

The Impact of COVID-19 Pandemic on Undergraduate Enrollment in the United States: A Quantitative Analysis

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Abstract

The COVID-19 pandemic has significantly impacted higher education in the United States. The number of students enrolled at various colleges and universities changed significantly. This study examines enrollment trends from 2016 to 2022. It examines how things changed at different schools and states by comparing data from before and after the pandemic. The research uses regression analysis to understand regional shifts in enrollment. The results show student enrollment decreased during and after the pandemic, but not everywhere. The economy, government rules, and online learning options made a difference in each state. Community colleges lost many students, while some online universities got more. Regular universities had money troubles, so they cut programs and laid off staff. Many students put off school or quit because of money problems or personal issues. This paper provides perspectives on the long-term impacts of the pandemic on education. It proposes potential topics for further study, including changes in enrollment patterns, institutional financial stability, and the role of online learning in shaping the future of higher education.

Keywords: COVID-19 pandemic, Higher education enrollment, Online learning adoption, Institutional financial stability, Economic impact on education, Student retention strategies

1. Introduction

The COVID-19 pandemic brought unexpected challenges to colleges and universities around the world. In the United States, schools had to quickly switch to online learning, and many experienced changes in student enrollment. Understanding these changes is important for educators, policymakers, and school leaders. This study shows how undergraduate enrollment changed over three time periods: before the pandemic (2016–2019), during the pandemic (2020–2021), and after the pandemic (2022). We aim to find patterns and the reasons behind these enrollment changes by studying data from different schools and regions. The primary purpose of this study is to show how enrollment numbers shifted due to the pandemic and how different schools and regions were affected. Our findings provide valuable information on the long-term impact of the pandemic on higher education. We also suggest areas for future research, such as how schools adapted to these changes and what policies can help.

2. Research Objective

- Assess trends in undergraduate enrollment before, during, and after the COVID-19 pandemic.
- Analyze the impact of the pandemic using regression models for pre-pandemic, pandemic, and post-pandemic periods.
- Identify states and institutions most affected by the enrollment changes.

3. Literature Review

The COVID-19 epidemic affected the undergraduate enrollment in the US. Most institutions found it challenging to maintain enrollment, as the epidemic introduced uncertainty and financial challenges for both institutions and students. Scholars have also considered how the nomination trend during the epidemic was different from the previous economic recession. Research suggests that online learning played a major role in student's preferences, while others favored studying at home. Fewer students signed up due to the change, as most were favorites to traditional learning. Economic difficulties also contributed to the decline. The students and their parents were affected by economic difficulties, which postponed or left their education. Institutions implemented flexible teaching methods and financial assistance programs to combat these issues and motivate students to keep learning. The epidemic also impacted on the teacher's well-being. The teacher's capacity to inspire students was impacted by their stress. Consequently, student enrollment and motivation declined.

3.1. Pre-Pandemic Enrollment Trends

Before the pandemic outbreak, the number of students pursuing degrees in colleges and universities was already on a trend. By fall 2021 there were 15. Four million students enrolled, which marked a 3

3.2. Impacts of the COVID-19 Pandemic on Enrollment

The pandemic made the decrease in students even worse in fall 2020 compared to fall 2019 (NCES, n.d.), with a 9

3.3. Comparison with Previous Economic Recessions

Times of downturns in the past have resulted in more people pursuing education to upgrade their skills and boost their job prospects when unemployment rates are high historically this phenomenon has been observed, such as during the 2008 recession, where student enrollment surged across various types of institutions (Rizaldi & Fatimah, n.d.), however, the COVID-19 recession presented a different scenario with the pandemic introducing new obstacles like health concerns and the abrupt shift, to online learning these factors may have disrupted the usual trend of increased enrollments during economic downturns observed in previous recessions.

4. State-Level Variations in Enrollment Trends

Enrollment patterns during the pandemic showed changes in states. Utah and New Hampshire observed an increase in enrollment numbers, while Alaska and Rhode Island faced significant drops in enrollment levels. These discrepancies indicate that situations and public health policies influenced how students enrolled based on available online education resources in each region.

5. Institutional Responses and Adaptations

Higher education institutions responded to the pandemic by implementing various strategies to mitigate enrollment declines. Many expanded online course offerings, adjusted admissions policies, and increased financial aid to support students facing economic hardships. Despite these efforts, challenges such as the digital divide and varying levels of institutional resources influenced the effectiveness of these interventions.

6. Societal Impact

This study has important social benefits by helping teachers, policymakers, and institutions understand how student enrollment has changed due to the COVID-19 epidemic. By identifying trends and challenges, this research can support the development of strategies to improve student retention and access to higher education (Alizadeh et al., 2023). A significant impact is on students and their families. Many students faced financial difficulties, disruption of learning and uncertainty about their education. Understanding enrollment trends can help institutions create better support systems, such as financial aid programs and flexible learning options, to ensure students can complete their education (Naseer et al., 2023). Additionally, this study benefits universities and colleges by informing them how they can be compatible with future crises. Schools can use this research to develop long-term strategies, such as improving online learning infrastructure and making policies supporting the student's success during the emergency. Policymakers can also use conclusions to shape educational policies that ensure access to quality education for all students regardless of economic or regional differences (Hammad et al., 2023). Governments can help strengthen the higher education system by supporting enrollment inequalities and struggling institutions.

7. Research Directions

This study highlights many areas for future research that can help understand and address the long-term effects of the COVID-19 epidemic on higher education. An important direction is examining the long-term educational and career results of the students who experienced disruption of their education (Robinson et al., 2022). Studying their undergraduate rates, employment opportunities and economic stability can provide valuable insight into how the epidemic has shaped his future. Another possible research field is the effectiveness of institutional reactions to epidemics. Future studies can analyze how universities adapted to online learning, student support programs, and financial support policies, assessing which strategies successfully maintained enrollment and student success (Betthäuser et al., 2023). Additionally, further research can detect the role of technology in shaping the future of higher education. The epidemics accelerated the adoption of digital teaching equipment, but more studies are required to understand their long-term effects on student engagement, academic performance, and access. Regional differences in enrollment trends also require intensive examination. Future research can compare how urban and rural institutions were affected and whether some areas experienced more important challenges in recovering from the decline in enrollment (Aristovnik et al., 2023). Finally, future studies should focus on policy recommendations to help universities and governments prepare for crises. Checking how various policies have affected enrollment recovery may provide valuable guidance to shape higher education strategies in the coming years.

8. Long-Term Implications

During the outbreak, universities and colleges took action to address decreasing enrollment numbers by introducing approaches. They broadened their online course options, modified admission rules, and enhanced financial assistance to help students with difficulties. However, obstacles, such as access to technology and differences in resources between institutions, affected how well these measures worked.

9. Data and Methodology

9.1. Data Description

The dataset used in this study includes undergraduate enrollment information from American universities from 2016 to 2022. The academic year, a unique identifier for each institution, full-time equivalent (FTE) undergraduate enrollment numbers, the institution's classification (public or private), and the state in which the institution is located are some important variables included in the dataset. We performed a data reengineering procedure using Google Maps API to add state names to the dataset. Since there were only institution names in the dataset initially, a unique list of institutions was made, and the API was used to search for their locations. The states in which these institutions were located were then ascertained using the

addresses that had been extracted. This method allowed for a more thorough examination of regional variances and guaranteed that the dataset accurately reflected enrollment trends at the state level.

9.2. Preprocessing and Cleaning

Several crucial procedures were taken during pre-processing to guarantee data usability and integrity. First, the data set was cleansed of irrelevant entries and non-US locations. To prevent discrepancies in the analysis, missing values in the state and institutional columns were correctly handled. Following that, the data was divided into three distinct periods. These are the pre-pandemic period from 2016 to 2019, the epidemic period from 2020 to 2021, and the post-pandemic period in 2022. This classification made a systematic comparison of enrollment trends before, during, and following the pandemic possible. Additionally, institutions without states explicitly listed were given state information based on their extracted addresses through the implementation of the Google Maps API. This dataset reengineering made an accurate regional analysis of enrollment shifts possible. By employing these preprocessing techniques, the study ensures that the data is well-structured, complete, and suitable for conducting a robust statistical analysis of undergraduate enrollment trends in the U.S. higher education sector.

10. Statistical Methods

10.1. Regression Model

An analysis of enrollment trends was performed using an ordinary least squares (OLS) regression model, which estimates the relationship between undergraduate enrollment and key factors such as time and type of activity. The regression equation used for this analysis is given as

$$E_i = \beta_0 + \beta_1 Y_i + \beta_2 A_i + \epsilon_i \tag{1}$$

Where E_i represents undergraduate enrollment, Y_i is the year that captures temporal changes, A_i denotes the type of activity that accounts for institutional variations, β_0 is the intercept, β_1 and β_2 are the regression coefficients, and ϵ_i is the error term capturing unexplained variability.

The model follows a standard linear regression framework that allows the identification of changes in enrollment patterns across distinct historical phases. By performing separate regressions for different periods, this approach provides a more nuanced understanding of how undergraduate enrollment responds to external factors such as economic conditions, policy changes, demographic shifts, and institutional strategies. The model gives a better picture of how undergraduate enrollment has changed over time and how outside factors might have impacted these trends by segmenting the analysis into different periods.

11. Metrics

- R-squared (R^2):** To assess model fit.
- Percentage Change:** Used to compare enrollment trends across states.

12. Results

The coefficient of determination (R^2) is used as a key statistical measure to evaluate the effectiveness and dependability of the regression model. A higher means the model does a better job of predicting enrollment trends. Besides this, we also looked at percentage changes in enrollment across different states. This helped us compare how undergraduate enrollment increased or decreased in various regions. By doing this, we could see if some states faced bigger challenges due to policy changes, economic conditions, or population shifts. We carefully prepared the data before running the regression analysis to ensure accuracy and consistency. This included cleaning the data to remove errors, dealing with missing values to avoid affecting the results, and uniformly organizing activity types across all institutions. These steps were important to reduce bias and improve the data quality. Proper preparation ensured that the results were reliable and useful for policymakers, educators, and institutions looking to understand and respond to changes in enrollment patterns.

13. Descriptive Statistics

The dataset comprises 30,488 observations across 50 states. Average enrollment during pre-pandemic, pandemic, and post-pandemic periods was:

Period	Pre-pandemic (2016–2019)	Pandemic (2020–2021)	Post-pandemic (2022)
Average Enrollment	2909.95	3106.66	2979.33

Table 1: Average undergraduate enrollment across three periods: pre-pandemic, pandemic, and post-pandemic.

Regression Results

Pre-Pandemic

$$E_i = -1.816 \times 10^5 + 89.43Y_i + 2223.32A_i \tag{2}$$

$$(R^2 = 0.036, p < 0.05)$$

Pandemic

$$E_i = 1.68 \times 10^5 - 83.86Y_i + 2410.16A_i \tag{3}$$

$$(R^2 = 0.031, p < 0.05)$$

Post-Pandemic

$$E_i = -0.712Y_i + 2364.27A_i \tag{4}$$

$$(R^2 = 0.03, p < 0.05)$$

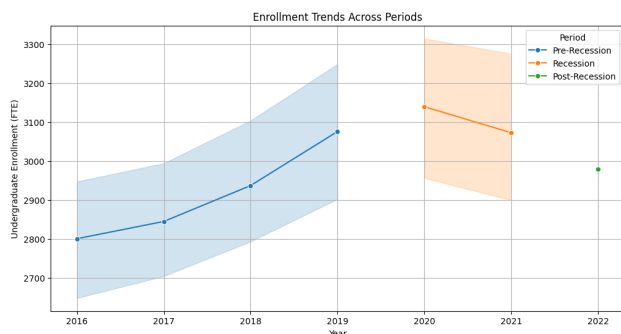


Figure 1: Enrollment trends across all periods.

Figure 1 shows the enrollment trends across different economic periods, categorized as Pre-Recession, Recession, and Post-Recession. The x-axis represents 2016 to 2022, while the y-axis represents undergraduate enrollment in Full-Time Equivalents (FTE). The Pre-Recession period, spanning from 2016 to 2019, shows a steady increase in enrollment, represented by a blue line with a shaded confidence interval indicating variability. During the Recession period (2020-2021), the enrollment trend declined, as depicted by the orange line, which includes a shaded region reflecting data uncertainty. Lastly, the post-recession period of 2022 is marked by a green dot, signifying enrollment stabilization or potential recovery. This visualization provides insights into how economic conditions impact student enrollment, highlighting the fluctuation in trends during different financial circumstances. The confidence intervals suggest possible variations in data reliability, emphasizing the need for further analysis to understand long-term enrollment behavior.

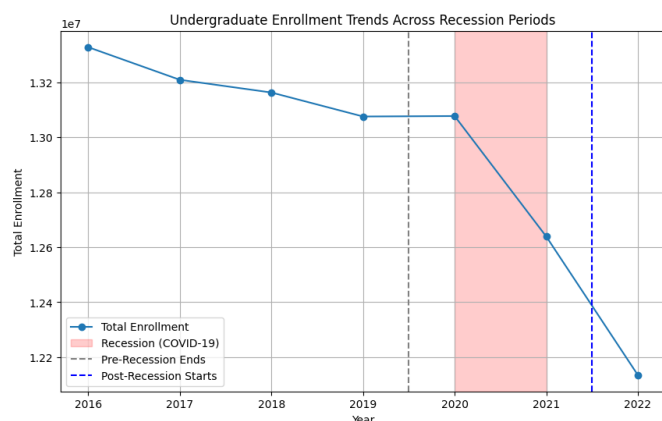


Figure 2: Enrollment trends across recession periods

Figure 2 presents undergraduate enrollment trends across different economic phases, particularly highlighting the impact of the COVID-19 recession. The x-axis represents the years from 2016 to 2022, while the y-axis denotes total undergraduate enrollment in millions. The solid blue line represents total enrollment, showing a gradual decline from 2016 to 2019, followed by a more noticeable drop during the COVID-19 recession, which is highlighted in a red-shaded area covering 2020 and

2021. A vertically dashed black line marks the end of the pre-recession period, indicating a shift in enrollment trends. The enrollment decline became more severe during the recession, suggesting that the pandemic significantly disrupted student enrollment. The blue dashed vertical line represents the start of the post-recession period in 2022, where enrollment appears to be at its lowest. This visualization emphasizes the sharp decline in student enrollment during the pandemic. It suggests further research on factors contributing to this trend, such as economic instability, shifts to online learning, and changing student priorities. The figure also underscores the long-term effects of recessions on higher education, highlighting the importance of policies that support student retention and enrollment recovery.

14. State-Level Analysis

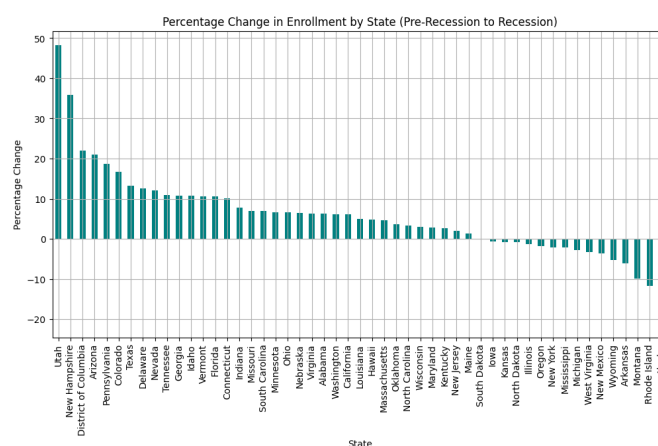


Figure 3: Percentage change in enrollment by state (Pre-Recession to Recession)

Figure 3 shows a comparative view of the geographic variations in enrollment trends by showing the percentage change in undergraduate enrollment across various U.S. states from the pre-recession period to the recession period. The y-axis shows the percentage change in enrollment, and the x-axis shows the states. The bars show whether student enrollment increased or decreased in a state during the pre-recession to recession transition. The states with the largest positive percentage changes were Utah, New Hampshire, and the District of Columbia; Utah led the pack with growth of almost 50%. These increases imply that, due to demographic changes, policy changes, or educational incentives, some states could maintain high enrollment rates during economic downturns. On the other hand, states like Rhode Island, Montana, and Alaska saw the biggest drops, with Alaska seeing a drop of almost 20%. These unfavorable patterns could result from shifting student preferences toward alternative educational options, declining birth rates, or economic difficulties. The figure highlights the need for state-specific strategies to maintain and support enrollment during economic downturns and offers important insights into how recessions affect higher education differently across regions. It emphasizes how crucial it is to research the underlying factors causing these

Top 5 States with Growth	Percentage
Utah	+52.56%
New Hampshire	+42.49%
District of Columbia	+24.62%
Arizona	+22.24%
Colorado	+17.20%

Table 2: Top 5 states with the highest percentage growth in undergraduate enrollment from pre-recession to recession period.

Top 5 States with Decline	Percentage
Alaska	-21.10%
Rhode Island	-11.73%
Arkansas	-9.83%
Wyoming	-6.12%
Montana	-5.83%

Table 3: Top 5 states with the highest percentage decline in undergraduate enrollment from pre-recession to recession period.

trends, such as employment prospects, tuition regulations, and state funding for higher education.

15. Discussion

The pandemic's impact on undergraduate enrollment was highly state-specific. States like Utah and New Hampshire demonstrated resilience, likely due to strong public institution networks. In contrast, Alaska and Rhode Island experienced significant declines, possibly due to their reliance on smaller private colleges.

15.1. Key Insights

Enrollment declined more sharply post-pandemic than during the pandemic. Public institutions fared better than private institutions, as reflected in regression coefficients.

16. Conclusion

The COVID-19 pandemic led to a significant shift in undergraduate enrollment patterns across the United States. Regression analysis highlights the varying resilience of states and institutions. Future research should explore additional factors, such as online learning adoption and demographic changes.

Appendix A. List of States in Study

Alabama, Minnesota, Colorado, Alaska, Arizona, New Jersey, California, Georgia, Arkansas, Louisiana, Pennsylvania, Tennessee, Connecticut, New York, Washington, Texas, Maryland, South Carolina, Delaware, District of Columbia, Florida, North Carolina, Mississippi, Illinois, Kentucky, Massachusetts, Hawaii, Idaho, Iowa, Kansas, Indiana, Michigan, Maine, West Virginia, Missouri, Oregon, Ohio, Nebraska, Montana, Nevada, New Hampshire, New Mexico, North Dakota, Vermont, Oklahoma, Wyoming, Rhode Island, South Dakota, Wisconsin, Utah, and Virginia.

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