Wage Profile and Gender Gap in Science and Technology: Regional Disparities in Brazil

Perfil salarial y brecha de género en ciencia y tecnología: disparidades regionales en Brasil

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Abstract

Introduction

Economies with a strong STEM component tend to show better economic indicators and perform better in terms of innovation and job creation. However, little is known about wage distribution in STEM in Brazil and how it varies by gender and region.

Objective

This article aims to investigate the regional distribution and wage premium of the Brazilian STEM workforce, with a specific focus on gender disparities between STEM and non-STEM fields.

Methodology

Using microdata from the Annual Social Information Report (RAIS), we apply an econometric model that adapts the Oaxaca-Ransom wage decomposition.

Results

The STEM workforce represents 1.8% of the formal labor market and is unevenly distributed: the highest concentration is in the Southeast, and the lowest in the North and Northeast. Gender gaps in STEM vary by region, being smaller in core STEM areas and larger in those with higher female representation. Moreover, wage premiums are higher in the South than in the North.

Conclusions

Our findings highlight the geographical distribution of STEM employment across Brazilian regions and the regional differences in fields of knowledge. We observe that men receive higher wage premium than women across a broader range of activities.

Keywords:

STEM; gender gap; wage premium; Brazilian regions; female participation; RAIS; regional disparities; STEM occupations; econometric model; Oaxaca-Ransom decomposition; STEM fields; labor market.

JEL Classification: J16; J31; O15.

Resumen

Introducción

Las economías con un fuerte componente STEM presentan mejores indicadores económicos y un mayor desempeño en términos de innovación y creación de nuevos empleos. Sin embargo, se sabe poco sobre la distribución salarial en STEM en Brasil y sus diferencias según el género y la región.

Objetivo

El objetivo de este artículo es investigar la distribución regional y la prima salarial de la fuerza laboral brasileña en STEM, analizando específicamente las disparidades de género entre los campos STEM y no STEM.

Metodología

Utilizando microdatos del Informe Anual de Información Social (RAIS), se aplica un modelo econométrico basado en la descomposición salarial Oaxaca-Ransom.

Resultados

La fuerza laboral STEM representa el 1,8% del mercado laboral formal y está distribuida de forma desigual: la mayor concentración se encuentra en el sureste y la menor en el norte y noreste. Las brechas de género en STEM varían por región, siendo menores en áreas STEM fundamentales y mayores en aquellas con más mujeres. Además, las primas salariales son más altas en el sur que en el norte.

Conclusiones

Nuestros hallazgos resaltan la distribución geográfica del trabajo en STEM en las regiones brasileñas y las diferencias regionales en los campos de conocimiento. Observamos que los hombres presentan mayores primas salariales que las mujeres en un conjunto más amplio de actividades.

Palabras clave:

STEM; brecha de género; prima salarial; regiones brasileñas; participación femenina; RAIS; disparidades regionales; ocupaciones STEM; modelo econométrico; descomposición de Oaxaca-Ransom; campos STEM; mercado de trabajo.

Clasificacion JEL: J16; J31; O15.

1. Introduction

The acronym STEM (Science, Technology, Engineering, and Mathematics) emerged in the late 1990s as part of a policy agenda aimed at increasing the number of individuals trained in these fields of study, driven by the demands of the technological race. Economies firmly based on STEM activities exhibit better economic indicators and perform better in innovation and creation of new jobs (Deming and Noray, 2018). Also, these economies have higher employment rates, registered patents, wages, and even exports (for example, see Davis et al., 2021).

This paper aims to investigate the regional distribution of the workforce in Brazil in fields directly applying science and technology, shedding light on regional disparities regarding STEM wage premiums, female participation, and the gender wage gap. This includes examining variations in female participation across different sub-areas within STEM and across regions. The study addresses the following research questions: Are there disparities across Brazilian regions in STEM wage premiums? How does female participation in STEM vary across areas and sub-fields, and what is the gender wage gap in STEM sub-fields compared to non-STEM fields? The paper's main contribution is to provide a regional analysis of the STEM workforce, highlighting gender disparities and wage patterns across specific knowledge fields. It emphasizes the significant regional variation in the composition of STEM occupations in Brazil.

Developed countries have experienced growth in the STEM job market, likely due to the increasing integration of technology in recent years. In 2015, approximately 6.2% of the employed population in the United States worked in STEM fields. Employment in these areas grew by about 10% between 2009 and 2015, and the STEM workforce was projected to grow by nearly 30% between 2014 and 2024 (Fayer et al., 2017).

On the other hand, developing economies have shown a low percentage of workers in STEM fields. As a comparison, Brazil's STEM workers represented around 2.6% of the total labor force in 2015 (Fernandes, 2021). Nations like Brazil, Mexico, Chile, and Argentina increasingly promote STEM-related industries such as information technology, renewable energy, and biotechnology as part of their development strategies. However, female participation in STEM remains uneven and often limited despite this growth. While more women are entering university STEM programs, particularly in biological sciences and health-related fields, their presence is significantly lower in engineering, computer science, and physics. The gender gap varies across countries; Chile and Mexico, for instance, show particularly low female representation in engineering and tech sectors (Bordón et al., 2020; Ramírez-Corona, 2022), while countries like Argentina and Bolivia report slightly higher but still unequal participation (World Economic Forum, 2016). Structural barriers, cultural norms, and lack of mentorship opportunities contribute to this disparity, highlighting the need for more inclusive policies and support systems to encourage and retain women in STEM careers (Hernández Herrera & Hernández Herrera, 2023; Risco, 2024).

This globally observed female underrepresentation within STEM occupations raises policymakers' concerns regarding talent retention and the need for diversity within STEM fields. Therefore, this study sheds light on the wage premium between STEM and non-STEM fields, as well as the STEM gender gap, to map which STEM areas have less female representation in Brazil and how large the wage gap is. To do this, we utilize the Annual Social Information Report (RAIS) dataset, which contains information on the Brazilian formal labor market, with a methodology of wage decomposition as proposed by Oaxaca (1973) and Oaxaca and Ransom (1994).

This study corroborates this trend within Brazil, demonstrating a similar pattern across the spectrum of STEM disciplines. The study also shows that the female participation rates vary across specific STEM fields. For instance, the participation levels of women range from below 14% among multidisciplinary scientific professionals in the Southern regions to as high as 60% among professionals in the biological sciences.

The article is divided into four sections, in addition to this introduction. Section two motivates studying STEM occupations in Brazil through a literature review. Section three outlines the methodology and description of the data used. Section four discusses the results obtained. Finally, following the presentation of results, the concluding remarks are presented.

2. The role of STEM activities and female underrepresentation

The expansion of the science and technology sector in modern economies has significantly contributed to increasing wage differentials in STEM careers, with technological shifts being identified as a key driver of wage inequalities (Katz and Murphy, 1992; Bound and Johnson, 1995; Borjas and Ramey, 1995). Scholars such as Juhn et al. (1993) attribute rising wage disparities in the U.S. to the escalating returns on skills. Consequently, the underrepresentation of minorities in highly skilled occupations has emerged as a critical facet of inequality. Blau and Khan (2000) and Goldin et al. (2020) explore the increasing returns to education and the narrowing gender gap within high-skilled professions in the United States. Podobnik et al. (2020) highlight that STEM fields are associated with both prosperity and inequality at the individual, firm, and national levels. STEM firms in the S&P 500 contribute more to wealth inequality and exhibit larger growth rates than non-STEM firms.

Research on the regional distribution of the STEM workforce in Brazil reveals several key findings. Bonini and Custodio (2023) identify a higher average STEM wage premium in the country's main technology clusters, indicating a growing demand for STEM workers. Silva Kubrusly et al. (2008) note that most formal employment is concentrated near state capitals, particularly in trade and services, while industry is moving towards the interior, especially in the more developed south and southeast regions. Guimarães et al. (2006) highlight the role of human capital, particularly the quality of education, in explaining wage inequality across regions. Ariza and Raymond Bara (2020) further underscore the impact of technological change on employment, noting a decline in medium-skilled occupations and adverse effects on women, alongside positive outcomes for younger workers and those with higher levels of education.

The underrepresentation of women in STEM fields has been a persistent issue historically in Europe and the United States (Landivar, 2013; Burke, 2007; Fayer et al., 2017). Research on the underrepresentation of women in STEM fields has produced several theoretical frameworks to explain this phenomenon.

One influential perspective is the stereotype threat theory, which is particularly relevant in fields like mathematics, engineering, and information technology. This approach emphasizes the negative impact of stereotypes on women's choices and performance. Awareness of negative stereotypes about women's abilities in these fields can impair performance due to fear of confirming those stereotypes (Spencer et al., 1999). This dynamic can reduce interest and participation in mathematics, engineering, and IT (Shapiro and Williams, 2012; Beblo et al., 2003).

The literature on socialization and gender roles in STEM emphasizes the impact of early socialization processes. Girls often socialize differently from boys from a young age, shaping their attitudes and decisions regarding academic and career paths. Traditional gender roles may discourage girls from pursuing STEM disciplines and careers, resulting in lower female participation (Olsson and Martiny, 2018; Cong et al., 2021).

The lack of representation and role models is another critical factor. Men have historically dominated STEM fields and remain the majority in academia, particularly in senior positions in countries such as the United States (Beede et al., 2011; Holman et al., 2018; Lincoln et al., 2012). Several studies argue that the scarcity of female mentors and role models in mathematics, engineering, and IT contributes to a lack of encouragement and support for women pursuing these careers. Owuondo (2023) illustrates that the lack of female representation is portrayed not merely because of individual choice, but as a structural barrier reinforced by multiple layers of influence.

The role of implicit biases and discrimination is also well documented. While women may be equally represented in undergraduate mathematics courses, they remain underrepresented in engineering due to persistent biases. Implicit biases and explicit discrimination can create unwelcoming or hostile work environments, discouraging women from entering or remaining in these fields. This includes bias in hiring, promotion, and workplace culture (Jackson et al., 2014; Kong et al., 2020).

Educational factors also play a role. Disparities in access to resources, the quality of instruction, and support systems may contribute to the underrepresentation of women in STEM (Kahn and Ginther, 2017; Wang and Degol, 2017; Saucerman and Vasquez, 2014). These issues are often interconnected with gender stereotypes, cultural norms, lack of role models, and aversion to competition or risk. Collectively, these factors can shape decisions that steer many women away from core STEM disciplines.

Lastly, the lens of intersectionality is essential. Gender interacts with other social categories (such as race, ethnicity, socioeconomic status, and disability) to produce unique barriers and experiences for women in STEM, especially in mathematics, engineering, and IT.

In Brazil, women represented 45.8% of the total labor force in 2020, according to the most recent data released by the Brazilian Institute of Geography and Statistics (IBGE) and surveys conducted by the Institute for Applied Economic Research (IPEA). However, this participation is not homogeneous across knowledge fields. Kemechian et al. (2023) assess the lower participation of women in STEM jobs in Brazil. They identify several key challenges women face in these careers, including the lack of flexible work systems, the scarcity of gender-sensitive organizational and labor policies, and the prevalence of traditional cultural models. The study compares the Brazilian case with the U.S., Canada, and France, finding that while the challenges are similar, their relative importance differs in Brazil compared to these other countries.

Therefore, the Brazilian government has implemented initiatives to promote STEM education and research to increase worker participation in STEM fields, including scholarships, grants, and funding for STEM-related projects and institutions (Arbix et al., 2016). For instance, the Science Without Borders program aimed to send Brazilian students abroad to study STEM subjects, fostering international collaboration and knowledge exchange.

3. Database and methodology

The database with wage information comes from the Annual Social Information Report (RAIS) of 2021. This data is reported by the Ministry of Labor in Brazil, corresponding to the information provided in December 2021. The information on employees' occupations, made available by RAIS, is based on the Brazilian Classification of Occupations (Ministério do Trabalho e Emprego, 2002), which, in turn, is aligned with the Standard Occupational Classification (SOC). The armed forces were excluded from the database due to their specific wage-averaging and career process.

To identify STEM-related occupations, this study adopts the classification criteria proposed by Seemann and Bonini (2017), who follow the criteria of the U.S. government's Department of Commerce, Economics and Statistics Administration (ESA) (Beede et al., 2011). It includes core STEM occupations, professional and technical support jobs in computer science, mathematics, engineering, physical sciences, and earth sciences. In addition, we incorporated architects, psychologists, and higher education professors in STEM discipline; occupations included in STEM definitions by the U.S. Bureau of Labor Statistics since 2015. As a result, the present study used 184 occupation codes to define the STEM group, as listed in Table A1 of the Appendix.

3.1 The regression model

The STEM wage premiums and gender wage gaps are estimated using the methodology introduced by Oaxaca (1973) and refined by Oaxaca and Ransom (1994). The model involves adapting this methodology to use binary variables, as explained by Gardeazabal and Ugidos (2004), which are gender and occupation groups (STEM x non-STEM).

To analyze the relationship between wage and gender gap, or field gap (STEM vs. non-STEM), we utilize a semi-logarithmic model. Equation [1] represents this model, where the dependent variable y_i represents the logarithm of the hourly wage for an individual *i*. This variable is obtained by dividing the nominal value of the worker's wage by the number of contracted hours per week.

$$y_i = \beta_0 + \beta_1 S_i + \beta_2 X_i + \beta_3 H_i + \mu_i \qquad [1]$$

β_0 represents the constant term. S_i is composed of categorical variables of schooling, specifically, incomplete high school, complete high school, incomplete college, bachelor's degree, master's degree, and doctorate. For comparison, we omitted the first education level (incomplete high school), therefore, the analysis will be in comparison with this education level group. X_i represents individual characteristics, such as age, age squared, and employment tenure, where employment tenure is measured as the number of months the individual spent in the current job. μ_i is a mean zero error term.

Equation [1] represents a general form for two models, which differ by the term H_i. In the first wage formation process, H_i is the binary variable that defines the occupation group, STEM = 1 vs. non-STEM=0, providing the estimates for the STEM wage premiums. In the second wage formation process, H_i represents a binary variable concerning gender, where female=1 and male=0. In this case, the coefficient provides estimates for the average wage difference between women and men, which is the gender gap. For this last model, we split the analysis between STEM and non-STEM groups, verifying the difference in the gender gap among these groups.

As the model is semi-logarithmic, the estimated coefficient represents the difference between the logarithms of wages. Using the technique suggested by Halvorsen and Palmquist (1980), we take the antilogarithm of the estimated dummy coefficient, subtract 1, and multiply the result by 100. This procedure allows the coefficient to be interpreted in percentage terms, estimating the ratio between the median wages of the groups (STEM/non-STEM) and (female/male).

4. Results

Table 1 presents an overview of the geographic distribution of employment in Brazil. The first column shows the total number of formally registered workers in 2021, excluding armed forces members and individuals with zero average wages that year, and the second column presents the share of STEM workers as a percentage of the total workforce shown in column one. The group of STEM workers is formed according to the occupation codes listed in Table A1 of the Appendix. The distribution of STEM workers throughout the country can be observed in column three. Southeastern regions account for nearly 80% of the country's STEM workforce, while the Northern and Northeastern regions comprise less than 14% of the national STEM workforce.

Regarding female participation in STEM occupations, the last column of Table 1 indicates that the two northernmost regions of the country have higher female representation. In contrast, the southeast region has the lowest female representation. The following analysis of the distribution of STEM sub-areas in each region sheds light on the reasons behind these regional differences regarding female participation in the STEM workforce.

Based on Table A1, Table 2 provides a detailed breakdown of the composition of the STEM

Table 1. Distribution of the STEM workforce across Brazilian regions

Region	Total labor force	STEM representation in total labor force %	Regional participation in the national STEM workforce	Female participation in STEM %
Northeast	12,047,040	1.1%	10.42%	36.38%
North	3,873,272	1.1%	3.26%	34.6%
Midwest	6,379,421	1.3%	6.72%	29.3%
South	13,130,372	1.4%	15.22%	30.2%
Southeast	34,232,484	2.3%	64.38%	27.9%
Brazil	69,701,956	1.8%	-	29.45%

Source: authors' formulation based on RAIS (Ministério do Trabalho e Previdência, 2021).

Table 2. STEM occupational groups and gender profile by region

STEM Field	Region	Total %	Female %
Support Managers	Northeast	5.6%	21.2%
	North	4.6%	18.8%
	Midwest	6.0%	21.5%
	South	8.5%	21.9%
	Southeast	9.6%	26.1%
Multidisciplinary Scientific Professionals	Northeast	0.6%	18.7%
	North	0.7%	22.7%
	Midwest	0.4%	12.6%
	South	0.6%	13.9%
	Southeast	0.9%	26.8%
Researchers	Northeast	1.66%	35.63%
	North	4.7%	25.7%
	Midwest	1.9%	37.1%
	South	3.2%	28.2%
	Southeast	3.1%	41.1%
Computer Science Professionals	Northeast	35.4%	19.6%
	North	26.7%	16.1%
	Midwest	49.6%	19.8%
	South	48.3%	20.7%
	Southeast	53.8%	21.0%
Mathematics, Statistics, and Physics Professionals	Northeast	2.5%	40.0%
	North	2.6%	37.2%
	Midwest	2.0%	36.9%
	South	1.5%	42.9%
	Southeast	2.3%	38.8%
Engineers and Architects	Northeast	26.6%	22.8%
	North	29.0%	21.6%
	Midwest	20.9%	21.8%
	South	19.4%	22.8%
	Southeast	19.2%	21.0%
Biological Sciences Professionals	Northeast	9.1%	57.4%
	North	13.8%	52.5%
	Midwest	10.1%	48.6%
	South	7.5%	48.6%
	Southeast	4.5%	60.0%
Tertiary Education STEM Professors	Northeast	3.3%	39.1%
	North	4.2%	45.8%
	Midwest	1.0%	33.9%
	South	1.7%	40.9%
	Southeast	1.0%	33.2%
Psychologists	Northeast	17.8%	84.3%
	North	13.7%	87.7%
	Midwest	7.9%	86.5%
	South	9.0%	86.9%
	Southeast	5.4%	84.5%

Note: Total % represents the field's representativeness of each region.

Source: authors' elaboration based on RAIS (Ministério do Trabalho e Previdência, 2021) and Table A1.

workforce in each region and the corresponding female participation in each field. The reason for conducting a more detailed analysis of the STEM subfields is that the gender profile and average wages vary across these occupational categories. More importantly, the composition of the STEM group, in terms of the relative weight of each subfield, also varies across Brazilian regions. This dynamic helps explain the findings of this study: in the North and Northeast regions, there is a higher female participation in the STEM workforce, which is, in turn, associated with lower STEM wage premiums.

The data reveals regional disparities in STEM fields and women's participation. The northern and northeastern regions have fewer computer science and support managers but more biological sciences and psychology professionals, where women are highly represented. Women comprise over 80% of psychologists in all regions and more than 48% of biological science professionals in three regions. This higher presence in these fields contributes to a more balanced gender representation in STEM in the northern regions.

Meanwhile, in the other regions, especially in the Southeast, computer science professionals and engineers constitute more than 60% of the STEM group. However, biologists and psychologists account for 10% of STEM employees in the Southeast region.

Table 2 highlights the underrepresentation of women in specific STEM groups, including support managers, computer science professionals, engineers, and multidisciplinary scientific professionals. Within this latter category, encompassing roles such as biotechnology professionals, metrology professionals, control and automation engineers, and mechatronics engineers, women constitute only 13.8% and 12.5% in the South and Midwest regions, respectively. As Kahn and Ginther (2017) argued, this low female participation is particularly concentrated in engineering and the math-intensive science fields of geosciences, economics, math/computer science, and physical science.

4.1 Wage differential estimates: STEM vs. non-STEM

The estimates for the wage premiums across five regions, presented in Figure 1, result from applying the model described by Equation [1], with the variable H_i incorporating the STEM vs. non-STEM occupation dummy variable. The model is tailored for each of the five regions, with a gender-based division of worker groups. The estimated ratio[4] between the average STEM wages and non-STEM wages is illustrated in the graph of Figure 1. All estimates are statistically significant at the 1% significance level.

Although a STEM wage premium occurs in the five Brazilian regions, workers in the Southeast region enjoy the highest wage premiums. At the same time, women in the North and Northeast earn the smallest STEM wage premium. In the Southeast, the average male STEM worker earns 58% more than his non-STEM counterpart, and the average female STEM worker earns 50% more than non-STEM women. In contrast, in the North, male STEM workers earn 37% more than non-STEM males, while female STEM workers earn only 20% more than their non-STEM peers.

Furthermore, the male STEM premium surpasses the female premium across all five regions, notably with the Northeast region showcasing the most substantial gender gap. Interestingly, in the Midwest region, male and female premiums nearly equalize. This result appears to contrast with what has been reported in the literature on the STEM workforce in the United States, for example, where the STEM wage premium for women exceeds that of men (Beede et al., 2011). Considering that, in the United States, the majority of STEM jobs are concentrated in computing and IT

4 The exponentiated coefficients approximate the ratio of the medians (not the means) of the wage distribution between groups. This is because the ordinary least squares (OLS) estimator on a log-transformed dependent variable is interpreted in terms of the conditional median of the original dependent variable when the error term is not symmetrically distributed, which is the common case for wage data (wages are usually skewed).

(Schabel and White, 2014), this discrepancy underscores the need for a deeper investigation into the composition of the STEM workforce in Brazil.

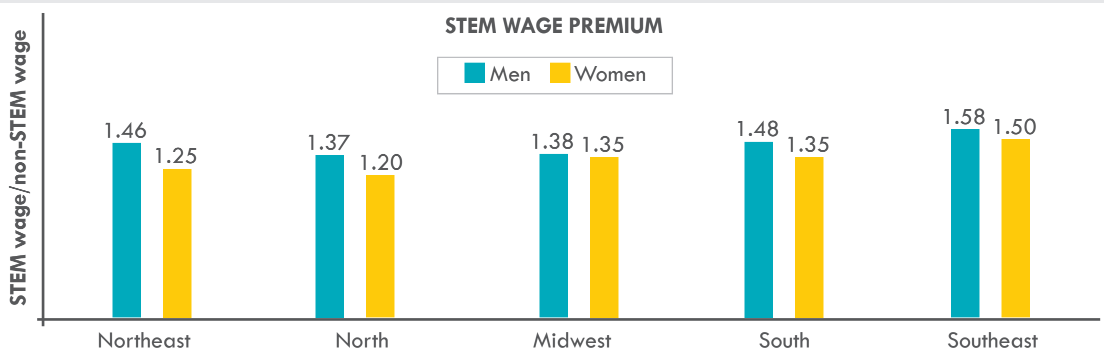
4.2 Estimates for the gender gap: STEM vs. non-STEM

The second model, expressed by Equation [1], aims to estimate the gender wage differential, where Hi is a binary variable (male=0, female=1). The Hi coefficient, estimated for the five regions, represents the difference between female and male average wages, exhibiting a statistically significant negative value at the 2% confidence level. Applying the model to STEM and non-STEM groups allows the gender wage relationship to be derived for each occupation category.

Figure 2 presents the outcomes for all occupations and their respective employees. The wage relationship is below unity across all five regions, signifying a disadvantage for female workers. Women, on average, earn less than their male counterparts in both the STEM and non-STEM groups. Among STEM occupations, the average female wage does not surpass 83% of her male counterpart, given the productivity features of age, education, and tenure. In the Northern and Northeastern regions, STEM women experience the most significant gender disadvantage, where STEM women earn 71% and 76% of the average man's wage, respectively. On the other hand, in these regions, non-STEM women face the smallest disadvantages. Except for the Midwest region, non-STEM women face a comparatively lower disadvantage than STEM women. Once this result differs from observations in the United States and Western Europe, as reported, for example, by Ceci et al. (2014) and Dunning (2012), a more detailed investigation may shed light on the reasons for such departure from international evidence.

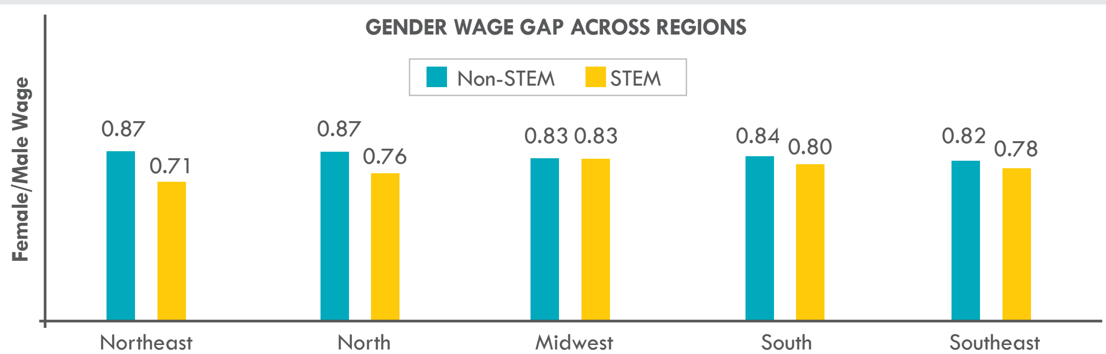
Indeed, such an unexpected finding is not consistent across specific STEM fields. Conducting a more detailed analysis, using the three primary

Figure 1. Estimates of the STEM wage premiums for men and women



Fuente: authors' formulation based on RAIS (Ministério do Trabalho e Previdência, 2021).

Figure 2. The gender gap in Brazil: STEM x non-STEM groups



Fuente: authors' formulation based on RAIS (Ministério do Trabalho e Previdência, 2021).

fields of STEM (namely core STEM, or STEM*), which are the support managers, the IT professionals, and the engineers, we illustrate the gender wage gap in Figure 3. The core STEM occupations are the most significant in terms of the number of employees, except in the North and Northeast regions. They represent 67.5%, 60.3%, 76.6%, 76.2%, and 82.6% of the STEM workforce in the Northeast, North, Midwest, South, and Southeast regions, respectively.

The gender wage gap in core STEM occupations is smaller than in the complete STEM set, with reductions of 20, 14, 8, 12, and 9 percentage points in the Northeast, North, Midwest, South, and Southeast regions, respectively. Figure 2 and Figure 3 show that the wage disadvantage for women is less pronounced in core STEM fields compared to the broader STEM category. This suggests that women in core STEM roles experience a smaller wage gap than non-STEM women, a pattern observed consistently across all five Brazilian regions. This helps explain the discrepancy with evidence from countries like the United States, where the STEM wage premium for women is higher than for men, implying a smaller wage disadvantage for women in STEM in those countries. In such contexts, core STEM occupations carry more weight within the overall STEM group than in Brazil; only in the Southeast region do the IT and computer science subfields account for more than 60% of the STEM workforce.

4.3 Gender wage gap estimates by STEM field

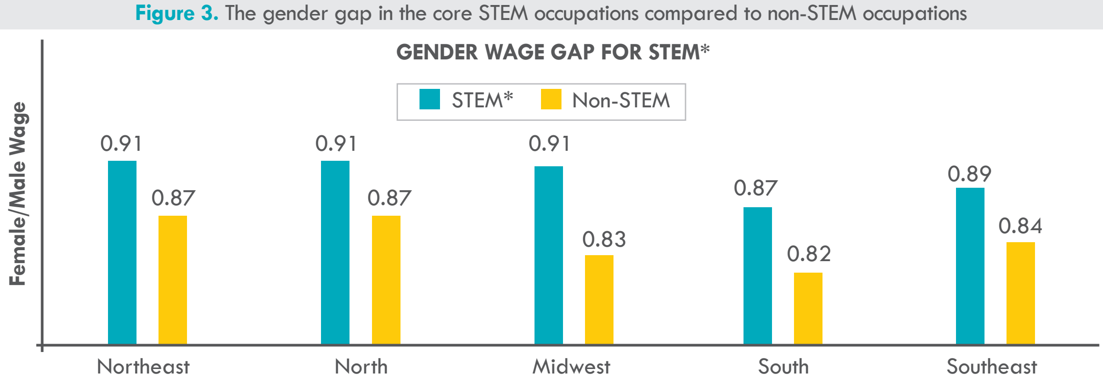
Focusing on a more disaggregated analysis of the gender gap, Table 3 brings estimates for specific STEM fields. Estimates of the female-to-male wage ratio were made based on Equation [1] for each of the five regions and the nine STEM field groups, and the coefficients are statistically significant at a 5% confidence level.

In the Northeast region, the gender wage gap varies significantly across STEM fields. Support managers and IT professionals show smaller disparities with ratios of 0.94 and 0.92, respectively. However, fields such as researchers (0.73) and mathematics, statistics, and physics professionals (0.76) exhibit larger gaps, indicating that women earn 73% and 76% of what men earn in these professions. Biological science professionals also face a considerable wage gap, with a ratio of 0.84.

In the North region, disparities are more pronounced in some fields. Multidisciplinary scientific professionals have the lowest wage ratio at 0.54, suggesting significant inequality. Conversely, support managers and IT professionals have a ratio of 0.82 and 0.92, respectively, showing smaller gaps. Psychologists in the North achieve wage parity, with a ratio of 1.00.

The Midwest region presents a mixed picture. Support managers (0.96) and engineers and architects (0.93) show smaller wage gaps, while

Figure 3. The gender gap in the core STEM occupations compared to non-STEM occupations



Note: STEM* represents the occupations of support managers, IT professionals, and engineers.

Fuente: authors' formulation based on RAIS (Ministério do Trabalho e Previdência, 2021).

Table 3. Estimates for the gender wage gap for each STEM field

STEM Field / Region	Northeast	North	Midwest	South	Southeast
Support Managers	0.94	0.82	0.96	1.01	0.91
Multidisciplinary Scientific Professionals	0.88	0.54	0.81	0.83	1.01
Researchers	0.73	0.84	0.91	0.76	0.81
IT Professionals	0.92	0.92	0.88	0.86	0.87
Mathematics, Statistics, and Physics Professionals	0.76	0.79	0.80	0.87	0.85
Engineers and Architects	0.88	0.88	0.93	0.88	0.90
Biological Science Professionals	0.84	0.88	0.76	0.67	0.74
Post-secondary Teaching Occupations	0.85	0.79	0.99	0.94	0.94
Psychologists	1.00	1.00	0.96	0.94	0.96

Source: authors' elaboration based on RAIS (Ministério do Trabalho e Previdência, 2021).

multidisciplinary scientific professionals (0.81) and biological science professionals (0.76) have more considerable disparities. Tertiary education professors almost achieve wage parity with a ratio of 0.99.

In the South region, support managers reach a parity with a ratio of 1.01. However, disparities are evident in fields like biological science professionals (0.67) and IT professionals (0.86). Researchers and multidisciplinary scientific professionals show ratios of 0.76 and 0.83, respectively, indicating larger gaps.

The Southeast region shows varied results. Multidisciplinary scientific professionals achieve near parity with a ratio of 1.01. However, fields such as biological science professionals (0.74) and IT professionals (0.87) display more significant wage gaps. Support managers, engineers, and architects show moderate disparities with ratios of 0.91 and 0.90, respectively.

These findings show substantial regional variability in gender wage disparities within Brazil's STEM sectors, with some regions achieving closer parity in specific fields while others exhibit significant gaps.

5. Discussion

The Brazilian STEM regional landscape shown in the previous section is strongly linked to the historical productive specialization and agglomeration patterns. Regions such as the Southeast and South benefit from long-established industrial clusters, where dense networks of firms, universities, and research institutions create environments conducive to productivity gains, knowledge spillovers, and skill matching. Such agglomeration effects support higher wage levels, particularly in core STEM fields like engineering and IT. Conversely, the North and Northeast regions, characterized by weaker historical industrial bases and more recent engagement with STEM-intensive sectors, exhibit lower wage premiums. These patterns align with regional development theories emphasizing the cumulative nature of industrial capability and labor market maturity (Diniz, 2001; Haddad and Hewings, 2005).

This research revealed that 64% of the STEM workforce is concentrated in the country's Southeast region – Table 1. The finding illustrates the economic dynamism of this region, where 2.3% of its workforce is employed in STEM activities. The regional market offers the highest STEM occupational premiums in the country, both for men and women. However, STEM workers in the northern regions account for 1.1% of the workforce. The two lowest wage premiums are those for women in the North and Northeast regions. Moreover, our disaggregated analysis illustrates that professionals in computer science and support management account for 30% and

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40%, respectively, of the total STEM workforce in these two regions. In contrast, these two groups comprise 64% of the total STEM workforce in the Southeast region.

The strong link between STEM employment and economic dynamism is well documented. STEM workers significantly contribute to GDP growth, with studies estimating that a 28% increase in STEM jobs could substantially boost per capita GDP (Ahmadov, 2020). Firms with higher proportions of STEM professionals tend to be more productive, with elasticities ranging from 0.20 to 0.45, particularly in manufacturing, where high-skilled STEM workers can contribute up to four times more productivity than non-STEM employees (Bijnens and Dhyne, 2021). In Brazil, this relationship is reflected in the regional distribution of STEM employment. Bonini et al. (2022) show that eight federal units –mainly including states from the South and Southeast regions– concentrate 81.17% of the country's STEM workforce. These regions account for 76.5% of the national GDP, highlighting the close alignment between STEM labor and economic output.

In the past two decades, the Brazilian government has invested in the development of biotechnology, particularly through research centers and federal universities. The South, Southeast, and Northeast regions are home to states with significant innovation capacity in biotechnology (Ramos et al., 2024). The Northeast has the highest proportion of multidisciplinary scientific professionals within its STEM workforce, as shown in Table 2. Ramos et al. (2024) further highlight that the region leads in the share of STEM researchers specializing in agricultural and medical biotechnology, as several northeastern states have made significant investments in medical biotechnology, particularly in research related to vaccines, pharmaceuticals, and diagnostic tools (Magalhães et al., 2022). These efforts have the potential to advance healthcare and stimulate the development of innovative medical technologies.

Thus, while the initial findings of the present research may seem intriguing compared to international data, our disaggregated analysis reveals a reversal in the STEM premium for women compared to men. IT professionals and support managers –fields that command higher wages and lower female representation– make up the majority of the STEM workforce in the Southeast region. Moreover, in the South and Southeast regions, where these occupations dominate the workforce, the discrepancy in STEM premiums between the complete STEM group and the core STEM occupations is minimal, unlike the notable disparity observed in northern regions.

The regional concentration of industries relying on STEM skills, especially computer science professionals and support managers, makes the Southeast a focal point for STEM job expansion. The region has a significant concentration of industries, including finance, technology, and manufacturing. Industries heavily relying on STEM skills often offer higher salaries to attract and retain qualified professionals, contributing to the observed wage premiums. A similar pattern is observed in the US by Even et al. (2023), who found a high STEM wage premium, compared to 11 OECD countries, despite the US having a larger share of STEM workers.

Our disaggregated analysis also indicates that the gender gap is smaller for women employed in core STEM activities, as illustrated by Table 3. On the other hand, the northern regions have a higher percentage of careers with relatively lower wages and higher female participation, such as psychology and biological science professionals.

Moreover, female participation in the eight specific STEM field groups is consistent across regions. Therefore, these results suggest that Brazil does not exhibit regional specificities regarding the factors discussed in Section 2 that discourage women from entering STEM fields.

Efforts to enhance diversity and inclusion in STEM fields are ongoing, aiming to address gender disparities in the workforce. Encouraging more women and underrepresented groups to pursue STEM careers is a priority. The Senate approved a project encouraging women's participation in science by reducing cultural barriers to their involvement in science, technology, engineering, mathematics, chemistry, physics, and information technology[5].

The limitations of our study relate to the dataset used in this research. As the RAIS microdata refers to formal employment, the STEM wage premium may be underestimated when compared to non-STEM workers. The average wage is probably lower when informal jobs are included in the non-STEM group.

6. Final considerations

This study examined the prevalence and wage premium of STEM careers in Brazil, focusing on the country's five major regions: Northeast, North, Central-West, Southeast, and South. The objectives were to: (i) assess the STEM premium while controlling for individual characteristics such as education, age, and tenure; (ii) analyze gender wage differentials by comparing STEM and non-STEM work groups; and (iii) explore these differentials within various STEM sub-areas.

Our findings highlight the geographical distribution of STEM work across Brazilian regions and regional differences in fields of knowledge. We observed that men experience a more substantial wage premium than women within a broader set of activities. However, this profile is inconsistent across different STEM activities.

A larger STEM wage premium for men and a greater wage gap for women were identified compared to non-STEM occupations. However, in core STEM fields where female representation is lower, the gender wage gap is less prominent. This highlights the importance of considering field-specific and overall STEM dynamics when analyzing gender wage disparities.

Regional variability was also noted in female wage disadvantages. The North and Northeast regions exhibit the smallest gender wage gap on average in non-STEM occupations but show a higher female wage disadvantage within STEM occupations compared to non-STEM roles. This discrepancy may be due to a higher proportion of professionals in biological sciences in the northern regions, while the southern regions emphasize IT and computer science professionals.

Regional economic activities, educational institutions, and local demand for specific STEM skills might influence these variations. Future research should better explore the underlying reasons for these regional differences to understand the dynamics of STEM occupations in Brazil. Besides that, we also plan to study the differences across Latin American countries, as there might be differences in gender per field across countries (Bordón et al., 2020; Ramírez-Corona, 2022; World Economic Forum, 2016).

7. Appendix

Table A1. STEM Occupational Groups according to the Brazilian Occupation Classification

Occupation Group Code	Type of Occupation	Disaggregated Occupation Code
1425	Information Technology Managers	142505, 142510, 142515, 142520, 142525, 142530, 142535
1426	Research and Development Managers and Related	142605, 142610
2011	Biotechnology and Metrology Professionals	201105, 201110, 201115
2012	Metrology Professionals	201205, 201210, 201215, 201220, 201225
2021	Control and Automation Engineers, Mechatronics Engineers and Related	202105, 202110, 202115, 202120
2030	Biological Sciences Researchers	203005, 203010, 203015, 203020, 203025
2031	Natural and Exact Sciences Researchers	203105, 203110, 203115, 203120, 203125
2032	Engineering and Technology Researchers	203205, 203210, 203215, 203220, 203225, 203230

5 See more at Projeto de Lei do Senado (PLS) 398/2018, Senado Federal (2021).

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Table A1. STEM Occupational Groups according to the Brazilian Occupation Classification (continuation)

Occupation Group Code	Type of Occupation	Disaggregated Occupation Code
2034	Agricultural Researchers	203405, 203410, 203415, 203420
2111	Mathematics Professionals	211105, 211110, 211115, 211120
2112	Statistics Professionals	211205, 211210, 211215
2122	Computer Engineers	212205, 212210, 212215
2123	IT Administrators	212305, 212310, 212315, 212320
2124	Information Technology Analyst	212405, 212410, 212415, 212420, 212425, 212430
2131	Physicists	213105, 213110, 213115, 213120, 213125, 213130, 213135, 213140, 213145, 213150, 213155, 213160, 213165, 213170, 213175
2132	Chemists	213205, 213210, 213215
2133	Atmospheric, Space Sciences, and Astronomy Professionals	213305, 213310, 213315
2134	Geologists, Oceanographers, Geophysicists, and Related	213405, 213410, 213415, 213420, 213425, 213430, 213435, 213440
2140	Environmental Engineers, and Related	214005, 214010
2142	Civil Engineers and Related Professionals	214205, 214210, 214215, 214220, 214225, 214230, 214235, 214240, 214245, 214250, 214255, 214260, 214265, 214270, 214275, 214280
2143	Electrical, Electronics, and Related Engineers	214305, 214310, 214315, 214320, 214325, 214330, 214335, 214340, 214345, 214350, 214355, 214360, 214365, 214370
2144	Mechanical Engineers and Related Professionals	214405, 214410, 214415, 214420, 214425, 214430, 214435
2145	Chemical Engineers and Related Professionals	214505, 214510, 214515, 214520, 214525, 214530
2146	Metallurgical, Materials, and Related Engineers	214605, 214610, 214615
2147	Mining Engineers and Related Professionals	214705, 214710, 214715, 214720, 214725, 214730, 214735, 214740, 214745, 214750
2148	Surveying Engineers and Cartographic Engineers	214805, 214810
2149	Production, Quality, Safety, and Related Engineers	214905, 214910, 214915, 214920, 214925, 214930, 214935, 214940
2141	Architects	214105, 214110, 214115, 214120, 214125, 214130
2211	Biologists and Related Professionals	221105
2212	Biomedical Scientists	221205
2221	Agricultural, Forestry, and Livestock Engineers	222105, 222125
2222	Food Engineers and Related Professionals	222205, 222215
2515	Psychologists	251505, 251510, 251515, 251520, 251525, 251530, 251535, 251540, 251545
2341	Mathematics and Statistics Professors	234105, 234110, 234115, 234120, 234125
2342	Physical and Chemical Sciences Professors and Related Fields	234205, 234210, 234215

Note: Brazilian Occupation Classification (CBO) follows the Standard Occupational Classification (SOC) system.

Source: authors' elaboration based on CBO (Ministério do Trabalho e Emprego, 2002).

Author's Contributions

Patricia Bonini: conceptualization, funding acquisition, investigation, methodology, project administration, supervision, validation, writing (original draft), and writing (review of draft and revision/editing).

Fernanda Da Silva: data curation, formal analysis, software, visualization, writing (original draft), and writing (review of draft and revision/editing).

Gabriela Sótero: data curation, and formal analysis.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article. We confirm that we have no financial, personal, or professional affiliations that could be perceived as having influenced the research, findings, or conclusions presented in this manuscript.

Source of Data

The data utilized in this study were sourced from the Annual Report of Social Information (RAIS) for the year 2021. RAIS is a publicly accessible database maintained by the Brazilian Ministry of Labor, which provides comprehensive employment and wage information for Brazil's formal labor market.

Ethical Implications

The authors have no ethical implications that need to be declared in the writing and publication of this article.

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