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Spatial Patterns of Women Enrolled in Undergraduate Higher Education Coursework in the US from 2010 to 2020.

Dorcaslove Naa Oyo Quartey
Western Michigan University

SPATIAL PATTERNS OF WOMEN ENROLLED IN UNDERGRADUATE HIGHER EDUCATION COURSEWORK IN THE US FROM 2010 TO 2020.

Dorcaslove Naa Oyo Quartey, M.S.

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Higher education in the United States has witnessed a significant transformation over the years, characterized by a positive change in women's enrollment across colleges and universities. Despite significant gains in recent decades, differences in women's participation to higher education persist across the United States. This may be due to several reasons. This thesis investigates the spatial patterns of women's enrollment in undergraduate higher education coursework across the United States from 2010 to 2020. As women's participation in higher education has become increasingly pivotal for societal progress, understanding the geographical distribution of their enrollment provides critical insights into regional disparities. Employing data from the American Community Survey (ACS) at the census tract level, a 5-year estimate was utilized. Hotspot analysis was employed. The analyses encompassed correlation analysis and multiple regression analysis. The study identified and analyzed the spatial trends, clusters, and disparities in women's enrollment, shedding light on the factors influencing women's enrollment participation in undergraduate education in the US. This analysis found that women's enrollment increased in most parts of the US however, percentage increase varied widely across the country. The largest percentage increase was experienced in the Northeast, West and in the South.

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by

Dorcaslove Naa Oyo Quartey

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Thesis Committee:

Kathleen M. Baker, Ph.D. GISP., Chair
Lisa M. DeChano-Cook, Ph.D.
Nicholas L. Padilla, Ph.D.

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GLOSSARY

PER2010 - Percentage of women enrolled undergraduate coursework in the US in 2010.

PER2020 - Percentage of women enrolled undergraduate coursework in the US in 2020.

PERCHANGE- Percentage change of women enrolled undergraduate coursework in the US between 2010 and 2020.

COED- a female student in a college or university that has both male and female students.

CHAPTER 1
INTRODUCTION

Higher education enables individuals to expand their knowledge and skills, clearly express their thoughts orally and in writing, grasp abstract concepts and theories, and increase their understanding of the world and their community (UN, 2006). Higher education is a valuable cultural and scientific resource that facilitates individual advancement and fosters economic, technological, and societal transformation. It facilitates the dissemination of knowledge, exploration, and invention, as well as equipping learners with aptitudes essential for adapting to dynamic labor markets (UNESCO, 2023). Higher education follows school education like high school or secondary school. It includes undergraduate, postgraduate, vocational education, and other training (Bhat, 2012). Colleges, universities, community colleges, vocational schools, and other institutions offer postsecondary programs. Institutions offering higher education programs can be private or public. Pursuing higher education can lead to the award of an academic degree. The decision to pursue higher education is often intertwined with one's career aspirations, influencing the choice of courses and fields of study.

Higher education, referred to as postsecondary education by the US Department of Education, is defined by the National Center for Education Statistics (NCES) as the level of education that follows high school (Statistics, E., 2015). This level of education is optional in the US. A bachelor's degree is awarded after the completion of an undergraduate degree. Undergraduate students can choose major and minor courses during their study (Anoshkova, 2015).

In recent years, a significant trend has been observed in the United States: a marked rise in the enrollment of women in undergraduate higher education coursework (Berg, 2019). This study aims to explore the spatial patterns and distribution of women's enrollment in undergraduate

higher education coursework from 2010 to 2020 and uncover factors that have contributed to the increase in women's undergraduate coursework enrollment in some census tracts in the US. Identifying these factors could assist census tracts with lower rates of women's undergraduate enrollment in enhancing their participation levels.

Problem Statement

Despite a national increase in women's undergraduate enrollment from 29% of undergraduate enrollees being women in 1947 to nearly 60% today (Doyle, 2010; Ramage, 2017), the spatial distribution of this growth remains underexplored. Over the last decade existing research has documented the overall rise in female enrollment, but crucial questions remain unanswered: how do percentages vary across regions have hot spots of high and low enrollment persisted or shifted over time and how do socioeconomic factors like poverty and demographics influence these spatial patterns? Understanding these geographic differences is crucial for informing targeted interventions and promoting equitable participation in higher education for all women across the US. This research aims to address this gap by analyzing the spatial patterns and temporal evolution of female undergraduate enrollment from 2010 to 2020, investigating the role of key socioeconomic factors in shaping these patterns in areas where there has been an increase in women's undergraduate enrollment and providing evidence-based recommendations for policy and practice.

Research Objectives

The objectives of this research are to:

1. Investigate the temporal stability or shifts in hot and cold spots associated with high and low women's enrollment rates within the time frame of 2010 and 2020.
2. Identify geographical regions (census tracts) with a high positive percentage change of women enrolling in higher education in the U.S in 2010 and 2020.
3. Examine various factors contributing to the positive percentage change in women's enrollment within higher education coursework across distinct geographical areas (census tracts) in the United States between 2010 and 2020.

Significance of Research

This research focuses on how women's enrollment in U.S. undergraduate programs varies across different regions from 2010 to 2020. By studying changes over time and identifying areas with both high and low enrollment rates, I identify where differences persist, and new trends are emerging in women's access to higher education. The study also examines what factors contribute to positive changes or growth in enrollment, providing insights into what is driving progress and offering crucial information for targeted efforts to create equal educational opportunities for women nationwide. Ultimately, this research helps better understand how geography and socioeconomic factors influence women's undergraduate education, paving the way for future initiatives to make undergraduate education more inclusive for women in areas with low undergraduate participation.

Organization of Thesis

The rest of the thesis consists of four chapters. Chapter two presents the literature review for the thesis. This review covers the history of women in higher education in the US,

the regional variations in women's undergraduate enrollment, the exploration of factors that affect the enrollment, and the temporal shifts in women's enrollment. Chapter three discusses the research methodology, which includes types and sources of data and methods of data analysis. Chapter four discusses the results of the study. Chapter five, which is the concluding chapter, presents the discussion which is a summary of the key findings and the recommendations based on the study.

CHAPTER 2
LITERATURE REVIEW

This chapter presents a review of literature pertinent to the thesis topic, organized into four distinct sections. The first section offers an insightful overview of the historical trajectory of women in higher education within the United States. Following this, the subsequent section provides an exploration of the socioeconomic and sociocultural determinants, elucidating their profound impact on women's higher education enrollment trends. The third section delves into regional variations in enrollment rates across higher education institutions. Lastly, the fourth section focuses on the temporal shifts in female enrollment, offering a dynamic perspective on changes over time.

History of Women in Higher Education in the US

Women's access to higher education in the United States was a hard-won right that took nearly two centuries to accomplish, with significant progress made from the 1790s through 1900. Women such as Mary Wollstonecraft, Frances Wright, Mary Lyon, Catharine Beecher, Margaret Fuller and many others were radical pioneers who advocated for women's rights to educational opportunities Dentith (2016). Over the past two centuries, the landscape of women's lives in America has undergone significant transformations due to the influence of education. The trajectory of women's inclusion in higher education has been intricately connected to economic and social variables. For certain women, education has emerged as a conduit for achieving social mobility, providing a pathway to enhance their societal standing (Solomon 1985). Women changed not only the demography of college campuses but also what goes on there (Aleman et al., 2002). The history of women's education in the United States focuses on three historical periods: the antebellum era from the 1780s to the 1860s, the progressive era from the 1860s to the 1920s, and the era of World Wars from the 1920s to the 1980s (Su, 2022).

The Antebellum Era

The period from 1780 to 1860 marked a significant expansion in opportunities for women to pursue higher education. This era saw a shift from a focus on domestic skills to a more academic curriculum. In 1790, "higher education for women" was defined by proficiency in needlework, familiarity with *belles lettres*, a fashionable writing style, and a rudimentary grasp of geography, history, and arithmetic (Nash, 2000; Su, 2022).

During the 1830s and 1840s, a significant and prolonged debate was sparked by more women expressing a desire to attend higher education institutions. This debate persisted for a century. Conservatives argued that such education would undermine women's traditional roles as homemakers, wives, and mothers. In contrast, liberals contended that a woman with a college education would excel in her roles as a homemaker, wife, and mother (Parker, 2015).

By 1840, the landscape had changed dramatically. The definition of women's higher education had broadened to include a three-year course of study in the sciences, literature, composition, philosophy, rhetoric, and trigonometry. By 1860, the term "women's higher education" had evolved further to denote a course of study leading to a bachelor's degree. This was a clear indication of the strides made in recognizing women's capacity and right to pursue higher education (Malkmus, 2001). Also, in this era, seminaries started to earnestly provide educational opportunities to women. By the mid-19th century, a significant number of seminaries and academies were actively involved in women's education. These institutions were established and promoted with great enthusiasm, leading to the creation of numerous female seminaries. A pivotal moment in this progression was the decision by Oberlin College in Oberlin, Ohio, to admit women. In 1837, Oberlin became the first American institution of higher learning to open its doors to women, setting a precedent for other institutions to follow (Chamberlain, 1988). Out of the 6,085 seminaries and academies present in America in 1850,

a considerable proportion were dedicated to educating women, either exclusively or alongside men (Sweet, 1985).

Coeducation, also known as joint education, involves the schooling of both males and females within a single institution. The inception of coeducation can be traced back to the establishment of Mount Holyoke Female Seminary by Mary Lyon in 1837. Notably, Oberlin College established itself as the pioneering coeducational institution, admitting women and granting its first bachelor's degree to female students. Since these milestones, there has been a consistent increase in the participation of women in higher education. This upward trajectory has not only prompted adjustments in academic curricula and extracurricular activities but has also played a pivotal role in broadening the scope of opportunities available to female graduates in their post-collegiate life and professional pursuits. Departing from traditional roles confined to daughter, wife, and mother, women have attained a notable degree of economic and social independence through their active involvement in higher education (Aleman et al., 2002). This period laid the groundwork for the continued advancement of women's higher education, setting the stage for the further strides that would be made in the years to come.

The Progressive Era

During this era, women established a unique campus life, linking the curriculum to the extra-curriculum and demonstrating the importance of higher education in women's lives and to the progress of womanhood (Gordon, 1990).

The United States in the Progressive Era witnessed a rapid transformation of society. With increasing expansion of capitalism, urbanization, influx of new immigrants, and the continuous industrialization, social problems kept arising to challenge educational and political leaders (Su, 2022).

Historical works on women's education during the Progressive Era emphasize themes of women's agency for accessing higher education, institutional changes, women's college experiences, and purpose and function of schooling. Having access to higher education was generally acknowledged to provide power and agency for women in the feminist movement (Su, 2022). Opportunities available to women underwent significant expansion with the enactment of the Morrill Land Grant Act of 1862, which broadened both the purpose and the structure of higher education by introducing state-sponsored education. Through the Morrill Land Grant Acts, 30,000 acres of land were allocated, leading to the establishment of 69 land grant institutions (Pasque et al., 2023)

The Era of World Wars

During World War II, higher education institutions in the United States had declining numbers of male enrollment and provided an opportunity for women in higher education coeducation(coed) and women's colleges (Parker, 2015). Multiple colleges for women were established during this time, opening doors for American women to receive higher education. Both private and public coeducation institutions played a role in this development. The myth of the negative impact of education on women's health was shattered, contributing to the changing attitude of American society towards women receiving higher education (Ovcharenko, 2021). According to the University of Chicago wartime affected campus life in profound and unexpected ways. When men withdrew from college to aid the war effort, women's presence and campus visibility increased. Women's proportion of the undergraduate population increased from 22% in 1910 to 34% in 1920. During World War II, women outnumbered men on campus, constituting fifty-seven percent of the undergraduate population in 1945 (Mercado & Turk, 2009).

Over the past century, women in the US have gained access to higher education. Access to higher education was and is still seen as a means for women to gain independence and

participate in the public sphere. Higher education is a mechanism to prepare women for professional positions, enabling them to enter the job market and political arena **(**Kelly et al., 1991).

Distribution Patterns of Women's Enrollment in Higher Education in American History

The historical landscape of women's higher education in America exhibits a dynamic evolution marked by distinct patterns and geographical shifts. In 1742, the establishment of Bethlehem Female Seminary in Pennsylvania marked a seminal moment, signaling the initiation of women's higher education (The Bethlehem Gadfly, 2019). This trend gained momentum in the Northeast during the late 18th century with the founding of Litchfield Academy (1792) in Connecticut and Bradford Academy (1803) in Massachusetts.

As the 19th century unfolded, the expansion of women's education moved westward. In 1821, Clinton Female Seminary in Georgia laid the foundation for Georgia Female College. The westward trajectory reached a significant milestone in 1827 with the establishment of Lindon Wood School for Girls, heralded as the first women's college west of the Mississippi. Simultaneously, Massachusetts emerged as an educational hub with the inception of Wheaton Female Seminary in 1834. The diverse educational landscape was further enriched by institutions such as Columbia Female Academy in Missouri, founded in 1833 and later evolving into Stephens College (Lewis, 2019).

The distribution patterns of women's enrollment in higher education were shaped by factors, including the availability of educational institutions, cultural attitudes prevalent in different regions, and economic considerations. The historical narrative underscores the diversity and complexity of women's participation in higher education.

Factors Influencing Higher Education Participation

While students are provided with education, various factors throughout their lives can hinder their participation in opportunities beyond high school. The decision not to continue the educational path into higher education can be influenced by several reasons (Temple, 2009).

Numerous factors contribute to an individual's inclination to participate in higher education, encompassing parental education levels, academic performance, socio-economic standing, geographical location, and rural versus urban upbringing (Connor et al., 2001; Marks et al., 2000). Educational achievement disparities are often shaped by the accessibility and quality of resources, such as school size and infrastructure. Typically, urban areas are better equipped than their remote counterparts (Verdis et al., 2019). Socio-economic status plays a pivotal role in shaping educational opportunities. Affluent students often have superior access to resources, which can enhance academic performance and influence university enrollment. Conversely, students from less privileged socio-economic backgrounds may encounter financial hurdles and restrictions in their educational choices (Prakhov & Bugakova, 2023). Socio-cultural factors also present obstacles for women seeking higher education (Rida et al., 2020). The pursuit of higher education for women is intricately tied to shifts in employment, marriage, childbearing, and income patterns (Parvazian et al., 2017).

The economic climate of an area, including the unemployment rate, can impact the perceived value of a college education, thereby affecting enrollment rates. Students from disadvantaged backgrounds may be more sensitive to the cost of education (Declercq & Verboven, 2015). Factors such as the proximity of a university to a metropolitan area and the presence of multiple universities in the vicinity can also sway enrollment decisions (Catma & Varol, 2023). Financial incentives, such as scholarships, stipends, and cash rewards, can significantly bolster women's independent pursuit of higher education (Rida et al., 2020).

The reluctance of some students to pursue college education is often attributed to a lack of motivation. High school experiences, encompassing interactions with educators and administrators, as well as academic readiness, significantly shape students' attitudes toward higher education. Beyond educational influences, students are also impacted by their community and familial relationships, all of which collectively contribute to their decision-making regarding college attendance. Particularly, students without family members who have pursued higher education tend to rely heavily on their school as their primary support system. Consequently, expectations set by the high school environment play a crucial role in influencing students' decisions and transitions (Temple, 2009).

In the realm of factors influencing higher education participation, the impact of self-esteem becomes particularly noteworthy. Positive self-esteem emerges as a significant motivator, propelling individuals toward academic achievement and fostering the motivation to actively participate in higher education. When students possess a positive self-image, they are more likely to engage proactively in the pursuit of higher education. Conversely, the influence of low self-esteem becomes a notable obstacle to higher education participation. Lower self-esteem is correlated with adverse consequences, including diminished academic performance, challenges in building positive relationships within the academic community, and a reduced ability to persevere through academic challenges. These consequences, stemming from low self-esteem, can collectively act as deterrents to women considering or actively participating in higher education (Watermark Insights, 2002).

While women have made significant strides in participation of undergraduate higher education in the US, issues of gender inequity and discrimination continue to exist, particularly in certain fields such as STEM (Science, Technology, Engineering, and Mathematics) (Noonan, 2017; Beede, 2011) &). One of the biggest barriers to STEM programs is the

continuous perception as male-dominated, and this system contributes to a lack of interest in these programs through psychological barriers from the media, the ability beliefs of teachers, and parents and peers (Blackburn, 2017).

In addition to individual factors, external elements such as viruses and pandemics can significantly impact participation in higher education. Notably, the recent COVID-19 pandemic has emerged as a significant factor affecting women's enrollment in higher education (Adler, 2021). The pandemic triggered a significant increase in mental health issues, particularly anxiety and depression, among women. This rise in mental health concerns has had consequential implications for women's participation in undergraduate enrollment (Fruehwirth, 2021).

Government-provided financial aid serves as a crucial support system for less affluent students, assisting them in covering the costs associated with college education. This aid is often need-based, but it can also be merit-based, rewarding students who demonstrate strong academic performance through good grades or test scores. In states with specific types of educational boards, the pathway to public or nonprofit college may be somewhat more accessible for these students. Furthermore, during periods of economic downturn and job scarcity, the role of government assistance becomes even more critical in influencing students' decisions about pursuing higher education (Lowry, 2019).

Regional Differences in Higher Education Enrollment

Examining the dynamics of higher education enrollment reveals significant regional disparities that demand thorough investigation. The growth rate of women's enrollment varies

across regions, contributing to visible social inequalities exacerbated by rising tuition and living expenses. These financial challenges disproportionately affect lower-income and marginalized communities (King, 2023; Langthaler et al., 2012).

The differences in college enrollment between rural and nonrural students are predominantly attributed to socioeconomic status (Byun et al., 2015). Rural students including women face lower enrollment rates compared to their nonrural counterparts, with the gap widening for those with lower socioeconomic status (SES). Even when SES is taken into account, rural students have a 6% lower chance of attending postsecondary education than nonrural students, resulting in greater socioeconomic inequality in college access in rural areas (Wells, 2023). Additionally, parental education levels are lower in rural areas, with fewer parents holding a bachelor's degree compared to suburban and urban areas (Byun et al., 2012).

The unequal access to higher education in America, particularly in rural areas, poses a significant barrier to women's participation. Education deserts refer to regions where local colleges and universities are sparse, posing significant challenges for residents seeking to pursue higher education in close proximity (Hillman, 2016). The existence of "education deserts" underscores the geographical disparities in educational opportunities, a critical concern given that nearly half of all students prefer attending local colleges. These disparities can perpetuate existing inequalities and hinder upward mobility for women. A regional analysis highlights stark contrasts, with the Rocky Mountain and Plains regions facing the most limited access to higher education, while New England and the Mid-Atlantic regions demonstrate the highest accessibility (Johnson, 2019).

To address these regional differences in terms of higher education enrollment, it is essential to implement effective strategies that promote equal access to educational opportunities. Government bodies and academic institutions are instrumental in developing and

executing initiatives aimed at increasing enrollment and improving the accessibility of post-secondary education, especially for students from disadvantaged backgrounds (Jackson, 2019).

Temporal Changes in Women's Enrollment in Higher Education

The last two decades have witnessed a substantial increase in women's enrollment in higher education, signifying a pivotal shift in academic history, as noted by Ryan (1993). In the United States, women's success in higher education is evident through their rising enrollment and graduation rates. Specifically, from 1988 to 1998, women's enrollment in degree-granting higher education institutions saw a significant 16% increase, surpassing the 6% increase for men, as reported by Bonner (2005). According to Swail (2019), the proportion of women enrolled in undergraduate higher education in the United States has seen a steady increase since 1970. The enrollment rate was 43% in 1970, which rose to 45% in 1975. By 1980, the figure had increased to 51%, and by 1985, it had reached 53%. The 1990s saw a slight increase, with the rate at 54% in 1990 and 54.5% in 1995. The upward trend continued into the new millennium, with the rate at 55.5% in 2000, 56% in 2005, and maintaining at 56% in 2010. A slight dip occurred in 2015 with the rate at 55.5%, but it rebounded to 56% in 2020.

On a global scale, the progression of women's participation in higher education has seen remarkable improvements. The period from 1999 to 2005 marked a clear rise in global participation rates for women, indicating a positive move towards gender inclusivity. This upward trend is further emphasized by the Global Gender Parity Index (GPI), which shows a decreasing gender gap in enrollment ratios. From 1999 to 2004, the GPI for gross enrollment in higher education showed promising growth in over 77% of the 57 countries with available data, demonstrating a worldwide commitment to improving educational opportunities for women (Morley, 2010).

This transformative shift in enrollment patterns signifies not only an increase in numbers but also a broader societal recognition of the importance of women's education. The temporal changes reflect the evolving landscape of higher education, wherein efforts are being made globally to ensure equal participation and opportunities for women.

CHAPTER 3
RESEARCH METHODOLOGY

Introduction

This chapter explains how the research was conducted. It illustrates the research design methods of collecting and analyzing data that were considered during the design and conduct of the study.

Research Design and Data

The research design of this thesis focuses on investigating the spatial distribution and patterns of women's enrollment in higher education coursework between 2010 and 2020 and examining the influence of selected socio-economic factors on these patterns. Data for this study includes women's undergraduate enrollment data in the United States for the years 2010 and 2020, obtained from the Census Bureau website through the American Community Survey (ACS) using census tracts as the geographical scale. Though this study focuses on changes occurring between the decennial census years of 2010 and 2020, ACS 5-Year estimates were used as the primary data source. While decennial census data is available only every 10 years, the multi-year ACS estimates incorporate sample data from the years between 2010 and 2020 as well, spanning 2006-2010 and 2016-2020. These provide more nuanced annual visibility into the trends and shifts taking place across the period of interest rather than just comparing two static data points a decade apart. Additionally, upon examination it was found that the decennial census data for 2010 and 2020 did not contain a reliable set of matching variables. Key indicators around educational attainment, employment status, and income measurements had differing definitions and operationalizations that would preclude direct comparisons. ACS data are estimated more frequently than decennial data, which can be beneficial for up-to-date information. ACS provides a richly detailed, multivariate, composite picture of small

areas. Census tracts provide a better representation of neighborhood boundaries compared to larger geographies like counties (Spielman & Singleton, 2015). Using census tracts as the geographical scale for this thesis is justified by their ability to provide detailed, localized data that reflects the socio-economic conditions and demographic characteristics of small areas. The census tract boundary shapefile, which is necessary for the spatial analysis, was also acquired from the Census Bureau website (Tiger/line).

Additionally, the study incorporates the Social Vulnerability Index (SVI) themes specifically the sum of the themes; Socioeconomic status (SPL Theme1), Household composition and disability (SPL Theme2), Race/ethnicity and language (SPL Theme3), Housing or transportation status (SPL Theme 4) sourced from the Centers for Disease Control and Prevention (CDC). Social vulnerability is defined as the disadvantage conveyed by poor social conditions determining the degree to which one's life and livelihood are at risk from a particular and identifiable event. SVIs aggregate social factors that can show how different groups, like women, might be affected in their education choices. SVIs include education and socioeconomic status, which are relevant to studying women's enrollment in higher education. Using SVI data can help understand the broader social context influencing women's educational opportunities. SVIs have been used in health and medicine fields, indicating their relevance in analyzing social conditions (Mah et al., 2023). The remaining factors are income, demographics, poverty, and attainment, also from the US Census bureau website to explore the impact of socio-economic factors on women's enrollment patterns. The selection of these additional factors was informed by methodologies employed in prior research. Income, in this study, is represented by the percentage of the earnings of families. The focus was on the percentage of families earning less than $10,000 and those earning more than $200,000. This range was chosen to examine the extremes of the income spectrum and their potential impact on educational enrollment.

Demographic factors include various characteristics that define a population, such as age and gender. For this study, the total population estimate, and the total number of females were the demographic variables of interest. These were selected to provide a broad overview of the population and to specifically analyze women's enrollment patterns. Educational attainment was measured by the achievement of a bachelor's degree. Variables used were the percentage of females with a bachelor's degree. These were chosen to assess the overall educational landscape and specifically the educational achievements of women. These variables were selected to provide a comprehensive and multifaceted view of the factors influencing women's enrollment patterns over the decade from 2010 to 2020.

The analysis utilized a combination of ArcGIS Pro, Python, R, and SPSS (Statistical Package for the Social Sciences). ArcGIS Pro facilitated data visualization, enhancing spatial understanding. Python was employed for exploratory data analysis, enabling initial insights into the dataset. R was instrumental in conducting segmented regression, allowing for the identification of nuanced relationships within the data. Finally, SPSS supported the execution of correlation analysis and multiple linear regression. Offering a solid statistical basis for the analysis, this approach enhanced the understanding of socio-economic influences on research findings.

Method of Data Analysis

In this research, quantitative methods were employed to examine the enrollment patterns of women in undergraduate education for the years 2010 and 2020. The percentage of women enrolled in undergraduate higher education for each year was determined by considering the ratio of the total number of women enrolled to the total population, multiplied by 100 thereby considering the underlying population.

Subsequently, the percentage change in women's enrollment between 2010 and 2020 was calculated. Exploratory Data Analysis (EDA), as defined by Albert (2012), was initially conducted to gain insights into these data, focusing on identifying general patterns and potential deviations. Scatterplots were made for the percentage of women enrolled in undergraduate coursework in the US in 2010 (PER2010), the percentage of women enrolled in undergraduate coursework in the US in 2020 (PER2020) and the percentage change of women enrolled in undergraduate coursework in the US between 2010 and 2020 (PERCHANGE).

To further investigate these dynamics and identify potential thresholds or breakpoints within these data, a segmented linear regression analysis was conducted on the percentage of women enrolled in undergraduate coursework in the US in 2010 (PER2010), the percentage of women enrolled in undergraduate coursework in the US in 2020 (PER2020) and the percentage change of women enrolled in undergraduate coursework in the US between 2010 and 2020 (PERCHANGE). Segmented linear regression (SLR) provides a piecewise linear approximation for a specified dataset. It partitions the dataset into a series of subsets with contiguous ranges. For each of these ranges, it determines a linear regression. This approach typically yields a higher degree of accuracy compared to a single line regression applied to the entire dataset. This model allows for different linear relationships in different segments of the data, which can more accurately capture the underlying trends if the data has structural changes or non-linearity. Segmented linear regression provides a robust approximation (Stadnik, 2020). The Segmented Linear Regression (SLR) was utilized to identify distinct thresholds. These thresholds were subsequently employed to classify census tracts, exhibiting statistically significant high percentage changes from 2010 to 2020, into four separate categories The first group comprises census tracts where the percentage of women's enrollment in 2010 fell below the 2.449% threshold. The second group includes census tracts where the percentage exceeded the 2.449% threshold. The third group consists of census tracts where the percentage of

women's enrollment in 2020 was below the 5.551% threshold. The fourth group encompasses census tracts where the percentage surpassed the 5.551% threshold. The objective of this classification was to discern the socio-economic factors influencing women's enrollment in undergraduate coursework. The specific socio-economic factors identified, and their implications are elaborated upon in the subsequent section of this thesis.

A hotspot analysis was conducted using the Getis-Ord Gi* statistic to identify significant spatial clusters, specifically hotspots and cold spots, of women's enrollment percentages. This analysis was performed separately for the years 2010 and 2020, allowing for the identification of areas with notably high (hotspots) and low (cold spots) enrollment of women in each of these years. Hotspot maps were also made utilizing vector data to pinpoint statistically significant areas of high and low within this dataset. These significant areas are achieved by aggregating individual occurrences into larger, defined shapes or by clustering nearby points based on a predetermined distance measure. This technique effectively identifies clusters where similar values—either high or low—are geographically concentrated (Bambrick, 2016). These maps helped to investigate the temporal stability or shifts in hot and cold spots associated with high and low women's enrollment rates within the time frame of 2010 and 2020.

To further investigate the temporal shifts, differences in means between 2010 and 2020, a paired samples t-test was applied to the percentage of women enrolled in higher education within census tracts in 2010 and 2020. A paired-samples t-test is used to compare the means between two related groups or conditions, or to evaluate the mean difference within a single group at two distinct times (Ross & Willson, 2017). Utilizing the paired samples t-test helped to analyze whether there is a statistically significant change in women's enrollment within specific census tracts from 2010 to 2020. This method compares the average enrollment

percentages at these two points in time, providing insights into trends and shifts in women's participation in undergraduate higher education across the US.

A choropleth map was constructed to visualize the percentage change in women's enrollment from 2010 to 2020. This map effectively highlighted the census tracts that experienced significant growth in women's enrollment during this period. Additionally, a hotspot analysis was performed on the same percentage change data to statistically identify areas of notably high and low growth in women's enrollment over the decade.

Hotspots identified on the map depicting percentage change were selected for further analysis. Census tracts within these hotspots were then classified into four groups, based on the thresholds determined by the Segmented Linear Regression. These categorized data formed the basis for subsequent stages of the analysis.

A correlation analysis was carried out to explore relationships between socioeconomic factors (SVI themes, Demographics, Attainment, Poverty, and Income) and the percentage change in women's undergraduate enrollment. It is important to note that correlation does not imply causation, as highlighted by Pott (2008). Acknowledging this limitation, a multiple regression analysis was conducted in an attempt to determine causation. Variables exhibiting statistically significant correlations with women's undergraduate enrollment were used as predictor variables (independent variables), while the percentage change of women's undergraduate enrollment from 2010 to 2020 served as the response variable. The Variance Inflation Factor (VIF) was employed to assess the presence of multicollinearity. Multicollinearity involves a significant linear relationship among independent variables in a multiple regression model, which can distort the outcomes of regression analyses. Multicollinearity is present when the VIF is higher than 5 to 10. (Kim, 2019).

Figure 1 presents a categorical breakdown of the factors that determine overall community vulnerability, as conceptualized by the Centers for Disease Control and Prevention's Social Vulnerability Index (SVI). The index aims to quantify the vulnerability of every census tract in the United States based on social factors across four themes. The themes are Socioeconomic Status, Household Composition & Disability, Minority Status & Language, and Housing Type & Transportation.

Socioeconomic Status: This theme includes indicators such as poverty levels (specifically, populations living below 150% of the poverty line), unemployment rates, high housing costs relative to income (housing cost burden), lack of high school diploma, and lack of health insurance coverage.

Household Characteristics: This theme captures the demographic composition and dynamics of households, including vulnerable age groups (such as those aged 65 & older and those 17 & younger), civilians with a disability, single-parent households, and English language proficiency.

Racial & Ethnic Minority Status: This theme encompasses various racial and ethnic groups, including Hispanic or Latino, Black or African American, Asian, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, and those identifying with two or more races, with an emphasis on non-Hispanic or Latino ethnicity.

Housing Type & Transportation: This theme addresses factors related to living arrangements and mobility, such as the prevalence of multi-unit structures, mobile homes, overcrowding, lack of vehicle access, and group quarters.

In this thesis, the comprehensive approach of the Social Vulnerability Index (SVI) is utilized to evaluate the impact of various socio-economic factors on women's enrollment in

undergraduate higher education coursework in the U.S. from 2010 to 2020. This approach underscores the multifaceted nature of social vulnerability and the significance of considering a broad spectrum of factors when analyzing and interpreting enrollment patterns. The aim is to provide a nuanced understanding of how these socio-economic factors could potentially influence women's decisions to pursue higher education, thereby informing future educational policies and strategies.

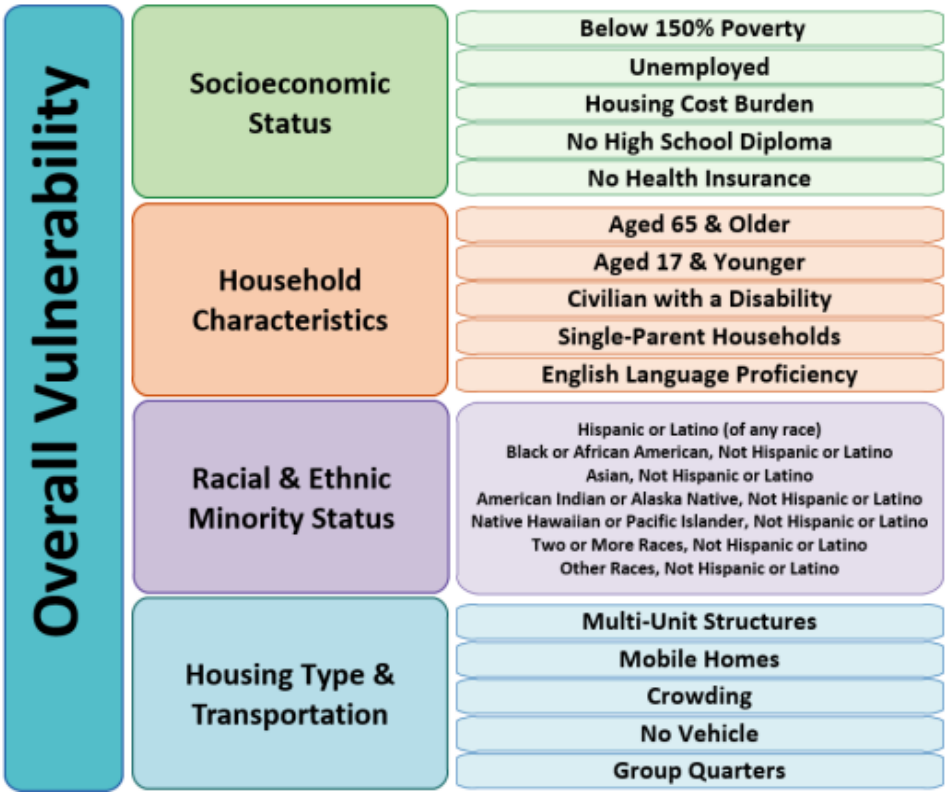

Figure 1. Social Vulnerability Index (SVI) themes.

Source: Centers for Disease Control and Prevention (CDC)

CHAPTER 4
RESULTS AND DISCUSSION

This chapter delves into the analysis and discussion pertinent to the study's research objectives. It examines the findings from both spatial data analyses regarding women's undergraduate enrollment between 2010 and 2020, focusing on the socio-economic factors influencing these enrollment trends over the decade

Exploratory Data Analysis

An Exploratory Data Analysis (EDA) was conducted to investigate enrollment percentages and to explore the correlation between enrollment percentages in 2010 and 2020, along with the corresponding percentage change. The EDA led to the formulation of insightful questions that are systematically addressed in the next stages of the analysis.

There was a statistically significant strong positive correlation (r= 0.817) between the percentage of women enrolled in 2010 and in 2020 (Table 1). This indicates census tracts with high representation of women in 2010 also tended to have high percentages in 2020. Similarly, census tracts with low 2010 percentages remained relatively low in 2020. In other words, the two variables move in the same direction—when one increases, the other tends to increase as well as shown in Figure 2.

There was a statistically significant negative correlation (r = -0.169) between 2010 enrollment percentage and the percent change from 2010-2020. This suggests census tracts with already high women’s enrollment in 2010 saw lower growth rates over the decade compared to census tracts starting with lower 2010 percentages. There is a statistically significant positive correlation (r = 0.261) between 2020 enrollment percentage and 2010-2020 percent change. Census tracts ending with higher female representation in 2020 tended to see slightly greater growth over the past decade.

Table 1. Correlation between PER2010, PER2020 and PERCHANGE

VARIABLES	CORRELATION COEFFICIENT
Correlation between the percentage of women enrolled in undergraduate coursework in 2010 and 2020	**0.817****
Correlation between the percentage of women enrolled in undergraduate coursework in 2010 and the percentage change of women enrolled in undergraduate coursework from 2010 to 2020	**-0.169****
Correlation between the percentage of women enrolled in undergraduate coursework in 2020 and the percentage change of women enrolled in undergraduate coursework from 2010 to 2020	**0.261****

** indicates results that are statistically significant at the 0.001 level

From the scatterplot analysis (Figure 2), exploring the relationship between women's enrollment percentages in 2010 and the percent change up to 2020, along with the 2020 enrollment figures against the decade's percent change, highlights intriguing trends that necessitate further exploration. Although there is a negative correlation between the percentage change in women's enrollment from 2010 to 2020 (PERCHANGE) and the percentage of women enrolled in undergraduate coursework in 2010 (PER2010), and a positive correlation between PERCHANGE and the percentage of women enrolled in undergraduate coursework in 2020 (PER2020), the scatterplots suggest the presence of non-linear relationships as clearly shown in Figure 3 and Figure 4.

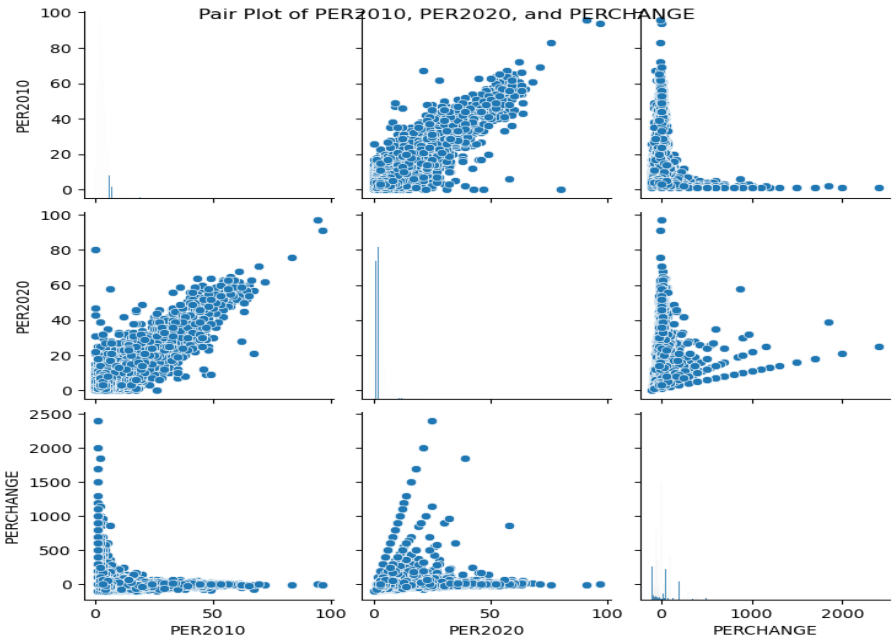

Figure 2. Scatterplot showing the correlation between PER2010, PER2020 and PERCHANGE

To dissect these patterns, a segmented linear regression analysis was conducted. This methodological approach, especially the identification of breakpoints, is crucial for a refined understanding of factors driving enrollment changes, revealing the complex interplay of dynamics influencing educational trajectories over the period.

From Tables 2 and 3, the segmented regression results for PER2010 show:

Breakpoint (psi1.PER2010 at 2.449%): The model estimates that the relationship between PER2010 (percentage of women enrolled in 2010) and PERCHANGE (percentage change in women's enrollment from 2010 to 2020) changes at the value of 2.449%. The standard error of this estimate is very small (0.014), indicating precision in the breakpoint estimate.

Coefficients: Before the breakpoint, for every 1% increase in PER2010, there is an associated 86.322% decrease in PERCHANGE, which is a strong and statistically significant relationship

(p < 2e-16). After the breakpoint, the effect reverses; for every 1% increase in PER2010, PERCHANGE increases by 86.400%, indicating a strong positive relationship.

Table 2. PER2010 threshold

Estimated Break-Point (s)	Estimate	Standard Error
psi1.PER2010	2.449	0.014

PER2010 is the independent variable and PERCHANGE is the response variable.

Table 3. Coefficients of the linear terms

	Estimate	Standard Error	t value	Pr(>|t|)
(Intercept)	184.975	1.804	102.51	<2e-16 ***
PER2010	-86.322	1.076	-80.24	<2e-16 ***
U1.PER2010	86.400	1.080	80.03	NA

*** indicates results that are statistically significant at the 0.001 level

These results suggest a dual relationship where initially, higher enrollment rates are associated with a decrease in enrollment change. Once past a critical threshold (the breakpoint), further increases in initial enrollment rates are associated with an increase in enrollment change. In areas with initially high enrollment rates but below the threshold, the negative association with enrollment change could reflect a saturation effect. As enrollment rates approach the threshold, the pool of potential new students might shrink, leading to smaller percentage changes in enrollment. Essentially, when a large proportion of the target population is already enrolled, the room for growth diminishes. Past the breakpoint, the positive relationship might indicate

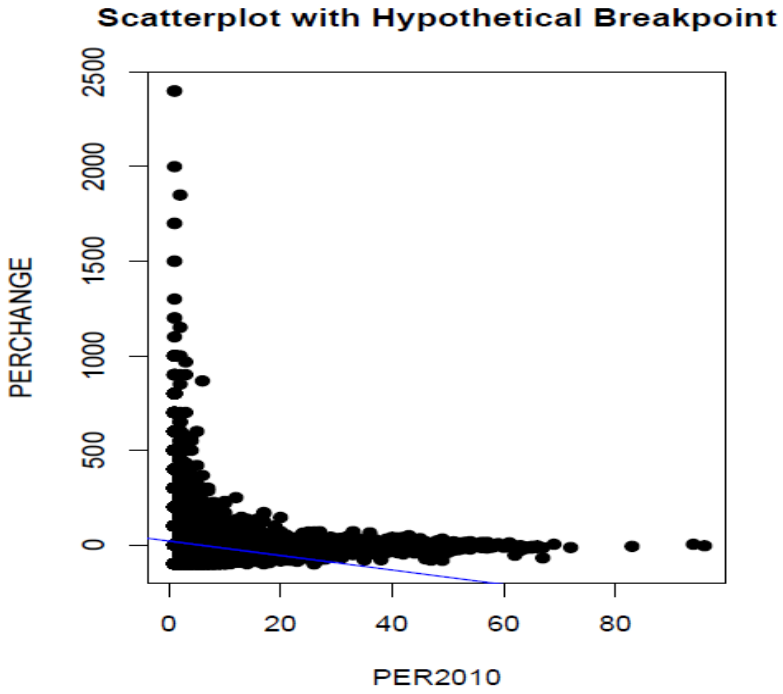

Figure 3. Scatterplot showing correlation between PER2010 and PERCHANGE.

Blue line represents the line of best fit

that areas with extremely high initial enrollment rates overcome the saturation effect through self-reinforcing educational ecosystems. In these communities, the culture, infrastructure, and expectations surrounding education might create momentum that encourages even higher rates of enrollment.

From Tables 4 and 5 the segmented regression results for PER2020 show:

Breakpoint (psi1.PER2020 at 5.551%): The model estimates a breakpoint in the relationship between PER2020 (percentage of women enrolled in 2020) and PERCHANGE at a PER2020 value of 5.551%, with a standard error of 0.043, indicating that the estimate is fairly precise.

Coefficients: (Intercept) -83.3057: This value suggests that when PER2020 is zero, the expected PERCHANGE is -83.3057, which is a theoretical interpretation since PER2020 cannot be zero.

PER2020 Coefficient (36.6985): Before the breakpoint, for every one percent increase in PER2020, the PERCHANGE increases by 36.6985 units, suggesting a strong positive relationship that is statistically significant ($p < 2e\text{-}16$).

U1.PER2020 Coefficient (-39.2425): After the breakpoint, the relationship changes; for each additional percent increase in PER2020, the PERCHANGE is expected to decrease by 39.2425 units.

Table 4. PER2020 threshold

Estimated Break-Point(s)	Estimate	Standard Error
psi1.PER2020	5.551	0.043

PER2020 is the independent variable and PERCHANGE is the response variable.

Table 5. Coefficients of the linear terms

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-83.3057	0.6898	-120.8	<2e-16 ***
PER2020	36.6985	0.2675	137.2	<2e-16 ***
U1.PER2020	-39.2425	0.2883	-136.1	NA

*** indicates results that are statistically significant at the 0.001 level

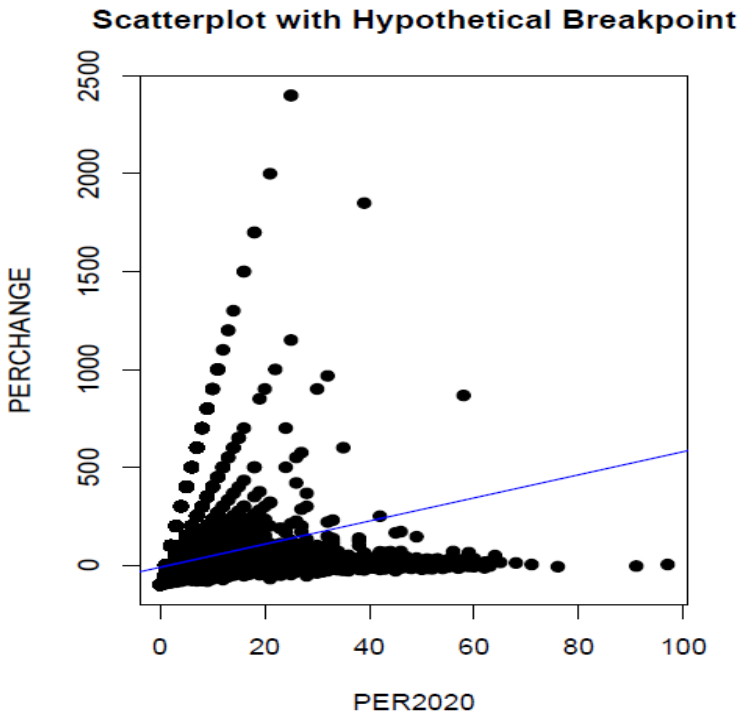

Figure 4. Scatterplot showing correlation between PER2020 and PERCHANGE

Blue line represents the line of best fit.

These findings indicate a changing relationship where initially, higher enrollment rates in 2020 are associated with an increase in the enrollment change rate, but past a certain point, further increases are associated with a decrease in enrollment change. The initial positive relationship between higher enrollment rates in 2020 and the rate of enrollment change suggests that as more women enroll in undergraduate programs, the momentum for further enrollment increases. This could be due to a variety of factors, such as increased visibility of education's benefits within the community, more substantial peer influence, and enhanced community support for education. Once enrollment rates surpass the breakpoint, the relationship inverses, with further increases associated with a decrease in enrollment change. This could indicate that beyond a certain level of enrollment saturation, additional factors may act as deterrents to

further growth. This suggests a complex dynamic where factors influencing enrollment growth may differ at higher levels of initial enrollment.

Addressing Thesis Objectives

1. Investigate the temporal stability or shifts in hot and cold spots associated with high and low women's enrollment rates within the time frame of 2010 and 2020.

Are hot and cold spots of high and low women's enrollment rates stable over time or shifting between 2010-2020?

A hotspot map indicates clusters of census tracts with statistically significant levels of women's enrollment changes, not just high or low values in isolated tracts. Specifically, a hotspot detects spatial groupings of tracts with similarly pronounced increases or decreases that are unlikely to have occurred by random chance.

Figure 5 is a map showing hotspots and cold spots of the percentage of women who enrolled in higher education in 2010. Hotspots were identified in California, southern Oregon, western and southern Nevada, southern Idaho, western and southern Arizona, Utah, Colorado, Wyoming, Wisconsin, Illinois, Michigan, northern Florida, Alabama, South Carolina, New Jersey, Delaware, and Maine. Cold spots were mostly found in the Midwest, some parts of the South, and the northern parts of the West.

Figure 6 is a map showing hotspots and cold spots of the percentage of women who enrolled in higher education in 2020. Hot spots were found in the California, Nevada, Idaho, some parts of Utah, Wyoming, Louisiana, Arizona, Florida, Alabama, Georgia, South Carolina, Pennsylvania, New York and Maine. Cold spots were identified in the Midwest, mid and northern Great Plains, some parts of the South and the northern part of the West.

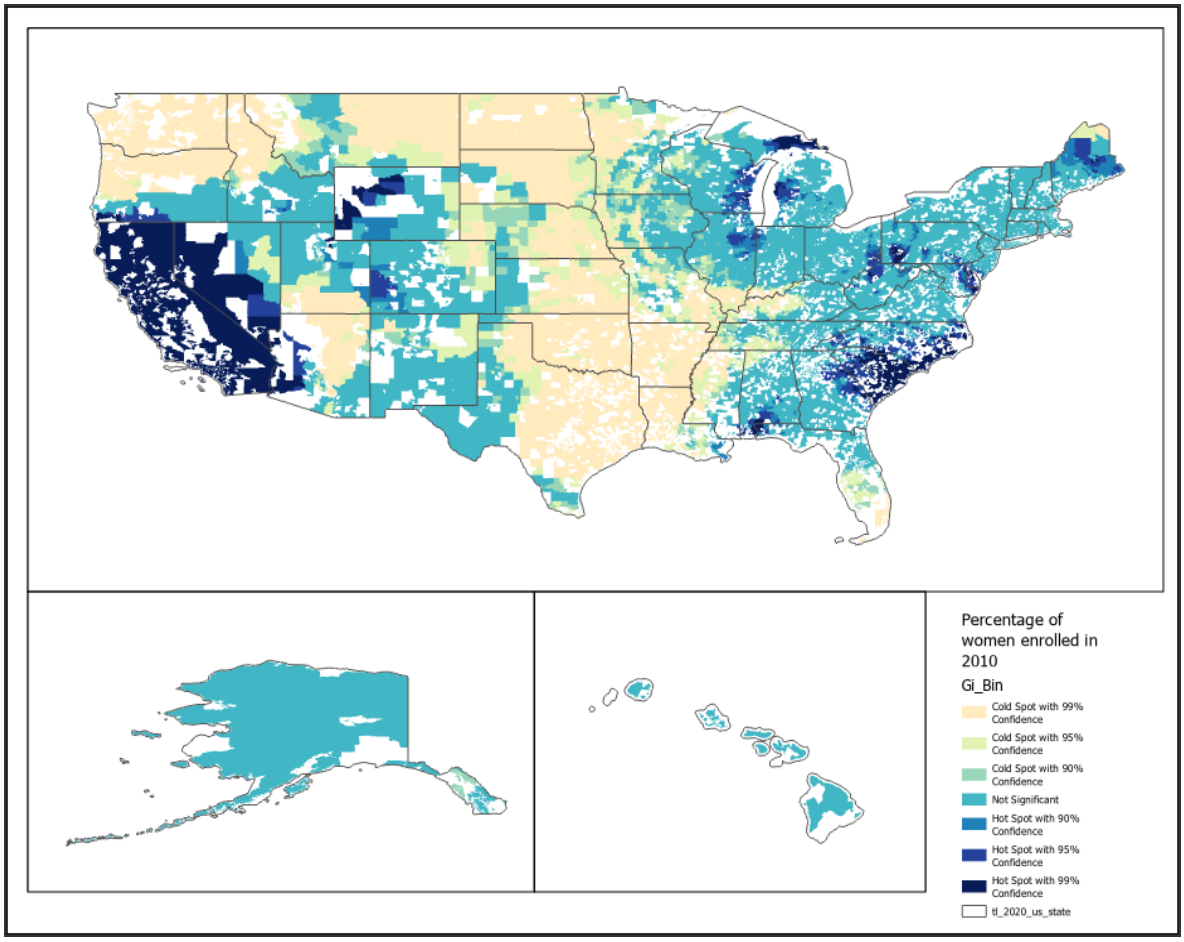

Figure 5. Hotspot analysis of percentage of women enrolled undergraduate coursework in the US in 2010

By comparing these two maps (Figure 5 and Figure 6) of examining women's enrollment in higher education across 2010 and 2020, the analysis reveals distinct patterns in undergraduate enrollment. While certain regions display consistent enrollment patterns over the two periods, notable variations are observed as well. Specifically, areas in the Northeast, Southeast, and West Coast emerge as hotspots with higher rates of women's enrollment, indicating regions of concentrated educational engagement among women. Conversely, the Midwest, Great Plains, and Northwest are identified as cold spots, characterized by lower levels of women's enrollment in higher education. For census tracts that maintained high enrollment from 2010 to 2020, there may be factors that have consistently supported

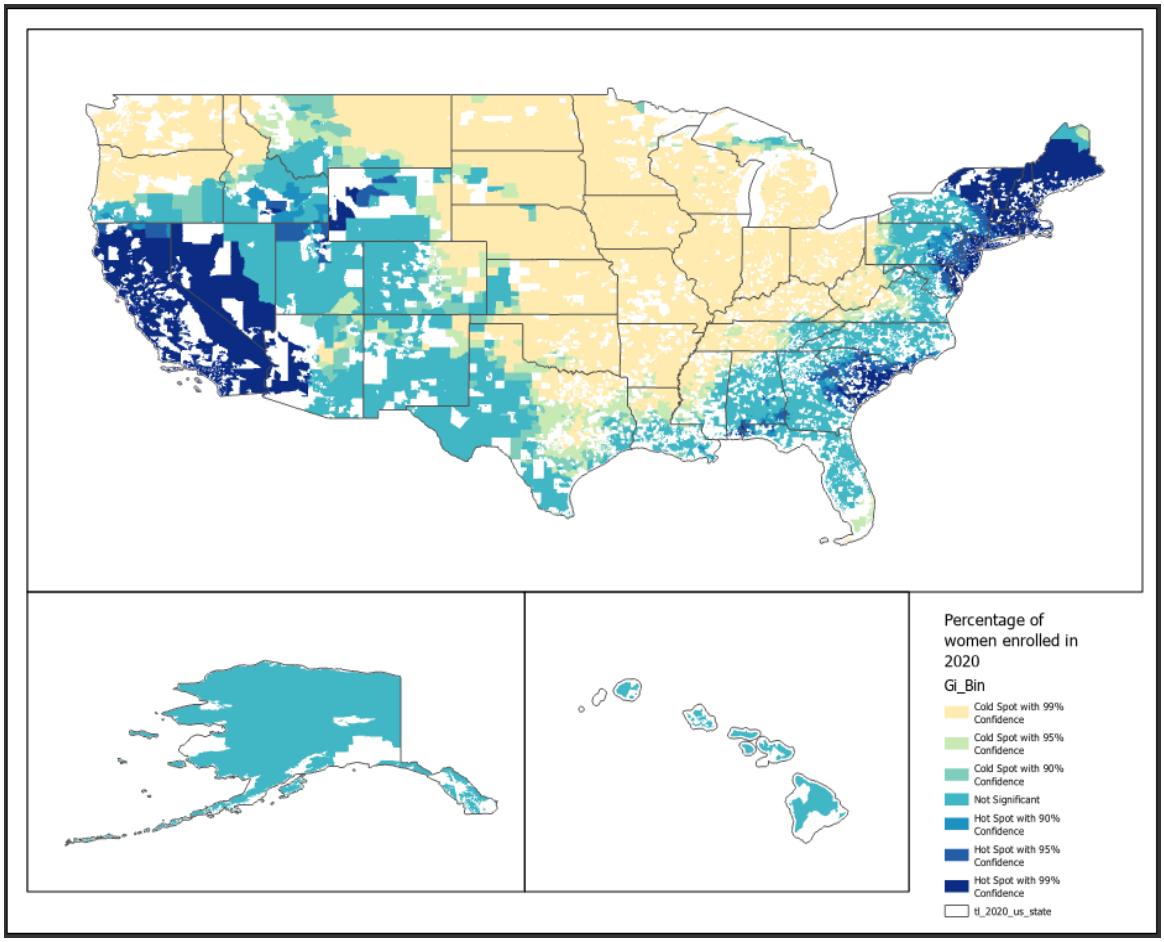

Figure 6. Hotspot analysis of percentage of women enrolled undergraduate coursework in the US in 2020

women's enrollment. There were shifts (cold spots) in enrollment in the eastern part of the Midwest (Michigan, Wisconsin, Vermont etc.). This may be due to several factors e.g., demographics, educational attainment, poverty etc.

Table 6 is a paired samples t-test output. There was a p-value of <0.001 which means, there is a statistically significant difference in the percentage of women enrolled in higher education in 2010 and 2020. As much as there were some areas that were consistent in enrollment, statistically, there was a difference (shifting) in women's undergraduate in the US for 2010 (before) and 2020 (after).

Table 6. Paired samples t test of women's enrollment in higher education in 2010 and 2020

	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference		t	df	Significance	
				Lower	Upper			One-Sided p	Two-Sided p
PER2010-PER2020	0.368	2.584	0.010	0.348	0.389	35.405	61740	<0.001	<0.001

2. Identify geographical regions (census tracts) with a high positive percentage change of women enrolling in higher education in the U.S in 2010 and 2020. Which census tracts in the United States experienced substantial positive percentage changes in women's enrollment in higher education between 2010 and 2020?

Figure 7 shows the percentage change of female enrollment by US census tracts from 2010 to 2020. Some key observations include the following:

The most significant increases appear to be concentrated within census tracts located along the East and West coasts, particularly within major metropolitan areas such as New York, Los Angeles, and the San Francisco. Some tracts show over 250% increases indicating rapid expansions of female participation in higher education. Portions of the Midwest and Southern US have more mixed trends - some areas show moderate gains of 75.01-250% which is still substantial growth, while others in yellow indicate declines up to -11.99% fewer enrolled females in 2020 compared to 2010.

Figure 8 indicates a clear regional pattern, with the highest growth rates clustered particularly within California, Arizona, Utah, Nevada, Idaho, Wyoming, Florida, and Georgia. There are clusters of census tracts with declining rates of female enrollment in the Upper Midwest around Illinois and Michigan. There are both hotspots and not statistically significant clusters in Texas, which are geographically close to one another. Washington, Oregon, Montana, Hawaii, Alaska and Colorado seem more stagnant without statistically significant clusters. Figure 9 shows statistically significant census tracts with high women's enrollment. These census tracts were further divided into regions namely, the Northeast, South and West.

3. Examine various factors contributing to the positive percentage change in women's enrollment within higher education coursework across distinct geographical areas (census tracts) in the United States between 2010 and 2020 is objective 3. The question guiding this objective is:

What factors, both socio-economic and demographic, contribute significantly to the observed percentage change in female enrollment within higher education institutions across diverse census tracts in the United States during the period from 2010 to 2020?

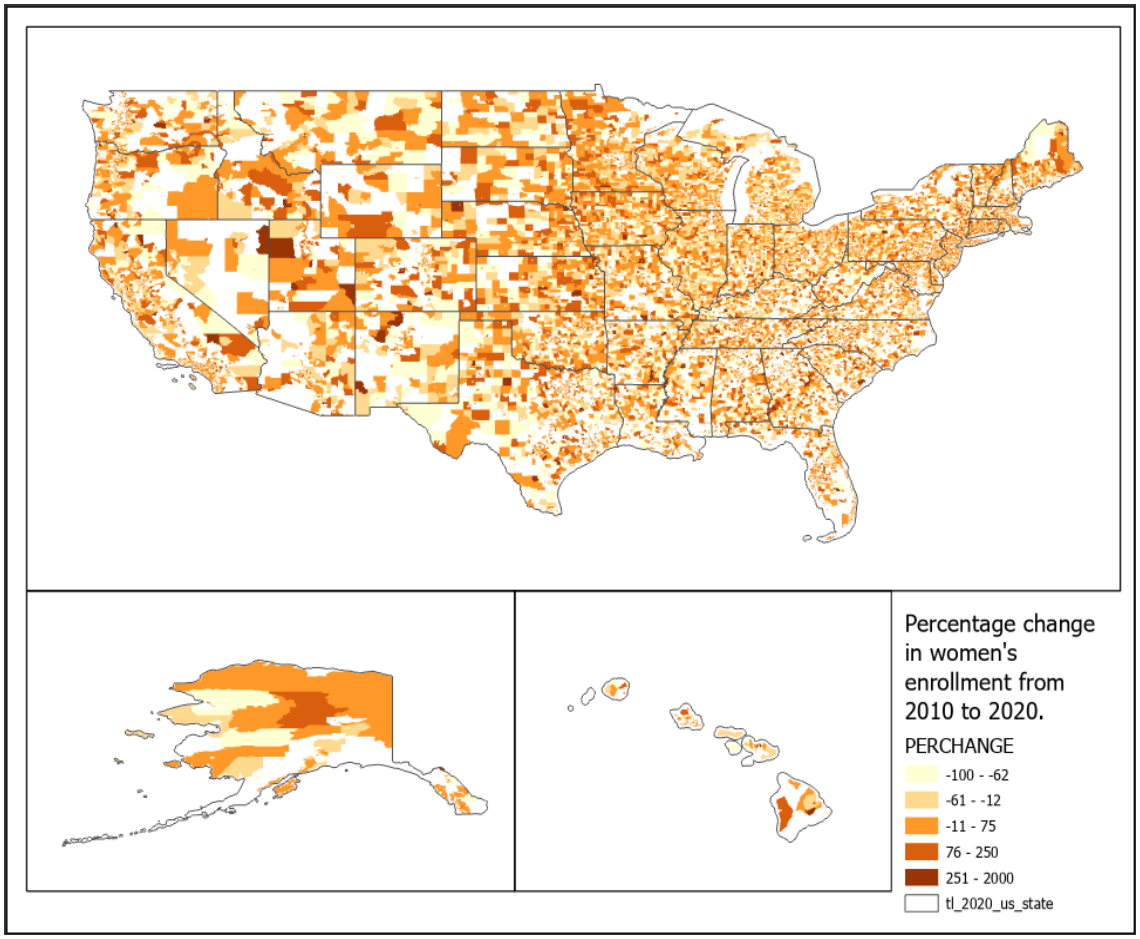

Figure 7. Choropleth map showing the percentage change in women's enrollment from 2010 to 2020 by census tracts.

Upon identifying areas with a statistically significant high percentage change (hotspots), these areas (Northeast, South and West) are organized into four distinct groups based on their relationship to the identified breakpoints in PER2010 and PER2020 data. Specifically, these groups are as follows: areas occurring before the PER2010 breakpoint of 2.449 (designated as Group 1), areas occurring after this breakpoint (Group 2), areas before the PER2020 breakpoint of 5.551 (Group 3), and areas following this latter breakpoint (Group 4) as shown in Table 7.

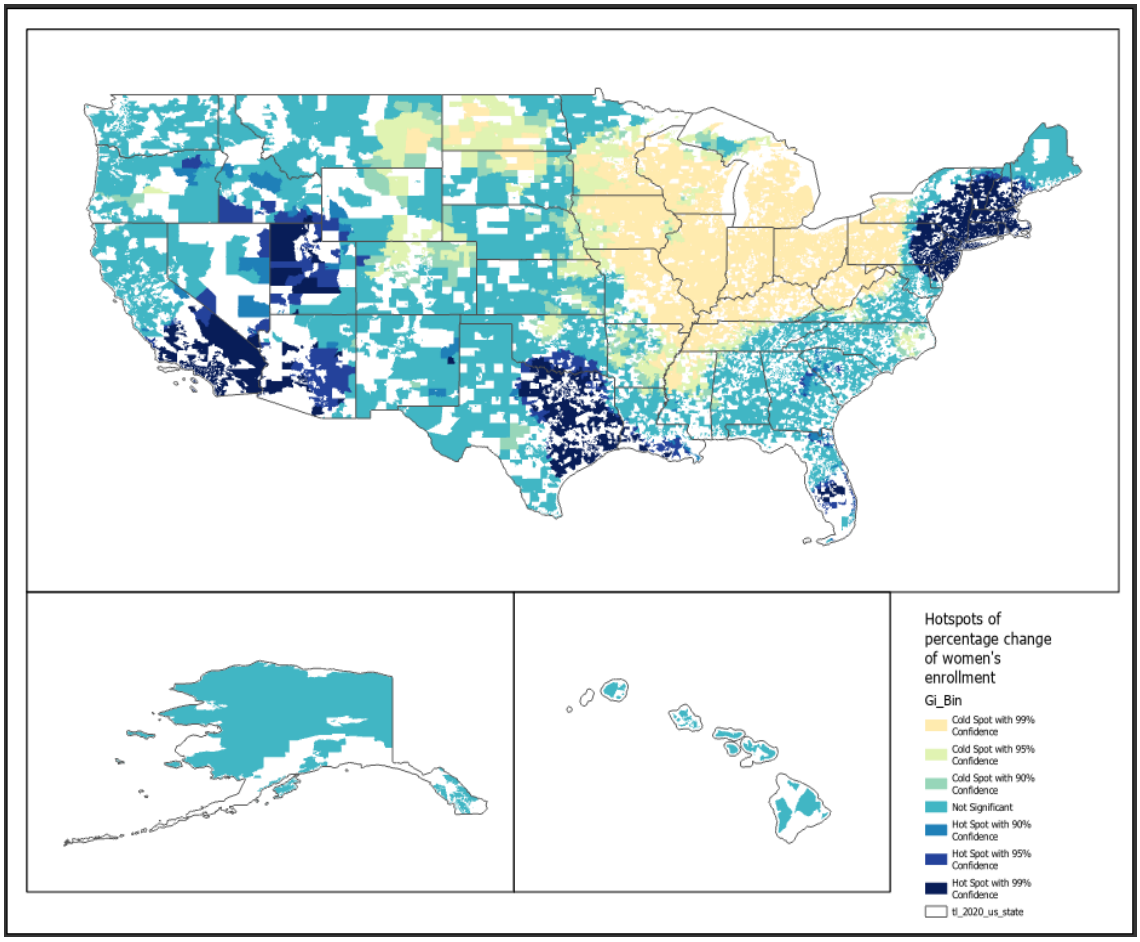

Figure 8. Hotspots for female enrollment from 2010 to 2020 by census tracts.

In Table 8 statistically significant socio-economic factors that correlated with the high percentage change in women's undergraduate enrollment were identified. A multiple linear regression was done with the statistically significant socio-economic factors as the independent variables and the PERCHANGE as the dependent variable.

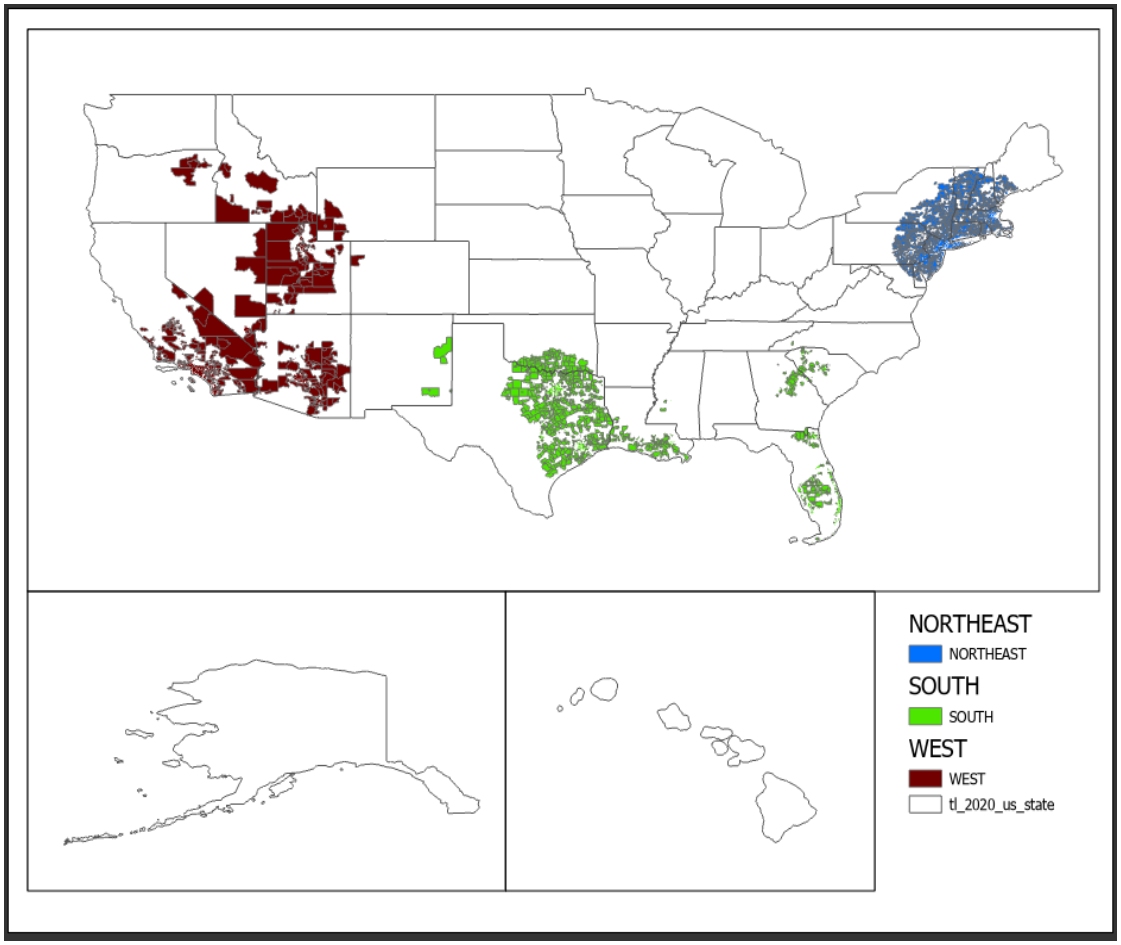

Figure 9. Statistically significant census tracts with high women's undergraduate enrollment from 2010 to 2020.

Multicollinearity

In order to ascertain the reliability of the regression analysis, multicollinearity among the independent variables was meticulously assessed utilizing the Variance Inflation Factor (VIF). This step was crucial to ensure that the independent variables selected for the analysis did not exhibit significant interrelationships, which could potentially skew the results. The regression analysis was conducted for each group with PERCHANGE serving as the dependent variable, incorporating the socio-economic factors identified as statistically significant in Table 8. To maintain the integrity of the analysis, any factors exhibiting VIFs greater than 5—a

threshold indicating substantial multicollinearity—were systematically excluded from subsequent analyses. This iterative process was repeated until all remaining

Table 7. Categories based on thresholds

Groups	Description
Group 1(Below 2010 threshold)	Census tracts with the percentage of women enrolled undergraduate coursework in the US in 2010 that fell below the threshold of 2.449%
Group 2(Above 2010 threshold)	Census tracts with the percentage of women enrolled undergraduate coursework in the US in 2010 that fell above the threshold of 2.449%
Group 3(Below 2020 threshold)	Census tracts with the percentage of women enrolled undergraduate coursework in the US in 2020 that fell below the threshold of 5.551%
Group 4(Above 2020 threshold)	Census tracts with the percentage of women enrolled undergraduate coursework in the US in 2020 that fell above the threshold of 5.551%

Table 8. Correlation between PERCHANGE and socioeconomic factors for all groups

	Group 1	Group 2	Group 3	Group 4
SVI theme 1(Socioeconomic status)	0.016	0.006	**0.018****	0.027
SVI theme 2(Household Characteristics)	0.013	0.004	0.014	0.032

Table 8 — continued

SVI theme 3(Racial and Ethnic Minority Status)	0.014	0.005	0.014	0.031
SVI theme 4(Housing Type and Transportation	0.015	0.005	0.014	0.031
Population estimate (female population)	**-0.023****	**0.114****	-0.008	**-0.186****
Population estimate (total population)	-0.004	**0.093****	**0.019****	**-0.146****
Female attainment percentage (bachelor's degree)	0.000	**0.043****	**0.036****	**0.074****
Income percentage (less than 10,000)	**0.031****	-0.017	**0.038****	0.006
Income percentage (200,000 or more)	-0.011	**-0.067****	-0.005	-0.001

** indicates results that are statistically significant at the 0.001 level

statistically significant factors demonstrated VIF values below 5, effectively minimizing concerns related to multicollinearity. This rigorous approach ensured that the final regression models were both robust and reliable, providing a solid foundation for interpreting the impact of socio-economic factors on the percentage change of women enrolling in undergraduate higher education.

Analysis Results for Group 1 (Below 2010 Threshold)

From Table 9 the regression model has a relatively low R-squared value of 0.001, indicating that only 0.1% of the variance in the percentage change in women's undergraduate enrollment (PERCHANGE) is explained by the socioeconomic factors included in the model. This suggests there are other important statistically significant factors not accounted for that influence changes in women's enrollment. Table 10 which shows the model overall is statistically significant (p=0.005) meaning the relationships found between the socioeconomic predictors and PERCHANGE are unlikely due to chance. From Table 11, the positive coefficient (1.234) of the income percentage (10,000 or less) indicates that in census tracts with high positive change in female enrollment, areas with families earning $10,000 or less are associated with even greater increases in female undergraduate enrollment. This suggests that in communities seeing significant educational shifts, lower income may be a driving factor or at least correlate with these increases. This could reflect effective targeting of educational outreach or financial aid programs towards lower-income populations, contributing to increased accessibility of higher education for women in these areas.

Table 9. Regression model for Group 1

Model	R	R Square	Adjusted RSquare	Std. Error of the Estimate
1	0.031[a]	.001	.001	142.625

a. Predictors: (Constant), Income percentage (10,000 or less)

Table 10. ANOVA for Group 1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	161064.426	1	161064.426	7.918	0.005[b]
	Residual	165866765.150	8154	20341.767		
	Total	166027829.576	8155			

a. Dependent Variable: PERCHANGE
b. Predictors: (Constant), Income percentage (10,000 or less)

Table 11. Regression analysis for Group 1

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Standard Error	Beta			Tolerance	VIF
1 (Constant)	62.445	1.594		39.186	<0.001		
Income percentage (10,000 or less)	1.234	0.439	0.031	2.814	0.005	1.000	1.000

a. Dependent Variable: PERCHANGE

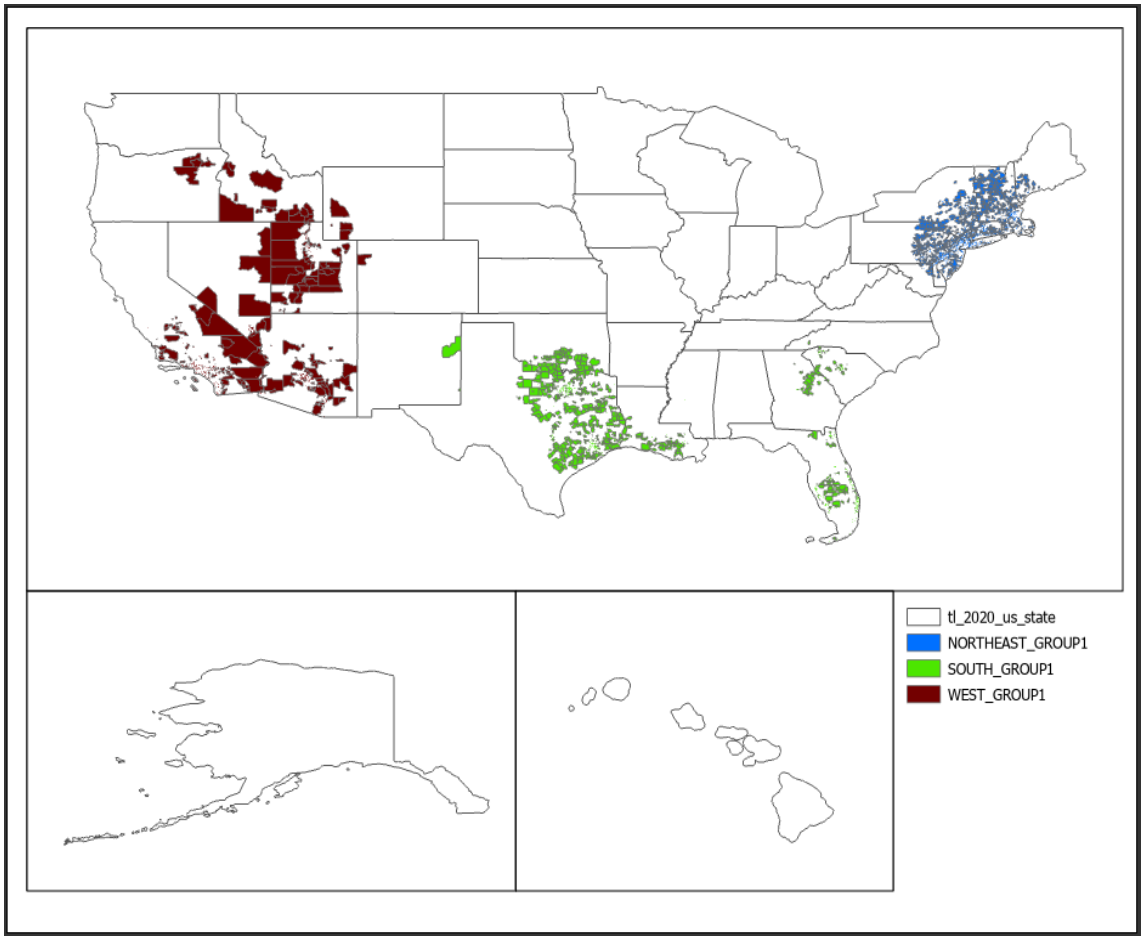

Figure 10. Map depicting census tracts identified in the growth hotspot analysis with PER2010 falling below 2.445%.

Analysis Results for Group 2 (Above 2010 Threshold)

From Table 12 the regression model has an R-squared of 0.014, indicating that 1.4% of the variance in PERCHANGE is explained by the socioeconomic predictors. The overall model is statistically significant ($p<0.001$) as shown in Table 13. From Table 14 the positive coefficient (0.006) of the female population indicates that an increase in the female population within a census tract is associated with an increase in the percentage change of women enrolling in undergraduate education. This suggests that areas with larger female populations see higher growth in female enrollment in higher education.

The positive coefficient (0.023) of educational attainment emphasizes the importance of existing educational levels within a community as a motivator for further educational pursuit.

The negative coefficient (-1.499) of the income percentage (200,000 or more) continues to suggest that higher income levels are associated with less pronounced increases in female enrollment. This is consistent with the findings from Group 1.

Table 12. Regression model for Group 2

Model	R	R Square	Adjusted RSquare	Std. Error of the Estimate
1	0.119[a]	0.014	0.014	46.524

a. Predictors: (Constant), Population estimate (female population), Female attainment percentage (bachelor's degree), Income percentage (200,000 or more).

Table 13. ANOVA for Group 2

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	259554.250	3	86518.083	39.972	<0.001[b]
	Residual	18151329.046	8386	2164.480		
	Total	18410883.295	8389			

a. Dependent Variable: PERCHANGE
b. Predictors: (Constant), Population estimate (female population), Female attainment percentage (bachelor's degree), Income percentage (200,000 or more).

Table 14. Regression analysis for Group 2

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Standard Error	Beta			Tolerance	VIF
1 (Constant)	-36.091	1.776		-20.325	<0.001		
Population estimate (female population)	0.006	0.001	0.094	8.495	<.0001	0.953	1.049
Female attainment percentage (bachelor's degree)	0.023	0.006	0.038	3.533	<0.001	0.996	1.004
Income percentage (200,000 or more)	-1.918	0.513	-0.042	-3.737	<0.001	0.949	1.054

a. Dependent Variable: PERCHANGE

Analysis Results for Group 3 (Below 2020 Threshold)

From Table 15 the model has a low R-squared of 0.005, indicating socioeconomic factors explain only 0.5% of the variance in PERCHANGE. However, the model is statistically significant ($p<0.001$) according to Table 16.

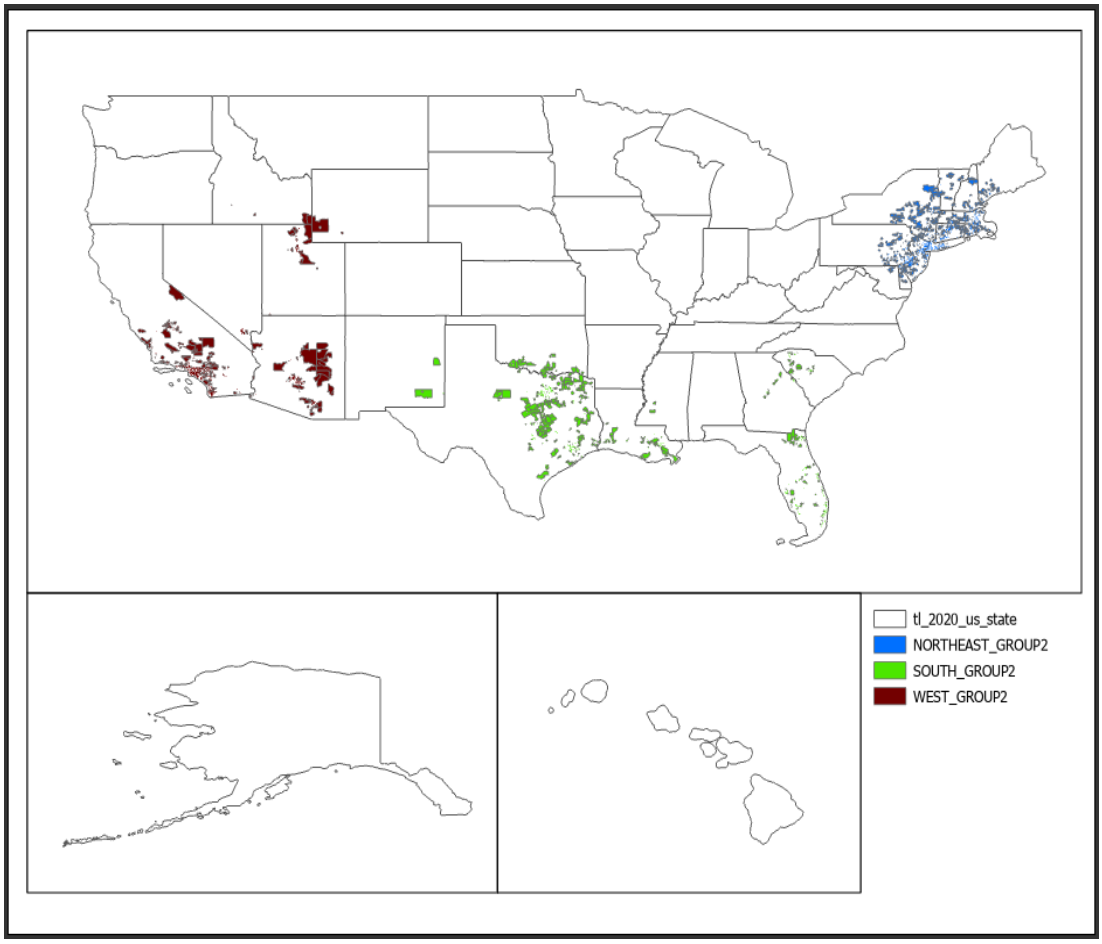

Figure 11. Map depicting census tracts identified in the growth hotspot analysis with PER2010 falling above 2.445%.

From Table 17, 2.582 indicates a positive association with PERCHANGE, suggesting higher socioeconomic status within census tracts is associated with an increase in the percentage change of female enrollment, which is statistically significant. This suggests a higher socioeconomic status correlates with increases in female enrollment changes, possibly reflecting the availability of resources or value placed on education within these communities.

The coefficient (0.002) of the total population with a significance level of <0.001 indicates a positive relationship between total population size and the percentage change in female enrollment. This suggests that, all else being equal, larger populations are associated with marginally higher percentage changes in female enrollment.

The coefficient (0.036) suggests that higher educational attainment within the female population is positively associated with PERCHANGE and is statistically significant. 5.815 indicates that lower income levels are significantly positively associated with PERCHANGE, suggesting that census tracts with a higher percentage of the population earning less than $10,000 see a greater increase in the percentage change of female enrollment. Both higher educational attainment within the female population and a higher proportion of lower-income earners are positively related to enrollment changes. These could indicate the effectiveness of targeted educational policies or programs aimed at improving access to higher education for women, especially from lower-income backgrounds.

Table 15. Regression model for Group 3

Model	R	R Square	Adjusted RSquare	Std. Error of the Estimate
1	0.074[a]	0.005	0.005	89.724

a. Predictors: (Constant), Population estimate (female population), Female attainment percentage (bachelor's degree), Income percentage (200,000 or more).

Table 16. ANOVA for Group 3

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	558005.622	4	139501.405	17.329	<0.001[b]
	Residual	101981876.904	12668	8050.353		
	Total	102539882.526	12672			

a. Dependent Variable: PERCHANGE
b. Predictors: (Constant), SVI theme 1(Socioeconomic status), Population estimate (total population), Female attainment percentage (bachelor's degree), Income percentage (less than 10,000)

Table 17. Regression analysis for Group 3

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Standard Error	Beta			Tolerance	VIF
1 (Constant)	-12.600	2.984		-4.222	<0.001		
SVI theme 1(Socioeconomic status)	2.582	0.948	0.028	2.722	0.006	0.744	1.345
Population estimate (total population)	0.002	0.001	0.032	3.452	<0.001	0.924	1.082
Female attainment percentage (bachelor's degree)	0.036	0.008	0.039	4.351	<0.001	0.997	1.003
Income percentage (less than 10,000)	5.815	1.502	0.041	3.872	<0.001	0.704	1.419

a. Dependent Variable: PERCHANGE

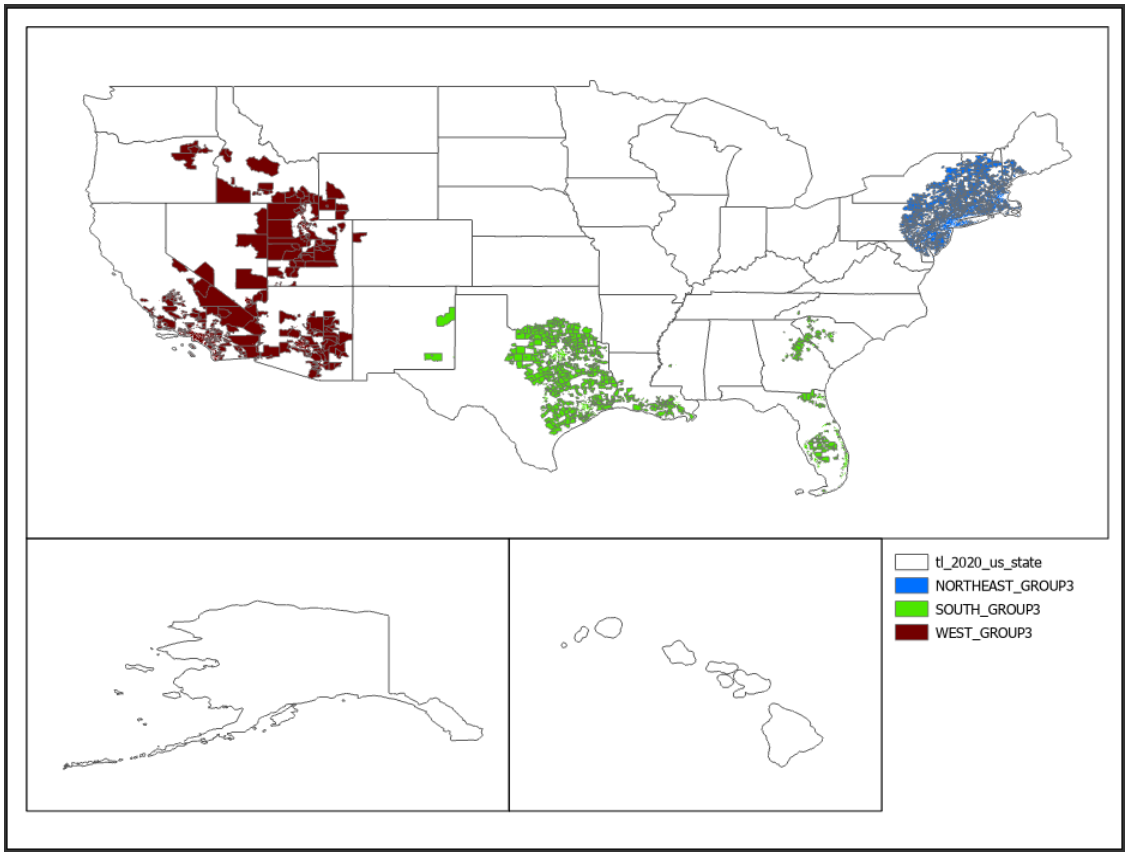

Figure 12. Map depicting census tracts identified in the growth hotspot analysis with PER2020 falling below 5.551%.

ANALYSIS RESULTS FOR GROUP 4 (ABOVE 2020 THRESHOLD)

From Table 18 the model has an R-squared value of 0.035, indicating that 3.5% of the variance in PERCHANGE is explained by the population estimate. The overall model is statistically significant ($p<0.001$) as shown in Table 19. From Table 20 the negative coefficient (-0.052) of the female population with a significance level of <0.001 suggests that lower female populations are associated with a higher percentage change in female enrollment. This could indicate that in areas with larger female populations, the relative increase in female enrollment in undergraduate education is somewhat dampened, possibly due to a variety of factors including saturation or differing socio-economic conditions that affect enrollment growth rates.

Table 18. Regression model for Group 4

Model	R	R Square	Adjusted RSquare	Std. Error of the Estimate
1	0.186[a]	0.035	0.034	229.980

a. Predictors: (Constant), Population estimate (female population)

Table 19. ANOVA for Group 4

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1865262.881	1	1865262.881	35.266	<0.001[b]
	Residual	52044409.221	984	52890.660		
	Total	53909672.101	985			

a. Dependent Variable: PERCHANGE
b. Predictors: (Constant), Population estimate (female population)

Table 20. Regression analysis for Group 4

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Standard Error	Beta			Tolerance	VIF
1 (Constant)	209.884	18.800		11.164	<0.001		
Population estimate (female population)	-0.052	0.009	-0.186	-5.939	<0.001	1.000	1.000

a. Dependent Variable: PERCHANGE

Figure 13. Map depicting census tracts identified in the growth hotspot analysis with PER2020 falling above 5.551%.

Chapter Summary

Analysis conducted for this study provide a comprehensive examination of trends in women's undergraduate enrollment across the United States from 2010 to 2020. The exploratory data analysis (EDA) revealed statistically significant correlations between the enrollment percentages across the years in question, indicating that areas with high enrollment rates in 2010 tended to maintain them in 2020, and similarly, areas with low rates continued on that trend.

The presence of non-linear relationships between the percentage changes in women's enrollment over the decade and the enrollment figures at the beginning and end of the period. This was elucidated through the creation of scatterplots which indicated the necessity for a segmented linear regression analysis to further dissect these patterns.

The segmented regression analysis uncovered breakpoints, suggesting a dual relationship: regions with initially higher enrollment rates experienced a decrease in enrollment change, while surpassing a certain threshold, the increase in initial enrollment rates corresponded with an increase in enrollment change. This complex interplay of dynamics offers a nuanced understanding of the factors influencing educational trajectories.

Hotspot mapping added a spatial dimension to the analysis, highlighting clusters of census tracts with significant changes in women's enrollment, and revealing that certain regions such as the Northeast, Southeast, and West Coast experienced higher enrollment rates. These hotspots indicate potential areas where policy interventions or educational resources might be particularly effective.

The study also investigated socio-economic factors that contributed to the observed changes in enrollment. The analysis showed that while these factors accounted for some variance in enrollment changes, they did not wholly explain the trends, suggesting that other, unmeasured factors may play significant roles.

Further, the analysis conducted through the paired samples t-test confirmed a statistically significant difference in the percentage of women enrolled in higher education between 2010 and 2020, indicating a shift in women's undergraduate enrollment patterns over the decade in question.

Regional analysis illustrated that the most significant increases in female enrollment occurred along the East and West Coasts. The socio-economic and demographic factors contributing to these trends were explored through regression models, which provided insights into the complex relationship between educational attainment, income levels, and changes in women's enrollment.

In summary, this study has unearthed spatial and socio-economic patterns affecting women's undergraduate enrollment, uncovering both consistent trends and notable shifts over the past decade. These findings contribute to a deeper understanding of the educational landscape in the United States and pave the way for targeted interventions to support women's access to higher education.

CHAPTER 5
KEY FINDINGS, CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

Introduction

This chapter discusses outcomes of this research, which provided answers regarding the data in relation to the specific objectives of the study. Looking specifically at the spatial patterns and distribution of women's undergraduate enrollment in the US from 2010 to 2020, the analysis identified socioeconomic factors that affected undergraduate enrollment rates for women across certain census tracts in the US.

Key Findings

In the United States, there was a noticeable uptick in women's undergraduate enrollment between 2010 and 2020. However, this upward trend was not uniformly observed across all census tracts throughout the decade. Specifically, regions in the Northeast, Southeast, and West Coast exhibited sustained high levels of enrollment during both 2010 and 2020, indicating the influence of persistent factors that promote women's undergraduate enrollment across these years. Conversely, the Midwest saw a notable transformation in its enrollment landscape, transitioning from a region of high enrollment (a hotspot) in 2010 to one of lower enrollment (a cold spot) by 2020. This shift in the Midwest's enrollment status underscores the dynamic nature of educational trends and points to underlying causes that merit further investigation.

For census tracts that were PERCHANGE hotspots with initial enrollment rates below the 2010 threshold of 2.449%, the analysis indicated that lower income levels were associated with increases in enrollment, whereas higher income levels showed the opposite effect. The reason could be that lower-income communities may benefit more from financial aid, scholarships, and targeted educational outreach programs designed to increase access to higher

education. These initiatives can significantly impact enrollment rates by alleviating financial barriers and raising awareness about the importance and viability of undergraduate higher education. Conversely, in higher-income areas, the negative relationship with enrollment changes could reflect a saturation effect, where a higher baseline of educational attainment leaves less room for substantial percentage increases. Additionally, individuals in these areas might have access to a broader range of educational and career opportunities, not solely focused on traditional undergraduate pathways. There was also a significant positive correlation between female educational attainment and enrollment changes, with an inverse relationship for larger female populations. High levels of educational attainment may act as a beacon, inspiring further pursuit of education within the community.

For tracts with initial enrollment rates above the 2010 threshold, a positive association with female population size suggests nuanced influences of community size on educational trends. Larger female populations could indicate more community resources, such as schools, libraries, and support programs, potentially fostering a more conducive environment for educational pursuit and achievement. The presence of a sizable female population interested in education might create a reinforcing cycle of motivation and support, where peers, family members, and role models within the community inspire more women to pursue higher education, unveiled a significant positive correlation between female educational attainment and enrollment changes.

In areas with enrollment rates below the 2020 threshold of 5.551%, both total population size and low-income estimates had impacts on enrollment changes. Total population had an impact on the enrollment changes though minimal. As the population increases the enrollment rates also increase, which was also seen in the previous groups.

The analysis for census tracts with higher enrollment rates in 2020 underscores the importance of role models and the cultural valuation of education, where success stories of higher education attainment encourage more women to enroll. Despite facing socioeconomic challenges, communities might demonstrate a strong resolve to overcome these barriers, with education seen as a key pathway to improving one's circumstances. The relationship might also reflect community and cultural dynamics where the value placed on education is high. In such contexts, families and communities may prioritize education for women despite facing socioeconomic challenges.

Conclusion

The analysis reveals the multifaceted influences of socio-economic factors on women's undergraduate enrollment trends. Lower income levels correlate with an increase in enrollment, emphasizing the possibility of the pivotal role of financial aid, scholarships, and educational outreach programs in enhancing access to higher education for underprivileged communities. Larger female populations could also benefit from extensive support systems and resources, fostering educational aspirations and achievements. However, the presence of educational role models and a culture that values higher education significantly boosts undergraduate enrollment changes, acting as a powerful motivator for women to pursue undergraduate studies. Conversely, higher income levels and larger female populations in certain contexts exhibit an inverse relationship with enrollment changes, underscoring the need for tailored interventions to address specific barriers and promote educational aspirations. Ultimately, the findings highlight the importance of targeted financial support, community engagement, and the cultivation of educational role models to effectively increase female participation in undergraduate education across diverse socio-economic landscapes.

Recommendations

For census tracts grappling with low female enrollment in undergraduate programs, the findings offer actionable insights. Increasing scholarship opportunities could serve as a pivotal strategy, effectively mitigating financial barriers that deter women's access to higher education. By prioritizing scholarships and financial aid targeted towards women, these census tracts can foster a more inclusive educational landscape, enabling women from diverse economic backgrounds to pursue undergraduate studies. This approach not only addresses immediate financial constraints but also contributes to a broader cultural shift towards valuing and supporting women's educational achievements. In communities where female educational attainment is already high, policymakers should focus on sustaining and amplifying this positive trend. Initiatives to create supportive networks, mentorship opportunities, and career counseling services can empower women to continue their academic journeys. Additionally, fostering collaborations with organizations can open pathways for internships, research opportunities, and eventual employment, further incentivizing women to pursue undergraduate education.

Further Research

Subsequent research could explore how the presence or accessibility of institutions offering undergraduate degrees influences enrollment patterns within census tracts. This study could examine factors such as distance to the nearest college or university, the variety of programs offered, and the impact of these institutions' availability on local communities' educational outcomes. It would also be intriguing to explore the transformation of the Midwest from being a hotspot for female enrollment in undergraduate programs in 2010 to a cold spot by 2020. Understanding the dynamics and factors contributing to this shift could provide valuable insights into regional educational trends.

Limitations

Socio-Economic Factors: This study incorporates certain socio-economic factors in its analysis. However, it may not account for all relevant variables. For instance, cultural or personal factors that could influence women's decisions to pursue higher education may not be captured by the data used in this study.

Macro-Level Influences: The analysis does not adjust for the potential impacts of broader economic, political, and social policy changes that occurred between 2010 and 2020. Macro-level factors such as economic recessions, shifts in the political climate, or changes in the availability of student aid could have influenced the observed trends in women's enrollment in higher education.

Unaccounted Factors: There may be other factors not included in the analysis that could influence the observed spatial patterns. These could include college admissions policies, cultural norms, individual aspirations, and other elements that might affect women's decisions to enroll in undergraduate coursework. The potential influence of these unaccounted factors represents a limitation of the study.

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