A Geospatial Analysis of a Transit Program on California Community College Students

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A GEOSPATIAL ANALYSIS OF A TRANSIT PROGRAM ON CALIFORNIA COMMUNITY COLLEGE STUDENTS

A Dissertation Presented

to
The Faculty of the School of Education
Organization and Leadership Department

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

by
Alicia Kathryn De Toro
San Francisco
April 2018
THE UNIVERSITY OF SAN FRANCISCO
Dissertation Abstract

A GEOSPATIAL ANALYSIS OF A TRANSIT PROGRAM ON CALIFORNIA COMMUNITY COLLEGE STUDENTS

Subsidized transit policy is a strategy used to lessen environmental impacts and increase institutional accessibility in higher education. Program funding to support this subsidized transit policy can vary between institutions. This research focuses on the geographic analysis of Eco Pass, a student led initiative implemented in the Foothill De Anza Community College District in California to offset transportation costs for students. Through the use of Environmental Science Research Institute software, the research aimed to determine which geographic areas, if any, were of high and low probability of Eco Pass use from data during 2011-2017 using Tobler’s first law of geography. Exploratory regression was conducted using income, population, crime, vehicle ownership, and educational attainment (per census block) to determine Eco Pass use prediction. The results of the analysis indicate that over time the mean of the Eco Pass population, by student address, shifted eastward for the entire district. The impact of De Anza College’s Eco Pass students impacted the overall district, more than Foothill. Exploratory regression of selected variables revealed that population, with crime index on the borderline, as predictors of Eco Pass use. Ultimately, regression models were rejected to non-stationarity.

Recommendations based on findings include assessing the goals of the Eco Pass policy. This study found that Foothill has less influence in the district Eco Pass geographic distribution and no significance of hot or cold spots. De Anza college has the larger influence and the largest area of high probability of use is that adjacent to the
campus community. Spatial analysis based on Tobler’s law indicates that the district Eco Pass policy is providing access to students who differ from its own community, but further analysis resulted in discussion around the impacts of the changing composition of the district community. Being that the district exists within the unique area of the Silicon Valley, these changes will ultimately impact the student population.
Signature Page

This dissertation, written under the direction of the candidate’s dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

Alicia K. De Toro ___________________________ April 26, 2017
Candidate

Dissertation Committee

Dr. Danfeng Koon ___________________________ April 26, 2018
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Dr. Nicola McClung __________________________ April 26, 2017

Dr. Darrick Smith ___________________________ April 26, 2017
Acknowledgements

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."

John Muir, naturalist

My background in environmental sciences allowed for a unique experience in a social science based doctoral program. But as stated by John Muir, all things are interconnected. Expanding my education to deepen my understanding of organization and leadership allowed me to explore ideas that further reinforced my environmental science knowledge. Like an ecotone, where two communities meet, my knowledge represents the overlapping communities of social and environmental sciences. In a time where we are experiencing impacts from climate change, to me this is an important space. For without a healthy environment, the Earth cannot support a healthy population.

I have met many colleagues during my time in this doctoral program in the school of Education at the University of San Francisco. It is because of these supportive individuals that I have been able to accomplish this goal, some of whom I would like to personally thank. Dr. Patricia Mitchell has always been a compassionate and exemplary scholar who I continue to admire. She provided me with support during a time of personal struggle, which is appreciated. My committee members Dr. Danfeng Koon, Dr. Nicola McClung, and Dr. Darrick Smith are ascending leaders in the scholar community who provided me with encouragement throughout the dissertation process. I definitely would not have made it without them and I appreciate their encouragement. They each are
important contributors to the future of education and I am proud to have worked with them. Additionally, I would like to thank Thanh Ly for all of the work that she does for the Organization and Leadership program; she is an amazing asset.

During this program I met many new friends. These colleagues provided a community of supporters with similar interests that I could not have found elsewhere. I will cherish the memories and remember our learning experiences. I look forward to working with many of them in our future. Friends and family who have supported me through this process will be happy to see more of me and should know that I appreciate every conversation, text, shoulder for crying, and everything else that got me here. Ultimately, I would like to acknowledge my mother and father, Judith and Pedro De Toro. My parents have always supported me in my academic endeavors. To be capable of unconditional love is a unique characteristic and they have it. I am forever grateful for all that they have done to provide me with access to higher education and the resources necessary to achieve this goal. Thank you.
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CHAPTER ONE: THE RESEARCH PROBLEM

Introduction

Scientific models indicate that climate change is occurring. Global changes in temperature, soil moistures, precipitation, drought frequency and intensity, and sea level rise are already having negative impacts on social and economic systems. The burden of climate change will disproportionately impact poorer countries and lower income populations around the world. In addition to the direct environmental fall out, there will be social implications that exacerbate the hardships suffered by people of color and/or low-income communities in areas such as health, employment, housing, and food (“NAACP | Environmental & Climate Justice,” n.d.). Leaders who foresee the need to prepare populations for a changing environment through lessening future anthropogenic impacts have embraced environmental policy (U.S. Global Change Research Program, 2014).

Despite the current political discourse in the United States, there is no debate within the scientific community on the anthropogenic responsibility for climate change. According to the International Panel on Climate Change, “Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gasses are the highest in history. Recent climate changes have had widespread impacts on human and natural systems” (Pachauri, 2014). The dependence on fossil fuels for transportation along with the “American Dream” mindset used to encourage single-family homeownership has created a network of planned communities through sprawl. The carbon dependent society that exists in the United States is not sustainable (Wheeler, 2009). Policies and strategies focused on minimizing environmental degradation vary. As a means to address carbon emissions,
organizational transportation focused policies aim to reduce vehicle emissions through mass transit, carpooling, and parking initiatives (Withgott & Laposata, 2014).

A specific response to offsetting carbon emissions at an organizational level is that of subsidized bussing. Universities and employers offer transit subsidies and passes to encourage use of public transportation. Many community colleges, in particular, have adopted these policies for both environmental reasons and access and equity concerns. The state of California provides higher education opportunity through the community college system, which serves as the entry point to higher education for many underrepresented groups such as low-income, African American, Latinos, immigrants, and working adults (Dowd, 2003). Community colleges are the only branch of the California Higher education system that does not have extensive requirements for admission to ensure that higher education is available to “any student capable of benefiting from instruction” (“Admission Requirements,” 2012; UC Office of the President, 2007). With specialized courses in vocational and academic subjects, along with basic skill and English as second language courses, financial assistance opportunities, and specialized programs to assist with student success, transit passes for community college students are a valuable resource to low-income groups (Sengupta & Jepsen, 2006).

While there are studies that provide evidence of the environmental impact of Eco-passes, there are fewer that study the equity and access impacts of these transit policies. This research examines the geographic impact of an Eco Pass policy by studying the distribution of Eco pass users relative to the community where the college resides.
Statement of the Problem

Universal transit, universal access, fare-free access, and Eco Passes are agreements between colleges and local transportation agencies that result in subsidized mass transit fees for students, allowing them to use the service at a discounted rate (Hess, Brown, & Shoup, 2004). Use of these passes has been rooted in both environmental and social goals (“De Anza College Eco Pass”, 2011).

Environmental benefits of subsidized transit are well documented. Research demonstrates that alternative transportation options reduce single car ridership and thus offset some of the negative environmental impacts of transportation. This is revealed by the decrease in demand for on-campus parking and an increase in transit system usage in studies of subsidized transit program implementation (Brown, Hess, & Shoup, 2003). Alternative transit is encouraged in dense urban areas where traffic congestion causes concern about air quality. Promoting mass transit, and encouraging “carpooling” and other alternatives, lowers the number of cars on the roadways, ultimately decreasing air pollution (“Transportation Research Board,” 2001). These results are desirable and necessary in achieving organizational goals for leaders who embrace sustainability.

Subsidized transit passes create positive environmental impacts that benefit society, however, there are less obvious social impacts derived from improved access to public resources, namely community colleges. Research conducted on universal access passes has revealed that when subsidized transit is readily available, participation in mass transit systems increases immediately upon implementation. Studies have shown that growth in participation has ranged from 71 percent to 200 percent (Brown, 2001). Subsidized transit passes create more users of mass transit, but they also help to make the playing field slightly
more level among varying socioeconomic statuses. In a car-dominated community, busing makes higher education more accessible to those in lower socioeconomic groups who may not be able to afford their own cars. This type of financial assistance is uniquely important to low-income students on community college campuses (Brown, Hess, & Shoup, 2003).

In fall 2010 student leaders began advocating for subsidized transportation on the De Anza College campus. They proposed that the Foothill De Anza Community College District (FHDA) establish a subsidized transit plan with the Santa Clara Valley Transportation Authority (VTA), deemed “Eco Pass.” The program is similar to the other subsidized transit programs yet has a name that gives it instant marketability to the environmentally conscious consumer.

Leading up to the decision to allow the greater campus to vote on the initiative, the De Anza Student Body (DASB), or the governing body representing students at the college, debated the numerous pros and cons of implementation in session. Meeting minutes indicate that senators who favored the transportation fee that would later establish the transit program stated that there would be relief of “traffic and parking congestion on campus,” an increase in affordable transportation for students, especially in comparison with the regular cost of a Valley Transportation Authority pass, and a reduction of the college’s carbon footprint. Concerns were raised regarding inconsistent accessibility; the potential impact on campus carpools, the requirement that students pay the additional Valley Transportation Authority fee despite the lack of use, and the apprehension that low participation could fail to offset the transit pass cost. Ultimately, the proposed benefits outweighed the dissent and the motion to approve the ballot measure for the Eco Pass subsidized transit program passed with no objections from DASB representatives (De Anza Associated Student Body, 2011).
After the DASB student leaders embraced the Eco Pass program the student body followed, with 89% of students voting in favor of the ballot measure on May 15, 2011 (“De Anza College,” 2011). Approval of the student body moved the Eco Pass forward and it proposed that the Foothill De Anza Community College District Board of Trustees take action to charge a mandatory quarterly fee of up to five dollars to all full-time De Anza College students and a mandatory quarterly prorated fee to all De Anza College part-time students to make VTA Eco Passes available to all De Anza students.

The Board of Trustees then passed the aforementioned transportation fee resolution for De Anza Community College and implementation began in Fall 2011 (Foothill De Anza Community College District, 2013).

Although the use of subsidized transit occurs in many organizations, most research has been conducted on four-year university programs. Very little information exists on community college programs and increased research is necessary to fully understand how transit passes impact access, inclusion, and diversity on community college campuses. Through quantitative analysis of cross-sectional data, this research examines whether decreasing public transportation costs through Eco Passes increases accessibility to students and changes the demographic composition of on-campus community college student populations.

**Purpose of the Study**

The purpose of this study is to analyze a sample of students who requested to use subsidized transit in a community college district. Although a significant amount of research exists about the effect of universal passes on university campuses, there is insufficient literature analyzing their impact on community college populations. Research shows that university administrators support universal access passes because of the reduced
demand for on-campus parking, increased accessibility to housing and employment, recruiting and retention, reduction in costs of attendance, and increase in transportation equity (Transportation Research Board, 2001). Community colleges are unique from four-year universities because of the limited requirements for admission and the cost of attendance. The influences of community colleges on underserved groups is substantial, therefore more exploration into the effects of universal passes is warranted and necessary.

The Foothill De Anza Community College District are well known for their high academic standing. In 2015-2016 De Anza was identified as the number one large community college in California and Foothill was named the number one medium California community college. The two colleges have the highest graduation, transfer, and retention rates of all community colleges in California (“The 15 Best Community Colleges in California | 2015-2016,” 2015). Despite the colleges residing in affluent communities, the resources at these colleges are beneficial to success, which are valuable to many students throughout the South San Francisco Bay Area. Access to campus, and thus the assistance available, is important to student success, especially for students from lower-income communities. This study focuses on identifying communities who are served using the Eco Pass subsidized bussing program.

This study uses the theory of the first law of geography (FLG), through spatial analysis, to identify areas of high and low Eco Pass usage to determine community characteristics relative to the campuses. In addition, other variables available from the Environmental Science Research Institute (ESRI), gathered from the United States Census, were used in an attempt to identify factors that predict Eco Pass use (“Census and ACS—Esri Demographics | ArcGIS,” n.d.) to determine whether Eco Pass policies are in fact
providing more community college access to lower-income communities.

FLG is a theory developed by Waldo Tobler, which states, “everything is related to everything else, but near things are more related than distant things” (Miller, 2004). The theory states that “similar values for nearby features occur because of similar conditions” (Mitchell, 1999). Based on this theory, communities closest to the colleges, and thus the students that reside within them, will be most like the communities the colleges inhabit. In contrast, communities farther away from the colleges, will be less like the closer communities. Since the colleges in this study are located within affluent communities, this theory states that the further a student travels to access campus, the less likely their community will be similar to that of the college.

In this study, each student address was plotted, grouped by census block, and spatial statistics, including median center analysis were conducted. Lastly the ESRI/census data was connected to the student data to determine the impact of selected variables on the prediction of Eco Pass use. Data used in this study included 2017 median income, 2017 total population, 2017 crime index, household ownership or leasing of vehicle, and 2017 educational attainment (“Census and ACS—Esri Demographics | ArcGIS,” n.d.). The connection of this data provided insight for analysis of the sample.

**Significance**

Assessing a sample of subsidized transportation users within a community college district population in a spatial context contributes to our understanding of affordable access to higher education at the community college level. Decreasing financial barriers that exist in this system of higher education is important because of the unique mission of community college in California to provide education to any and all who would benefit from it.
Although public transportation exists, it only allows for physical access to campuses at a cost to the individual user. The subsidization of public transportation is a strategy used by higher education institutions to assist with managing parking and transportation for campus access and studies have indicated a significant increase in transit ridership as a result.

This research allowed for a better understanding of the geographies of students who are likely or unlikely to request an Eco Pass in the Foothill De Anza Community College district. Determining differing characteristics allows for further evaluation of benefits and purpose of existing campus programs and future program development alignment with student needs. Also, identification of predictors to Eco Pass use was beneficial to a better understanding of the social or demographic variables that may or may not influence subsidized bussing use in community colleges.

On a larger scale this research contributes to the breadth of knowledge on higher education and transportation policies. It creates a more profound, multidimensional understanding of community college students’ needs, which, in turn, contributes to a greater understanding of the importance of aligning programs and policies to student needs.

Research Questions

This research aimed to analyze a sample of students who chose to use subsidized transportation. The two main research questions were

1. What geographic neighborhoods/communities are most likely to utilize Eco Pass to access the community colleges? What geographic neighborhoods/communities are least likely to utilize Eco Pass to access the community colleges?

2. Do the selected variables of median income, total population, crime index, household vehicle ownership or lease, or educational attainment alone or in combination predict
Eco Pass use?

**Delimitations**

This study analyzed the students from Foothill De Anza Community Colleges enrolled in courses during Fall 2011 through Spring 2017 who requested Eco Passes. The data for this study was gathered from the district’s Office of Institutional Research and Planning (“Welcome!,” n.d.). Analysis of census block data was selected by the researcher to drill down in to the smallest geographic scale.

Additional delimitations include selection of variables, which were determined by the researcher, informed by the literature and the availability of data. The selection of variables was limited to availability of data. For this study manipulation of data occurred to limit the impact of outliers that existed within the dataset. A 30-mile district radius was created to identify Eco Pass users who reasonably could access the Valley Transportation Authority network. This removed geographic outliers that may have been the result of inaccurate data entry, to limit impact on findings.

**Limitations**

The limitations of this study include limitations of available Foothill De Anza data, generalizability, the inability to account for illegal use of Eco Passes, and incomplete data. The data used for designating the geospatial distribution was limited by Foothill De Anza data. As previously mentioned, collection of the district data could include data entry errors. Students may have used permanent home addresses instead of local addresses, which would skew the geographic distribution of the sample. It has been documented that students sometimes lend their passes to other non-students; thus, fraudulent use of the system is a potential influence as well. Other transit agencies have been concerned about this issue, but
for this study, the influence of theft will not be considered.

Additionally, the availability of data impacted the results of this study. Geographic Information Science was used for mapping the distribution in a geographic spatial context to show relationships. Various types of spatial analysis were conducted using ArcGIS software, but the analysis was limited to the data, system capabilities, and delimitations and limitations of the ESRI analysis embedded within the datasets used. Variables used for projection of Eco Pass use included public college population data and available census data, which was limited because census data is collected every five years and thus was not available for the specific years of Eco Pass requests; this limited the researcher to use the 2017 ESRI census data projections.
CHAPTER TWO: REVIEW OF LITERATURE

A comprehensive literature review was conducted to guide this research. A foundational understanding of community college is imperative to this study and served as the starting point for research. The topics that served as a focus within the subject included history and purpose of community colleges, access and barriers to community colleges, and transportation policies.

Purpose of Community Colleges

The inception of the California Community College began in the early 1900’s. In his piece titled *The Junior College, or Upward Extension of the High School*, C.L. McLane, the Superintendent of the Fresno City School District at the time, identified the need for college access in California in a geographic context. California is geographically large and the number of universities was insufficient; there were only two “great universities,” Stanford University and the University of California at Berkeley, at the time. This created a cultural hardship for students and families who were far from higher education campuses. Parents who sent their child to a university would have to travel far to visit and vice versa for the student- limited family time was a concern for educational leaders and politicians. Fresno leadership argued that “there is no institution of higher education within two hundred miles of Fresno where students may continue their studies beyond the regular high school courses” and many who wish to attend “cannot afford the expense necessary to college attendance” (McLane, 1913).

Currently the California Community Colleges (CCC) comprise the largest system of higher education in the nation serving 2.1 million students annually through a network of 113 colleges. The CCC’s provide educational opportunities to all potential students, with
programs such as workforce education, certificates and degrees for vocational training, and transfer to four-year institutions. (“Chancellor’s Office Portal Home,” 2017). Chancellor Eloy Ortiz Oakley stated in the 2016 State of the System report, the CCCs the state faces many challenges, including “delivering a workforce that fuels our state’s changing economy.” He predicts a shortage of one million middle skilled workers (those who have credentials, certification and associates degrees) and of 1.1 million workers with a bachelor’s degree. He states that the CCCs are “well positioned” to wrestle these issues stating, “our colleges are the most powerful engines of social and economic progress in the state.” Together relationships with the University of California and California State Universities will assist with transfer rates to address the lack of bachelor’s degrees, improve completion rates, close achievement gaps, and work towards more investment in public higher education (Oakley, 2016).

According to the Institute for Higher Education Leadership and Policy educational attainment is down in the State of California. Success of California is dependent upon an educated workforce, specifically the Latino population (Moore, Shulock, & California State University, 2010). Community colleges serve as the “entry point to higher education for youth and adults who are historically underrepresented in higher education” and serve more “first generation, part time, nontraditional age, low income, minority, and female students than any other type of public higher education institution” (Bragg & Durham, 2012). Kindergarten thru twelfth grade education for the underrepresented minority groups are more likely to have attended segregated, overcrowded schools with low concentration of qualified teachers and college preparatory curriculum, which hinders college success (Moore, Shulock, & California State University, 2010). It is essential to improve access and
completion rates for underrepresented minority students (Public Policy Institute of California, 2017).

**Access and Barriers to Community College**

Community colleges are often referred to as the “people’s college” and “democracy’s college” due to role in expanding higher education enrollments and increasing educational opportunities (Dowd, 2003). In his presidential address to American Educational Research Association (AERA) in 2013 William Tierney acknowledged that education in the 21st century has been “exceptional in the wrong way.” Education was once an option for social mobility, but the United States now has less upward mobility and low-income continuance compared to other industrialized countries, thus “moving out of the poorest sector of society [has become] even harder.”

The recession during the beginning of the century exacerbated the existing issues with poverty. It is at this point that Tierney (2013) addressed the role and the responsibility of the intellectual in eliminating poverty. He addressed the question “what might we recommend to increase access to college and to create a college-going culture in low-performing schools?” through five recommendations: offer courses and curriculum that prepare students for college-level work by ninth grade, utilize classes during high school to provide feedback to students so they are aware of their level of preparation and provide the resources necessary for students to overcome identified deficiencies, immerse students in supportive environments that consists of people who encourage college going, encourage college entry by providing assistance in completion of critical steps, and increase assistance and awareness of financial aid to students and families. Tierney believes that the role of the intellectual is to be involved and engaged, to go beyond the Ivory tower. Beyond the role of
the researcher he feels that intellectuals are responsible in all areas and that education benefits the country, not just from training, but also from democratic engagement (Tierney, 2013).

Expanding on the ideas of Tierney, Scherrer (2014) respectfully states that educational reform has focused narrowly on one of the two components of poverty. He states that there are two dimensions of poverty; resource availability and ability to convert said resources to a usable form. Together these components of equality will result in equity. Educational reform typically is generated from a resource-based perspective, focusing solely on buffering of poverty through the provision of resources. A new lens is necessary to ensure success, one that includes a perspective of capabilities. This perspective identifies the value of the resource, which is dependent upon the individual’s ability to utilize. In addition to consideration of both variables of poverty and a different view, the Scherrer states that a collective or collaborate approach is necessary. This ensures that multiple organizations hold the responsibility of eliminating poverty. Ultimately the existence of poverty in society depends upon social and economic policy. Until reform is broadened and bolder, inequities will continue to come from the narrow-focused reform of the resource-based perspective (Scherrer, 2014). This collaborative effort is one that has been taken on by the community colleges.

Ninety five percent of community colleges have open admission policies giving these institutions a critical responsibility for educating the most diverse learning groups. Without these open admissions policies, these would be less educational opportunities for low-income, immigrant, and first-generation students. To address the particular needs of this portion of the population, colleges have been focusing on the “equity agenda,” which
consists of access, readiness, and success. The idea behind the implementation of specific
programs is to “adopt an equity agenda that deliberately links access to college readiness,
success would be more attainable by diverse student groups” (Bragg & Durham, 2012).

In addition to access issues, there are obstacles, or barriers that exist. Community
college student success is difficult to measure (Sengupta & Jepsen, 2006). Barriers faced by
students include the relationship of access to completion, equity gaps, linking access to
readiness, students’ disconnect of readiness and aspirations, and importance of
understanding the community needs in policy formation (Bragg & Durham, 2012). Bragg
and Durham (2012) state that the community colleges are stuck in a catch 22, with the
pressure “to maintain open access while producing many more students who complete and
receive a credential.” They do not support “the refocus of higher education from access to
completion” as encouraged in national conversation by President Obama. They state that
“by offering the primary pathway to higher education for historically underserved students,
including learners who are underprepared for college-level coursework and who struggle to
finish, community colleges diminish their chances of demonstrating success.” A shift in the
interpretation of “college success” without acknowledgment of the interdependence of
access and success would be devastating to the community colleges (Bragg & Durham,
2012).

Other perspectives consider lack of financial aid, lack of financial aid information, in
addition to lack of college preparedness to be the barriers to higher education (Dowd, 2003;
Tierney, 2013). As colleges address the concept of access and completion through on
campus programs and policies, physical access must also be acknowledged.
Physical ability to access resources is addressed by transportation studies. Options for students to get to campus, to be in the classroom, to physically immerse oneself in the higher education environment, are an important component. There are two primary ways that students can participate in community college classes; on-campus or online. Low-income students face barriers to both. Accessibility to online learning environments is hindered affordability of technology as addressed by the digital divide (“The Digital Divide,” n.d.). The ability to access the physical campus is another hindrance to low-income learners; “transportation is a major component of the cost of attending college” (Brown, Hess, & Shoup, 2001). Sanchez, Qing, & Zhong-ren, (2004) found that households receiving Temporary Assistance for Needy Families (TANF) from the Department of Health and Human Services had low rates of vehicle ownership. Lack of vehicles has led to their dependency on public transit. If students fall into this category, then they too will benefit from assistance in transportation costs. Staff at Rio Honda Community College reported “that students were spending more on transportation expenses then they were on books,” which ultimately led to the launch of the GO RIO subsidized bus pass program (Martinez & Castañeda-Calleros, 2009).

**University Transportation Policies**

Transportation Demand Management (TDM) plans are documents created by universities to address transportation needs. They entail parking oversight, unlimited-access transit, and transit improvements. TDMs are comprised of policies designed to "seek to reduce or mitigate the negative aspects of automobile travel including congestion, air quality, and transportation inequity." They are also designed to “build upon positive aspects of a balanced transportation to foster economic development, expanded housing choices,
and a reduction in capital expenditure on transportation infrastructure” (Bond & Steiner, 2006).

Alternative transportation inclusion at universities is not a modern concept. After World War II suburban sprawl began to occur in many areas of the United States, including the San Francisco Bay area. The American Dream of single-family home ownership corresponded with a move of land development away from the center of urban areas. Coinciding with the move in residences came the dependence on the automobile. Over time it has become the norm in many social groups to participate in single user vehicle transportation, however this is not financially feasible for those who exist in the low-income bracket (Wheeler, 2009). During the 1960’s some universities implemented bus pass programs. The idea moved slowly to more schools during the 1980’s, but gained momentum in the 1990’s because of transit system maturation, fiscal situations, student and administrative goals. Today, transit programs at colleges include goals aimed at reduction in demand of parking, increased access to housing, employment, etc., reduction of congestion on campus in nearby neighborhoods (Transportation Research Board, 2001).

Fare free transit, universal access, and Eco pass are all terms for subsidized transportation at universities and community colleges. They give the appearance of free transit, however “shadow fare” is subsidized by the university or college, which results in a lower cost to users. An agreement is made between the university and the transit agency with a designated price for ridership. The cost covers the group as designated by the agreement, typically students. The funds for the fiscal coverage can come from different groups on campus, sometimes being paid for from parking funds collected through issuance of permits. Universal access is a strategy that is used in transportation demand management
in predicting transportation needs considering campus needs and growth (Hess, Brown, & Shoup, 2004).

Universal access (UA) is beneficial to all stakeholder groups. According to Brown, Hess, and Shoup “unlimited Access reduces parking demand, increases students’ access to the campus, helps to recruit and retain students, and reduces the cost of attending college” (2001). Universities like UA because it reduces parking demand, increases student access to housing and employment, recruiting and retention of students, reduces the cost of attendance, and increases transportation equity colleges. Universal Access also reduces vehicle travel and emissions, decreasing impacts of air pollution, resulting in support from the environmentally conscious. Improved air quality incentive- in areas that struggle with meeting the requirements of Clean Air Act (1990), some programs are able to use funding aimed at decreasing air pollution (Transportation Research Board, 2001). Increased mobility provides more opportunity for employment, internships, and other social, cultural, educational, and recreational opportunities (Hess, Brown, & Shoup, 2004).

According to the Transportation Research Board National Research Council (2001), student support, supportive administration, sufficient transit agency capacity, and patience are necessary for success of universal access programs. In some cases, the funding for the transit subsidy for the Universal access pass programs comes from the student body itself. Student fee use for financing requires students to vote to impose the fee (Transportation Research Board, 2001). System capacity is a concern because of the spike in ridership (can be expected to double or even triple), this can be risky for transit agencies because of the increased demand on service and their ability to meet the new demand (Transportation Research Board, 2001).
Hess, Brown, & Shoup (2004) have extensively researched universal access passes. In their study that looked at 35 universities in the United States, the authors found that universal, or fare free access was beneficial to students and transit agencies, through evidence of increased ridership. Research has shown that characteristics of colleges such as town or city size, size of student population, and urban or rural location, do not influence universal access success, indicating that universal access is plausible for all types of college campuses. The Transportation Research Board National Research Council (2001) reinforces this, “although is it believed to be impractical in large urban areas, prepaid transit that would allow users unlimited access to high-quality service has been tried and proven successful in university communities through the country.” Provision of subsidized transit influences student behavior and has shown a shift from cars to buses for some users. Passes also “reduces parking demands, increases access to social services and employment, helps recruitment and retention, reduces costs of attendance, and increases transportation equity” (Balsas, 2003).

Offering transit passes shifts the “bus-car frontier,” which can be used to designate how many will utilize transit in addition to those who already do. Additional research has revealed that those who will choose to utilize universal access have a difference of value in time and money than those who do not. Thus, those who utilize universal access are more likely to be lower income students that have a lower value associated with time and/or do not have the extra income to offset time costs (Brown, Hess, & Shoup, 2001).

Universal access passes exist at many large universities including: the University of Washington, University of Wisconsin at Milwaukee, University of Pittsburgh, University of
Florida, and the selected University of California, and California State Universities (Transportation Research Board, 2001; Brown, Hess, & Shoup, 2001).

The major issues in implementation of universal access include impacts on transit demand, equity of fee implementation, and fraudulent use of the system (Transportation Research Board, 2001).

The literature indicates that programs are beneficial, which is reflected in the high number of users after implementation. From the university vantage, these programs also decrease the demand for parking. Ultimately the users, and the greater community, benefit by reducing traffic and congestion by taking drive-alone riders off the road.

**Eco Pass Policy**

Eco Passes are a variation of universal pass programs, typically focusing on employer-based transportation subsidies. These programs are offered by transit agencies in Dallas, Denver, Salt Lake, and San Jose. Employers pay the cost as the university would in a traditional universal access program. Similarly, this lowers the cost per individual in comparison to the standard rates offered by the transit agency (Shoup, 2004). The benefits are similar as well. Eco Passes decrease the demand and need for parking, which can save employers money on capital costs. Eco Passes result in the same benefits to the transit agencies as well, providing a steady revenue source. Commuter studies in the Silicon Valley for companies that have implemented the Eco Pass have shown a decrease of 16% in solo-drivers, from 76% pre-implementation to 60% solo drivers post implementation (Hess, Brown, & Shoup, 2004).

The benefits of the Eco Pass and Universal Access (fare free) programs are revealed in the transit agencies willingness to extend the option to other groups. Seattle Metro has an
agreement with the University of Washington that allows ticket holders for stadium events to use their tickets as a transit pass on game day. Analysis of ridership increased by five times after the implementation of the Eco Pass program in comparison to prior ridership for game day events. Internationally this concept has been used in sporting events as well, including the 2004 Athens Olympics and sporting events in German cities (Shoup, 2004).

Other industries that are utilizing subsidized transit passes are those of hospitality and residences. To decrease their parking demands and to encourage use of local transit, “transit-in-lieu-of-parking” arrangements are used by hotels. Coronado, California has a reduced parking requirement for the lodging industry if they offer guests free transit passes. This concept is also used in living communities and apartments. Cities can use the same strategy as Coronado in community developments. By including provisions or benefits to developers who incorporate free transit passes to the residents the requirements for parking are decreased. Developers are also encouraged to include transit amenities in the community to ease the use of transit. The inclusion of the transit passes is also used by the complex management to attract residents who have fewer vehicles and want to access transit lines (Shoup, 2004).

Overall, this literature suggests that the use of subsidized transportation increases student use of transit services. Community colleges are the largest providers of higher education to underserved students. Although most of the literature on subsidized transit has been studied in four-year university settings, less is known about the impact on community college student populations. Given the expressed purpose of community colleges in providing access to underserved students, research on the impact of transit subsidies like the Eco Pass on the environment as well as on economic and social concerns is necessary.
CHAPTER THREE: METHODOLOGY

Research Questions

This research analyzes the characteristics of a sample of students who registered for subsidized bussing in a community college district. Understanding the predictors of Eco Pass adds to the greater knowledge of transit policies in higher education. The two main research questions were:

1. What geographic neighborhoods/communities are most likely to utilize Eco Pass to access the community colleges? What geographic neighborhoods/communities are least likely to utilize Eco Pass to access the community colleges?

2. Do the selected variables of median income, total population, crime index, household vehicle ownership or lease, or educational attainment alone or in combination predict Eco Pass use?

To answer the research questions data was collected from Foothill De Anza. Although the data was accessible through convenience sampling due to the relationship of the researcher with the district, interest was the main driver for this research. The methods used in this study are grounded in geospatial analysis. Through the use of FLG theory, differences of communities relative to the college and district were observed. The available data created a unique opportunity to inform subsidized transit in the other similar CCCs. At the time of this study 58 CCC’s were identified as having a subsidized transit program that may benefit from this research.
Background: Foothill De Anza Community College District

The Foothill De Anza Community College District (FHDA) is home to 2 of the 113 other community colleges in the state of California (“Home Portal,” n.d.). However, this district is unique due to its location within the Silicon Valley. De Anza Community College resides in the affluent community of Cupertino, otherwise known as the home of Apple computers (Ha, 2015). As shown in figure 1, 92% of the surrounding community’s workforce is considered white-collar with the median household income being $119,980.

![Figure 1. Environment Systems Research Institute Community Analyst output infographic for a ten-minute walking distance radius from the De Anza Campus.](image)

According to United States Census data, 93% of the population has some college and/or a Bachelor’s, graduate, or professional degree.
These statistics fare well for a certain demographic of De Anza’s students, but the student population is not derived solely from this immediate and well-resourced area. In 2012, CNN reported that De Anza boasts over 70% success rates, making it one of three-dozen top-performing community colleges in the U.S. The article quoted President Brian Murphy, “many students drive past other community colleges to attend classes at De Anza” (Clark, 2012). This statement implies that there are alternative community college choices in closer proximity to certain students, however despite an extended commute they choose De Anza because they desire a better education. Consequently, subsidized transportation passes are beneficial to low-income students who wish to access the campus for higher education and social services.

De Anza College and Foothill Colleges share similar demographics as they both reside in the affluent communities. Foothill College is nestled in the Los Altos hills where
the town enjoys a median household income of $200,001 and 0% unemployment; 85% of
the employment is categorized as white collar and 96% of community members have some
higher education. Foothill College’s success rates are also similar to De Anza (Figure 2).
Together these colleges exist in and serve some of the most affluent communities in Silicon
Valley. Preliminary research reveals inequalities in income that exist along the Valley
Transportation Authority transit routes. The income disparities between communities
connected to the colleges through the transit network are displayed in Figures 3 and 4.
When the Associated Students of Foothill College presented the same transportation measure as DASB to their student body during the winter of 2013 it passed with 1,112 out of 1,333 votes (Foothill De Anza Community College District, 2013). Implementation of the Eco Pass program gave students from both colleges access to the large transportation network provided by Valley Transportation Authority (Figure 4).

Figure 4. Map depicting the transportation network provided to students through the approval of the Eco Pass program at each campus location.
The ability of student leaders to pass a subsidized bussing initiative demonstrates their understanding of the importance of social and economic diversity in their schools. However, increased research is necessary in order to more fully understand how transit passes positively contribute to this diversity on community college campuses. Community colleges are the only branch of the California Higher education system that do not have extensive requirements for admission to ensure that higher education be available to “any student capable of benefiting from instruction” (“Admission Requirements,” 2012; UC office of the President, 2007).

Initial research of potential variables that may influence Eco Pass user-ship reveals that the Valley Transportation Authority transit network has a far reach not only geographically, but also potentially socioeconomically as well (Figures 3 & 4). Median household income data from the U.S. Census reveals a diverse distribution of variation when added as a layer onto a geographic map. Exploration of the geographic distribution of the student population will allow for a better analysis than the use of flat, two-dimensional data. Based on this initial map there is a lot of opportunity for the Foothill De Anza campuses to pull students from many different communities through the implementation of the Eco Pass. In addition to the social impacts of implementation, there is potential for impacts on the environmental and economic aspects as well.

**Methods**

This research utilized Geographic Information Science as the instrument for quantitative analysis. ESRI’s ArcGIS is a computer software program that captures, stores, checks, and displays data related to positions on Earth’s surface. Through the use of ArcGIS software programs, geographic coordinates (latitude and longitude) are connected to data
For this project, the data was collected from the Foothill De Anza Community College District. The data included: student address, college campus, and Eco Pass requests. This study included student data for students who were enrolled and requested Eco Passes at the corresponding college during the study period from Fall 2011 through Spring 2017.

Sample
The population of this study is students within community colleges who resided in modern suburban and exurban metropolis (Walker & Schafran, 2015). The characteristics of the population have a wide range due to the admissions policies of community colleges (California Community Colleges, 2012). Thus, the population consists of all ages that are able to attend the colleges. Purposive sampling will be used to collect the data through an export of data from the Foothill De Anza Community College District’s database.

Data Sources
Two data sources informed this study: Foothill De Anza Community College District provided data and ESRI data. The data collected from Foothill De Anza included Eco Pass requests, college campus, and student address locations. The ESRI data was used in the exploratory regression and was gathered from a web-based tool that allowed export of income, population, crime index, vehicle ownership or lease, and educational attainment from the United States census (Table 1) (ESRI Community Analyst, n.d.).

Exploratory variables were selected based on postulation of relationships to Eco Pass need. The 2017 median income by census block was selected based on the postulation of a relationship between income and need to transit. Students who have a lower income may be less likely to have access to transportation. Thus, income was explored as a predictor. The
variable of population was expected to have an affiliation with Eco Pass usage because of the higher likelihood of accessibility to transit in densely populated areas. As stated by Cervero & Guerra, “[i]t is broadly accepted that fairly dense urban development is an essential feature of a successful public transit system.” Crime index data compiled by Environmental Systems Research Institute was used as a variable due to use avoidance of mass transit systems in areas of high crime (Spicer & Song, 2017). The ESRI crime index is the result of a calculation which utilizes the primary crime reporting categories used by the Federal Bureau of Investigation—murder, rape, robbery, assault, burglary, theft, and motor vehicle theft (“Crime Indexes—Esri Demographics | ArcGIS,” n.d.). Household vehicle ownership or lease was used with the expectation that students who have access to a vehicle are less likely to need transit assistance, and therefore will be less likely to request Eco Pass. Educational attainment was used based on the prediction that students who reside in areas with strong representation of community members with high education experience would be more likely to have access to transit resources, thus less likely to be dependent upon the district subsidized transit.
Table 1.

<table>
<thead>
<tr>
<th>Predictors of Eco Pass usage.</th>
<th>Data Source</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 Median Income</td>
<td>ESRI/Census</td>
<td>Students using Eco Pass will more likely come from communities of lower income households</td>
</tr>
<tr>
<td>2017 Total Population</td>
<td>ESRI/Census</td>
<td>Denser populations or higher population per census block will most likely contain higher Eco Pass use</td>
</tr>
<tr>
<td>2017 Crime Index</td>
<td>ESRI/Census</td>
<td>Students using Eco Pass will not likely come from communities with a higher crime index</td>
</tr>
<tr>
<td>Household vehicle ownership or lease</td>
<td>ESRI/Census</td>
<td>Students using Eco Pass will most likely come from communities where vehicle availability is relatively low</td>
</tr>
<tr>
<td>2017 Educational Attainment</td>
<td>ESRI/Census</td>
<td>Students using Eco Pass will most likely come from communities where educational attainment is lower than that of the college communities</td>
</tr>
</tbody>
</table>

As shown in table 1, the relationship of Eco Pass usage with the selected variables differs from a hypothesized positive to negative correlation. Of the selected variables, it was expected that Eco Pass would have a positive relationship with only population. Research indicates that ridership increases with population. Population density is considered an “essential feature of a successful public transit system,” which influences the infrastructure development by transportation agencies. The ability of a transit system to succeed is dependent upon optimization of high ridership to offset costs (Cervero & Guerra, n.d.).

Conversely, the relationships between Eco Pass and the other variables was predicted to be negative. Initial analysis of the literature indicated that lower income
students are more likely to use subsidized bussing due to the financial savings, thus indicating that lower income areas would result in higher Eco Pass usage (Brown, Hess, & Shoup, 2001). Similarly, the crime index was expected to impede on Eco Pass use due to the perception of crime associated with transit. The fear associated with the perception of crime can cause avoidance and whether the potential crimes are believed to occur in the transit hub or during pedestrian access, the perception will impact use (Spicer & Song, 2017). Likewise, was the expectation that Eco Pass use would decrease with vehicle ownership and educational attainment. The convenience of having access to a personal vehicle led to the expectation that students would prefer to drive, rather than use Eco Pass. The likelihood of higher education levels in the community were expected to differ between the colleges and the users’ residences being that the colleges exist in highly educated areas.

**Data Analysis**

To better understand the social impacts relative to campus communities of Eco Pass implementation spatial statistical analysis was conducted. Use of descriptive statistics was used to quantify geographic mean and standard deviational ellipses. To determine whether Eco Pass usage by students was not geographically random, spatial autocorrelation was conducted. To predict the probability of Eco Pass use in specific geographic areas hotspot analysis was conducted. To assess the influence that the median income, total population, crime index, household vehicle ownership or lease, or educational attainment had on Eco Pass distribution, an exploratory regression was conducted to inform the ordinary least squares regression analysis. These methods are described in more detail below.

Initially the geographic distribution of all Eco Pass addresses was reviewed to inform the decision-making process for this study. This process revealed obvious outliers in
Hawaii and Washington, with potentially others. This outcome implied possible collection and entry errors exhibiting limitations within the provided data or perhaps these were permanent addresses of parents but not the residential addresses of the students. Since it is not feasible for students to access either of these colleges using the Valley Transportation Authority transit network in these locations. Through the use of a 30-mile buffer and dual hot spot analysis, outliers were removed.

To address the research questions, specialized spatial analysis tools within the ESRI spatial analysis were used. These included measurement of geographical distributions, analyzing patterns and mapping clusters, and modeling spatial relationships. Geospatial distribution patterns analyses were used to identify the location of the students who requested Eco Pass at each of the colleges within the Foothill De Anza Community College District. To address the first research questions specifically, “What geographic neighborhoods/communities are most likely to utilize Eco Pass to access the community colleges? What geographic neighborhoods/communities are least likely to utilize Eco Pass to access the community colleges?” the ArcGIS spatial statistics tool of median center, standard deviational Ellipses (Table 2), spatial autocorrelation, and hot spot analysis was used.
Table 2
Spatial statistics used in the Eco Pass analysis with calculation methodology and visual representation.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Calculation</th>
<th>Visual Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Center</td>
<td>Uses an iterative algorithm to find the point that minimizes Euclidean distance to all features in the dataset</td>
<td>![Median Center Diagram]</td>
</tr>
<tr>
<td>Standard Deviational Ellipse</td>
<td>The attribute values for these ellipse polygons include X and Y coordinates for the mean center, two standard distances (long and short axes), and the orientation of the ellipse.</td>
<td>![Standard Deviational Ellipse Diagram]</td>
</tr>
<tr>
<td>Spatial Autocorrelation</td>
<td>This tool determines whether features and locations are clustered, dispersed, or random using Moran’s I index.</td>
<td>![Spatial Autocorrelation Diagram]</td>
</tr>
<tr>
<td>Hot Spot Analysis</td>
<td>This tool indicates which features have high or low z-scores and p-values using the Getis-Orf Gi* statistic for each feature in a given dataset.</td>
<td>![Hot Spot Analysis Diagram]</td>
</tr>
</tbody>
</table>
The second research question focused on whether the selected variables of income, population, crime index, vehicle ownership or lease, and educational attainment were statistically significant predictors for Eco Pass use. This allows for a better understanding of the communities that students using Eco Pass come from and whether the Eco Pass policy is providing more access to communities that have been traditionally excluded from higher education. To achieve this exploratory regression was used. This tool within ArcGIS runs all possible combinations of the five selected variables to identify which combination, if any, best predict Eco Pass use. The informed output is then run through ordinary least squares regression to determine whether the effect, if any, is statistically significant.

**Ethical Considerations**

Although the risks are minimal, and the data has already been collected by the Foothill De Anza District for use in analysis, confidentiality and security are concerns. This research does not require Institutional Review Board approval because it “involves existing data” and this research does not include work with any human subjects” (C. Lusareta, personal communication, March 23, 2017). The data was encrypted, protected, and stored on a computer that will only be accessed by the researcher. If the data were to accidentally be made public the risk would be minor since the only identifier will be the student address; this data requested will not include names or any other identifiable information. All efforts were made to safeguard the data and no breaches of confidentiality occurred.
Summary

Analyzing programs affecting community college students is important in determining future directions and goals of subsidized transportation policies. This research intends to analyze the geographic distribution of Eco Pass users in an attempt to better understand which communities the program serves. Understanding of the relationships between variables that contribute to Eco Pass use will result in a contribution to the understanding of subsidized transit students, which can assist in program oversight and greater understanding of the overall subject of universal access.
CHAPTER FOUR: RESULTS

Introduction

This research seeks to analyze the characteristics of a sample of students who registered to use subsidized bussing, Eco Pass, in a community college district. A thorough understanding of the selected predictors of Eco Pass usage contributes to higher education transit policy and access discourse. The two main research questions were:

1. What geographic neighborhoods/communities are most likely to utilize Eco Pass to access the community colleges? What geographic neighborhoods/communities are least likely to utilize Eco Pass to access the community colleges?
2. Do the selected variables of median income, total population, crime index, household vehicle ownership or lease, or educational attainment alone or in combination predict Eco Pass use?

Findings

Geographic Distribution of Eco Pass Users

To determine geographic distribution as designated in the first research question, both descriptive and inferential statistics were conducted at the district and individual college levels. Analysis of the median center by year for the district revealed that during the time period of 2011 through 2017, as the Eco Pass policy matured, the median center of district Eco Pass distribution shifted east (Figure 5), meaning that a stronger pull was coming from the eastern part of the South Bay area from neighborhoods and communities that are less like the affluent communities surrounding the focal community college campuses of this study.
Although the eastward shift of the median for the district was informative, more was revealed when median center was observed at the college level (Figure 6).
When analyzed by campus the distribution of Eco Pass reveals distinct differences that are not observed in the collective analysis. Further analysis, shown in figure 7, allowed for measurement of the distances from the college to the corresponding mean for each year sampled.
Applying Tobler’s First Law of Geography to analyze the distances between campus location and median allows for interpretation of this data. The law states that as distance increases, so does similarity. This indicates that De Anza’s Eco Pass program use has increased over the selected time period for students from communities that are dissimilar to that of the college. Interestingly, Foothill has experienced fluctuations over time and ultimately users’ communities over the selected times are more similar to that of the college campus. Districtwide there has been an increase in distance over the study time beginning in 2011 with a mean of 10.4 miles, a peak of 12.39 in 2016, and a decrease slightly to 11.46 in 2017.

The standard deviational ellipses shown in figure 8 reinforced the findings of the median center. Campus based analysis shows the distribution of Eco Pass users for De Anza to come from the South Bay area, whereas Foothill Eco Pass users are more inclusive of the peninsula. This information contributes to the first part research question one, “What geographic neighborhoods/communities are utilizing Eco Pass access to community
Further inquiry was conducted to dive deeper into this question and to address the second part, “What geographic neighborhoods/communities are not utilizing Eco Pass to access community colleges?”

Figure 8. Map showing standard deviational ellipses, showing one standard deviation by year for all Foothill De Anza Eco Passes.

To address the non-use in addition to the use of Eco Pass a geographic hot spot analysis was performed. Spatial joining of the Eco Pass users’ home addresses and census block data provides evidence that the communities and neighborhoods that Eco Pass users reside in is not random (Figure 9). Autocorrelation analysis indicated clustering of the features in the sample (Figure 10). This implies that the patterns of Eco Pass count in the sample are not due to randomness, thus rejecting the null hypothesis and providing evidence that there are
underlying phenomena impacting the distribution of the Eco Passes for the overall Foothill De Anza Community College District. Subsequently, a hotspot analysis was conducted to gain a better understanding of concealed patterns in the sample.

Figure 9. Map with results of spatial join showing Eco Pass count per California Census Block group at the regional level closest to the college campuses.

Tobler’s first law of geography states that in order to conduct hot spot analysis, spatial patterns must be designated at non-random through autocorrelation (Miller, 2004). In order to determine if Hot Spot Analysis (Getis-Ord Gi*) could be utilized in this study autocorrelation for district Eco Pass had to first be determined. The ESRI ArcGIS software measures spatial autocorrelation for both feature locations and values simultaneously to
determine clustering, dispersion, or randomness. As shown in figure 10 the output indicated that Eco Pass distribution was clustered, thus indicating that Hot Spot Analysis could be conducted.

![Significance Level and Critical Value Chart]

Figure 10. Results of spatial autocorrelation of Eco Pass counts for Foothill De Anza College District indicating clustering, non-randomness.

The 99% confidence regional hot spot is shown resulting in Figure 11. This map shows the inferential analysis for each census block group at various confidence levels, revealing areas that are more likely to have high Eco Pass usage. These hot and cold spots were then exported for a deeper analysis and understanding of the areas where Eco Pass use
is most and least likely to occur, thus identifying which neighborhoods are more likely to use or not use Eco Pass for the overall district as posed in the first research question.

Figure 11. Map of hot spot analysis output based on the 99% confidence interval features of the region.

The visual representation of the hot spots reveals that a major hot spot exists around the De Anza campus, while a cold spot exists around Foothill. This finding is beneficial to the colleges in assisting with marketing and policy creation and evaluation. It may be more beneficial for De Anza college to conduct outreach and promote the Eco Pass, specifically in the hot spot areas, than Foothill. This study indicates that it would be more effective for Foothill to look into other strategies to providing access to the campus or other alternative transportation programs such as carpooling, to achieve a stronger environmental impact.
As with the overall district data, Eco Pass spatial distribution for each college was assessed to determine clustering, dispersion, or randomness to determine if Hot Spot analysis could be conducted independently at the college level. Spatial autocorrelation was conducted on both Foothill and De Anza Eco Pass users separately, which resulted with both data subsets revealing clustering, with a p value of zero and z scores of 63.14 and 122.39 respectively. This satisfied the criteria for spatial autocorrelation and allowed for continuation of Hot Spot analysis at the campus level.

The results of further analysis on the individual campus’ influence on overall district Eco Pass use as revealed in figures 12 and 13 shows that Foothill College does not have any significant impact. This means that Foothill campus on an individual level does not have any features that can be used to predict Eco Pass usage. The use of Eco Pass for Foothill students may be clustered, but no hot spots or cold spots exist. This indicates that it is not possible to determine areas where students may or may not be using Eco Pass using this analysis.
Figure 12. Map of hot spot analysis of the 99% confidence interval features of the Eco Pass distribution for Foothill only.

De Anza users are most predominant in the sample, which was likely to influence the campus contribution to overall Eco Pass use. This is expected due to the access availability based on the transit network. It is not surprising that analysis of the region of high probability Eco Pass use for De Anza is expansive. This may provide insight on the effectiveness of transit policy implementation or it may identify a need for more subsidy at the campus level. This research is not able to determine which it is at this time, however further research could be conducted. If future research indicated that implementation was satisfactory, then it would be recommended that campus leaders at Foothill reevaluate
program management. Perhaps Foothill college needs a transit program that aligns more closely with their current student needs, or maybe they would like to encourage more enrollment from areas not currently served by Eco Pass. If the second were true and the need at De Anza is greater, then it would be advised that campus leaders to strengthen the support of students with transportation needs.

**Figure 13. Map of hot spot analysis of the 99% confidence interval features of the Eco Pass distribution for De Anza only.**

Descriptive and inferential analysis for the district and respective campuses led to the findings that there are underlying differences in the spatial distribution of Eco Pass users at the campus level with regards to demand.
Demographic variables and their impact on Eco Pass usage.

Modeling relationship tools within ArcMap were used to address the second research question addressing the influence of median income, total population, crime index, household vehicle ownership or lease, and/or educational attainment on Eco Pass use. ArcMap’s Spatial Statistics tool of exploratory regression was used to select the combination of variables that were best predictors of Eco Pass usage to run in an ordinary least squares regression. A subset of variables, including median income, total population, crime index, household ownership, leasing of vehicle, and educational attainment were the selected because of their connection to community needs. These variables were hypothesized to predict Eco Pass usage. Lower median income is hypothesized to predict greater Eco Pass usage because lower income populations are less likely to own cars and more likely to need transportation subsidies. Population was used because increased traffic occurs in areas of high density, indicating that students that reside in denser areas may be more likely to use subsidized transit. Crime index was hypothesized to predict Eco Pass usage because students might be less likely to use Eco Pass in areas of higher crime for fear of safety (Ferrell, Mathur, Meek, & Piven, 2012). Vehicle ownership or lease was used because use of Eco Pass is hypothesized to be less likely for someone who has access to a vehicle. Lastly, educational attainment was selected as an oft-used proxy for socio-economic status although it may be imprecise for this analysis for several reasons. Research indicates that approximately 50% of mass transportation users have a bachelor’s degree, however this sample contains students who are potentially striving for an undergraduate degree. Although Foothill and De Anza offer specialized courses in vocational training, post baccalaureate students who may be utilizing career training do not represent a significant
portion of the district population ("California Community Colleges Chancellor’s Office - Data Mart," n.d.).

Exploratory regression was used to determine if the selected variables could have influenced Eco Pass count. This tool ran all possible combinations of the explanatory variables to find which variable(s) passed the ordinary least squares regression diagnostic requirements. Then the selected variable(s) were run for the Eco Pass count at the 99% hot and cold spots as represented in figure 11. This initial inquiry eliminated the variable of educational attainment and the OLS was conducted using the variables of median income, total population, crime index, and household ownership, or leasing of vehicle.

Exploratory regression for the hot spot output did not reveal any models with an $R^2$ greater than .014, indicating a poor fit and tells us that combinations of the variables of median income, total population, crime index, and household ownership, or leasing of vehicle only explain at most 14% of Eco Pass requests. Analysis for the hot spots revealed a higher $R^2$ with a maximum of 0.24 for combinations that met the additional criteria for OLS. The cold spots output was the lowest of all the explanatory assessments, with the highest $R^2$ of 0.02.

As was indicated in the exploratory regression output, the adjusted $R^2$ of the OLS performed on the collective data over all years equaled 0.24 with the multiple $R^2$ of 0.26 (Appendix A). Table 3 shows the results of the OLS regression, indicating population as the only variable with statistical significance. This indicates a possible positive correlation between population and Eco Pass use meaning that in areas of high population more Eco Passes are requested. Crime Index was the only additional variable that approached having statistically significant impact on Eco Pass usage.
Table 3

Ordinary Least Squares Regression output.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-7.69</td>
<td>-0.47</td>
</tr>
<tr>
<td>Median Income</td>
<td>0</td>
<td>-0.92</td>
</tr>
<tr>
<td>Population</td>
<td>0.02</td>
<td>2.00</td>
</tr>
<tr>
<td>Crime Index</td>
<td>0.16</td>
<td>1.93</td>
</tr>
<tr>
<td>Vehicle</td>
<td>0.01</td>
<td>0.30</td>
</tr>
</tbody>
</table>

* p<0.5 level  
** indicates borderline results at p<0.5 level

Lack of statistical significance in the relationship between Eco Pass and median income or vehicle attainment is a finding itself. Interestingly, these variables are identified in the research as a means of assessing potential subsidize bussers, however the findings of this research indicate that although low income and students without vehicle access may use the Eco Pass, others do as well, and that income and lack of vehicle are not statistically significant predictors of Eco Pass requests.

Although population density was found to be statistically significant, the overall model was deemed untrustworthy because it failed to meet the requirements for stationarity. Stationarity determines “whether the explanatory variables have a consistent relationship to the dependent variable both in geographic space and in data space” (“Interpreting OLS results—Help | ArcGIS for Desktop,” n.d.). In addition, spatial autocorrelation of the residuals resulted in clustering, which indicated that the model was biased due to missing variable(s) (“How Spatial Autocorrelation”, n.d.).
Overall, the lack of statistical significance of the selected variables provides insight. The fact that educational attainment, median income, and vehicle attainment do not predict Eco Pass use for the Foothill De Anza Community College District implies that the environmental impact of subsidized bussing may be more substantial than the social impacts of campus access for low socioeconomic students. Median income and vehicle ownership are not predictors of Eco Pass use, which indicates that the implementation of Eco Pass is used by a variety of students from different communities with varying characteristics. This is important because it indicates that the students who are using Eco Pass are not solely those who have the least access to college but includes a wide range of students.

**Summary of Findings**

Overall the finding of this study include:

- Foothill De Anza district geographic mean of Eco Pass requests shifted eastward during period of analysis.
- Per college, the mean for Foothill fluctuated between the Sunnyvale and Mountain View areas while De Anza mean moved eastward.
- Distance between Eco Pass request addressees was initially greatest for Foothill. However, immediately it decreased with an increase in 2014, but never regaining the initial distance of 2011. In contrast De Anza had a steady increase in distance over the study period.
- Standard deviational ellipses reinforced the median data per campus, indicating a stronger representation of Eco Pass students for Foothill college in the peninsula (towards Palo Alto) and south just above De Anza’s reach. De Anza’s pull is stronger in the San Jose area.
• Eco Pass requests are clustered indicating an underlying phenomenon at play.

• The area closest to De Anza college campus is where the majority of Eco Pass students live, with two patches of representation elsewhere. These patches are located in the east area of San Jose and the Mountain View area.

• Individual campus hot spot analysis failed to showed any geographic significance for Foothill Eco Pass usage, whereas De Anza showed strong geographic significance throughout the study parameter of 30 miles.

• Exploratory regression of selected variables showed no predictive capabilities of variables including median income, educational and vehicle attainment. Population and to some extent crime index resulted in significance (or borderline significant), but the stationarity requirement of the model was not met. Additionally, the residuals were not randomly distributed, thus determining any combination of the variables as non-predictive.

Through the use of geospatial analysis, the two research questions were answered. Findings revealed that there is a difference in Eco Pass users based on campus, there are differences in community demographics between likely and unlikely Eco Pass users, and the selected variables of median income, population, crime index, vehicle access, and educational attainment are not strong predictors for Eco Pass use in the sample.
CHAPTER FIVE: DISCUSSION OF FINDINGS

Understanding the use of Eco Pass at Foothill De Anza Community College District is important to the overall knowledge of transit policy and equity access at community colleges. Proponents of Eco Pass policies have argued that these policies can reduce harmful emissions, reduce parking and traffic congestion, and provide increased access to community college education to low-income and students of color. This study tested these arguments by using geo-spatial analysis of Eco Pass users addresses at two community colleges during a seven-year span of implementation.

Discussion of findings

Using measurement of distance between annual medians and college campus and Tobler’s first law, the district overall had an increase in distance with the implementation of the Eco Pass. De Anza is pulling in more students who reside in communities that differ from the college community, more so than Foothill. The influence of De Anza users on the district distribution is understandable due to the college’s close proximity to the largest web of transit infrastructure. Differentiation between the college communities and that of Eco Pass users is ultimately the greatest for De Anza college.

The impact of Eco Pass users from De Anza was observed in the hot spot analysis conducted for each of the colleges. Hot spot analysis for the Foothill sub sample indicated that there were no communities identified as having either higher or lower Eco Pass use than the overall study site. The hot spot analysis for De Anza revealed potential Eco Pass use throughout the bay area, specifically the San Francisco Peninsula, the East Bay area, and the South Bay. As was mentioned in the findings, the hot and cold spots identified differences in the campus’ relationships with Eco Pass. Analysis indicates that
Foothill may want to focus on other alternatives to transportation, while De Anza may benefit more from Eco Pass marketing due to the high probability of Eco Pass use throughout a large geographic area.

The second research question was answered through the regression analysis. This study indicated that selected variables of median income, total population, crime index, household vehicle ownership or lease, and educational attainment do not predict Eco Pass use for the two community colleges in this study. Analysis showed the selected variables in any arrangement do not predict Eco Pass use. Although the variables lacked predictive power, they do provide insight. Ultimately, the regression analysis revealed that predicting Eco Pass use is complicated. The study suggests that Eco Passes are being used by a wide range of students, not just those in low socioeconomic groups. This may be due to the unique nature of the cost of living in the Silicon Valley, where many high paid technology employees are struggling themselves ("Scraping by on six figures? Tech workers feel poor in Silicon Valley’s wealth bubble | Technology | The Guardian," n.d.).

Connecting the findings to the literature reveals that although low income and targeted students may be utilizing Eco Pass, the population of users is more substantive. Geographic access through the use of Eco Pass supplements accessibility as intended in the creation of the California Community College system providing opportunity on a micro scale through urban areas rather than across the state (McClane, 1913). Many students from different areas of the southern San Francisco bay area are benefitting from the subsidized transit. This research suggested that a large diversity of students use Eco Pass districtwide as shown by the failure of the selected variables of income, crime, vehicle ownership, and educational attainment to predict Eco Pass usage. This indicates
that many students from differing communities utilize the bus pass program, not exclusively students from lower income communities.

This research confirms that Universal Access is beneficial to all stakeholders as stated by Brown, Hess, and Shoup (2001). Social benefits to specific groups may be difficult to determine, as revealed in this research, and further research is needed. However, this research did not support the idea that Eco Pass provides more access to the colleges for specific groups. Overall the environmental benefits of Eco Pass implementation are beneficial to many. Providing subsidized transit decreases traffic, parking demand, and pollution, and increases access for many. Combined, a lower carbon footprint and subsidized transit at Foothill De Anza are contributing positively to a healthier and more equitable future. Ultimately, whether environmentally minded subsidized bussing programs provides social benefits was not determined by this study.

**Implications for Practice**

The results of this study are beneficial to the Foothill De Anza Community College District and the corresponding colleges. As a result of the research there is now a better understanding of the geospatial dynamics that underlie Eco Pass use. Based on the analysis conducted in this study, there are different recommendations per campus.

**Foothill College**

Interestingly the results of this study indicate that despite students’ use of Eco Pass at Foothill College, the results did not indicate any area with geographic significance representing either high or low (hot or cold) Eco Pass use. This indicates that relative to De Anza, Foothill Eco Pas use is low. This indicates that this transportation policy may not be the best for Foothill campus, depending on the intent of current Eco Pass
administrators and leaders. Further analysis may indicate that the fees collected from students may be better used in a policy that attracts more student use. Additionally, if maintenance of the program is important for the student body of Foothill, this research indicates that expanded marketing of the Eco Pass would be beneficial.

**De Anza College**

Ultimately this research revealed that De Anza’s Eco Pass requests strongly impact the overall district use. Figure 11 shows the areas of high probability of Eco Pass use for the district, but compiled with the campus level hot spot analysis, it was discovered that De Anza is responsible for the majority of Eco Pass use. The areas in the district hot spot analysis map of high probability of Eco Pass use (Figure 11), show an expansive area adjacent to the campus as high probability of Eco Pass. Overall, this is disconcerting after overlaying the information presented in Chapter three of this paper. The high cost of living in Cupertino is not preferable for many groups (Writer, 2018). The struggles of living in the Silicon Valley are felt by many and college students are not exempt (“Silicon Valley’s Biggest Worry Should Be Inequality, Not a Bubble,” n.d.). Gentrification of the San Francisco region is pushing people further away from access to resources, such as the college, or into homelessness, which has become a regional problem (Chen, 2017). Considering the mission of the California Community Colleges, the Silicon Valley has presented a unique situation, which unfortunately surrounds the De Anza campus, and impacts the student population of the entire Foothill De Anza Community College District. The district has struggled with decreased enrollment for the past seven years, with De Anza college down over 3,300 full time equivalent students in the 2018-2018 academic year (Schively, Tim, 2017; Newell, Mallory, 2018). The
alteration of the economic and social landscapes of the San Francisco area could be influencing the college’s ability to serve students using prior leadership strategies through alterations of the composition of the communities.

The knowledge gained from this research will inform the district and colleges of how subsidized transit through this student led initiative is beneficial. As mentioned previously, De Anza may be interested in marketing Eco Pass availability in certain areas whereas Foothill may be interested in alternatives, depending on their objectives and goals. As mentioned, further research would be helpful in identifying the underlying phenomena predicting Eco Pass usage at the campus level.

**Future Research**

The knowledge gained from this research supports the work that of the Foothill De Anza Community College District. A more elaborate analysis of the student population at each college would provide more information to assist with program alignment.

Although the model was insufficient to identify any specific predictors for Eco Pass use in the selected sample, expansion of the variables to include diversity may result in more adequate predictors of Eco Pass use. Understanding the connections to diversity could be conducted through the use of ESRI’s diversity index, which may provide more insight. This geographic dataset contains an index representative of racial and ethnic diversity that could provide insight connecting Eco Pass to race (ESRI, 2014).

Additionally, now that a quantitative analysis has been completed a qualitative analysis consisting of interviews or surveys of Eco Pass users would provide more
insight. Student perspectives on Eco Pass could provide information on how to better improve the student experience, as well why they choose to use Eco Pass.

Conclusion

This research revealed that there are certain neighborhoods and communities that are more likely or less likely to use Eco Passes, but was not able to identify a predicting variable beyond population disproving social impacts represented by income, crime, vehicle attainment, or education level. Brown, Hess, and Shoup stated that universal access is used by those who have differing values of time and money (2001). However, this study did not show that income influences Eco Pass use at an individual level.

The commitment of the students within the Foothill De Anza Community College District exhibits the future impacts of their capabilities as leaders of environmental change. Although it was not determined that the Eco Pass is used by any specific groups, the data indicates that the subsidized bussing program is being utilized. The identification of population as a predictor of Eco Pass use is beneficial for De Anza college specifically because it can be used to determine areas of focused marketing. Future research should be conducted to answer questions resulting from this research to assist with transportation management at a campus level.

Epilogue

Recently there has been significant activity surrounding Eco Passes within the Foothill De Anza Community College District. Continued engagement from the student body, particularly at the De Anza campus, has ensured that Eco Pass will remain in place. During the Spring 2017 term, student leaders worked diligently in opposition to the increased fee proposal of $40 incrementally by $5 over a four-year period. The student
leaders offered a counter proposal with 20 representatives speaking on behalf of the student body at the Valley Transportation Authority board meeting held on June 1, 2017. They cited opposition to the proposed increase, “noting equity issues, affordability issues, and the importance of access to education and sustainable transportation options.”

Compromise was made and the Valley Transportation Authority approved a fee increase of $20, half of that proposed, over a four-year period (Santa Clara Valley Transportation Authority, 2017).

Further reinforcement of the student body’s commitment to the social and environmental benefits of the Eco Pass were revealed during Fall 2017. The fees which cover Eco Pass are self-imposed by the student body, thus the fee increase of $2.75 per tier that aligned with the agreement made with Valley Transportation Authority in Spring had to pass a student body vote. During the week of November 13th the student body at De Anza College voted to once again self-impose the fee with the increase. If this vote did not pass the Eco Pass would be eliminated altogether. Ninety percent of student voters supported the fee increase and corresponding Eco Pass overall, thus maintaining the Eco Pass subsidized bussing program for the college (“SOVS: Student Online Voting System,” n.d.).
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Retrieved March 23, 2017, from  


Appendix A

Ordinary Least Squares Regression Report

Summary of OLS Results - Model Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient [a]</th>
<th>StdError</th>
<th>t-Statistic</th>
<th>Probability [b]</th>
<th>Robust_SE</th>
<th>Robust_t</th>
<th>Robust_Pr [b]</th>
<th>VIF [c]</th>
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OLS Diagnostics

Input Features: FHDAalBlockGroupwNull_3
Dependent Variable: FHDAALBLOCKGROUPWNULL_3

Number of Observations: 116
Akaiake's Information Criterion (AICc) [d]: 1141.826491
Multiple R-Squared [d]: 0.262495
Adjusted R-Squared [d]: 0.235918
Joint F-Statistic [e]: 9.876848
Prob(>F), (4,111) degrees of freedom: 0.000001*
Joint Wald Statistic [e]: 31.372262
Prob(>chi-square), (4) degrees of freedom: 0.000003*
Koenker (BP) Statistic [f]: 11.624636
Prob(>chi-square), (4) degrees of freedom: 0.020372*
Jarque-Bera Statistic [g]: 35.262838
Prob(>chi-square), (2) degrees of freedom: 0.000000*

Notes on Interpretation

* An asterisk next to a number indicates a statistically significant p-value (p < 0.01).

[a] Coefficient: Represents the strength and type of relationship between each explanatory variable and the dependent variable.
[b] Probability and Robust Probability (Robust_Pr): Asterisk (*) indicates a coefficient is statistically significant (p < 0.01); if the Koenker (BP) Statistic [f] is statistically significant, use the Robust Probability column (Robust_Pr) to determine coefficient significance.
[c] Variance Inflation Factor (VIF): Large Variance Inflation Factor (VIF) values (> 7.5) indicate redundancy among explanatory variables.
[e] Joint F and Wald Statistics: Asterisk (*) indicates overall model significance (p < 0.01); if the Koenker (BP) Statistic [f] is statistically significant, use the Wald Statistic to determine overall model significance.
[f] Koenker (BP) Statistic: When this test is statistically significant (p < 0.01), the relationships modeled are not consistent (either due to non-stationarity or heteroskedasticity). You should rely on the Robust Probabilities (Robust_Pr) to determine coefficient significance and on the Wald Statistic to determine overall model significance.
[g] Jarque-Bera Statistic: When this test is statistically significant (p < 0.01) model predictions are biased (the residuals are not normally distributed).
The above graphs are Histograms and Scatterplots for each explanatory variable and the dependent variable. The histograms show how each variable is distributed. OLS does not require variables to be normally distributed. However, if you are having trouble finding a properly specified model, you can try transforming strongly skewed variables to see if you get a better result.

Each scatterplot depicts the relationship between an explanatory variable and the dependent variable. Strong relationships appear as diagonals and the direction of the slant indicates if the relationship is positive or negative. Try transforming your variables if you detect any non-linear relationships. For more information see the Regression Analysis Basics documentation.

Ideally the histogram of your residuals would match the normal curve, indicated above in blue. If the histogram looks very different from the normal curve, you may have a biased model. If this bias is significant it will also be represented by a statistically significant Jarque-Bera p-value (*).
This is a graph of residuals (model over and under predictions) in relation to predicted dependent variable values. For a properly specified model, this scatterplot will have little structure, and look random (see graph on the right). If there is a structure to this plot, the type of structure may be a valuable clue to help you figure out what's going on.
## Ordinary Least Squares Parameters

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