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Analysis of the Impact of Educational Attainment on Nominal Wages and Wage Growth Rates

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Abstract: This study explores the impact of educational attainment on nominal wages and wage growth rates, focusing on whether education reduces or exacerbates wage inequality. As globalization and technological advancements reshape the labor market, understanding these dynamics is crucial for identifying and supporting disadvantaged groups to mitigate economic instability. Utilizing data from the U.S. Department of Labor, this research employs box plots and log-difference analysis to examine wage distribution and convergence among different educational groups. This research indicates that wage disparities are more significant among individuals with higher levels of education, whereas wages tend to be more consistent within groups of those with less education. Additionally, wage growth shows greater volatility and disparities are more pronounced among those with less education, whereas those with higher education generally experience more stable, incremental salary increases. In addition, the wage gap between highly educated and less educated individuals is also becoming increasingly pronounced. These results suggest that targeted policies are needed to address wage disparities and support disadvantaged groups, particularly those with lower educational levels who may be more vulnerable to the economic shifts brought about by globalization and technological advancements.

Keywords: Educational Attainment, Wage Inequality, Nominal Wages, Wage Growth Rates, Labor Economics.

1. Introduction

1.1. Research Background and Motivation

Education plays a crucial role in the contemporary labor market. Studies from various countries and different time periods consistently show that individuals with higher education levels tend to earn more than those with lower levels of education. Despite the substantial evidence supporting the positive correlation between education and labor market status, social scientists remain cautious when asserting a causal relationship between education and income. For instance, Cheah, Carnevale and Wenzinger stated in their research that not all workers with more education earn more than those with less education, due to the heterogeneity in educational levels and fields of study [1]. Furthermore, with the development of automation and information technology, the demand for skills in the modern labor market is constantly evolving, leading to significant differences in the opportunities available to workers with varying levels of education. According to a study by Autor and Dorn, although the

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overall skill level of society today is much higher than it was fifty years ago, the opportunities for low-educated individuals to engage in technical work have significantly diminished [2]. Against this backdrop, this study aims to explore wage inequality from the perspective of the impact of educational attainment on nominal wages and wage growth rates. Additionally, by comparing wage trends among workers with different educational backgrounds, this study seeks to assess whether educational attainment helps to alleviate or exacerbate the wage gap between highly educated and less educated workers.

1.2. Literature Review

Regarding the issue of wage inequality, much of the literature tends to examine wage disparities among different labor groups from the perspective of external factors. For example, Acemoglu and Restrepo in 2022 studied how automation and technological advancements lead to wage inequality by influencing the allocation of tasks, using both simulation and empirical methods [3]. Similarly, Valletta emphasized that as technological advancements in the workplace progress, particularly with the increasing reliance on computers, this development has reinforced wage disparities [4]. However, the mechanisms through which external factors and workers' own factors, such as education, affect wages are different. External factors influence wage levels by altering the demand structure of the labor market, replacing low-skill jobs, thereby impacting wage levels. In contrast, education affects wages mainly by enhancing an individual's productivity, knowledge, and skills, enabling them to secure higher-paying jobs. Moreover, the influence of education is usually long-term; as educational attainment increases, an individual's income and job stability may continue to improve, while external or social influences may be more immediate, potentially causing sudden job losses and significant wage fluctuations in the short term. Therefore, analyzing wage levels based solely on external factors cannot fully explain the issue of wage inequality.

Some studies on the indirect relationship between education and wages, which may result in discrepancies when compared to direct research. For instance, Daly, Jackson, and Valletta used the Phillips Curve model to investigate the correlation between educational attainment and unemployment rates, and to ascertain the connection between educational levels and wages, with respect to the relationship between unemployment rates and wage levels [5]. Such studies usually focus on a macroeconomic perspective and often infer the impact of education on wages indirectly through unemployment rates, which may introduce some errors.

This study aims to build upon previous research, further expanding the understanding of wage inequality by analyzing the issue from the perspective of internal factors. Additionally, this study will focus on micro-level analysis to avoid interference from macroeconomic factors, directly examining the impact of educational attainment on wages. Given that most existing literature focuses on short-term effects, this study intends to delve deeper into the differences and trends among various educational levels over time, thereby revealing the long-term impact of education on wages.

1.3. Research Contents

The focus of this study is to investigate the impact of educational attainment on nominal wages and wage growth rates. The central research question is how educational levels influence individual wage levels and whether the wage gaps between groups with different educational levels are narrowing or widening. The study primarily employs box plots and log-difference analysis to illustrate the wage distribution and wage growth rates across different educational groups. Box plots are used to visually represent the characteristics of wage distribution, such as the median, dispersion, and outliers. Log-difference analysis is primarily utilized to quantify the wage gaps between groups with varying educational levels and to observe how these gaps change over time. Through this research approach,

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the study aims to provide new insights into how educational attainment influences wage inequality and to offer robust data support for policymakers.

2. Methodology

2.1. Education Level and Nominal Wage

This study uses different levels of education as a categorization criterion to examine the median weekly nominal wage and the wage growth rate. Nominal wages reflect the current income disparity among different groups, while the wage growth rate reveals the potential for future income disparity. For example, while the current nominal wage may be higher for those with higher levels of education, a higher wage growth rate for those with lower levels of education suggests that the wage gap between these groups may narrow over time.

The categorization criteria in this study cover different levels of educational attainment, including those with a bachelor's degree or higher, those with some college education, high school graduates who did not continue their education, and those who did not complete high school.

2.2. Data Sources

This paper utilizes the data published by the Federal Reserve Bank of St. Louis [6]. Murray states, "Quarterly earnings can vary due to fluctuations in overtime pay, bonuses, payday weeks, average weekly hours paid, or base wages."[7]. This explains why using weekly nominal earnings data can more accurately capture short-term income fluctuations, thereby enhancing the precision and reliability of the analysis. The dataset records changes in median weekly nominal earnings across different education levels over time, covering 98 quarters from Q1 2000 to Q2 2024, provided by the U.S. Department of Labor.

2.3. Box Plot

During the data pre-processing for the box plots, the study first cleansed the data by removing outliers and missing values, then categorized it according to educational attainment. The processing differs for nominal wages and wage growth rates. Nominal wages are handled directly, while wage growth rates require additional steps like smoothing and trend adjustment for stability.

In this study, box plots are used to illustrate the distribution of nominal wages and wage growth rates across educational levels, emphasizing comparisons between groups and visualizing data skewness. Analyzing central tendencies, such as the median or mean, allows for an assessment of typical wage levels within each educational group, helping confirm whether higher educational attainment correlates with higher wages.

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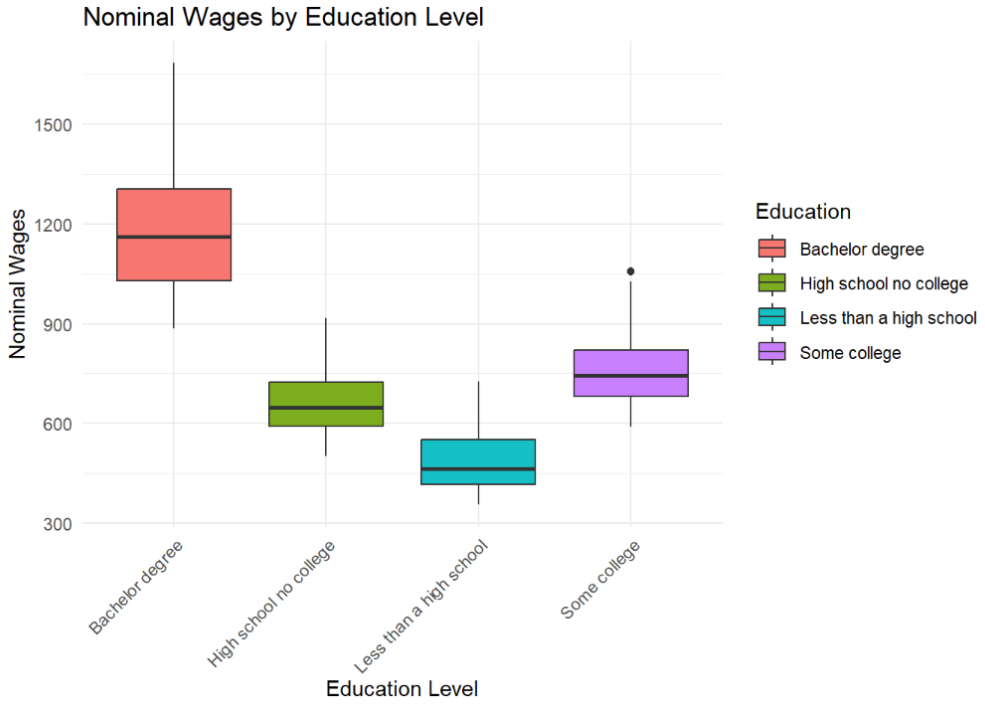

Figure 1: Nominal Wages by Education Level.

Figure 1 is a box plot illustrating the distribution of nominal wages across different educational attainment groups. It displays that the group with a bachelor's degree has the highest median nominal wage, approximately $1,200, follow by the individuals with some college education and those with a high school diploma but no further education, while individuals who did not complete high school have the lowest median wage, approximately $500. In other words, higher educational attainment is often positively correlated with higher wages.

Moreover, dispersion, such as variance or standard deviation, reveals the volatility within each educational group's wages. Larger dispersion may indicate significant wage inequality within the same educational group. Additionally, box plots allow for assessing data symmetry and skewness. If the box is skewed in one direction, the data may have positive or negative skewness, indicating wage distribution inequality. For example, if a group shows positive skewness in wage distribution, it means most individuals in that group earn below the average wage, with only a few earning significantly more.

As shown in Figure 1, there are significant differences in wage distribution ranges among different educational groups. The wage distribution range for individuals with a bachelor's degree is wide, with some earning as much as $1,500, while the lowest wage is around $900. On the other hand, the wage distribution for those who did not complete high school is relatively concentrated and low, with the highest wage under $700 and the lowest around $400. The length of the box indicates that groups with a high school diploma or lower have less internal wage disparity, while individuals with a bachelor's degree have greater internal wage disparity. This suggests that wage inequality may be more pronounced in higher educational groups.

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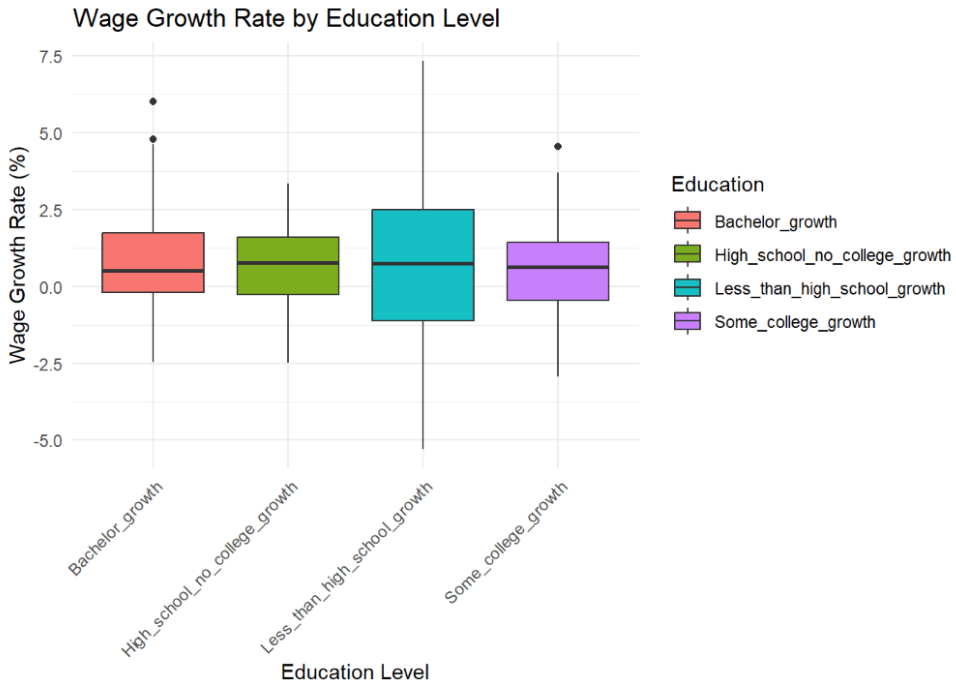

Figure 2: Wage Growth Rate Distribution.

Figure 2 illustrates the wage growth rate performance of groups with different educational attainment. Overall, individuals who did not complete high school show the greatest volatility in wage growth rates, ranging from -5% to 7.5%, indicating that some individuals in this group experienced significant wage increases, while others saw wage decreases. This result also indicates greater inequality in wage growth within the group of individuals who did not complete high school. In contrast, the median wage growth rate for those with a bachelor's degree is close to 0%, with a relatively narrow distribution range. This suggests that although the group with a bachelor's degree has higher nominal wages, their wage growth rate is not significant, possibly indicating that wage growth flattens at higher wage levels. Furthermore, the wage growth rates for high school graduates with no college education and those with some college education are relatively close, with median growth rates around 1% and relatively close distribution ranges. This suggests that wage growth rates remain comparatively stable within these two educational categories, also demonstrating that greater educational achievement does not inherently equate to more rapid wage growth.

2.4. Log-Difference Analysis

In the data pre-processing process for log-difference, after ensuring no missing or outlier data, the differences of the two nominal wage data for each educational level is log-transformed. Once the log transformation is complete, the next step is to calculate the log differences relative to the baseline educational level, which is the bachelor's degree or higher. After calculation, the log difference data is visualized and decomposed to better observe the data trends.

This study employs a log-difference analysis method by calculating the log differences between each group and the baseline group, which is individuals with a bachelor's degree or higher, to quantify the differences between groups. Log differences capture relative changes or growth rates of variables, providing a standardized growth rate that facilitates comparisons across different scales or magnitudes. This study focuses on the convergence of nominal wage gaps between groups. By examining the convergence of trend components among groups, it is possible to assess whether relative differences between groups are gradually narrowing.

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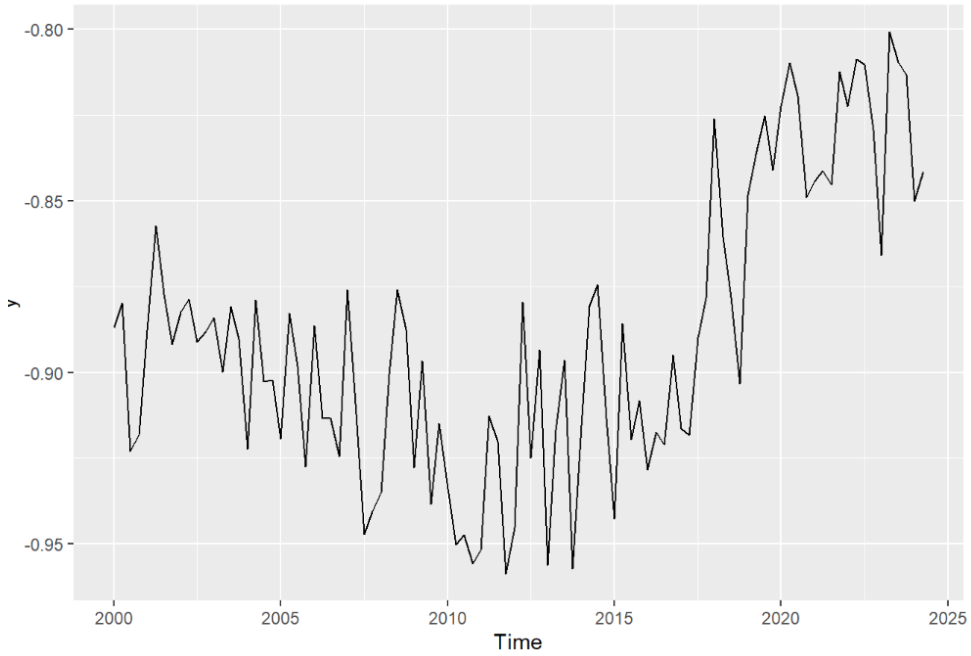

Figure 3: Log Difference Between Individuals with a Bachelor's Degree and Individuals with Less Than a High School Degree.

Log-difference analysis further reveals the convergence trends of wage gaps between different educational attainment groups. In Figure 3, the log difference between individuals with a bachelor's degree and those who did not complete high school shows an upward trend over time. This trend suggests that the wage gap between the group that did not complete high school and the group with a bachelor's degree is widening, indicating that the lower-educated group is losing wage competitiveness.

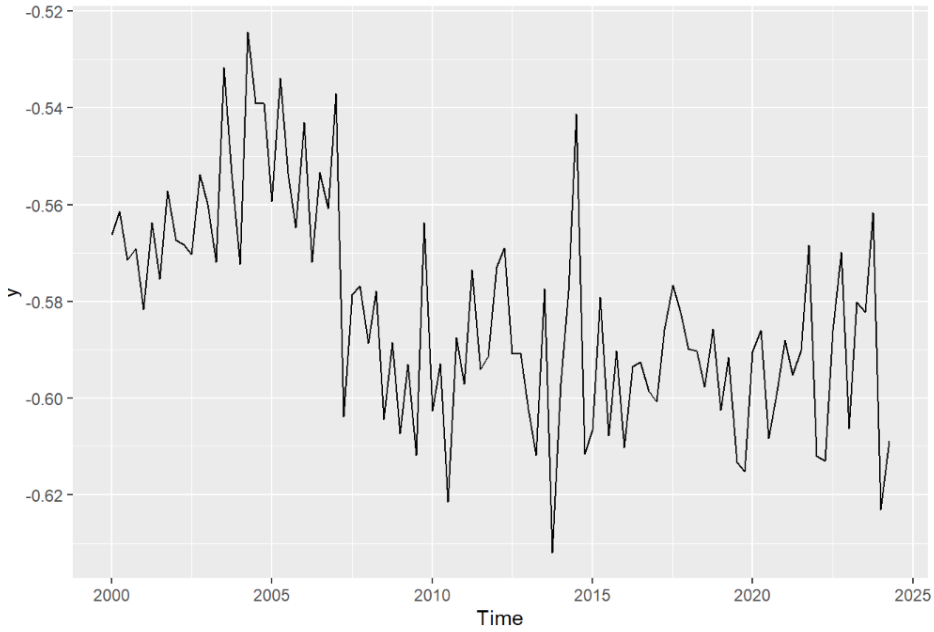

Figure 4: Log Difference Between Individuals with a Bachelor's Degree and Individuals with Less Than a College Degree

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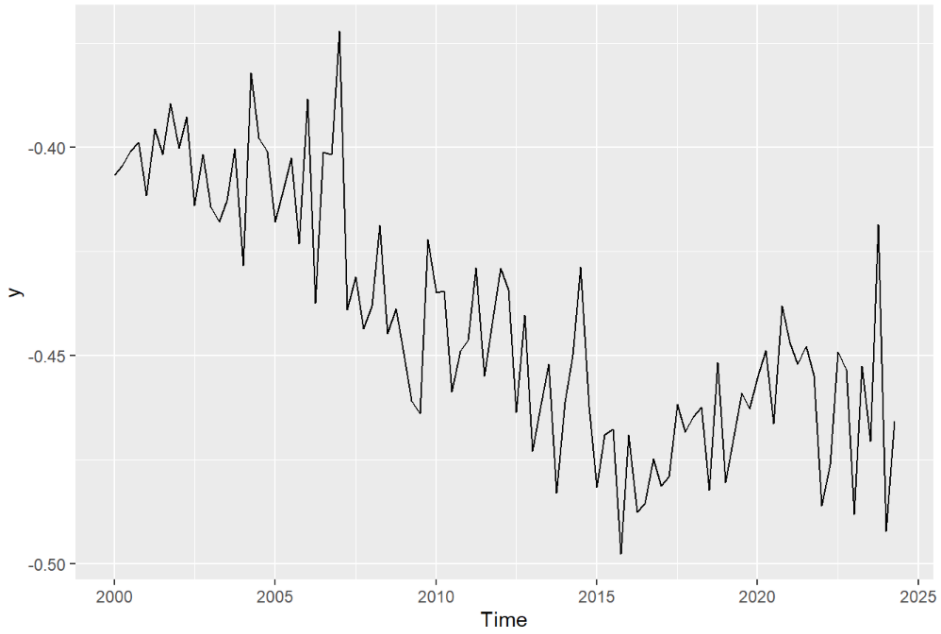

Figure 5: Log Difference Between Individuals with a Bachelor's Degree and Individuals with Some College

On the other hand, Figure 4 and 5 describe the trend of decreasing volatility between the log differences between high school graduates with no college education and those with some college education compared to individuals with a bachelor's degree, indicating that the wage gaps between these two groups and the group with a bachelor's degree are narrowing. This analysis underscores the importance of educational attainment in shaping wage gaps, with higher education clearly leading to a higher starting point, but the relative position of lower-educated groups depends on their opportunities for further education and training on the job.

3. Discussion

Regarding Conclusion 1, "Wage disparity is greater within higher-educated groups, while wages are more concentrated within lower-educated groups," the primary reason is that higher-educated groups tend to choose industries with a high wage ceiling, where wage disparities are significant. Top positions in these industries, such as executives or senior technical staff, command very high wages, while entry-level or non-core positions within the same industry may have wages well below the industry average, leading to substantial wage differences among individuals with the same educational background. According to Mishel and Bivens, the widening wage gap between the vast majority of workers and top-tier workers is one of the causes of growing inequality [8]. At the same time, higher education is not homogeneous. Graduates from top universities usually secure higher starting salaries and broader career development opportunities, while graduates from ordinary or lower-ranked schools, although holding the same bachelor's degree, often face lower employment opportunities and wages. This disparity caused by school reputation and educational quality further exacerbates wage inequality within higher-educated groups. In contrast, lower-educated groups have limited employment choices, with relatively similar skill demands, leading to more uniform wages. Additionally, lower-educated groups typically face career advancement bottlenecks, making it challenging for them to achieve significant salary increases over their careers. Thus, wages are more concentrated within lower-educated groups.

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Regarding Conclusion 2, which states that "Wage growth exhibits greater volatility and inequality is more pronounced among individuals with lower levels of education, while those with higher education tend to experience more stable and gradual wage increases," the 2008 financial crisis emerges as a pivotal influence, disproportionately impacting workers with lesser educational attainment. Following the financial crisis, the U.S. economy plunged into a severe recession, leading to business closures and soaring unemployment rates. During economic downturns, companies frequently resort to layoffs, often starting with those who possess fewer skills and lower levels of education, in an effort to sustain operations and cut costs. This practice leads to a significant increase in unemployment rates among less-educated demographics, subsequently causing downward pressure on wages. In contrast, higher-educated groups usually work in relatively stable, high-skill jobs, such as in finance, law, and healthcare industries. At the same time, Shibata mentioned in his article that the although global financial crisis had a significant negative distributional impact on employment prospects, workers with higher education were less affected during any economic recession [9]. Employees in these industries were able to maintain high wage levels even during the crisis and quickly recover after the economic recovery. Moreover, high-skilled industries are more likely to attract capital investment and technological advancements during recovery, helping them quickly restore wage levels and further increase them, which corresponds to the relatively stable wage growth rates observed in the box plots for higher-educated groups. However, the recovery of low-skilled industries is slower, and many low-educated workers continue to face low wages and job instability, contributing to the significant volatility in wage growth rates among lower-educated groups.

Regarding Conclusion 3, 'The wage gap between individuals with higher education and those with lower education is widening.' the primary reason is that higher-educated groups tend to choose industries with a high wage ceiling, where wage disparities are significant. The rise of information technology and automation in the early 21st century has increased the demand for highly educated workers, leading to higher wages for them. Conversely, lower-educated workers face wage stagnation or decline due to the risk of being replaced by automation and outsourcing. Additionally, globalization has worsened the situation for low-skilled workers, as manufacturing jobs have moved to low-cost countries, reducing employment opportunities and wages for those without a high school diploma, while higher-educated workers benefit from opportunities in industries like finance and technology.

4. Suggestions

Mellacher and Scheuer suggest that policies and institutions should not focus solely on raising the relative wages of low-skilled workers [10]. Therefore, the government can provide more vocational training programs and continuing education opportunities, especially for lower-educated groups. These programs should focus on developing relevant skills in high-demand industries, thereby enhancing the competitiveness of lower-educated groups and expanding their career development and employment opportunities. At the same time, the government should ensure that the promotion of automation and digitization creates new employment opportunities for low-skilled workers while creating positions for high-skilled employees. For example, when automated logistics replace sorters, the maintenance and cleaning of automated equipment could provide jobs for low-skilled workers. Additionally, to address job instability among lower-educated groups, the government can expand social security and employment support for lower-educated individuals, such as unemployment benefits or job opportunity information, especially during economic downturns. By combining the above policies with skill upgrading and job opportunity expansion, the income gap between high-educated and low-educated groups can be narrowed to some extent.

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5. Conclusion

This study explores the relationship between educational attainment and wage dynamics, revealing a positive correlation between higher levels of education and both higher wages and more significant wage disparities within groups. Specifically, individuals with a bachelor's degree exhibit the highest median wages but also show considerable wage disparity within the group, whereas those without a high school diploma earn lower wages, which are more concentrated. The study also indicates that the wage gap between bachelor's degree holders and those without a high school diploma is further widening, underscoring the critical role of higher education in wage disparity.

However, the research has some limitations. For instance, the study only considers education as an influencing factor, neglecting other factors such as external economic conditions or individual worker differences, which might also impact wage dynamics. Additionally, the research might have employed certain simplifying assumptions during the data analysis process, such as the stability of wage growth rates and the homogeneity of returns to education. While these assumptions help streamline the analysis, they may overlook the complexity of real-world scenarios, potentially affecting the accuracy of the findings. Future research could focus on integrating both internal and external factors into a modeling analysis, such as automation and globalization, to better understand the interplay between these factors, educational attainment, and wage inequality. Furthermore, future studies could explore the nonlinear relationship between education and wages, especially at higher education levels. A higher level of education does not always lead to proportionately higher wages; sometimes, there might be diminishing returns or income saturation effects. Capturing such nonlinear relationships would require more sophisticated statistical models.

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