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Examining the Impact of Baumol's Cost Disease in Brazilian Municipal Education: A Decade Analysis (2009-2019)

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Abstract

This paper examines the phenomenon known as Baumol's cost disease within the Brazilian educational sector between 2009 and 2019, marked by substantial changes in teacher salaries and student-teacher ratios. Baumol's cost disease describes the rise in salaries despite low productivity growth in sectors that do not benefit substantially from technological improvements. In education, salaries increased by establishing a national wage floor and decreasing student-teacher ratios. The study adapts Baumol's model to the modern educational context, analysing the correlation between teacher remuneration and productivity and incorporating contemporary economic and policy dynamics. The findings indicate that, contrary to the theoretical expectation of a U-shaped curve for per capita educational spending, costs per student tend to decrease with the increase in municipal population size, with an exception observed in the largest cities. This paper contributes to the understanding of public spending on education in Brazil, highlighting the need for differentiated policy approaches to manage escalating costs in smaller municipalities and ensure equitable education quality across different municipal sizes.

Keywords: Baumol's Cost Disease, municipal education spending, productivity in education, economic analysis of education, teacher salaries

1. Introduction

Introduced by Baumol and Bowen in 1965, the concept of Baumol's Cost Disease describes the outcome of uneven technological advancement across sectors, notably in education, where automation is less applicable. This phenomenon manifests in the disconnect between rising wage costs and productivity improvements. It increases educational services accompanied by a significant cost rise due to the lack of technical progress inclusion. Meanwhile, in industry, it is possible to increase production without a rise in costs thanks to technical progress. In Brazil, this dynamic is evidenced by the significant increase in the unit labour cost in education, from R$95 in 2009 to R$328 in 2019, reflecting factors such as salary adjustments for teachers against the national floor and a reduction in the number of students, exacerbated by municipal expansion.

Expanding the educational sector, implying a cost rise, only becomes viable with increased budget share. This situation causes the resources allocated to education to compete with other essential needs. This dynamic explains why the budget directed to education constitutes the largest fraction of municipal budgets. It is no coincidence that this item has figured among the expenses of greatest expansion both in the United States and European countries, driven by a significant increase in teacher remuneration, as pointed out by Lipsky (2019). The author reports that, in the United States, during the 1970s, expenditure on salaries in the educational sector already represented the sector's largest expense.

Considering the budget constraint, balancing rising costs and obtaining effective educational outcomes requires promoting productivity in the sector to ensure financial sustainability and efficiency. The analysis seeks to verify whether the expansion of educational services in Brazil was accompanied by increased costs, particularly wages, contrasting with the stagnation in the sector's productivity, a direct reflection of the educational sector's insensitivity to technical progress.

This study aims to diagnose educational spending from 2009 to 2019. The results confirmed the occurrence of cost disease in Brazil. In addition to the stagnation of Brazilian students' educational outcomes in PISA between

2010 and 2020 (Ministry of Education). This phenomenon had the particularity of the difference between productivity and remuneration of educators being increased due to the higher average cost of municipalities with fewer inhabitants.

The econometric results confirmed the diagnosis of Baumol's cost disease. The labour cost per student in education has significantly increased over the past decade. However, the cost increase was also due to the creation of municipalities that further burdened the cost per student. In these municipalities, the cost and productivity differential is greater due to the small size of student classes.

A cross-section model was applied to all Brazilian municipalities to verify the occurrence of the Baumol effect. The dependent variable is the unit cost per student, and the explanatory variables are the excess in wage expenditures compared to the gain in productivity in the industrial sector and GDP expansion.

This finding can guide the search for measures to mitigate cost disease with the introduction of measures to improve the performance of teachers and students. In this context, studies such as those carried out by Hanushek and Woessmann (2015), Levin and McEwan (2001), and Hallinger (2023) are relevant because they present measures that can raise the productivity of teaching.

The paper is divided into five sections, including the introduction and conclusion. In Section 2, the article addresses Baumol's Cost Disease, exploring its manifestation in the Brazilian educational context and the interaction between economic dynamics and educational policies. Section 3 describes adapting Baumol's model to the contemporary educational context, focusing on the relationship between teacher remuneration and productivity. Section 4 presents the methodology used to test Baumol's model using data from Brazilian municipalities. Section 5 reveals significant trends in labour costs in education from 2009 to 2019, highlighting differences among municipalities of various sizes. Section 6 discusses the rise in labour costs in education and the decreasing student-teacher ratio in Brazil, despite stagnant productivity, employing quantitative methods to assess the adapted Baumol model, considering variables like municipal population, per capita income, and its growth. This section highlights the uniqueness of the Brazilian educational scenario, where the existence of small municipalities influences the exacerbation of Cost Disease. The article's conclusion emphasises that Baumol's Cost Disease is evident in Brazilian municipal education, particularly in very small municipalities, highlighting the need for educational policies and financing strategies adapted to this context to tackle rising labour costs and maintain educational quality.

2. Theoretical Framework

This section presents the definition of Baumol's cost disease theory. It is an economic concept describing the disproportionate cost rise in low-productivity sectors, mainly where automation and efficiency improvements are less applicable. The high percentage of above-productivity payments to educators may have a political motivation.

The political motivation behind the above-productivity payment for educators, according to the public choice school, reflects the interest of politicians in obtaining electoral support from influential groups, such as teachers' unions, through salary benefits. Thus, politicians seeking election would approve salary increases for educators to be re-elected.

The study explores the relationship between Baumol's Cost Disease Theory, which explains the disproportionate rise in costs within sectors experiencing low productivity growth, and Public Choice Theory, which analyses politicians' motivations to secure electoral support from influential groups, such as teachers' unions, by offering salary benefits.

The 'Baumol's Cost Disease' is an economic phenomenon characterised by wage increases in low-productivity sectors. Hartwig and Krämer define this concept: *Baumol assumes that wages grow in both sectors at a rate set by the productivity growth in the progressive sector. Under these assumptions, productivity growth that is 'unbalanced' between industry and the rest of the economy triggers a long-term structural change in which most services become increasingly expensive*. This phenomenon was first described by Vandermeulen (1968) as 'Baumol's disease'(Hartwig and Krämer, 2023, p. 321).

William Baumol, in 1993, described education as a 'non-progressive' sector due to its limited capacity to benefit from technological progress, in contrast to sectors such as industrial, considered 'progressive'. In Brazil, between 2009 and 2019, primary education illustrated this phenomenon through the cost growth per student. This increase was primarily driven by teacher salaries, which rose above inflation. The increased productivity in the industrial sector made the rise in teachers' salaries possible. In this context, wage growth reflects the challenge of attracting talent to competitive markets, especially in sectors like education, where automation is less feasible.

This situation is mainly due to the high participation of small municipalities in the representation of this index, in contrast to the theory that predicted a greater participation of more populous municipalities. The dependence of these new municipalities on federal and state transfers, such as the Municipalities Participation Fund (MPF), has increased municipal expenses without ensuring a proportional improvement in the quality or quantity of public services.

According to Public Choice Theory and Wagner's Law, larger municipalities face higher costs due to administrative complexity, which would associate higher public spending with larger and more developed municipalities. This finding is because, as a municipality grows, its administration tends to become more complex and bureaucratic, thereby increasing expenses and leading to a proportionally greater increase in the costs of public services.

According to Buchanan and Tullock (1965) and Olson (1965), within the framework of Public Choice Theory, it is common for the interests of specific groups to take precedence in budget allocations, thus undermining the general welfare of the public. The budgetary revenue ends up being an attraction that draws the interest of specific groups. Not for another reason, Olson (1965) states that the administrative machine's complexity prevents closer monitoring. Referring to the USA, Olson (1965, p. 166) stated: Harold Laski charged (with some exaggeration) that "political parties in the United States are not organisations to promote ideas but loose federations of machines for getting enough votes to enable the parties to lay their hands on the spoil."

It is observed that the total per capita public expenditure and per capita education expenditure vary according to the size of the population groups in the cities. For cities with up to 3,000 inhabitants, the average expenditure per student is R$ 1,446.23, and the per capita public expenditure is R$ 6,869.49. In cities with a population between 3,001 and 10,000, the expenditure per student and per capita are R$ 1,093.54 and R$ 3,514.76, respectively. In municipalities with 10,001 to 20,000 inhabitants, these values are R$ 994.39 for expenditure per student and R$ 3,048.05 per capita. Cities with a population of 20,001 to 50,000 have an expenditure per student of R$ 964.64 per capita of R$ 2,904.42. For population groups of 50,001 to 100,000, the values are R$ 889.65 and R$ 2,892.31, respectively. Surprisingly, cities with more than 100,000 inhabitants show an even lower expenditure per student, at R$ 821.27, but the per capita public expenditure rises to R$ 3,124.80. These data contradict the theoretical expectation of a U-shaped curve for per capita education expenditure, suggesting that in Brazil, expenditures tend to decrease with the increasing population size in cities, except for a slight increase in per capita expenditure in cities with more than 100,000 inhabitants.

The explanation for the higher per capita spending of Brazilian municipalities with less than 20,000 inhabitants is the presence of diseconomies of scale. Medium-sized municipalities benefiting from economies of scale tend to have lower costs, unlike the tiny ones, especially those with less than 3,000 inhabitants, which exhibit high per capita expenses.

The distortion observed in the uncontrolled growth of Brazilian municipalities has its roots between 1988 and 2000. During this period, 1,438 new municipalities were established in Brazil, representing approximately 25% of the total existing. This increase in the number of municipalities was accompanied by a growth in public expenditure, highlighting failures in the administration of public policies. In 1997, most of these new municipalities had a population of fewer than 20,000 inhabitants.

The motivation for creating new municipalities was that the divided municipalities began receiving a larger amount of MPF (Municipal Participation Fund) than before the division. For example, in 1996, Alta Floresta received R$ 1,950,000 from the MPF, and with the loss of the Buritis District, it was allocated R$ 1,947,000 in 1997, while the new municipality received R$ 647,000 from the MPF. In other words, for the same region, there was an increase in MPF resources of R$ 643,000, as described by Nunes and Nunes (2010).

The maintenance of these municipalities was only possible with federal and state contributions. According to a study by Gomes and MacDowell (2000), in 1996, the contribution of own revenues to the total current revenue of Brazilian municipalities with up to 5,000 inhabitants was only 9%. This rate was even lower in North and Northeast municipalities, 2.9% and 4.4%, respectively. For Nunes and Nunes (2010), the dependence of these municipalities on transfer revenues highlights the absence of economic autonomy.

Implementing new governmental structures often fails to achieve economic efficiency, mainly when the demand for education is inelastic due to constitutional mandates and laws such as no. 11.114/2005(Brasil, 2005), which requires minimum spending and the maintenance of elementary education. This scenario is a classic example of 'diseconomies of scale,' where the increase in government expenditure - including the administration of personnel and the construction and maintenance of infrastructure - does not correspond to a proportional improvement in the quality or quantity of public services offered. Economies of scale, on the other hand, seek to optimise production by maximising available resources, resulting in lower production costs and an increase in the supply of goods and services. In the case of creating a new municipality, we observe an increase in public spending without a corresponding improvement in services provided to the population, highlighting a clear economic disadvantage in this administrative expansion.

In summary, the impact of cost disease on education financing in Brazil has been exacerbated due to a high percentage of municipalities lacking economic autonomy and having small populations. This fact has further increased the costs of providing educational services. The influence of lobbying groups and political parties contributed to the increase in per capita costs in large cities and the creation of economically dependent municipalities, leading to higher municipal expenses and, consequently, an increase in per capita public expenditure, including that on students. The theory of Baumol's Cost Disease, formulated by William Baumol, is an economic concept that explains the disproportionate rise in costs in low-productivity sectors, especially where automation and efficiency improvements are less applicable.

3. The Model

3.1 Introduction to Baumol's Model

Developed in 1967, Baumol's model explains why some sectors experience increased costs, a phenomenon he termed 'cost disease'. According to Baumol, the sectors most affected by this disease pay wage increases despite low productivity growth. Most education, health, and social care expenditures contribute to personnel costs, making this model particularly relevant for their analysis.

In this study, the model was adapted to the contemporary educational context, drawing on the works of Nose (2015) and Nunes and Nunes (2023). This adaptation involved modifications to reflect the dynamics of the educational sector more accurately, particularly regarding the relationship between the GDP of progressive and non-progressive sectors. These modifications include the constancy of the relationship between the GDP of progressive and non-progressive sectors, as expressed by the formula $Y_{2t}/Y_{1t} = K$, and the specific characterisation of sector 1 as non-progressive and sector 2 as progressive.

The primary objective of this section is to investigate the correlation between teachers' remuneration and productivity. Like Baumol's model, the adopted approach focuses on the concept that wage expenditure tends to increase over time in sectors with low productivity growth, such as education, even if productivity remains relatively stable.

Education incorporates less technical progress than high-productivity sectors, where automation and efficiency can be continuously enhanced, causing a rise in wage expenditure. Baumol describes this phenomenon as a "cost disease", in which sectors with low productivity growth experience wage increases to attract employees, aiming to maintain parity with more productive sectors.

The proposed model identifies two key sectors: the government and the industry. The government, tasked with managing educational expenditures, does not factor private investments into its calculations. 'Educational GDP' encompasses all educational spending, including salary expenditures and other current costs (OCC). The industrial sector's GDP is equated to the value of its production. The model posits that the aggregate product is the cumulative GDP of both the industrial and educational sectors. The methodology for GDP calculation is illustrated in the subsequent table.

Table 1. GDP calculation model: government and industrial sectors

	Σ	Σ	
Sector 1	W_{1t}	OCC_{1t}	Y_{1t}
Sector 2	W_{2t}	P_{2t}	Y_{2t}
Total	W_t	I_t	Y_t

Source: Elaborated by author.

To test Baumol's model, we examine the key assumption that technological progress in the industrial sector is superior to that in the educational sector (r_2-r_1). This relation indicates that industrial productivity growth is higher than educational productivity. In line with testing Baumol's model, this study specifically analysed labour productivity in the industrial sector across various Brazilian municipalities. The study aimed to estimate the productivity of both the educational and industrial sectors, contrasting it with the evolution of teachers' salaries.

This study analysed labour productivity in the industrial sector across 4288 Brazilian municipalities between 2009 and 2019. We employed a cross-sectional approach to test the propositions of the Baumol Model using a quantitative methodology.

The accounting and educational performance data were collected from the FINBRA/STN website and the Ministry of Education (MEC), respectively. The Instituto Brasileiro de Geografia e Estatística (IBGE) website provided additional information on population, per capita income, and growth. To assess labour productivity in the industrial sector, we analysed the number of workers per municipality provided by the Ministry of Labour's RAIZ system. Additionally, we used IBGE data on municipal GDP, school-age population, economically active population, and the total population, resulting in 4,288 observations.

3.2 Teachers' Salary Growth Model

The growth of teachers' salaries, belonging to the non-progressive sector, rises at the rate of productivity growth in the progressive sector. In Brazil, this increase tends to be more significant, influenced not only by the high demand for public schools due to the lack of income of a large portion of the population but also by other factors such as the pursuit of teaching quality, governmental education policies, and the need to improve educational infrastructure. Furthermore, the law provides the equalisation of salaries for teaching professionals. The National Plan for Education (PNE), law number 13.005/2014, stipulates that the average income of teachers should be equal to that of other professionals with equivalent educational levels. These aspects, along with achieving universal coverage of public education, contribute to the increase in education expenditure in the country.

Considering these dynamics, it becomes evident that Brazil's evolving education landscape reflects broader socio-economic trends and policy choices. Consequently, the interplay between these various elements shapes the overall expenditure in the education sector. Equation (1) disaggregates the public expenditure on municipal primary education relative to the proportion of the municipal GDP into three distinct components:

(a) the school-age population as a proportion of the economically active population (SAP/EAP);

(b) the number of students as a proportion of the economically active population also referred to as educational coverage (NS/EAP); and

(c) the expenditure per student on education as a proportion of the GDP per economically active population, represented by ((EMPPE/NS)/(GDP/EAP)), as per equation (1):

$$\frac{EMPPE}{GDP} = \frac{SAP}{EAP}\,\frac{NS}{EAP}\,\frac{\frac{EMPPE}{NS}}{\frac{GDP}{EAP}} \tag{1}$$

where,

EMPPE = expenditure on municipal public primary education;

GDP = Gross Domestic Product of the Municipalities;

SAP = school-age population;

EAP = economically active population;

NS = number of students measured by school enrolments.

As per equation (1), the EMPPE/GDP variable reflects the expenditure related to municipal public primary education of the municipal GDP. It calculates this expenditure on primary education from the sum of expenditures on payroll and other current and capital expenses (OCCE).

In this equation, the EMPPE/GDP variable increases with a rise in education spending, an increase in the number of students, and an increase in per capita expenditure per student. On the other hand, GDP growth, an increase in the economically active population, and an increase in the school-age population tend to decrease the EMPPE/GDP ratio.

It is relevant to note that the payroll (PR) results from the teachers' salaries (W_1) and the number of teachers (NT). Therefore, the payroll can increase with the hiring of more teachers and with an increase in salaries.

This relation expresses the number of teachers by the teacher-student ratio (θ) salary and adds the other current and capital expenses (OCCE). Then, divide this sum by the number of students. Additionally, calculate the current and capital expenses (CCE) per student by dividing these expenses by the number of students. Equations (2), (3), and (4) provide a detailed illustration of this calculation.

$$\frac{EMPPE}{GDP} = \left(\frac{PR+OCCE}{NS}\right) \tag{2}$$

$$\frac{EMPPE}{GDP} = \left(\frac{W1*NP+OCCE}{NS}\right) \tag{3}$$

$$\frac{EMPPE}{GDP} = PR\theta + \frac{OCCE}{NS} \tag{4}$$

Thus, the EMPPE/GDP ratio quantifies the expenditure on primary education in relation to the Municipal Gross Domestic Product (GDP), considering the number of students. This ratio provides a measure of resource allocation for primary education, indicating the amount of financial resources invested per student.

From this perspective, two assumptions of Baumol (1967) model are adopted. The production function of sector 1 and sector 2.

$$Y_{1t} = a\ L_{1t}e^{r_{1t}} \tag{5}$$

$$Y_{2t} = b\ L_{2t}e^{r_{2t}} \tag{6}$$

where,

L_{1t} is the labour employed in sector 1, and L_{2t} is the total number of workers employed in the sector, divided by the number of students. Y_{1t} is the output of sector one, and Y_{2t} is the output of sector 2.

Following Baumol's classic model of unbalanced growth, the nominal wages in both sectors are interrelated in the long term and increase at the rate of labour productivity growth in the progressive sector. In other terms, the model assumes a common growth in wages across these sectors:

$$W_{1t} = W_{2t} = be^{r_{2t}} \tag{7}$$

Baumol's model also assumes that the output ratio of the progressive sector to the nonprogressive sector is kept constant: $Y_{2t}/Y_{1t} = K$ (constant output ratio assumption).

Given this assumption, the total labour force of the economy at time t is denoted as $L_t=L_{1t}+L_{2t}$, and the amount of labour in each sector can be expressed as follows:

$$L_{1t} = \frac{L_t}{1+\frac{a}{b}Ke^{(r_2-r_1)t}} \tag{8}$$

$$L_{2t} = \frac{\frac{a}{b}ke^{(r_{2t}-r_{1t})}\ L_t}{1+\frac{a}{b}Ke^{(r_{2t}-r_{1t})}} \tag{9}$$

In this way, the unit labour cost in the non-progressive sector can be calculated as:

$$\frac{C_{1t}}{Y_{1t}} = \frac{W_{1t}\,L_{1t}}{Y_{1t}} = \frac{(1+\alpha_t)be^{r_2t}}{ae^{r_1t}} \tag{10}$$

After taking the natural logarithm of this expression and performing total differentiation, the percentage change in the unit labour cost in education is determined by (a) the difference in productivity growth between the two sectors and (b) the change in the wage premium.

$$\Delta log\frac{C_{1t}}{NS_{1t}} = (r_2 - r_1) + \frac{\Delta\alpha_t}{NS_t} \tag{11}$$

With the school-age population denoted by NS_t and following the identity equation:

$$\frac{C_{1t}}{Y_{it}} = \frac{C_{1t}}{NS_t}\frac{NS_t}{Y_t}\frac{Y_{1t}}{Y_t} \tag{12}$$

After performing a series of algebraic operations, it becomes evident that the expenditure on education relative to the GDP of sector 1, indicated as C_{1t}/Y_{1t}, evolves into C_{1t}/NS_{1t}.

This refined expression epitomises the cost of education per student. It comprises three distinct elements: the Baumol effect, wage premium fluctuations, and GDP per capita growth in the educational context. Notably, the output contribution from the education sector remains constant and, as such, will be excluded from Equation (13).

$$\Delta ln\left(\frac{C_{1t}}{NS_t}\right) = (r_{2t} - r_{1t}) + \frac{\Delta\alpha_t}{1+\alpha_t} + \Delta\log\frac{Y_t}{NS_t} \tag{13}$$

Since the final product of education is a service, it is impossible to measure it quantitatively, as is done in industry. The outcomes of education are long-term, such as the development of skills, which makes it difficult to quantify productivity in a standardised manner. Therefore, we will employ the average wage growth in relation to labour productivity growth in the industrial sector.

The viability of this hypothesis is supported by the study's assumptions that the wage level in the non-progressive sector (specifically, that of teachers) (W_1) is determined by the sector's productivity (r_2) and the constant rate of GDP growth (as illustrated in equations (14) and (15).

$$W_{1t} = \frac{(1+\alpha_t)be^{r_2 t}}{be^{e^{r_2 t}}} \tag{14}$$

$$W_{2t} = be^{r_2 t} \tag{15}$$

In this approach, the model considers that the total labour force of the economy (L_t) is comprised of the amount of labour employed in the educational sector (L_{1t}) and in the industrial sector (L_{2t}). This is expressed as follows:

$$Y_{1t} = aL_{1t}e^{r_1 t} \tag{16}$$

$$Y_{2t} = bL_{2t}e^{r_2 t} \tag{17}$$

where:

Y_t = Municipal GDP;

Y_{1t} = output of the municipal public primary education;

L_{1t} = number of workers in municipal primary education;

L_{2t} = number of workers in the industry;

"a" and "b" are constants; and

r = productivity, and r_1 is considered to be absent, thus $r_1<r_2$.

Taking into account the unit labour cost in primary education C_{1t}/Y_{1t}, that is, the total cost divided by the sector's GDP, along with the sector's cost (C_{1t}) as defined by personnel expenses W_{1t} in equation (10), we can obtain a tool to analyse educational expenditure per student. The total labour cost divided by production is called "labour unit cost." This metric helps evaluate labour efficiency and the impact of labour costs on production.

In microeconomics, labour cost, which includes wages, benefits, and other workforce-related expenses, is a significant component of the average cost of producing goods or services. This average cost often exhibits a U-shaped curve due to the nature of fixed and variable costs: it initially increases at low production levels due to high fixed costs per unit, then decreases with increased production as fixed costs are spread out and variable costs rise, and finally, it increases again at high production levels due to loss of productivity. The decrease in productivity is explained by the increase in the number of workers without the corresponding addition of other production factors. This phenomenon is known as the theory of diminishing returns, initially addressed by David Ricardo.

Thus, taking into account that the GDP (Y_{1t}) was established by equations (5 and 6), we can find the relationship between the cost of labour and the increase in educational services with the expansion of the economy.

This understanding is further deepened when examining the cost per student C_{1t}/Y_{1t}, which can be decomposed into a price effect and an income effect. The price effect corresponds to the first two terms of equation (12), namely the Baumol effect (1967), characterised by the difference in productivity growth between the sectors. The second term is the income effect.

$$\frac{C_{1t}}{Y_{1t}} = \frac{W_{1t}L_{1t}}{Y_{1t}} = \frac{(1+\alpha_t)be^{r_2 t}}{ae^{r_2 t}} \tag{18}$$

$$\Delta log\frac{C_{1t}}{NS_{it}} = (r_2 - r_1) + log\left(\frac{Yi_t}{NS_{it}}\right) \tag{19}$$

Another change involved replacing the expression (r_2 - r_1) with the modified Baumol variable ($pr_{it} – y_{it}$). Thus, the personnel expenditure (W1tL1t) corresponds to the payroll (PR), and the growth rate of this expense is pr. Then, the variable C_{1t} is explained by the excess in wage expenditures compared to the gain in productivity in the industrial sector and GDP expansion. This surplus obtained in the industry allows for the financing of the educational sector.

$$\Delta log\frac{C_{it}}{NS_{it}} = \frac{1}{Y_{it}}[\Delta log(pr_{it}) - \Delta \log(y_{it})] + log\frac{Y_{it}}{NE_{it}} \tag{20}$$

Equation 20 changes the metric to cost per user. This metric, the cost of providing the service divided by the number of users, indicates how much it costs to serve each student.

Akerlof and Yellen (1986) support the assumption that wages in less productive sectors tend to rise in response to wage increases in more productive sectors. They argue that workers assess their wages in nominal terms (Nunes and Nunes (1997)) and comparison with other workers. Thus, remuneration in the industrial sector serves as a benchmark for wages in other sectors. This reaction helps explain why wages in low-productivity sectors may increase, even without significant productivity improvements.

4. Methodology

The previous section shows a cost metric per user in the educational sector. To empirically test Equation (20) we use cross-sectional data spanning from 2009 to 2019. Equation (21) represent the estimated model. In this equation, the time index and the logarithmic difference have been removed:

$$Log\ \frac{C_i}{NS_i} = \beta_1[\log\ (pr_i) - log\ (y)] + \beta_2 log\frac{Y_i}{NS_i} + \delta Z_i + u \quad (21)$$

where Z_i is a matrix of regressors, including the intercept for municipality i, the error term includes unobserved effects of the municipality and an idiosyncratic error component. We estimate this equation for testing.

To ascertain whether the increase in teachers' salaries is attributable to the Baumol effect, the following hypothesis were tested:

- Hypothesis: $\beta_1 > 0$ indicates the occurrence of the Baumol effect in the Brazilian educational sector.

The data used in this study ranges from small municipalities with fewer than five thousand inhabitants to major cities such as São Paulo (12.5 million inhabitants), Rio de Janeiro (6.72 million), and Brasília (3 million). Considering the population variation and the potential existence of significant disparities in per-student costs and the use of cross-sectional data, heteroscedasticity is anticipated, as noted by Daryanto (2020).

The presence of heteroscedasticity renders the Ordinary Least Squares (OLS) model inefficient, impacting the validity of statistical tests. Thus, the efficiency and reliability of standard errors and test statistics become compromised, potentially leading to incorrect inferences. Therefore, addressing this issue is crucial. Initial attempts with Weighted Least Squares (WLS) regression proved ineffective according to the Breusch-Pagan test.

However, it is possible to employ regression with heteroscedastic data. This proposition is supported by Gujarati and Porter (2011), who state that the presence of heteroscedasticity does not negate the properties of the estimators. If the sample is large, standard errors can be adjusted. Previous studies have addressed this issue, as informed by Fika (2022). These authors computed robust standard errors using the vcovHC() function to enhance the estimates' reliability.

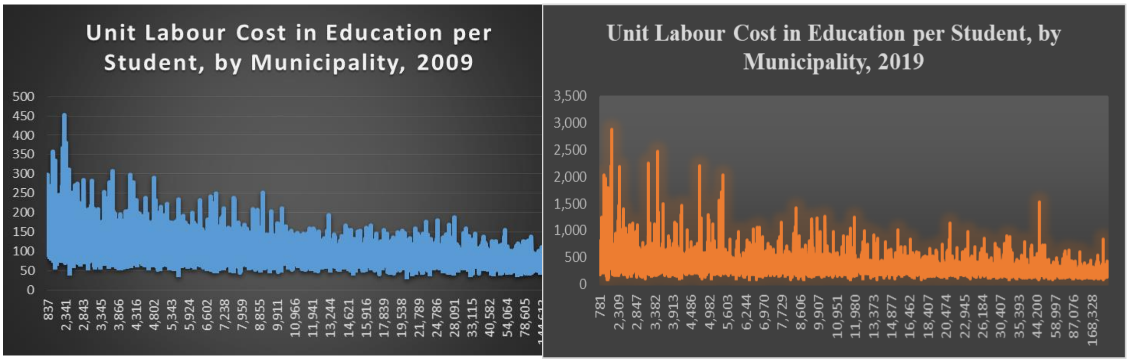
Another important requisite of employing heteroscedastic data is the existence of theoretical grounding in specifying the regression equation. The choice of explanatory variables for the unit cost per student is associated with the items influencing it. Considering that the specification followed theoretical foundations, adjustments with robust standard errors can contribute to achieving representative parameters influencing the cost.

The vcovHC() function adjusts the variance-covariance matrix of the model's estimators to account for heteroscedasticity, thereby becoming an efficient tool for implementing robust standard errors in statistical analyses. Additionally, the corrected estimators proposed by Cribari-Neto, Ferrari, and Cordeiro (2000) were found to be suitable.

After applying robust standard errors, the model showed no significant changes in the coefficients or their standard errors, affirming its robustness even in the face of heteroscedasticity, as indicated by the Breusch-Pagan test. This method bolsters confidence in the coefficient estimates and provides more reliable standard errors for the coefficients in the WLS model.

5. Results

In both 2009 and 2019, it was observed that the unit labour cost was high in smaller municipalities, primarily due to smaller class sizes and the consequent lower student-teacher ratio. In contrast, larger municipalities with populations over fifty thousand tend to have lower unit labour costs due to the ability to distribute fixed expenses, such as salaries, across larger classes. This relation increases per capita costs in municipalities with fewer than 5,000 students.



Unit labour cost at December 2019 prices, according to the size of the municipality.

Source: Ministry of Education and IBGE, compiled by the authors.

Figure 1. Comparison of unit labour costs in municipalities by size, 2009 vs 2019

The labour cost per student in education has significantly increased over the past decade. This increase is partly due to rising municipal revenues, growing from in real terms. The student population decreased from 17,372,419 in 2009 to 15,261,665 in 2019, while the number of teachers increased from 762,928 to 1,167,399, as the Ministry of Education reported.

The rise in the minimum salary for teachers, which exceeded the inflation rate, has contributed to this increase in labour costs per pupil. The minimum wage was R$950.00 in 2009, and by 2019, it had increased to R$3,440.29, outpacing the 76.4% estimated cumulative inflation during the same period by the IPCA. The real increase in the minimum salary was 105.3%. The variation in wages indicates that teachers' real income increased more than the cost of living.

Additionally, this salary growth has exceeded the productivity growth in the manufacturing industry, which accumulated a rate of 6.5%, as shown in the following graph.

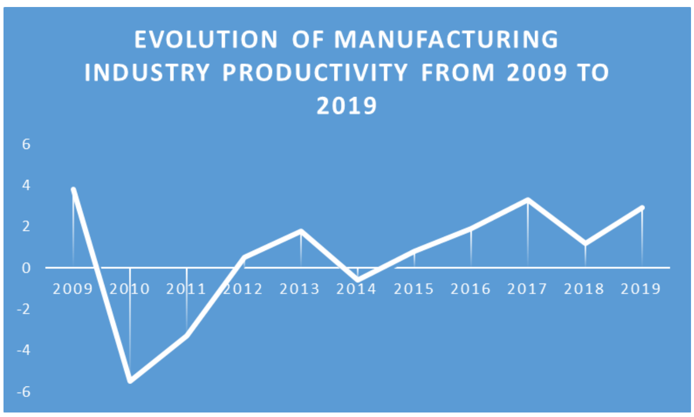


Figure 2. Productivity growth in the manufacturing industry

Source: Confederação Nacional de Indústria.

Salaries that outpace productivity growth can diminish profits, thereby restricting a company's growth potential. Lower profits limit a company's ability to finance its expansion, potentially impacting economic growth.

In the context of GDP growth and its impact on labour costs per student in education, a reduced impact is expected between 2009 and 2019 due to GDP growth deceleration. According to IBGE, Brazil's total real GDP growth was approximately 33.39% from 1999 to 2009 and 14.19% from 2009 to 2019, reflecting a slowdown in the latter period.

Over the period from 2009 to 2019, the total costs per pupil in Brazil's smaller municipalities have increased relative to those in larger cities. This more significant expenditure per student in smaller municipalities is linked to the maintenance of smaller class sizes. Moreover, hiring new teachers, despite a decrease in the number of students, has further escalated the costs.

Table 2. Top 10 Brazilian municipalities with the highest unit cost variation per student from 2009 to 2019

municipal code	R$ cost in 2019	R$ cost in 2009	cost variation	population
3550308	12,252,023	11,037,593	1,214,430	5,359
3304557	6,718,903	6,186,710	532,193	4,578
1302603	2,182,763	1,738,641	444,122	2,720
5208707	1,516,113	1,281,975	234,138	5,085
2304400	2,669,342	2,505,552	163,790	12,831
1100205	529,544	382,829	146,715	40,469
5002704	895,982	755,107	140,875	7,813
3543402	703,293	563,107	140,186	5,823
3509502	1,204,073	1,064,669	139,404	3,683
1600303	503,327	366,484	136,843	27,928

Source: Ministry of Education and IBGE, compiled by the authors.

The coefficient for the independent variable "x" is approximately 0.1567. This implies that for each additional unit spent on wages (x), the cost per labour unit increases by an average of 0.1567 units, holding all other factors constant. This is the marginal effect of wage expenditure on the cost per labour unit. The significant value of the coefficient can be attributed to Baumol's cost disease phenomenon, which is observed in the educational sector. There has been a noted increase in the number of teachers while the number of students has decreased. This phenomenon contrasts with the industrial sector, where workers produce progressively more due to technological advancement. In education, however, productivity gains are limited because the nature of teaching work is less susceptible to efficiency gains through technology. Thus, costs increase without a corresponding increase in output, explaining the rise in cost per labour unit.

The findings from the study reveal significant trends in labour costs within the education sector between 2009 and 2019. Smaller municipalities consistently faced higher labour costs per unit due to smaller class sizes and lower student-teacher ratios, illustrating Baumol's cost disease, where costs rise without a corresponding increase in output due to limited productivity gains. Conversely, larger municipalities benefited from economies of scale, achieving lower per-unit labour costs.

Financial data from FINBRA indicated rising municipal revenues. At the same time, educational statistics showed a decline in student numbers and an increase in teacher hires, paralleling a substantial rise in teachers' real income, which outstripped both inflation and productivity growth in the manufacturing sector.

Table 3 presents the unit labour costs across Brazilian municipalities, illustrating the abovementioned trends. The regression model yielded significant coefficients and a robust R-squared value, indicating that the explanatory variables effectively account for variations in the dependent variable. The negative coefficient for 'log(turmas19)' suggests an inverse relationship with the dependent variable, consistent with economies of scale as class sizes increase.

Table 3. Econometric results: impact of baumol effect on unit labour costs in Brazilian schools

```
                    ECONOMETRIC RESULTS
Balanced Panel: n = 4288, T = 1, N = 4288
Coefficients:
                   Estimate  Std. Error  t-value  Pr(>|t|)
(Intercept)      2.27236696  0.03643500  62.3677 < 2.2e-16 ***
x                0.15671453  0.00684441  22.8967 < 2.2e-16 ***
log(z)          -0.25630733  0.00955833 -26.8151 < 2.2e-16 ***
log(turmas19)   -0.15142427  0.00608215 -24.8965 < 2.2e-16 ***
log(despK)       0.00113090  0.00033016   3.4253 0.0006199 ***
log(ns)          0.01561191  0.00079503  19.6369 < 2.2e-16 ***
log(esc19)       0.03609920  0.00634833   5.6864 1.384e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares:    323.96 R-Squared:      0.59348
Residual Sum of Squares: 131.7  Adj. R-Squared: 0.59052
F-statistic: 200.432 on 31 and 4256 DF, p-value: < 2.22e-16
```

Despite the model’s robustness and lack of evidence of serial correlation, heteroscedasticity in the residuals necessitates corrective measures, such as applying the vcovHC function, to ensure reliable inferences from model estimations.

The regression model presents significant coefficients for all variables, indicating their relevance in explaining the dependent variable. The intercept, at approximately 2.2724, suggests the baseline level of the dependent variable when all independent variables are zero. This result is highly significant, as indicated by the p-value of less than 2.2e-16.

The coefficients of ‘log(turmas19)’, ‘log(despK)’, ‘log(ns)’, and ‘log(esc19)’ are -0.1514, 0.0011, 0.0156, and 0.0361, respectively. Each of these coefficients reflects the average change in the dependent variable for a one-unit change in the respective independent variable, controlling for the effects of other variables. The negative coefficient of ‘log(turmas19)’ suggests an inverse relationship with the dependent variable. Increasing the number of classes within educational institutions can lead to economies of scale. This phenomenon typically occurs when the expansion of classes is not matched by a proportional increase in faculty, often resulting in higher student-to-teacher ratios.

The model’s R-squared value of 0.59 indicates that the independent variables explain approximately 59.35% of the variance in the dependent variable. The adjusted R-squared, a more precise measure, stands at 0.59, slightly lower due to the adjustment for the number of predictors.

The F-statistic of 200.432 with a highly significant p-value (less than 2.22e-16) suggests that the model is statistically significant. This indicates a strong overall fit of the model to the data.

In summary, the regression model demonstrates strong statistical significance with a good fit, indicating that the selected variables are important predictors of the dependent variable in this context.

Given the significant p-value, the test provides strong evidence of heteroscedasticity in the regression model’s residuals. This means that the variability of the errors is not constant across observations. However, the Program vcovHC (plm) function for random effects cross section model was applied to correct the model.

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The Breusch-Godfrey/Wooldridge test result for your panel data model indicates no significant serial correlation in the idiosyncratic errors, suggesting that the model’s error terms do not exhibit autocorrelation problems.

Table 4. Studentized Breusch-Pagan test

:		Significance Level
BP	177.11	pvalue< 2.2e-16
df	31	

The Breusch-Godfrey/Wooldridge test result for your panel data model indicates no significant serial correlation in the idiosyncratic errors, suggesting that the model’s error terms do not exhibit autocorrelation problems.

Table 5. Breusch-Godfrey/Wooldridge test for serial correlation

:		Significance Level
chisq	0.38625	pvalue= 0.5343
Df	1	
Alternative hypothesis: serial correlation in idiosyncratic errors		

7. Conclusion

The study discussed costs and productivity in education, highlighting the rise in teacher salaries and the decrease in the student-teacher ratio in Brazil despite low productivity growth. The study utilises quantitative methods and statistical data to test Baumol's adapted model, considering variables such as municipal population, per capita income, and income growth per capita.

The analysis of data collected from 2009 to 2019 reveals a complex picture of municipal finances in education in Brazil. Contrary to theoretical expectations of a direct relationship between the size of a municipal population and educational costs, the Brazilian reality shows the opposite. Per capita education expenses tend to decrease as the municipal population increases, challenging the conventional theory of economies of scale in the public sector.

The findings indicate that contrary to theoretical expectations, per capita education costs tend to decrease as the population size of municipalities increases, on average. This phenomenon suggests using consortiums among municipalities, common actions in the health sector to seek cost reductions in education and the need for federal programmes through agreements to reduce the cost per student.

The results of this study have significant implications for the planning and management of education in Brazilian municipalities. They demonstrate the high cost of educational policy without the corresponding result in teaching quality, especially in municipalities with fewer inhabitants.

This study underscores the need for differentiated educational policies considering each municipality's specificities and the importance of financing strategies seeking efficiency and equity. While widely recognised, the phenomenon of Baumol's Cost Disease manifests uniquely in Brazil, reinforcing the need for ongoing dialogue between economic theory and political practice to ensure the right to quality education for all.

The study's limitation is that it focuses only on a ten-year period, which may not capture specific regional or local nuances. Furthermore, Baumol's model was applied without considering cultural and political differences between municipalities, which can significantly influence the results. Thus, future studies could incorporate these elements to understand the issue comprehensively. Among these elements, the proposal of practical solutions stands out, such as using educational consortia between municipalities, with the same intensity observed in the health sector, where they are widely utilised.

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