junto ao setor sucroenergético brasileiro, de forma que uma maior alavancagem está associada a um melhor desempenho da empresa, especificamente, para empresas com níveis de dependência financeira superiores a 57,52%. Além disso, avalia-se a causalidade reversa entre desempenho da empresa e a dependência financeira através de duas hipóteses concorrentes: a hipótese eficiência-risco (*efficiency-risk hypothesis*) (H_2) e a hipótese do valor de franquia (*franchise-value hypothesis*) (H_{2a}). Utilizando a análise de regressão quantílica, constata-se que há um efeito negativo entre o desempenho da empresa e a sua alavancagem para todos os valores de eficiência até cerca de 0,57, indicando que a hipótese eficiência-risco não é válida para todos os valores relevantes de eficiência. No setor sucroenergético brasileiro, fica evidente o impacto da alavancagem sobre o desempenho das empresas e vice-versa. Aditivamente, o tamanho da empresa, a tangibilidade de seus ativos, a idade, a liquidez corrente e a categoria da propriedade (empresa familiar ou não) foram fatores relevantes na determinação da alavancagem das usinas de açúcar e etanol.
Palavras-chave: Eficiência; Endividamento; Alavancagem; Setor sucroenergético
Códigos de Classificação JEL; C58; G32; L25
Anpec: 8

Abstract

This paper investigates the relationship between the performance and capital structure of sugar and ethanol mills in Brazil. In particular, we address the following questions: i) Does higher leverage lead to better company performance? ii) Does efficiency have a significant effect on leverage above traditional financial metrics? To answer both questions, the article relies on two hypotheses: i) higher leverage reduces agency costs and inefficiency, leading to an improvement in company performance, as stated by Jensen and Meckling (1976) (H_0), and ii) companies with better performance opt for lower leverage (efficiency-risk hypothesis) (H_2), as proposed by Berger and Bonaccorsi di Patti (2006). Using annual data from 2006 to 2015 from a sample of sugar-energy mills in Brazil, our results do not reject the hypothesis of the agency cost of external shareholders in this industry, and we found that greater leverage is associated with better mill performance, specifically for mills with levels of financial dependence greater than 57.52%. In addition, we assess the reverse causality between mill performance and financial dependence through two competing hypotheses: the efficiency-risk hypothesis (H_2) and the franchise value hypothesis (H_{2a}). Using quantile regression analysis, we find a negative effect of company performance on leverage for all efficiency values up to roughly 0.57, indicating that the efficiency-risk hypothesis is not valid for all efficiency values. In the Brazilian sugar-energy industry, the impact of leverage on mill performance is evident. Additionally, we also found that mill size, the tangibility of its assets, its age, its current liquidity, and whether the mill is family owned or not to all be relevant factors in determining the leverage of sugar-energy mills.
Keywords: efficiency, indebtedness, leverage, sugar-energy industry
JEL Classification Codes: C58; G32; L25
Anpec: 8

1. Introduction

The sugar-energy industry in Brazil experienced significant growth following the establishment of the National Fuel Alcohol Program (*Proálcool*), which began in 1975 with the large-scale production of ethanol in the country. A new cycle of rapid growth in the sector was observed in the 2000s, after the introduction of flex-fuel vehicles. However, since the 2010s, the trajectory of the sector has been marked by crises characterized by persistent financial difficulties, high debt levels, and low mill profitability (Santos *et al.*, 2016).

Over the past few years, the most researched topics regarding the Brazilian sugar-energy industry have included the above-mentioned items, in addition to those that addressed the effects of weather on sugarcane productivity (Marin et al., 2013) and the commitment of agribusiness revenue to financial expenditure in the industry (El Montasser et al., 2015; Ramos, 2018). While the Brazilian industry has at one point consisted of up to 500 sugarcane mills, only 371 active units existed in the country in 2018 (Brasil, 2019). This decrease was due to either the bankruptcy or closing of mills that resulted from weather adversities and a crisis that devastated the sugar-energy industry in the first half of the 2010s, both of which impacted the productivity of sugarcane fields (Ramos, 2017; Rissardi Júnior, 2015; Siqueira, 2013).

Beginning in 2008, the worsening financial situation of mills led to the entry of new actors into sugarcane production, significantly altering the corporate and organizational configuration of the industry (Vian *et al.*, 2017). Since, the sector has experienced a stagnation in total recoverable sugar production per hectare (TRS/ha). Investment in greenfield projects essentially ceased and mills began to close, beginning a new era of crisis for the sugar-energy industry. Between 2008 and 2015, 96 units ceased their activities in the country (EPE, 2017; UNICA, 2017), despite the size and potential of the industry.

We therefore observe that the Brazilian sugar-energy industry was affected by several problems related to economics, finances, and operations following the international financial crisis of 2008. This supports the claim that a high level of debt in the industry contributed to a reduction in investment in sugarcane production and, consequently, to lower agricultural productivity, further aggravating the situation of mills. Although the causes and consequences of the crisis of the sugar-energy industry have been widely discussed in the economic literature (Mendonça et al., 2012; Rezende and Richardson, 2015; Santos et al., 2016; Vian et al., 2017), no studies have analyzed the capital structure of mills and its impact on mill performance.

To illustrate the need for resources in the sector, we note that the agroindustrial cash cost of the 2017/2018 harvest was R$ 98.33/tonne[1] of processed sugarcane in the state of São Paulo (PECEGE, 2018). Mills must maintain a certain level of cash for both recurrent and exceptional activities, including unplanned transactions or transactions resulting from the vulnerabilities of a business, such as weather adversities or operational losses. As a result, the sugar-energy industry demands a significant volume of monetary resources annually-resources that are used to guarantee its activities, including the renewal of sugarcane fields, crop treatment, machinery and equipment maintenance, and industrial processing, among others.

The resources used to finance the activities of the industry can be derived from the cash flows of mill operations, in addition to those contributed by shareholders (equity) and obtained from financial institutions and trading partners (debt). The type of financing and access to financial resources for investment can influence the cost of capital of mills and consequently affect their performance.

A greater of share of debt in a company's capital structure - that is, higher leverage - can lead to a higher risk of dissolution and liquidation of the company. Moreover, during crop seasons with greater difficulties, higher leverage has a negative impact on mill performance (Campello, 2003; Opler and Titman, 1994). Alternatively, an increase in financial leverage is expected to reduce information costs, reduce inefficiency, strengthen management, and thus improve the performance of the company (Fosu, 2013; Jensen, 1986; Jensen and Meckling, 1976).

Martins et al. (2015) argue that a high level of debt of a company, especially of a sugar-energy mill, results in a variety of consequences, including i) an increase in interest rates on new loans and financing, ii) difficulties with accessing credit due to constraints and limitations of credit guarantees, iii) a loss of flexibility in the allocation of financial resources, and iv) a reduction in investment, thus preventing a faster recovery of the industry. In this article, we focus on empirically evaluating the effects of capital structure on the performance of sugar-energy mills in Brazil, and vice versa, from 2006 to 2015.

The objectives of this article are to i) evaluate the effect of leverage on mill performance, using the agency cost model of Jensen and Meckling (1976); ii) discuss the determinants of debt levels among mills; and iii) verify the performance[2] of mills - specifically, whether mill performance affects capital structure, and if this effect is similar across different capital structures. The two central hypotheses of this article are as follows: i) greater leverage reduces agency costs and inefficiency, and thus leads to an improvement in mill performance (H_0), and ii) conversely, the best performing

[1] According to PECEGE (2018), an average sugar-energy mill in the state of São Paulo processed 2,405,991 tonnes of sugarcane in the 2017/2018 harvest. This implies a total industry processing cost of R$ 236.6 million.

[2] This article will use an estimate of efficiency that is derived from a DEA model (data envelopment analysis) to evaluate the role of leverage in resolving agency conflicts in the Brazilian sugar-energy industry.

mills opt for higher leverage (efficiency-risk hypothesis) (H_2). We specifically examine whether leverage has a positive effect on efficiency (or vice versa), and if this pattern is consistent across the spectrum of different capital structures.

Given the importance of the sugar-energy industry in agribusiness, an understanding of the capital structure and the factors determining the indebtedness of sugar-energy mills is critical, and this study proposes to contribute to this understanding. Despite the relevance of the topic, no study[3] has yet analyzed the impacts of capital structure on the performance of mills (or vice versa). The studies available, such as those by Rodrigues and Rodrigues (2018), Martins et al. (2015), and Noriller et al. (2011), are limited to analyses on the evolution of economic and financial indicators, without necessarily discussing mill performance. Thus, this article seeks to close the gap in the economic literature regarding the relationship between the performance and capital structure of sugar-energy mill in Brazil.

The paper is organized as follows: i) the next section presents a brief review of literature on the relationship between mill performance and capital structure; ii) Section 3 describes the methodology used in the empirical model and variables); iii) Section 4 discusses the results of the study; and iv) Section 5 presents the conclusions of the paper.

2. Literature review

2.1 Relationship between mill performance and capital structure

A vast literature contains the theoretical arguments of the determinants of a company's capital structure (Harris and Raviv, 1991; Jensen and Meckling, 1976; Modigliani and Miller, 1958; Myers, 1977; Titman and Wessels, 1988). In addition, a company's performance is also influenced by its level of indebtedness, and vice versa (Berger and Bonaccorsi di Patti, 2006; Margaritis and Psillaki, 2010). Section 1.2.1.1 is dedicated to analyzing the effects of capital structure under corporate performance, while section 1.2.1.2 discusses the reverse causality between mill performance and capital structure.

2.1.1 Impact of leverage on company performance

As presented by Jensen and Meckling (1976), an agency relationship consists of a contract under which shareholders (principal or director) hire another individual (agent) - in this case, managers - to execute the management of the company on their behalf, which implies the delegation of decision-making power to the agent. In this same vein, the agency theory, which analyzes the problem of an agency's principal agent or dilemma, which asserts that the interests[4] of the principal and agent are not always perfectly aligned, generating, in turn, conflicts and agency costs.

Conflicts arise when managers coordinate activities and actions with a view to maximizing their own usefulness, rather than maximizing the value of the company, which corresponds to the objective of external shareholders. As a result, agency conflicts arise when managers make decisions regarding investment, financing, and dividend policies (Rodrigues, 2015). In their own interests, managers can use free cash flow[5] to, for example, consume excessive gratuities or invest in dubious or high-risk projects.

High levels of indebtedness can impose investment discipline on managers, drive them to reduce waste, and ultimately pressure them to generate cash flows to meet debt commitments (interest and amortization). In these situations, debt has a positive effect on the value of the company; specifically, financial leverage (or a low net worth to total assets ratio) acts as a disciplinary mechanism in the mitigation of agency costs and thus contributes to an improvement in the performance[6] of the company (Fama and French, 2001; Jensen, 1986). Thus, the hypothesis of the agency cost of external shareholders (H_o) assumes that high levels of leverage reduce the agency costs of external shareholders, increase the value of the company by restricting or encouraging managers to act more in line with the interests of shareholders, and increase mill performance.

Governance structure can enable increased levels of financial leverage, reduce costs to the agency, and, consequently, improve the performance of the company by: i) the threat of company wind up and liquidation, which allows for personal losses to managers in the form of wages and salaries, privileges, and benefits (Grossman and Hart, 1982; Williams, 1987); ii) the pressure to generate positive cash flow to meet debt commitments (Jensen, 1986); iii) the mitigation of conflicts between the principal and the agent, with respect to making investments (Myers, 1977); iv) the risks assumed

[3] This is one of the first studies to consider the association between productive efficiency and leverage in the Brazilian sugar-energy industry. Any studies analyzing the relationship between performance and capital structure in the Brazilian sugar-energy industry are unknown.
[4] “If both parts of the relationship are useful maximizers, there are good reasons to believe that the agent will not always act in the interests of the principal” (Jensen and Meckling, 1976, p. 308).
[5] Free cash flow to equity (FCFE) is the cash available following the payment of debts and reinvestment needs; specifically, it is equivalent to the cash flow that could be paid as dividends (Damodaran, 2004). Jensen (1986) calls this situation the "free cash flow theory” or the "free cash flow hypothesis."
[6] The conceptual link between productive efficiency and agency costs was initially presented by Stigler (1976), who suggested that the choice of capital structure can help mitigate agency costs.

(Jensen and Meckling, 1976; Williams, 1987); and v) the policy for dividends (Fama and French, 2001; Jensen, 1986; Jensen and Meckling, 1976; Rodrigues, 2015; Stulz, 1990).

While increasing leverage may reduce the agency costs of external shareholders, the opposite effect may arise in relation to the company's debt agency costs-where higher leverage could result in lower efficiency. For example, creditors will require higher interest rates to offset the higher level of risk assumed that arises from possible financial problems or the possible bankruptcy of the company, given its high level of leverage.

Agency costs may also emerge from the relationship between capital providers, specifically between creditors (debt) and shareholders (equity investors), when a risk of default is present. In this situation, according to Myers (1977), problems of underinvestment or of debt overhang may arise, in which a leveraged company[7] reduces its investment-particularly in more profitable projects or in relation to better operational performance strategies-as creditors capture most of the benefit from projects, resulting in low levels of return to shareholders.

The presumption that creditors benefit more than shareholders can contribute to a company avoiding new investment opportunities that could positively contribute the company's market value. In a leveraged company, especially those on the verge of default, the level of debt is a limiting variable in the evaluation of new projects and investment opportunities, which have a higher risk of not being financed since the cash flow generated must be first used to honor debt commitments (Milanez, 2012). In this case, leverage has a negative impact on investment and therefore on the value of the company, as argued by Myers (1977)[8].

Nonetheless, while the agency costs of external shareholders contribute to the positive effect of leverage on company performance, the agency costs of debt have a negative effect on company performance. Thus, as highlighted by Jensen and Meckling (1976), we expect that the effect of leverage on mill performance is not monotonic.

2.1.2 Reverse causation between mill performance and capital structure

Capital structure has an impact on mill performance. However, mill performance may also affect the determination of its capital structure, implying the possibility of reverse causality of mill performance on capital structure. In addition to the classic determinants of capital structure, Berger and Bonaccorsi di Patti (2006) formulated two hypotheses to analyze the relationship between a company's performance and its capital structure: i) the efficiency-risk hypothesis (H_2) and ii) the franchise value hypothesis (H_{2a}).

Under the efficiency-risk hypothesis, the firms with best practices can opt for greater financial leverage, as their higher efficiency reduces the cost of potential bankruptcy and financial difficulties. Under this hypothesis, for a given capital structure, efficiency is positively associated with the expected level of return. This increased efficiency to a certain extent replaces investor equity debt (Berger and Bonaccorsi di Patti, 2006). Differences in efficiency allow companies to adjust their capital structure so that efficiency gains replace equity against bankruptcy and insolvency costs (Rebelo, 2016).

In contrast, the franchise value hypothesis focuses on the income effect generated by efficiency in determining capital structure. The economic revenues derived from efficiency prompt shareholders to make additional contributions as a way of avoiding income losses in the event of the company's liquidation. Companies with high levels of efficiency attempt to protect expected results by obtaining incremental equity. Firms with best practices opt for lower levels of leverage and, consequently, greater equity participation to protect their incomes or the value of the company in a possible situation of wind up and liquidation. Thus, in addition to the substitution effect, the relationship between efficiency and capital structure can also be characterized by the presence of an income effect.

Even best practice firms face a tradeoff between the benefits of greater leverage (primarily tax benefits) and the possible costs and financial difficulties of honoring debt commitments. A value-maximization company would operate at the point where benefits are equal to expected costs, although they could opt for higher or lower levels of indebtedness, as recommended by the efficiency-risk and franchise value hypotheses (Berger and Bonaccorsi di Patti, 2006; Demsetz and Villalonga, 2001).

The efficiency-risk hypothesis and franchise value hypothesis present opposing views on the effects of company performance on capital structure and thus, on leverage. The first focuses on the substitution effect, while the second, on the income effect. The empirical analysis of this study aims to determine the net effect derived from these hypotheses-rather, whether one effect has dominance over the other in determining capital structure and follows the methodology of Berger and Bonaccorsi di Patti (2006), Cheng and Tzeng (2011), Margaritis and Psillaki (2010), and Rebelo (2016).

3. Methodology

[7] "A firm with risky debt outstanding, and which acts in its stockholders' interest, will follow a different decision rule than one which can issue risk-free debt, or which issues the debt at all" (Myers, 1977, p. 149).

[8] According to Myers (1977) and Galai and Masulis (1976), the value of a company can be influenced by financing decisions. However, this theory contrasts with that of Modigliani and Miller (1958), who argued that investment decisions can be made independent of financing decisions.

This section is divided into two parts. The first contains the specification of the empirical model, and the second details the variables used in the econometric models and provides a description of the data and the sample.

3.1 Empirical model

We used two equations, both regression models with panel data, to test the hypotheses in this analysis. We first present an equation of mill performance to test the hypothesis of the agency cost of external shareholders (H_o) and second, we use an equation of mill leverage to test the hypothesis of reverse causality (efficiency-risk hypothesis and franchise value hypothesis).

3.1.1 Mill performance

The agency cost hypothesis tests are generally performed using regressions of the company's performance measures in relation to leverage, in addition to other control variables (Berger and Bonaccorsi di Patti, 2006). Thus, following the premises of the agency cost model, and allowing backward effects in the specification of the empirical model, the regression to estimate the performance of the Brazilian mills, as presented by Margaritis and Psillaki (2010), is given by Equation (1):

$$EE_{i,t} = \alpha_0 + \alpha_1 LEV_{i,t-1} + \alpha_2 LEV_{i,t-1}^2 + \alpha_3 Z_{1i,t-1} + u_{i,t} \tag{1}$$

Where $EE_{i,t}$ is the performance measure of each mill i in time period t; $LEV_{i,t-1}$ is the leverage of mill i in time period t-1; $Z_{1i,t-1}$ is a vector of co-variables (control variables); and $u_{i,t}$ is the stochastic disorder (stochastic error term).

Considering the hypothesis of agency cost, the effect of financial dependence (LEV) on the efficiency score should be positive, so that $\alpha_1 > 0$ and $\alpha_1 + 2\alpha_2 LEV_{i,t-1} > 0$. Meanwhile, in situations where the level of financial dependence-and hence of leverage-is sufficiently high, its effect on the efficiency score may be negative.[9]

The quadratic specification of Equation (1) is consistent with the possibility that the relationship between the efficiency score and financial dependence is not monotonic-or rather, the relationship may be positive or negative, depending on the level of leverage. Financial dependence will have a negative effect on the efficiency score for the values that meet the conditions of Equation (2).

$$LEV_{i,t-1} < \frac{-\alpha_1}{2\alpha_2} \tag{2}$$

The condition to guarantee the inverse relationship between the variables $EE_{i,t}$ and $LEV_{i,t-1}$ is that $\alpha_2 < 0$. The control variables included in Z_1 contain the characteristics of each mill and are presented in Section 1.3.2.1 (items from iii to xi). In capital structure theory, antagonistic hypotheses prevail in certain situations. However, as signaling, information costs, and corporate control issues play an important role in determining capital structure, these variables will comprise the vectors Z_1 and Z_2.

3.1.2 Leverage model

Due to the possibility of reverse causality of mill performance on the mill's capital structure, we will estimate Equation (3). Here, we aim to test the two hypotheses of mill performance (the efficiency-risk hypothesis and the franchise value hypothesis) on the mill's capital structure.

Our regression to estimate mill leverage, according to the mill's performance measure and other factors previously identified in the literature-included in the vector Z_2-is given by Equation (3).

$$LEV_{i,t} = \beta_0 + \beta_1 EE_{i,t-1} + \beta_2 EE_{i,t-1}^2 + \beta_3 Z_{2i,t-1} + v_{i,t} \tag{3}$$

[9] The most leveraged companies tend to face credit restrictions that prevent them from adjusting the relationship between capital (K) and labor (L) and consequently obtaining an efficient allocation of the factors of production (Spaliara, 2009). In addition, according to Sharpe (1994), highly leveraged companies are less likely to accumulate labor compared to less leveraged companies. In this respect, a range of studies has analyzed the negative effects of leverage and debt on labor (L): Benito and Hernando, 2008; Cantor, 1990; Nickell and Nicolitsas, 1999. Furthermore, high financial dependence can have a negative effect on the performance of companies with strong growth opportunities (Jensen, 1986; McConnell and Servaes, 1995; Myers, 1977).

Where $LEV_{i,t}$ is the leverage of mill *i* in time period *t*; $EE_{i,t-1}$ is the performance measure of each mill *i* in the time period *t-1*; Z_2 is a vector of co-variables (control variables); and $v_{i,t}$ is the stochastic disorder (stochastic error term). The control vector Z_2 contains all variables of Z_1, in addition to the variable *CURRENCY*. Therefore, unlike Z_1, the control vector Z_2 contains an additional variable - *CAMBIO*.

Under the efficiency-risk hypothesis, efficiency has a positive effect on leverage, so that $\beta_1 > 0$ and $\beta_1 + 2\beta_2 EE_{i,t-1} > 0$. The condition to guarantee the U-shaped inverse ratio of $LEV_{i,t}$ over $EE_{i,t-1}$, is that $\beta_2 < 0$. However, mill performance will have a negative effect on leverage for the values that meet the conditions of Equation (4).

$$EE_{i,t-1} < \frac{-\beta_1}{2\beta_2} \tag{4}$$

3.2 Selected variables, data, and sample

The first part of this section consists of a description of the variables used the model, in addition to a presentation of the theoretical and empirical bases for the selection of these variables and the sign expected for each of the estimated parameters. The second part of this section provides details of the data and the sample.

3.2.1 Selected variables

We first present the dependent variables of Equations (1) and (3). We then review the variables that compose the vectors Z_1 and Z_2.

i. Mill performance (EE)

In the economic literature, we find several measures for capturing mill performance and testing the hypothesis of the agency cost of external shareholders. These measures include i) financial indices derived from the company balance sheet (BP) and the profit and loss statement (P&L) (Ang et al., 2000); ii) the return on mill shares and share volatility (Cole and Mehran, 1998); and iii) Tobin's q, resulting from the ratio of the value of the mill to the replacement value of its assets (Zhou, 2001).

This study uses the approach presented by Margaritis and Psillaki (2007, 2010), in which the performance of Brazilian sugarcane mills is measured by an efficiency score obtained by a DEA model (data envelopment analysis) on an input-oriented basis, assuming constant returns to scale (CRS).

We composed our DEA model of two input variables and two output variables. Our two input variables included to measure the resources used in production were i) the sugarcane processing of each mill, in tonnes, over the years and ii) fixed assets, in thousands of reais (BRL), at constant 2015 prices. In this case, we used the centered General Price Index - Internal Availability (IGP-DI)[10] as a deflator. Meanwhile, our two output variables were i) total ethanol production (anhydrous and hydrated) in thousands of cubic meters (m^3) and ii) total sugar production (VHP, granulated, demerara, etc.) in thousands of tonnes.

Theoretically, the ability of a mill to improve its performance (efficiency scores) in relation to a best practice frontier-or in relation to the best industry performance-will depend on its level of leverage. Following Leibenstein (1966), our performance measure was used as a proxy for agency costs, derived from the discrepancy between a mill's capacity and its actual production. Using this measure, we can compare mills of similar technologies with their best practice frontier peers.

ii. Debt participation (LEV)

Known as financial dependence[11], LEV represents the proportion of a company's total resources (total assets) that are financed by debt-or rather, from sources of financing other than their own (Assaf Neto and Lima, 2014). The calculation of financial dependence is given by Equation (5).

$$LEV_{i,t} = \frac{Liabilities_{i,t}}{Total\ assets_{i,t}} \tag{5}$$

Where $Liabilities_{i,t}$ corresponds to the sum of current liabilities and the long-term debt of mill *i* in period *t*.

[10] Calculated from the geometric mean of the values of the current and subsequent month (months *t* and *t+1*) of the original General Price Index - Internal Availability (IGP-DI).

[11] We use share of debt as a proxy for financial leverage. Without distinction, in this study, any mention of leverage refers to the share of debt in the capital structure of the mill, or to the financial dependence of the mill.

Capital structure and, consequently, financial dependence, are important determinants of company performance (Brander and Lewis, 1986; Maksimovic, 1988). The effect of leverage on the performance of the mills is expected not to be monotonic, and thus we also include the square of this variable in the model to allow non-linearity in LEV.

Below we present the variables that compose the vectors Z_1 and Z_2 in Equations (1) and (3). Following the economic literature, the variables correspond to the determining factors[12] and level of indebtedness of sugar-energy mills in Brazil.

iii. Mill size (SZ)

The size of a mill can be represented by the volume of its sales, so we use the natural logarithm of net operating revenue as a proxy to measure mill size.

We expect the sign of this variable to be positive in the efficiency score in Equation (1), since larger mills are expected to use superior technology. Additionally, these mills may also enjoy economies of scale through the dilution of fixed costs, which leads to an optimal level of production costs and management ownership (Himmelberg et al., 1999).

However, mill size has an ambiguous effect *a priori* on moral hazard. The largest mills may present inefficiencies and incur higher monitoring and agency costs, increasing the desired size of management structure. According to Williamson (1967), such a situation brings decreasing returns of scale. The non-linear effect of mill size (SZ) on efficiency ($EE_{i,t}$) will become more flexible in the model by including the square of the natural logarithm of net operating revenue (SZ2), as proposed and performed by Himmelberg et al. (1999) and by Margaritis and Psillaki (2010).

iv. Tangibility (TANG)

Tangibility represents the proportion of property, mill, and equipment-given by the item, fixed assets-in the total assets of the company, as used by Rajan and Zingales (1995) and presented by Equation (6).

$$TANG_{i,t} = \frac{Fixed\ assets_{i,t}}{Total\ assets_{i,t}} \quad (6)$$

The indicator of tangibility is easily monitored to mitigate agency conflict and provides a good measure of collateral. Thus, the greater the tangibility, the greater the ability to take on debt using physical assets as collateral. In addition, greater tangibility presents a higher liquidation value, which mills can exercise when in a delicate financial situation. The greater the tangibility, the less difficulty in obtaining external financing, as a result of less asymmetry of information and, consequently, greater leverage (Harris and Raviv, 1991; Titman and Wessels, 1988).

v. Intangibility (INT)

Intangibility reflects the ratio of intangible assets to equity capital employed by a mill, as seen in Equation (7).

$$INT_{i,t} = \frac{Intangible\ asset_{i,t}}{Net\ equity_{i,t}} \quad (7)$$

This variable represents future opportunities[13] for growth, as presented by Myers (1977). However, the effect of intangibility on mill performance may be ambiguous, especially if these opportunities result from excessive risk behavior towards equity (Titman and Wessels, 1988).

vi. Mill quality (QDE)

Asset turnover will be used as a proxy for the quality of a mill, since it identifies the degree of efficiency with which mill assets are used for the effective generation of revenue (Assaf Neto and Lima, 2014). Specifically, it measures how many times net sales have covered, over a given period of time, the mill's total assets, according to Equation. (8).

$$QDE_{i,t} = \frac{Net\ operating\ revenues_{i,t}}{Total\ assets_{i,t}} \quad (8)$$

Highly efficient mills choose to avoid the burden of paying long-term interest and consequently prefer more short-term debt in their capital structure. The higher the turnover of the asset, the better the quality of the mill and the shorter the maturity of the debt (Stephan et al., 2011). Indirectly, considering the signaling hypothesis based on asymmetric information theory, mills with short-term debt send a signal that they are low-risk and therefore highly efficient (Diamond, 1984, 1991; Flannery, 1986; Stephan et al., 2011).

[12] In addition to the variables presented in this section, according to Gleason et al. (2000), the determinants of corporate indebtedness have a strong correlation with the cultural, legal, political, economic, and technological environments.
[13] Intangible assets constitute additional mill purchase options in future periods (Myers, 1977).

vii. Age (AGE)

In this study, AGE will be given by the natural logarithm of the difference between the reference year and the year of the mill's opening with The Department of Federal Revenue of Brazil (*Receita Federal do Brasil*) (Brasil, 2018).

As mills age, more information about them becomes available and they establish a market reputation, thereby generating less information asymmetry. In addition, a negative relationship exists between the age of a mill and its financial dependence, resulting in lower indebtedness in its capital structure (Bandyopadhyay and Barua, 2016; Petersen and Rajan, 1994).

viii. Profitability (RENT)

The profitability of a mill can be expressed by earnings before interest and taxes (EBIT) in relation to the total of its assets, according to Equation. (9).

$$RENT_{i,t} = \frac{EBIT_{i,t}}{Total\ assets_{i,t}} \tag{9}$$

Profitability reflects how effectively the mill is using its assets to generate profit before the payment of contractual obligations. Here, a positive effect of (past) profitability on the efficiency of a mill is expected, as noted by Margaritis and Psillaki (2007).

ix. Current liquidity (LC)

We measure the relationship between current liabilities and current assets as presented in Equation (10) and performed by Stephan et al. (2011).

$$LC_{i,t} = \frac{Current\ assets_{i,t}}{Current\ liabilities_{i,t}} \tag{10}$$

The current liquidity index represents the volume of resources that the mill has in circulating assets and rights (i.e., cash and cash equivalents, accounts receivable, and inventories) in relation to its short-term debt (e.g., accounts payable, notes payable, accrued expenses) (Assaf Neto and Lima, 2014).

The liquidity index can have an ambiguous impact on the capital structure of mills. The higher the liquidity of a mill's assets (e.g., the marketing of ethanol relative to sugar) and the higher the current liquidity index, the lower the sensitivity to interest payment, and the higher the long-term debt. Mills with higher liquidity indices - meaning, higher than the unit - may opt for more debt, especially long-term debt, showing a positive relationship between liquidity and long-term debt (Bandyopadhyay and Barua, 2016).

Meanwhile, the most liquid mills can use these assets to finance their investments. Consequently, the mill's liquidity position can have a negative impact on its leverage (Ozkan, 2001).

x. Long-term debt (DLP)

The ratio of long-term debt to the total assets of a mill, expressed by Equation (11), represents the volume of assets that are financed with loans or other debt obligations that mature over a period of more than one year.

$$DLP_{i,t} = \frac{Long\ term\ debt_{i,t}}{Total\ assets_{i,t}} \tag{11}$$

This solvency or hedging index measures the percentage of assets a mill would need to settle to pay off its long-term debt and represents a measure of long-term indebtedness (Brito et al., 2007).

xi. Property (PROP)

Between 1930 and 1990, the sugarcane industry in Brazil was intensely marked by government intervention and the formation of family business groups, mostly Italians and their descendants (Ramos and Szmrecsányi, 2002). Beginning in the 2000s, new mills were installed and/or acquired under the ownership of non-family organizations, particularly by foreign corporate groups and foreign funds (Siqueira and Castro Junior, 2010).

A relatively extensive literature exists regarding the effects of property on the performance of the company (Abdallah and Ismail, 2017; Cui et al., 2019; Demsetz and Villalonga, 2001; Denis and Denis, 1994; Gomez-Mejia et al., 2011; Paniagua et al., 2018; Vu et al., 2018). However, differing theories have contradictory arguments regarding the impact of family ownership on mill performance (or vice versa), as outlined below.

Family property reduces the problem of the agency's principal agent or dilemma, whereby, according to the agency theory, we would expect a positive effect of family property on company performance (Anderson and Reeb, 2003;

Morck et al., 1988; Villalonga and Amit, 2006). Nevertheless, another trend in the economic literature associates a reduction in company performance with the ownership of family property, as family members tend to occupy key management positions within these organizations. In this context, family businesses are inefficient due to management selection problems, the practice of nepotism (Claessens et al., 2002), and a search for non-financial interests[14] (Bertrand and Schoar, 2006; Chen et al., 2014; Morck and Yeung, 2003).

Management discipline can be weaker, or even absent, in family businesses, if managers are chosen because of their kinship and not because of their technical skills and abilities (Anderson and Reeb, 2003; Schulze et al., 2001). Furthermore, family businesses encourage the consolidation and exploitation of private control benefits, which can prevent effective internal monitoring mechanisms-such as a board of directors-and external corporate governance mechanisms (Denis and Denis, 1994).

In this study, the effect of ownership type was controlled for by dividing the sample mills into two groups: i) mills belonging to households or related individuals (family businesses) and ii) mills owned by financial institutions (e.g., banks, investment funds, and insurers) and mills with other types of ownership (others). We used a dummy variable to represent ownership type, where 1 represents family businesses and 0 represents non-family businesses.

xii. Exchange rate (CAMBIO)

Specifically in the 2000s, the sugar-energy mills in Brazil captured resources abroad in U.S. dollars, through private banks, domestic subsidies, low interest rates in the international market, and the appreciation of the Real during its expansion period (Mendonça et al., 2012; Santos et al., 2016). During the same period, access to credit allowed higher levels of investment in the sector, given the devaluation of the Real against the Dollar, and in 2008, the sector began to accumulate a billion-dollar debt.

The exchange rate is therefore an important variable in determining the level of leverage of the Brazilian sugar-energy industry, and we included it only in the control vector Z_2. We used the commercial exchange rate for purchases (R$/US$) and annual average from BACEN (2019). This variable was the same for all companies, showing the same value for all mills, every year.

3.2.2 Data and sample

The data we used are annual and consist of information from sugar-energy mills in Brazil, between the years of 2006 and 2015. This time period allowed for the lag structure of Equations (1) and (3). In addition, the period was sufficient to include the effects of agency costs and management practices that likely manifested in the performance measures of the mills. Table 1 presents a summary of the variables used in our econometric models, including a brief description of the variables, their source, and the authors substantiating the choice of these variables.

Table 1. Variables used in econometric models

Variable	Acronym	Description	Source	Theoretical and empirical references
Share of debt	LEV	Share of debt	FS*	Brander and Lewis (1986); Gleason et al. (2000); Maksimovic (1988)
	LEV2	Square of share of debt	FS*	
Mill size	SZ	Natural logarithm of net operating revenue, used as a proxy to measure the size of the mill	FS*	Gleason et al. (2000); Himmelberg et al. (1999); Margaritis and Psillaki (2010)
	SZ2	Square of the natural logarithm of net operating revenue, included to allow non-linearity in SZ	FS*	
Tangibility	TANG	Ratio of fixed assets to total assets of the mill	FS*	Gleason et al. (2000); Harris and Raviv (1991); Lei et al. (2018); Titman and Wessels (1988)
Intangibility	INT	Ratio of intangible assets to net worth	FS*	Myers (1977); Titman and Wessels (1988)
Quality of the mill	QDE	Asset management (ratio of net operating income to total assets of the mill)	FS*	Diamond (1984, 1991); Flannery (1986); Stephan et al. (2011)

[14] Interest in non-financial factors is associated with concern for “socio-emotional wealth”. Family businesses are more likely to place emphasis on non-financial factors (Gomez-Mejia et al., 2011).

Age	AGE	Natural logarithm of the difference between the reference year and the date of the mill's opening with the Department of Federal Revenue	Brasil (2018)	Bandyopadhyay and Barua (2016); Petersen and Rajan (1994)
Profitability	RENT	The ratio between EBIT and the total assets of the mill	FS*	Margaritis and Psillaki (2007)
Current liquidity	LC	Ratio of current assets to current liabilities	FS*	Bandyopadhyay and Barua (2016); Stephan et al. (2011)
Long-term debt	DLP	Ratio of long-term debt to total assets of the mill	FS*	Brito et al. (2007)
Property	PROP	Binary variable (*dummy*), which takes value of 1 for family businesses and 0 for others	NovaCana (2018)	Demsetz (1983); Demsetz and Villalonga (2001); King and Santor (2008)
Exchange rate	CAMBIO	Natural logarithm of the annual average exchange rate in R$/US$.	Bacen (2019)	Mendonça et al. (2012); Santos et al. (2016)

Source: Prepared by the authors.
Note: *Financial statements[15]

Our sampling process is not probabilistic, since we selected mills based on available and accessible information that was essential to the study. Our sample is of 32 mills beginning in 2010, since some mills only began operating after the start of the analysis in 2006. Between 2006 and 2015, on average, the mills sampled accounted for 35.7%, 33.9%, and 38.6% of the national sugarcane, ethanol, and sugar production, respectively.

4. Results and discussion

4.1 Descriptive statistics

Table 2 presents the annual descriptive statistics (arithmetic mean and standard deviation) of the variables used in the econometric models, as presented in Equations (1) and (3).

Table 2. Descriptive statistics (arithmetic mean and standard deviation) of the variables used in the econometric models

Variable	Year									
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CRS[1]	0.936	0.930	0.971	0.934	0.929	0.922	0.896	0.913	0.914	0.841
	(0.104)	(0.062)	(0.038)	(0.076)	(0.050)	(0.052)	(0.114)	(0.062)	(0.070)	(0.095)
VRS[1]	0.964	0.953	0.979	0.951	0.951	0.951	0.926	0.940	0.946	0.928
	(0.078)	(0.055)	(0.036)	(0.073)	(0.050)	(0.050)	(0.115)	(0.061)	(0.067)	(0.077)
EE[1]	0.971	0.976	0.991	0.982	0.976	0.969	0.968	0.971	0.967	0.906
	(0.054)	(0.038)	(0.016)	(0.024)	(0.025)	(0.035)	(0.036)	(0.035)	(0.035)	(0.076)
LEV	0.585	0.620	0.750	0.706	0.646	0.650	0.673	0.699	0.731	0.773
	(0.120)	(0.167)	(0.151)	(0.131)	(0.159)	(0.158)	(0.169)	(0.178)	(0.220)	(0.3)
SZ[2]	0.685	0.589	0.595	0.814	1.004	1.265	1.324	1.375	1.422	1.729
	(0.851)	(1.099)	(0.793)	(0.898)	(1.147)	(1.895)	(2.091)	(2.184)	(2.253)	(2.912)
TANG	0.503	0.506	0.555	0.512	0.476	0.464	0.437	0.430	0.388	0.419
	(0.189)	(0.210)	(0.174)	(0.175)	(0.158)	(0.138)	(0.124)	(0.130)	(0.119)	(0.154)
INT	0.001	0.022	0.044	0.051	0.038	0.064	0.268	0.368	0.047	0.133
	(0.002)	(0.120)	(0.138)	(0.114)	(0.094)	(0.181)	(1.239)	(1.287)	(0.696)	(0.852)
QDE	0.739	0.486	0.481	0.568	0.581	0.555	0.540	0.526	0.505	0.599
	(0.329)	(0.254)	(0.268)	(0.295)	(0.282)	(0.28)	(0.234)	(0.185)	(0.159)	(0.202)
AGE	28.357	27.400	27.645	28.645	28.750	29.750	30.750	31.750	32.750	33.750
	(13.256)	(14.801)	(15.147)	(15.147)	(15.738)	(15.738)	(15.738)	(15.738)	(15.738)	(15.738)
RENT	0.102	0.008	-0.034	0.051	0.087	0.074	0.036	0.036	0.016	0.068

[15] All mills in the sample are legally constituted as joint-stock companies and have financial statements published in the official register of the federal government or the state in which the mill's office is located, as stipulated in Article 289 of the Brazilian JSC law (*A Lei das Sociedades por Ações*) (BRASIL, 2018). We thus obtained the financial statements of each mill for our period of analysis (2006 to 2015), and tabulated the variables of interest for this study, including fixed assets.

	(0.083)	(0.053)	(0.238)	(0.061)	(0.062)	(0.086)	(0.079)	(0.061)	(0.058)	(0.088)
LC	1.729 (0.897)	1.812 (1.665)	1.132 (0.966)	0.945 (0.542)	1.086 (0.685)	1.189 (0.812)	1.322 (0.949)	1.221 (0.808)	1.281 (0.874)	1.278 (0.805)
DLP	0.161 (0.100)	0.221 (0.140)	0.229 (0.144)	0.217 (0.121)	0.199 (0.123)	0.234 (0.141)	0.263 (0.159)	0.276 (0.131)	0.315 (0.181)	0.284 (0.167)
PROP	0.857 (0.356)	0.867 (0.346)	0.839 (0.374)	0.839 (0.374)	0.813 (0.397)	0.813 (0.397)	0.813 (0.397)	0.813 (0.397)	0.813 (0.397)	0.813 (0.397)
CAMBIO	2.175 (0)	1.947 (0)	1.834 (0)	1.997 (0)	1.759 (0)	1.674 (0)	1.954 (0)	2.157 (0)	2.353 (0)	3.331 (0)
Notes[3]	28	30	31	31	32	32	32	32	32	32

Source: Prepared by the authors.
Notes: The value in parentheses corresponds to standard deviation;
[1] Corresponds to the geometric mean of the Malmquist indices;
[2] In millions of reais, at constant 2015 prices;
[3] Number of mills (DMUs) in each year, i.e., the number of cross-sectional units in the regression model with panel data.

Figure 2 presents the share of debt in the open capital of mills between 2006 and 2015, in boxplots. The diamonds represent the average of this indicator for Brazilian open capital mills, based on data provided by the Instituto Assaf Neto (2018).

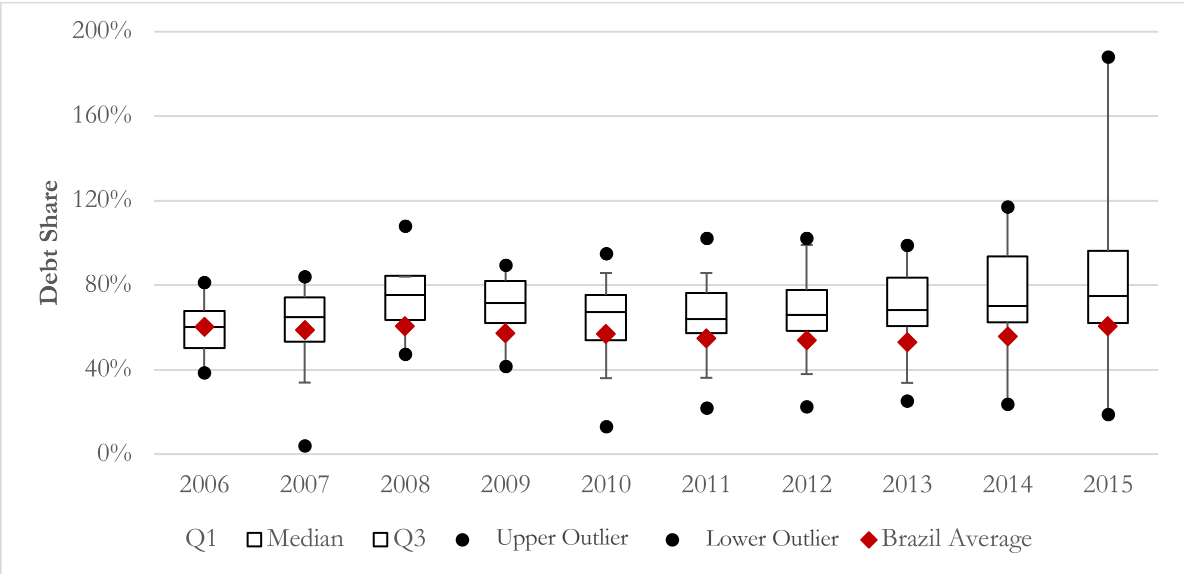

Figure 2. Boxplots of share of debt (LEV) in the sugar-energy industry and the average debt share in open capital mills (diamonds) between 2006 and 2015
Source: Prepared by the authors using data from the study and the Instituto Assaf Neto (2018)

The mills in the Brazilian sugar-energy industry for the period of analysis-with the exception of 2006-demonstrated a debt share that was higher than the average for open capital mills in Brazil. This implies that sugar-energy mills had higher levels of indebtedness and leverage compared to other companies in the Brazilian economy. The combination of lower growth rates and more severe financial conditions in the sector from 2010 to 2014 resulted in a deterioration of the balance sheets of these mills, as bank loans accounted for a major share in overall liabilities and resulted in a reduction in profitability (EBIT/total assets) (Table 2).

Following 2008, we observed significant heterogeneity in the industry and a deepening of the divide between mills, confirming great disparities among mills in technical and economic terms. For example, in 2015, the mill with the lowest level of leverage had a debt share of only 18.92% of its capital structure. Meanwhile, at the other extreme, the debt share of another mill was 188.17%. This latter share indicates that the mill has negative equity (negative shareholder equity), since accumulated losses over multiple harvests exceeded the resources provided by the mill's shareholders and accumulated profits, and ultimately implies that the mill is essentially operating on debt only.

4.2 Results of empirical models

4.2.1 Mill performance model

Using the panel data, we estimated a standard ordinary least square (OLS) regression model for pooled data, a fixed-effects model, and a random-effects model. Using the three models, we aimed to estimate the performance of the Brazilian mills, as outlined in Equation (1). We present our statistical results-with model coefficients-and other econometric tests in Table 3.

To confirm that no multicollinearity exists between the explanatory variables, we calculated the Pearson linear correlation coefficient between pairs of variables (Appendix A). Similar to the findings of Bandyopadhyay and Barua (2016), we found all correlation coefficients between independent variables to be below 0.70, indicating no serious problem of multicollinearity among the variables used in the empirical models.

Using the Wooldridge test for autocorrelation in panel data (Wooldridge, 2010), we rejected the null hypothesis of first-order serial autocorrelation. However, to detect the presence of heteroscedasticity, we performed both modified Wald tests for group heteroscedasticity (Greene, 2003) and the Breusch–Pagan/Cook–Weisberg test, which is based on the Lagrange multiplier (Breusch and Pagan, 1979; Cook and Weisberg, 1983). Both tests suggested that the assumption of homoscedasticity was not valid. Thus, we used the Huber–White method for heteroscedasticity-consistent standard errors (Huber, 1967; White, 1980).

To define our most appropriate model-a least squares model with dummy variables for fixed effects or a model of error components (a random-effects model)-we applied the Hausman specification test and the Lagrange multiplier by Breusch and Pagan (Breusch and Pagan, 1980). Using the Hausman test, we could not reject the null hypothesis[16], since the estimated value χ^2 was not significant. Therefore, we concluded that the random-effects model was the most appropriate model.

On the advice of the statistical tests and the selection of the random-effects model as the most suitable, we then analyzed the results of the coefficients contained in the last column in Table 3, specifically of the factors related to the performance of the sugar-energy mills in Brazil.

The empirical specification of our model for mill performance-Equation (1)-allows for financial dependence to either have a positive effect (assumption of agency costs of external shareholders) or a negative effect (assumption of debt agency costs) on the performance of mills. The model also allows for the reversal of this effect at the point where the expected costs of financial difficulties outweigh any gains obtained through debt rather than equity investors. Thus, our results showed that the terms linear financial dependence (LEV) and quadratic dependence (LEV2) both have a statistically significant effect on the efficiency score. Nevertheless, by replacing the regression coefficients estimated by the random-effects model in Equation (2), we find that leverage has a negative effect on efficiency for the values for which $LEV_{i,t-1} < 0.575$. This result shows that the effect is not positive for all values for financial dependence of the Brazilian plants, confirming the argument by Jensen and Meckling (1976) that the effect of leverage on company performance is not monotonic.

We found support for the hypothesis of the agency cost of external shareholders in the Brazilian sugar-energy industry (H_o was not rejected), implying that higher leverage is associated with better company performance, specifically for companies with higher levels of financial dependence (above 57.52%). In this situation, the higher leverage can lead to a reduction in capital expenditure-due to the fiscal benefit of debt-and to an improvement in cash flows, thus improving the performance of companies.

Table 3. Results of estimates of panel data model: company performance model (dependent variable $EE_{i,t}$)

Variable	Stacked data (OLS)	Fixed effect[1]	Random effect[1]
	Coefficients		
Constant	0.432	-0.026	0.046
	(0.63)	*(-0.03)*	*(0.07)*
LEV	0.355**	0.104	0.237**
	(2.43)	*(0.80)*	*(2.06)*
LEV2	-0.293*	-0.117	-0.206**
	(-2.72)	*(-1.10)*	*(2.06)*
SZ	0.095	0.191	0.165***
	(0.93)	*(1.63)*	*(2.06)*
SZ2	-0.005	-0.008***	-0.007**
	(-1.21)	*(-1.91)*	*(2.06)*
TANG	-0.045	-0.003	-0.014
	(-1.37)	*(-0.06)*	*(2.06)*
INT	0.010	0.013	0.011
	(1.48)	*(1.12)*	*(2.06)*
QDE	0.014	0.030	0.021

[16] The null hypothesis of the Hausman specification test is that the estimates of the fixed-effects model and those of the random-effects model do not differ substantially (Gujarati and Porter, 2011).

	(0.55)	*(0.86)*	*(2.06)*
AGE	-0.003	-0.042**	-0.012
	(-0.59)	*(-2.13)*	*(2.06)*
RENT	0.004	-0.011	0.008
	(0.05)	*(-0.19)*	*(2.06)*
LC	0.022*	0.004	0.014**
	(3.46)	*(0.40)*	*(2.06)*
DLP	-0.058	-0.033	-0.061
	(-1.29)	*(-0.52)*	*(2.06)*
PROP	-0.053*	-	-0.056**
	(-3.20)	-	*(2.06)*
F / Wald (χ^2) Test [2]	6.13*	4.51*	54.25*
R^2	0.219	0.089	0.191
Hausman test		10.66	
Breusch–Pagan Lagrange multiplier test (BP)		28.14*	
Wooldridge autocorrelation test: F (1.31)		1.651	
Modified Wald test for groupwise heteroscedasticity: χ^2		1,661.60*	
Heteroscedasticity test (BP/Cook–Weisberg): χ^2		28.14*	

Source: Prepared by the authors using Stata

Note: In parentheses are the *t*-statistic (in the stacked and fixed-effects models) and the *Z*-statistic (in the random-effects model).
[1] Generalized least squares (GLS) regression estimates with robust standard errors (Huber–White Sandwich)
[2] Wald (χ^2) test for random-effects model
- Variable omitted due to collinearity
* Statistically significant at 1%
** Statistically significant at 5%
*** Statistically significant at 10%

Meanwhile, for companies with a debt share of capital below 57.52%, we found an inverse relationship between efficiency and leverage. We could not conclude that the impact of financial dependence on mill performance is positive, due to the range of values assumed by this variable. Therefore, the hypothesis of the agency costs of external shareholders (H_o) is valid only for values of financial dependence above 57.52%. Mills in this situation have reduced both agency costs and inefficiencies, which have resulted in an improvement in their performance. However, we note that the direction of this relationship can change at any given point when the disciplinary effects of increasing leverage become unsustainable.

When analyzing the relationship between the capital structure and the performance of French industries, Margaritis and Psillaki (2010) also found that financial dependence has a significant effect on efficiency. They found a positive effect of financial dependence on the average leverage for each of the analyzed sectors; this effect remained positive despite the value of leverage, unlike the results we found in this study for the sugarcane processing mills in Brazil.

We expected that with a substantial increase in the financial leverage of mills in the sugar-energy industry, most of the cash generation would be directed towards debt amortization, thus reducing investments in crop treatments and sugarcane field renewal, and ultimately in yield and performance. This implies that the mills would cut their investments in sugarcane fields while attempting to recover financially, resulting in a drop in agricultural productivity and an aging crop. According to Martins et al. (2015), when mills undergo a period of crisis and low levels of profitability, they resort to debt contracts (or a re-contract), a situation that can incur higher financial costs and further aggravate the situation and performance of the mill.

Nevertheless, for a certain range of values, we found a positive relationship between leverage and mill performance. This result demonstrates the impact of the contractual obligations (covenants) entered into by mills when taking out loans, which can include i) the maintenance of a certain technical–financial performance, ii) the maintenance of a minimum cash balance, and iii) the non-distribution of dividends above the minimum required by the company by-laws. The covenants, provided they are effectively requested and overseen, reduce the risk of nonpayment of the debt, and also generate incentives for maintaining mill performance through investment discipline. This latter role of covenants is extremely important in mill administration because the cost of the overinvestment problem among mills with low growth rates will certainly be higher.

The hypothesis of agency costs of external shareholders is valid for values of financial dependence above 57.52%, because as leverage increases, a mill captures the additional tax savings (tax benefit) from interest payments, and gains control and discipline through improved management. Nevertheless, even in this interval $(0.57, +\infty)$, the relationship between financial dependence and mill performance is not monotonic. The higher this value is above 0.57, these benefits are gradually offset by the costs from eventual bankruptcy and insolvency[17] of the mill, to the point where these costs

[17] As presented by Ross et al. (2015), costs related to financial restructuring or bankruptcy are high. Altman (1984) estimates that, on average, total bankruptcy costs ranged from 11 to 17% of the company's market value up to three years prior to the company's bankruptcy. In some cases, costs exceeded 20% of the company's value measured immediately before bankruptcy.

begin to outweigh the benefits of leverage. In this situation, leverage levels become unsustainable and are more likely to destroy shareholder value, given the high probability of insolvency of the mill and conflict among investors.

In relation to mill size, its effect is similarly non-monotonic, as its sign was positive for the linear variable (SZ), but negative for the quadratic variable (SZ2). This result shows a positive effect on the efficiency score for smaller mills, but negative for larger mills. Yet, the hypothesis in the economic literature that the size of a mill has an ambiguous effect *a priori* from the perspective of moral hazard is confirmed. Tannuri-Pianto et al. (2009) obtained similar results when analyzing the efficiency of Brazilian electricity distributors, concluding that large companies were among the most inefficient.

The negative effect of company size-in the case of larger mills-on performance may reflect a loss of control in management and loss of agility in the decision-making process. Larger mills are required to have a larger radius for sourcing sugarcane and consequently have higher origination costs. Therefore, larger mill size may represent efficiency losses in the transport of raw material, and a higher risk for industrial asset idleness and diseconomies due to low capacity utilization.

We found that large mills became increasingly inefficient over the period of analysis (2006–2015), as they estimated their processing capacity relative to a period of government-driven euphoria for the sector. However, due to the low profitability or technical inability derived from exogenous factors such as weather or crop health (i.e., diseases and pests), such mills faced no incentive nor sufficient supplies of raw material to operate at full capacity. Therefore, we note that our results reflect our specific period of analysis and will not necessarily be repeated in future analyses, since in a scenario of higher profitability, this relationship would likely not occur, with economies of scale prevailing over other effects.

The results in Table 3 also show that the type of property (family versus non-family business) has a statistically significant effect on mill performance. Family businesses, on average, are less efficient than non-family businesses, according to the results of Schulze et al. (2001), Claessens et al. (2002), Anderson and Reeb (2003), Morck and Yeung (2003), Bertrand and Schoar (2006), and Chen et al. (2014). In addition, our results confirm those of Yamada (2014), which showed that efficiency was higher in non-family companies than in family companies, specifically in the production of sugarcane in the municipalities of Quirinópolis (Goias-GO) and Mineiros (GO).

From the perspective of the agency theory, we had expected a positive effect of family ownership on mill performance. However, our results showed the opposite, also a current trend in the economic literature that associates a reduction in the performance of the company with the holdings of family property. In this respect, we see the need for the professionalization of the sugar-energy industry in the areas of organization, management, and governance, with an emphasis on the transition from family-operated, traditional management to a more professional setting with ethical and legal principles that meet the model for best mill organization and governance practices. Other variables, such as tangibility (TANG), intangibility (INT), mill quality (QDE), age (AGE), and profitability (RENT)-while not statistically significant-presented coefficient signs that were to be expected, based on the economic literature.

4.2.2 Leverage model

As outlined in Section 1.1, this article also seeks to analyze the determinants of mill indebtedness levels and whether mill performance has an effect on capital structure.

Table 4 therefore presents the coefficients from Equation (3) to evaluate reverse causality and mill performance with regard to capital structure, and to test the two hypotheses by Berger and Bonaccorsi di Patti (2006). The results of the statistical tests first showed that the data were not homoscedastic (Breusch and Pagan, 1979; Cook and Weisberg, 1983) and showed the presence of first-order serial correlation (Wooldridge, 2010), so we then used estimators for robust clustered standard errors. In addition, we could reject the null hypothesis of the Hausman test, indicating that the best model is that of fixed effects. We also found the fixed-effects model to be appropriate given the heterogeneity of sugar-energy mills.

In our analysis, we employed an OLS regression model for pooled data, a fixed-effects model, a random-effects model, and a quantile regression model (quantile 50). We used quantile regression to account for asymmetry in the distribution of the dependent variable since the LEV distribution is leptokurtic[18] and left-skewed. Thus, depending on the results of the statistical tests, we will analyze the last column of Table 4, which shows the panel estimation of the quantile regression of fixed effects with a nonseparable disturbance term, as proposed by Powell (2014).

Regardless of the model analyzed, we found the coefficient of the linear variable (EE) to be positive ($\beta_1 > 0$) and the coefficient of the quadratic specification (EE2) to be negative ($\beta_2 < 0$). This result demonstrates an inflection point between the hypotheses presented by Berger and Bonaccorsi di Patti (2006)-the efficiency-risk hypothesis and the franchise value hypothesis-in relation to the effect of mill performance on capital structure. We found no strict dominance of any hypothesis of reverse causality between the performance of the mill and its capital structure.

[18] The kurtosis coefficient is 5.22 for the LEV variable, while the asymmetry coefficient is 0.74.

Our results showed a negative effect between mill performance and company leverage for all values of $EE_{i,t-1}$ up to roughly 0.57,[19] considering the quantile 0.50 of the quantile regression. However, we found the efficiency-risk hypothesis to prevail for companies with efficiency scores greater than 0.57, indicating that this hypothesis is not valid for all relevant efficiency values. These results are consistent with the hypothesis of the agency cost of external shareholders.

Thus, for low efficiency scores, our results are consistent with the predominance of the franchise value hypothesis, under which companies seek to protect the economic revenues derived from efficiency using marginal increments of equity in their activities. Meanwhile, for high efficiency levels, our results are more consistent with the efficiency-risk hypothesis, where efficiency results replace equity with debt. This finding is similar to that of Berger and Bonaccorsi di Patti (2006), who concluded that the franchise value hypothesis takes precedence over the efficiency-risk hypothesis at low efficiency levels and vice versa at high efficiency values.

Table 4. Estimates from the panel data model: leverage model (dependent variable: $LEV_{i,t}$)

Variable	**Stacked data (OLS)**	**Fixed effect**[1]	**Random effect**[2]	**Quantum regression**[3] **q50**
	Coefficients			
Constant	1.416	3.934***	3.438***	-
	(1.07)	*(1.79)*	*(1.72)*	-
EE	0.619	0.429	0.418	0.739*
	(0.79)	*(0.95)*	*(1.04)*	*(453.53)*
EE2	-0.484	-0.372	-0.369	-0.644*
	(-1.02)	*(-1.23)*	*(-1.40)*	*(-620.23)*
SZ	-0.156	-0.519	-0,427	-0.156*
	(-0.81)	*(-1.56)*	*(-1.36)*	*(-68.53)*
SZ2	0.006	0.019	0.015	0.006*
	(0.76)	*(1.48)*	*(1.27)*	*(66.26)*
TANG	0.065	0.038	0.045	0.072*
	(1.02)	*(0.43)*	*(0.62)*	*(171.65)*
INT	0.007	0.004	0.004	0.039*
	(0.57)	*(0.58)*	*(0.50)*	*(489.72)*
QDE	0.232*	0.082	0.110**	0.232*
	(5.08)	*(1.26)*	*(2.32)*	*(1,181.52)*
AGE	-0.038**	-	-0.045	-0.065*
	(-2.19)	-	*(-0.99)*	*(-724.39)*
RENT	-0.251***	-0.211	-0.211	-0.357*
	(-1.82)	*(-1.48)*	*(-1.43)*	*(-521.63)*
LC	-0.085*	-0.061*	-0.069*	-0.057*
	(-7.85)	*(-3.37)*	*(-4.55)*	*(-1,034.91)*
DLP	0.795*	0.555*	0.620*	0.729*
	(11.91)	*(3.59)*	*(4.90)*	*(2,640.04)*
PROP	-0.009	-	0.016	0.044*
	(-0.27)	-	*(0.48)*	*(98.63)*
CAMBIO	0.064	0.076***	0.074**	0.040*
	(1.61)	*(1.98)*	*(2.05)*	*(90.31)*
F / Wald (χ^2) test [4]	22.33*	15.30*	221.43*	
R^2	0.526	0.487	0.503	
Hausman test		136.88*		
Wooldridge autocorrelation test: F (1.31)		19.85*		
Modified Wald test for groupwise heteroscedasticity: χ^2		935.91*		
Heteroscedasticity test (Breusch–Pagan/Cook–Weisberg): χ^2		13.06*		

Source: Prepared by the authors using Stata

Notes: In parentheses are the student *t*-statistics (in stacked data and fixed-effects models) and the *Z*-statistic (in the random-effects model and the quantile regression).

[1] Ordinary least squares (OLS) regression, within estimator, for robust clustered standard errors

[2] GLS (generalized least squares) regression estimates with robust clustered standard errors

[3] Quantile panel of fixed effects with non-additive term

[19] Given the simultaneity of performance and leverage models, the inflection values are relatively close (near 0.57).

[4] Wald test (χ^2) for the random-effects model
- Variable omitted due to collinearity or absent from model
* Statistically significant at 1%
** Statistically significant at 5%
*** Statistically significant at 10%

The size of a mill has proven to influence its indebtedness capacity. Nevertheless, similarl to the performance model, we found that the effect of mill size on leverage is not monotonic since SZ and SZ2 showed the opposite signs. Given that the coefficient of the variable SZ2 was positive, we can infer that the larger the company, the greater its financial leverage. Larger companies are financially stronger and therefore in a better position to assume refinancing risk, are likely to have lower bankruptcy costs, and consequently, have a larger share of debt in their capital structure, as identified by Titman and Wessels (1988).

According to Santos et al. (2016), the largest mills need investments in tangible assets and need significant resources to overcome the high barriers to entry into the sugar-energy industry. Since these investments have reached maturity and therefore their long-term returns, maintaining the financial balance of the mill becomes necessary so that the mill's debt obligations are spread out over the long term. In early 2010, the largest mils in the sector with access to finance took advantage to acquire mills that were in judicial recovery or in a delicate financial situation. This resulted in a process of mergers and acquisitions and, consequently, an increase in the indebtedness of economic companies/groups, as reflected in the SZ2 variable in the empirical model.

From 2006 to 2015, sugar-energy mills had higher levels of leverage compared to other companies in the Brazilian economy. Typically, the most leveraged companies are mature and intensive in fixed assets. They maintain a higher level of indebtedness, as they have more assets that can serve as collateral, mitigating the costs of bankruptcy and insolvency. This reinforces the positive effect of the tangibility variable (TANG) on the leverage of the sugar-energy mills. Rather, mills with higher fixed assets (greater tangibility) resort to more debt, which is consistent with the signaling hypothesis, as this scenario implies fewer problems of information asymmetry.

However, as the assets in this industry are highly specialized, the cost of any bankruptcy or insolvency are high. If a mill enters into receivership, it loses growth opportunities, and any remaining assets, depending on their unique nature, will have little value to third parties. This is evidence of a recent process in the Brazilian sugar-energy industry following 2015, in which mergers and acquisitions were concentrated in the procurement of raw material to occupy the capacity of other mills. For example, in 2018, the Raízen and São Martinho groups acquired only the sugarcane fields of the Usina Furlan, highlighting the low attractiveness of the industrial asset itself (Ramos and Rocha, 2018).

We found that age (AGE) had a negative and significant effect on the leverage of mills, indicating that older mills used less third-party capital to finance their activities. These mills hold an established reputation in the market and an increased availability of information, which implies less information asymmetry. Additionally, older mills have a higher proportion of accumulated profits over time, resulting in lower indebtedness in their capital structure.

Mill liquidity, which is reflected in a mill's continued ability to honor financial obligations, affects its capital structure. An increase in mill liquidity leads to a decrease in its financial leverage, and vice versa. This result signals that a decision of short-term indebtedness is crucial for the company, to not compromise its operations, financial stability, or liquidity. In this study, we found a negative and significant ratio[20] of current liquidity (LC) to the capital structure of the Brazilian sugar-energy mills. This result confirms those of Lipson and Mortal (2009), Akdal (2010), and Ozkan (2001), who also found a negative relationship between these variables, indicating that mill liquidity has a negative impact on its debt decisions.

A mill can obtain liquidity by maintaining adequate cash or by lengthening debts, keeping them in the long term. Current liquidity has a negative effect on long-term debt, indicating that mills with low liquidity (i.e., more prone to liquidity risks) prolong their liabilities to minimize the risk of refinancing debt and opt for more long-term debt. This is one of the reasons why we observed a positive relationship between long-term debt (DLP) and debt participation (LEV).

Beginning in 2007, with the devaluation of the Real against the Dollar, we observed an increase in the levels of financial leverage of the mills, according to the expressive participation of foreign currency debts in the composition of the total debt of these companies. The results confirmed the positive relationship between the exchange rate (CAMBIO) and the participation of third-party capital / debt participation (LEV).

The exchange rate is a relevant variable in explaining the level of indebtedness of the Brazilian sugar-energy mills, since the largest share of their liabilities was indexed in foreign currency during our period of analysis (2006–2015). The mills contracted debt on the international market, as sugar exports functioned as a natural hedge. However, after 2011, a fall in the international price of sugar and the devaluation of the Real against the Dollar inflated mill debt (in reais), leading some to judicial recovery and others to finalize their activities.

5. Conclusions

[20] The current liquidity index coefficient estimate is significant at the 1% level.

In this study, using a sample of mills from the Brazilian sugar-energy industry, we sought to address the following questions: i) Does the strongest leverage lead to better performance of the mill? and ii) Does efficiency have a significant effect on leverage in addition to traditional financial metrics? With respect to the first question, the central hypothesis of this article was that the greatest leverage reduces agency costs and inefficiency, and thus leads to improvement in company performance (H_0).

We could not reject the hypothesis of the agency cost of external shareholders (H_o) in the Brazilian sugar-energy industry, implying that higher leverage is associated with better mill performance, specifically for mills with levels of financial dependence higher than 57.52%. The results of this article, which are consistent with the agency cost hypothesis of Jensen and Meckling (1976), corroborate the empirical evidence in the economic literature for other countries and other sectors. In addition, we assessed the reverse causality between mill performance and financial dependence through two competing hypotheses: the efficiency-risk hypothesis (H_2) and the franchise value hypothesis (H_{2a}). Using quantile regression analysis, we found a negative effect between the performance of the mill and its leverage, for all efficiency values up to roughly 0.57, indicating that the efficiency-risk hypothesis is not valid for all relevant efficiency values. Additionally, mill size, the tangibility of mill assets, age, current liquidity, and property (whether a family business or not) proved to be relevant factors in determining the leverage of the mills in the sugar-energy industry.

Our results showed that the capital structure and the performance of the mill vary depending on specific factors. We note that our results represent the industry average; however, Brazilian mills are quite heterogeneous, with significant technical and economic disparities and our results, therefore, may vary greatly from the observation of an individual company.

While a poorly administered capital structure may lead to financial difficulties and value deterioration, as observed in the period of 2006 to 2015, strategies focused on operational performance-coupled with the competitive advantages of the mill-and the restoration of adequate technical conditions for production are critical. Such strategies should aim to minimize the risks inherent in the activity and guarantee greater financial flexibility for the replacement of industry parts and the maintenance of sugarcane fields.

The planning and management of the capital structure of a mill contribute much more to preventing the destruction and deterioration of value than vice versa, meaning, to increase the creation and generation of value. When managers (agents) make decisions regarding capital structure, they have more to lose than gain in terms of value, as shown by the significant number of mills in the sector in judicial recovery or that have closed their activities, primarily between 2008 and 2015. In general, companies can create much more value for shareholders in their activities than through financial engineering.

With our results, we could evaluate the determinants of the level of indebtedness of sugar-energy mills in Brazil and observe that capital structure influenced company performance. Furthermore, the results showed the potential for companies in this industry to readjust their financial position and capital structure, disregarding best corporate governance practices, to recover mill performance and efficiency and, consequently, increase the production of sugar and ethanol in the medium and long term.

This article sought to provide insight for policymakers, industry actors, and potential investors to guide planning and decision-making. The study differentiated from and largely contributed to the economic literature in three respects: i) using the efficiency scores obtained from a DEA model-rather than financial metrics from a conventional model-to measure mill performance; ii) demonstrating that efficiency scores as a proxy for agency costs are an important factor in the determination of the capital structure; and iii) providing empirical evidence of the relationship between capital structure and the performance of Brazilian sugar-energy mills.

In the sugar-energy industry, the impact of leverage on mill performance and vice versa is evident. However, further work can analyze the real impact of leverage on performance in the context of a lack of options and funding lines guaranteeing the continuity of investments, especially in the area of agriculture. Future studies may extend this analysis to compare performance and capital structure among other players in the global sugar market, such as India, Thailand, Pakistan, China, and Mexico, and examine additional aspects of ownership, including certain features of governance.

References

ABDALLAH, A. A. N.; ISMAIL, A. K. Corporate governance practices, ownership structure, and corporate performance in the GCC countries. **Journal of International Financial Markets, Institutions and Money**, v. 46, p. 98–115, 2017.

AKDAL, S. **How do Firm Characteristics Affect Capital Structure? Some UK Evidence.** Londres: [s.n.].

ALTMAN, E. I. A Further Empirical Investigation of the Bankruptcy Cost Question. **The Journal of Finance**, v. 39, n. 4, p. 1067–1089, 1984.

ANDERSON, R. C.; REEB, D. M. Founding-Family Ownership and Firm Performance: Evidence from the S&P 500. **The Journal of Finance**, v. 58, n. 3, p. 1301–1328, 2003.

ANG, J. S.; COLE, R. A.; LIN, J. W. U. H. Agency costs and ownership structure. **The Journal of Finance**, v. LV, n. 1, p. 81–106, 2000.

ASSAF NETO, A.; LIMA, F. G. **Curso de administração financeira**. 3a edição ed. São Paulo, SP: Atlas, 2014.
BACEN. BANCO CENTRAL DO BRASIL. **SGS - Sistema Gerenciador de Séries Temporais**. Disponível em: <https://www.bcb.gov.br/acessoinformacao/legado?url=https:%2F%2Fwww4.bcb.gov.br%2Fpec%2Fseries%2Fport%2Faviso.asp>. Acesso em: 24 jan. 2019.
BANDYOPADHYAY, A.; BARUA, N. M. Factors determining capital structure and corporate performance in India: Studying the business cycle effects. **Quarterly Review of Economics and Finance**, v. 61, p. 160–172, 2016.
BENITO, A.; HERNANDO, I. Labour demand, flexible contracts and financial factors: Firm-level evidence from Spain. **Oxford Bulletin of Economics and Statistics**, v. 70, n. 3, p. 283–301, 2008.
BERGER, A. N.; BONACCORSI DI PATTI, E. Capital structure and firm performance: A new approach to testing agency theory and an application to the banking industry. **Journal of Banking and Finance**, v. 30, n. 4, p. 1065–1102, 2006.
BERTRAND, M.; SCHOAR, A. The Role of Family in Family Firms. **Journal of Economic Perspectives**, v. 20, n. 2, p. 73–96, 2006.
BRANDER, B. J. A.; LEWIS, T. R. Oligopoly and Financial Structure: The Limited Liability Effect. **The American Economic Review**, v. 76, n. 5, p. 956–970, 1986.
BRASIL. **Emissão de Comprovante de Inscrição e de Situação Cadastral**. Disponível em: <http://www.receita.fazenda.gov.br/PessoaJuridica/CNPJ/cnpjreva/Cnpjreva_Solicitacao.asp>. Acesso em: 22 out. 2018.
BRASIL. **Lei Nº 6.404, de 15 de dezembro de 1976**. Disponível em: <http://www.planalto.gov.br/ccivil_03/leis/L6404consol.htm>. Acesso em: 1 fev. 2018.
BRASIL. **Instituições cadastradas no MAPA como produtores, cooperativas ou comercializadoras de produtos vinculados à produção canavieira**. Disponível em: <http://sistemasweb.agricultura.gov.br/sapcana/downloadBaseCompletaInstituicao!downloadArquivoXLS.action>. Acesso em: 24 jan. 2019.
BREUSCH, T. S.; PAGAN, A. R. A Simple Test for Heteroscedasticity and Random Coefficient Variation. **Econometrica**, v. 47, n. 5, p. 1287–1294, 1979.
___. The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. **The Review of Economic Studies**, v. 47, n. 1, p. 239–253, 1980.
BRITO, G. A. S.; CORRAR, L. J.; BATISTELLA, F. D. Fatores determinantes da Estrutura de Capital das Maiores Empresas que atuam no Brasil. **Revista de Contabilidade e Finanças**, v. 43, p. 9–19, 2007.
CAMPELLO, M. Capital structure and product markets interactions: Evidence from business cycles. **Journal of Financial Economics**, v. 68, n. 3, p. 353–378, 2003.
CANTOR, R. Effects of leverage on corporate investment and hiring decisions. **Quarterly Review 15, Federal Reserve Bank of New York**, v. 15, n. 2, p. 31–41, 1990.
CHEN, C. J.; HSU, C. Y.; CHEN, Y. L. The impact of family control on the top management compensation mix and incentive orientation. **International Review of Economics and Finance**, v. 32, p. 29–46, 2014.
CHENG, M.-C.; TZENG, Z.-C. Does Leverage and Efficiency Affect Each Other. **Journal of Accounting, Finance and Economics**, v. 1, n. 1, p. 77–95, 2011.
CLAESSENS, S. et al. Disentangling the Incentive and Entrenchment Effects of Large Shareholdings. **The Journal of Finance**, v. 57, n. 6, p. 2741–2771, 2002.
COLE, R. A.; MEHRAN, H. The effect of changes in ownership structure on performance: Evidence from the thrift industry. **Journal of Financial Economics**, v. 50, n. 3, p. 291–317, 1998.
COOK, R. D.; WEISBERG, S. Diagnostics for Heteroscedasticity in Regression. **Biometrika**, v. 70, n. 1, p. 1–10, 1983.
COSTA, C. C. DA; BURNQUIST, H. L. Impactos do controle do preço da gasolina sobre o etanol biocombustível no Brasil. **Estudos Econômicos (São Paulo)**, v. 46, n. 4, p. 1003–1028, 2016.
CUI, Y. et al. Top management team knowledge heterogeneity, ownership structure and financial performance: Evidence from Chinese IT listed companies. **Technological Forecasting and Social Change**, v. 140, n. August 2018, p. 14–21, 2019.
DAMODARAN, A. **Finanças corporativas: teoria e prática**. 2a. ed. Porto Alegre, RS: Bookman, 2004.
DEMSETZ, H. The Structure of Ownership and the Theory of the Firm. **The Journal of Law & Economics**, v. 26, n. 2, p. 375–390, 1983.
DEMSETZ, H.; VILLALONGA, B. Ownership structure and corporate financing. **Applied Financial Economics**, v. 19, n. 24, p. 1975–1986, 2001.
DENIS, D. J.; DENIS, D. K. Majority owner-managers and organizational efficiency. **Journal of Corporate Finance**, v. 1, n. 1, p. 91–118, 1994.
DIAMOND, D. W. Financial Intermediation and Delegated Monitoring. **The Review of Economic Studies**, v. 51, n. 3, p. 393–414, 1984.
DIAMOND, D. W. Monitoring and Reputation : The Choice between Bank Loans and Directly Placed Debt. **Journal of Political Economy**, v. 99, n. 4, p. 689–721, 1991.
EPE. **Cenários de oferta de etanol e demanda do Ciclo Otto: Versão Estendida 2018-2030**. Rio de Janeiro, RJ: [s.n.]. Disponível em: <http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/cenarios-oferta-etanol-e-demanda-

ciclo-otto>.
FAMA, E. F.; FRENCH, K. R. Disappearing dividends: changing firm characteristics or lower propensity to pay? **Journal of Financial Economics**, v. 3, p. 3–42, 2001.
FERRAZ DIAS DE MORAES, M. A.; ZILBERMAN, D. The Free Market: The Profound Changes and the New Agenda. *In*: **Production of Ethanol from Sugarcane in Brazil**. Cham: Springer International Publishing, 2014. p. 149–193.
FLANNERY, M. J. Asymmetric Information and Risky Debt Maturity Choice. **The Journal of Finance**, v. 41, n. 1, p. 19–37, 1986.
FOSU, S. Capital structure, product market competition and firm performance: Evidence from South Africa. **Quarterly Review of Economics and Finance**, v. 53, n. 2, p. 140–151, 2013.
GALAI, D.; MASULIS, R. W. The option pricing model and the risk factor of stock. **Journal of Financial Economics**, v. 3, p. 53–81, 1976.
GLEASON, K. C.; MATHUR, L. K.; MATHUR, I. The interrelationship between culture, capital structure, and performance: Evidence from European retailers. **Journal of Business Research**, v. 50, n. 2, p. 185–191, 2000.
GOMEZ-MEJIA, L. R. et al. The Bind that ties: Socioemotional wealth preservation in family firms. **The Academy ofManagement Annals**, v. 5, n. 1, p. 653–707, 2011.
GRASSI, M. C. B.; PEREIRA, G. A. G. Energy-cane and RenovaBio: Brazilian vectors to boost the development of Biofuels. **Industrial Crops and Products**, v. 129, p. 201–205, 2019.
GREENE, W. H. **Econometric Analysis**. Fifth Edit ed. New Jersey: Upper Saddle River, 2003.
GROSSMAN, S. J. .; HART, O. D. The Economics of Information and Uncertainty. *In*: MCCALL, J. J. (Ed.). . **The Economics of Information and Uncertainty**. [s.l.] University of Chicago Press, 1982. p. 107–140.
GUJARATI, D. N.; PORTER, D. C. **Econometria Básica**. 5a Edição ed. Porto Alegre, RS: AMGH Editora Ltda, 2011.
HARRIS, M.; RAVIV, A. The Theory of Capital Structure The Theory of Capital Structure. **The Journal of Finance**, v. XLVI, n. 1, p. 297–355, 1991.
HIMMELBERG, C. P.; HUBBARD, R. G.; PALIA, D. Understanding the determinants of managerial ownership and the link between ownership and performance. **Journal of Financial Economics**, v. 53, p. 353–384, 1999.
HUBER, P. J. **The behavior of maximum likelihood estimates under nonstandard conditions**Fifth Berkeley Symposium on Mathematical Statistics and Probability. **Anais**...Berkeley: University of California Press, 1967Disponível em: <http://www.scopus.com/inward/record.url?eid=2-s2.0-33846983865&partnerID=tZOtx3y1>
IAF. INSTITUTO ASSAF NETO. **Estrutura de capital e alavancagem**. Disponível em: <http://www.institutoassaf.com.br/2012/painel.aspx>. Acesso em: 24 jan. 2019.
JENSEN, M. C. Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers. **American Economic Review**, v. 76, n. 2, p. 323–329, 1986.
JENSEN, M. C.; MECKLING, W. H. Theory of the firm: managerial behavior, agency costs and ownership structure. **Journal of Financial Economics**, v. 3, p. 305–360, 1976.
KING, M. R.; SANTOR, E. Family values: Ownership structure, performance and capital structure of Canadian firms. **Journal of Banking and Finance**, v. 32, n. 11, p. 2423–2432, 2008.
LEI, J.; QIU, J.; WAN, C. Asset tangibility, cash holdings, and financial development. **Journal of Corporate Finance**, v. 50, p. 223–242, 2018.
LEIBENSTEIN, H. Allocative efficiency vs. “X-efficiency”. **American Economic Review**, v. 56, p. 392–415, 1966.
LIPSON, M. L. .; MORTAL, S. Liquidity and capital structure Marc. **Journal of Financial Markets**, v. 12, p. 611–644, 2009.
MAKSIMOVIC, V. Capital Structure in Repeated Oligopolies. **The RAND Journal of Economics**, v. 19, n. 3, p. 389–407, 1988.
MARGARITIS, D.; PSILLAKI, M. Capital structure and firm efficiency. **Journal of Business Finance and Accounting**, v. 34, n. 9–10, p. 1447–1469, 2007.
___. Capital structure, equity ownership and firm performance. **Journal of Banking and Finance**, v. 34, n. 3, p. 621–632, 2010.
MARIN, F. R. et al. Climate change impacts on sugarcane attainable yield in southern Brazil. **Climatic Change**, v. 117, n. 1–2, p. 227–239, 2013.
MARTINS, H. H. et al. Estrutura de capital e alavancagem financeira de empresas da agroindústria canavieira: um estudo multicaso para o Centro-Oeste. **Gestão & Regionalidade**, v. 31, n. 93, p. 76–93, 2015.
MCCONNELL, J. J.; SERVAES, H. Equity ownership and the two faces of debt. **Journal of Financial Economics**, v. 39, n. 1, p. 131–157, 1995.
MENDONÇA, M. L.; PITTA, F. T. .; XAVIER, C. V. **A agroindústria canavieira e a crise econômica mundial**. São Paulo, SP: [s.n.].
MILANEZ, E. F. **Efeitos de alavancagem e oportunidades de crescimento sobre o investimento das empresas brasileiras** (En, Ed.)XXXVI Encontro da ANPAD. **Anais**...Rio de Janeiro, RJ: EnANPAD, 2012
MODIGLIANI, F.; MILLER, M. H. The cost of capital, corporation finance and the theory of investment. **The American Economic Review**, v. 48, n. 3, p. 261–297, 1958.

MONTASSER, G. EL et al. Are there multiple bubbles in the ethanol-gasoline price ratio of Brazil? **Renewable and Sustainable Energy Reviews**, v. 52, p. 19–23, 2015.
MORCK, R.; SHLEIFER, A.; VISHNY, R. W. Management ownership and market valuation. An empirical analysis. **Journal of Financial Economics**, v. 20, n. C, p. 293–315, 1988.
MORCK, R.; YEUNG, B. Agency Problems in Large Family Business Griups. **Entrepreneurship Theory and Practice**, v. 27, n. 4, p. 367–382, 2003.
MOREIRA, J. R.; PACCA, S. A.; PARENTE, V. The future of oil and bioethanol in Brazil. **Energy Policy**, v. 65, p. 7–15, 2014.
MYERS, S. C. Determinants of corporate borrowing. **Journal of Financial Economics**, v. 5, p. 147–175, 1977.
NICKELL, S.; NICOLITSAS, D. How does financial pressure affect firms? **European Economic Review**, v. 43, n. 8, p. 1435–1456, 1999.
NORILLER, R. M. et al. Comparação econômico-financeira por índices-padrão de usinas sucroenergéticas listadas nas BM&F Bovespa S.A. **Revista de Administração da UEG**, v. 2, n. 2, p. 58–78, 2011.
NOVACANA. **As usinas de Açúcar e Etanol do Brasil**. Disponível em: <https://www.novacana.com/usinas_brasil>. Acesso em: 20 ago. 2018.
OPLER, T. C. .; TITMAN, S. Financial Distress and Corporate Performance. **The Journal of Finance**, v. 49, n. 3, p. 1015–1040, 1994.
OZKAN, A. Determinants of capital structure and adjustment to long run target: Evidence from UK company panel data. **Journal of Business Finance and Accounting**, v. 28, n. 1–2, p. 175–198, 2001.
PANIAGUA, J.; RIVELLES, R.; SAPENA, J. Corporate governance and financial performance: The role of ownership and board structure. **Journal of Business Research**, v. 89, n. February, p. 229–234, 2018.
PECEGE. **Custos de produção de cana-de-açúcar, açúcar, etanol e bioeletricidade no Brasil: Fechamento da Safra 2017/2018**. Piracicaba, São Paulo: [s.n.]. Disponível em: <http://bioscirep.org/cgi/doi/10.1042/BSR20130081>.
PETERSEN, M. A.; RAJAN, R. G. The Benefits of Lending Relationships: Evidence from Small Business Data. **The Journal of Finance**, v. XLIX, n. 1, p. 3–37, 1994.
POWELL, D. **Did the Economic Stimulus Payments of 2008 Reduce Labor Supply ? Evidence from Quantile Panel Data Estimation Did the Economic**. Santa Monica: [s.n.].
RAJAN, R. G.; ZINGALES, L. What Do We Know about Capital Structure? Some Evidence from International Data. **The Journal of Finance**, v. 50, n. 5, p. 1421–1460, 1995.
RAMOS, C. S. **Mais usinas ficarão sem processar cana na safra 2018/19**. Disponível em: <https://www.valor.com.br/agro/5204657/mais-usinas-ficarao-sem-operar-na-proxima-safra>. Acesso em: 24 fev. 2019.
___. **Queda do açúcar e alta do dólar inflam dívidas das usinas**. Disponível em: <https://www.valor.com.br/agro/5676479/queda-do-acucar-e-alta-do-dolar-inflam-dividas-das-usinas>. Acesso em: 24 jan. 2019.
RAMOS, C. S.; ROCHA, A. DO A. São Martinho e Raízen confirmam compra de canaviais da Usina Furlan. **Valor Econômico**, p. Agronegócios, 5 jul. 2018.
RAMOS, P.; SZMRECSÁNYI, T. Evolução histórica dos grupos empresariais da agroindústria canavieira paulista. **História Econômica & História de Empresas**, v. 1, p. 85–115, 2002.
REBELO, S. C. F. **A estrutura de capital e a performance das empresas hoteleiras portuguesas e espanholas**. [s.l.] Universidade do Algarve, 2016.
REZENDE, M. L.; RICHARDSON, J. W. Economic feasibility of sugar and ethanol production in Brazil under alternative future prices outlook. **Agricultural Systems**, v. 138, p. 77–87, 2015.
RISSARDI JÚNIOR, D. J. **Três ensaios sobre a agroindústria canavieira no Brasil pós-desregulamentacão**. [s.l.] Universidade Estadual do Oeste do Paraná, 2015.
RODRIGUES, LUCIANO; RODRIGUES, LUCAS. Economic-financial performance of the Brazilian sugarcane energy industry: An empirical evaluation using financial ratio, cluster and discriminant analysis. **Biomass and Bioenergy**, v. 108, n. April, p. 289–296, 2018.
RODRIGUES, R. L. **Teoria de Agência, governança corporativa e política de dividendos: evidências nas empresas brasileiras de capital aberto**. [s.l.] Universidade de São Paulo, 2015.
ROSS, S. A. . et al. **Administração Financeira**. 10a. ed. [s.l.] McGraw-Hill Education, 2015.
SANTOS, G. R. DOS; et al. A agroindústria canavieira e a produção de etanol no Brasil: características, potenciais e perfil da crise atual. *In*: SANTOS, G. R. DOS (Ed.). . **Quarenta anos de etanol em larga escala no Brasil : desafios, crises e perspectivas**. Brasília, DF: IPEA, 2016. p. 17–45.
SCHULZE, W. S. et al. Agency Relationships in Family Firms: Theory and Evidence. **Organization Science**, v. 12, n. 2, p. 99–116, 2001.
SHARPE, S. A. Financial Market Imperfections, Firm Leverage, and the Cyclicality of Employment. **The American Economic Review**, v. 84, n. 4, p. 1060–1074, 1994.
SIQUEIRA, P. H. DE L. **Análise das estratégias de crescimento e de localização da agroindústria canavieira no Brasil e suas externalidades**. [s.l.] Universidade Federal de Lavras, 2013.
SIQUEIRA, P. H. DE L.; CASTRO JUNIOR, L. G. DE. Fusões e aquisições das unidades produtivas e da agroindústria

de cana-de-açúcar no Brasil e nas distribuidoras de álcool hidratado etílico. **Revista de Economia e Sociologia Rural**, v. 48, n. 4, p. 709–735, 2010.
SPALIARA, M.-E. Do financial factors affect the capital-labour ratio? Evidence from UK firm-level data. **Journal of Banking and Finance**, v. 33, n. 10, p. 1932–1947, 2009.
STEPHAN, A.; TALAVERA, O.; TSAPIN, A. Corporate debt maturity choice in emerging financial markets. **Quarterly Review of Economics and Finance**, v. 51, n. 2, p. 141–151, 2011.
STIGLER, G. J. The Xistence of X-Efficiency. **The American Economic Review**, v. 66, n. 1, p. 213–216, 1976.
STULZ, R. M. Managerial discretion and optimal financing policies. **Journal of Financial Economics**, v. 2015, p. 3–27, 1990.
TANNURI-PIANTO, M. E.; SOUSA, M. DA C. S. DE; ARCOVERDE, F. D. Fronteiras de eficiência estocásticas para as empresas de distribuição de energia elétrica no Brasil: uma análise de dados de painel. **Estudos Econômicos**, v. 39, n. 1, p. 221–247, 2009.
TITMAN, S.; WESSELS, R. The Determinants of Capital Structure Choice. **The Journal of Finance**, v. XLIII, n. 1, p. 1–19, 1988.
UNICA - UNIÃO DA INDÚSTRIA DE CANA-DE-AÇÚCAR. **UNICADATA**. Disponível em: <http://www.unicadata.com.br>. Acesso em: 11 ago. 2017.
VIAN, C. E. F.; RODRIGUES, L.; SILVA, H. J. T. Evolution in Public Policies Designed to Develop the Sugar–Energy Industry in Brazil. *In*: CHANDEL, A.; SILVEIRA, M. H. L. (Eds.). . **Advances in Sugarcane Biorefinery. Technologies, Commercialization, Policy Issues and Paradigm Shift for Bioethanol and By-Products**. 1. ed. [s.l.] Elsevier, 2017. p. 279–306.
VILLALONGA, B.; AMIT, R. How do family ownership, control and management affect firm value? **Journal of Financial Economics**, v. 80, n. 2, p. 385–417, 2006.
VU, M. C.; PHAN, T. T.; LE, N. T. Relationship between board ownership structure and firm financial performance in transitional economy: The case of Vietnam. **Research in International Business and Finance**, v. 45, n. September 2017, p. 512–528, 2018.
WHITE, H. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. **Econometrica**, v. 48, n. 4, p. 817–838, 1980.
WILLIAMS, J. Perquisites, Risk, and Capital Structure. **The Journal of Finance**, v. 42, n. 1, p. 29–48, 1987.
WILLIAMSON, O. E. Hierarchical Control and Optimum Firm Size. **Journal of Political Economy**, v. 75, n. 2, p. 123–138, 1967.
WOOLDRIDGE, J. W. **Econometric Analysis of Cross Section and Panel Data**. London, England: The MIT Press, 2010.
YAMADA, S. **Cadeia produtiva da cana-de-açúcar em Goiás e análise de desempenho em eficiência de sistemas produtivos**. [s.l.] Universidade de Brasília, 2014.
ZHOU, X. Understanding the determinants of managerial ownershipand the link between ownershipand performance: comment. **Journal of Financial Economics**, v. 62, p. 559–571, 2001.