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Asymmetry in Cost Behavior in Brazilian Hospitals

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Abstract: Objectives: Investigating if the proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior of public and private hospitals in Brazil. Methods: In order to test the sticky cost phenomenon in a different sector of companies and industries, we used panel data regression to investigate the asymmetric cost behavior in Brazilian hospitals, analyzing the hospital cost behavior regarding the variation in revenues and verifying whether the proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior. As a result, this research took the findings obtained by the models applied to data from the 101 hospitals comprising the sample, spread over the 2010–2019 period. The research was divided into four sections. The first section tested asymmetry for fixed assets over total assets for hospitals in general. The second section divided the sample into public and private hospitals. The third section analyzed the sample of conglomerates against a single hospital. Finally, the fourth section tested the asymmetry of the hospitals in the sample measured by the number of beds. Results: The evidence documented here partially confirms the results of literature on the existence of asymmetric cost behavior regarding variations in revenue. The H_1 hypothesis that the proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior was confirmed, especially for private and small hospitals regarding fixed assets.

Keywords: cost asymmetry; asymmetric behavior; fixed assets; Brazilian hospitals

JEL Classification: C15; F34; G32; G33

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1. Introduction

The 2020 SARS-CoV-2 virus pandemic caused a collapse in all areas, especially health. However, before this health crisis, Brazilian hospitals were already suffering from disruptions, such as a lack of beds. Of the 493,010 beds in Brazilian hospitals, 66.6% assist the 77.8% of the population who exclusively use the Unified Health System (SUS). Meanwhile, the remaining 33.4% assist the 22.2% of the population with private supplementary health insurance (Viana et al. 2023).

Between 2000 and 2018, up to two-thirds of all national health spending accounted for hospital services. However, a significant part of the spending has not been well allocated, generating inefficiency in hospitals, mainly due to the excessive number of unnecessary admissions and lengths of stay and underutilization of the installed infrastructure (Carpanez and Malik 2021).

Saldiva and Veras (2018) point out that the proper functioning of a country's health system depends on two factors: sufficient funding and appropriate resource management. The manager must understand cost behavior and control processes to achieve profit growth, organizational sustainability, and a competitive edge over competitors. Decision-making without full knowledge of the costs involved—and how they may vary depending on the level of elasticity—can lead to negative results (Garrison et al. 2021).

In accounting literature, the traditional view considers that costs undergo a linear change in response to changes in the volume of activities (Garrison et al. 2021). However, Noreen and Soderstrom (1997), when evaluating which costing method would be most appropriate for hospitals in one US state, found the first empirical evidence that costs increase more as the volume of activity increases than they decrease.

The study by Anderson et al. (2003) made an important contribution to management accounting by confirming robust empirical evidence of the so-called "sticky cost" behavior, also known in Portuguese as "rigid costs" or "asymmetric costs" (Richartz et al. 2014). These authors believe that the asymmetric cost behavior is due to the decisions of managers when a company's activities slow down. They must decide between maintaining the installed infrastructure and leaving it underutilized for at least a short period or immediately reducing the cost structure and bearing the additional costs of replacing the structure when activities increase (Anderson et al. 2003). The opposite, called "*anti-sticky*" behavior, is observed when costs decrease by a greater proportion when reducing activities than they increase when accelerating. Usually, it occurs in organizations that already have idle installed capacity before the decrease in sales volume (Homburg et al. 2019).

In Brazil, the studies by Medeiros et al. (2005) and Richartz et al. (2014) investigated companies listed on the Brasil, Bolsa, Balcão (B3) and showed a *sticky* behavior. However, even though these studies have pointed to asymmetric cost behavior in all companies, there are differences in the *sticky* level between company segments, as each branch of activity has particular characteristics regarding production, operations, and the economic environment (Subramaniam and Watson 2016). Based on the observation of 9592 publicly traded US companies over 22 years (1979–2000), Subramaniam and Watson (2016) classified and evaluated the cost behavior of companies in four major groups (industry, retail, finance, and services).

Companies in the industrial sector showed a greater asymmetric cost behavior. Meanwhile, retail companies showed a lower *sticky* behavior. The result is explained by the cost structure of an industry that demands a greater intensity of investment in inventories (Subramaniam and Watson 2016) and fixed assets (Anderson et al. 2003; Balakrishnan et al. 2004; Calleja et al. 2006; Subramaniam and Watson 2016), making it difficult to adjust costs in the event of a reduction in sales volume.

Although hospitals are classified as service companies, their cost structure is similar to that of an industry regarding the intensity of fixed assets. Thus, hospitals' characteristics include a high investment in fixed assets and the permanent need for an intense workforce, which leads to asymmetric cost behavior. Furthermore, demand uncertainty represents another factor specific to the operation of hospitals that hinders the decision to adjust costs and favors *sticky* behavior (Balakrishnan and Gruca 2008; Zhu et al. 2021; Ibrahim et al. 2022).

The first known study to show *sticky* behavior in hospitals in the United States was by Noreen and Soderstrom (1997). In addition to analyzing quantitative data, the authors interviewed hospital managers to identify the percentage of underused installed capacity in the cost centers. Later, Hyun et al. (2005) also verified the *sticky* phenomenon in hospitals in Korea. They identified that the more intensive a hospital is regarding fixed assets or human resources, the more asymmetrically its costs behave.

Moreover, the cost behavior of the three major departments of a hospital is different. The department that handles direct patient services, such as the operating room, maternity ward, and pediatrics, shows more cost asymmetry than the auxiliary services (laboratory, physiotherapy, pharmacy, etc.) and administration (dietetics, laundry, accounting, etc.) departments. The result is that the cost of adjusting resources in the end area is higher than in the middle areas. In other words, it is much easier to expand or reduce a physiotherapy service, for example, than to increase or decrease an Intensive Care Unit (ICU)

(Balakrishnan and Gruca 2008). In addition to the infrastructure, the workforce in the end area is trained and specialized (doctors, nurses, technicians), difficult to replace, and more expensive than the professionals who work in the middle departments (Banker et al. 2013b; Smith and Preker 2001).

In Brazil, Avelar et al. (2021) found asymmetric behavior for the total cost of health plan operators (HPOs). However, we have not yet found any study related to the asymmetric cost behavior of Brazilian hospitals. Despite the importance of the *sticky* phenomenon for management accounting, regarding the potential distortion it can cause in the estimates used in budgeting, there are few studies on the subject. Most are concentrated in the United States, leaving a gap in developing countries (Ibrahim et al. 2022). Furthermore, in the national literature, most studies on *sticky* behavior have focused only on identifying the phenomenon with little attention to the explanatory variables (Richartz et al. 2014).

Given the above and seeking to contribute to the literature on cost rigidity in Brazilian hospitals, this study aimed to answer the following question: *what are the main explanatory factors for the asymmetric cost behavior in Brazilian hospitals?* Moreover, it aimed to identify *sticky* behavior in Brazilian hospitals based on available data and under the perspective of the "*adjustment cost*" theory. This study analyzed whether the degree of fixed assets, funding sources, conglomerate arrangements, and hospital size could explain the asymmetric cost behavior of hospitals. Therefore, this study's general objective comprised investigating whether the proportion of fixed assets over total assets is positively associated with asymmetric cost behavior.

In addition to the theoretical contributions, this study also aimed to contribute to the practical field since understanding cost behavior and the factors that lead to asymmetry can help assess the financial condition of hospitals. Furthermore, it helps develop appropriate incentives to shape the decision-making of managers (Avelar et al. 2021), who may be physicians (hybrid professionals-managers) or other health professionals. More specifically, information from sticky costs can assist in contract negotiations with payers, assessing the efficiency and effectiveness of operations, isolating unnecessary costs, and facilitating the redesign of care delivery processes to reduce costs.

2. Theoretical References

Studies on asymmetric costs have mainly used three theories to explain the sticky phenomenon, namely: (i) 'adjustment cost' theory; (ii) 'optimistic management expectation'; (iii) and 'agency cost' (Banker and Byzalov 2014; Banker et al. 2011; Jiang et al. 2016).

A gap in the existing "adjustment cost" theory is the investigation of asset- and personnel-intensive enterprises at the same time. Studies such as those by Yang et al. (2020) position an interesting perspective: rationality in decisions to maintain idle infrastructure due to fear of restructuring costs.

Thus, investigating the behavior of "adjustment costs" in health services, especially in hospitals, represents an interesting research design as the hospitals have an intensive use of assets and human resources in their cost structure, and, at a time of declining activity, immediately reducing costs can lead to even greater additional costs with the reacquisition of assets and their installation and the hiring and training of specialized personnel. Furthermore, the demand for hospital services is uncertain, so it is believed that hospital managers, as suggested by Yang et al. (2020), make rational decisions by weighing up short-term costs and long-term benefits and by keeping infrastructure costs underutilized at a time of declining demand to prevent additional costs in the future.

Notably, the 'adjustment cost' theory assumes that organizations will incur additional costs when disposing of fixed assets and laying off employees, as well as when repurchasing assets and hiring and training staff. Therefore, when activity declines, management is unwilling to reduce costs, resulting in cost rigidity (Yang et al. 2020).

The 'optimistic management expectation' theory suggests that the manager's positive view of the decrease in sales, believing it to be temporary, does not immediately reduce the idle capacity costs, resulting in asymmetric cost behavior (Yang et al. 2020). The optimistic view of managers is more evident in times of economic prosperity and, consequently, a greater occurrence of the sticky phenomenon compared to periods of economic recession (Alavinasab et al. 2017).

Finally, the 'agency cost' theory supports the manager's preference to meet personal interests by not reducing idle capacity costs, as doing so would reduce profit and consequently their bonus, leading to sticky cost behavior (Yang et al. 2020).

3. Hypotheses Development

This research observes asymmetric behavior based on adjustment cost theory (Yang et al. 2020). Based on the need to understand the costs reported in the financial statements of Brazilian hospitals, the cost behavior regarding the variation in revenues will be analyzed. In order to contribute to this issue, Richartz (2016) developed an explanatory model for asymmetric cost behavior based on a study of Brazilian companies listed on BM&BOVESPA. This study aims to investigate whether the intensity of asset use is one of the main factors affecting the asymmetry of hospital costs and whether the proportion of fixed assets over total assets can measure it.

According to Anderson et al. (2003), costs are more rigid during periods of macroeconomic growth, and adjustment costs tend to be higher when cost activities depend more on the assets owned and people employed by a company than on the materials and services it purchases.

As cited in the literature, managers face the choice between reducing resource expenditures and delaying cuts. However, delaying cuts can be appealing because it avoids adjustment costs that would be incurred if activity levels were to increase in the future (Balakrishnan and Gruca 2008).

Given the need to understand the costs reported in the financial statements of Brazilian hospitals, the behavior of costs in relation to revenue variation will be analyzed. Based on this, we defined the following study hypothesis:

H_1. *The proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior of hospitals.*

Moreover, Holzhacker et al. (2015) analyzed the impact of regulation on cost behavior. They were based on data from the German hospital industry and concluded that the increase in cost elasticity and the reduction in cost asymmetry in response to regulatory change would be greater in for-profit organizations than in non-profit organizations. Thus, our hypothesis holds that there would be evidence that the same occurs with Brazilian hospitals, with greater asymmetry in public hospitals than in private hospitals.

The authors mentioned above measured the asymmetry of costs by the cost of adjusting capacity, managerial incentives, and individual expectations regarding future demand.

In an effort to contribute to this issue, Richartz (2016) developed an explanatory model for the asymmetric behavior of costs based on a study conducted with Brazilian companies listed on B3. The aim here is to investigate whether the intensity of asset use is one of the main factors affecting the asymmetry of hospital costs, and whether it can be measured by the proportion of fixed assets to total assets.

In this study, we measured asymmetry by the proportion of fixed assets over total assets, which defined our second hypothesis:

H_2. *The source of private funding (predominantly) is positively associated with the asymmetric cost behavior of hospitals. It is noteworthy that the concept of cost rigidity is associated with the two established hypotheses to observe the phenomenon through the adjustment cost theory (Yang et al. 2020) in health services, which is a contribution of this search for literature on asymmetric cost behavior.*

The methodology presents the research sample and the models used to test the hypotheses presented.

4. Research Methodology

This study sought to test the sticky costs phenomenon in Brazilian hospitals (relevant organizations in the context of care, strategic for the SUS hierarchization process) by analyzing the cost behavior of hospitals regarding the variation in revenues. Thus, we verified whether the proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior, thereby contributing to deepening the understanding of this subject.

The first step involved defining the variables to study the asymmetric cost behavior. Afterward, this definition was divided into six groups based on the representativeness of fixed assets over total assets. In other words, a group of hospitals with higher representativeness of fixed assets and another group with lower investments in this asset group to investigate the relationship between investment and cost

This study used a sample of 101 public and private Brazilian hospitals with at least ten years of information to calculate the variables required in the research. The surveyed sample spanned from 2010 to 2019. The initial period was selected based on the adoption of the international accounting standards in Brazil in 2010. Additionally, the analysis extends only until 2019 to exclude data affected by the COVID-19 pandemic, which impacted institutional results in the post-2020 period.

The analyses will be longitudinal since studies based on broader time series show cost trends for hospitals more clearly and also provide greater credibility to the results (Borgert et al. 2015; Richartz et al. 2014).

The data was collected for the full period analyzed, although the number of hospitals changes each year because some may not exist at the beginning or end of the period. It is worth noting that, according to Balakrishnan et al. (2014) and Banker et al. (2014), information with discrepancies was excluded from the sample without affecting the validity of the results. Thus, hospitals that presented information outside the survey or the curve, such as the number of beds, were removed.

The information collected from the *Valor Pro®* database came from the non-consolidated financial statements, which were updated using the National Consumer Price Index (IPCA). Table 1 shows this information.

Table 1. Variables used in the study.

Variables	Used in the Studies of:
Net Sales Revenue (NSR)	Calleja et al. (2006); He et al. (2010); Richartz et al. (2014); Banker et al. (2013a); Kama and Weiss (2013); Borgert et al. (2015); Grejo et al. (2019).
Sold Product Cost (SPC)	Calleja et al. (2006); Anderson et al. (2007); Richartz et al. (2014); Banker et al. (2013a); Kama and Weiss (2013); Borgert et al. (2015); Grejo et al. (2019)
Fixed Assets (FA)	Borgert et al. (2015); Grejo et al. (2019).
Total Assets (TA)	Calleja et al. (2006); Werbin et al. (2012).
Fixed Assets/Total Assets (FA/TA)	Kremer (2015); Richartz (2016); Reis and Borgert (2019); Grejo et al. (2019).

NRS hospital's Net Sales Revenue, SPC hospital's cost for the period. Source: Prepared by the author (2024).

The data on net sales revenue, sold product cost, administrative expenses, sales expenses, fixed assets, and total assets were tabulated in a *Microsoft Excel 2016®* spreadsheet and exported to the *Stata 13* statistical *software*.

To meet this study's proposed objective, we searched the literature for a suitable statistical technique for analyzing the asymmetric cost behavior. Panel data regression analysis proved more appropriate for this research since it uses quantitative variables and time series capable of capturing the variables' behavior. Anderson et al. (2003, 2007), He et al. (2010), Banker et al. (2013a), and others have used the panel data regression technique in their studies on asymmetric cost behavior to treat the data.

In this research, we do not deal with the model with price adjustment costs with gradual response in relation to shocks and the costs of Dib (2003), but the sticky cost phenomenon of Anderson et al. (2003).

There is no consensus in the literature on the measures used for asset intensity: it can be estimated by dividing total assets by sales revenue (Anderson et al. 2003; He et al. 2010; Dalla Via and Perego 2014); or estimated by fixed assets divided by sales revenue (Weidenmier and Subramaniam 2003; Jalilian and Elyssai 2014). This research links the two streams when it associates fixed assets divided by revenue with the model by Anderson et al. (2003), given the high specificity of assets in hospitals—especially fixed assets (Milgrom and Roberts 1990; Hoffmann 2017).

In the panel data study, the values of one or more variables were collected for several sample units. In other words, in this study, the information on net sales revenue, sold product cost, administrative expenses, sales expenses, general expenses, fixed assets, and total assets were collected from the financial statements of several hospitals over ten years (2010–2019). From the point of view of investment theory, one explanation for the sticky cost phenomenon is that it would be a cost of adjustment to the desired capital stock: the faster these costs grow with the level of investment, the slower the firm's response to the discrepancy between the expected shadow price and the relative price of capital (Haavelmo 1960; Lucas and Prescott 1971; Chirinko 1993).

Thus, we used the following model proposed by Anderson et al. (2003) regarding the sticky costs. An empirical analysis model to verify the reaction of costs to variations in net sales revenue, which is made up as follows:

$$log\left[\frac{\mathrm{Costs_{it}}}{\mathrm{Costs_{it-1}}}\right] = \beta_0 + \beta_1 log\left[\frac{\mathrm{Revenue_{i,t}}}{\mathrm{Revenue_{i,t-1}}}\right] + \beta_2 \mathrm{Dummy_{i,t}} * log\left[\frac{\mathrm{Revenue_{i,t}}}{\mathrm{Revenue_{i,t-1}}}\right] + \varepsilon_{i,\ t} \quad (1)$$

Due to the number of years analyzed, the logarithm is used in the model because it can improve the comparability of variables between hospitals and minimize heteroscedasticity problems. The *dummy* variable is taken as 1 when revenue decreases from one period to the next. Therefore, the *dummy* variable gains a value of 0 when revenue increases (Anderson et al. 2003).

The B0 coefficient is the intercept of the line on the y-axis. In other words, it is the value of y when x equals zero. The B1 measures the cost increase corresponding to a 1% increase in revenue. Thus, the sum of the B1 and B2 coefficients indicates the reduction in costs as a result of a 1% decrease in revenue (Anderson et al. 2003; Medeiros et al. 2005).

The variables were "*winsorized*" to reduce the dispersion of the sample data to the 95% level. The *winsorization* process is an alternative for working with data with greater dispersion without losing the extreme observations.

The panel data model was used to analyze the data, which involves observing different observations at different points in time (Wooldridge 2008). Equation (2) represents the general model for this methodology:

$$Y_{i,t} = \beta_{0it} + \beta_{1it}x_{1it} + \beta_{nit}x_{kit} + e_{it} \quad (2)$$

The subscript i represents the different individuals, and the subscript t denotes the period analyzed. $Y_{i,t}$ represents the dependent variable; $\beta_{0i,t}$ refers to the intercept value; β_k is the angular coefficient of the model's k covariates; and $e_{i,t}$ is the forecast error.

The Chow and Hausman tests were used to fit the relationships between variables to the models and improve the fit of the models. Autocorrelation and heteroscedasticity tests were conducted to ensure the validity of the results.

Cost asymmetry occurs when revenue increases or decreases, and the crossed *dummy* was the key coefficient for asymmetric verification. The β1 coefficient measures the percentage change in costs with a 1% increase in NSR (impact of Revenue on cost). The sum of the β1 and β2 coefficients results in the percentage change in costs with a 1% reduction in NSR (impact of the reduction in costs in response to the decrease in revenue). For the first research hypothesis (H_1) to be accepted, the β1 coefficient must be greater than zero, and the β2 coefficient must be significantly lower than zero.

As mentioned, the variable is important because it indicates the phenomenon observed in the research. Since it takes on the value of 1 for cases of reduced revenue and 0 for cases of increased revenue, its coefficient, when statistically significant, indicates asymmetrical behavior for cases of increased or decreased revenue regarding cost variation. Therefore, when analyzing the results, it is important to observe this coefficient in the models presented in the research.

The next section shows the study's results. Initially, the results present the descriptive statistics of the variables used in the models, followed by the results of the econometric models and their interpretations.

5. Results and Discussion

5.1. Results

The data analysis is divided into two topics. The first sets out the results, followed by the second, which shows the research discussions. Thus, they present the behavior of costs as shown by the sticky costs. In other words, they show the asymmetry of costs regarding the revenue of the hospitals comprising the sample.

Table 2 shows the statistical description of the dependent variables in the estimated models: Hospital Net Sales Revenue, Costs of Provided Services, and Fixed Assets over Total Assets.

Table 2. Descriptive statistics of the variables.

Data	Observations	Mean	Standard Deviation	Minimum	Maximum
Revenue Variation	502	0.11%	0.10%	−0.09%	0.32%
Cost Variation	450	0.10%	0.11%	−0.12%	0.33%
Fixed Assets/Total Assets	586	2.95%	2.01%	1.28%	8.68%

Source: Prepared by the authors (2024).

Table 2 shows the variability in the data. On average, the variation in revenue is 0.11%, with a standard deviation of 0.10%, a lower limit of variation of −0.09%, and an upper limit of variation in revenue of 0.32%. Regarding costs, we observed similar behavior, suggesting, a priori, a low propensity to cost asymmetry. On average, the cost variation is 0.10%, and the standard deviation is 0.11%. The overall cost variation is negative 0.12%, with a growth of 0.33%. Furthermore, the sample category includes a fixed asset variable. This variable averages 2.95 but varies from 1.28% to 8.68%. The research database comprises 380 observations for public hospitals (49.35%) and 390 observations for private hospitals (50.65%).

Based on the information summarized in Table 2, Table 3 shows how the variations behave for both private and public hospitals. There is no difference in the presented variables. We can see that, for both private and public sectors, the mean, standard deviation, minimum, maximum, and observations of the cost, revenue, and fixed assets over total assets variables are similar.

There is no difference in the descriptive statistical variables between the public and private sectors. Both are the same.

Table 4 shows the revenue *dummy*. This variable will be used to indicate the asymmetric cost behavior of the increase or decrease in revenue. There are 434 observations in the sample in which the change in revenue is positive because the phenomenon is 0 and 68 observations in which the phenomenon is 1, i.e., the change in revenue is negative. The required *dummy* will be constructed and explored using the revenue *dummy*.

Table 3. Descriptive statistics of the variables for public and private hospitals.

Private Hospital					
Data	**Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Revenue Variation	253	0.11%	0.10%	−0.09%	0.32%
Cost Variation	225	0.10%	0.10%	−0.12%	0.33%
Fixed Assets/Total Assets	293	3.13%	2.01%	1.28%	8.68%
Public Hospital					
Data	**Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Revenue Variation	249	0.11%	0.10%	−0.09%	0.32%
Cost Variation	225	0.10%	0.11%	−0.12%	0.33%
Fixed Assets/Total Assets	293	2.78%	2.01%	1.28%	8.68%

Source: Prepared by the authors (2024).

Table 4. Revenue *Dummy*.

Dummy			
Revenue	**Frequency**	**Percentage**	**Cumulative**
0	434	86.45	86.45
1	68	13.55	100
Total	502	100	

Source: Prepared by the authors (2024).

After presenting the descriptive statistics, Table 5 shows the results of the econometric models to assess the asymmetric cost behavior and its relationship with fixed assets. Table 6 also shows the results for public and private hospitals.

Table 5. Asymmetry for fixed assets.

Models	**Asymmetry for Fixed Assets (ASSIFAS)**									
	*** General ASSIFAS**	***p*-Value**	*** ASSIFAS < m**	***p*-Value**	*** ASSIFAS > m**	***p*-Value**	*** ASSIFAS < p**	***p*-Value**	*** ASSIFAS > g**	***p*-Value**
ΔREVENUE	0.707737 (0.060408)	0	0.800491 (0.07192)	0	0.5895 (0.0952804)	0	0.864299 (0.0980466)	0	0.655828 (0.0937133)	0
ΔCROSSED	0.024257 (0.0118749)	2.04	0.0215 (0.0054414)	0	0.015549 (0.0211236)	0.462	0.016705 (0.0075317)	0.027	0.040836 (0.0408364)	0.004
Constant	0.020989 (0.0069638)	0.003	0.008323 (0.0077484)	0.283	0.035411 (0.0137998)	0.01	−0.002527 (0.0099947)	0.8	0.033255 (0.0332545)	0.007
Degree of Model Fit—Adjusted R2	0.4193		0.5188		0.3296		0.557		0.4105	
Methodology Used	The data was run in Stata using the command to control for heteroskedasticity through the code (vce, robust). The xtserial autocorrelation control did not indicate the presence of autocorrelation in the data. The Chow test rejected the null hypothesis indicating the use of panel data, and the Hausman test, also conducted in Stata, indicated the use of random effects. This aligns with the structure of the data observed in the sample. All models have random effects, and The data (within parentheses) indicates the standard error									

Source: Prepared by the authors (2024). Caption: * General ASSIFAS = Asymmetry for fixed assets over total assets for all hospitals. * ASSIFAS < m = Asymmetry for fixed assets over total assets lower than the median. * ASSIFAS > m = Asymmetry for fixed assets over total assets greater than the median. * ASSIFAS < p = Asymmetry for fixed assets over total assets of less than 25%, small hospitals (fixed assets). * ASSIFAS > g = Asymmetry for fixed assets over total assets greater than 75%, large hospitals (fixed assets).

Initially, regarding fixed assets (Table 5), the theory proposed by Anderson et al. (2003) was applied. The model tested the asymmetry for fixed assets over total assets for the hospitals in the sample, in which, for every 1% increase in revenue, the cost increases by 0.70%, and if revenue decreases by 1%, the cost decreases by 0.72%. The phenomenon is even more significant in the model that tested asymmetry for small hospitals regarding fixed assets lower than the median.

Table 6. Asymmetry for fixed assets in public hospitals compared to private hospitals.

Models	Asymmetry for Fixed Assets Public Hospitals versus Private Hospitals (ASSIFAS-Hpu X Hpri).											
	* ASSIFAS-Hpri	*p*-Value	* ASSIFAS-Hpu	*p*-Value	* ASSIFAS-Hpri > m	*p*-Value	* ASSIFAS-Hpri < m	*p*-Value	* ASSIFAS-Hpu > m	*p*-Value	* ASSIFAS-Hpu < m	*p*-Value
ΔREVENUE	0.787166 (0.661501)	0	0.641182 (0.0951862)	0	0.82202 (0.1224735)	0	0.793452 (0.1069768)	0	0.44207 (0.1271076)	0.001	0.808618 (0.1095664)	0
ΔCROSSED	0.024318 (0.0048472)	0	0.027169 (0.0231982)	0.242	0.307038 (0.2879223)	0.286	0.02245 (0.0073946)	0.002	0.031392 (0.0218992)	0.152	0.023602 (0.0993904)	0.812
Constant	0.014393 (0.0079669)	0.071	0.026631 (0.0111716)	0.017	0.010077 (0.0181297)	0.578	0.109271 (0.0121404)	0.368	0.051181 (0.0200566)	0.011	0.005106 (0.0108065)	0.637
Degree of Model Fit—Adjusted R2	0.4996		0.3592		0.4359		0.5438		0.2792		0.4941	
Methodology Used	The data was run in Stata using the command to control for heteroskedasticity through the code (vce, robust). The xtserial autocorrelation control did not indicate the presence of autocorrelation in the data. The Chow test rejected the null hypothesis indicating the use of panel data, and the Hausman test, also conducted in Stata, indicated the use of random effects. This aligns with the structure of the data observed in the sample.											
All models have random effects and The data (within parentheses) indicates the standard error												

Source: Prepared by the authors (2024). Caption: * ASSIFAS-Hpri = Asymmetry for private hospitals. * ASSIFAS-Hpu = Asymmetry for public hospitals. * ASSIFAS-Hpri > m = Asymmetry for private hospitals greater than the median. * ASSIFAS-Hpri < m = Asymmetry for private hospitals lower than the median. * ASSIFAS-Hpu > m = Asymmetry for public hospitals greater than the median. * ASSIFAS-Hpu < m = Asymmetry for public hospitals lower than the median.

The impact of the variation for this group is greater and has a very significant effect on the *crossed* dummy. For every 1% increase in revenue, the cost increases by 0.80%, and if revenue decreases by 1%, the cost decreases by 0.82%. The coefficient is even higher in the model that tests hospitals with very low fixed assets (25%), and the phenomenon exists for them. For every 1% increase in revenue, the cost increases by 0.86%, and if revenue decreases by 1%, the cost decreases by 0.87%. If we look at large hospitals (even for revenue variation), the magnitude is lower and does not show the asymmetry effect.

However, there is already an asymmetric event for hospitals larger than the median (75% of fixed assets). For every 1% increase in revenue, the cost increases by 0.65%, and if revenue decreases by 1%, the cost decreases by 0.69%.

In turn, when considering the division of the hospital sample into public and private, it shows an asymmetric effect for private hospitals. For every 1% increase in revenue, the cost increases by 0.78%, and if revenue decreases by 1%, the cost decreases by 0.80%. Meanwhile, there is no asymmetrical effect for public hospitals. However, there is no effect for private hospitals larger than the median, while for those smaller than the median, there is an effect. For every 1% increase in revenue, the cost increases by 0.79%, and if revenue decreases by 1%, the cost decreases by 0.81%. On the other hand, we found no asymmetry in the public hospital sample, either lower or higher than the median.

The study also presents additional tests observing the asymmetric relationship of costs for conglomerates and individual hospitals and regarding the number of beds. Tables A1 and A2 show both results in Appendix A. Within the groups analyzed, we found no cost asymmetry in the Conglomerate results, which the smaller amount of data for these groups can explain. However, the sample of hospitals analyzed by number of beds reinforces what has already been noted—there are sticky costs for medium and small hospitals.

5.2. Discussion

This study's findings corroborate the results of previous studies, both nationally and internationally. Although there are no similar studies in Brazil on cost asymmetry in hospitals, these findings reinforce the studies by Medeiros et al. (2005), Richartz et al. (2014), and Grejo et al. (2019), which found the existence of cost stickiness in Brazilian companies.

In Brazil, no hospital group has national coverage, that is, all hospitals only operate regionally. The biggest proof of market fragmentation is that all Brazilian private hospitals have a market share of less than 1% based on the number of beds offered. The largest private hospitals in the country are philanthropic and/or non-profit. In this segment, there is a great demand for new investments, but Brazilian legislation restricts the participation of foreign companies in hospitals (Areias and Carvalho 2021).

Thus, to complete the studies on the phenomenon, this study has segmented itself into Brazilian hospitals, which allowed us to measure the variability in the asymmetric cost behavior, individualizing it into public and private.

As observed in hospitals with the influence of the intensity of fixed assets on the cost behavior of total assets, observed in groups 1 and 2, this finding does not corroborate the findings of Calleja et al. (2006), Bugeja et al. (2015), Magheed (2016), and Richartz (2016). They found that fixed assets influence the behavior of costs or expenses in the sense of inducing or increasing asymmetry regarding sticky costs since the sample only showed asymmetry in hospitals with small fixed assets.

One of the most surprising findings was that cost asymmetry occurred in private hospitals but not in public hospitals. The finding goes against what was expected based on Holzhacker et al.'s (2015) findings that there would be a greater reduction in cost asymmetry for for-profit organizations than for non-profit organizations. As mentioned above, the authors concluded that for-profit hospitals show a greater response than non-profit and government hospitals, which was not the case in this study.

Based on the results presented for the hospitals that showed asymmetry, we can understand that the determinants and causes of the fluctuations in cost behavior could be the possibility of management. According to Fazoli et al. (2018), especially for fixed assets, knowing how this factor influences asymmetric behavior provides evidence of the need to act on resource adequacy issues, for example, by acquiring assets that replace rental costs or by checking the adequacy of contracts.

However, there are exchange rate issues that are unfavorable to the import of high-tech hospital equipment, in addition to bureaucratic barriers associated with the import process, especially for small hospitals—always with professional management.

As Calleja et al. (2006) point out, understanding asymmetric cost behavior can result in a better and more robust planning and control system, and to avoid or minimize the effects of this behavior, managers need to be able to identify and manage unused resource capacity. Based on the same authors, managing resource capacity does not necessarily mean reduction, which may not be possible or feasible, but rather alternative ways, such as transferring unused resources to alternative activities.

The inertia of hospital managers regarding investment adjustments can be explained by the difficulty in establishing an operational plan to effectively face epidemiological demands in Brazil, due to the accelerated growth of the elderly population (Bezerra et al. 2018), lack or difficulty of access to georeferenced data on chronic diseases or demands for health services (Sousa et al. 2020).

It is worth pointing out that the differences between the results obtained here and the findings of the other studies mentioned may be related to the characteristics of the companies involved in each study. In this study's case, the findings are different from those of the comparative studies, despite Camacho and Rocha (2008) claims that the hospital and company segments are similar because they have their own assets and liabilities.

Furthermore, other organizational factors, such as managers' decisions, the macroeconomic environment, market regulations, and agency problems, have not been considered in studies, but they influence the behavior of companies' costs. In general terms, it is also possible that the economic, social, and cultural differences specific to the countries where the other studies were carried out influence the diversity found.

The difference in results may also be related to the period of analysis of this study and the others since different periods reflect divergent economic times that demand specific management from companies, which may have influenced the results. Finally, it should be noted that this research did not consider the pandemic period. It ended the year before the pandemic (2019), which could have changed this study's full analysis.

6. Conclusions

This study aimed to analyze the cost behavior regarding the variation of revenues from 2010 to 2019 for Brazilian hospitals, verifying whether the participation of fixed assets over total assets is positively associated with the asymmetric cost behavior of hospitals.

The study used data from 101 hospitals available on the Valor Pro® database (net sales revenue, sold product cost, administrative expenses, sales expenses, fixed assets, and total assets) and on the DATASUS portal (beds and complexity). The panel data analysis methodology was used to answer the research problem. Furthermore, autocorrelation and heteroscedasticity tests were carried out to ensure the validity of the results.

The evidence documented here partially confirms the findings of Anderson et al. (2003) that costs behave asymmetrically regarding variations in revenue. Hypothesis H_1, which states that the proportion of fixed assets over total assets is positively associated with the asymmetric cost behavior, was confirmed for hospitals.

However, when controlled in public and private hospitals, the results do not provide evidence that the intensity of the influenced asset influences the behavior of the cost of services provided by public hospitals. Meanwhile, private hospitals showed cost asymmetry. This surprising result also goes against Holzhacker et al.'s (2015) findings, according to which there would be a greater reduction in cost asymmetry for for-profit organizations than for non-profit organizations.

The adjustment (or not) of costs derives from a complex budgetary process based on the forecast of profits and associated costs over a period of time; the necessary investments, and thus the multidisciplinary health team involved in management, must be committed to stipulating the goals and guarantee of results. However, management does not always have adequate technical knowledge to deal with budgeting—especially Capital Expenditure—CAPEX.

The importance of developing specialized literature on management control and finance for hospital institutions is highlighted, seeking to improve the skills of professionals responsible for managing budgets, investments, and costs in hospital scope, especially executives, managers, and clinical managers, as they are responsible for making decisions regarding the intertemporal allocation of resources. The study promoted an empirical contribution to the literature on cost rigidity in Brazilian hospitals, as well as consciously analyzing the theory that should underlie this literature.

The sample was formed for convenience based on data available in the Valor Pro® database. Another methodological choice that should be highlighted was the study period, which does not include the years 2020 and 2021, the pandemic years (SARS-CoV-2 and its variants), and strong changes in the standards and levels of care in the organizations studied.

Furthermore, there are organizational factors not considered in this research, such as managers' experience, macroeconomic environment, market regulation, and agency problems, but which influence hospital cost behavior. In general terms, it is also possible that economic, social, and cultural differences specific to the countries in which the other studies were developed influence the diversity found.

Future research could investigate the possible asymmetric behavior of administrative expenses by applying the same methodology and verifying whether the results are confirmed, especially for hospital conglomerates.

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Appendix A

Table A1. Asymmetry for conglomerates versus singular.

Models	**Asymmetry for Conglomerates versus Singular (ASSIFAS-cong X sing)**			
	*** ASSIFAS-cong**	***p*-Value**	*** ASSIFAS-un**	***p*-Value**
ΔREVENUE	0.807341	0	0.697542	0
ΔCROSSED	−0.325627	0.816	0.025393	0.032
Constant	0.009574	0.688	0.021972	0.003
Degree of Model Fit—Adjusted R2	0.4598		0.4145	
Methodology Used	Panel data regression robust to heteroscedasticity.			
All models have random effects.				

Source: Prepared by the author (2022). Caption: * ASSIFAS-cong = Asymmetry for hospitals that are conglomerates. * ASSIFAS-sing = Asymmetry for a single hospital.

Table A2. Asymmetry regarding the number of beds.

Models	**Asymmetry Regarding the Number of Beds (ASSIFAS-B)**							
	*** ASSIFAS-B > m**	***p*-Value**	*** ASSIFAS-B < m**	***p*-Value**	*** ASSIFAS-B < p**	***p*-Value**	*** ASSIFAS-B > g**	***p*-Value**
ΔREVENUE	0.630622	0	0.778355	0	0.83527	0	0.43294	0.035
ΔCROSSED	−0.047203	0.011	0.026306	0	0.022188	0.007	−0.016188	0.492
Constant	0.026903	0.035	0.015378	0.063	0.002642	0.76	0.05362	0.018
Degree of Model Fit—Adjusted R2	0.3283		0.495		0.5422		0.1689	
Methodology Used	Panel data regression robust to heteroscedasticity.							
All models have random effects.								

Source: Prepared by the author (2022). Caption: * ASSIFAS-B > m = Asymmetry for hospitals with a higher number of beds than the median. * ASSIFAS-B < m = Asymmetry for hospitals with fewer beds than the median. * ASSIFAS-B < p = Asymmetry for hospitals with less than 25% of beds (a small number of beds). * ASSIFAS-B > g = Asymmetry for hospitals with more than 75% of beds (a large number of beds).

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