2018

Modeling the In-state Geographic Market Changes of South Dakota Public University Enrollments, 2006 to 2015

John Green
South Dakota State University

MODELING THE IN-STATE GEOGRAPHIC MARKET CHANGES OF SOUTH DAKOTA PUBLIC UNIVERSITY ENROLLMENTS, 2006 TO 2015

BY

JOHN GREEN

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Geography

South Dakota State University

2018

MODELING THE IN-STATE GEOGRAPHIC MARKET CHANGES OF SOUTH DAKOTA PUBLIC UNIVERSITY ENROLLMENTS, 2006 TO 2015

BY

JOHN GREEN

This thesis is approved as a creditable and independent investigation by a candidate for the Masters of Science degree in Geography and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Robert Watrel, Ph.D
Thesis Advisor Date

Robert Watrel, Ph.D
Head, Department of Geography Date

Dean, Graduate School Date

ACKNOWLEDGEMENTS

I would like to first thank the entire faculty and staff of the Department of Geography for their continued support throughout this program and their commitment to independent research and professionalism. To my thesis advisor, Dr. Robert Watrel, thank you for your support and for helping me to focus my research into this thesis. To Dr. Jamie Spinney, I sincerely thank you for your time and effort to help me answer questions about my research as they arose. To Dr. Darrell Napton, I would like to thank you for always having an open door and helping me foster my passion for Geography.

To my friends and my roommates, I cannot thank you enough for your support throughout this process. To my family, I cannot overstate how much your support has meant to me throughout my education. To my brother, Joe, thank you for providing me an outlet to talk to when I felt overwhelmed. To my sister, DeLaney, thank you for your constant advice and support. To my father, Jim, thank you for showing me an example of what it means to be a lifelong learner. And to my mother, Claire, thank you for guiding me in this process and sharing in all my struggles and successes.

TABLE OF CONTENTS

ABBREVIATIONS

BHSU	Black Hills State University
DSU	Dakota State University
GLA	Gross Leasable Area
LQ	Location Quotient
NSU	Northern State University
SDBOR	South Dakota Board of Regents
SDSMT	South Dakota School of Mines & Technology
SDSU	South Dakota State University
USD	University of South Dakota

LIST OF EQUATIONS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

MODELING THE IN-STATE GEOGRAPHIC MARKET CHANGES OF SOUTH DAKOTA PUBLIC UNIVERSITY ENROLLMENTS, 2006 TO 2015

JOHN GREEN

2018

The spatial nature of how high school students choose a college has become an integral part of the recruitment process at universities across the country. In South Dakota, the impact of distance on enrollment at state operated institutions influences the geographic footprint of each university. Between 2006 and 2015, the nature of those enrollment numbers and geographic footprints changed within the state, creating enrollment stagnation or decline at state run institutions. This research paper addresses the geographic nature of those enrollment declines, models the college enrollment decision of students in the state, and applies those findings towards potential enrollment projections. Results indicate that underperforming markets in eastern South Dakota may be responsible for enrollment stagnation and the target of future enrollment planning focuses.

Key Terms: College Enrollment, Spatial Interaction, Retail Model, Location Quotient, South Dakota

CHAPTER I: INTRODUCTION

Enrollment competition among colleges has increased in the last two decades, making the impact of location in the college selection process more important than in previous decades (Smith, Spinelli, and Zhou 2002). Within this context of increased college competition in a static space, the importance of understanding how potential students evaluate their educational options has implications for the recruitment of new students. However, this process is not exclusive to high school seniors considering their post-secondary education options. Rather, this process is present in all human decisions that involve location selection based upon distance and some measure of locational utility (Johnston 2010).

This research examines the broader problem of spatial decision-making, and how these heuristics change with distance. The spatial decision-making process has given rise to several geographic theories and models that attempt to quantify the impact of distance on human decision-making. Some of those theories include the Gravity Model, Reilly's Law, and the Huff Model (Suarez-Vega 2015). In today's world, stores such as Target and Walmart regularly attempt to quantify that decision-making process as it relates to consumer shopping behavior. It is a similar process to the ones that determined why certain places and cities were founded in a given location, and why other locations were not chosen (Greenwood 2005). That selection process involves human preference of certain places that are competing with each other in a two-dimensional space (Cadwallader 1975). The problem is, therefore, defined as the spatial competition between two or more places for a given interaction.

In 2013, South Dakota State University (SDSU) established a goal that enrollment at the university should increase by nearly 2,000 students over the course of a five-year period. Three and half years into that five-year period, enrollment at SDSU has increased by only 200 students. The goal was established in 2010 when system wide enrollments at public institutions in South Dakota peaked at over 26,000 students (SDSU 2010). Between the years of 2011 and 2015, those record high enrollment numbers waned to just over 23,000 students. Further investigation into the spatial nature of the enrolment decline within the state shows that there is spatial disparity in declining university enrollment across the state. The differing nature of the college decision process within the spatial context of each of South Dakota's 66 counties may help explain the reasons why the state's counties unevenly supply students to each public university. The various social and economic differences between each of the state's 66 counties, combined with differing distances from each college, have contributed to the current changes in enrollment patterns at SDSU. A better understanding of how those factors have changed from 2006 to 2015 has the potential to provide important insights that could help SDSU achieve its goal of a 2,000-student increase in enrollment.

Because there are fewer South Dakota students enrolling in state universities, the competition for in-state students is very high. As a land grant institution, it is reasonable to suspect that SDSU represent every area of the state, as part of its goal to provide high levels of access to higher education within the region. Since an in-state targeted enrollment increase must come from South Dakota residents, there is a higher likelihood of those students staying in South Dakota after college (Cooke and Boyle 2011). This creates an economic boost to the state, because more of its professionals are unlikely to take their talents to neighboring states. South Dakota is currently one of the largest per capita exporters of recent college graduates, which creates a shortage of professionals and offers little return on investment within the state (Bui 2016). Specifically, this research is important to SDSU, because an increase in enrollment means an increase in revenue, and, therefore, an increased budget. The budget increase is important, because it allows the university to meet other goals outlined in its master plan to become a more regionally important and nationally recognized university.

Within the geographic context of the state of South Dakota, this research attempts to demonstrate how the spatial decision-making process can be used to explain where South Dakota high school students attend college after graduation, and why that process is different in the various regions of the state.

The college decision-making process within the study area can be defined on two scales. The first scale deals with the changes in enrollment trends in the urban and rural counties of South Dakota, and the potential impact of local influences on that process. The second scale addresses the influence that distance from a university to those local counties may have on the enrollment process. The data that are needed for this analysis are aggregated by county or school district. The data show the enrollment from each county, in a given year, to each of the six public universities within the state. Other required data include information from each university that students may consider in the decision-making process, such as tuition, student size, scholarship endowments, and number of majors offered at the school.

The spatial and temporal context of this research is confined to the state of South Dakota between the years of 2006 and 2015. The data are aggregated by each of South

Dakota's 66 counties, displayed in figure 1.1. The study area for this research is confined to U.S. state of South Dakota, which represents a governmental unit under one governing board of education, the South Dakota Board of Regents (SDBOR). Across a larger, multi-state study region, attraction influences would be more varied, while other push factors and pull factors, such as in-state tuition rates, are more easily defined within one state boundary. The time period for this project was selected due to data availability, and the time in which the statewide enrollment decline appeared. The decrease in state enrollment numbers began in 2011, which allows for analysis for the five years prior when enrollment was growing, and for the five years after 2011 when enrollment declined.

Maps were used to illustrate the spatial distribution of enrollment trends within the state. Location Quotient maps illustrate how some counties supply enrollment at a disproportionate rate to a given state institution and how those patterns have changed during the study period. Maps showing the spatial probabilities of enrollment from the Huff Model were used to quantify potential enrollment probabilities throughout the state. These probabilities were then compared to observed enrollment trends to showcase the spatial nature of residual errors in the expected enrollment compared to observed data (Smith, Spinelli, and Zhou 2002).

The results of this study show the spatial nature of enrollment in South Dakota, and specific trends and patterns of student preference at the county level. Those patterns and trends may help to quantify the probability of a student from a given location enrolling in a given institution in the state. The results of this analysis should help guide South Dakota State University to effectively invest in recruitment of currently undersupplying counties in the state with high mobility students, in order to move closer to their enrollment goal of 14,000 students. This research answers how and why students in South Dakota are choosing their post-secondary education, and the location of under-supplying student markets that may help SDSU achieve its enrollment goals outlined in their *Impact 2018* master plan.

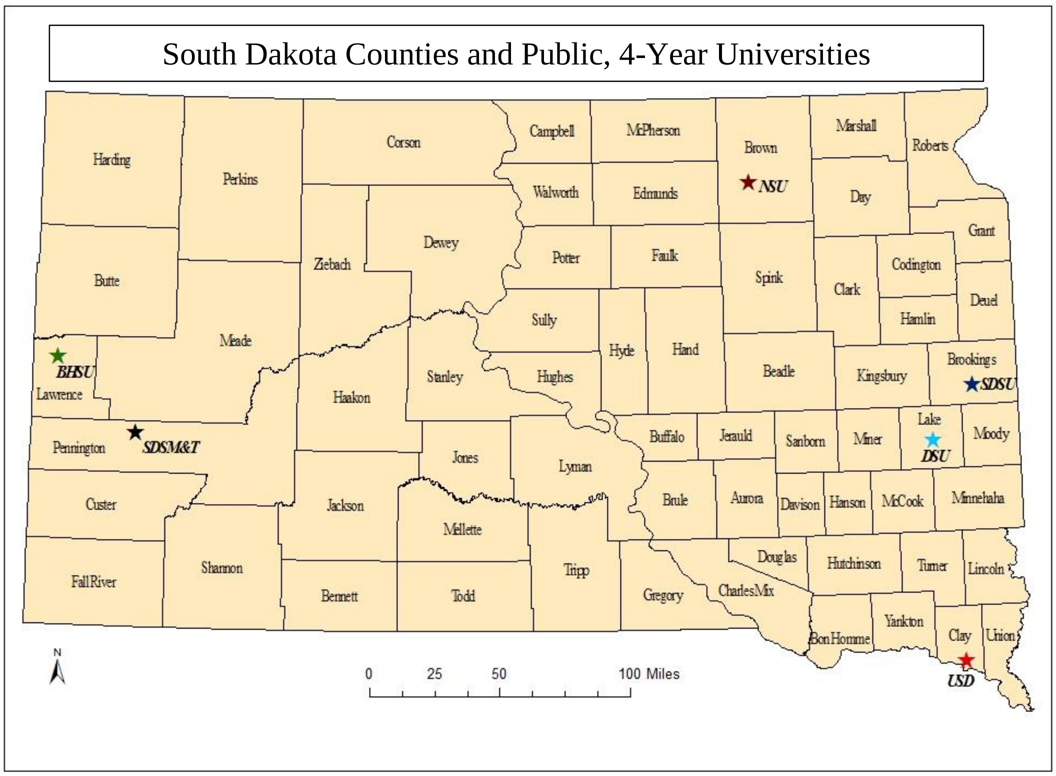

Figure 1.1. Reference map of South Dakota counties and public, 4-year universities.

CHAPTER II: LITERATURE REVIEW

Introduction of the Problem

The role that spatial interaction and relative location have played in human history have been essential to understanding location theory (Thompson and Pred 1969). Models of human decision-making quantify the nature of why humans interact with one place compared to a competing place (Mayo, Jarvis, and Xander 1988). The role that distance plays in that process has been studied extensively, from the context of location theory of historical cities (Bairoch and Braider 1988) to the probability of a consumer purchasing a product at one grocery chain over another (Huff 1968). The role of the distance variable and its interaction with other variables involved in human decision-making have made the study of spatial interaction a cornerstone of geographic thought (Pattison 1964).

In the context of college decisions, a person is subjected to the same type of criteria to decide on their educational location as they are for more basic items such as bread or milk (Dramowicz 2005). While the temporal scale of their decision, the economics of the investment, and the cumulative impacts on their life may be completely different between where to buy bread and where to go to college, the process by which competing locations are measured is essentially the same, whether shopping for bread or a four-year degree (Wolpert 1970).

Understanding the patterns of enrollment decisions is related to the concept of spatial interaction and distance decay (Tobler 1970), market segmentation (Reilly 1931), and destination utility based on economic factors (Hotelling 1929). Many studies have used specific approaches to model enrollment patterns across space. These techniques include qualitative surveys of student preference and socio-economic background (Gnass

2016), quantitative regression modeling (Leppel 1993), and probability mapping (Chen, Kennedy, and Kovacs 2007). Most of the articles published on college selection tend to focus on the socio-economic factors involved in the decision, spatial competition, or the effects of distance on the college decision.

South Dakota Enrollment

Between 2006 and 2015, the state of South Dakota witnessed a rise and fall in its statewide public four-year college enrollments. South Dakota's system of higher education reached a peak enrollment in 2010, with over 26,000 students enrolled at all six Regental institutions (South Dakota Board of Regents 2016). In the period between 2011 and 2015, enrollment declined to just over 23,000 students (South Dakota Board of Regents). That decline created a gap between the enrollment projections and the actual realized enrollment at some universities within the state. Those projections were made based on the 2010 enrollment numbers, which were assumed at the time to be part of a long-term steady enrollment increase, not a short-term anomaly of higher enrollment (South Dakota Board of Regents 2010). The realization of those trends created stagnation in system wide enrollment, which has increased the competition for students within the state (South Dakota Board of Regents 2016).

From an economic perspective, this decrease has also exasperated the existing issue that South Dakota (and many other rural states) face with young professionals leaving the state for job opportunities after attending college. South Dakota loses a large number of in-state educated students to neighboring states after graduation (Bui 2016). Because this migration of young professionals across state lines is more prevalent for non-resident students returning to their home states than in-state students leaving the state altogether (Cooke and Boyle 2011), maximization of resident student enrollment is an important aspect in mitigating the loss of young professionals in the state. Additionally, the difference in placement rates for each university adds increased pressure on enrollment strains, since some universities produce significantly higher numbers of professionals in certain fields than other universities in the study area (South Dakota Board of Regents 2016).

Socio-Economic and Empirical Modeling

In many cases, empirical analysis and regression modeling have been used to better understand and predict the college decision process. Among those studies that empirically analyzed student enrollment, DesJardin, Dundar, and Hendel's (1999) work is especially relevant to modeling enrollment for large, public universities. The researchers used logit models to predict enrollment at a public, land grant university, and their findings showed that institutional characteristics and student aptitude were the most significant factors affecting the enrollment decision (DesJardin, Dundar, and Hendel 1999). However, their model did not include geography, and no student surveys were conducted to better describe the qualitative factors involved in the decision process. Finger (2016) used a factorial survey to assess the constraints upon select demographic cohorts of students who planned on attending college in Germany.

A study conducted in 1993 found that students were more likely to weigh factors such as price and availability of their preferred academic major early on in the decision-making process, while location was the primary variable weighed later in the decision-making process. While that may make location appear low on the priority list for students, it is the main factor that will lead to a student selecting one local college over another, assuming elements such as financial aid and choice of major are similar at both institutions (Leppel 1993). This creates the dynamic for spatial interaction modeling between colleges, using factors such as enrollment size, tuition, number of majors, and distance from home.

High School Surveys

Surveys assessing enrollment processes have been used by educational researchers and geographers alike to provide qualitative analysis on the enrollment decision. Rouse (1994) used the combined analysis of the National Longitudinal Survey, the High School and Beyond Survey, and the Current Population Survey to understand the economic incentives involved in a high school student choosing a 2-year college instead of a 4-year college in California. In some cases, surveys have been used to assess the level of enrollment after the implementation of policy changes (Cappellari and Lucifora 2009) or to better understand socio-economic factors affecting adolescents' enrollment decision after high school (Eccles, Vida, and Barber 2004).

As it relates to this study, surveys were used to understand how students prioritize certain attributes of colleges as they relate to one another. In 2012, a college preference survey was used to understand how students' enrollment decisions are influenced by their classmates' enrollment decisions within the context of geographic competition (Fletcher 2012). Fletcher's (2012) findings indicated that students were 3% more likely to attend a given college when that college was ranked 10% or higher in their classmates' survey of preferred colleges. Additionally, past research has also focused on the impact of university perception on enrollment. Researchers in Colorado found that with increasing distance from a given campus, positive perception of the university declined, and was instead replaced with unknown or negative perception (Landrum, Turrisi, and Harless 1999).

In South Dakota, researchers from Simpson & Scarborough conducted a prospect research survey in 2016 for SDSU to assess the perception of SDSU and its primary in-state and out-of-state competitors (Edwards, Himmelfarb, and San Juan 2016). Results from that survey identified the primary factors involved in the college selection process, and the positive or negative perceptions of SDSU involved in their decision-making process.

Spatial Competition

Many studies have been conducted on the spatial competitiveness of colleges, but these studies typically focused on a limited number of factors to measure competition between schools, such as tuition or reputation of the schools. For example, McMillen, Singell, and Waddell (2007) found that while all colleges will have some type of local or regional pull, many colleges will be more likely to draw a larger percentage of their students from local sources, regardless of whether or not the institution is public or private. They concluded that the main factor influencing whether or not schools had a large geographic recruitment pool was the prestige and size of the university, not whether or not it was private or public (McMillen, Singell, and Waddell 2007). In that study, small private schools had similar footprints to smaller public schools. It was only the most well-known schools in the area that had a larger geographic footprint.

Huff probability models have been used extensively in retail and marketing research to determine store competitiveness and new areas for expansion (Huff 1968). The factors that can be used to quantify spatial patronage probability are often varied and tend to be specific to the context (Dock, Song, and Lu 2015). In their study of restaurant utility, variables such as menu price, available seating, and average dining time were included in their basic model, which accounted for distance and attraction of each location. The diversity of factors permitted by Huff Model analysis make it suitable to study consumer behavior in spatially competitive markets (Huff 1968)

With this utility model, Huff-type analyses has expanded the modeling capabilities of spatial interaction in the presence of intervening opportunities, which has allowed for geographically targeted marketing of patrons. In the college enrollment process, Chen, Kennedy, and Kovacs (2007) used Huff patronage probabilities as part of their larger regression model for enrollment. In some studies, the usefulness of the Huff Model emanates from its ability to simply identify the location and level of spatial competition in each market, as opposed to the raw output of potential patrons in a given market (Aiton and Mclane 2014).

Effects of Distance on Enrollment

In some cases, literature has focused on geographic market analysis of recruiting areas, as opposed to spatially disaggregated regression modeling through the use of location quotients. The impact of distance on spatial relationships is often central to geographic research and is at the core of understanding the influence of one location over another in space (Nekola and White 1999). Location quotients are used by geographers and economists to measure the occurrence of one phenomena at a given scale compared with the occurrence of that same phenomena at a different scale. Location quotients have been used extensively to determine the relative location of a place compared to other aggregated locations (Miller, Gibson, and Wright 1991). Brown and Chung (2006) found that location quotient scores are useful in studies that treat each county as an independent measurement in the greater framework of the study area.

In 2005, location quotients and a gravity model were used to determine counties within the state of Ohio that either under- or over-supplied students to Bowling Green State University (BGSU). The location quotients assessed each county's unique value to the Ohio statewide system and to the BGSU system itself. The gravity model predicted enrollment over space for BGSU compared to the Ohio statewide enrollment, which also calculated residual errors. These errors were then used to better predict the spatial scale of enrollment patterns within the state, and to identify potential new market areas for students based on the difference between actual and potential enrollment (Smith, Spinelli, and Zhou 2002).

A similar study was conducted at Stephen F. Austin State University (SFASU) in Texas in 2008 (Arreguin 2008). That study examined the role that intervening opportunities played in the enrollment decision across the state, stratified by two-year and four-year schools. The results indicated a negative correlation between students enrolled at SFASU and the number of intervening colleges located between the county of origin and the SFASU campus (Arreguin 2008).

Mixed Methods Analysis

Only a few studies have focused on the college decision process as it relates to space, competition, and non-geographic factors, such as socio-economic status or spatial competition for students. For example, Chen, Kennedy, and Kovacs (2007) considered all three factors using multiple regression to determine the significance of location, socio-economic status, and spatial competition in the enrollment decision. They examined the impact of those factors on the enrollment in the pharmacy school at East Tennessee State University. Some of the variables chosen for the model included distance, Huff probability, prestige of competing pharmacy schools, and whether the county was located east or west of the Appalachian Mountains. They found the most significant factors influencing enrollment in their pharmacy college were Huff probabilities, the prestige of competing institutions, and the presence of the Appalachian Mountains either east or west of the student's home (Chen, Kennedy, and Kovacs 2007), while demographic factors were not significant in the enrollment decision.

Research on the influence of distance in the enrollment decision was conducted for the University of Georgia (UGA) system compared with the enrollment in the Georgia college system, the latter of which consisted of mostly two-year institutions (Alm and Winters 2009). The study found that students who were interested in pursuing a four-year degree were not likely to be significantly influenced by distance to that institution. However, students who were interested in pursuing a two-year degree were significantly more likely to attend a local college as opposed to enroll in the UGA system (Alm and Winters 2009). Similar conclusions were reached by Bellinger-Hass (2013), who used GIS to model and predict enrollment in Ohio two-year institutions, based on demographic data at the census block level. The study concluded that students who lived within 30 miles of a given institution, and were part of a specific range of socio-economic groups, were more likely to enroll at a local college than students either outside that distance, or from a different demographic background (Bellinger-Hass 2013). This conclusion differed from research conducted by Chen, Kennedy, and Kovacs (2007), which found that socio-economic background was not significant in the enrollment decision in that region for their pharmacy school.

CHAPTER III: METHODS

Data Collection and Analysis

The data for this research consisted of geographically stratified in-state enrollment numbers for each public university in the state of South Dakota. The goal of this research is to understand and quantify the role that geography plays in the college decision within the state for high school seniors, and how that role may change in different locations throughout the state. Enrollment data for each public institution within the state were available through the South Dakota Board of Regents website. The enrollment data are aggregated by student county-of-origin, and stratified by institution specific enrollment by year from 2006 to 2015. These data are publicly available for every year from 2011 to 2015 for fall semester enrollment numbers through the Board of Regents website (South Dakota Board of Regents). Enrollment data for the 2006 to 2010 period, were acquired directly from the Board of Regents.

County level data were the most appropriate aggregation scale for this analysis for two distinct reasons. The first is that county boundaries, unlike school districts or other administrative boundaries have not changed within the state in the last 10 years. As some school districts in rural parts of South Dakota have lost population, boundary adjustments and consolidation have reshaped school districts in the state. These changes can happen as often as every two years, which would make data more difficult to collect for the study period, or potentially unavailable if a school district was dissolved. The second reason is that county level data consolidate student numbers into larger populations in more rural areas of the state, which decreased the impact of enrollment changes. In some small districts, as few as five students were enrolled in the SDBOR system. In a given year, if a student graduates from the system and there are no new enrollees from the district, a 20% reduction in the district supply to the system will occur, which could significantly affect Location Quotient scores and the interpretation of results.

In order to answer the specific research question of this project, the analysis should seek to combine multiple approaches to quantify and explain the decision-making process of a high school senior selecting a four-year university anywhere within the state in South Dakota. Since this project deals with spatial decision-making and human behavior, a mixed methods approach, consisting of both quantitative and qualitative analysis, is arguably the most appropriate for understanding the college selection process (Chen, Kennedy, Kovacs 2007). The analysis for this project will include two primary methods of analysis: location quotient mapping and spatial probability mapping using gravity models.

The Location Quotient analysis measures the rate of enrollment in each county for each university compared to enrollment rates aggregated at larger scales. The results of the analysis are used to identify those counties that over supply or under supply different state institutions of higher education, delineate the geographic footprint of each college in the state, and identify potential socio-economic trends that influence enrollment rates from some counties. The results were also examined to gain a better understanding of how certain counties' supply rates has changed over time. Additionally, the results were compared to the results from the high school survey to better understand why some counties export students at higher rates than others based on college attributes and location.

Retail models, such as the Huff Model and the Spatial Gravity Model, have been effectively used to quantify the spatial probability of enrollment and the residual gaps that occur in enrollment based on distance and population (Ali 2003). These models were used to measure the probability of a given student in a given location enrolling at a specific state institution. The results of that analysis quantified how distance, and the presence of competing schools, influence a given student's enrollment decision.

Location Quotient Analysis

Location quotient scores have been effectively used to compare the prevalence of a phenomena at different scales since the 1940's (Miller, Gibson, and Wright 1991). The rate comparison process allows for a simple and effective overview of a region's import or export industries, and is considered a key tool used in regional analysis by economists and geographers (Miller, Gibson, and Wright 1991). Location quotients have been used by some universities to measure market penetration within their state, and to better understand the regional attraction of a given university as compared to other post-secondary options within the state (Smith, Spinelli, and Zhou 2002).

In this study, location quotient scoring was used to measure the rate of enrollment participation in each county for a given university in South Dakota. That rate was compared to the statewide enrollment for a given university to generate a proportional comparison between each county's enrollment participation in a single year. The location quotient equation (equation 3.1) creates a baseline percentage of occurrence at a large scale (typically state or national level) in the denominator, while the percentage of occurrence at a smaller scale is used in the numerator.

$LQ = ((X_a/Y_a)/(X_b/Y_b))$ (Equation 3.1)

Where:

X_a = Specific enrollment at aggregate a
Y_a = Total enrollment at aggregate a
X_b = Specific enrollment at aggregate b
Y_b = Total enrollment at aggregate b

In location quotient scoring, a score of one represents an identical rate of occurrence of industry across both scales. Values below one represent rates of occurrence at the smaller aggregation unit that are lower than expected, as compared to the same rate at the larger scale. Conversely, scores above one indicate a rate of occurrence at the smaller aggregation scale that is higher than the expected value generated at the larger aggregation scale.

For this analysis, the rate of enrollment at the county level was compared to the statewide enrollment to better understand the geographic footprint and spatial disparity in enrollment for each school. Therefore, equation 3.1 was changed to equation 3.2 to better represent the specific dataset that was measured.

$LQ = ((X_a/Y_a)/(X_b/Y_b))$ (Equation 3.2)

Where:

X_a = Enrollment in school X at county level a
Y_a = Total SDBOR Enrollment at county level a
X_b = Total statewide Enrollment in school X at statewide level b
Y_b = Total SDBOR enrollment at statewide level b

The analysis that follows used location quotient scores to quantify market disparity for each school within the state, and subsequently map the resulting footprints for each university over the 2006 to 2015 period. The outcome of this analysis enhances our understanding and adds clarity to the nature of enrollment dynamics in the state, and reveals some baseline trends that can be further analyzed and discussed as they relate to SDSU and their enrollment goals outlined in their *Impact 2018* master plan.

Ten-year and Five-year Footprint Analysis

The location quotient analysis showed a large discrepancy in the geographic footprint of each university in the state. The nature of the scores for each university indicated how each university performs in specific counties as compared to their statewide total. Location quotient scores that are relatively even and steady throughout the region indicate a large geographic footprint and spatially diverse markets. These scores may not climb above 2.0 – 3.0, and typically do not fall below 0.5. Schools in this category have the majority of counties within the state supplied in the “normal” range, which is between 85% and 125% of the statewide score. These scores reflect a university that attracts its students evenly from all regions of the state, at approximately the average of its state percentage share. Relatively even scores may be associated with the diversity of programs available at the university, regional or national reputation, or effective marketing across the geographic footprint of the state (Landrum et. al., 1999).

Schools that have scores above 3.0 or 4.0 have extremely strong attraction within that specific county. In the context of this analysis, universities that score much higher than expected are attracting a disproportionate number of their students from limited sources. Location quotients can be understood as the market penetration for each university within the study area, and a high score indicates an extreme over penetration in a given county. Conversely, if a university has an exceptionally high score in a single county, it must have a corresponding low score in another county. If a university is over performing in a specific market, it must also be underperforming in a different (likely more remote) market (Smith, Spinelli, and Zhou 2002).

Micropolitan and Rural Differences

The next Location Quotient analysis technique used a scale change in the denominator of the equation to create a new comparison basis for the counties within the study area. Previously, the county enrollment percentages were divided by statewide enrollment shares to create a Location Quotient based for each university in each county. In this analysis, the county averages were compared to the average of the counties around them in specific areas.

The purpose of this scale comparison was to understand how equidistant rural and micropolitan counties may be supplying SDSU and the University of South Dakota (USD) at uneven rates. Micropolitan counties considered in this analysis were located in eastern or central South Dakota, in the primary footprint of both universities. Each micropolitan county had a city with a population between 10,000 and 49,999 within its borders, surrounded by counties with a predominantly rural population.

Differences in enrollment rates between neighboring counties may indicate a trend of cultural or socio-economic factors influencing enrollment for a given university more than simply distance. With a better understanding of the disparity in rural and micropolitan enrollment rates for SDSU and USD, SDSU may be better able to increase enrollment participation from specific micropolitan counties that represent large students markets in Board of Regents system.

The reasons for this rural-micropolitan trend difference may be a result of the different cultures and majors that are reflected on each Board of Regents campus. For example, students from rural Spink County may be more likely to attend SDSU due to the presence of the college of agricultural and biological science majors, which may allow those students to major in field that they 1) already have familiarity with, and 2) identify with from a cultural perspective more than a different major. In neighboring Brown County, the higher percentage of urban students may be less attracted to the agricultural climate of SDSU, because a smaller portion of the workforce within the city is directly related to production agriculture (Burke, Davis, Stephan 2015).

Spatial-Temporal Trends

The location quotient footprint analyses calculated the market penetration of each university in the state. The analysis also provided an indication of the extent to which some of those footprints have changed over the study period. The analysis involved the change in scoring of the five-year location quotient average (2011-2015) compared to the ten-year Location Quotient averages of each county for SDSU, USD, and NSU. The difference in score between the two time periods represented the change in market penetration in each county, and may help explain changes in student enrollment patterns in the state within the study period.

Huff Model Analysis

Spatial gravity models are used to measure probability of behavior over space (Dramowicz 2005). They assess the probability of a given object moving from a specific origin to a specific destination, or destinations. In geographic terms, they measure the rate at which phenomena move across the surface of the earth, based upon predetermined attributes. These could be the migration of people from one location to the other, based upon the number of people living in the origin or destination. The attributes could also reflect attractive properties of one destination compared to unattractive qualities of another. These are termed “push” and “pull” factors, and are key elements to determining the movement motivations of people over space.

A common subset of spatial gravity models that deal with location attraction are often referred to as retail trade models. These models describe the likelihood of people patronizing one given location instead of some other location, based on origin-destination distance, and other push or pull factors for the origin(s) or destination(s). These models are often used to determine a new store location, assess retail trade regions for a given store or company, and to understand consumer behavior over space (Huff 1968).

As it relates to this research, retail trade models can be used to help understand how students in South Dakota evaluate their choices for post-secondary education. In these models, the students behave as potential patrons that are attracted to one university over another based on their proximity to that university, and the positive attributes of that university. The resulting output of retail trade models can be used to determine primary college trade markets, and probability gradients of student enrolling at one university over another under optimum conditions. Additionally, some models can be manipulated to understand how various destination attributes (pull factors) may change the spatial extent of a trade area. In this research, one positive attribute included in the retail trade area analysis was the student population on campus. The concept of spatial gravity implies that there is a relationship between two places, which is directly proportional to their mass (or population) and indirectly proportional to the distance between them (Dramowicz 2005). If students are equally attracted to areas of larger student concentrations, then probability gradients that do not account for mass should look different than those that do. Thus, in South Dakota, the largest universities should have a disproportionately larger trade area when mass is considered a primary factor in the analysis. In order to determine just how important student mass is in the college decision process, this research used gravity weighed models that are based on high school seniors' and juniors' responses to a survey that was conducted in the winter of 2016 within the study area. The students' responses were a rank order of their primary influences for selecting a given university over another.

The primary retail trade model used in this research project is the Huff Model. The Huff Model was developed in 1963 by David Huff, a leading scholar in the quantitative revolution period of geography in the 1950's and 1960's. The model, which measures the impact of spatial competition, is a variation of earlier models including Reilly's Law of Retail Gravitation (Reilly 1931) and Hotelling's Principle (Hotelling 1929). Those models measure consumer behavior as a function of mass and distance (Reilly's Law), and the effect of distance and attribute attraction (Hotelling's principle). The Huff Model also considers mass, distance, and destination attraction, but it expands the usefulness of the earlier models to include the role that spatial competition plays in consumer choice. Spatial competition, as measured by a unique set of positive (destination attributes) and negative (origin distance) parameters, allows for a more accurate assessment of real consumer movement in space than prior models (Huff 1968). The strength of the Huff Model lies in its ability to accurately determine the impact of destination attributes on market area, and to determine how competition between locations may impact the primary trade area of a given location.

This research used the Huff Model to create probability gradient maps for each of South Dakota's six Board of Regents institutions. These trade areas reflect the proximity of potential students to a given university and the destination attributes of a given university that might attract students. The results quantified student enrollment patterns and the influence each university has in the state as it relates to geographic area of influence.

The standard Huff Model's equation is:

$$P_{ij} = ((A_j^{\alpha}/D_{ij}^{\beta})/(\sum N_j^{\alpha}/D_{ij}^{\beta})) \qquad \text{(Equation 3.3)}$$

Where:

P_{ij} = Probability of patron *i* choosing destination *j*
A_j = Attraction of destination *j*
α = Positive parameters of attraction
D_{ij} = Distance between Patron *i* and Destination *j*
β = Distance Decay Parameter
N_{ij} = Attraction of competing destinations
D_{ij}= Distance from consumer to competing destinations

Destination Utility

The numerator of the Huff Model is also known as destination utility. It represents the sum potential of a college to attract a given student, based on destination attraction divided by distance. Destination utility for one location does not consider competing locations, their proximity, or their utility. The overall probability of a student choosing one location over another is, therefore, a function of the destination utility of one location, divided by the sum of the destination utility of all other locations in the study area.

Therefore:

$$\textit{Destination Utility} = \sum(A_{ij} + B_{ij} + \dots N_{ij}) \qquad \text{(Equation 3.4)}$$

The destination utility of a location is a function of the sum of its attraction attributes, divided by distance. The attraction attributes can be based on any quantitative data. Typically, in retail trade models, the gross leasable area (GLA) or yearly sales totals will be used as an attraction parameter (Dramowicz 2005). In this research, the attraction attributes used to determine destination utility were determined through a review of the literature of how students evaluate college attributes when deciding where to continue their education. The following factors were identified as the primary consideration among high school students when evaluating their college decision: (1) academic prestige; (2) cost of attendance; (3) location; and, (4) campus attributes.

These factors were then weighed by the results of a survey of local high school students conducted in the winter of 2016 by Edwards, Himmelfarb, and San Juan. The survey was sent to over 22,000 regional (in and out-of-state) high school students in December of 2016, with 776 responses. The results of the survey indicated the percentage of students that ranked the most influential of the four attraction attributes in their college selection process. In this way, university attraction for all six Board of Regents universities was established, and the utility of each university could be calculated as a function of distance from a given student to a given university, and proximity of other competing universities.

The utility scores for the Huff Model enrollment probability projection were calculated using the results of that December 2016 survey. The utility scores for each major category were summarized from the composite score of several sub factors considered to be influential in the overall major category score.

The sub factors for each major category ranked as most important in the college selection process by those students surveyed were: (1) **Academics**: four-year graduation rate, six-year graduation rate, placement rates, and number of academic program options; (2) **Cost of Attendance**: average in-state tuition, average financial aid package, and percentage of students receiving aid; (3) **Location**: town population and university enrollment; (4) **Campus Attributes**: campus amenities, community amenities, and proximity.

The utility scores for each school were created from these factors as a summation of variable scores. Within each factors, some variables were represented as integers, while others represented fractions or percentages. Within the overall calculation of university utility, this presented a problem as variables represented with large four or five-digit integers would have far greater influence in the model than the variables represented as fractions or decimals. To solve this issue, psychometric t-scores were derived from Z-scores to standardize all utility scores in the model. These scores represent the percentile of each university's individual variable score as they relate to each other in the dataset. Therefore, all values are positive and fall between 0 and 100. This normalization allowed for a fair way to compare each variable score in the overall utility model.

The utility of each university used in the model reflects the sum of psychometric t-score transformation of the Z-values of each subcategory. Each parameter utility score was raised to an exponent representing the results from the student preference survey. The exponent reflects the percentage of students who rated the given category as the most influential factor in their college decision process. This relationship is expressed in equation 3.5.

(Equation 3.5)

$$\textit{Individual University Utility} = (\textit{T-score academics})^{\alpha} + (\textit{T-score cost})^{\alpha} + (\textit{T-score Location})^{\alpha} + (\textit{T-score Amenities})^{\alpha}$$

Where α = 1 + the percentage of students who ranked the given category as the most influential in their collegiate decision.

The accuracy of this Huff Model for enrollment is, therefore, derived from the real-world calibration used by including student preference ranking to weigh each utility score for each university within the model. All universities within the study area received a perceived utility score based on student preference ranking of factors involved in their college decision. Those scores represent the summation of each of the four factors listed as most important to students in their college decision. Summarized values of university utility are included in table 3.1.

Table 3.1. Summarized psychometric t-score values for each SDBOR university.

University	***Summarized Utility T-Score***
SDSU	314.58
USD	258.08
BHSU	125.34
DSU	143.96
NSU	202.81
SDSMT	136.82

Distance Decay Parameter

The distance decay parameter, or β in the model equation, represents the rate at which distance from the potential patron to the market influences the probability of patronization. Distance decay is defined as the decreased occurrence of a given phenomenon as distance from the source of the phenomenon increases (Nekola and White 1999). This parameter mimics Tobler's First Law of Geography that states that all spatial occurrences are related, but that near occurrences are more related than spatially distant occurrences (Tobler 1970). The level of distance decay can vary greatly, depending on the phenomena being measured. In the world of spatial gravity and retail trade analysis, the rate of decrease is often non-linear, and instead mimics an exponential rate of decrease. In the Huff Model, typical distance decay parameters range in value between 0 and 3, depending upon the type of relationship that exists in the dataset (Dolega, Pavlis, Singleton 2016).

Using several sets of values for the distance decay parameter allowed for a more accurate representation of the dataset, and the varying influence of distance in the model (Dolega, Pavlis, Singleton 2016). The parameters used reflect the relative influence of distance on the two largest universities as one value, and the influence of distance on the four smaller universities as a second distance parameter. Therefore, SDSU and USD had smaller decay parameters than the four smallest universities at all stages of the model. In order to reflect the varied nature of the influence of distance on the overall model, three sets of two distance parameters were used to best estimate the real-world effect of distance on enrollment patterns. In each set of those decay parameters, the lower value always reflected the decay for SDSU and USD, while the larger parameter reflected the distance decay of the other four universities. The pairs of parameters used are 1.0 and 1.12 (Beta A), 1.175 and 1.325 (Beta B), and 1.1 and 1.175 (Beta C).

Huff Model Extrapolation

The Huff Model analysis determined the potential market areas of students within the state for each of South Dakota's six public universities. The analysis was conducted under three different constraints that gave differing influence for the impact of distance and proximity in the model, both between the two groups of universities (Flagship/Land-Grant and Regional), and between separate sets of model parameters. The analysis used Euclidean distance from the geographic mean center of 365 unique zip codes that reside partially or completely within South Dakota. The Euclidean distances were calculated using ArcGIS 10.5, and reflect the distance from one given zip code to each of the six public university campuses within the state. In the model, when a university had a distance decay parameter different than 1.0, the Euclidean distance of all 365 points to the given university was raised to the exponent of the given model iteration (Beta A, B, or C). That transformation reflected the different influence distance has on universities in the study region and their perceived utility in the state. For example, if the Euclidean distance of the Jefferson zip code to the USD campus was measured at 27.9 miles under a decay parameter of 1, the transformed distance would increase to 49.9 miles under the parameter of 1.1 in the Beta A iteration of the model. These distance values from point to point were added to the polygon shapefile of actual zip codes to represent the distance from the given polygon mean center to each SDBOR university campus.

The numerator in the model of university utility was calculated for each school at each of the 365 zip codes based on the measured utility of each university, and the transformed distance from that point to a given campus. These values were then summarized to create the denominator of the model. The denominator represents the sum of the distance weighed utility for all six SDBOR universities in the given zip code. Each of the six individual universities occupy a share of that utility, which is their potential market share within the given zip code. The results, therefore, represent the maximum potential market share that could be occupied by each university in each of South Dakota's 365 zip codes. This analysis was conducted under three different constraints, which added varying weights to the impact of distance on each university in the model.

A spatial join function in ArcGIS 10.5 was used to generate the mean model output of all zip codes that fell either entirely or partially within a given county. The output of this process was an average probability of enrollment for each of South Dakota's 66 counties. The average probabilities of enrollment were used to measure residual errors in the observed and expected dataset, measure the accuracy of each model under different distance parameters, and the market difference in actual student enrollment compared to potential enrollment. The difference in potential enrollment was then used to understand how many more (or fewer) students SDSU could expect to enroll from within the state, if all marketing goals were reached.

The result of the Huff Model analysis provides a market assessment of (1) how many in-state students SDSU may expect to enroll based on spatial gravity constraints under optimum conditions, and (2) which specific markets those students may come from. As this output relates to the goals outlined in the *Impact 2018* guidelines, the numbers derived from the analysis represent the possibility of SDSU achieving their enrollment goals based solely on in state students.

CHAPTER IV: RESULTS

Location Quotient Results

The Location Quotient analysis that follows illustrates the nature of enrollment market penetration for each university in South Dakota. Three separate analyses with Location Quotients were used to illustrate the geographic footprint of each university in the state, the spatial and temporal patterns of market penetration for the largest universities in the state, and the relative difference in micropolitan and rural county scoring between SDSU and USD. These analyses examine the market gap that exist in the state for several universities within specific regions, as well as the relative enrollment disparity between universities in specific geographic markets.

Footprint Analysis Results

The results of the footprint analysis for both five-year and ten-year average scores for each university can be found in figures 4.1 and 4.2, respectively. A reference map of South Dakota counties and university locations is listed in figure 1.1. The results of the footprint analysis for each university are discussed in the following pages. The discussion includes figures and tables related to the Location Quotient scores over the five-year and ten-year study periods analyzed in this research.

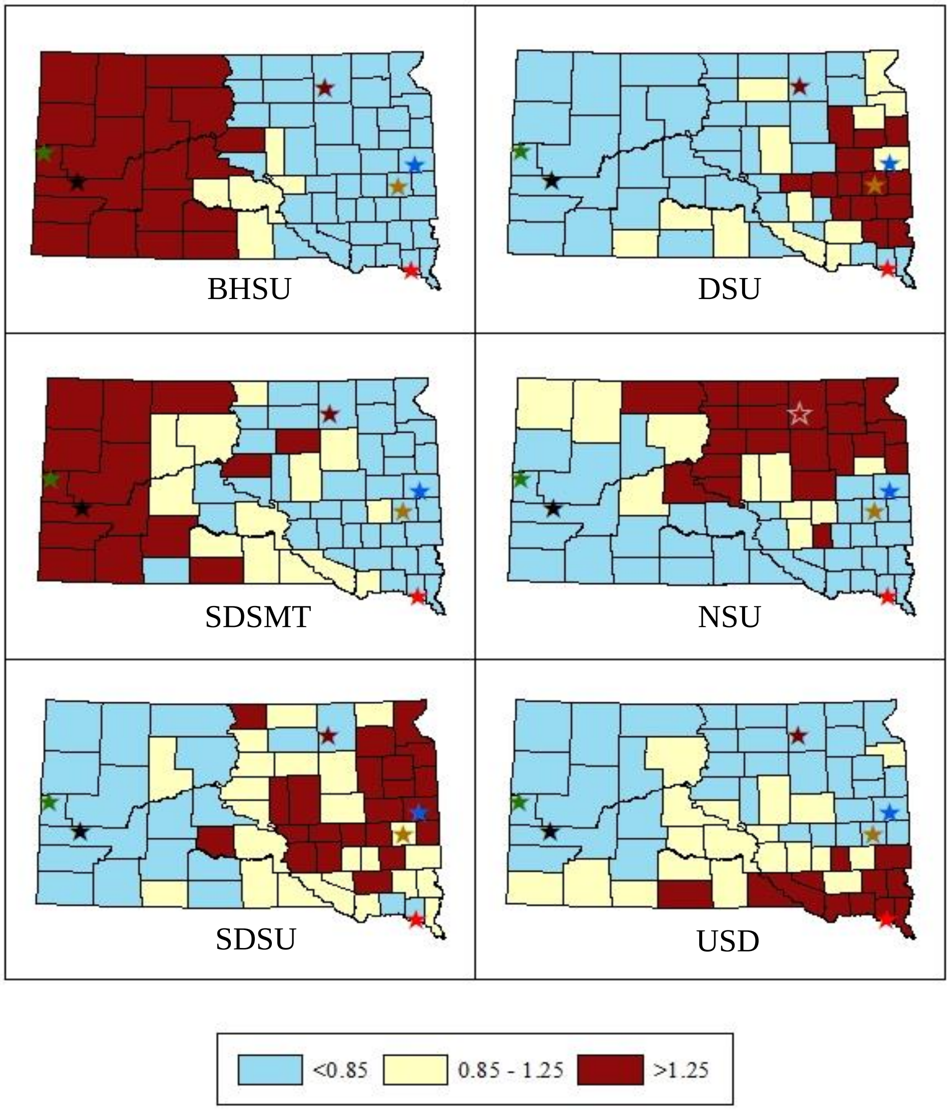

Figure 4.1. 2011-2015 mean Location Quotient score for each SDBOR university.

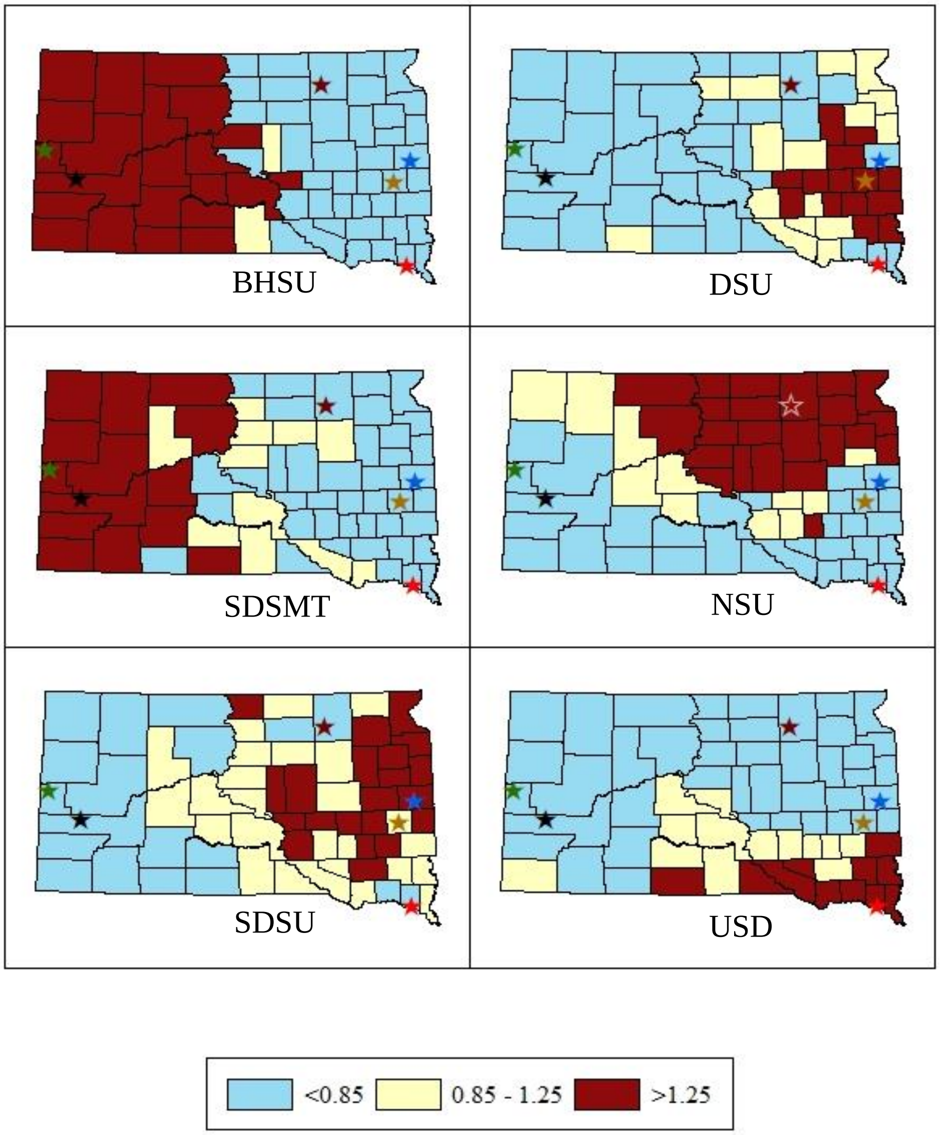

Figure 4.2. 2006 – 2015 mean Location Quotient score for each SDBOR university.

South Dakota State University

In the case of SDSU, many different factors affect the makeup of their regional attraction. For SDSU, the primary supply region of students is the northeast and east central regions of the state (figure 4.1). In those regions, 21 counties supplied students at or above the 125% threshold in the ten-year analysis (figure 4.2) compared to the state average for SDSU. In the five-year analysis, 22 counties supplied SDSU at higher than expected rates, including a single county (Jones at 126%) in western South Dakota. Moving into the southeast and central portions of the state, most counties supplied in the normal range of 85% to 125%. The main exceptions to that pattern are Yankton, Clay, and Union counties, which supplied at 73%, 86%, and 45%, respectively. Those counties are located in close proximity to the University of South Dakota, and the lower scores most likely reflect that competition proximity. In the western region of the state, most counties supplied SDSU below the 85% threshold. These geographic patterns show that SDSU has a relative even distribution of students enrolled on campus from the eastern two-thirds of the state. In the northeast portion of the state, enrollments tend to be higher than expected, but do not grossly exceed the expected rate. The values of highest and lowest scoring counties in table 4.1 reflect an even dispersion of location quotient scores across large portions of the state. In the far western portion of the state, location quotient scores drop below the 85% threshold, which could be representative of both the distance to the SDSU campus and the presence of Black Hills State University and South Dakota School of Mines and Technology.

Table 4.1. SDSU highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Brookings	2.26	2.27
Kingsbury	1.72	1.70
Moody	1.64	1.69
Hamlin	1.59	1.62
Roberts	1.57	1.56
Lowest Scoring Counties		
Harding	0.36	0.39
Lawrence	0.41	0.39
Clay	0.45	0.40
Meade	0.48	0.49
Pennington	0.50	0.51

Black Hills State University.

The geographic footprint of Black Hills State University (BHSU) was scored consistently higher than average across the entire western half of South Dakota, while the entire eastern portion of the state scored below average (figure 4.1). The number of counties in the normal range for BHSU are almost nonexistent. The values found in table 4.2 indicate a strong sub-regional attraction for BHSU that reflects a tendency for western South Dakota students to choose BHSU at a disproportionate rate. The location quotient scores for BHSU in the immediate counties surrounding the campus are three or four times greater than the expected value.

The ten-year average scores are similar to the five-year results, with slight changes in scores in central South Dakota (figure 4.2). Both Hughes and Lyman counties, which are in the central portion of the state, had enrollment rates that were higher than expected for BHSU. Both counties are roughly equidistant to the BHSU campus as they are to SDSU or USD. In other words, though the distance to the three universities is approximately the same, students in the west-central portion of the state are choosing BHSU at a disproportionately higher rate. Peer influence, targeted marketing, or cultural differences may be responsible for the discrepancy in west-central South Dakota students enrolling at a higher-than-expected rate at BHSU.

Table 4.2. BHSU highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Lawrence	4.29	4.25
Butte	3.92	3.88
Harding	3.29	3.13
Meade	3.24	3.25
Pennington	2.88	2.83
Lowest Scoring Counties		
Union	0.12	0.12
Clay	0.17	0.17
Minnehaha	0.21	0.19
Brookings	0.21	0.18
Lincoln	0.22	0.22

Northern State University

The market area for Northern State University (NSU) was quantified using the scores from the location quotient footprint analysis in table 4.3. In the 2006-2015 analysis map (figure 4.2), NSU had 23 counties with an average location quotient of over 1.25, most of which were located in the north central portion of the state. That represents 23 counties supplying NSU at a rate 25% higher than expected compared to their statewide average in the SDBOR system during the same time period (11%). In that same period, NSU also had 32 counties supplying their enrollment at 85% or less than the expected value (location quotient of 0.85 or less). Of those 23 counties supplying at a higher than expected rate, all were located in north-central portion of South Dakota, while all the counties with a location quotient of 0.85 or lower were located in the southern or western portions of the state. From 2011 to 2015, NSU had 21 counties with an LQ score of 1.25 or higher, and 35 counties scoring below the 85% threshold (figure 4.1).

Table 4.3. NSU highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Brown	5.29	6.27
McPherson	3.84	4.19
Edmunds	3.81	4.47
Potter	3.21	3.53
Marshall	3.19	3.17
Lowest Scoring Counties		
Shannon	0.07	0.11
Bon Homme	0.07	0.13
Buffalo	0.10	0.65
Clay	0.18	0.15
Butte	0.24	0.29

University of South Dakota

It would be expected that the university with the second highest enrollment in the state and the designated flagship of the Board of Regents System would have a relatively even enrollment supply across the state. The values in table 4.4 instead indicate a strong regional supply from a select number of counties, and a relatively low supply from most other regions in the state. For USD, the ten-year averages indicate that 11 counties were supplying enrollment at 1.25 times the expected value based on statewide averages. In that same period, 43 counties were supplying at or below the 85% threshold (figure 4.2). The relatively low number of counties supplying at a high rate stands out given the total enrollment of USD (10,600). The highest concentration of high scores for USD came from counties in the far southeastern portion of the state, near the Vermillion campus (figure 4.1). From 2011-2015 (five-year average), the patterns of location quotient scores changed to a somewhat more balanced footprint. In that time period, USD had 35 counties supplying at 0.85 or less, 19 supplying in the expected range, and 12 counties supplying at higher than expected rates (>1.25).

Scores below 85% in 43 counties in the ten-year study period indicate that enrollment is being supplied at higher than expected rates from very few counties. If USD had a balanced and regional footprint, every county in the state would be supplying at the same rate as their statewide enrollment share. However, these scores indicate that distance has a strong influence in the enrollment decision for USD students, and that the majority of their students are enrolling from counties in close proximity, and not from the state as a whole.

Table 4.4. USD highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Clay	2.72	2.73
Yankton	2.19	2.26
Union	2.07	2.03
Bon Homme	1.69	1.73
Gregory	1.64	1.36
Lowest Scoring Counties		
Harding	0.33	0.48
Campbell	0.37	0.46
Deuel	0.40	0.39
Brookings	0.41	0.38
Lawrence	0.43	0.48

Dakota State University and South Dakota School of Mines & Technology

The final type of footprint visible in the data was represented by Dakota State University (DSU) in Madison, and South Dakota School of Mines and Technology (SDSMT) in Rapid City. For both of those universities, the extent of their primary footprint was located in the immediate counties surrounding Lake and Pennington counties, respectively (figure 4.1). Each university had counties that were supplying at or above four times the expected rate, indicating an extreme oversupply from local counties compared to other universities in the state (table 4.5 and 4.6). Those patterns are also similar for both universities in the ten-year period between 2006 and 2015 (figure 4.2). In these localized footprints, students from those oversupplying counties make up a disproportionate share of the overall enrollment for that school, while counties that are outside that footprint supply at much lower than expected rates. In the context of spatial competition and the goals outlined by SDSU in their master plan, the types of footprints present for these two universities may be strongly influencing enrollment deficits in the markets for other colleges in South Dakota.

Table 4.5. DSU highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Lake	4.49	4.23
Jerauld	2.04	1.74
Sanborn	1.98	1.87
Kingsbury	1.75	1.85
McCook	1.71	1.82
Lowest Scoring Counties		
Todd	0.20	0.30
Haakon	0.21	0.37
Dewey	0.22	0.14
Shannon	0.27	0.36
Potter	0.28	0.32

Table 4.6. SDSMT highest and lowest Location Quotient scores in each study period.

Highest Scoring Counties	***5 YR LQ***	***10 YR LQ***
Pennington	3.42	3.44
Corson	3.01	2.15
Harding	2.96	2.98
Todd	2.40	2.05
Fall River	2.38	2.59
Lowest Scoring Counties		
McPherson	0.00	0.18
Kingsbury	0.12	0.12
Clark	0.12	0.20
Brookings	0.14	0.13
Clay	0.18	0.20

Spatial-Temporal Results

Results of the Spatial-temporal Analysis can be found in figure 4.3. In the study period, both USD and SDSU recorded more positive changes in Location Quotient score than negative changes in the comparison between the ten-year and five-year averages in the state. However, USD had more counties with positive score changes than did SDSU. SDSU also had more counties than USD that decreased in score between the ten-year and five-year time periods. Among these gains and losses, there were some notable spatial trends in the results.

First, USD experienced most of its gains in market share from the southwest and west central portions of the state, while most losses occurred in rural southeastern counties (figure 4.3). For SDSU, the primary regions of gains were in the northcentral portion of the state, and in rural southeastern counties. Notable among those positive gains for SDSU were McCook and Yankton counties, which decreased in Location Quotient score for USD in the same time period.

For SDSU, the other notable spatial trend seen in the Location Quotient change analysis was the net decrease for NSU scores in many counties surrounding the Aberdeen campus, compared to the subsequent increase in many of those same counties for SDSU. This specific spatial trend could have been caused by changes in marketing, decreases in certain academic programs offered at NSU, or changing demographics in college preference in the area.

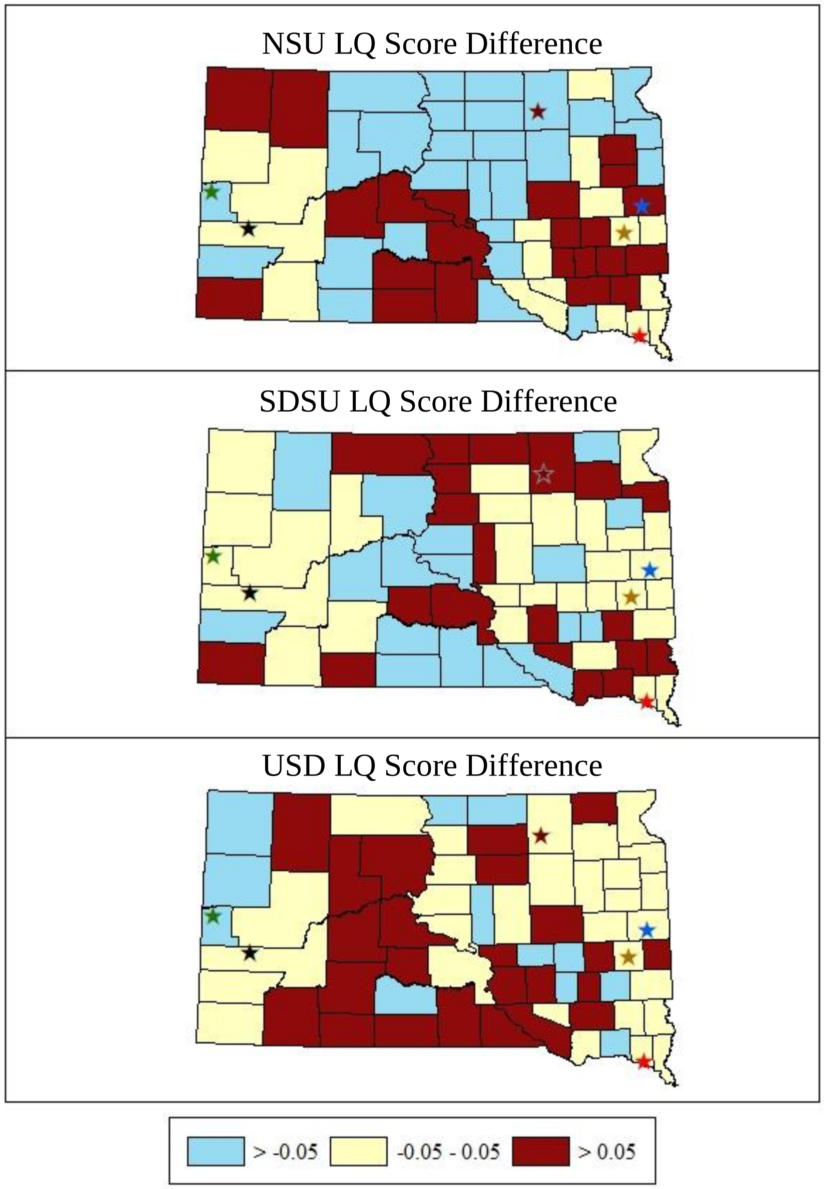

Figure 4.3. Percentage change in mean Location Quotient score from ten-year to five-year study period.

Micropolitan and Rural Analysis Results

The results of the analysis showed that rural students are enrolling at SDSU at a higher rate than micropolitan or urban students in eastern South Dakota. In every micropolitan set of counties in eastern South Dakota, Location Quotient scores were higher in surrounding rural counties compared to the micropolitan anchor in the region.

In table 4.7, values were typically lower in micropolitan counties than their surrounding rural counties for SDSU. Conversely, USD scored consistently higher in most of those same micropolitan counties than they did in the rural counties surrounding them. The notable exceptions to that pattern for USD were Brown and Davison counties, which had several scores below their surrounding rural counties. In Brown County, the presence of Northern State University in Aberdeen, which shares many similar academic programs with USD, may be affect general enrollment rates for USD in the region. The combination of shared programs and increased distance from Vermillion may result in more rural students in the areas surrounding Brown County choosing USD at a similar rate to their peers in micropolitan Brown County.

These patterns suggest that there may be some distinct difference in how the utility of SDSU is weighed by students from relatively high population counties, as compared to less densely populated counties in the same region of the state. These results may have a significant influence on the enrollment goals for SDSU, since those micropolitan counties represent a large share of the current origin of supply to the South Dakota Board of Regents system.

Table 4.7. Five-year average Location Quotient differences between micropolitan and rural counties in six eastern South Dakota markets.

Micropolitan and Surrounding Counties	***SDSU LQ***	***Difference***	***USD LQ***	***Difference***
Brown	**0.588**		**0.478**	
Spink	1.106	+0.548	0.560	+0.082
Edmunds	0.742	+0.154	0.469	-0.009
Day	1.367	+0.779	0.600	+0.122
Faulk	1.054	+0.466	0.573	+0.095
McPherson	0.962	+0.374	0.543	+0.065
Beadle	**1.111**		**0.856**	
Spink	1.106	-0.005	0.560	-0.296
Clark	1.546	+0.435	0.567	-0.289
Kingsbury	1.717	+0.606	0.564	-0.292
Miner	1.415	+0.304	0.821	-0.035
Sanborn	1.270	+0.159	0.659	-0.197
Jerauld	1.363	+0.252	0.556	-0.300
Hand	1.256	+0.145	0.884	+0.028
Davison	**0.994**		**1.088**	
Hanson	1.217	+0.223	1.371	+0.283
Hutchinson	1.333	+0.339	1.214	+0.126
Douglas	1.149	+0.155	1.440	+0.352
Aurora	1.261	+0.321	1.173	+0.085
Sanborn	1.270	+0.276	1.270	+0.182
Codington	**1.266**		**0.824**	
Grant	1.437	+0.171	0.857	+0.033
Deuel	1.365	+0.099	0.396	-0.428
Hamlin	1.586	+0.320	0.632	-0.192
Clark	1.546	+0.280	0.567	-0.257
Day	1.367	+0.101	0.600	-0.224
Hughes	**1.046**		**1.017**	
Sully	0.949	-0.097	0.490	-0.527
Hyde	1.512	+0.466	0.502	-0.515
Lyman	1.225	+0.179	0.877	-0.140
Stanley	0.832	-0.214	0.975	-0.042
Yankton	**0.860**		**2.189**	
Bon Homme	1.054	+0.194	1.692	-0.497
Hutchinson	1.333	+0.473	1.214	-0.975
Turner	1.111	+0.251	1.529	-0.660
Clay	0.447	-0.413	2.723	+0.534

Location Quotient Discussion

The implications of the results of the Location Quotient analysis have a direct impact on the understanding of market segmentation within the public university system. For SDSU and USD, the location quotient footprints revealed two primary trends. The first trend indicated that socio-economic factors may influence enrollment in South Dakota's micropolitan counties. In those counties, USD scored consistently higher in its market share than it did in the surrounding rural counties. Conversely, SDSU scored lower in each of those micropolitan counties compared to its market share in the surrounding rural counties. These results suggest that there may be a trend of students from more urban counties in the state choosing USD at a disproportionately high rate compared to those same students choosing SDSU. The second trend revealed by the location quotient scores highlights the relative advantage SDSU has in the geographic footprint of the state (figure 4.4). While USD had 12 counties score above the 120% market threshold, SDSU had 22 counties at or above that level. All of USD's highest scoring counties were along or south of the Interstate 90 Corridor, while SDSU's were more evenly distributed throughout the eastern portion of the state. Since the statewide five-year enrollment rates for the two universities were similar (32.17% for SDSU and 27.83% for USD), the discrepancy in the number of counties at the highest threshold indicates a distinct difference in the character of in-state enrollment for the two universities. In order for USD to maintain its statewide enrollment, a disproportionate number of students must come from those 12 counties. In some counties, those enrollments score at over 250% of the expected market share. For SDSU, the presence of the high-threshold scores in 22 counties equates to a closer representation of market share in each county compared to the statewide market share. For SDSU, no single county scored above the 250% market share, and most were under 150% of their statewide score. These results further confirm that the nature of the enrollment patterns for SDSU are unique compared to other universities in the state, and they represent the most geographically comprehensive presence across the state.

As it relates to their enrollment goals, SDSU may have a significant advantage over USD in markets in the state that are at extreme distances from either campus. The difference in tertiary market penetration may have implications when understanding the role of distance on the decision-making process at both universities. While SDSU and USD both have low location quotient scores in western South Dakota, SDSU has relatively consistent scores across most of eastern South Dakota. USD scores low in all but the southeast corner of the state, indicating a difference in market penetration for each school. That difference in market penetration may be important when considering new, geographically-targeted marketing efforts by SDSU. If students in the extreme southeastern corner of the state are choosing USD at disproportionate rates, it is unlikely that marketing efforts by SDSU in that area will create a large positive gain in students. However, markets that are farther away from the USD campus that are currently scoring high in market penetration may be more susceptible to competition from SDSU, due to the increased influence of distance to the USD campus in those markets.

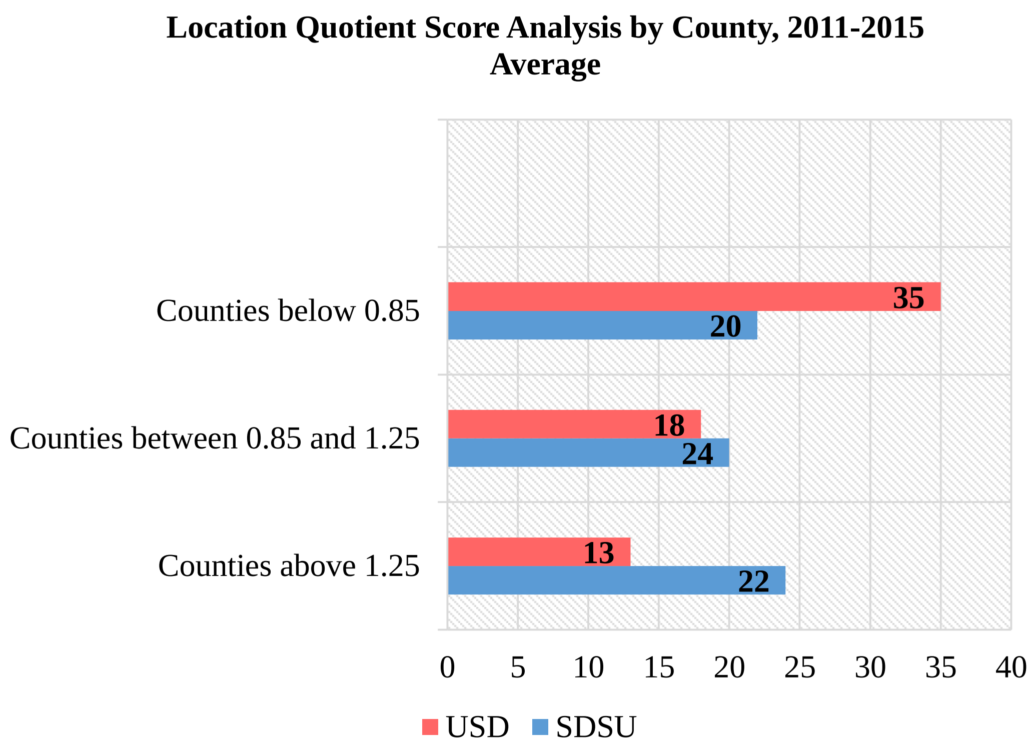

Figure 4.4. Location Quotient score comparison between South Dakota State University and the University of South Dakota, 2011-2015.

Other patterns in this analysis show that there is a distinct difference in the relative performance of both universities within the micropolitan counties in eastern South Dakota. Of the six micropolitan counties listed, USD scored higher in the given micropolitan county than the surrounding rural counties on four occasions. In each of those same six study areas, SDSU scored lower in the micropolitan counties than the surrounding rural counties. Those patterns may suggest that there is a key difference in perception or marketing for both universities in micropolitan counties in eastern South Dakota. Within that context, SDSU may be able to increase enrollment by targeting those micropolitan markets, but only after assessing how and why students within those counties are choosing USD at a relatively higher rate than SDSU. The answers to that investigation may show a difference in marketing focus for each university, a difference in the perception or attraction for both universities from micropolitan students, or some key cultural differences that those students are identifying more with at the USD community than the SDSU campus.

Huff Model Analysis Results

Results from the Huff Model analysis are organized into Beta A results and Beta N results, which are presented in the following subsections. The model outputs for SDSU and USD are displayed in figure 4.5. A reference map of South Dakota Counties and locations of public universities is shown in figure 1.1. The purpose of The Huff Model Analyses are to determine the probability of enrollment for SDSU and USD when both distance and spatial competition are present. The utility of each university was calculated as part of an overall destination attraction factor, determined through analyses of student preference in university selection.

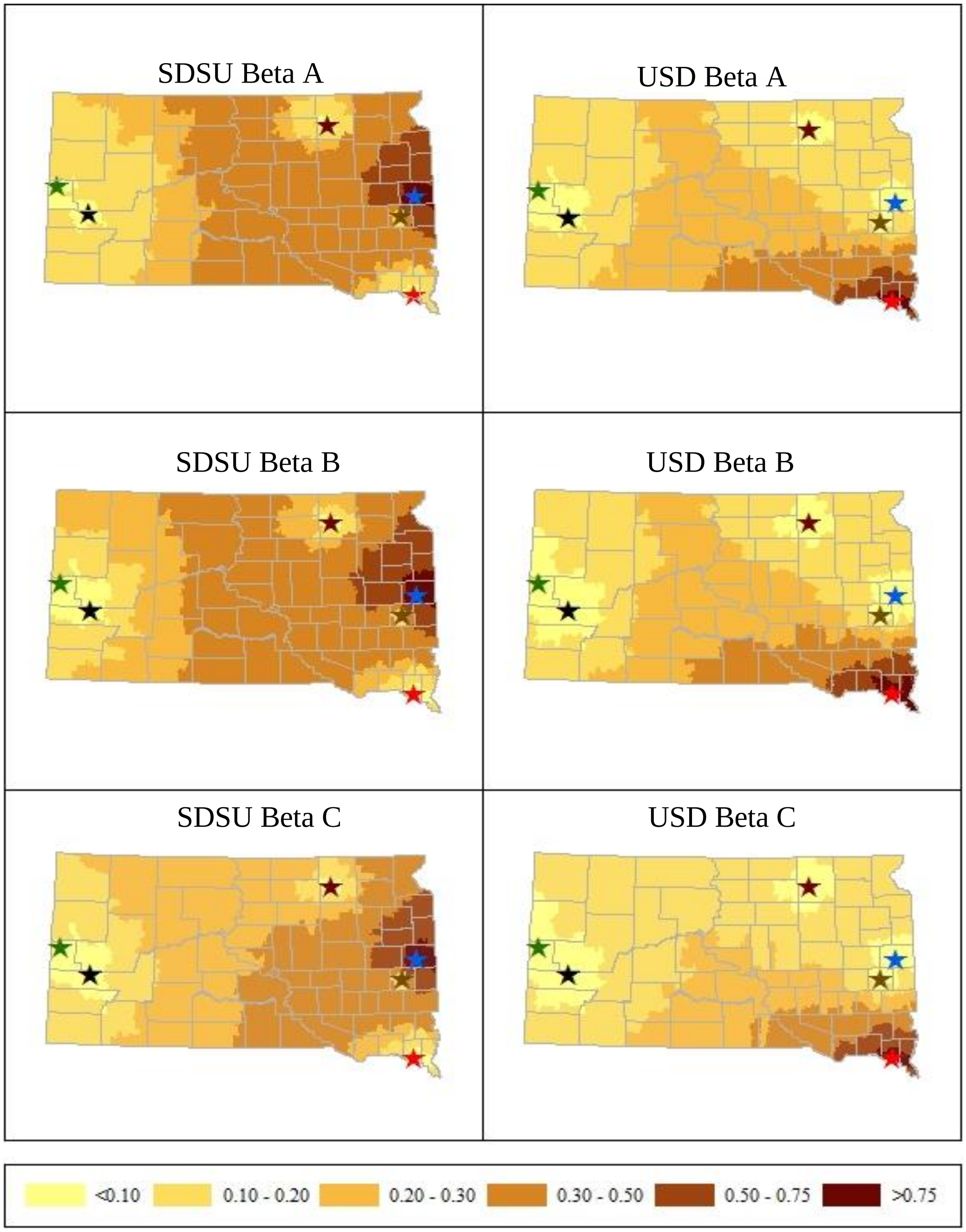

Figure 4.5. Huff Model probabilities for SDSU and USD at the Beta A, B, and C constraints.

Beta A Results

The results of the Huff Model analysis performed under the distance decay parameters of Beta A (1 and 1.12) revealed several trends in the nature of the spatial markets of each university within the state. Geographically, the core trade area for SDSU was centered in the extreme east central portion of the state, while the secondary market (>0.30 Probability of enrollment) included most of the eastern half of the state (figure 4.5). In the analysis, the model indicated that there were 29 counties that were undersupplying the SDSU student market within the state, based on the five-year average enrollment at SDSU from each county between 2011 and 2015. The counties with the largest supply gap for SDSU were Minnehaha, Lake, Codington, Brown, Davison, and Beadle County. Based on the analysis, if all counties are considered, SDSU enrollment could increase incrementally by approximately 400 students, based solely on undersupplying markets. That analysis is only a summary of the model outputs, which underestimated the student supply of 36 counties in the five-year period from 2011 to 2015. By excluding those underestimated values which are not observed in the actual dataset, the potential enrollment increased to approximately 750 students.

The model results for USD indicate a significantly different geographic footprint than SDSU (figure 4.5). The primary trade area for USD was limited to the extreme southeast corner of South Dakota, and represented a smaller footprint than the same primary trade area for SDSU. The model output included both positive and negative changes in enrollment based on market supply, depending on which counties were included in the calculation. Under the Beta A parameters, USD had 45 counties supplying the market at lower than expected rates, resulting in a net decrease of 836 students. If markets indicated in the model that are over-supplying the system are excluded from the summarized output, USD could expect a net gain of 254 students from within the state. Under the Beta A parameters, the influence of distance on the model is similar for both the Flagship/Land-Grant (SDSU and USD) universities and the smaller regional universities (DSU, BHSU, NSU, SDSMT). Under this particular decay parameter, the four smaller universities were influenced slightly more by distance than the two larger universities to reflect differences in perceived utility and virtual distance.

Beta B Results

Under the distance decay parameter of Beta B (1.175 and 1.325), the larger differential of the influence of distance on the model produced the highest market gap between observed data and expected data in the analysis for SDSU. The model indicated that 37 counties within the state were undersupplying SDSU, producing a market gap of approximately 509 students that were unaccounted for compared to the observed results. Excluding over-supplying markets from the analysis, the summarized output for SDSU rises to approximately 969 students, which is the largest market gap in the analysis for the university.

For USD, the market difference under the Beta B parameters indicated that 807 fewer students could be expected to enroll based on the number of counties that under-supply the university. Under this particular decay parameter, USD has 42 counties that supply the market at a lower than expected rate. If those counties in the dataset that oversupply are not considered in the sum total, USD could expect to enroll approximately 413 more students from South Dakota.

The increase in net enrollment gains for both universities, compared to the Beta A constraint, is consistent with the increase in physical size for both universities' primary trade areas. For SDSU, the main increase in physical trade area occurs in the west central portion of the state, while USD's main increases occur in the south-central portion of the state and north of Interstate 90 in eastern South Dakota (figure 4.5).

The values generated from this iteration of the model are the largest increases in enrollment for both universities in the analysis. The Beta B parameter assigns relatively high influence for distance in the model for the smaller universities, while assigning relatively low influence for distance in the model for the two larger universities. The reasoning behind this disparity between the influence of distance in the model stems from the disparity between attractions for each university. According to Reilly, the perceived utility of a given location is directly proportional to its perceived attraction and inversely proportional to its distance from the consumer (Reilly 1931). Under this analysis, the attraction of each university is unique and constant throughout all iterations of the model. The purpose of the various iterations of the decay parameter is to quantify the virtual distance of each university to the consumer, as it relates to both real distance, and perceived market penetration because of university utility in the region. Therefore, the Beta B iteration of the model rewards the high perceived utility of SDSU and USD, while penalizing the universities with significantly lower perceived utility.

Beta C Results

The distance decay parameter was set at 1.1 and 1.175 for the Beta C parameter in the third model output. In the final run of the Huff Model, the impact of distance was decreased for the regional universities compared to the first two iterations of the analysis.

The result created a net negative change in enrollment for both SDSU and USD. For SDSU, the model output indicated there were 21 counties supplying enrollment at a lower than expected value, creating market deficit of 217 students. If the summarized market changes did not consider counties that are already over supplying enrollment for the university, the net market difference changes to a positive number. Under that scenario, SDSU could expect to enroll 476 more students from South Dakota. For USD, there is a large net deficit of students if all counties and markets are included in the analysis (-1264). If the oversupplying counties are not accounted for, the net increase in enrollment becomes a positive 234 students.

Enrollment projections for both universities are impacted by the role of distance. The Beta C parameter caused a net decrease in enrollment compared to the first two iterations of the Huff Model. While the adjusted totals for both universities moved the net change in enrollment back into the positive, the increased influence of distance in the decision-making process directly benefited the four smallest universities in the state the most. In the first two model outputs, the attraction of both SDSU and USD was amplified by the discrepancy between the impact of distance between those two universities and the other four smaller colleges. Under the Beta C parameter, the influence of distance in the decision-making process was increased to reflect a greater tendency towards proximity-based selection. These trends are evident in the changes in size of the primary market areas for both universities (figure 4.5). For both universities, this shrinking physical market size and lowered maximum probability of enrollment created net negative values in enrollment change when considering all markets in the state. When only underperforming markets were considered, the enrollment changes became positive gains for both universities, but those gains were the most modest of the three model outputs.

The importance of modeling the output under the Beta C parameter stems from the unknown impact that distance may have on the decision-making process. By decreasing the disparity between the influences of distance on the regional or sub regional universities in the dataset, the Beta C model allows for a more conservative estimate of potential enrollment increases for universities throughout the state. It is therefore important to note that even under the most conservative of the three models, SDSU could still expect to increase enrollment by nearly 500 in state students when considering underperforming markets within the study area. Under the goals outlined in *Impact 2018*, those conservative estimates would still place overall university enrollment over 13,000 students, and bring the university significantly closer to their 14,000 student enrollment goals.

Statistical Validation

In order to understand how the model results accord with the observed data, a Chi Square test was conducted for each iteration of the model under the various distance decay parameters. The Chi Square test is a summarized measure of the squared, standardized error between expected results and observed datasets. In this analysis, each model output in each county for SDSU was treated as an expected value, while the original county percentage of enrollment for SDSU was considered the actual, observed result. The error in the expected percentage of enrollment (five-year average) compared to the actual observed enrollment average (five-year average) was measured in each county.

In the attached Chi Square value table (table 4.8), the threshold value is 84.821 for an alpha significance level (a) = 0.05.

If H_0: No significant difference between the observed values expected values exists
H_a: A significant difference between observed values and expected values exists

Thus, any value lower than 84.821 will result in a failure to reject the null hypothesis and will correspond to the model being considered a good fit to the observed data at significance level a = 0.05.

In the original validation of the datasets, outliers were retained as part of the overall expected values. Under that premise, each of the iterations of the Huff Model analysis scored above the specified Chi Square threshold value of 84.821, and they therefore could not be considered a good fit to the observed dataset.

When the outliers in each output were removed from the dataset, each model fit the observed results significantly better than the previous test that did not remove the outliers. With the outliers removed from the dataset, the Beta A iteration of the model scored 78.468, which was below the threshold value of 84.821. That value for the Beta A validation corresponds with a failure to reject the null hypothesis (H_0), meaning that the expected values from the model are a good fit to the observed dataset. Although the other two iterations of the model still scored above the threshold value (103.309 for Beta B and 562.560 for Beta C), both scores improved significantly when outliers in the dataset were removed.

In this analysis, the purpose of the using the Huff Model was to measure the residual gaps in specific markets within the state, as they relate to enrollment trends in the five-year period from 2011 to 2015. The purpose of the analysis was not to measure the effectiveness of the Huff Model at enrollment predictions, but rather to understand the market segmentation in the state. The difference in the Beta values were intended to account for differing influences of distance both in the study area itself, and between the different types of universities in the study area. Beta A (1.0 and 1.1) was intended to reflect low influence of distance on the model, and low disparity between the decay parameters for all universities in the study area. Beta B (1.175 and 1.325) was intended to account for high distance influence in the model, and high disparity between universities in the dataset. The resulting output of the Beta B parameter was a poorer predictor of the observed dataset than the Beta A parameter. However, the larger residual errors in the Beta B parameter are useful in understanding both the spatial competition within the state under those specific parameters, and potential enrollment gains for SDSU from those specific markets. Beta C (1.1 and 1.175) was intended to show high influence of distance on the model, and low disparity between the universities in the dataset. The Beta C iteration was the poorest fit to the observed dataset, but like Beta B, may also provide insight into market segmentation and enrollment gaps that exist in the state if students weigh distance as a high priority for their college decision.

The results of the calibration for the model indicate that if the Huff Model were to be used to predict student enrollment in South Dakota’s universities, the constraints of the Beta A iteration of the model would be the most appropriate. If the purpose of the analysis is to quantify and map market gaps in the state based on the unknown influence of distance on the decision-making process, then all three iterations of the model provide insight into potential enrollment projections.

Table 4.8. Chi square values for South Dakota State University Huff Model.

Distance Decay Parameter	X^2	***Test Statistic***	***Degrees of Freedom***	$p > 0.05$
Beta A	84.821	74.469	65	0.091
Beta B	84.821	103.309	65	0.001
Beta C	84.821	126.138	65	0.000004

Huff Model Analysis Discussion

The Huff Model analysis of enrollment sought to understand where market gaps exist for SDSU and USD in the state, and what impact those under-supplying markets have for both universities. The model was run with three different sets of parameters for distance to account for discrepancies in the distance decay function across the study area for the different types of public universities in the state. In two of the three outputs of the model, there was a net potential enrollment increase in students for SDSU, while USD had an enrollment decrease in all three model outputs. When those model outputs excluded the raw numbers from counties that were over supplying each school, SDSU had a net increase in enrollment potential in all three model outputs that ranged between 476 and 969 students. USD also had a positive output in each model when over supplying counties were not considered in the summarized outputs, although the enrollment increase was more modest, ranging from 234 to 413 students.

The Huff Model outputs in themselves only provide a baseline of potential enrollment market changes within the state for the two universities. The model represents the probability of a student in South Dakota choosing a given university in the state, based on spatial competition and university attraction. The results of the Huff Model analysis are most influential only if the identified under-supplying markets for both universities are located in their primary trade areas (Aiton and Mclane 2014). It would be expected that counties that are farther away from a given university would observe a predictable drop in enrollment participation, while nearer counties would participate at higher rates. In this analysis, the counties that undersupplied SDSU at the highest rates were Minnehaha, Codington, Lake, Beadle, and Davison counties, respectively. All of these counties are located in the eastern portion of South Dakota, in relatively close proximity to SDSU. Each of the counties, with the exception of Davison, is closer to the SDSU campus in Brookings than the USD campus in Vermillion. These results indicate that the primary markets within the state that are under supplying the enrollment of SDSU at the highest rates are not distant counties in western South Dakota or counties containing a different college. The bulk of the market gap for SDSU is located in markets close to the SDSU campus, in micropolitan and urban counties in eastern South Dakota. In the context of the Huff Model analysis, these results indicate that SDSU's enrollment increase should be focused in their primary recruitment area and that the successful implementation of that targeted marketing could reasonably result in an added 500-1000 in-state students.

While the Huff Model analysis can provide a baseline projection of potential enrollment changes, the strength of the model is not in the raw numbers generated for each market or summarized statewide enrollment gains. The variability of market elasticity, consumer choice, and normalization of scores create some level of uncertainty in using the Huff Model outcomes to directly state expected changes in enrollment. The strength of the Huff Model instead is its ability to quantify how and where spatial competition unfolds across geographic space. The identification of underperforming markets, when accounting for spatial competition, will allow SDSU to target those specific markets, and helps demonstrate where and how market gaps are occurring within the state. In Lake County, the model output states that SDSU is underperforming and could expect a maximum of approximately 100 more students to enroll under optimum conditions. While that number is important, and may very well be realistically achievable for the university, the more significant finding in the Huff Model analysis instead is the nature of spatial competition in Lake County. The model indicates that in Lake County, even when considering the proximity and attraction of DSU to local students, SDSU is still significantly underperforming in that market. The strength of the Huff Model is its ability to identify market gaps while still taking into consideration spatial proximity and competition. Therefore, the number of students that the model predicts to be unaccounted for by SDSU (500-1000 more students) may not be as important as the identification of where those students reside, and the level of underperformance in some markets that has occurred over the five-year study period from 2011 to 2015. Synthesizing these results, it can be concluded that SDSU is grossly underperforming in some specific markets in eastern South Dakota, which is significantly impacting enrollment for the university. That resulting enrollment discrepancy from those markets may total between 500 and 1000 more students in South Dakota who should be enrolled at SDSU, many of whom reside in the eastern portion of the state, in relatively close proximity to the SDSU campus.

CHAPTER V: CONCLUSIONS

The purpose of this research process was to investigate the potential for SDSU to increase its enrollment based on the goals that are outlined in their university master plan, which is entitled *Impact 2018*. That master plan outlined a goal to have 14,000 students enrolled at the university by 2018, which represents an increase of approximately 1,500 students from the current 2016 enrollment level. When the master plan was created, the South Dakota Board of Regents documented a decrease in statewide enrollment at all six public institutions of approximately 2,500 in-state students. That decrease has created budget shortfalls and campus-wide planning issues at all six public universities in the state.

This research was conducted under the assumptions that the enrollment goals outlined by SDSU in their master plan could be met by increasing marketing within the state in an attempt to increase penetration in their primary market. This research was based on the premise that the key element in increasing the SDSU campus-wide enrollment lies in a better understanding of geographic markets of students in the state. Specifically, a better understanding of how those students may be influenced by distance to the campus and the university's marketability compared to the marketability and distance of the other five regental institutions in the state. The primary concern of this project was the market under-supply and over-supply, by county, that may be hindering SDSU in their enrollment goals.

The Location Quotient analysis revealed that there is a distinct difference in the geographic footprint of SDSU compared to the other five SDBOR universities in the study area, especially in eastern South Dakota. SDSU has the most homogenous enrollment participation in the state, which may be beneficial when targeting markets in eastern South Dakota that are relatively isolated from other universities. In eastern South Dakota, micropolitan county students are choosing USD at a disproportionate rate compared to rural students in surrounding counties. When considering spatial competition and proximity, the Huff Model analysis revealed that SDSU has not yet reached their maximum market penetration in the state. Depending on the model iteration used, there may be an approximate difference of 500-1000 students between potential and realized enrollment in the state for SDSU. Most of those students reside in many of the same micropolitan counties of eastern South Dakota identified in the Location Quotient analysis. The synthetization of these results implies that some level of geographic targeted marketing could be used to increase enrollment of in-state students in South Dakota.

In their *Impact 2018* master plan, SDSU set a goal to increase enrollment to over 14,000 students by the 2018 academic year. As of 2016, the enrollment has increased by fewer than 200 students from the time the goal was announced. The results of this research project indicate that SDSU could move close to achieving their enrollment goals of 14,000 students, and that they may be able to do so based almost entirely on in-state students from eastern South Dakota.

REFERENCES

Aiton, Chelsey, and Brenden Mclane. 2014. “Calibrating the Huff Model for Outdoor Recreation Market Share Prediction.” 17-18.

Ali, Kamar Md.. 2003. “Analysis of Enrollment: A Spatial-Interaction Model.” *Journal of Economics* 29, no.2: 67.

Alm, James, and John V. Winters. 2009. “Distance and Intrastate College Student Migration.” *Economics of Education Review* 28:728-38.

Arreguin, Marcus A. 2008. “Spatial Interaction Models of Freshmen Recruitment and Retention at Stephen F. Austin State University for the Years 2001-2005.” Master's thesis, Stephen F. Austin State University, Nacodoches, Texas. Stephen F. Austin State University.

Bairoch Paul and Christopher Braider. 1997. *Cities and Economic Development: from the Dawn of History*. Chicago: The University of Chicago Press. 11.

Bellinger-Hass, Aimme. 2006. “Analyzing Student Enrollment at Clark State Community College.” Pennsylvania State University: 1-46.

Bottum, Mackenzie S. 1989. “Retail Gravity Model.” *Appraisal Journal* 57:133-172.

Brown, Lawrence A., and Su-Yeul Chung. 2006. "Spatial Segregation, Segregation Indices and the Geographical Perspective." *Population, Space and Place* 12, no.2: 125-43.

Bui, Quoctrung. 2016. "The States that College Graduates are Most Likely to Leave." *The New York Times.* November 22, 2016.

Burke, Matthew R., Elizabeth Davis, and Jennifer L. Stephan. 2015. "College Enrollment Patterns for Rural Indiana High School Graduates." *Society for Research on Educational Effectiveness.*

Cadwallader, Martin. 1975. “A Behavioral Model of Consumer Spatial Decision Making.” *Economic Geography* 51: 339-349.

Cappellari, Lorenzo and Claudio Lucifora. 2009. “The ‘Bolonga Process’ and College Enrollment Decisions.” *Labour Economics* 16, no.6: 638-647.

Chen, K., Kennedy, J., Kovacs, J.M. et al.. 2007. “A Spatial Perspective for Predicting Enrollment in a Regional Pharmacy School.” *GeoJournal* 70: 133.

Cooke, Thomas J., and Paul Boyle. 2011. "The Migration of High School Graduates to College." *Educational Evaluation and Policy Analysis* 33, no.2: 202-13.

DesJardins, Stephen L., Halil Dundar, and Darwin D. Hendel. 1999. "Modeling the College Application Decision Process in a Land-Grant University." *Economics of Education Review* 18, no.1: 117-32.

Dock, Joel P., Wei Song, and Jia Lu. 2015. "Evaluation of Dine-In Restaurant Location and Competitiveness: Applications of Gravity Modeling In Jefferson County, Kentucky." *Applied Geography* 60: 204-09.

Dolega, Les, Michalis Pavlis, and Alex Singleton. 2016. "Estimating Attractiveness, Hierarchy, and Catchment Area Extents for a National set of Retail Centre Agglomerations." *Journal of Retailing and Consumer Services* 28: 78-90.

Dramowicz, Ela. 2005. "Retail Trade Area Analysis Using the Huff Model." *Directions Magazine* 29.

Eccles, Jacquelynne S., Mina N. Vida, and Bonnie Barber. 2004. "The Relation of Early Adolescents' College Plans and Both Academic Ability and Task-Value Beliefs to Subsequent College Enrollment." *The Journal of Early Adolescence* 24, no.1:63-77.

Edwards, Dana, Himmelfarb, Daniel, and Christopher San Juan. 2016. "South Dakota State University Prospective Market Research." 10-14.

Fan, Lei, William W. Wilson, and Bruce Dahl. 2012. "Congestion, port expansion and spatial competition for US container imports." *Transportation Research Part E: Logistics and Transportation Review* 48: 1121-136.

Finger, Claudia. 2016. "Institutional Constraints and The Translation of College Aspirations into Intentions-Evidence from a Factorial Survey." *Research in Societal Stratification and Mobility* 46:112-128.

Fletcher, Jason M. 2012. "Similarity in Peer College Preferences: New Evidence from Texas." *Social Science Research* 41, no.2: 321-30.

Gnass, Karen M. 2016. "The College Transition for First-Year Students from Rural Oregon Communities." *Journal of Student Affairs Research and Practice* 53:269-280.

Goenner, Cullen .F. and Kenton Pauls. 2006. "A Predictive Model of Inquiry to Enrollment." *Research in Higher Education* 47: 935.

Golledge, Reginald G. 1996. "Geographical Theories." *International Social Science Journal* 48, no. 150:461-476.

Greenwood, Michael J. 2005. Modeling Migration. *Encyclopedia of Social Measurement* 2:725-734.

Hotelling, Harold. 1929. "Stability in Competition." *Economic Journal* 39: 41–57.

Huff, David L. 1968. "A Graphic Interpretation of the Friction of Distance in Gravity Models." *Annals of the Association of American Geographers* 58:814-824.

Johnston, Ron J. 2010. "Latent Migration Potential and the Gravity Model: A New Zealand Study." *Geographical Analysis* 2, no.4: 387-97.

Landrum, R. Eric, Rob Turrisi, and Clayton Harless. 1999. "University Image: The Benefits of Assessment and Modeling." *Journal of Marketing for Higher Education* 9, no.1: 53-68.

Leppel, Karen. 1993. "Logit Estimation of a Gravity Model of the College Enrollment Decision." *Research in Higher Education* 34, no.3: 387-98.

Mayo, E. J., L. P. Jarvis, and J. A. Xander. 1988. "Beyond the Gravity Model." *Journal of the Academy of Marketing Science* 16, no.3: 23-29.

McMillen, Daniel P., Larry D. Singell, Jr., and Glen R. Waddell. 2007. "Spatial Competition and the Price of College." *Economic Inquiry* 45: 817-33.

Miller, Mark M., Lay James Gibson, and N. G. Wright. 1991. "Location Quotient: A Basic Tool for Economic Development Analysis." *Economic Development Review* 9, no.2: 65.

Morgan, Kevin and Cooke, Philip. 1998. *The Associational Economy: Firms, Regions, and Innovation*. England: Oxford University Press.

Nekola, Jeffrey C. and Peter S. White. 1999. "The distance decay of similarity in biogeography and ecology." *Journal of Biogeography* 26, no.4: 867–878.

Pattison, William D. 1964. The Four Traditions of Geography. *Journal of Geography* 63, no.5: 211-216.

Reilly, William J. 1931. "The Law of Retail Gravitation." *Knickerbocker Press*.

Rodrigue, Jean-Paul, Claude Comtois, and Brian Slack. 2017. "Spatial Interactions and the Gravity Model." *Geography of Transport Systems*. New York: Routledge: 425.

Rouse, Cecilia E.. 1994. Edited by Ronald G. Ehrenberg. "What to Do after High School: The Two-year versus Four-Year College Enrollment Decision." *Choices and Consequences: Contemporary Policy Issues in Education*: 59-74. Ithaca, New York: ILR Press.

Smith, Bruce W., Joseph G. Spinelli, and Yu Zhou. 2002. "Geographic Patterns of Student Enrollment in Ohio's State-Assisted Universities." *Ohio Journal of Science* 102: 34-39.

South Dakota Board of Regents. 2010. a. “Fall Headcount Enrollment Grows Slightly at Public Universities.” *Press Releases*.

South Dakota Board of Regents. 2016. b. “Fall Headcount Enrollment Grows Slightly at Public Universities.” *Press Releases*.

South Dakota Board of Regents. 2016 .c. “SDBOR College Matriculation Dashboards.” *Dashboards, 2011-2015.*

South Dakota Board of Regents. 2016. d. “SDBOR College Placement Dashboards.” *Dashboards, 2011-2015.*

Suarez-Vega, Rafael. 2015. “Locating a Supermarket Using a Locally Calibrated Huff Model.” *International Journal of Geographical Information Science* 29:217–233.

Thompson, Bryan, and Allan Pred. 1969. "Behavior and Location. Foundations for a Geographic and Dynamic Location Theory. Part I." *Economic Geography* 45, no.2: 183.

Tobler, Waldo R. 1970. "A Computer Movie Simulating Urban Growth in the Detroit Region." *Economic Geography* 46: 234-240.

Wolpert, Julian. 1970. Departures from the Usual Environment in Location Analysis. *Annals of the Association of American Geographers* 60:220-229.