

## The reflection of gender inequality in mathematics during secondary school in the labor market

*Reflexo da desigualdade de gênero em matemática durante o ensino médio no mercado de trabalho*

*Reflejo de la desigualdad de género en matemáticas durante la enseñanza secundaria en el mercado laboral*

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### ABSTRACT

This work aims to investigate the relation between gender inequalities in mathematics and salary and occupational disparities in the labor market, which has not been addressed in other studies so far. To this end, longitudinal monitoring was carried out of students graduating from public schools in Ceará, in 2012 to 2014, and their entry into the job market in 2019. To verify this effect on income differentials, participation in the formal market and in the in the science, technology, engineering and mathematics (STEM) areas, the Oaxaca-Blinder decomposition and entropy balancing methods were used, applied to the Permanent System of Assessment of Basic Education of the state of Ceará (SPAECE), School Census and Annual Social Information Report (RAIS) bases. From the results, it was observed that when girls were equated with boys in cognitive skills in mathematics, salary and occupational inequalities reduced between these groups. Mathematics skills also positively influenced the probability of being in the job market, in addition to reducing the gender gap among young people.

**Keywords:** Gender Disparity. Mathematics Performance. STEM.

### RESUMO

Este trabalho tem por objetivo investigar a relação entre as desigualdades de gênero em matemática e as disparidades salariais e ocupacionais no mercado de trabalho, até então não abordada em outros estudos. Para tanto, realizou-se um acompanhamento longitudinal dos alunos egressos das escolas públicas do Ceará, de 2012 a 2014, e o ingresso no mercado de trabalho em 2019. Para verificar esse efeito sobre os diferenciais de rendimentos, participação no mercado formal e no mercado nas áreas de ciência, tecnologia, engenharia e matemática (STEM), utilizaram-se os métodos de decomposição

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de Oaxaca-Blinder e balanceamento por entropia, aplicado às bases do Sistema Permanente de Avaliação da Educação Básica do Ceará (SPAECE), Censo Escolar e da Relação Anual de Informações Sociais (RAIS). Dos resultados, observou-se que, com a equiparação das meninas com os meninos em habilidades cognitivas em matemática, as desigualdades salariais e ocupacionais reduziram entre esses grupos. As habilidades em matemática também influenciam positivamente a probabilidade de estar no mercado de trabalho, além de reduzir a diferença de gênero nos jovens.

**Palavras-chave:** Disparidade de Gênero. Desempenho em Matemática. STEM.

## RESUMEN

Este trabajo tiene como objetivo investigar la relación entre las desigualdades de género en matemáticas y las disparidades salariales y ocupacionales en el mercado laboral, que no se ha abordado en otros estudios hasta el momento. Para ello, se realizó un seguimiento longitudinal de los estudiantes graduados de escuelas públicas de Ceará, en el período de 2012 a 2014, y de su ingreso al mercado laboral en 2019. Para verificar este efecto sobre los diferenciales de ingresos, la participación en el mercado formal y en él se utilizaron áreas STEM, los métodos de Descomposición Oaxaca-Blinder y Balanceo de Entropía, aplicados a las bases SPAECE, Censo Escolar y RAIS. A partir de los resultados, se observó que cuando se equiparó a las niñas con los niños en habilidades cognitivas en matemáticas, se encontró que las desigualdades salariales y ocupacionales se redujeron entre estos grupos. Las habilidades matemáticas también influyen positivamente en la probabilidad de inserción laboral, además de reducir la brecha de género entre los jóvenes.

**Palabras clave:** Disparidad de Género. Rendimiento en Matemáticas STEM.

## INTRODUCTION

In developing countries, large gender disparities still persist in average income, jobs, prestigious occupations, and leadership roles (CEDA, 2013; Goldin, 2014). Women continue to score worse in mathematics even while gender gaps in human capital, as determined by education, have decreased in the labor market (Goldin, 2014).

There is a strong correlation between mathematics test performance, mathematics-based curriculum, college academic qualifications, and future earnings, suggesting that the gender gap in math proficiency may explain part of the salary (Murnane *et al.*, 2000; Altonji, Blom and Meghir, 2012; Rebollo-Sanz and De La Rica, 2020).

When analyzing the performance of young people in mathematics in proficiency tests, some differences can be noted. The results of the International Student Assessment Program (PISA) reveal that, in 2019, 68.1% of Brazilian students did not have a basic level of mathematics, the minimum for the full exercise of citizenship (OECD, 2019). When comparing performance on standardized tests by gender, girls maintain leadership in reading indicators. However, boys outperform girls in mathematics (OECD, 2019). PISA data also reveals a correlation between performance in mathematics and professional aspirations. In Brazil, among youth high-performing in mathematics or science, around one in three boys expects to work as an engineer or science professional at age 30, while only one in five high-performing girls is expected to do the same (OCDE, 2019).

The results of the 2019 edition of the Basic Education Assessment System (SAEB), which was published in 2020, indicate that high school mathematics performance is concerning, as only 5.2% of third-grade public school students demonstrated adequate mathematical learning, according to the *Todos Pela Educação* report (2021). According to the 2017 SAEB, 7.5% of girls have proficient (or adequate) mathematical knowledge. Of the boys, 11.3% finished basic schooling, indicating that they were aware of the requirements for this skill.

Curi (2006) emphasizes that young people's proficiency test scores have a significant impact on how much they will make in the future. Low cognitive performance as measured by proficiency is associated with lower wages and a higher probability of unemployment (OECD, 2012).

The following queries still need to be answered in light of the scenario: Are gender disparities in the youth labor market explained by differences in mathematical cognitive abilities? Are the earnings and career choices of young people influenced by their success on math competency tests?

The implications of young people's performance in mathematics and gender disparities in the labor market for this demographic are not well understood in Brazil. Curi (2006) offers information on future incomes and educational success. However, the study makes no effort to quantify how gender disparities in cognitive capacities contribute to gender variations in labor market performance. The magnitude of gender differences in cognitive abilities, especially in mathematics, must be empirically documented in light of the paucity of studies employing national data. Then, the impact of these differences on labor market performance must be evaluated.

Therefore, this work seeks to contribute to the literature by verifying whether gender disparities in mathematics acquired during high school affect wage and occupational inequalities in the youth labor market. Thus, the purpose of this research is to analyze the effect of young people's math skills on gender inequalities in the labor market from the perspective of wage income differentials, the likelihood of being hired into the formal workforce, and the choice of science, technology, engineering and mathematics (STEM)-related careers.

In order to achieve these goals, the database was built in the following ways: socioeconomic and educational data on 12th-grade students from 2012 to 2014 were obtained from the School Census and microdata from the Permanent Evaluation System of Ceará (SPAECE), and job market data was gathered from microdata compiled from the Annual Social Information List (RAIS) 2019. We used the entropy balancing approach (2012) in conjunction with the Oaxaca-Blinder decomposition (1973) to confirm the impact of mathematical skill on wage disparities, labor market involvement, and STEM career choices. Finally, using Portuguese proficiency as a placebo test, a robustness analysis will be conducted.

## THEORETICAL REFERENCE

The theory of human capital assumes its acquisition through schooling and lifelong learning. Despite the high cost of these activities, they are typically anticipated to yield future benefits, such as earnings increases and improved employability. Following the seminal contributions of Schultz (1961), Becker (1962), and Mincer (1974), many studies have investigated individuals' returns to human capital in the labor market, finding a positive relationship between schooling and individual earnings: on average, an additional year of schooling is associated with an increase of approximately 10% in earnings (Psacharopoulos and Patrinos, 2004).

Due mostly to a significant increase in women's educational attainment, gender gaps have decreased in recent years across a number of labor market sectors, including employment rates, hours worked, and wage rates. However, in recent years, other aspects of gender inequality — like the kinds of professional occupations — have proven harder to change or are evolving more slowly (Blau and Kahn, 2017).

Several studies have already found that cognitive skills are positively associated with an individual's success in the job market, participation in society, and economic growth (Oreopoulos and Salvanes, 2011; Hampf, Wiederhold and Woessmann, 2017).

An increase in a person's number skills proficiency level on the Programme for the International Assessment of Adult Competencies (PIAAC) is associated with a 20% salary increase and an average 8% improvement in their chances of finding employment (Hampf, Wiederhold and Woessmann, 2017). The first wave of PIAAC data was gathered from August 2011 to March 2012, while the second wave was gathered from April 2014 to March 2015. The database explores several approaches that aim to identify the cause of skills returns in terms of higher wages and better employment opportunities. Similar findings were obtained by Murnane, Willett, and Levy (1995) when assessing the impact of secondary school graduates' mathematical proficiency on their earnings at age 24, and they discovered that cognitive skills had a positive and growing influence on salaries.

Based on PIAAC 2012 data for 23 countries, Rebollo-Sanz and De La Rica (2020) note that men perform 4% better than women in mathematics, evidence of the gender gap. Furthermore, the results indicate that these gender differences in skills strongly affect the observed gender gaps in labor market participation. In particular, they explain 45% of the observed gender gap in labor force participation for young workers. Gender differences in math skills are also crucial to understanding the gender pay gap. On average, differences in mathematical skills explain 40% of the observed gender pay gap. This impact increases with age; mathematical skills explain 44% of the wage gap between young men and women and up to 55% for workers aged between 30 and 39. These results are in line with the study by Hanushek *et al.* (2015), who highlight that the returns to cognitive skills between men and women are not statistically different.

Curi (2006) provides evidence of the impact of math proficiency on young people's employment prospects in the national literature. In their research, math proficiency is significantly and positively correlated with future salaries. The study crossed data from the 2000 and 2010 censuses, the National Household Sample Survey (PNAD), and the SAEB to follow the two generations at three moments in their lives: childhood (4–5 years old), the school phase of completing high school (17–18 years old), and the job market (23–24 years old). Estimated results indicate that a 10% increase in math proficiency score increases salary five years after high school graduation by 4.6%, on average.

The assessment of gender inequalities from the perspective of cognitive skills, with an emphasis on mathematics performance, is relevant. PISA data persistently shows that girls, at the age of 15, perform around 5% lower in mathematics skills than their male peers (Arora and Pawlowski, 2017). This gender disparity may contribute to fewer women in STEM fields. Card and Payne (2021) showed that, in the US and Canada, the gender gap in the likelihood of graduating with a STEM-related degree explains about 20% of the wage gap between young college-educated men and women, suggesting that the gender gap in STEM is important for understanding the gender earnings gap.

Several articles have linked the gap in mathematics performance on exams as a way to explain the gender gap in STEM-related university choices. Aucejo and James (2016) found that boys' advantage in mathematics performance can explain about 6.5 percentage points of the 17 percentage point gender gap in STEM in England. Similarly, Speer (2017) points out that it can explain about six of the 17 percentage points in his US sample. Card and Payne (2021) found that among STEM-ready students, about three of the five percentage points of the gender gap in STEM is due to the math performance advantage.

However, there is a dearth of information in Brazilian literature regarding the connection between basic education math proficiency and STEM career choice. According to a business mobilization for innovation research conducted by the National Confederation of Industry (Confederação Nacional da Indústria *et al.*, 2021), one in three Brazilian boys who excel in mathematics and science anticipate



identified 164 occupation codes that align with the STEM category, based on the criteria established by the U.S. Economics and Statistics Administration (ESA).

Table 1 presents the variables utilized in this study, along with their descriptions and the respective databases from which they were sourced.

To achieve the objectives of this study and examine whether gender disparities in the labor market are influenced by inequalities in mathematics proficiency between young men and women, three outcome variables were analyzed: i. the logarithm of wages; ii. a binary variable (dummy) indicating the choice of STEM occupations; and iii. a binary variable (dummy) reflecting participation in the labor market.

## ECONOMETRIC MODELING

### WAGE ESTIMATION

The initial step in the procedure involves estimating Mincerian equations, developed by Mincer (1974),<sup>1</sup> which allow for an analysis of the impact of each explanatory variable on the natural logarithm of wages ( $\ln W$ ). The logarithm of wages is modeled using a set of control variables ( $X_i$ ), which capture various worker characteristics, such as race/ethnicity, whether the family received cash transfer during their student years, age, parents' educational attainment, and other factors outlined in Table 1. These control variables provide a detailed understanding of how individual and socioeconomic attributes influence wage outcomes, shedding light on the disparities observed in the labor market. For each individual  $i$ , the labor market outcome (wages) will be regressed on a set of variables representing human capital levels, along with a gender indicator. This relationship can be expressed by Equation 1:

$$\ln W_i = \beta_0 + \beta_1 \text{Sex}_i + \beta_2 \text{Sup}_i + \theta X_i + u_i \quad (1)$$

Coefficient ( $\beta_1$ ) represents the adjusted gender gap in the labor market outcome, conditional on the same levels of observed human capital. In this study, human capital is characterized by the variable of enrollment in higher education.

The model was subsequently expanded to incorporate a more direct measure of human capital, specifically cognitive skills, as reflected by mathematics performance.

$$\ln W_i = \beta_0 + \beta_1^* \text{Sex}_i + \beta_2 \text{Sup}_i + \beta_3 \text{Prof\_Math}_i + \theta X_i + u_i \quad (2)$$

In Equation 2, coefficient  $\beta_1^*$  measures the adjusted gender gap for individuals who not only share the same traditional levels of human capital but also possess similar math skills on average. Even when controlling for comparable educational levels, the composition of human capital related to cognitive skills in mathematics is expected to have a positive and significant effect on wages ( $\beta_3 > 0$ ). Furthermore, if gender gaps in mathematics skills (favoring men) exist and if these skills are significant in reducing gender inequalities in the labor market, it is expected that the estimated gender difference ( $\beta_1^*$ ) in Equation 2 will be smaller than in Equation 1 ( $\beta_1^* < \beta_1$ ). This is because, in

1 The model proposed by Jacob Mincer in 1974 is a fundamental tool in economics for analyzing how education and experience influence workers' wages. The Mincer model is grounded in the idea that education and experience enhance a worker's productivity, making employers more willing to offer higher wages to those with greater skills and experience. Additionally, the model incorporates other factors that may affect wages, such as personal characteristics (e.g., gender and race). In essence, the Mincer model provides a framework for understanding how investments in education and the accumulation of experience can lead to better opportunities and higher earnings in the labor market.

**Table 1 – Variables description.**

Variables used	Description	Source
Student Characteristics		
Bolsa Família	Binary; equals 1 if someone in the student's household receives Bolsa Família	SPAECE
EEEP	Binary; equals 1 if the worker completed high school in a vocational school (Escola Estadual de Educação Profissional)	SPAECE
Female	Binary; equals 1 if the individual is female	SPAECE
White	Binary; equals 1 if the individual self-identifies as white	SPAECE
Black	Binary; equals 1 if the individual self-identifies as black	SPAECE
HigherEd	Binary; equals 1 if the individual enrolled in higher education	RAIS
Mother_Ed	Binary indicator of low maternal education: equals 1 if the mother "Never studied or did not complete the 4th grade (5th year)" or "Completed the 4th grade (5th year) but not the 8th grade (9th year)"; 0 otherwise*	SPAECE
Father_Ed	Binary indicator of low paternal education: equals 1 if the father "Never studied or did not complete the 4th grade (5th year)" or "Completed the 4th grade (5th year) but not the 8th grade (9th year)"; 0 otherwise*	SPAECE
Math Score	Student's score in mathematics in SPAECE	SPAECE
Portuguese Score	Student's score in Portuguese language in SPAECE	SPAECE
Std_Math	Standardized math proficiency (mean zero, standard deviation one)	SPAECE
Std_Portuguese	Standardized Portuguese proficiency (mean zero, standard deviation one)	SPAECE
RMF	Binary; equals 1 if residing in the Fortaleza Metropolitan Region	RAIS
RMJN	Binary; equals 1 if residing in the Juazeiro do Norte Metropolitan Region	RAIS
Labor Market		
Avg_Wage	Average wage received	RAIS
LnW	Natural logarithm of the worker's wage	RAIS
First_Job	Binary; equals 1 if it is the individual's first job	RAIS
Experience	Work experience in number of months	RAIS
Labor	Binary; equals 1 if the student is active in the labor market	RAIS/SPAECE
Firm_Size	Establishment size – number of employees (up to 2=2; 5–9=3; 10–19=4; 20–49=5; 50–99=6; 100–249=7; 250–499=8; 500–900=9; >1000=10)	RAIS
Occupations		
STEM	Binary; equals 1 if the occupation is in a STEM-related field, 0 otherwise	RAIS

Source: authors' own elaboration (2022).

STEM: Science, Technology, Engineering, and Mathematics; EEEP: *Escola Estadual de Educação Profissional*;

RMF: *Região Metropolitana de Fortaleza*; RMJN: *Região Metropolitana de Juazeiro do Norte*.

the second equation, the variable referring to mathematics skills was included to control for this factor. As a result, men and women would, on average, share similar math skills (Rebollo-Sanz and De La Rica, 2020).

Since this study longitudinally tracks high school graduates to identify those who entered the job market, it seems that only students present in RAIS in 2019 have information on labor market-related variables, creating a potential sample selection bias. To address this issue, we applied the Heckman correction to minimize the impact of this problem.

There are several estimation methods designed to address the aforementioned selection bias. The conventional approach for estimating labor supply without selection bias is based on the Heckman (1979) correction, which involves a two-equation model: the participation equation and the wage equation. The participation equation estimates the probability of an individual participating in the labor market, while the wage equation explains wages based on the Mincerian human capital framework. This framework includes a correction term derived from the distribution of the error term in the participation equation, ensuring that the wage estimates account for potential selection bias.

In general, this type of model assumes a standard normal distribution for the error term of the participation equation, which is estimated using a probit model. The dependent variable is a binary indicator (dummy) that takes the value of 1 if the individual is employed (engaged in paid work) and 0 otherwise. Additionally, a set of individual-level variables that may influence entry into the formal labor market is included, such as dummies for Extended Elementary Education Program (EEEP), Bolsa Família (a social welfare program), Black, and White. These variables help capture the factors that affect the likelihood of labor market participation.

Once the selection equation has been estimated, the inverse Mills ratio ( $(\vartheta\lambda_i(\theta_\varepsilon))$ ), also known as the hazard rate, is calculated. This is a by-product of the Heckman model estimation. This value is then included as an explanatory variable in the main regression to correct for potential selection bias. If the estimated coefficient of the inverse Mills ratio in the main regression is statistically significant, it indicates the presence of a selection bias in the labor market that would otherwise be omitted. The inclusion of this variable helps to address and correct such bias.

To provide greater robustness to the results, we applied the decomposition method developed by Oaxaca (1973) and Blinder (1973). This method calculates the wage differential between two groups (in this case, men and women) and decomposes it into components explained by observable characteristics (such as education, experience, and skills) and unexplained components (often attributed to discrimination or unobservable factors). The Oaxaca-Blinder (OB) decomposition for the two groups of students can be described as follows (Equation 3):

$$D_W - D_M = [\hat{\beta}_W(X_W - X_M)] - [X_M(\hat{\beta}_W - \hat{\beta}_M)] \quad (3)$$

Where:

$D_w$  and  $D_M$  are the mean wages for women and men, respectively.

$X_w$  and  $X_M$  are the mean values of observable characteristics for women and men, respectively.

$\hat{\beta}_w$  and  $\hat{\beta}_M$  are the estimated coefficients from wage regressions for women and men, respectively.

The first term,  $\hat{\beta}_w(X_w - X_M)$ , represents the portion of the wage gap explained by differences in observable characteristics between men and women. The second term,  $X_M(\hat{\beta}_w - \hat{\beta}_M)$ , captures the unexplained portion of the wage gap, often interpreted as discrimination or differences in returns to characteristics between the two groups. This decomposition helps to identify the sources of wage disparities and assess the role of observable and unobservable factors in driving gender wage gaps.

We aimed to examine how income differences would change if girls had the same distribution of the mathematics proficiency variable as boys. To achieve this, we employed the entropy balancing method developed by Hainmueller (2012). This method allows for the reweighting of a dataset such that the distributions of observed variables are adjusted to satisfy a set of predefined moment conditions. Specifically, the method ensures exact balance over the first, second, and potentially higher moments of the covariate distributions. By doing so, it improves the balance of covariates across all time points included in the reweighting process, providing a robust way to simulate the scenario where girls have the same mathematics proficiency distribution as boys. This approach helps isolate the impact of mathematics proficiency on income differences between genders.

Let  $W_i$  be the entropy balancing weight chosen for each control unit. These weights are determined through a reweighting scheme that minimizes the entropy distance metric, as follows (Equation 4):

$$\min_{w_i} H(w) = \sum_{\{i|D=0\}} w_i \log(w_i/q_i) \quad (4)$$

Subject to the following balance constraints and normalization (Equations 5, 6 and 7):

$$\sum_{\{D=0\}} w_i = 1 \quad (5)$$

$$W_i \geq 0 \text{ for all } i, \text{ such that } D=0 \quad (6)$$

$$\sum_{\{D=0\}} w_i c_{ri}(X_i) = m_r \text{ com } r \in 1, \dots, R \quad (7)$$

Where:

$q_i = 1/n$  denotes the base weight, where  $n$  represents the sample size of the control units. Additionally,  $C_r(X_i) = m_r$  defines a set of  $R$  constraints related to the moments of the covariates in the reweighted control group. Initially, the covariates to be included in the reweighting process are selected. For each covariate, a set of balancing constraints (as defined in Equation 5) is established to align the moments of the covariate distributions between the reweighted treatment and control groups. These moment constraints can include the mean (first moment), variance (second moment), and skewness (third moment).

Therefore, entropy balancing aims to find a set of weights  $W = [W_1, \dots, W_n]'$  that minimizes the entropy distance (Equation 4) between  $W$  and the base weight vector  $Q = [q_1, \dots, q_n]'$ . This minimization is subject to the balancing constraints specified in Equation 5, the normalization constraint in Equation 6, and the non-negativity constraint in Equation 7.

According to Hainmueller (2012), the weights obtained by entropy can be easily combined with any other standard method that the researcher is interested in using to model the results in the pre-processed data. Furthermore, it can be combined with any other pairing technique, as long as it allows the use of weights. Thus, since the Oaxaca (1973) and Blinder (1973) decomposition methodologies allow the use of weights, it follows that the two methods can be combined.

## PARTICIPATION IN THE LABOR MARKET

For the outcome variable related to labor market participation, a probit model was estimated. The dependent variable is binary, taking a value of one if the individual is active in the labor market and zero otherwise. Following the same approach as before, the equation is first estimated using gender and other control variables that may influence labor market participation, such as Bolsa Família, Black, White, EEEP, and parental education. In the second

model, mathematics performance is included to assess its impact on gender disparities in labor market participation. Subsequently, the Oaxaca-Blinder decomposition is applied, both with and without entropy balancing.

## *PARTICIPATION IN THE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS LABOR MARKET*

Labor market participation in the STEM category was analyzed using a probit model. The dependent variable was a dummy variable, taking a value of 1 if the individual is employed in the STEM sector and 0 if otherwise. This section follows the same strategy as the previous ones. First, the equation was estimated using variables related to individual characteristics (such as gender, education, EEEP, parental education, etc.) and labor market characteristics (such as establishment size and experience). In the second model, math skills were included as an additional variable. Finally, the gender differential in the probability of young individuals being employed in the STEM category was calculated using the Oaxaca-Blinder decomposition, weighted by the entropy balancing method.

## RESULTS

### DESCRIPTIVE ANALYSIS

The descriptive analysis of the data highlights differences and outlines the profile of the sample, taking into account demographic, individual, and work characteristics by gender (as shown in Table 2).

According to the data, there is a gender pay gap. Men earn, on average, more than women, even though women have higher levels of human capital. Women earn an average of R\$1,222.00, while men earn R\$1,328.00. In other words, women earn 8% less than men. According to the Brazilian Institute of Geography and Statistics (IBGE, 2021), even though women have a higher level of education than men, their salaries can be up to 24% lower for the same or similar roles.

Among the characteristics of individuals in the labor market, the data show an average of 24 months of work experience, with 9% of the sample being in their first job. A notable observation in the first job variable is the gender disparity. While 7.6% of men are entering the labor market, this figure rises to 12% for women, underscoring the barriers women face in gaining initial employment. Additionally, 44% of men are active in the labor market, while women's participation is 12 percentage points lower than that of men.

Regarding entry into the STEM job market, the data indicate that 1.1% of men are employed in this field, while female participation is significantly lower at 0.34%. It is important to note that this analysis focuses exclusively on students who graduated from public high schools and entered the formal job market. This limited scope may explain the relatively low proportion of individuals in these categories. The findings align with research by Noonan (2017), who observed that women represent only 25% of all workers in the STEM field with a university degree.

One notable observation is that women exhibit lower levels of proficiency in mathematical skills. On average, the difference in mathematics performance between men and women in the labor market is 2.47%, equivalent to six points on the scale.

Examining the total sample, approximately 61% of the parents of students who were in their third year of high school between 2012 and 2014 did not complete elementary education. Mothers exhibit a slightly lower percentage of low educational attainment (defined as never having studied, not completing the 4<sup>th</sup> or 5<sup>th</sup> grade, or completing the 4<sup>th</sup> or 5<sup>th</sup> grade but not the 8<sup>th</sup> or 9<sup>th</sup> grade), reaching 52.46%.

**Table 2 – Descriptive statistics of variables.**

Variables	Men			Women			TOTAL		
	n	Mean	Sd	n	Mean	Sd	n	Mean	sd
Labor	27339	0.440982	0.485294	33105	0.326325	0.468875	60217	0.37961	0.48529
Average Salary	12056	1328.664	757.8986	10803	1222.844	1023.277	22859	1278.654	894.709
STEM	12056	0.011364	0.105997	10803	0.003425	0.058426	22859	0.007612	0.08692
Math Skill	12056	278.563	56.64511	10803	271.6788	51.732060	22859	275.3094	54.48591
Human Capital	12056	0.129728	0.336018	10803	0.193743	0.395248	22859	0.251236	0.43373
EEEP	12056	0.212094	0.408808	10803	0.294918	0.456027	22859	0.251236	0.43373
Bolsa Família	12056	0.585758	0.492080	10730	0.599627	0.489997	22667	0.593903	0.49111
Black Race	11981	0.132794	0.341817	10743	0.085916	0.283556	22724	0.110632	0.31648
White Race	11981	0.185794	0.388957	10743	0.182258	0.386075	22724	0.184123	0.38759
Mother's Education (Low)	10605	0.51702	0.499734	9888	0.532767	0.498950	20493	0.524618	0.49941
Father's Education (Low)	9898	0.600829	0.489753	9147	0.621078	0.485145	19045	0.610554	0.48764
RMF	12056	0.587757	0.492259	10803	0.556234	0.496851	22859	0.57286	0.49467
RMJN	12056	0.066855	0.249788	10803	0.078219	0.268428	22859	0.072225	0.25887
Establishment Size	12056	6.394741	2.732608	10803	6.459317	2.925459	22859	6.425259	2.82551
First Job	12056	0.076311	0.265505	10803	0.120522	0.325586	22859	0.097205	0.29624
Work Experience	12056	24.73753	25.3555	10803	23.48815	23.684260	22859	24.14396	24.58731

Source: own elaboration based on research data (2022).

SD: standard deviation; STEM: Science, Technology, Engineering, and Mathematics; EEEP: *Escola Estadual de Educação Profissional*; RMF: *Região Metropolitana de Fortaleza*; RMJN: *Região Metropolitana de Juazeiro do Norte*.

Regarding the type of school origin, it is observed that 25.12% of students come from vocational schools. Data from 2021 in Ceará indicate that 30.9% of high schools offer technical or vocational courses. There is a significant demand for this type of education, as it enhances qualifications and improves opportunities for entering the labor market.

## SALARY ESTIMATION

We used three models, following the steps described in the methodology. Models 1 and 2 are estimated by ordinary least squares (OLS), considering the control variables described in Table 1 and differing only in the presence of the math skills variable, represented by Model 2. Equations 1 and 2 of the methodology relate to these models. Model 3 follows the same analysis as Model 2. However, we performed the Heckman correction procedure to address the possibility of a sample selection problem. So, the inverse Mills ratio variable has been added to the wage regression in this model to account for the sample selection bias that comes from people working full-time.

According to Table 3, the results of Model 1 reveal that, when controlling for similar (observed) levels of education, the wage gap between men and women is, on average, 10%. This indicates that young women earn, on average, 90% of what men earn, highlighting a persistent gender

disparity in the labor market. These findings align with data from IBGE (2021), which reported that, in 2019, women earned 77.7% of men's income, further underscoring the ongoing wage inequality between genders.

**Table 3 – Salary estimation equation.**

Dependent Variable: Log of Average Salary			
Independent Variables:	(1) OLS	(2) OLS	(3) Heckman Correction
	Coef.	Coef.	Coef.
<b>Gender</b>	-0.0971***	-0.0885***	-0.0860***
	(0.0051)	(0.0051)	(-0.0125)
<b>Human Capital</b>	0.1798***	0.1600***	0.1595***
	(0.0094)	(0.0094)	(-0.0278)
<b>Mathematical Skill</b>	-	0.0388***	0.0392***
		(0.0030)	(-0.0498)
<b>Sociodemographic Controls</b>	Y	Y	Y
<b>Labor Market Controls</b>	Y	Y	Y
<b>Heckman Correction</b>	N	N	Y
<b>Observations</b>	17616	17616	17616
<b>R2</b>	0.1348	0.1441	.

Source: authors' own elaboration based on survey data (2022).

OLS: ordinary least squares. Significance levels of the coefficients: \*\*\*p<0.01; \*\*p<0.05; \*p<0.1.

To assess the extent to which differences in mathematics performance among high school students influence future gender wage inequalities in the formal labor market, we need to compare the gender disparities observed in Model 1 with those in Models 2 and 3. When comparing Model 1 with Model 2, we find that, as expected, the inclusion of the mathematics ability variable reduces the coefficient associated with the gender wage gap by 8.8% in relative terms. This suggests that the gender wage gap would be, on average, 8.8% smaller if young men and women had similar mathematics skills. Model 3 incorporates the Heckman correction to address a potential sample selection bias; however, the Mills ratio variable was not statistically significant, indicating that selection bias is not a concern in this analysis.

These findings align with the results of Rebollo-Sanz and De La Rica (2020), who observed similar outcomes in their analysis using the OECD PIAAC dataset. The PIAAC dataset includes individual salary information from 23 countries, and their study also highlights the role of mathematics skills in explaining gender wage disparities, further supporting the significance of this factor in understanding labor market inequalities.

It is important to highlight that these results fall within the 95% confidence interval<sup>2</sup> and are based on a significance level of 5%. As a result, all estimates are statistically significant, meaning that the findings of the study are supported by a robust statistical foundation. This indicates that the true effect or estimated value lies within the range defined by the confidence interval. Such statistical

<sup>2</sup> The authors are willing to provide the values of the confidence interval limits upon request.

certainty strengthens the reliability of the data interpretation and allows for more confident conclusions about their implications for the population under study.

To enhance the robustness of the results, we applied the entropy balancing method to the mathematics proficiency variable. This approach ensures that the groups (women and men) are perfectly balanced, eliminating significant differences in the three moments of the distribution of this variable. The algorithm used to balance the mathematics proficiency variable for girls and boys is detailed in Equations 4, 5, 6, and 7 of the methodology. Following this, the Oaxaca-Blinder decomposition method was applied both with and without weighting by the entropy weights between the two groups, as outlined in Equation 3 of the methodology. The Oaxaca-Blinder method is employed in this study to test the robustness of the results presented in Table 3 and to measure the wage differential between men and women, decomposing it into an explained and an unexplained portion. Initially, the decomposition was conducted without weighting, meaning it did not account for the weights generated by entropy balancing. This first analysis excludes the mathematics performance variable from the sample. In contrast, the second model in Table 4 incorporates mathematics proficiency, allowing for a more comprehensive evaluation of its impact on the wage gap.

**Table 4 – Oaxaca-Blinder decomposition of the earnings differential among young people.**

Dependent Variable: Log of Average Salary		
Groups	WITHOUT ENTROPY BALANCING	WITH ENTROPY BALANCING
	Coefficient	Coefficient
Young Women (1)	7.0834***	7.1047***
	(0.0038)	(0.0045)
Young Men (2)	7.1673***	7.1673***
	(0.0038)	(0.0038)
<b>Total Difference (1–2)</b>	<b>-0.0839***</b>	<b>-0.0626***</b>

Source: authors' own elaboration based on survey data (2022).

Significance levels of the coefficients: \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; \* $p < 0.1$ .

The results presented in Table 4 show that the income differential between young men and women is statistically significant at the 1% level and unfavorable to women in both models. The total income differential, calculated by subtracting the coefficient for the group of young women from that of the group of young men, is negative. This indicates that young women earn lower incomes compared to men, highlighting a clear disadvantage for women in the labor market.

To ensure a balanced comparison between the groups, entropy balancing was applied, effectively homogenizing the two groups with respect to mathematics performance. After balancing, men and women exhibited similar levels of mathematics proficiency. As a result, any observed differences in outcomes between the groups can no longer be attributed to disparities in their mathematics performance, allowing for a more accurate analysis of other contributing factors.

Table 5 displays the measures of mean, variance, and skewness imbalances before and after applying entropy balancing to the standardized mathematics proficiency variable for the groups of women and men. Before the balancing procedure, the groups were not adequately balanced, as evidenced by the differences in their statistical parameters. However, after applying entropy balancing, these parameters (mean, variance, and skewness) were effectively adjusted, ensuring that the groups are now balanced with respect to the observed variable. This adjustment allows for a more accurate and fair comparison between the groups.

**Table 5 – The moment conditions of the mathematics performance variable before and after entropy balancing.**

Before Balancing						
	Men			Women		
	Mean	Variance	Skewness	Mean	Variance	Skewness
Std_Math	0.1263	1.112	0.3414	-0.1011	0.8841	0.5086
After Balancing						
Std_Math	0.1263	1.112	0.3414	0.126	1.112	0.3418

Source: authors' own elaboration based on survey data (2022).

After determining the weights that made the sample more homogeneous, the Oaxaca-Blinder decomposition of income was re-estimated, this time incorporating the weights generated by entropy balancing for mathematics performance. This adjustment ensures that comparisons are now made between young individuals with similar characteristics in terms of mathematics proficiency levels. The results of this post-weighting estimation are presented in the second model in Table 4, providing a more refined analysis of the wage differentials between men and women while controlling for differences in mathematics performance.

By incorporating mathematics proficiency into the analysis, the goal is to determine whether young women, when matched with young men in terms of mathematics performance distribution parameters (such as mean, variance, and skewness), tend to achieve wage incomes more comparable to those of young men. This approach helps isolate the impact of mathematics skills on the gender wage gap, allowing us to assess whether differences in mathematics performance contribute significantly to the observed income disparities. If the wage gap narrows or disappears when mathematics proficiency is balanced, it would suggest that improving women's mathematics skills could play a crucial role in reducing gender-based wage inequalities in the labor market.

According to the results presented in Table 4, even after controlling for mathematics proficiency, the income differential between young men and women persists, albeit at a reduced level, and remains unfavorable to women. Before weighing, the total difference in the logarithm of wages was -0.084. After equating the mathematics performance levels of both groups through entropy balancing, the total difference in the logarithm of wages decreased to -0.063 points. This represents a reduction in the total wage differential of approximately 24% when young women's mathematics proficiency is matched to that of young men. Although the magnitude of this impact differs from the findings in Model (2) of Table 3, it reinforces the robustness of the results, indicating that a portion of the wage gap between men and women can indeed be attributed to differences in cognitive skills, particularly in mathematics. This highlights the role of mathematics proficiency in explaining gender-based wage disparities.

## PARTICIPATION IN THE LABOR MARKET

To estimate labor market participation and assess how mathematical skills influence the probability of being employed in the formal labor market in 2019 for men and women, this study used a probit model with a binary dependent variable indicating whether a high school student from the 2012–2014 cohort was participating in the formal labor market in 2019 (1) or not (0). The explanatory variables align with those in Table 3 from the Mincerian wage estimations. The results, presented in Table 6, show gender disparities through the marginal effects of the probit model, both with and without the standardized mathematics proficiency variable. These findings are linked to the "Labor market participation" section of the methodology, highlighting the role of mathematics skills in shaping labor market entry and gender disparities.

**Table 6 – Marginal effects of the labor market participation.**

Dependent Variable: Labor		
Variable	(1) PROBIT	(2) PROBIT
	dy/dx	dy/dx
Gender	-0.1104***	-0.1081***
	(0.0045)	(0.0046)
Math Skill	-	0.0102***
		(0.0024)
Sociodemographic Controls	Y	Y
Observations	46842	46842

Source: authors' own elaboration based on survey data (2022).

Significance levels of the coefficients. \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; \* $p < 0.1$ .

As shown in Table 6, gender disparities in labor market participation among young people are evident. According to Model 1, the probability of engaging in formal paid work is 11 percentage points lower for young women compared to men, aligning with data from IBGE (2021), which indicates that women's labor market participation is 20% lower than that of men. This highlights persistent gender-based barriers in the labor market, even among younger generations.

When controlling for mathematics skills, as shown in Model 2, the marginal effect of the gender variable decreases, indicating that disparities in mathematics proficiency between men and women also contribute to explaining gender disparities in labor market participation. With the inclusion of this variable, the gender gap in the probability of entering the labor market narrows by approximately 2% in relative terms. This suggests that improving mathematics skills among young women could help reduce gender-based inequalities in labor market access.

The results show that the inclusion of this variable positively influences the probability of being in the labor market, in addition to helping to reduce the adjusted gender gap.

A study by Aucejo and James (2016) revealed that individuals who graduated from high school with low levels of mathematics proficiency faced a 50% higher likelihood of unemployment compared to their peers with stronger mathematics skills. This finding highlights the critical role of mathematics competency in determining employment outcomes and underscores the need for targeted educational policies to improve mathematics performance. Enhancing mathematics education could serve as a key strategy to reduce unemployment rates and promote greater equity in labor market opportunities.

To reinforce these findings, the Oaxaca-Blinder decomposition method was applied once more, both with and without weighting by entropy balancing between the two groups (Table 7). The key difference between the results in Tables 4 and 7 lies in the focus of the analysis: while Table 4 examined wage differentials, Table 7 estimates the difference in the probability of labor market participation between men and women. This shift in focus allows for a deeper understanding of how gender disparities, particularly in mathematics proficiency, influence not only earnings but also access to the labor market itself.

The results in Table 7 reveal that the difference in labor market participation between young men and women is statistically significant at the 1% level and unfavorable to women. The overall difference in participation is negative, indicating that young women are less likely to participate in the labor market compared to young men. These findings align with and reinforce the probit estimates presented in Table 6, further highlighting persistent gender disparities in labor market access.

**Table 7 – Oaxaca-Blinder decomposition of the labor market participation.**

Dependent Variable: Labor		
Groups	WITHOUT ENTROPY BALANCING	WITH ENTROPY BALANCING
	Coefficient	Coefficient
Young Women (1)	0.3434***	0.3544***
	(0.0029)	(0.0031)
Young Men (2)	0.4519***	0.4519***
	(0.0034)	(0.0034)
<b>Total Difference (1–2)</b>	<b>-0.1084***</b>	<b>-0.0975***</b>

Source: authors’ own elaboration based on survey data (2022).  
 Significance levels of the coefficients. \*\*\*p<0.01; \*\*p<0.05; \*p<0.1.

After applying entropy balancing to mathematics proficiency, a reduction in the total difference in labor market participation is observed, decreasing from -0.108 to -0.097. These results indicate that mathematics performance positively contributes to narrowing the gap between the groups, thereby increasing the likelihood of young women participating in the labor market. This suggests that improving mathematics skills among young women could play a significant role in reducing gender disparities in labor market access.

### OCCUPATIONAL CHOICE IN THE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS CATEGORY

According to the Organization for Economic Cooperation and Development (OECD, 2015) report, *The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence*, less than 5% of women in OECD countries consider pursuing careers in engineering and computing.

According to Bonini *et al.* (2020), in Brazil, the workforce in STEM fields represents only 0.79% of the total labor market. Regarding female underrepresentation in STEM careers, Brazil shows relative homogeneity across its regions, with female participation ranging from 20.4 to 24.6%, a pattern similar to that observed in other countries. Additionally, workers in STEM fields tend to experience greater job stability, highlighting the importance of promoting gender diversity in these high-demand and secure occupations.

To construct the econometric model, three models were developed to estimate the probability of participating in the STEM labor market, following a similar approach to the estimations in the previous section. In the first two models, participation in the STEM market is measured through the marginal effects derived from the probit model, while the third model incorporates the Heckman correction to address potential selection bias. Starting with the second model, the mathematics ability variable is included, and in the third model, the Heckman correction is applied. These estimations are detailed in the “STEM market participation” section of the methodology, providing a robust framework for analyzing the factors influencing STEM labor market entry.

Table 8 shows that, when considering Models 1 and 2, the marginal effect of the gender variable is negative and significant, indicating that young women are less likely to be employed in a STEM occupation. However, when controlling for math skills, this effect is reduced by approximately 10% in relative terms. In Brazil, the absolute participation rate of men in the STEM market has evolved more rapidly over the years than that of women. Although women represent 47% of the entire workforce, only 24% work in STEM careers (Fernandes, 2021).

In addition to reducing the adjusted gender gap among young people, the findings indicate that mathematics skills positively influence the likelihood of entering the STEM labor market. According to Model 3, which incorporates the Heckman correction for selection bias, there is a notable increase

**Table 8 – Marginal effects of the Science, Technology, Engineering, and Mathematics labor market participation.**

Variable	(1) PROBIT	(2) PROBIT	(3) Heckman Correction
	dy/dx	dy/dx	dy/dx
Gender	-0.004426***	-0.0036216***	-0.0091***
	(0.0007)	(0.0006)	(0.1434)
Human Capital	0.0206646***	0.0164161***	0.0162***
	(0.0029)	(0.002)	(0.2661)
Mathematical Skill	-	0.0010686***	0.0030***
		(0.0002)	(0.1477)
Sociodemographic Controls	Y	Y	Y
Labor Market Controls	Y	Y	Y
Heckman Correction	N	N	Y
Observations	18375	18375	18375

Source: authors' own elaboration based on survey data (2022).

Significance levels of the coefficients. \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; \* $p < 0.1$ .

in the probability of working in STEM fields. This aligns with the findings of Black *et al.* (2021), who demonstrated that individuals who completed more advanced mathematics courses in high school were significantly more likely to secure STEM-related occupations.

Table 9 displays the results of the Oaxaca-Blinder decomposition by gender, analyzing the occupational choices of young men and women within the STEM category. The findings reveal a significant disparity in STEM participation between the two groups in 2019, with young men demonstrating a higher likelihood of entering STEM careers compared to young women. The total difference in participation, as shown in the unbalanced model, underscores the lower representation of women in STEM fields relative to men. These results highlight persistent gender-based inequalities in occupational choices and emphasize the need for targeted policies and interventions to promote greater gender equity in STEM careers.

After applying entropy balancing, a reduction in the total difference of -0.001 points is observed, demonstrating that mathematics proficiency positively contributes to narrowing the gap between the groups. This result suggests an increased probability of young women entering the STEM category, thereby reducing the gender gap in opportunities within this occupational sector when their levels of mathematical ability are comparable to those of men. These findings highlight the critical role of mathematics skills in promoting gender equity in STEM careers and underscore the importance of fostering equal opportunities for skill development.

## ROBUSTNESS ANALYSIS

To assess the robustness of the results obtained through the Oaxaca-Blinder decomposition, a placebo test was conducted by substituting Portuguese language proficiency for math skills in both the Mincerian models and the models of labor market participation and choice of STEM fields. The results are presented in Table 10. The rationale behind the placebo test is that the labor market does not differentiate wages between men and women based on greater cognitive language skills. Consequently, the expected outcome of the estimations is that the coefficients should not be statistically significant when Portuguese language proficiency is used as the variable.

**Table 9 – Oaxaca-Blinder decomposition of the Science. Technology. Engineering. and Mathematics labor market participation.**

Dependent Variable: STEM		
Groups	Without Entropy Balancing	Without Entropy Balancing
	Coefficient	Coefficient
Youngs Women (1)	0.0038***	0.0047***
	(0.0006)	(0.0008)
Youngs Men (2)	0.0126***	0.0126***
	(0.0011)	(0.0011)
<b>Total difference (1-2)</b>	<b>-0.0088***</b>	<b>-0.0078***</b>

Source: authors’ own elaboration based on survey data (2022).  
 Significance levels of the coefficients. \*\*\*p<0.01; \*\*p<0.05; \*p<0.1.

Model 1 involves inference using only the human capital variable and the control variables, excluding proficiency. Model 2 incorporates the Portuguese language proficiency variable but does not account for the weighting generated by entropy balancing in the distribution of Portuguese performance between men and women. Model 3 is the primary model, as it includes Portuguese language proficiency while weighting the distribution of performance between men and women using entropy balancing.

When examining the Mincerian models of wage differences between men and women, it is evident that there is no change in the total difference across the models (ranging between 0.084 and 0.087 in favor of men), even when accounting for Portuguese language proficiency. This indicates an average wage difference of R\$ 104.41 to R\$ 107.98 in 2019 and suggests that language proficiency does not influence the wage gap, as expected for a placebo test.

The same pattern is observed in the models analyzing labor market participation. Model 3, which estimates the difference in participation between men and women by weighting the two groups based on Portuguese language performance, even shows a reduction of 0.01 percentage points in women’s participation compared to the other models. These results suggest that the placebo variable does not mitigate gender differences in labor force participation.

Finally, participation in the STEM fields remains unchanged between the two groups, even when considering the weights generated by entropy balancing (Model 3). These results underscore the robustness of the findings presented in this article.

## CONCLUSION

This study sought to quantify gender disparities among young individuals in the labor market, controlling for comparable levels of mathematical proficiency, while also evaluating the influence of mathematics performance on participation in the formal labor market and STEM occupations. By incorporating not only personal, socioeconomic, and parental education factors but also a direct measure of cognitive skills, this research provides novel empirical insights into the role of such skills in shaping gender disparities in the labor market — a dimension that has been overlooked in prior literature. This contribution advances the understanding of the mechanisms underlying gender inequalities in workforce participation and occupational choice.

Another key contribution of this study is the innovative database employed to assess these effects. Through the development of unique identifiers in partnership with Seduc, a longitudinal sample was constructed by integrating multiple datasets: the SPAECE database for 2012, 2013, and 2014; the corresponding school census data for those years; and the 2019 RAIS. This methodology allowed for the tracking of young

**Table 10 – Placebo test using portuguese language proficiency.**

Wage	Without Entropy Balancing		With Entropy Balancing			
	Model 1		Model 2		Model 3	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Women (1)	7.083	0.000	7.083	0.000	7.080	0.000
Men (2)	7.167	0.000	7.167	0.000	7.167	0.000
Total difference (1 - 2)	-0.084	0.000	-0.084	0.000	-0.087	0.000
Explained Difference	0.017	0.000	0.021	0.000	0.015	0.000
Unexplained Difference	-0.101	0.000	-0.105	0.000	-0.103	0.000
Labor Market Participation	Model 1		Model 2		Model 3	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
	Women (1)	0.343	0.000	0.343	0.000	0.335
Men (2)	0.452	0.000	0.452	0.000	0.452	0.000
Total difference (1 - 2)	-0.108	0.000	-0.108	0.000	-0.117	0.000
Explained Difference	-0.0004	0.720	0.004	0.000	-0.003	0.004
Unexplained Difference	-0.108	0.000	-0.113	0.000	-0.114	0.000
STEM	Model 1		Model 2		Model 3	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
	Women (1)	0.004	0.000	0.004	0.000	0.004
Men (2)	0.013	0.000	0.013	0.000	0.013	0.000
Total difference (1 - 2)	-0.009	0.000	-0.009	0.000	-0.009	0.000
Explained Difference	0.0004	0.166	0.00040	0.123	0.0001	0.617
Unexplained Difference	-0.009	0.000	-0.009	0.000	-0.009	0.000

Source: authors' own elaboration (2022).

individuals who graduated from state schools in Ceará between 2012 and 2014, capturing their proficiencies in mathematics and Portuguese Language, as well as their subsequent entry into the labor market in 2019. This approach not only enhances the robustness of the analysis but also provides a comprehensive framework for examining the long-term influence of cognitive skills on labor market outcomes.

The findings of this study align with the theoretical perspectives outlined in the literature. It was observed that mathematics performance plays a relevant and significant role in understanding gender disparities in the youth labor market. Specifically, mathematical skills were found to help explain the wage gap between genders, highlighting their importance in shaping income differences. In the labor market participation models, mathematical proficiency was shown to positively influence the likelihood of being active in the labor market while also reducing the gender gap among young individuals. Furthermore, in the models analyzing STEM occupations, mathematical skills were found to decrease the gender gap in labor market participation in this specific field by approximately 10%. Additionally, a strong performance in mathematics was shown to facilitate entry into the STEM labor market. These results underscore the critical role of mathematical proficiency in addressing gender disparities and promoting equitable labor market outcomes.

To strengthen the robustness of the findings, the entropy balancing method was employed to adjust mathematics proficiency, ensuring that the distributions of this variable were equivalent between groups of young women and men. This adjustment effectively aligned the mathematics performance of girls with that of boys. Following this, the study estimated disparities in wage outcomes, labor market participation, and participation in the STEM labor market. The analysis was conducted in two stages: first, without applying any weighting, and second, by weighting the groups according to the mathematics performance of the young individuals during high school. This methodological approach provides a more accurate and nuanced understanding of the impact of mathematics proficiency on gender disparities in labor market outcomes.

The unweighted results revealed significant gender-based disparities among young individuals across the applied models. However, after controlling for mathematics performance through entropy balancing, the gender gap in the labor market was observed to decrease, although women continued to face disadvantages compared to men. This suggests that, while mathematics proficiency plays a role in mitigating gender disparities, other explanatory and potentially discriminatory factors persist in driving gender inequality in the youth labor market. To further validate the robustness of the findings, a placebo test was conducted using Portuguese language proficiency in both the balancing process and the models. The results confirmed that the observed effects for mathematics proficiency are robust, as Portuguese proficiency — a variable theoretically unrelated to labor market outcomes — did not produce significant changes in the gender gap.

This analysis suggests that, in addition to implementing public policies aimed at reducing gender disparities in the labor market, these efforts should be complemented by targeted educational policies. Specifically, promoting measures to address the disadvantage girls face compared to boys in mathematics proficiency is essential for reducing gender disparities in labor market outcomes, particularly in wages and labor market participation. In Brazil, the gender wage gap in the formal labor market stands at 35% (Yahmed, 2018). If this wage discrimination were reduced, the country's gross domestic product (GDP) could increase by 3.3%, equivalent to an estimated gain of approximately R\$380 billion (World Bank Group, 2018). These findings underscore the economic and social importance of addressing gender inequalities through both labor market interventions and educational reforms.

According to Lee (2010), the democratization of education, particularly the inclusion of women in STEM fields, was a pivotal factor in South Korea's development from the 1960s onward. In light of this evidence, policymakers in public education should prioritize the reinforcement of high-quality, inclusive, and gender-sensitive STEM education. Such measures would not only help reduce gender inequalities in mathematics performance but also contribute to strengthening the country's overall development. By fostering an educational environment that empowers women in STEM, Brazil can take significant steps toward achieving greater gender equity and economic progress.

It is important to highlight that the primary limitation of this study lies in the database used, as the longitudinal tracking was restricted to students graduating from state schools in Ceará and their subsequent entry into the formal labor market. This limitation stems from the challenges in accessing identified databases that allow for cross-referencing with other external datasets on a national scale. Nevertheless, it is reasonable to assume that the findings can be generalized to other states, given that gender inequality in mathematics performance during basic education is not a region-specific issue. A study conducted by IDados (2021) using data from the 2017 Prova Brasil for Brazil confirms that boys consistently outperform girls in mathematics, regardless of the level of education, which aligns with the broader literature. This suggests that the observed patterns are likely applicable beyond the context of Ceará.

For future research aiming to examine this effect in other states, it is recommended to pursue access to and acquisition of identified data through collaboration with the National Institute of

Educational Studies and Research Anísio Teixeira (INEP) and the Ministry of Labor. Such partnerships would enable the cross-referencing of educational databases with labor market datasets, thereby expanding the scope and generalizability of the findings. This approach would provide a more comprehensive understanding of gender disparities in mathematics performance and their implications for labor market outcomes across Brazil.

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