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The Market Power of Brazilian Private Higher Education Institutions: An Efficiency-Frontier Approach

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The Market Power of Brazilian Private Higher Education Institutions: An Efficiency-Frontier Approach

Abstract

The Brazilian government started to implement, mainly from the 2000s onwards, mechanisms to stimulate the supply and demand for higher education in Brazil. Especially the offer of private higher education has shown strong growth in recent years as a result of systematic public policies, which has increased competition in this market. In this expansion scenario, it remains to be seen how the competitive market environment is configured in terms of market power. Therefore, this article intends to estimate the market power of Brazilian higher education institutions - HEIs from an alternative use of the stochastic frontier model, as proposed by Kumbhakar et. al (2012), for the period 2010 to 2019. This method is adopted because it solves the impasse of the lack of information on marginal costs, which prevents the application of other models for estimating market power. The results pointed to the presence of positive and significant market power of Brazilian HEIs, which may imply anti-competitive behavior.

JEL-Codes: I220, L100.

Keywords: higher education market, market power, stochastic frontier.

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1. Introduction

In the last 30 years, several countries around the world have experienced an expansion in the number of university vacancies, in the midst of transformations of the labor market and the technological changes driven by the internationalization of production processes (Flannery and O'Donoghue, 2013; Heinesen, 2018; Oppedisano, 2011, 2014).

Following this international trend of higher education expansion, the Brazilian government began implementing institutional and financial mechanisms, particularly from the 2000s onwards, to stimulate both the supply and demand for higher education in the country. The common objectives of these mechanisms were to internalize the positive effects generated by higher levels of education on the economy, as well as to increase the supply of more qualified and specialized workers, in line with the new requirements of production processes (Zoghbi, Rocha and Mattos, 2013). These transformations in higher education were characterized by easier access to education and the proliferation of universities, driven by increased demand for higher education resulting from economic and institutional changes. Subsequent reforms further expanded the higher education system, a trend that continues today (Cunha, 2010).

Thus, the supply of higher education grew significantly during this period due to systematic public policies motivated by the benefits that could be provided by a more educated population. This growth was reflected in a greater number of public and, especially, private higher education institutions (HEIs), an increase in the number of available places, and an expansion in the number of courses registered by the Brazilian Ministry of Education (MEC) (Chaves and Amaral, 2016; Senhoras, Takeuchi, and Takeuchi, 2006). In recent decades, some Latin American countries, including Brazil, have moved from small and elite public systems to more diversified ones, where private institutions play a key role, including by serving low-income students who are unable to enter selective public universities (McCowan, 2007).

Among the determinants for the growth in the supply of higher education, we can highlight the liberalization of regulation and government stimulus, particularly through the National Education Plan (Plano Nacional de Educação - PNE), was first developed in 1996 with the objective of determining guidelines, goals and strategies for higher education (Ladies, Takeuchi and Takeuchi, 2006). On the other hand, since 2003 the growth rate of the population aged 18 to 24 (the main target group of higher education policies) has been negative, which has contributed to the real expansion of the system (Gomes and Moraes, 2012).

The large number of vacancies offered by private HEIs, compared to the number of students enrolled, may be seen as evidence of increased competition in the private higher education market. According to Musselin (2018), with growing competition, university leaders tend to proceed more strategic approaches, including a greater focus on their institution's reputation. In this scenario of expansion, it remains to be seen how the competitive environment in this market is shaped, specifically whether market power has become more or less concentrated.

Thus, the goal of this article will be to estimate the market power of Brazilian private higher education institutions. One option to obtain market power would be to estimate a total cost function, as in Weiher et al. (2002), or through the New Empirical Industrial Organization (NEIO) method, discussed by Bresnahan (1989), which allows for market power estimation without directly estimating marginal cost, using instead a regression that controls for variables affecting marginal cost. However, these methods have significant limitations, such as the need for data on all cost determinants (Kumbhakar, Baardsen and Lien, 2012; Perloff and Shen, 2012). Therefore, this paper opts for an alternative use of the stochastic frontier model, typically used in the efficiency literature, as proposed by Kumbhakar et. al (2012), for the period from 2010 to 2019. This method is adopted to solve the impasse of lack of information on marginal costs, which limits the application of other market power estimation models. Thus, it will also be possible to verify whether the expansion of higher education during this period fostered a more competitive market environment or, on the other hand, whether it disproportionately benefited a few providers with significant market power.

This article is organized as follows: section 2 presents the structure of the public and private higher education market in Brazil; section 3 brings some empirical work on the stochastic efficiency model, the methodology of the stochastic frontier estimator for market power, the empirical model and the data to be used; section 4 presents the obtained results and, section 5 brings some conclusions-

2. The higher education market in Brazil

In order to identify the market power, it is essential to define it properly, in such a way that only firms that really compete with each other are included in an analysis of market concentration. Defining a relevant market requires considering its dimension of product limits¹ (if there are substitutes in consumption or production) and geographic (local, national or international)², which is called the relevant economic market (Tremblay and Tremblay, 2012, p.184 -185). One way to present the higher education good would be to identify whether Higher Education Institutions (HEIs) offer three different types of products: teaching, research and extension, which are usually treated as complementary (Rubinstein and Weiss, 2006). In the present study, higher education will be treated in its product dimension as teaching, as it makes up the central axis of university activity and is an activity common to all institutions; and in its geographical dimension as local.³

¹ Here the higher education service will be treated as an asset/product/goods to follow the terminology of the antitrust literature.

² This usually depends on the value of the product, its weight and shipping costs (Tremblay and Tremblay, 2012, p.184-185). As it is a good that is a service, it can be said that its geographic market would be the area in which providers are able to attract consumers in the retail model in which location is a strategic variable (CADE, 2016).

³ This choice will be justified in the following chapter, which deals with the structure of the higher education market.

Higher education institutions in Brazil are classified according to the legal nature of their maintainers, between public institutions, created by bills, and private institutions, created by accreditation with the Ministry of Education (Senhoras, Takeuchi and Takeuchi, 2006). These institutions can be: (i) colleges, focused on specific areas of knowledge, (ii) universities, which, in addition to the functions of the faculty, must have professors who have a master's and doctorate degree and work full-time, intellectual production, investment in research, among others and (iii) university centers, which are institutions in transition from college to university. In 2017, the vast majority of HEIs in Brazil were from private colleges (1878 private colleges). But, on the other hand, a very small portion of private institutions were universities (only 93 private universities). The approach of this study will not consider the discrimination between these three types of HEI in the definition of the relevant market, following a discussion made by CADE in 2016.

In Brazil, there is also the possibility for HEIs to offer different types of courses and programs, with different services and aimed at consumers with different characteristics and objectives: (i) sequential courses by fields of knowledge, with different levels of coverage; (ii) undergraduate; (iii) graduate, open to candidates already graduated in undergraduate courses and; (iv) extension (according to article 44 of the “Lei de Diretrizes e Bases da Educação Nacional – LDB”). However, this paper will analyze the competition between institutions in terms of offering only the undergraduate course, as this is the main product offered by HEIs.

An important characteristic of private higher education institutions is the intense use of the distance learning educational modality, which uses information and communication means and technologies as a learning intermediary. As in distance learning, students and teachers do not need to be physically present in a classroom for the learning process to take place, educational institutions that offer distance courses incur with lower costs. This is because they do not need large physical spaces and infrastructure for face-to-face attendance to students, and because they are able to enroll a greater number of students for the same class. These characteristics helps to explain the large supply of private distance learning courses in Brazil compared to their demand.

The Brazilian competition authority (Conselho Administrativo de Defesa da Concorrência - CADE) considers the on-site higher education and distance higher education markets as distinct relevant markets, given the different characteristics between these two modalities, both in terms of supply (costs) and demand (the profile of students)⁴ (CADE, 2016). One of the main differences between on-site and distance courses is their geographic coverage, because while distance courses have a national coverage, on-site courses should only attract students who live or work in the vicinity of the HEI. In addition, market characteristics

⁴ Among the differences between presential and distance higher education courses, we can mention: the geographic scope; expansion cost, which is generally higher for face-to-face courses; monthly fee (higher in face-to-face courses); student income, as students enrolled in on-site courses tend to have higher incomes than others; age of students (according to the 2016 Higher Education Census, the average age of students in on-site courses was 24 years, and in distance courses was 34 years); maintenance costs (in general, on-site courses incur higher expenses with installation, travel and faculty).

tend to be spatially correlated (Gu, 2015). This justifies the choice of the relevant face-to-face higher education market as a local.

It is also possible that HEIs, especially large institutions, considered oligopolies, change their market positioning from mergers and acquisitions of rivals, contributing to a greater concentration in the relevant markets related to the provision of private higher education. Particularly, for-profit private institutions have stood out in the search for greater operational efficiency and greater cost management, which justifies merger strategies.⁵ These actions will be subject to examination and judgment by collegiate competition and regulatory bodies.⁶ In this sense, CADE carries out an examination of the concentration acts in the higher education market based on the product and geographic dimensions, in which, consider the existence of horizontal or vertical overlaps, the shareholding composition, the types and modalities of courses, the profiles of students (consumers) from the perspective of demand, geographic coverage, among others. CADE defines the relevant higher education markets based on the following elements: program types (sequential, undergraduate, specialization, master's or doctoral); Bachelor's, Licentiate and Technology courses; teaching modality; and courses and thematic axes (Corrêa, 2017).

To identify the product market based on demand, it is important to indicate the factors that determine substitutability between the courses offered by different HEIs. Differences in enrollment tend to be related to differences in individual and family characteristics of students (Peracchi, 2006). Among the reasons that induce students to choose certain educational institutions over others, the following can be listed: (i) the quality of the HEI; (ii) family income, as high-cost courses already exclude a large part of those interested; (iii) geographical difficulties, which limit access to certain courses and institutions, in such a way that the individual's choice is usually conditioned by their region; (iv) and a subjective component, which takes cultural and tradition issues into consideration (Ladies, Takeuchi and Takeuchi, 2006).

The increase in demand for higher education courses can be explained by the combination of the labor market's growing demand for a more qualified workforce with people's growing demand for social recognition and higher incomes resulting from higher salaries attributed to greater education (Kaganovich, Sarpça and Su, 2020; Schwartzman, 2015). Another factor in the expansion of demand for higher education can be attributed to the technological revolution (Peracchi, 2006) and the accelerated increase in the number of secondary education graduates (Senhoras, Takeuchi and Takeuchi, 2006).

HEIs compete to attract more students, and price competition between them becomes quite complex (Gu, 2015; Leslie and Brinkman, 1987; Weiler, 1984). And it is also to be expected that there will be some difference in the elasticity of demand between students who pay the full monthly fees, and those who receive discounts, because as the monthly fee increases, the elasticity coefficient should also increase. A

⁵ The higher education market is segmented into two main groups: public and private HEIs, the latter being divided into for-profit institutions, which represent the Second Sector, called Market; and non-profit, recognized as the Third Sector (Teodorovicz, Esteves and Leandro, 2015).

⁶ In Brazil, CADE is concerned with the competition policy, whereas MEC is concerned with the continuity of service provision.

higher price elasticity of demand, in turn, means that it is more sensitive to the price (monthly fee) (Bryan and Whipple, 1995; Liu et al., 2018).⁷ Furthermore, when investigating the regional market environment for a private HEI, Allen and Shen (1999) obtained the result that private education is a normal good, that is, they found a positive income elasticity of demand.

3. Stochastic Frontier Estimator of Market Power

The exercise of market power that companies eventually hold depends on the structural conditions described above as well as the strategic variables determining conduct (some of which will be analyzed in the following chapters). But before investigating this possibility of the existence of anti-competitive actions, it is essential to ascertain the market power of the firms.

The most widely used measure of market power in industrial organization is the Lerner Index (1934), given by the ratio of the divergence of price in relation to marginal cost in proportion to price:

$$\mathcal{L} = \frac{P - MC}{P}$$

where MC is the marginal cost, P is the price and \mathcal{L} is the market power that varies between zero and one. When $\mathcal{L}=0$ there is no market power, and as \mathcal{L} increases, market power increases. According to Beck et al. (2013) an advantage of using the Lerner Index is that it does not require a clear definition of the geographic market. However, to estimate \mathcal{L} it is necessary to first estimate the marginal costs, or through the New Empirical Industrial Organization (NEIO), discussed in Bresnahan (1989), which allows estimating market power without estimating the marginal cost directly, by considering, econometric estimations that control for cost shifters. To achieve this, it is necessary to have price data available for all inputs and outputs that, in general, are not directly observed (Bresnahan, 1989). Another disadvantage of this approach is that, as the Lerner index is calculated from observed and calculated information, some of the Lerner indexes may take on negative values. Furthermore, even if companies strive to minimize their costs, it is possible that they will not be able to achieve this objective accurately, and this estimation error should be taken into account when calculating mark-ups (Coccorese, 2014).

Therefore, this paper proposes the use of the method proposed by Kumbhakar et. al (2012) to estimate the market power of individual higher education institutions, given that the authors developed a method that resolves this impasse of lack of information on marginal costs, through the alternative use of the stochastic frontier analysis (SFA) model, typically used to estimate the frontiers of production, cost or profit functions.

⁷ Therefore, companies offering higher education courses are faced with a pricing problem that depends on the price elasticity of students in relation to the demand for education. Information about elasticity should help colleges adjust their prices to reach an appropriate enrollment quantity to an ideal allocation of their resources. Price elasticity of demand affects both capacity and production, which implies that being above a specific level of elasticity should cause excess idle capacity (Liu et al., 2018).

The main difference between the stochastic frontier model and NEIO approaches is that the stochastic frontier method uses the hypothesis that the markups is a systematic deviation from a marginal cost price frontier, ignoring the estimation of the demand function and elasticities required in NEIO to measure the distance between price and marginal cost. This gives SFA an advantage when data to estimate demand are not available. Furthermore, because the markup in SFA is measured for each observation, compared to a single parameter in NEIO, the approach is able to generate time-varying markups, as well as allowing the assessment of the presence of returns to scale (Lopez, He, and Azzam, 2018). Based on the theory of duality of cost and distance functions,⁸ SFA allows the use of both input price data and input quantity data to estimate market power.

If one conceives the plausibility of standard production function as applied to the education sector it is possible to rely on duality theory such that the production function $Y = f(X)$, can be represented by a minimum total cost function, $C(W, Y)$, where C is the minimum total cost and w is the vector of the input's prices used in production.

A well-known result is that under profit maximization, perfect competition and constant returns to scale, an implication is zero profit for the firm, with the embodied marginal revenue equating price reflecting price-taking behavior. Such case contrasts with non-competitive cases involving departures between price and marginal cost. Traditionally, what is done is to calculate the marginal cost from an estimated cost function and then check for the existence of profit. The problem is that a divergence between the price and the marginal cost may arise due to optimization errors of the agents involved. In addition, the estimation of costs and mark-up depend on an assumption of constant returns to scale, which is not always the case, and requires data on all determinants of the total cost.

But the method proposed by Kumbhakar et. al (op.cit.) overcomes these problems. Consider that:

$$P > MC \equiv \frac{\partial C}{\partial Y} \quad (2.1)$$

$$P \frac{Y}{C} > MC \frac{Y}{C} = \frac{\partial C}{\partial Y} \frac{Y}{C} = \frac{\partial \ln C}{\partial \ln Y} \quad (2.2)$$

$$\frac{P_{it}Y_{it}}{C_{it}} > \frac{\partial \ln C_{it}}{\partial \ln Y_{it}} \quad (2.3)$$

The left side of the equation represents the ratio between total revenue and total cost for HEI i at time t , and the right side is the cost elasticity with respect to output, $E_{C,Y}$. We can transform the above inequality into an equality by adding a non-negative one-sided term, u :

⁸ Both the cost function and the distance function are optimization problems. Duality Theory studies under which conditions these two optimization problems are related, and allows establishing alternative ways of representing these functions (Aparicio and Pastor, 2011).

$$\frac{P_{it}Y_{it}}{C_{it}} = \frac{\partial \ln C_{it}}{\partial \ln Y_{it}} + u, \quad u \geq 0 \quad (2.4)$$

The term representing the revenue share, $\frac{P_{it}Y_{it}}{C_{it}}$, can be affected by unobserved variables. This noise can be captured by a two-sided symmetric term, v , being that, by including this in (2.4), the equation becomes a stochastic frontier function.

Typically, stochastic frontier estimates refer to regression models in which the random (stochastic) part is split into two components: a random error term and a technical inefficiency component that are independent (Aigner, Lovell, and Schmidt, 1977; Battese and Corra, 1977; Meeusen and Broeck, van Den, 1977). The econometric formulation of a stochastic frontier with output orientation is:

$$y = x\beta + v - u \quad (2.5)$$

where y is the output, x is a vector of input, and β is a vector of unknown parameters. The error terms u and v are independent and can be represented as a composite error term: $\varepsilon = v - u$. The economic logic behind this specification is that the production process is subject to two economically distinguishable random disturbances with different characteristics. The term v is the usual random error, which follows a normal distribution and has a free signal, and can increase or reduce the product, while the term $u \geq 0$ measures the productive inefficiency, being non-negative.⁹ This disturbance u reflects the fact that each firm's output must be at or below the frontier. Any deviation is the result of factors within the firm's control, but the frontier itself may vary randomly across firms or over time for the same firm. It is necessary to make distributional assumptions about the inefficiency term, which generally assumes a seminormal, truncated normal, or exponential distribution (Aigner, Lovell, and Schmidt, 1977).

The stochastic efficiency frontier is based on strong econometric assumptions and requires a large number of observations, allowing the application of standard statistical tests (Poker Jr, Nunes and Nunes, 2013). To estimate the coefficients of stochastic frontiers, maximum likelihood estimators are generally used (Kumbhakar and Lovell, 2000).

3.1 Empirical work on stochastic efficiency frontier models

Production frontier models can be traced back to the work of Farrell (1957), who began to consider the possibility of estimating frontier production functions in an effort to fill the gap between production function theory and empirical work (Aigner, Lovell and Schmidt, 1977).

This type of analysis has also been carried out for the education sector, although with a different approach than the one proposed in this article. Zoghbi et al. (2009) and Poker et al. (2013) assessed the

⁹ If random errors, u , are absent, the model obtained is called a “medium frontier model”, the one most frequently estimated in econometric studies (Battese and Corra, 1977).

performance and relative efficiency of education spending across geographic areas at the primary and secondary levels. Zoghbi et al. (2009) derived simple quantitative performance indicators based on enrollment and completion rates as outputs of an efficient frontier analysis. They used a “production possibility frontier” and output efficiency scores to rank Brazilian states in terms of education spending efficiency. The authors used as inputs state education spending and an aggregate input indicator covering the number of teachers per student, average class hours, and school infrastructure. Poker et al. (2013), in turn, used the stochastic frontier analysis methodology to assess the quality of public spending on education based on the variation in the HEI-education.

Costa et al. (2015), Zoghbi, Rocha and Mattos (2013), Marinho, Resende and Façanha (1997) and Beasley (1995) estimated the efficiency of higher education institutions. According to Marinho, Resende and Façanha (1997), strict profit maximization is not the main organizing principle of HEI conduct, and thus, efficiency cannot be defined trivially. The authors used the nonparametric Data Envelopment Analysis (DEA) method because it is a flexible empirical approach for comparative efficiency measurement, in addition to dealing with difficulties related to the unavailability of input and output prices. They used as input data: building area, hospital area, laboratory area, total number of students, academic staff with doctorates/masters/specializations/second and first degrees, administrative staff, budget for current expenses, incoming students and entry of medical residents; and as output data: number of undergraduate/masters/doctorate courses, certificates issued, number of dissertations/theses, MEC evaluation for masters/doctorate courses. They found that most federal HEIs are efficient. Beasley (1995) also used a DEA-based model to compare university departments in terms of their overall efficiency. The author used as output measures: the number of undergraduate students, the number of postgraduate students, research revenue (as a proxy for research production) and the concept received by the research (excellence, A+, A or A-); and as input measures: general expenses, equipment expenses, and research income.

Zoghbi, Rocha and Mattos (2013), in turn, estimated the efficiency of HEIs with an emphasis on their determinants, taking into account the relative efficiency of public and private institutions in the application of their resources. To this end, they used a stochastic production function for higher education, in which each university must deal with its own production frontier, which depends on the complete set of stochastic elements considered important but which cannot be controlled by the universities. To apply the model, the authors used as inputs for the labor factor the total number of teachers per enrolled students, the total number of computers per student for the capital factor, and requirements of a pedagogical plan as a proxy for technology. In addition, they also included educational expenditures, data on students (percentage of students who work, race, maternal education, gender, age, and dropout rate), and characteristics of the state of the HEI as explanatory variables.

Costa et al. (2015) estimated dynamic efficiency frontiers for public higher education as a way of dealing with the different conditions and environments of the educational production sector, which has

many inputs and outputs. This study uses a dynamic model for the period 2004 to 2008, enabling the measurement of the variation in the efficiency of institutions over time. The authors considered quantitative and financial inputs, and outputs related to teaching and research, in the comparison between 49 federal public HEIs. Variable inputs that make the services offered by HEIs possible were used, such as current cost per student, student per teacher, student per staff, and faculty qualification index. The outputs were represented by teaching and research performance indicators (ratio between students graduated and enrolled, and the CAPES score for postgraduate studies). The results of the dynamic efficiency estimates for both groups, indicated that most universities were on the efficient frontier, with high efficiency scores, indicating that there were not many differences between HEIs in the use of inputs to generate teaching and research indicator outputs. In addition, the productivity indexes indicated that there was a loss of productivity for most universities between 2004 and 2008.

Johnes and Johnes (2009) estimated the cost of higher education institutions in England that allows institutions to differ in terms of efficiency and cost technologies. That is, they used frontier estimation methods with random parameters that allow unobserved heterogeneity in the cost function between institutions, on the one hand, and inefficiency, on the other hand, to be disaggregated.

So far, empirical studies have been presented using production frontier models in the education market. However, as far as we know, the use of the alternative stochastic frontier model to estimate market power according to Kumbhakar et. al (2012) has not yet been applied in the education sector, although there are studies that have replicated this methodology in other markets.

Coccorese (2014) analyzed the market power of individual banks in the banking sectors of 87 countries for the period 1994 to 2012 by applying the econometric method proposed by Kumbhakar et. al (2012), and obtained statistically positive Lerner indices as a result. Li et al. (2019) also used this method to assess market power in China's railway sector, since it only requires aggregated data on revenue and operating costs, without the need for detailed price data, which would make an analysis of market power in this sector unfeasible. The authors found that the railway operator has considerable market power, and that there is significant heterogeneity in market power among local railway offices.

Lopez et al. (2018) analyzed the mark-up in the US food industry using the stochastic frontier methodology developed by Kumbhakar et. al (2012) in an extended form, that is, they separated the non-competitive deviations into a deterministic deviation, which is a function of a vector of explanatory variables, from a purely stochastic deviation. They obtained as a result that a higher production volume leads to a higher revenue in relation to the variable cost. In addition, about half of the estimated profit came from stochastic deviations.

3.2 Empirical model

Following Kumbhakar et. al (2012), given a time period t and an HEI i , the empirical model starts with a logarithmic transcendental cost function (translog):

$$\begin{aligned} \ln C_{it} = & \beta_0 + \sum_{j=1}^J \beta_j \ln W_{jit} + 0,5 \sum_{j=1}^J \sum_{k=1}^J \beta_{jk} \ln W_{jit} W_{kit} + \beta_Y \ln Y + \sum_{j=1}^J \beta_{jY} \ln W_{jit} \ln Y_{it} \\ & + 0,5 \beta_{YY} (\ln Y)^2 + \beta_T T + 0,5 \sum_{j=1}^J \beta_{jT} \ln W_j T + 0,5 \beta_{TT} T^2 + \beta_{YT} T \ln Y \end{aligned} \quad (2.6)$$

where β are the unknown parameters to be estimated, W are the prices or quantities of inputs, and the indices j and k identify the production factors used in estimating the cost function. However, since the objective is to estimate only the mark-ups, it will only be necessary to estimate (2.3), and not the entire cost function given by (2.6). As seen previously, the variable Y represents production; however, when considering the HEIs as production units, we have a multiproduct case, since there are several course options offered by the same HEI.

From function (2.4), the expression for cost elasticity, $\frac{\partial \ln C}{\partial \ln Y}$, becomes:

$$\frac{\partial \ln C_{it}}{\partial \ln Y_{it}} = \beta_Y + \beta_{YY} \ln Y + \sum_{j=1}^J \beta_{jY} \ln W_j + \beta_{YT} T \quad (2.7)$$

Combining equations (2.3) and (2.5), we have:

$$\frac{P_{it} Y_{it}}{C_{it}} = \beta_Y + \beta_{YY} \ln Y + \sum_{j=1}^J \beta_{jY} \ln W_j + \beta_{YT} T + u_{it} + v_{it} \quad (2.8)$$

The compound error term in equation (4.8) ($u + v$) is the same as that which appears in stochastic frontier equations according to Aigner et al. (1977) and Meeusen and Van Den Broeck (1997) and, therefore, it is possible to use this approach to estimate the model in (2.8). However, the expression in (2.8) is not a cost function and the interpretation of the one-sided term, u , is not a cost inefficiency. According to Kumbhakar et. al (2012), the error term in (2.8) is related exclusively to the mark-up. Since the stochastic frontier approach uses the maximum likelihood method that relies on distributional assumptions about the error components, we follow the work of Kumbhakar et. al (2012) and Zoghbi et al. (2013), and make the following distributional assumptions:

$$u \sim \exp(\lambda)$$

$$v \sim N(0, \sigma_v^2)$$

that is, the error term u follows an exponential distribution with mean $1/\lambda$ and variance $1/\lambda^2$, and the error term v follows a normal distribution with mean 0 and variance σ_v^2 .

Since the distribution of v is symmetric, we can insert a minus or plus sign in v without harm. Thus, we can rewrite (2.6) as:

$$-\frac{P_{it}Y_{it}}{C_{it}} = -\left(\beta_Y + \beta_{YY}\ln Y + \sum_{j=1}^J \beta_{jY}\ln W_j\right) - u_{it} + v_{it} \quad (2.9)$$

From a statistical point of view, the compound error term in (2.9) is not different from the error term of a stochastic production frontier model, although the one-sided term in (2.9), u , is not an inefficiency term. The statistical similarity of (2.8) and (2.9) with stochastic frontier models justifies the choice of using the frontier tool to estimate the mark-up. Since the interest is in estimating the one-sided error term, u , which is related to the mark-up, we follow the estimation procedure for a cost frontier, according to equation (2.8), or a production frontier, according to equation (2.9).

The likelihood function is derived to estimate the model parameters using the assumptions of normal distribution for the error term v and exponential distribution for the error term u (as explained earlier). The parameters are then estimated using the maximum likelihood (MV) method.

Mark-up is commonly defined as the fraction by which price exceeds marginal cost, i.e., $\theta = (P - MC)/MC$, therefore, it can be related to the error term u . Using equation (2.4) we can observe that:¹⁰

$$\theta = \frac{P - MC}{MC} = \frac{\left(MC + u \frac{C}{Y}\right) - MC}{MC} \quad (2.10)$$

$$\theta = u \cdot \frac{\frac{C}{Y}}{MC} = \frac{u}{\left(\frac{\partial \ln C}{\partial \ln Y}\right)}$$

Therefore, after estimating u and using equation (2.8), it is possible to estimate θ from:

$$\hat{\theta}_{it} = \frac{\hat{u}_{it}}{\left(\hat{\beta}_Y + \hat{\beta}_{YY}\ln Y + \sum_{j=1}^J \hat{\beta}_{jk}\ln W_j\right)}$$

where \hat{u} is the estimator¹¹ of u by both equation (2.8) and (2.9). The parameters of (2.10) are replaced by their maximum likelihood estimates.

The estimation of the mark-up factor depends on the estimated values of u and the cost elasticity, and to estimate u (from (2.8) or (2.9)), there is no need for separate information on the price of production,

¹⁰ $P = \left(\frac{\partial \ln C}{\partial \ln Y} + u\right) \cdot \frac{C}{Y}$, $u \geq 0$

¹¹ See Jondrow et al. (1982)

since the revenues over total cost, which are normally observed, are sufficient. If the estimated u is small, the estimated value for the mark-up will also be small (provided that the estimated cost elasticity is not too far from unity).

The estimates of θ_{it} from equation (2.10) can be used to obtain Lerner's measure of market power (\mathcal{E}_{it}) from the relation $\mathcal{E}_{it} = \theta_{it}/(1 + \theta_{it})$. However, direct calculation of this index requires information on the price of output and estimates of marginal cost.

Furthermore, equation (2.7) measures cost elasticity, which is related to measures of returns to scale. This can be seen by analyzing the following relationship:

$$E_{cy} = \frac{\partial \ln C}{\partial \ln Y} = \frac{\partial C}{\partial Y} \frac{Y}{C} = \frac{MC}{AC} \quad (2.11)$$

where E_{cy} is the cost elasticity and AC is the long-run average cost. Returns to scale (R) are related to cost elasticity: $R = 1/E_{cy}$. This means that there will be constant returns to scale when $E_{cy} = 1$, increasing returns to scale when $E_{cy} < 1$, and decreasing returns to scale when $E_{cy} > 1$. Therefore, the model in (2.7) can also be used to calculate returns to scale (R) as well as the scale bias (ε). If the scale bias is statistically greater than zero, technological changes reduce economies of scale over time.

$$RT = 1 / \left(\hat{\beta}_Y + \hat{\beta}_{YY} \ln Y + \sum_{j=1}^J \hat{\beta}_{jY} \ln W_j + \hat{\beta}_{YT} T \right) \quad (2.12)$$

$$\varepsilon = \hat{\beta}_{YT} \quad (2.13)$$

In this paper it will be assumed that u follows an exponential distribution, however, this term could also assume a truncated normal, half-normal or gamma distribution.¹² It is also possible to include covariates that help to explain u directly and, therefore, have a relationship with the mark-up.

3.3 Data

The data used are annual and consist of an unbalanced panel, obtained by the Higher Education Census, made available by the National Institute of Studies and Educational Research Anísio Teixeira (INEP), for the period from 2010 to 2019,¹³ for all private HEIs in Brazil.

For the input variables, were considered the number of administrative technicians per student and professors per student, following studies such as those by Marinho, Resende and Façanha (1997) and Costa et al. (2015). In addition, the proportion of professors with doctorates and master's degrees, the proportion of professors with exclusive dedication, and the average workload of courses at a HEI were also considered

¹² In fact, the models were also replicated for other distributions of the term u - truncated normal and half-normal -, but as the results were extremely similar, only the results according to an exponential distribution of the term u were presented.

¹³ Currently, INEP provides information up to the year 2019, what is convenient as one can avoid possible distortions associated with the COVID pandemic period.

as inputs. As a variable that characterizes the infrastructure of the HEI, due to the lack of information in the Higher Education Census for the entire period analyzed (2010 to 2019), the students' perception of infrastructure and physical facilities was considered. This information is made available by the Preliminary Course Concept Indicator (CPC) database,¹⁴ which provides an average per course of the assessment made by students who took the National Student Performance Exam (Enade) that year. Then, a per HEI average was calculated based on this information per course.

It is possible that the share of total revenue of HEIs (PY/C) is related not only to the inputs and prices of the inputs available, but also to the quality they offer. Although measuring teaching quality can be quite controversial, a proxy widely used in the literature to signal quality is teaching and research performance (Costa et al., 2015; Peracchi, 2006; Sanders, 2002). In fact, Musselin (2018) and Gu (2015) point out that the activity of HEIs is often measured and transformed into numbers, classifications and grades that can be used as reputation and quality variables. Therefore, quality measures through the General Course Index (IGC)¹⁵ and the CPC made available by INEP, which evaluates higher education institutions, will be included as variables of interest. Furthermore, with the intention of comparing the quality of private HEIs with public HEIs, a variable was created for the deviation of the IGC of each private HEI in relation to the average IGC of public HEIs.¹⁶

A technology index T was also inserted into the database, as in Kumbhakar et al. (2012), which captures technical change, represented by a time trend variable. Another trend variable that was inserted is the proportion of enrollments in distance learning courses, since in the case of higher education, an important change that has been occurring since 2010 is the growth of higher education in the distance learning modality. Finally, was inserted one variable that indicates the number of full scholarships from the “University for All Program” (*Programa Universidade para Todos* - Prouni) available at each HEI.¹⁷

Most of the data were obtained from the INEP website, with revenue and output variables (number of enrollments) and input variables taken from the Higher Education Census, and quality and infrastructure proxy variables taken from the database of educational indicators for higher education. Data related to Prouni scholarships were taken from the MEC Open Data Portal.¹⁸

To estimate the market power of the higher education sector using the stochastic frontier method, it is best to consider comparable units, that is, only HEIs belonging to the same relevant market. Costa et al.

¹⁴ Quality indicator that evaluates undergraduate courses (INEP, 2021; v. < <https://www.gov.br/inep/pt-br/areas-de-atuacao/pesquisas-estatisticas-e-indicadores/indicadores-de-qualidade-da-educacao-superior/conceito-preliminar-de-curso-cpc>> Accessed on October 1, 2021.

¹⁵ The IGC calculation is carried out annually and takes into account the following aspects: average preliminary course concept (CPC), average evaluation concepts for stricto sensu postgraduate programs assigned by the Coordination for the Improvement of Higher Education Personnel (CAPES) in the last available triennial evaluation, and distribution of students among the different levels of education (undergraduate or stricto sensu postgraduate).

¹⁶ In Brazil, in general, public HEIs are recognized as being of higher quality (Costa et al. 2015).

¹⁷ This program provides full (100%) or partial (50%) scholarships for low-income students. (see < <http://prouniportal.mec.gov.br/infografico-como-funciona> > Accessed on October 1, 2023).

¹⁸ <http://dadosabertos.mec.gov.br/prouni>. Accessed on October 1, 2023.

(2015) used two subsets of HEIs according to the similarities of their teaching, research, and extension activities, that is, they considered a group of institutions that develop research, and another of institutions focused on undergraduate education. This division helps to reduce the heterogeneity that exists among HEIs. Furthermore, since students are expected to have a preference for higher education courses close to their hometowns, the market power of HEIs could be better characterized by considering regional markets. Therefore, in this paper, what is proposed is to repeat the estimation in three ways: first, considering all HEIs; second, considering a subdivision of HEIs with research expenditure versus HEIs without research expenditure;¹⁹ and third, considering another subdivision, according to the 5 regions of Brazil.

Table 1 below shows the total number of private HEIs present in the database by year, and the total number of private HEIs according to the subdivisions adopted. In the period from 2010 to 2019, the number of private HEIs increased. Furthermore, in relation to the first division, what is observed is that approximately 30% of private HEIs did not invest in research in all the years analyzed.²⁰ In relation to the second subdivision adopted, what is observed is that only the Southeast region concentrates more than 40% of all private HEIs in Brazil, in all years, although it was the only region with a decrease in the number of private HEIs over the period considered.

TABLE 1: Number of HEIs per year

| Year | Division 1 | | | | | | Division 2 | | | | | | | | | |
|------|--------------|------------------|-------|----------------|-------|--|------------|------|-----|-------|-----|-------|-------|-------|--------|-------|
| | Total IES | With research | | No research | | | North | | NE | | SE | | South | | Center | |
| | | | (%) | | (%) | | (%) | (%) | (%) | (%) | (%) | (%) | (%) | (%) | (%) | (%) |
| 2010 | 2080 | 1455 | 69.95 | 625 | 30.05 | | 113 | 5.43 | 369 | 17.74 | 969 | 46.59 | 327 | 15.72 | 202 | 9.71 |
| 2011 | 2089 | 1484 | 71.04 | 605 | 28.96 | | 121 | 5.79 | 372 | 17.81 | 970 | 46.43 | 332 | 15.89 | 206 | 9.86 |
| 2012 | 2134 | 1524 | 71.42 | 610 | 28.58 | | 121 | 5.67 | 386 | 18.09 | 977 | 45.78 | 348 | 16.31 | 206 | 9.65 |
| 2013 | 2089 | 1511 | 72.33 | 578 | 27.67 | | 113 | 5.41 | 381 | 18.24 | 941 | 45.05 | 351 | 16.80 | 212 | 10.15 |
| 2014 | 2080 | 1495 | 71.88 | 585 | 28.13 | | 118 | 5.67 | 390 | 18.75 | 932 | 44.81 | 349 | 16.78 | 209 | 10.05 |
| 2015 | 2073 | 1496 | 72.17 | 577 | 27.83 | | 120 | 5.79 | 396 | 19.10 | 921 | 44.43 | 349 | 16.84 | 207 | 9.99 |
| 2016 | 2100 | 1501 | 71.48 | 599 | 28.52 | | 126 | 6.00 | 419 | 19.95 | 919 | 43.76 | 350 | 16.67 | 210 | 10.00 |
| 2017 | 2131 | 1487 | 69.78 | 644 | 30.22 | | 138 | 6.48 | 457 | 21.45 | 949 | 44.53 | 363 | 17.03 | 216 | 10.14 |
| 2018 | 2214 | 1522 | 68.74 | 692 | 31.26 | | 146 | 6.59 | 508 | 22.94 | 952 | 43.00 | 366 | 16.53 | 236 | 10.66 |
| 2019 | 2137 | 1474 | 68.98 | 663 | 31.02 | | 141 | 6.60 | 493 | 23.07 | 915 | 42.82 | 354 | 16.57 | 234 | 10.95 |

Source: Prepared by the authors based on data provided by INEP, 2021.

Table 2 presents the variables used and some descriptive statistics for the period analyzed. The observation units considered are private HEIs, but it should be noted that some adjustments were necessary

¹⁹ To this end, a sum of the HEIs' research expenses was carried out over the 10 years analyzed, which allowed us to verify which institutions did not incur research expenses.

²⁰ It is worth noting that, according to the INEP Higher Education Census, all federal universities are within the group of HEIs with research.

to adapt the data related to the HEIs' sponsors. This is because, in some cases, the information related to total revenue (PY) and total expenditure (C) was reported by HEI and, in others, by sponsor.²¹ Therefore, in cases of aggregated information for sponsor, the value was divided between the HEIs of the sponsor weighted by the number of enrollments of the HEI.

TABLE 2: Descriptive analysis of variables

| Variables | Description | OBS. | Mean | S.D. | Min. | Max. |
|----------------------------|--|-------|---------|----------|-------|----------|
| Revenue and product | | | | | | |
| RS | (PY/C) | 21127 | 1.21 | 0.58 | 0.00 | 9.92 |
| y | Product: number of registrations | 21127 | 2733.50 | 13003.01 | 10 | 431410 |
| Inputs | | | | | | |
| x1 | Number of teachers per student | 21127 | 0.11 | 0.12 | 0.00 | 2.78 |
| x2 | Proportion of teachers with a doctorate | 21127 | 0.16 | 0.14 | 0 | 1 |
| x3 | Proportion of teachers with a master's degree | 21127 | 0.46 | 0.16 | 0 | 1 |
| x4 | Average workload of the institution's courses | 21085 | 3306.86 | 803.44 | 20.00 | 12166.00 |
| x5 | Number of administrative technicians per student | 21127 | 0.12 | 0.39 | 0.00 | 15,23 |
| x6 | Proportion of teachers with exclusive dedication | 21127 | 0.03 | 0.09 | 0 | 1 |
| x7 | Students' perception of infrastructure and physical facilities (average of HEIs) | 17132 | 3.44 | 1.17 | 0 | 5 |
| igc | Quality Index - General Course Index (average of HEIs) | 17307 | 2.41 | 0.56 | 0.22 | 4.93 |
| cpc | Quality Index - Preliminary Course Concept (average of HEIs) | 17132 | 2.09 | 0.92 | 0 | 4.86 |
| prouni | Total number of Prouni scholarships | 21127 | 98.81 | 541.32 | 0 | 36618.00 |
| fies | Total number of Fies scholarships | 19047 | 117.29 | 458.59 | 0 | 28474.00 |
| capital | Municipalities that are state capitals | 20440 | 0.35 | 0.48 | 0 | 1 |
| IES | | | | | | |
| municipalities | Number of HEIs present in the municipality | 21127 | 24.13 | 37.22 | 1 | 156.00 |
| dl | Trend variable (proportion of enrollments in distance learning courses) | 21127 | 0.02 | 0.10 | 0 | 1 |
| t | Trend variable (time) | 21127 | 5.53 | 2.88 | 1 | 10 |

Source: Prepared by the authors based on data provided by INEP, 2021.

The total revenue of HEIs (PY) is the sum of their own revenue, transfers and others, and the total expenditure (C) is the sum of personnel expenses (teachers, technicians and others), personnel charges, costs, investment, research and others. Only HEIs with at least 10 enrolled students remained in the sample, as information different from this is inconsistent with reality and may signal errors in the database.

²¹ In Brazil, there are HEIs that are their own maintainers, and there are HEIs that are part of a larger group of several HEIs that are managed by a single maintainer.

This descriptive analysis reveals a large dispersion in the number of enrollments among private HEIs in Brazil. Another characteristic observed in these HEIs is that the proportion of professors with a master's degree is much higher than the proportion of professors with a doctorate, while the proportion of professors with exclusive dedication is very low - only 0.3. It is also interesting to note that students' perception of the quality of the infrastructure and physical facilities of HEIs is quite positive when compared with the score that these HEIs achieved in the quality indexes developed by INEP (IGC and CPC). Regarding the location factor of private HEIs, more than 30% are located in the capitals of their respective states and, on average, compete with 23 others private HEIs in their municipalities. Finally, it is observed that the proportion of enrollments in distance learning courses is still quite low, but if analyzed year by year, this variable increased throughout the period analyzed: this proportion was 0.012 in the initial year of analysis, and 0.027 in the final year of analysis, which represents a growth of more than 100%.

Table 3 presents the mean and standard deviation of the variables according to the separation between a group of HEIs that have research expenses and another of HEIs that do not. Just over half of private HEIs in Brazil declare that they have research expenses, and the average number of enrollments is higher within this group of HEIs than the average number of enrollments of those that do not have research expenses. This may be related to the fact that research is generally more common in universities, which enroll a larger number of students. Regarding the inputs, what is observed is that the average number of professors per student, as well as the average number of administrative technicians per student, is higher among HEIs without research (which can be explained by the lower number of enrollments), although the proportion of professors with doctorates is lower for this group of HEIs, as is to be expected. Also, the average course workload of HEIs without research is slightly lower than that of HEIs with research. Students' perception of the infrastructure and physical facilities of HEIs is practically the same among students from HEIs with and without research. However, the IGC quality indicator points to higher scores among HEIs that have research, which indicates higher quality of courses. The number of scholarships offered by the Fies and Prouni programs is, on average, higher at universities with research. The average number of HEIs in capital cities, the average number of competitors in the HEI's municipality, and the proportion of enrollments in distance learning courses remained practically the same in the two groups analyzed.

TABLE 3: Analysis of variables according to division between HEIs with and without research

| Variables | With research | | | No research | | |
|----------------------------|---------------|---------|----------|-------------|----------|----------|
| | OBS. | Mean | S.D. | OBS. | Mean | S.D. |
| Revenue and product | | | | | | |
| RS | 14278 | 1.23 | 0.56 | 6849 | 1.18 | 0.62 |
| y | 14278 | 3022.79 | 11880.17 | 6849 | 2130.411 | 15060.37 |
| Inputs | | | | | | |
| x1 | 14278 | 0.10 | 0.12 | 6849 | 0.13 | 0.14 |
| x2 | 14278 | 0.17 | 0.15 | 6849 | 0.13 | 0.13 |
| x3 | 14278 | 0.46 | 0.16 | 6849 | 0.44 | 0.17 |
| x4 | 14248 | 3343.55 | 804.45 | 6837 | 3230.41 | 795.98 |
| x5 | 14278 | 0.11 | 0.37 | 6849 | 0.12 | 0.43 |
| x6 | 14278 | 0.03 | 0.09 | 6849 | 0.03 | 0.08 |
| x7 | 12123 | 3.45 | 1.17 | 5009 | 3.40 | 1.18 |
| igc | 12257 | 2.44 | 0.55 | 5050 | 2.33 | 0.06 |
| cpc | 12123 | 2.13 | 0.90 | 5009 | 2.00 | 0.96 |
| prouni | 14.278 | 108.17 | 467.24 | 6849 | 79.29 | 669.54 |
| fies | 12.848 | 124.87 | 337.43 | 6199 | 101.58 | 640.21 |
| capital | 13.837 | 0.34 | 0.47 | 6603 | 0.38 | 0.48 |
| IES municipalities | 14.278 | 24.38 | 37.94 | 6849 | 23.59 | 35.66 |
| dl | 14278 | 0.02 | 0.11 | 6849 | 0.01 | 0.08 |
| t | 14278 | 5.51 | 2.86 | 6849 | 5.58 | 2.92 |

Source: Prepared by the authors based on data provided by INEP, 2021.

Finally, Table 4 presents the average of the variables according to the breakdown of HEIs by region of Brazil. The Central-West, North and Northeast regions are those that have the highest average share of total revenue in relation to total cost. The Southeast, as expected, had the largest number of HEIs, but the highest average enrollment per HEI was observed in the South region, and the lowest in the North region. The ratio of professors per student is higher in the South region, however, the proportion of professors with a doctorate degree is higher in the Southeast. The average workload of courses in Brazilian HEIs and the proportion of professors with exclusive dedication are higher in the North region. Students' perception of HEI infrastructure did not vary much between Brazilian regions, while the average IGC index points to a higher quality of HEIs in the South region of Brazil.

TABLE 4: Analysis of variables according to the division of HEIs in each Region of Brazil

| | North | | NE | | SE | | South | | Center | |
|----------------------------|-------|---------|------|---------|------|---------|-------|---------|--------|---------|
| Variables | OBS. | Mean | OBS. | Mean | OBS. | Mean | OBS. | Mean | OBS. | Mean |
| Revenue and product | | | | | | | | | | |
| RS | 1255 | 1.29 | 4145 | 1.28 | 9218 | 1.19 | 3437 | 1.13 | 2127 | 1.30 |
| y | 1255 | 1978.48 | 4145 | 2052.68 | 9218 | 3004.24 | 3437 | 3843.67 | 2127 | 2481.79 |
| Inputs | | | | | | | | | | |
| x1 | 1255 | 0.10 | 4145 | 0.10 | 9218 | 0.11 | 3437 | 0.14 | 2127 | 0.09 |
| x2 | 1255 | 0.11 | 4145 | 0.13 | 9218 | 0.19 | 3437 | 0.15 | 2127 | 0.14 |
| x3 | 1255 | 0.39 | 4145 | 0.46 | 9218 | 0.45 | 3437 | 0.50 | 2127 | 0.42 |
| x4 | 1253 | 3541.39 | 4126 | 3404.27 | 9208 | 3341.78 | 3429 | 3087.09 | 2125 | 3244.38 |
| x5 | 1255 | 0.15 | 4145 | 0.09 | 9218 | 0.12 | 3437 | 0.12 | 2127 | 0.09 |
| x6 | 1255 | 0.04 | 4145 | 0.03 | 9218 | 0.03 | 3437 | 0.03 | 2127 | 0.03 |
| x7 | 1012 | 3.56 | 3153 | 3.39 | 7649 | 3.43 | 2864 | 3.49 | 1733 | 3.45 |
| igc | 1008 | 2.24 | 3186 | 2.32 | 7725 | 2.46 | 2901 | 2.51 | 1759 | 2.32 |
| cpc | 1012 | 1.98 | 3153 | 2.03 | 7649 | 2.13 | 2864 | 2.19 | 1733 | 2.09 |
| prouni | 1255 | 70.05 | 4145 | 75.71 | 9218 | 103.96 | 3437 | 146.11 | 2127 | 95.35 |
| fies | 1137 | 144.72 | 3757 | 165.41 | 8314 | 112.22 | 3094 | 85.79 | 1919 | 120.38 |
| capital | 1251 | 0.58 | 4121 | 0.48 | 9099 | 0.28 | 3426 | 0.26 | 2113 | 0.49 |
| IES municip. | 1255 | 10.28 | 4145 | 15.88 | 9218 | 31.43 | 3437 | 14.00 | 2127 | 22.65 |
| dl | 1255 | 0.00 | 4145 | 0.01 | 9218 | 0.02 | 3437 | 0.03 | 2127 | 0.02 |
| t | 1255 | 5.72 | 4145 | 5.81 | 9218 | 5.47 | 3437 | 5.59 | 2127 | 5.63 |

Source: Prepared by the authors based on data provided by INEP, 2021.

Still in the analysis of regions, it is observed that Prouni scholarships benefited, on average, more students from the South region, while Fies was more present in the North and Northeast regions of the country. It is also interesting to note that, while in the Southeast many of the HEIs are located in municipalities other than the capitals, in the North, Northeast and Central-West, approximately 50% of all HEIs are located in the state capitals. It is also observed that, on average, in the Southeast, HEIs face relatively greater competition with other HEIs within the municipality in which they are located, while this competition is much lower in the North region.

4. Results

The results obtained through the input function will be presented below, considering: (i) all Brazilian HEIs; (ii) only HEIs that have research expenditures and; (iii) only HEIs without research. Table 5 below presents the estimated parameters for these three types of estimation. Most of the coefficients of the inputs considered are statistically significant and, as expected, most of the inputs (teachers per student, proportion of professors with doctorates and master's degrees, and proportion of professors with exclusive dedication)

have a negative relationship with the RS ratio (the revenue share ratio). Furthermore, with the exception of the enrollment variable, the other variables presented a very similar behavior between the overall total of HEIs and the group of HEIs with research expenditures. Also, when comparing HEIs with and without research, it is observed that in HEIs without research, the number of enrolled students contributes more to changes in the RS ratio, while in HEIs with research, the other inputs were more capable of affecting RS, mainly the inputs of number of professors per student, proportion of professors with doctorates, and proportion of professors with exclusive dedication.

TABLE 5: Parameters estimated by the Input Function for all HEIs and according to the presence or absence of research

| Parameters | With research | | | | No research | |
|---------------|---------------|-------|---------------|-------|---------------|-------|
| | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. |
| registrations | <u>0.034</u> | 0.006 | <u>0.014</u> | 0.007 | <u>0.088</u> | 0.012 |
| x1 | <u>-0.327</u> | 0.062 | <u>-0.389</u> | 0.069 | -0.07 | 0.139 |
| x2 | <u>-0.298</u> | 0.043 | <u>-0.341</u> | 0.049 | <u>-0.192</u> | 0.086 |
| x3 | -0.061 | 0.033 | -0.046 | 0.038 | <u>-0.129</u> | 0.062 |
| x4 | <u>0.000</u> | 0.000 | <u>0.000</u> | 0.000 | <u>0.000</u> | 0.000 |
| x5 | 0.004 | 0.018 | -0.012 | 0.02 | 0.057 | 0.039 |
| x6 | <u>-0.190</u> | 0.060 | <u>-0.211</u> | 0.07 | -0.125 | 0.115 |
| x7 | <u>-0.008</u> | 0.003 | -0.002 | 0.004 | <u>-0.020</u> | 0.007 |
| dl | <u>-0.188</u> | 0.061 | <u>-0.141</u> | 0.068 | <u>-0.287</u> | 0.139 |
| t | <u>0.015</u> | 0.004 | <u>0.018</u> | 0.005 | 0.001 | 0.007 |
| const | <u>3.663</u> | 0.272 | <u>3.746</u> | 0.271 | 2.118 | 2.522 |
| sigma_u2 | 0.09 | 0.004 | 0.088 | 0.004 | 0.088 | 0.007 |
| sigma_v2 | 0.196 | 0.002 | 0.197 | 0.003 | 0.193 | 0.004 |
| Obs | 1728 | | 12577 | | 4551 | |

NOTE: The underlined coefficients were statistically significant at the 5% level.

Source: Prepared by the authors, 2021.

Table 6, in turn, presents the same estimated parameters, now considering the division of HEIs among the five regions of Brazil. In this case, many of the inputs considered were not statistically significant, but those that were remained, in general, maintaining the expected trend of a negative relationship with the RS ratio. The fact that the estimated coefficients have greater relevance in the Southeast is probably due to the fact that there are more observations in this region, since it concentrates most of the HEIs in Brazil. In general, the coefficients presented in this table, even when significant, presented a value close to zero. This must have happened because, when using this type of group division, we were left with few observation units in each group.

TABLE 6: Parameters estimated by the Input Function by region

| | North | | NE | | SE | | South | | Center | |
|---------------|--------------|--------|---------------|-------|---------------|-------|---------------|-------|---------------|-------|
| Parameters | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. | Coef. | S.E. |
| registrations | <u>0.064</u> | 0.029 | <u>0.068</u> | 0.017 | <u>0.022</u> | 0.008 | 0.008 | 0.011 | 0.005 | 0.020 |
| x1 | -0.198 | 0.387 | -0.230 | 0.181 | <u>-0.383</u> | 0.106 | <u>-0.187</u> | 0.091 | <u>-1.082</u> | 0.265 |
| x2 | 0.004 | 0.232 | <u>-0.529</u> | 0.131 | <u>-0.315</u> | 0.059 | -0.066 | 0.087 | <u>-0.298</u> | 0.140 |
| x3 | -0.122 | 0.142 | -0.077 | 0.081 | <u>-0.173</u> | 0.051 | 0.092 | 0.062 | 0.092 | 0.109 |
| x4 | 0.000 | 0.000 | <u>0.000</u> | 0.000 | 0.000 | 0.000 | <u>0.000</u> | 0.000 | 0.000 | 0.000 |
| x5 | 0.081 | 0.139 | -0.001 | 0.039 | 0.003 | 0.027 | -0.013 | 0.030 | 0.247 | 0.130 |
| x6 | -0.234 | 0.173 | -0.197 | 0.147 | -0.140 | 0.099 | -0.189 | 0.125 | -0.240 | 0.178 |
| x7 | 0.006 | 0.014 | <u>-0.020</u> | 0.009 | -0.006 | 0.005 | 0.000 | 0.007 | 0.003 | 0.011 |
| dl | -0.278 | 0.463 | -0.049 | 0.279 | <u>-0.185</u> | 0.087 | 0.057 | 0.088 | -0.319 | 0.209 |
| t | -0.012 | 0.020 | 0.013 | 0.011 | <u>0.022</u> | 0.006 | <u>0.036</u> | 0.007 | 0.018 | 0.012 |
| const | 16.913 | 37.795 | <u>3.614</u> | 0.959 | <u>2.780</u> | 0.235 | <u>1.690</u> | 0.126 | <u>2.475</u> | 0.443 |
| sigma_u2 | 0.074 | 0.013 | 0.117 | 0.011 | 0.0800 | 0.005 | 0.084 | 0.009 | 0.111 | 0.015 |
| sigma_v2 | 0.201 | 0.010 | 0.257 | 0.007 | 0.196 | 0.003 | 0.105 | 0.003 | 0.211 | 0.008 |
| Obs | 1012 | | 3168 | | 7838 | | 2907 | | 1740 | |

NOTE: The underlined coefficients were statistically significant at the 5% level.

Source: Prepared by the authors, 2021.

Finally, Tables 7 and 8 present the estimates for the mark-up component obtained through the stochastic frontier analysis presented, as well as the mark-up estimate (given by θ), the Lerner index estimate, and the return to scale (RTS) estimate. The main result obtained is the presence of a positive mark-up in all cases analyzed, that is, both when considering all Brazilian HEIs together, when considering only HEIs with research expenditures, and when considering the divisions between HEIs in each region of the country. Furthermore, the estimates in all cases were quite similar to each other.

The estimate of the Lerner index, which was obtained through the parameters estimated by the stochastic frontier, points to the presence of greater market power when considering only HEIs that invest in research. The same is observed for the North region, possibly because this region has a smaller number of HEIs.

We can raise other assumptions using the results obtained in relation to the estimated returns to scale. Since they were less than one, we can see that HEIs face decreasing returns to scale. This means that using positive market power to increase the number of higher education student enrollments may not be the most desirable choice. Perhaps market power could be reflected more, for example, in tuition fees.

Still regarding returns to scale, we can use scale bias to verify whether changes in the trend variable alter economies of scale over time (according to equation 16). With the results presented in Table 5, we verify that the coefficient of the time trend variable is positive and statistically significant, therefore,

possible technological changes reduce economies of scale over time. On the other hand, the trend variable of the proportion of enrollments in distance learning courses presented a negative and statistically significant coefficient. Therefore, as expected, this is a variable that contributes to increasing economies of scale in higher education.

The distribution of the Lerner index is presented in Appendix A.1 for the first year (2010) and the last year (2019) of the analysis period. What can be observed is that the frequency distribution of HEIs that present a certain level of market power remains practically the same for these two periods and, thus, probably also for the entire period considered. The main difference is that in 2019 there are some HEIs that are very small in terms of market power. This can even be observed by making a direct comparison between the distributions.

Next, an analysis was performed of the correlation between the Lerner index obtained in the previous stages and the number of benefits offered by the Fies and ProUni programs, with the intention of verifying whether the existence of a higher market power of HEIs may be related to the greater availability of scholarships for these HEIs. However, what was observed was a negative and significant correlation between the Lerner Index and scholarships from both Fies and ProUni. Therefore, the least competitive HEIs are those that use the most scholarships from these programs, possibly even due to their lower capacity to attract students interested in paying for their services. In fact, this situation is even stronger in HEIs that do not invest in research and in the North and Northeast regions.

TABLE 7: Estimated mark-up and returns to scale for all HEIs and according to the presence or absence of research

| | Description | Mean | S.E. | 1st quartile | Median | 3rd quartile |
|----------------------|-----------------------|-------|-------|--------------|--------|--------------|
| u | Mark-up component | 2.718 | 0.264 | 2.615 | 2.776 | 2.880 |
| theta | Mark-up estimate | 0.690 | 0.069 | 0.661 | 0.706 | 0.731 |
| lerner | Lerner Index estimate | 0.407 | 0.026 | 0.398 | 0.414 | 0.422 |
| RTS | Return to scale | 0.254 | 0.006 | 0.250 | 0.253 | 0.257 |
| IES with research | | | | | | |
| u | Mark-up component | 2.672 | 0.256 | 2.567 | 2.734 | 2.831 |
| theta | Mark-up estimate | 0.684 | 0.067 | 0.655 | 0.701 | 0.725 |
| lerner | Lerner Index estimate | 0.405 | 0.026 | 0.396 | 0.412 | 0.420 |
| RTS | Return to scale | 0.256 | 0.006 | 0.252 | 0.255 | 0.259 |
| IES without research | | | | | | |
| u | Mark-up component | 1.502 | 0.268 | 1.397 | 1.540 | 1.672 |
| theta | Mark-up estimate | 0.559 | 0.104 | 0.516 | 0.581 | 0.617 |
| lerner | Lerner Index estimate | 0.355 | 0.047 | 0.340 | 0.368 | 0.382 |
| RTS | Return to scale | 0.369 | 0.019 | 0.355 | 0.367 | 0.381 |

Source: Prepared by the authors, 2021.

TABLE 8: Estimated mark-up and returns to scale by region

| | Description | Mean | S.E. | 1st quartile | Median | 3rd quartile |
|---------------|-----------------------|--------|-------|--------------|--------|--------------|
| North | | | | | | |
| u | Mark-up component | 15.967 | 0.247 | 15.864 | 16.013 | 16.122 |
| theta | Mark-up estimate | 0.926 | 0.015 | 0.920 | 0.929 | 0.935 |
| lerner | Lerner Index estimate | 0.481 | 0.004 | 0.479 | 0.482 | 0.483 |
| RTS | Return to scale | 0.058 | 0.000 | 0.058 | 0.058 | 0.058 |
| NE | | | | | | |
| u | Mark-up component | 2.900 | 0.305 | 2.793 | 2.967 | 3.089 |
| theta | Mark-up estimate | 0.691 | 0.075 | 0.665 | 0.707 | 0.737 |
| lerner | Lerner Index estimate | 0.407 | 0.030 | 0.399 | 0.414 | 0.424 |
| RTS | Return to scale | 0.238 | 0.007 | 0.233 | 0.237 | 0.242 |
| SE | | | | | | |
| u | Mark-up component | 1.681 | 0.243 | 1.570 | 1.732 | 1.828 |
| theta | Mark-up estimate | 0.583 | 0.086 | 0.544 | 0.604 | 0.633 |
| lerner | Lerner Index estimate | 0.366 | 0.037 | 0.352 | 0.376 | 0.388 |
| RTS | Return to scale | 0.347 | 0.011 | 0.340 | 0.346 | 0.352 |
| South | | | | | | |
| u | Mark-up component | 0.946 | 0.248 | 0.836 | 0.973 | 1.094 |
| theta | Mark-up estimate | 0.452 | 0.115 | 0.409 | 0.472 | 0.516 |
| lerner | Lerner Index estimate | 0.307 | 0.061 | 0.290 | 0.320 | 0.340 |
| RTS | Return to scale | 0.479 | 0.026 | 0.459 | 0.478 | 0.498 |
| Center | | | | | | |
| u | Mark-up component | 1.407 | 0.288 | 1.273 | 1.470 | 1.588 |
| theta | Mark-up estimate | 0.524 | 0.110 | 0.468 | 0.551 | 0.588 |
| lerner | Lerner Index estimate | 0.337 | 0.053 | 0.319 | 0.354 | 0.371 |
| RTS | Return to scale | 0.374 | 0.027 | 0.361 | 0.368 | 0.378 |

Source: Prepared by the authors, 2021.

Table 9 – Correlation between the Lerner Index and Fies and ProUni scholarships

| | Research Division | | | Region division | | | | |
|--------|-------------------|-------------------|--------------|-----------------|------------|-----------|-----------|-----------|
| | All | Without research. | No research. | North | NE | SE | South | Center |
| Fies | -0.1076*** | -0.166*** | -0.0874*** | -0.237*** | -0.161*** | -0.074*** | -0.049*** | -0.099*** |
| Prouni | -0.0426*** | -0.0787*** | -0.0343*** | -0.0713** | -0.0654*** | -0.022* | -0.084*** | -0.061** |

Source: Prepared by the authors, 2021.

4. Conclusions

Brazil has experienced a rapid growth in both the number of places in higher education institutions and in the population's demand for higher education, especially since the 2000s. However, some systematic public policies motivated by the benefits that could be provided by a more educated population have caused the supply, mainly by private institutions, to experience a fast growth as compared to the amount of demand for courses at these institutions.

In this expansion scenario, it remains to be seen how the competition in the market environment is configured, in terms of market power being more or less strict. Therefore, this article sought to estimate the market power of Brazilian HEIs. To this end, we used a method proposed by Kumbhakar et. al (2012), which is an alternative use of the stochastic frontier model, typically used in the efficiency literature. With the estimation of the stochastic frontier model, it became clear that expenditure on educational inputs among HEIs that invest in research is more significant, given that it contributes more to their lower ratio between revenue and expenditure.

The results were obtained from data from the Higher Education Census for the period 2010 to 2019, considering all Brazilian HEIs, in addition to a division that separated only HEIs with research expenditures, and another division according to the HEIs in each region of Brazil. These results demonstrated the presence of a positive mark-up in all estimates made, which shows that there is market power in the higher education market in Brazil. In fact, apparently, such market power is stronger in the Northeast region, possibly because this region has a smaller number of HEIs, and among the HEIs that invest in research.

The estimates of returns to scale, also obtained from stochastic frontier estimates, demonstrated the presence of decreasing returns to scale in all cases analyzed. In other words, using positive market power to increase the number of higher education student enrollments may not be the most desirable choice. Perhaps market power could be reflected more, for example, in tuition fees. These analyses can be raised in future research.

As the time trend variable is positive, possible technological changes reduce economies of scale over time. On the other hand, the trend variable of the proportion of enrollments in distance learning courses presented a negative and statistically significant coefficient. Therefore, as expected, this is a variable that contributes to increasing economies of scale in higher education.

Therefore, this paper contributes to the analysis of the higher education sector, in order to warn about possible anticompetitive behavior by some HEIs. This is particularly important in view of the recent mergers and acquisitions witnessed in the sector in recent years. In fact, this is a topic that should be analyzed in future works, both from the perspective of the efficiency of such mergers and from the perspective of the presence of market power, as done in this article. Furthermore, a possible avenue for future research may involve econometric investigations on the determinants of market power in that sector.

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ANNEX - Distribution of the Lerner index of Brazilian HEIs (2010 and 2019)

