WATCH THEM SEGREGATE

Analyzing patterns of economic segregation and STEM jobs in commuter zones.

A Thesis Presented to the Faculty of Architecture and Planning
Columbia University

In Partial Fulfilment
of the Requirements
for the Degree
Master of Science in Urban Planning

By

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May 2018

Abstract

STEM occupations have been touted as the economic drivers at local and federal level (Langdon, McKittrick, Beede, Khan, & Doms, 2011), and planners and policymakers often engineer policies for growth and economic development around their demand and supply. These individuals make 29 times more than their non-STEM counterparts (Langdon et al., 2011), and are consistently growing in numbers for the past 40 years (Watson, 2017). Therefore, it is essential to assess their impact on regional patterns. The thesis posits that STEM occupations drive patterns of economic segregation and assesses the economically diversity of census tracts and concentration against the concentration of individuals involved in STEM occupations by employing quantitative and spatial methods. Upon analyzing the spatial relationship between the two parameters to STEM workers across the five commuter zones, Seattle (WA), Portland (OR), Denver (CO), Albuquerque (NM) and Fort-Worth (TX), it was found that individuals employed in STEM do play a statistically significant role in economic segregation at a regional level. Moreover, they play a major role in transforming the urban center of a region from economically diverse to economically segregated.

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Chapter 1 - The Diverging Economy

Introduction

STEM occupations or jobs in science, technology, engineering, and management primarily employ non-manual skills, innovation and scientific knowledge. As per U.S. Department of commerce, STEM workers play a key role in the sustained growth of the U.S. economy. Projections in 2011 by department suggested that 1 in 18 workers were employed in STEM occupations in 2010 (Langdon et al., 2011). The U.S. Bureau of Labor Statistics projects that during the period 2010–2020, employment in STEM occupations will grow by 18.7%, compared to 14.3% for all occupations (Baccalaureate and Beyond Longitudinal Study (B&B), 2011). The industry in-fact grew 24 percent based on the latest update issued by the department of commerce (Langdon,2017). Individuals employed in such occupations earn considerably more than the median earnings for all occupations. The median earnings for STEM occupations were $74,380 in 2009 and $78,270 in 2012, a number more than twice the median earnings for all occupations during the same time period (Baccalaureate and Beyond Longitudinal Study (B&B), 2011). It is likely that the degree of variation in income for STEM and non-STEM workers can result in income inequality. Moreover, the preferences of these high income based on their socio-economic status would determine their choice of neighborhoods, which could possibly result in patterns of economic segregation.

Research Question

By examining the indices that capture concentration of poverty and diversity in income of census tracts with a high concentration of STEM occupations, this research aims to determine the relationship between the two. This is done by observing and analyzing consistent/inconsistent patterns of concentrated poverty and economic segregation within commuter zones across the United States. The analysis is conducted upon evaluating five case study commuter zones Seattle (WA), Portland (OR), Denver (CO), Albuquerque (MN), and Fort-Worth (TX). As a result of this study, we determine whether *the* ***concentration of STEM occupations exacerbated economic segregation within commuter zones during 1980-2010.***

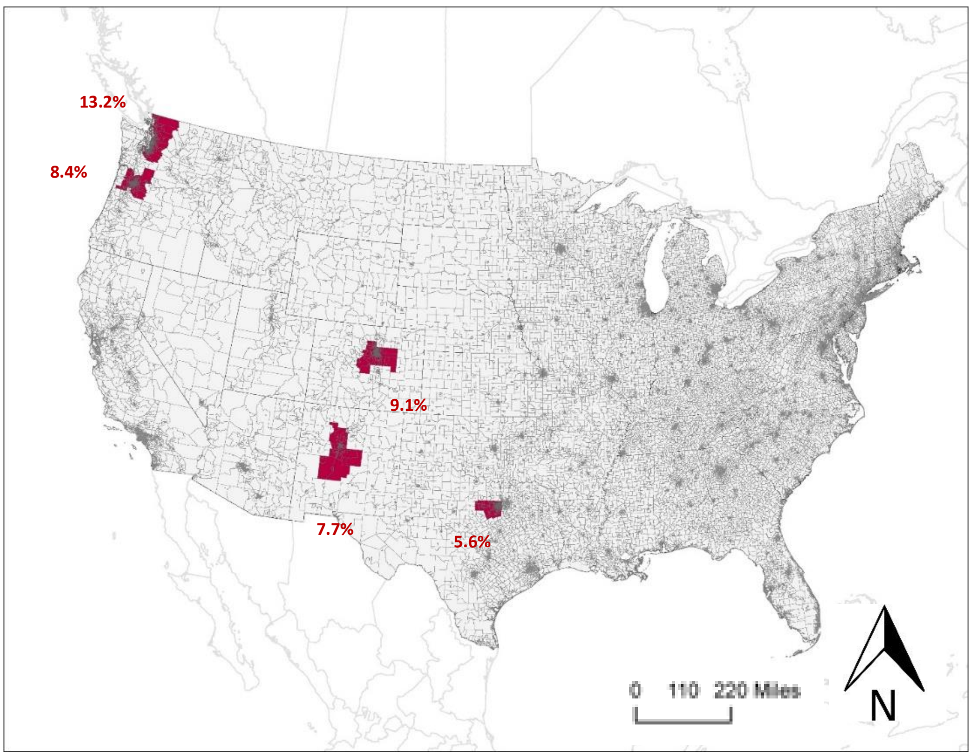


Figure 1- Commuter zones considered for case study, and the percentage of total workforce employed in STEM occupation. Data Source: Bloomberg (2015)

Background

In order to comprehend the association between STEM jobs to the economic segregation, it is essential to develop an understanding of what STEM occupations are. The acronym STEM refers to science, technology, engineering, and management. These occupations are used increasingly to emphasize on innovation, and its implication is widely discussed for the economy and labor market Despite its importance in policy making, there is contention on the definition of the STEM.

For this study, the Standard Occupational Classification (SOC) system, which is a federal standard, is used to determine whether a job is a STEM or not. STEM occupations include jobs such as engineers, mathematical and computer scientists, natural scientists, health diagnosing occupations, postsecondary teachers, *etc.* Computer occupations made up nearly 45 percent of STEM employment, and engineers made up an additional 19 percent (Watson, 2017). Mathematical science occupations and architects, surveyors, and cartographers combined made up less than 4 percent of STEM employment (Watson, 2017). Occupations which are listed as STEM-related such as dental hygienist and sales occupations are not included in the scope of this research.

The United States government has played its part to both create demand and supply for such occupations. The Congress has acknowledged the vitality of these jobs and has been allocating budget to promote the progress of science and useful arts since 1945. The federal government had committed to provide funding to enhance the STEM labor supply and promote research, under President Roosevelt (Rothwell, 2013). To "promote the progress of science and useful arts," Congress grants patents to the inventors. This drives the demand for such jobs.

Witnessing the unmet demand for trained individuals in the STEM, in 2006, President George w. Bush launched the American Competitiveness initiative to improve STEM education. Likewise, President Obama conducted the “Educate to Innovate” campaign to boost STEM education, He also spearheaded initiatives designed to improve the quality of K-12 STEM education (“President Obama Launches ‘Educate to Innovate’ Campaign for Excellence in Science, Technology, Engineering & Math (Stem) Education,” 2009).

With the growth of highly paid STEM occupation fostered by the innovation boom and government, jurisdictions have developed economic development plans keeping such jobs as the focus. These jobs assure of greater financial benefits to the jurisdictions, which they can redirect to create better public amenities such as schools, hospitals, infrastructure systems, *etc.* Thus, growth in STEM economy is pursued as a city building strategy. Therefore, when Amazon asked for an RFP for its second headquarters, 238 proposals were received by the company. This is interesting given that Amazon specifically mentioned in their RFP that the city should have a population of more than 1 Million, and there are only 10 cities in America that qualify based on this consideration. Obtaining employment which allows them to be placed in the ‘middle class,’ is one of the top priorities for the American household (Parilla, 2017). As emphasized by Amazon’s example, the decisions that policymakers tend to make, are taken under the intense pressure to deliver more sustained and inclusive economic growth to their communities and meeting this demand, especially in depressed parts of a country. This vying for tech polarized the geography, a trend also observed in the commuter zones included in this study. Four out of five commuter zones included in this case study have comprehensive plans that have explicit strategies to fuel economic growth based on the current STEM economy (“Seattle Economic Development Commission,” 2014.;“Economic Development Plan Fort Worth,”,2017,;“Denver Office of Economic Development,” 2017; “Economic Prosperity and Affordable Strategy”, 2012).

Redistributing benefits from these individuals are not the only motive of understanding the pattern of economic segregation that is caused by an increase in STEM occupations. Planning professionals need to safeguard these workers from the vulnerability of economic downturn. Workers in STEM occupation on an average experience lower unemployment rates than workers in any other field. This consistent low unemployment rate makes these occupations highly desirable. However, they are not completely immune to economic downturns. During the 2001 recession, the rate of unemployment for college-educated STEM workers increased than that of non-STEM workers. The two statistics converged to a 5 percent at the end of 2010 (Watson, 2017). As per Moretti (2012), certain companies employing STEM individuals under thriving market conditions can generate five times as many indirect jobs as direct jobs. Moretti termed this as the multiplier effect. Therefore, it is of interest to plan for industries that support such occupations, for sustained economic development of commuter zones. Planners should thrive to disincentivize concentration of STEM occupations within a singular industry, which might make them vulnerable to economic downturns.

Next, to establish a relationship between STEM jobs and economic segregation, the study provides an overview of the term economic segregation, how it is caused and what are its implications. To develop an understanding of economic segregation, one must understand the income inequality across American cities. Income inequality has been on the rise since 1970. According to the research conducted by Emmanuel Saez (Piketty & Saez, 2006), in 2015 households belonging to America's top 10 percent, earn more than nine times as much income as the bottom 90 percent. Moreover, the top 1 percent of America's households have more than doubled their share of the nation's income since the middle of the 20th century. Between 1960-

2011 the STEM labor force has grown at an average annual rate which is twice as much as the growth rate of the total workforce (Randall, Steele and Zimmer, 2014). Therefore, researchers can make a calculated assumption that the income generated by the STEM workers have added disproportionately to the growing economy and has contributed to the rising inequality.

The nexus between income inequality and economic segregation is well established by Sean F. Reardon and Kendra Bischoff (Reardon & Bischoff, 2011), in which they conclude that inequality occurs mainly due to preferences of individuals based on their socio-economic status. It is observed that during the same period, economic segregation has increased as well (Jargowsky, 1996, T. Watson, 2009). An individual household's choice determining their neighbor based on socio-economic characterization often leads to concentration and isolation of households belonging to the different income classes and given the strong correlation between income and race in the United States, it isolates the African-Americans more than any other group.

The rising economic segregation has important consequences on social welfare. It determines ones' education level, peers, and social networks. In addition to this isolation, the conditions are exacerbated by out-migration of economically well-off African Americans living in economically weaker neighborhoods. This phenomenon takes away economic resources away which catalyzes concentration of poverty, and formation of ghettos (Wilson, 2012).

While segregation is attributed to a large extent by occupation, education, and income , there are other factors that augment the effect, size and density of a metropolitan (Yang & Jargowsky, 2006), level of education attainment (Jargowsky, 1996), concentration of workers in creative class (Florida, Mell, & er, 2015)and number of jurisdictions (Lens & Monkkonen, 2016). For different commuter zones, the above criteria vary and therefore affects the region with varied intensities. As a result of the rapid increase in wealth due to the new economic landscape coupled with geographical features, some metropolitans have become more prosperous than others, resulting in divergent economies in towns that exist within proximity to one another (Moretti, 2012).

The parameters listed above contribute to the segregation of the five commuter zones studied with various intensities. The extent to which the households are distributed based on income will be determined by comparing the index of diversity (in this case the Theil index) and concentration of low-income households of each census tract.

Economic segregation has social and economic consequences for a region. As mentioned before, people choose their neighborhoods based on their income levels which allows them the ability to afford a house in the area. There are secondary considerations in this decision such as proximity to schools, amenities, safety, and parks. The ability to afford a residential unit is largely determined by the household's income. Therefore, it is safe to say that income determines residential sorting to a large extent. Most of the researchers state that the neighborhood in which anyone chooses to situate a household is in determines by their choices, however, it is evident that individuals who can afford a house in multiple neighborhoods owing to their high income determine the desirability of a certain neighborhood based on their choice, and individuals with low income who are not able to afford houses in that neighborhood are left with limited option and are forced to live in isolation. Thus, low income level households were in fact never provided an opportunity to be selective about the socio-economic group they reside with.

Determinations made by individuals with high income determine to a large extent the patterns of segregation.

These patterns accentuate the economic advantages of high-income households and exacerbate the economic disadvantage of low-income households in two categories of mechanisms, neighborhood composition effect which determines the composition of a neighborhood based on attributes such as poverty rates, level of education, single parent household *etc.* and spatial resource distribution which leads to unequal distribution of resources among the affluent and the poor (Reardon & Bischoff, 2011).

Coupled with non-ubiquitous distributions of public amenities, there is also a non-ubiquitous investment in the shared public resources. Thus, economic segregation also leads to a difference in the level of service based in the income classes. A considerable body of scholarship corroborates this theory. Segregation has been shown to have the first-order impact on several neighborhoods characteristic outcomes such as schooling (Baum-Snow & Lutz, 2011), health (Acevedo-Garcia, Lochner, Osypuk, & Subramanian, 2003) and inter-generational mobility (Chetty, Hendren, & Katz, 2016).

Economic segregation also has important consequences on political participation of low-income neighborhoods. Residential segregation along economic lines, created by the housing, transportation, and urban redevelopment policies, set in motion a chain reaction of developments that have harmed the civic environment in poor neighborhoods while nurturing the civic environment in rich ones (Widestrom, 2015, p. 166).

To uncover the connection between the two phenomena this thesis employs a systematic approach first to understand the measures of segregation at the macro level and how they have changed from 1980-2010. After that, the relationships of each measure are investigated and the census tracts which have a large concentration of STEM workers residing in them. The process iterated over five commuter zones allows us to drive conclusions based on similar or dissimilar trends. Previous scholarship in this realm of is discussed in the next chapter, subsequent to which a methodology is designed and detailed.

Chapter -2: Methods of Exploration

Previous Scholarship

There has been a tremendous amount of research on the impacts of income on economic segregation and its implications. Moreover, the increase in STEM occupations and statistics related to its growth is periodically documented by the Department of Commerce. Despite this, the effect of the distribution of STEM workers on the sorting of households has yielded little research. As a result, this research employs strategies previously used in the exploration of economic segregation to unravel the diversity or isolation of income groups in the selected commuter zones.

This study contributes to the literature on the causes of economic segregation in the United States. The earliest research exploring patterns of economic segregation and its implication was done by Park (1926, p.9), which stated "successful individuals [of minority groups] move out" so that.“ changes of economic and social status... tend to be registered in changes of location". In 1987, Wilson corroborated this research while stating out-migration of the Black middle class has isolated poor Blacks in the inner city, with disturbing "concentration effects."

Following which, Jargowsky (1996) in his research observed a steady increase in economic segregation in U.S. metropolitan areas since 1970 despite the slow decline in racial segregation. Most recently, Reardon and Bischoff (2016) find that economic segregation grew sharply in the 1980s, changed little in the 1990s, and then grew again in the early 2000s. The researchers attributed this to the rise in income inequality for the past four decades.

The role of factors other than income inequality in an increase of economic segregation has been intensively analyzed by researchers such as Baum-Snow and Pavan (2013, 2016). The authors document a positive relationship between city size and an increase in the dispersion of earnings; they interpret this relation as evidence of a skill-biased change in agglomeration economies. In 2016, Diamond studied the geographical sorting of college graduates across U.S. cities between 1980 and 2010, whereas the current study focuses on the determinants of occupational sorting within cities.

Income segregation has been widely studied, particularly about the role that neighborhood effects play in social and economic outcomes, such as education, health, and intergenerational mobility. Education and segregation have a strong two-way link, especially in countries (like the United States) where public spending in schooling is very localized. For example, Baum-Snow and Lutz (2011) analyze the response of white families in schooling enrolment (that took the form of migration to the suburbs and private school enrolment) following the racial desegregation of U.S. metropolitan areas in the 1960s and 1970s. Chetty and Hendren (2016) use tax records in a quasi-experimental setting to measure the strength of neighborhood effects on children and their ability to explain differences in inter-generational mobility across areas.

Although the effect of STEM workers has not been specifically investigated, the expansion of STEM economy, innovation economy or knowledge-based economy has been of interest to many researchers. The basis was laid down by Richard Florida in his book, The Rise of Creative Class (2002), which stressed on the implication of choices of one-third of the national workforce constituting the “Creative Class.” Fifteen years hence, the author reflected on the ‘route to urban revival’ he prescribed in his previous book, which leads to another work of insight- New Urban Crisis in 2017. In this book, he writes about the divergence in Urban cities between the “creative class” and the “service class.”

Another book that creatively dissects the impact of tech-industries on the economy is Enrico Moretti’s book, The New Geography of Jobs (2012). In this, the author discusses the talent disparities in the U.S. which has led to the formation of “Three Americas.” He explains that well educated, innovators create demand for other occupations creating a multiplier effect.

Empirical research on this topic includes work done by Florida and Mellander in 2015 in which the authors conduct a comprehensive study of urban segregation in U.S. metro areas and link this increase to the emergence of the creative class and the expansion of jobs in the high-technology industry. Recently, a research paper published by the Northwestern University and funded by the Ewing Marion Kauffman Foundation (Chicago) explores this nexus. The authors

Berkes and Gaetani exploits the network of patent citations to instrument for local trends in innovation.

Methodology

Measures of Economic segregation

In this research we determine the economic segregation in two ways, a) by determining the concentration of poverty within the census tracts, and b) by determining the entropy, or the weighted average deviation of each areal unit form the metropolitan area's diversity. This conserves the spatial relationship of the individual census tracts to the overall diversity that exists in the commuter zones, however, does not provide inferences related to spatial patterns.

Massey and Denton (1988) conceived residential segregation as a multidimensional phenomenon and upon extensive literature review and cluster analysis to identify 20 different indices of segregation, they classified them into five key dimensions of segregation. These dimensions describe the evenness, the exposure, the concentration, the centralization and clustering of the demographic groups.

Moreover, these measures were developed to evaluate residential segregation. However, they can be applied to understand representation of economic groups within the area. Thus, for the purpose of this study, the measures of residential segregation are adapted to evaluate income diversity within an area. The research is built on the premise, more the diverse the geography being evaluated is, the less segregated it shall be.

Within the research, the measure of evenness is explored. The research evaluates the entropy of an area to measure the evenness. The measure was proposed originally by Theil (Theil 1972; Theil and Finizza, 1971). The entropy index (also referred in this research as Theil score, Theil index and diversity index) measures the (weighted) average deviation of each areal unit from the metropolitan area's "entropy" or racial and ethnic diversity, which is greatest when each group is equally represented in the metropolitan area. A large entropy index indicates greater economic segregation while a score of 0 determines a perfect distribution of socio-economic groups.

E- Entropy index

P- Population belonging to the concerned income group

The city's entropy is given by:

$E = (P)\log[l/P] + (1-P)\log[1/(1-P)]$

and a unit's entropy is analogous:

$E_i = (p_i)\log[l/ p_i] + (1- p_i)\log[1/1- p_i)]$

The entropy index itself is the weighted average deviation of each unit's entropy from the city-wide entropy, expressed as a fraction of the city's total entropy:

$$H = \sum_{i=1}^{n} [t_i(E - E_i)/ET]$$

The measures prescribed by Massey and Denton are “aspatial” in nature. This leads to two well documented methodological problems: The Checkerboard Problem and the Modifiable Area Unit Problem. White (1986) and James and Taeuber (1985) give empirical examples of the index's performance.

To overcome the checkerboard problem and preserve the statistic which can determine isolation of very low-income households, we calculate the statistic representing the concentration of poverty of each census tract. For this, we calculate the ratio of individuals belonging to the ‘very-low’ income class to that of the entire population.

The concentration of poverty within the city is given by:

$C = P_{very\text{-}low} / P$

The concentration of poverty within the unit is given by:

$C = P_{i\_very\text{-}low} / P_i$

Deriving Data

The data used in this research is publicly available, anonymized and aggregated data, made available by the Bureau of Labor Statistics and Census Bureau. Data tables pertaining occupation of civilian of ages 16 and over, distribution of household income and median household income has been used.

While measuring the concentration of poverty, researchers employ federal poverty standard. This method has some flaws, primary of which is that it ignores the differences in cost of living across commuter zones. This overlooks the regional context.

The categories of income are determined by the household income dataset provided by the census bureau for the years 1980, 1990, 2000, and 2010. These data tables contain 17 income groups for 1980 and 1990 and 16 for 2000 and 2010. Thus, we classify these income groups into the defined income classes. As the income groups are absolute in their dollar value, projections were calculated to split them when required. After that, the households were classified based on their income classes.

To begin the process, the 2000 commuter zone boundary was imposed on the census tract cartographic boundaries of 1980, 1990, 2000 and 2010 to identify census tracts that fall within the scope of the study. After that, the collected data was made to associate with the cartographic boundaries. Upon analyzing the median household income within a commuter zone, the range was divided into 5 percentile range, which forms the basis for distribution of households is set.

Households earning less than 20 percentiles of the range of median household income was classified as 'very-low' income household, twenty to forty as 'low,' forty to sixty as the middle,' sixty to eighty as 'high' and more than eighty as 'very-high' income classes. These income classes were then used to calculate the two measures as described in the earlier section. The Theil index was determined using an open source software using R as a programming language.

The STEM occupations data is divided into 5 percentiles, and the census tracts which have the maximum number of such occupations are isolated, and their diversity measure and poverty concentration measures are compared. This process is iterated for 5 commuter zones and for the 4 years being analyzed. The statistic is tabulated to derive inferences. Together, the comparison of these statistics across the five commuter zones was synthesized into the analysis to create a relative understanding of spatial pattern delegated by STEM job across time and across the five case study regions. The findings and conclusions are based on the similar and dissimilar patterns that arise from this statistical and spatial analysis.

To obtain the occupation data Standard Occupation Classification (SOC) is used. This classification is used by federal agencies to classify workers into occupational categories for the purpose of collecting, calculating or disseminating data. All workers are classified into one of 867 detailed occupations according to the occupational definition. The list of 2010, 2000, 1990 and 1980 is provided by the Bureau of Labor Statistics. BLS has also provided *crosswalks* between the multiple lists, which allow one to establish horizontal consistency among the lists.

Using the above list, we determined the final occupations that are classified as STEM occupations. It was found that majority of the occupations were listed as *Professional Specialty Occupation.* The census bureau conducts individual level a category which can be found and is used by the census to collect statistics of employment.

The approach adopted for analysis

Previous scholarship has determined segregation based on 'knowledge-intensive activities' by workplace-related data (Berkes & Gaetani, 2018) or the number of patents or the proximity to employment centers or schools (Florida, Mell, & er, 2015; Acs, Pendall, Trekson, & Khare, 2017). Since there are no previous studies that determine the effect of the distribution of individuals who work in STEM occupations on the spatial pattern of socio-economic classes, the study examines economic segregation due to STEM occupations on a case by case basis. The study comparatively evaluates the measure of diversity and the measure of concentration for census tracts that have a high concentration of STEM occupations across the five commuter zones with the help of a series of statistical, comparative and visual analysis.

In their paper, the Cost of Segregation published in March 2017, Rolf Pendall, Gregory Acs, Mark Treskon, and Amy Khare analyzed 100 most populous commuting zones and documented its Generalized Neighborhood Sorting index (GNSI) and spatial proximity between black and white neighborhoods. Based on the analysis, Fort Worth at 43rd, Seattle was placed at 46th, Denver at 49th, Portland at 78th, and Albuquerque at 94th, thus representing various degrees of economic segregation. The idea is to compare commuter zones with varying proportions of individuals working in STEM occupations as compared to other commuter zones. Commuter zones which ranked lower than 50 were cities such as Pittsburg and New York. These cities have imposed a series of traditional land use regulations, which promote more economic segregation (D.S. Massey & Denton, 1993), and therefore were not considered for the comparing.

The first step includes understanding the diversity within the commuter zones. For this, the Theil index for the entire commuter zone is calculated and compared to the timeline. To understand the distribution of income in more nuanced manner, individual Theil score for census tracts is calculated. As mentioned before due to the checkerboard problem, we calculated an additional measure which provides an idea of economic segregation, which is the concentration of low-income households in census tracts. Once both the statistics are derived, a regression analysis is done to understand the extent to which stem jobs predict these two measures. Based on the data, the relationship between the concentration of poverty measure is much stronger with the STEM occupations that the economic diversity measure. A detailed discussion of both the relationship is included in the next chapter.

The nexus between the two phenomena is then assessed through comparative analysis. As per David Collier, Comparative Analysis is the "the examination of two or more cases to highlight how different they are, thus establishing a framework for interpreting how the parallel process of change is played out in different ways within each context" (Collier & Mahon, 1993). The methods of comparative analysis are used here the study conducts comparisons between multiple case studies. It is likely that the two regions may not have similar socio-economic environments. Therefore, an absolute measure cannot be employed (for example, the median income within one commuter zone might not be the median income of another commuter zone). Secondly, the index of economic segregation employed in this case does not have a unit associated with it.

The effect of STEM jobs across the timeline being studied, cannot be determined by running a regression on the change of the Theil score. The scores are comparative in nature, and while they are associated ordinally, no inference can be made of these scores in concentration. The concentration of poverty is a ratio, and one can easily determine its association with the increase or decrease in concentration of STEM jobs. The study aims to unravel the urban patterns and regression analysis, while provides a strong understanding of association, is asaptial in nature. Therefore, to investigate the spatial relationship of the areas with a high and low concentration of poverty vis-à-vis high concentration of STEM occupations, methods of visual analysis is adopted. Determinations such as leapfrog development, nodes with respect to clustered job and concentration level of poverty can be made. Finally, the cause/implication pattern of the two parameters mapped can be understood holistically while observing the changes in the region across time. Similar and dissimilar relationships can then be isolated upon comparative analysis across the five case study commuter zones to highlight general trends if any. Once the strength of the relationship and the spatial patterns are determined, this study provides a few recommendations for jurisdictions that eye STEM occupations as city building strategies and are interested in incentivizing them in order to increase economic growth.

CHAPTER 3 – Findings

Regional level analysis of selected parameters of segregation across the timeline

Commuter zones are large geographies and have been developed by USDA to delineate the economy better. Our largest commuter zone Seattle is close to 100 miles and includes parts of Mt. Baker Snoqualmie National Forest, Wenatchee National Forest and Mt. Rainer National Park. Thus, it is important to note that while movement of household belonging to specific socio-economic group forms a census tract which is extremely diverse, to begin with, increases the Theil score, thereby indicating that the census tract is now segregated. This movement, however, would not show any difference in the Theil score of the entire commuter zone. Therefore, these statistics are not coherent with the studies which have been done at a metropolitan level. However, it does help us understand the socio-economic context of the region at the time. All models are false, but some are useful (Box,

Commuter Zone	1980		1990		2000		2010	
	Theil diversity index	Concentration of poverty	Theil diversity index	Concentration of poverty	Theil diversity index	Concentration of poverty	Theil diversity index	Concentration of poverty
Seattle	0.3739	0.3264	0.4054	0.3580	0.3460	0.3873	0.4008	0.3333
Portland	0.3283	0.3412	0.2793	0.3580	0.4585	0.4163	0.4006	0.3801
Denver	0.3421	0.3107	0.2938	0.2163	0.3072	0.3152	0.3629	0.3128
Fort Worth	0.3415	0.0811	0.3751	0.3241	0.3679	0.3051	0.4899	0.2889
Albuquerque	0.3081	0.1210	0.3756	0.3163	0.4005	0.3102	0.4233	0.3330

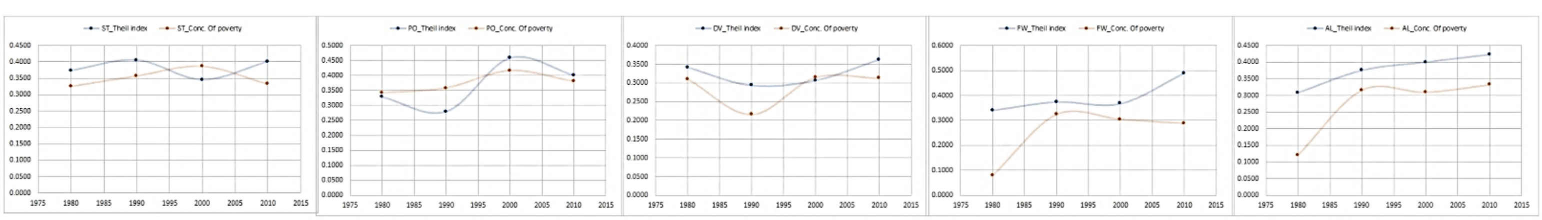


Figure 2: Comparative analysis of parameters for economic segregation. 2a. Data Table. 2b. Trends

In order to interpret Figure 2, one needs to observe the trend lines closely. An increase in Theil score and an increase in the concentration of poverty indicates that there is high economic segregation, with a lot of census tracts with concentrated poverty. A high Theil score and a low concentration of poverty indicates that the benefits of the economic boom were shared by the household in the bottom 20 percentile based on the median income of the commuter zone. A low diversity index and high concentration of poverty indicate towards the 'checkerboard problem.'

The calculated parameters for the 5 commuter zone when compared across the timeline reveal a nonlinear increase of economic segregation. During the period 1980-1990, Seattle, Fort Worth and Albuquerque witness an increase in their Theil scores thereby indicating that the region became economic segregated, on the other hand, the economic segregation within Portland and Denver decreased. In this decade the first two years were defined by the recession, wherein more than 12 million Americans faced joblessness. Steel and other heavy industries, particularly in the Midwestern Rust Belt struggled with competition faced from Japan and Germany, and the nation was experiencing large-scale deindustrialization. Therefore, high-income households in Portland and Denver declined marginally, which lead to the decline in economic segregation.

During the same time, the concentration of poor in the commuter zones increased. This is consistent with the deindustrialization argument, as loss of jobs increased the number of households in the bottom 25 percentile. Denver, however, does not comply with this trend. There is observed a fall in the number of households living in the bottom 25 percentile which could be ("Denver County vs. Colorado | Population Trends over 1969-2016,"). To understand this anomaly, a deep dive is required which is out of the scope of this research.

The 90s were the age of the internet marked by the World Wide Web and rapid growth in STEM occupations across the United States. Internet became the new frontier for businesses which spurred dramatic shifts in the existing economic landscape and had an equally dramatic effect on regional patterns. Based on the statistics calculated, there was an increase in the Theil index for Portland, Denver, and Albuquerque, that is to signify they became economically more segregated. There wasn't much change in diversity for Fort Worth, while in Seattle the diversity increased. The concentration of poor on the other hand increased in Seattle, Portland, Denver and decreased for Fort Worth and Albuquerque. The trends suggest that the commuter zone of Seattle suffered from a checkerboard problem during this time, as despite decrease in Theil index, there was an increase in the concentration of poor people. In the commuter zones of Portland, Denver, Fort-Worth and Albuquerque, the cities enjoyed financial benefits of the economic boom, but not much of the benefits were passed on to the people belonging to the lower income groups. These commuter zones demonstrate classic cases of economic segregation.

Last, we discuss the trends between 2000 and 2010. The economic boom continued over the first decade of the 21st century, and so did the number of STEM occupations. Despite a downturn between 2006 and 2009 and the dot-com bust, the number of STEM jobs did not dramatically decrease in the commuter zones being studied. As evidenced by the numbers, we observe a marginal decrease in concentrated poverty except in Albuquerque. This trend, however, does not provide a clear indication of a decrease in economic segregation especially with as the Theil index continues to increase. This further indicates that the socio-economic groups are represented unequally. The trends also suggest that during this period the fiscal benefits were distributed somewhat evenly, as more and more individuals were employed within STEM jobs.

Census tract level analysis of selected parameters of segregation across the timeline

Upon understanding the economic conditions and regional trends vis-à-vis parameters of segregation, the study delved deeper into the relationship between the STEM occupations and the selected measures of economic segregation.

The thesis aims to understand if STEM occupations exacerbate economic segregation. A statistically significant regression model of the parameters concerning the STEM occupations would indicate that STEM occupations do exacerbate economic segregation. Regression analysis will allow us to quantify the relationship between a parameter of economic segregation employed, the Theil index and the concentration of poverty, which are chosen in this case as a dependent variable, with the number of STEM occupations, chosen as the independent variables, also referred to as a covariate. This is done by using observations or the data associated with each of the census tracts. The value of quantifying the relationship between a dependent variable and a set of independent variables is that the contribution of each independent variable to the value of the dependent variable becomes known. The models are predicting the relationship between both the pairs, Theil index and STEM occupations and concentration of poverty and STEM occupation, are statistically significant. The summary of the models is summarized in the form of a table in Figure 3, and the linear regression models are illustrated in Figure 4.

The table in figure 3 summarizes R squared statistics and the slope for both Theil index and Concentration of Poverty. The values for Theil index have low R squared statistics. This indicates that the variability of Theil index around the data line is high, and while we can infer generalized trends from it since the relationship is still statistically significant, we cannot state that Theil index is well predicted by STEM occupations.

To determine the trends, we observe the figure 3. Theil index generally has a slightly positive or no correlation with the concentration of STEM jobs in a census tract. This indicates that the diversity of households belonging to various socio-economic background within census tracts decrease with an increase in the concentration of STEM occupations. Based on the trends it can be concluded that the chosen parameters are a better indicator in cases of Fort-Worth and Albuquerque which have smaller economies and high concentration of workers involved in knowledge-based industries. For larger economies such as Seattle, Denver, and Portland, more information is required to generate a model that can accurately predict economic segregation at a commuter zone level. Although the trends are consistent with the initial assumption, the results cannot be considered due to extremely low values of R squares.

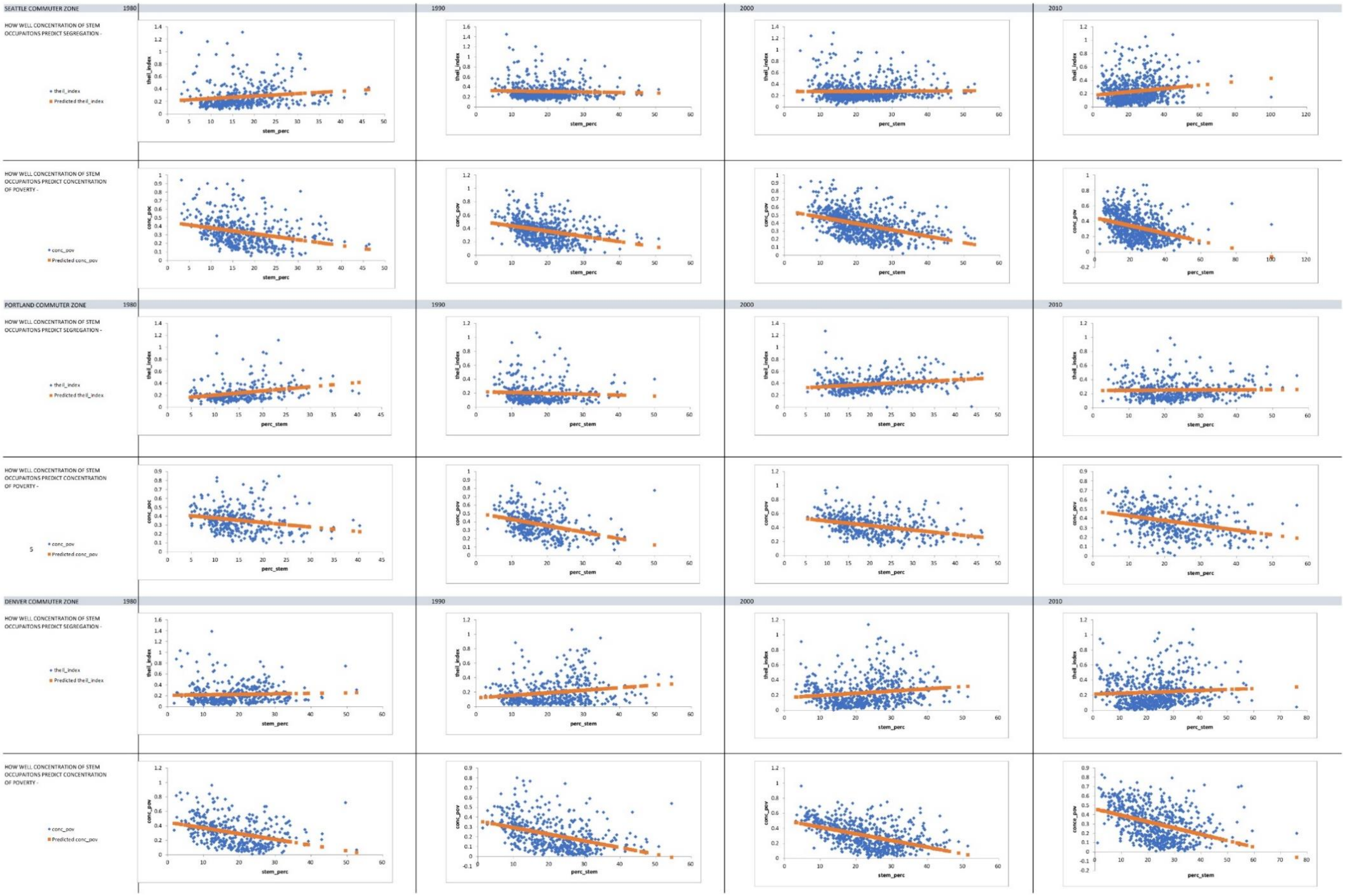
		Theil index		Concentration of poverty	
		R squared	Intercept	R squared	Intercept
Seattle	1980	2%	0.3%	9%	-0.7%
	1990	0%	-0.1%	11%	-0.7%
	2000	0%	0.0%	18%	-0.8%
	2010	3%	0.2%	12%	-0.5%
Portland	1980	7%	0.6%	5%	-0.5%
	1990	0%	-0.1%	14%	-0.7%
	2000	5%	0.3%	12%	-0.6%
	2010	0%	0.0%	10%	-0.5%
Denver	1980	21%	1.0%	33%	-0.6%
	1990	4%	-4.0%	44%	-2.0%
	2000	2%	0.3%	36%	-0.9%
	2010	5%	0.5%	27%	-1.0%
Fort-Worth	1980	21%	1.0%	33%	-0.6%
	1990	4%	-0.4%	44%	-1.6%
	2000	2%	0.3%	37%	-1.4%
	2010	5%	0.5%	27%	-1.0%
Albuquerque	1980	20%	1.0%	12%	-4.0%
	1990	12%	0.7%	28%	-1.0%
	2000	23%	1.0%	26%	-1.0%
	2010	2%	0.2%	12%	-0.5%

(blue)	***
(grey)	*

Figure 3: Compilation of R squared statistic and concentration of poverty statistics, with indicators of statistical significance.

On the other hand, STEM occupations provide better estimates of variability of the concentration of poverty. These results have high significance as well. In general, the concentration of poverty is inversely related to an increase in STEM occupations. One can interpret a census tract within which large cohort of people is employed in STEM occupations, the level of concentration of 'very low' income household belonging to the bottom 20 percentile of households based on the median income decrease. Based on the statistics observed for every 10 percent increase in STEM occupations, one can observe 0.07 – 0.4 percent increase in the concentration of poverty. The numbers for the intercept are low, representing only a marginal change in concentration of poverty based on STEM occupations.

Based on previous scholarship the study has determined that segregation is impacted by education, income, and employment. Individuals belonging to the STEM sector is a measure of employment, and therefore only partially explain and affect the increase and decrease of segregation. In the literature review it is also stated that STEM occupations have higher incomes. Moreover, a neighborhood with a large concentration of high-income households tend to have better public facilities. We can understand that the trends will become more prominent and the variability will become less as the effects of STEM occupations on schools and incomes are incorporated within the study model.


SEATTLE COMMUTER ZONE
1980
1990
2000
2010
HOW WELL CONCENTRATION OF STEM OCCUPAITONS PREDICT SEGREGATION -
theil_index
Predicted theil_index
stem_perc
perc_stem
HOW WELL CONCENTRATION OF STEM OCCUPAITONS PREDICT CONCENTRATION OF POVERTY -
conc_pov
Predicted conc_pov
PORTLAND COMMUTER ZONE
DENVER COMMUTER ZONE
conce_pov

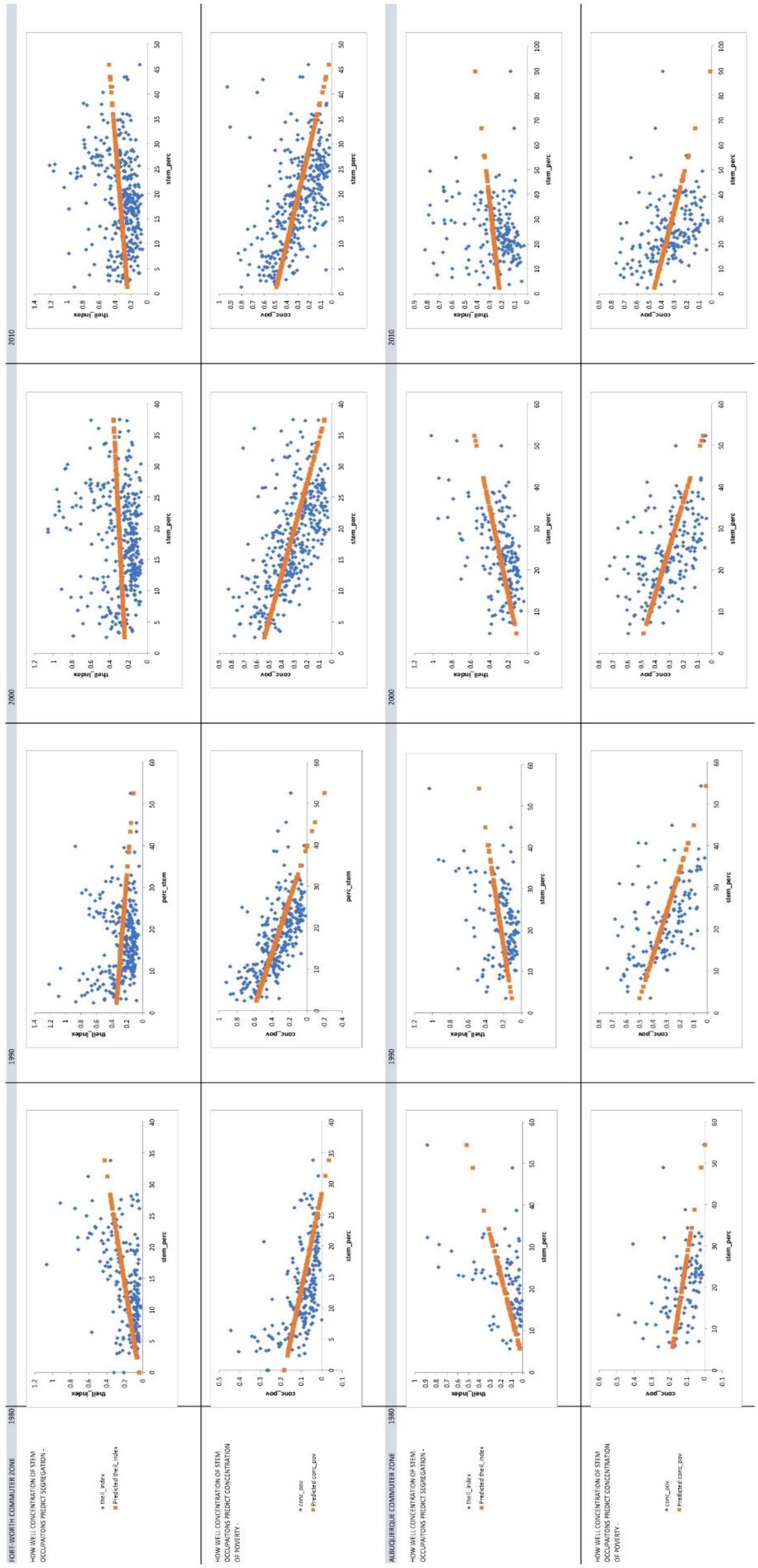


Figure 4: Statistical models indicating relationship between a. Theil score b. concentration of poverty parameter and individuals involved in STEM occupations.

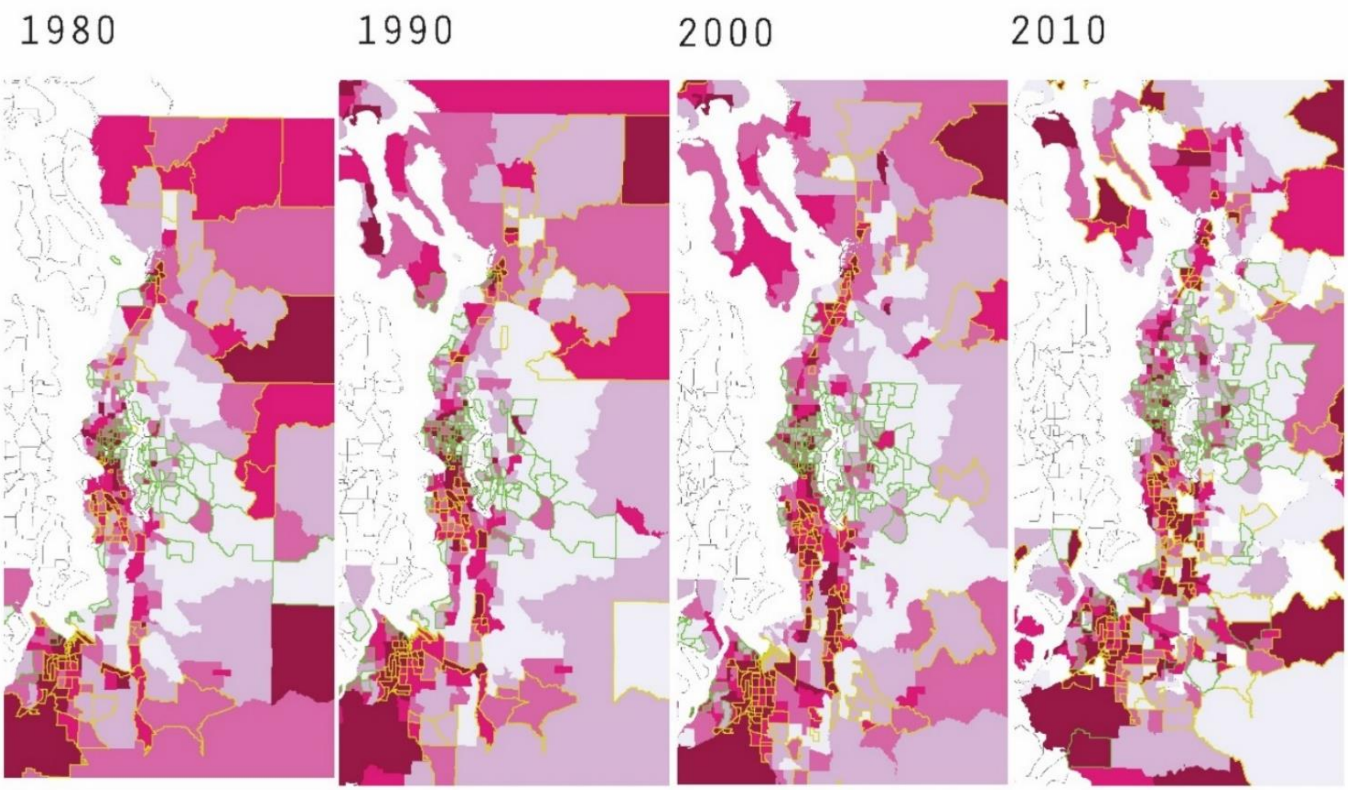
Deep Dive- Case Studies

Given the robust relationship of the concentration of poverty with STEM occupations, in this section, a visual analysis is conducted to the relationship between census tracts with a high concentration of STEM occupation and census tracts with a high concentration of poverty. Clusters of high concentration of poverty census tracts indicate high economic segregation. In cases where census tracts with a high concentration of STEM coincide with low concentration levels of poverty indicates that STEM occupations exacerbate economic segregation. If census tracts with concentration of STEM occupations occur both in low and high concentration of high concentration of poverty, it can be inferred that STEM does not have an effect on economic segregation.

SEATTLE (TACOMA-BELLEVUE)

The regional scale pattern for Seattle is illustrated in the Appendix- Fig 1. Areas with high concentration of STEM occupations include Everett, the county seat for Snohomish County, situated north of Seattle, North Bend (King's County) situated in the east and Tacoma (Pierce County) in the South. The western edge of the city is lined with Elliot Bay.

Seattle was a heavily industrialized city until 1980. It has served as the headquarters of Boeing, a company manufacturing airplane from 1916 until the 1970s. With the decline in demand for industrial goods post-Vietnam war, the city saw a massive decline in the economy. Seattle had an



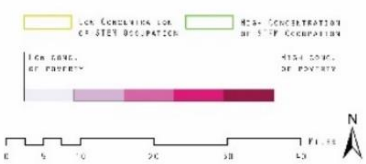


Figure 5: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Seattle 1980-2010.

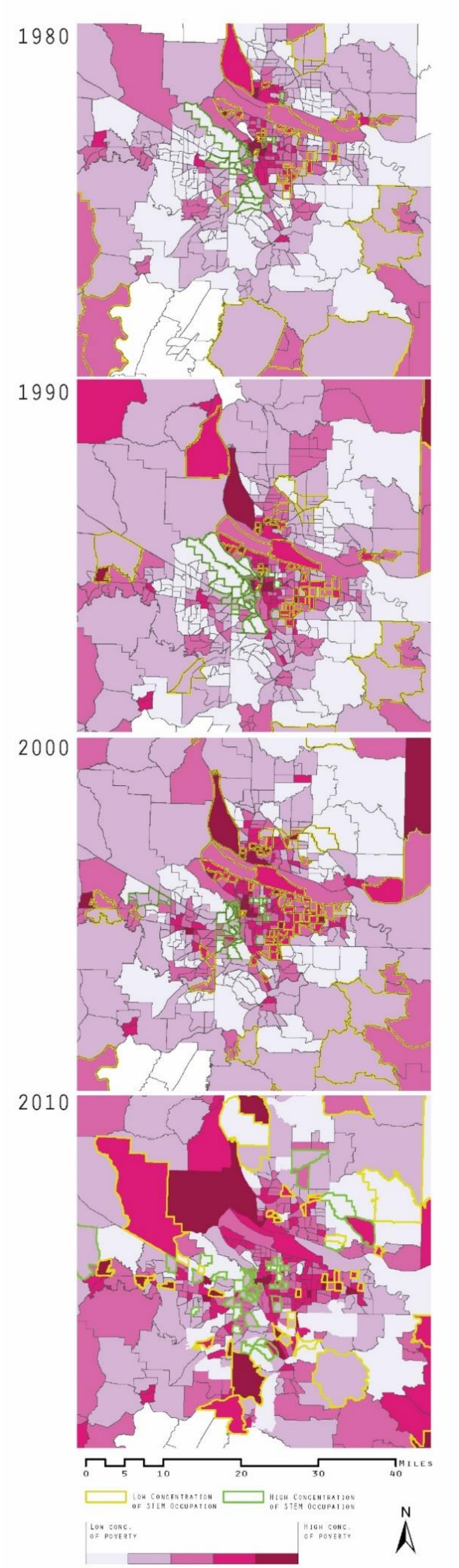
intense economy before the 1980s which had witnessed booms and busts. Therefore the commuter zone already exhibited an economically segregated pattern.

In 1980, census tracts inhabited by a high number of STEM workers had a high concentration of poverty in Seattle, whereas Bellevue, which also had high concentration of STEM workers had low concentration of poor households. In the literature review, it is stated that as the area increases, segregation in economy intensifies. Here we see Bellevue, with census tracts having a larger area, pushing the low-income households to its fringes. During this time Everett and Tacoma also had census tracts with individuals in STEM occupations, these census tracts had households belonging to varied levels of economic levels.

Microsoft’s first product BASIC came out in 1976 and was incorporated in Albuquerque, and by 1978 the sales exceeded one million. They moved to Seattle Commuter zone (in Bellevue) in 1979. BY 1985, the sales were recorded over $140 million. Unlike Boeing which contributed to the economy only by employing individuals, Microsoft initiated a realm of entrepreneurs which supported the technology created by Microsoft. Thus, during 1980 to 1990, Seattle commuter zone’s fortune was closely associated with the growth and economic trajectory of Microsoft. This transformed the city. Inferred from the figure, the concentration of poverty was pushed further out from the central, horizontal axis. More census tracts attracted individuals with STEM occupations. Census tracts in Tacoma and Everett which were previously had a low concentration of poor households saw an increase in the numbers. In Seattle, the census tracts which previously housed STEM workers witness a decline in poverty levels, however, not as low as Bellevue.

From 1990-2000, the census tracts with a high number of STEM individuals have compressed it around the central horizontal axis. Poverty continued to increase in Everett and Tacoma which also had the least concentration of STEM workers. The hubs grew around Bellevue. All these movements shifted the poor households further away from the center. The decline in poverty levels in census tracts which previously housed STEM workers, was witnessed again.

Lastly, in 2000-2010, census tracts which previously had a low number of STEM individuals, but did not have a high concentration of poor individuals, the poverty levels were exacerbated. There are dramatic changes in composition with parts of Tacoma and Everett housing more STEM workers than before. This decreased the concentration of poverty in those areas. The



STEM workers were distributed along the north-south line, and the poverty levels increased along the central axis. Certain census tracts which are situated further south of Tacoma has a high concentration of STEM occupations. IT will be interesting to find out 10 years hence, i.e., in 2010, if within these census tracts the concentration of poverty was reduced.

PORTLAND (VANCOUVER-HILLSBORO)

While Seattle's STEM workers occupied areas with high concentration of poverty and transformed them into areas with a low concentration of poverty, in Portland, such census tracts seem to be resilient to poverty throughout the timeline observed. The economic parameters of the surrounding areas changed, but census tracts with a high concentration of STEM workers remained affluent.

Portland has long been Oregon's dominant economic center. The city's importance stems largely from its

Figure 6: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Portland 1980-2010.

location. Situated on the confluence of Columbia and Willamette River, Portland is a major port in the Pacific North-West. During the post-war years, Portland maintained a strong commercial base and diversified its economy considerably (Price et al., 1987). This diversity allowed Portland to remain unfazed during economic downturn experienced by the rest of America in the 1970s and 1980s. This pattern is evidenced by the figures.

In 1986, the major STEM employers situated in Portland were Tektronix, Intel, Boeing of Portland, Floating Point System, and Electro-Scientific Industries.

As per the Fig. 6, in 1980 STEM workers situated themselves in the center of the city, around Beaverton, Tigard extending up to Hillsboro. Apart from these select census tracts, the concentration of poverty in the nearby census tracts observed is high. During this time, it is observed that the census tracts concentrated by STEM employees are present in areas with a low concentration of poverty.

A similar trend is observed during 1990. It is observed that the concentration of poverty levels has increased further, regardless of which the census tracts with STEM workers are able to maintain a mix of households wherein there is a high number of high-income and very high-income households.

In 2000 the number of census tracts with a high number of STEM employees increased. The pattern of the growth is observed moving westwards towards Hillsboro which houses Intel's largest campus. This movement can also be explained by the MAX light rail which connects Portland, Beaverton, and Hillsboro. The census tracts with a high number of individuals employed in STEM are still showing resilience to poor households. However the physical proximity is reduced. Ironically, the commuter zone is becoming more ubiquitous in the distribution of income.

Lastly, we observed the patterns in 2010. The concentration of poor households has yet increased. There also a dramatic decrease in concentration of poverty across the border in Washington. This can be explained by new light rail lines of MAX commuter rail opening which connects downtown Portland and Vancouver Washington.

These trends project an inverse reading to the expectation one has from a diverse economy such as the one observed in the Portland commuter zone and the main reason for this is the adoption of a regional boundary limiting the expansion of the city by Portland and its surrounding cities, called the Urban Growth Boundary. Adopted in 1977, this Boundary created an increased value of real estate in and around the city centers which can be afforded only by high-income households. It also slowly increases the concentration of poverty (here poverty being relative to the median income of the area) in the census tracts as the cost of living becomes higher, mainly attributed by the lack of land resources.

Vancouver however, does not fall within this boundary and is a part of another state. In a way, it is the ‘dirty little secret’ of Portland and has a neutralizing effect on the economic forces that play a role in the part of the commuter zone which is within Oregon.

DENVER (AURORA-LAKEWOOD)

When the transcontinental railroad bypassed Denver for cities like Cheyenne, Wyoming, efforts of business and civic leaders like John Evans helped to pass a bond to connect the 106-mile railroad from to Denver. This at the time was viewed as a risky investment by has paid off tremendously, as it was the key factor in the transformation of the city into one of the most thriving economies of the USA. Due to its strategic location, Denver has facilitated the movement across the breadth of the country for over 150 years. As a center of confluence, the region saw a growing manufacturing industry and became a telecom hub during the early 20th century.

Denver saw a boom attributed to 'tech' industries before the other case study commuter zones considered in this study. Post War George Wallace engineering firm which provided engineering expertise to the US Naval forces had his establishment in Denver. He moved the establishment later to a

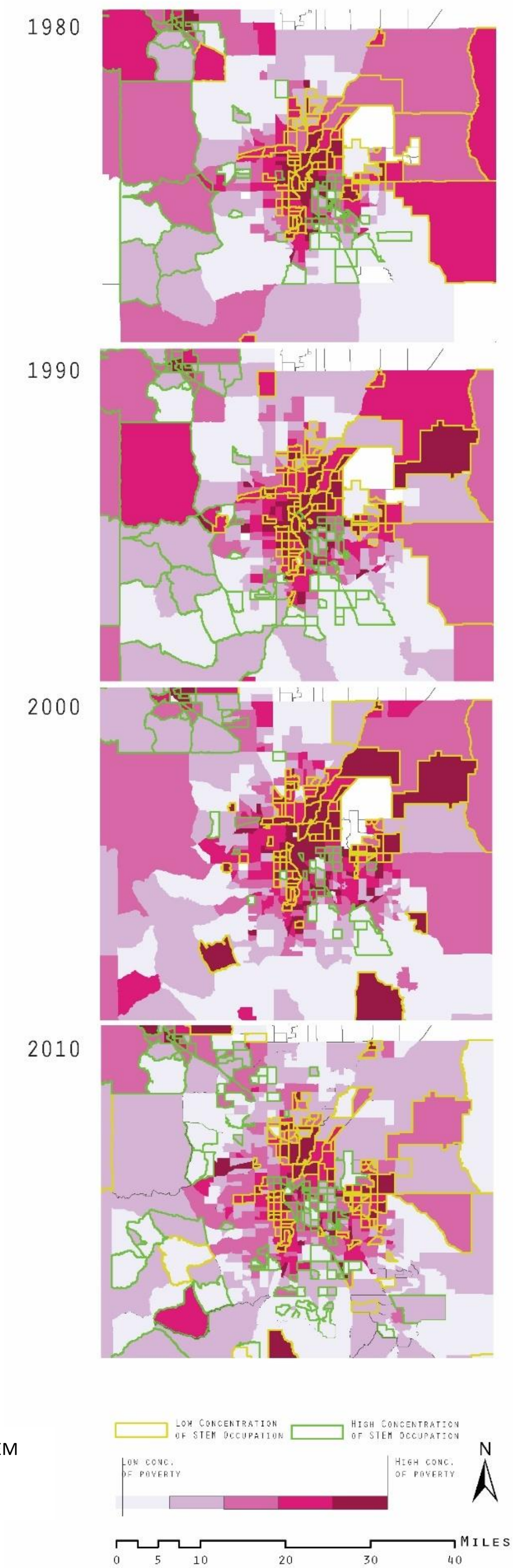


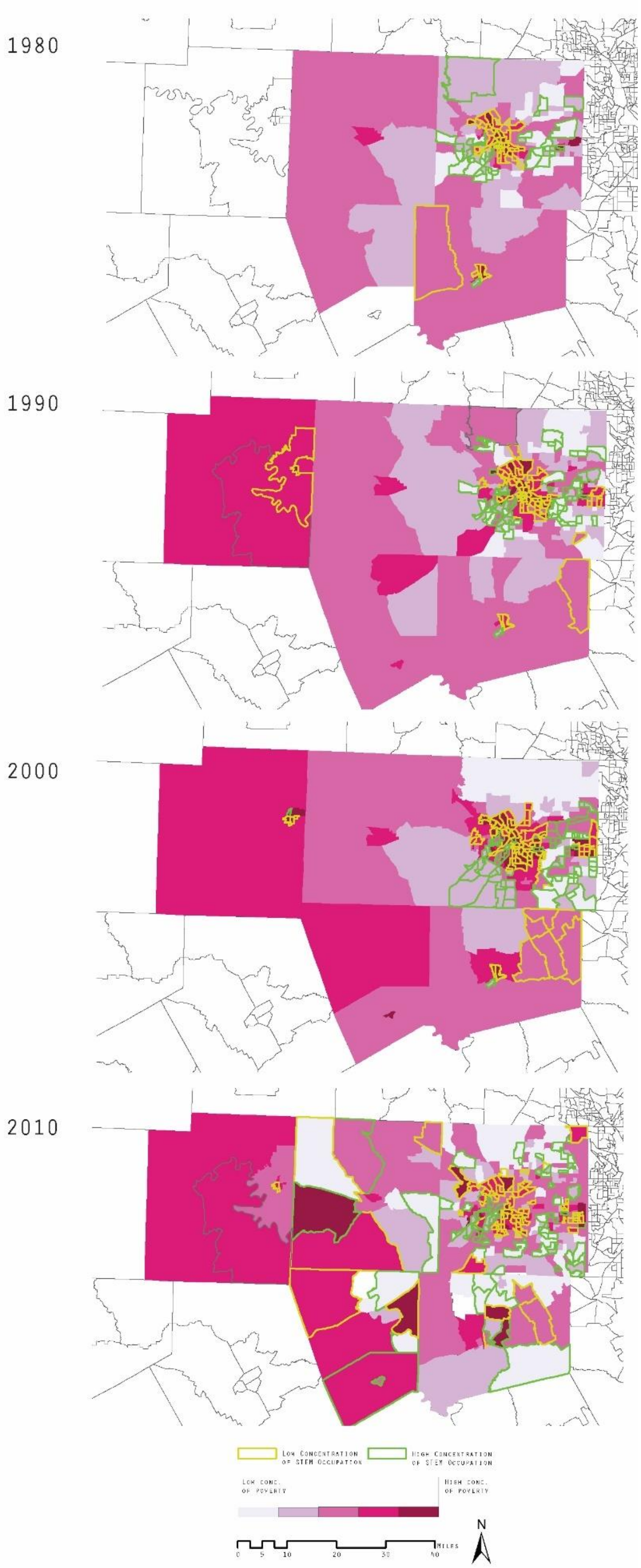
Figure 7: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Denver 1980-2010.

suburban office park in the south-east of Denver, around which a cluster of tech industries thrive soliciting expertise in data, telecom, aviation, *etc.* This made Denver extremely an attractive destination for migrants and also contribute to a massive over speculation of the success of the city, which inflated real estate rates.

Due to the above factors, during the economic distressed experienced by the country in the 1980s, Denver's economy fell precipitously, rendering a large population in the poverty level. This increase in the urban poor is evidence form concentration of poor income households mapped during 1980 (Fig 7). During the time the workers involved in STEM occupations remained close to the south of Denver, where George Wallace had established the Denver Technology Center decades before.

In the 90s, there were strategic attempts made by the administration to revive the city, such as low rentals for office space, to make the rates competitive and attracting more businesses. These exercises in economic planning paid off when by many industries revived in Denver. Today Denver's economy has strong industries across sectors such as Aerospace, Aviation, Bioscience, Telecom, Energy, Health and IT employing a large number of STEM workers ("Denver's Changing Economy," 2016).

Given the context, in the 1990s the area observed expansion in a number of census tracts which have a high concentration of STEM workers. However the concentration of poverty seems to increase around the urban core. Census tracts with the lowest concentration of STEM workers had a high concentration of poverty.



In the map of 2000, it is observed that the number of individuals in STEM jobs increased in LoDo (Lower Downtown), which was once a thriving tech hub under George Wallace. The wealth in Denver seems to be more ubiquitously distributed. Having witnessed extreme economic woes in the past four decades, Denver has adopted a comprehensive plan for the region in the year 2000 (Helicopter Planning, 2000), in a commitment to grow the economy equitably and control the urban growth pattern. In 2010, with clustering of STEM occupation around the city center, the concentration of poverty gripping the city center was finally alleviated. It will be interesting to note how the future growth post the adoption of this comprehensive plan will shape the patterns of economic segregation in the commuter zone.

Figure 8: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Fort Worth 1980-2010.

FORT-WORTH (DALLAS-ARLINGTON)

Fort Worth is a city created by war. With the discovery of oil in Texas, refinery and pipeline companies such as Sinclair Refining Company, Texaco, and Humble Oil and Refining (Exxon Company) converged on Fort Worth, which also developed into a center for oil stock exchanges. Fort Worth thrived as an economy during both the world war.

With the outbreak of World War II, the aviation industry came to Fort Worth. The opening of Dallas/Fort Worth International Airport in 1974 ushered in a new era of aviation history. At the time it was built, the airport was the largest in the world. The aviation/aerospace industry remains an important factor in Fort Worth's economy today.

Fort Worth enjoys the benefits of being a center in aviation industry, proximity to Dallas, the largest inland metropolitan in the USA and the thick labor force contributed by several reputed university communities primary of which are, Texas Christian University, Texas Wesleyan, University of North Texas Health Science Center and Texas A & M University School of Law. The primary employers for STEM workers in the area are Bell Helicopter, Lockheed Martin, American Airlines, and XTO Energy ("Economic Development Plan," 2017).

Fort-Worth is a small but fast-growing economy, the effects of which are illustrated in the figure above. The north-east part of the region consistently has a low concentration of poor households. This area is also close to the city of Dallas. As one moves towards the South-West, the concentration of poverty increases. Fort-Worth in the 1980s demonstrates a somewhat ubiquitous distribution of households of variating income levels. Individuals choose to live in the city center of Fort-Worth.

The map of 1990 exhibits that a higher number of census tracts have a large cohort of STEM workers than 1980. The concentration of STEM workers seemed to have leapfrogged and moved to another node within the geography in the south of the commuter zone, around an education center- the Texas Christian University. In the map of 2000, the workers seem to have moved westwards where another node appeared around the Westworth village. Subsequently, the concentration of poverty decreases around these nodes. In 2010, the commuter zone had a high concentration of census tracts across its length and breadth.

The leapfrogging of nodes where a high concentration of STEM workers exists indicate a massive trend of sprawl in Fort Worth. Without directed growth, this sprawl is expected to continue, most probably towards the west of the city limits.

ALBUQUERQUE (SANTA FE, LAS VEGAS)

It was founded in 1706 as the Spanish colonial outpost. The city had been a region of political tension until 1912 when it incorporated in the US.

The establishments critical for development are US military-based organizations. The thick labor of STEM workers is maintained by the University of New Mexico, Kirtland Air Force Base, Sandia National Laboratories the National Museum of Nuclear Science & History and Lovelace Respiratory Research Institute. The city also has played a key role in the

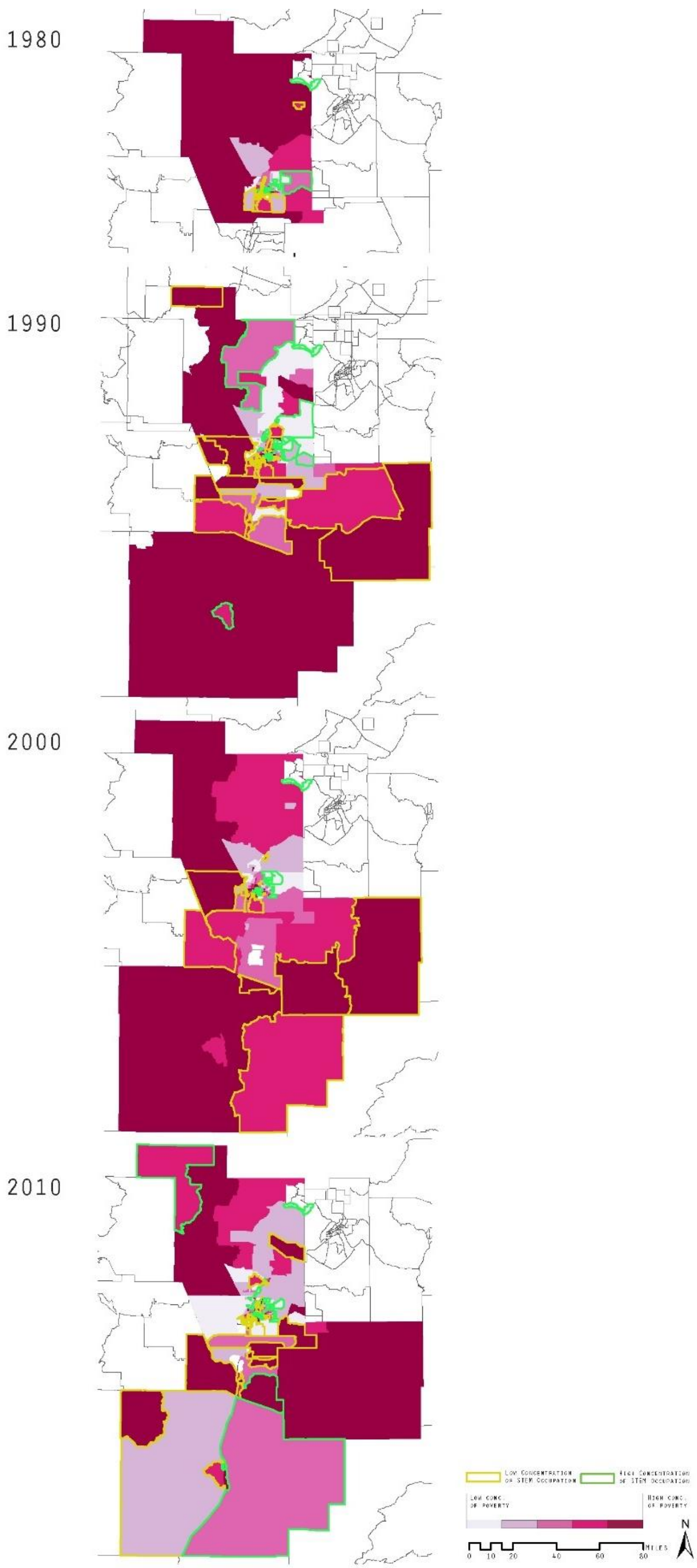


Figure 9: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Albuquerque 1980-2010.

atomic age. Sandia National Laboratories (Honeywell) mentioned before developed non-nuclear components for nuclear weapons. During the cold war, this area witnessed increased investment. The boom of Albuquerque's economy was short lived. Its downtown entered a phase of urban decline in the 1980s.

The trends witnessed in Albuquerque are similar to Fort Worth. Constrained by development in West and East the region grew South West and South East along the Rio Grande river. The concentration of poor income households remained at the periphery of the zone, with the center of the commuter zone remaining affluent throughout. The poverty levels are alleviated only in 2010, after three decades of sustained growth of STEM occupations.

There is observed a leapfrog effect in the growth 1980 to 2000 and then from 2000 to 2010 when the concentration of STEM workers moved from city center Albuquerque to portions of South Valley (in the South West). This area subsequently seems to have transformed into a hub with an increased number of STEM employees choosing to locate here.

Paul Allen, the co-founder of Microsoft worked at Honeywell, and Bill Gates joined him in Albuquerque to create Microsoft, in 1975. It was evaluated at $3 Million when it moved to Bellevue in Seattle. This move singlehandedly changed the fate of two commuter zones studied here. While we saw Seattle coping with dramatic changes, Albuquerque has almost similar patterns in the distribution of individuals pursuing STEM jobs and concentration of poverty throughout the period in discussion.

CONCLUSION

The data confirms that in the wake of deindustrialization, and subsequent two economic downturns, STEM occupations exacerbate economic segregation to a large extent. Planners and policymakers for decades have been approaching strategies of urban growth to manipulate the choices of individuals who are involved in knowledge-based communities banking on their tolerance, flexibility, and eccentricity, hoping to resolve the rigid patterns of economic divide created by industrialization and to bounce back from the financial impacts of the economic downturn caused during deindustrialization of American cities in 1980s.

This strategy worked initially for few commuter zones such as Seattle, Portland, and Denver, for a period of two decades. These trends provide an indication of positive economic growth for cities which have cheap land and labor and are still vying for more employment, but this growth should be viewed with scrutiny considering the patterns observed in commuter zones with more robust and diversified economy. It was expected that the incoming young, highly paid working-class households will make the regions witnessing an economic lull into be vibrant and contribute towards more investment. The workers exceeded the expectation, and the investment finally gave way to form new patterns of economic divide and clustering of poverty.

The initial growth in Seattle, Portland and Denver and the current economic mobility of Albuquerque and Fort Worth have provided inspiration and an economic growth model for cities across the rust belt in America and even in other cities, looking for city building strategies to sustain their middle class and maintain the viability of the urban centers. In the cases we observed the census tracts with a high concentration of STEM workers resist, convert or leapfrog the census tracts with a high concentration of low-income households. This negatively impacts the low-income households particularly and has severe cost implications for the entire region.

This system also creates a framework that favors individuals who are employed in the STEM and works towards betterment for their children's education, is mindful of access to employment based on their location and increases the quality of life that they enjoy. This fosters livability in the towns and cities. It decreases crime and conflict and increases access to healthcare, culture and other such infrastructure.

On the other hand, it makes the living conditions worse for the rest of the population. While driving these individuals further from the centers, the system increases their travel cost and travel time and provides more unpredictability in the choices of urban amenities and infrastructure access.

While this phenomenon can be considered similar to the suburban flight, there is a stark contrast. While suburbanization the typically wealthy lived far away from the city. This cohort had the wealth to maintain infrastructure for themselves through private investments, even when the government was unable to provide for them. They maintained their access to employment opportunities and enjoyed living by choice in socio-economic groups that mirror their choices in the neighborhood and make the same income.

In the current situation when the poor are being suburbanization. First and foremost is not a choice for them but merely a result of economic woes. It results in complete segregation of the low-income households resulting in their isolation. It reduces access to amenities and infrastructure, facilities which are essential for survival. It reduces access to employment which might increase the levels of unemployment, and consequently increase crime. It also isolates the individuals living in lower-income groups from the network of innovation. It reduces their probability of collaboration with like-minded individuals and creates economically viable products.

This paragraph underlines two hidden costs attributed to segregation. The low-income households, when distributed in sparsely populated census tracts, makes it difficult to provide for infrastructures such as electricity, water, sewage, and internet. Urbanists have focused so much on concentrated carbon footprint due to back to city movement of the erstwhile suburban (affluent) dwellers, that they fail to recognize the increased cost of providing amenities to the urban poor. Another cost that arises from this isolation of low-income households is the cost of innovation due to a lack of social network which had the potential to accelerate and co-curate an innovative idea into brilliant solutions which could possibly help alleviate our standard of living.

Due to limited investment in these areas, there is also a danger of urban decay and the towns and cities which were functioning cities when the affluent resided can fall into disrepair. This cost of blight is another underlying cost of segregation.

Thus, by comparing the case studies, one can safely say that the phenomenon of economic segregation is not only divisive, isolating and confining for the economically weaker section of the society, but also a costly affair for all.

RECOMMENDATIONS

Lastly, based on previous knowledge and inferences from the case studies, the study provides a few recommendations which will allow policymakers and urban planners to plan for growth while accounting for the negative externalities observed.

One of the most effective approach to maintain growth is the Urban Growth Boundary. A method which has been used in one of our case studies, Portland. It is observed that Portland manages to curb economic segregation, but by increasing concentration of low-income households in all census tracts. However, this outcome is especially not desirable by the dwellers. Their cost of living is dramatically increased.

A workaround for this is the urban service area which unlike the and urban growth boundaries, which physically constrain the development, the urban service area does so by controlling the level of service of infrastructure and extension of public water and sewer systems. St.Paul-Minneapolis adopted this strategy. Although a creative strategy it failed to curb the development of the policy failed to outline strict repercussions for developers not adhering to the policy (Fulton, 2001).

Observed in the case of Portland and Denver, the low concentration of poverty was observed along the routes of commuter rails. These rails connected the nodes of the urban system, which allowed the workers in STEM occupations to situate themselves along the line. This will increase connectivity to the areas with low-income households. This can potentially run a risk of getting gentrified by STEM workers, and therefore, parallel strategies to downzone growth away from the nodes and up zone areas around the nodes should be formed. Strategies to provide mixed-income and affordable housing should be adopted.

These high-density areas would maintain the intensity of innovation maximize serendipity. While maintaining access to network and infrastructure to all income-groups equitably, one can successfully plan for commuter zones.

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APPENDIX

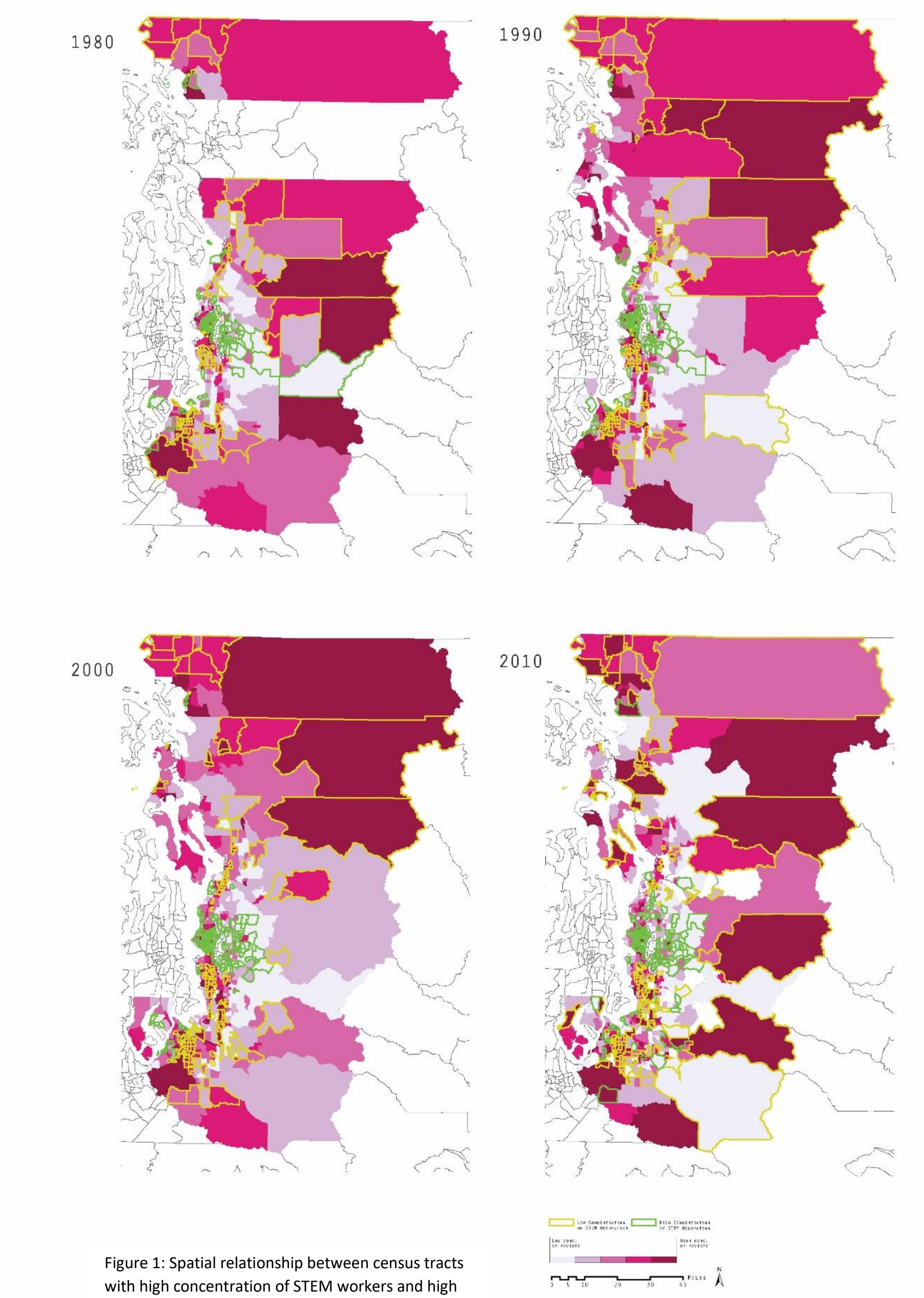


Figure 1: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Seattle 1980-2010.

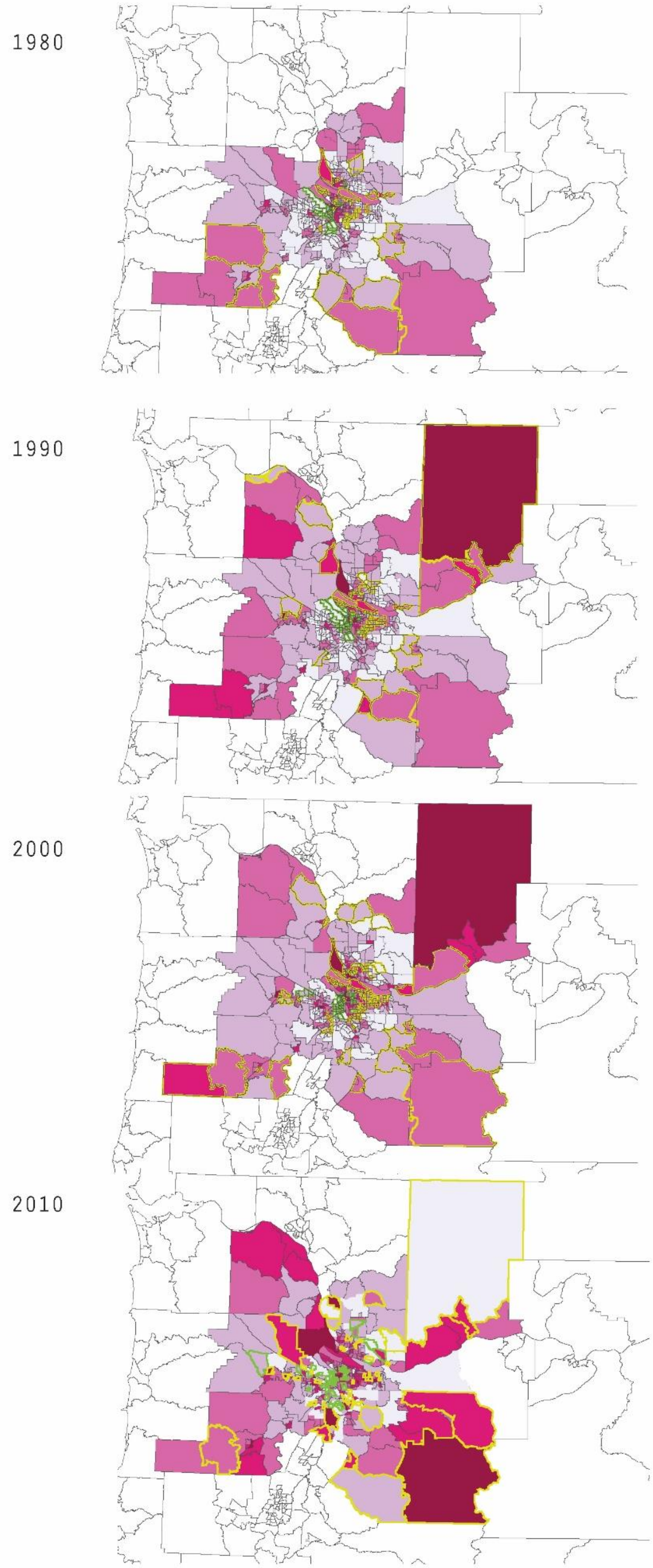
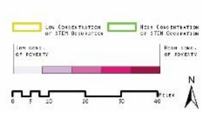
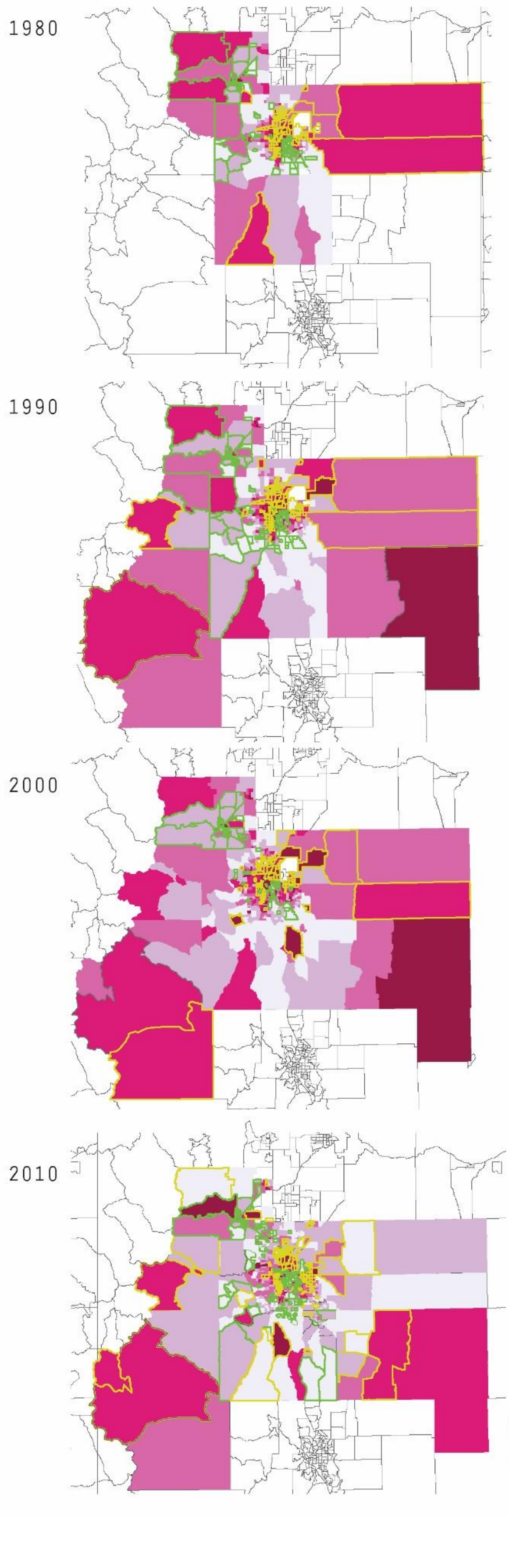


Figure 2: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of ‘very-low’ income households (poorest 20 % households), Portland 1980-2010.





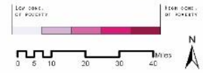


Figure 3: Spatial relationship between census tracts with high concentration of STEM workers and high concentration of 'very-low' income households (poorest 20 % households), Denver 1980-2010.