Riding tandem: Does cycling infrastructure investment mirror gentrification and privilege in Portland, OR and Chicago, IL?

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Abstract

Bicycles have the potential to provide an environmentally friendly, healthy, low cost, and enjoyable transportation option to people of all socio-economic backgrounds and demographics. Increasingly, however, the ways in which cycling culture is manifested in North American cities is being questioned on the grounds of transportation equity through concerns over gentrification and the cooption of cycling culture to promote the agendas of the privileged class. This research assesses the geographic distribution of cycling infrastructure with regard to community demographic characteristics to better assess claims that cycling investment arrives in tandem with incoming populations of privilege or is targeted towards neighborhoods with existing wealth. Using census and municipal cycling infrastructure data in Chicago and Portland from 1990 to 2010, we create gentrification and cycling infrastructure investment indexes at the census tract level. Linear regression models are used to estimate the extent to which community demographics associated with gentrification and cycling infrastructure investment are related and if community change is a major driver in investment or if existing community characteristics are also involved. In both cities, we identify a bias towards increased cycling infrastructure investment in areas of privilege, whether due to an increase in characteristics associated with gentrification or pre-existing conditions. This paper provides evidence that marginalized communities are unlikely to attract as much cycling infrastructure investment without the presence of privileged populations, even when considering population density and distance to downtown, two motivators of urban cycling. To alleviate the continuation of inequitable distributions of cycling investments, it is proposed that planning processes both actively seek out diverse stakeholders and be sensitive to citywide community input and stated needs in future transportation projects, contributing to reinvestment achieved through bottom-up processes of revitalization rather than through the impositions of gentrification.

Keywords: Bicycle parking, Bicycle lanes, Divvy stations, Gentrification, Census tract

Introduction

Bicycles have great potential to be an equitable, healthy and sustainable mode of transportation. Cycling infrastructure, including lanes, parking, or bicycle share programs, can help foster a safe and inviting environment where users of all abilities have high access to opportunities and services. Yet cycling advocacy is increasingly being critiqued from an ethical perspective. Blog articles such as: *Are Bike Lanes Expressways to Gentrification? (1)* and *On Gentrification and Cycling* (*2*) point to the perception in non-academic literature of mainstream cycling as a White affluent male activity, and describe how low-income and minority communities see cycling culture as accompanying processes of rising living costs, displacement, and the undermining of established local cultures during processes of gentrification. Recent academic papers, such as those by Hoffman and Lugo (3), Lubitow and Miller (4) and Stehlin (5), discuss underlying socio-political factors associated with gentrification, "White" cycling culture, and ongoing inequities in urban transportation networks and decision-making processes (*3-5*).

We empirically assess these claims by exploring relationships between the distribution of cycling infrastructure investment and community demographic characteristics in Chicago, IL and Portland, OR.

We begin by outlining the limited empirical evidence of cycling infrastructure investment mirroring gentrification and privilege in the literature. Next, we use census tract and municipal cycling infrastructure data from 1990 to 2010 to create gentrification and cycling infrastructure investment indexes. The years 1990 and 2010 are chosen for analysis to take advantage of census demographic data over a time period long enough to capture changes in community composition. However, this large grain of data makes interpretations of whether cycling infrastructure is a cause or effect of changing community characteristics impossible. Linear regression models provide evidence that cycling investment is related to both privileged current demographics and to markers of gentrification. Given the economic and health benefits of this transportation, we conclude with the need to balance investments and provide strategies to mitigate the continuation of investment disparities. Because this topic deals to a large degree with community perceptions of cycling and gentrification, there is a focus in the literature review on capturing the words and narratives of individuals who are not in academia. Newspaper articles and online media point out community views on social processes and serve as the inspiration for this research. Academic literature is drawn on to develop a working definition of gentrification and the analysis methodology.

Literature review

Characterized by investment in historically disinvested urban areas, gentrification is often realized through an influx of young, educated, artistic or "creative class" individuals seeking low rent and exciting cultural environments. This first wave of community change is followed by further investment as the area is recognized as up-and-coming. An often-cited definition of gentrification comes from Smith (*6)* as:

"the process by which central urban neighborhoods that have undergone disinvestments and economic decline experience a reversal, reinvestment, and the in-migration of a relatively well-off middle- and upper middle-class population" (p. 198).

With these processes of reinvestment can come new services and amenities to residents, increased community safety, and greater political influence. However, rising living costs, displacement of long-term residents and the loss of established culture are cited as negative side-affects of gentrifying communities (*3; 7; 8*). Studies have struggled with assessing the degree to which gentrification leads to displacement, as opposed to replacement or "exclusionary displacement" where households can no longer move into an area (9).

Other indicators such as income, percent of households that are tenants, adults with university degrees or professional occupations, and the percentage of the population working as artists are assumed to reflect demographic characteristics indicative of gentrification processes (7, 9, 10, 11).

This paper uses a range of indicators in order to capture a wide umbrella of community composition indicators associated with gentrification without attempting to explicitly quantify gentrification or discern the subtleties of displacement.

The goal of focusing on who lives in and who is moving into the community is to demonstrate how privileged populations shape our cities by attracting investment. While investments may come in many forms, our main focus is on cycling infrastructure.

Increasingly, cycling is being adopted by environmentally and socially conscious millennials but, as cycling becomes more popular, it is also viewed as a keystone activity of the demographic often present in the first waves of gentrification. Bicycle lanes have even been labeled the "white stripes of gentrification" (interview with Paige Coleman in Mirk (*9)*). Valencia Street in San Francisco, for example, has been a center for cycling activity and investment in San Francisco as well as gentrification, characterized by the shift of the primarily working-class Latino population to more a more affluent and white population (*10*).

Cycling and other sustainable initiatives are touted as altruistic endeavors for the common good but must still be approached with caution. "Common good" projects allow advocates to avoid hard discussions of justice by pushing forward projects that are intended to improve sustainability, livability or safety without acknowledging the desires of original community members or the historic contexts of racial and class tensions (*11*).

Active transportation (defined in this paper as walking, bicycling, or other non-motorized forms of transportation) projects are used by cities to boost the local image and create an environment attractive to the "creative class" (*4*). Cycling culture and the ubiquitous promise of livable, green, vibrant communities and robust commercial sectors are an attractive goal for local governments but are not deemed achievable in disinvested communities who have not undergone at least the first waves of gentrification. Some disinvested communities are reshaped to fit a "sellable" image (5) at the expense of at-

risk populations, while non-gentrifying disinvested communities, with already weak political agency, can face many hurdles, such as limited time or funding for outreach, campaigning, and attending meetings, when trying to capture limited active transportation funding

The 2015 Building Equity report (15), assembled by PeopleForBikes and Alliance for Biking and Walking, is a recent effort to provide American cities with insight on equitably implementing cycling infrastructure, particularly cycle tracks. The study focuses on using interviews with activists and planners in communities of color who work to build inclusive bicycle networks. In one such interview, Marven Norman from Inland Empire, a region east of Los Angeles, stated that cycling infrastructure goes "perpetually to those who have the time and the resources to ask for and demand the goods from the government," leaving disinvested communities behind once again.

The report (*12*) summarizes 2013 American Community Survey Data and finds that 20 percent of bicycle commuting in the United States is conducted by the richest income quartile while 39 percent is conducted by the poorest quartile. Pucher and Buehler (*13)* also found that the lowest quartile of household incomes in the United States have the highest share of cycling trips and the share of Black, Latino and Asian riders have all increased from 2001 to 2009. These findings demonstrate the presence of cycling culture in marginalized communities and, presumably, a demand for cycling amenities and safer infrastructure.

Additionally, Hispanic cyclists, followed by Black, are most likely to die in a bicycle crash in Chicago (1999-2011) (*14*). Although little research was found specifically addressing the issue of race or ethnicity and cycling safety, the rate of fatalities among Hispanic and Black riders may be due to a lack of cycling amenities and safety elements in disinvested and marginalized communities.

With such a high share of cyclists coming from low-income neighborhoods or communities of color, this paper will discuss whether there is merit to claims that there is a disconnect between the demand and supply of cycling infrastructure based on community privilege. For instance, the Portland Bureau of Transportation North Williams Traffic Operations Safety Project has become a poster child for the type of racial tensions and grievances that can arise when inequitable distribution is followed by investment only once there is an influx of the privileged population (*4*). The project was a bicycle lane improvement effort to increase safety along a major cycling commuter route that advocates believed would move ahead easily. However, at public meetings in 2011, community frustration about the planning process came to light. At one meeting, Sharon Maxwell-Henricks demanded to know why, "You say you want it 'safe' for everybody, how come it wasn't safe 10 years ago? That's part of the whole racism thing…we wanted safe streets back then; but now that the bicyclists want to have safe streets then it's all about the bicyclists getting safe streets" (*15*).

Lubitow and Miller (*4)* conclude,

"On the one hand, decision makers working for the city of Portland developed a narrative around bicycle lane expansion that highlighted the

importance of improving safety on the street, reducing accidents and promoting ease of movement for cyclists and commuters. On the other, long-time African American residents responded to the city's framing of the project by articulating a competing narrative that acknowledged an extensive history of exclusionary development, displacement, and gentrification in the area" (p. 124).

In Chicago, a different supply and demand controversy has arisen around the distribution of the docking stations for Divvy Bicycles, the city's bicycle share program that launched in June 2013,. The program was initially questioned when West and South Side Chicagoans realized that the vast majority of stations would be located near the lake shore or in the more affluent North Side region. Examining Divvy Bike's 2013 ridership data, it was found that there are in fact so few stations in the South Side that the average trip length of rides originating or terminating in the South Side is over half an hour (*16*). The bicycle share pricing scheme is such that a rider can take as many trips per day as desired, but after the 30-minute mark, the rider begins to incur additional costs at a rapid pace; a high density of stations is essential for successful bicycle share usage. The burden of limited station availability and the resulting additional costs for bicycle share users is particularly important given that South and West Side Chicago are predominantly low-income, non-White areas.

Following critique from community organizations such as Bronzeville Bikes, a South Side cycling advocacy group, the city and its partners have made efforts to increase citywide access to the program, but much work remains to be done at the time of writing. Divvy is set to expand throughout the summer of 2015, growing from 300 to 476 stations, but still will only serve about 56% percent of the city's population, according to Sean Wiedel, assistant commissioner of the Chicago Department of Transportation (*17*).

Bicycle ridership and proximity to amenities

In order to appropriately assess relationships between cycling investments and community composition, alternative explanations must be ruled out. High density and proximity to amenities and destinations, such as employment locations, services, or transit stations, can lead to increased walking and cycling (*18-21*), and thus, provide a greater impetus for investing in cycling infrastructure. The convergence of active transportation infrastructure investment around high destination and population densities would imply a more unbiased, although not necessarily equitable, geography of cycling infrastructure.

Hypothesis

The literature review for this study has attempted to give an overview of the demographic characteristics associated with gentrification and factors that create disparities in cycling investment. Discussion of the relationships between cycling culture, gentrification and marginalized communities were found (3, 4, 5, 14, 15), however, little attempt appears to have been made to quantify and empirically assess these connections to better understand patterns and characteristics of areas of investment. This study hopes to address this angle of the research by assessing claims that cycling investment is

disproportionately implemented in privileged or gentrifying areas. It is hypothesized that cycling infrastructure investment is not equitably distributed throughout the two study cities and is concentrated in areas that are currently privileged or experiencing an in-migration of privileged populations.

Methodology

Study Areas

Due to the presence of both a strong cycling culture and a history of socioeconomic segregation in each location, we analyzed Portland, OR and Chicago, IL, as defined by their respective city boundaries and used the census tract as our unit of analysis. Portland is an interesting case study because of its reputation as a cyclist's haven and its rapid gentrification. Chicago, on the other hand, has recently developed a robust bicycle share program and has a much larger and more racially and ethnically diverse population. Analyzing the distribution of cycling investments in each city allowed for some generalizations to be made while capturing area-specific attributes. We created a separate dataset for each city.

Cycling infrastructure index

In order to be as comprehensive as possible, we developed cycling infrastructure investment indexes using three data sources. Due to data availability, two slightly different approaches are used depending on the city.

The cycling infrastructure investment variable was calculated as a gradient measure of bicycle lanes and bicycle parking. Because Chicago now has a bicycle share program, we added bicycle share stations to Chicago's index. Bicycle lane data matching census years as closely as possible were obtained: 1991 and 2012 for Chicago (*22*) and 1990 (*23*) and 2010 (*24*) for Portland. The Chicago 1991 map and Portland 1990 map were unavailable in digital formats and had to be digitized manually for analysis in ESRI ArcGIS. The maps all included some level of identification between off-street trails, bicycle lanes, or recommended routes. Only off-street trails and bicycle lanes (including buffered bicycle lanes, cycle tracks, and boulevards) were included in the final datasets, while routes classified as "recommended" were excluded. Our assumption is that the latter have required minimal investment.

We compiled 2010 bicycle parking data for Portland (*25*) and 2012 data for Chicago (*26*), but found no reliable source of historic data. Chicago's Divvy bicycle share program rolled out in 2013 (*27*); Portland did not have a bicycle share program at the time of analysis. The bicycle share stations and bicycle parking locations are included in the infrastructure index as a measure of current conditions.

To account for variations in census tract size, we calculated a measure of change in relative bicycle lane coverage over time and by area [(km bicycle lanes 2010 – km bicycle lanes 1990)/km^2 2000 census tract area]. The bicycle data layers include off street paths and trails that do not follow vehicle roadways so a measure of bicycle infrastructure density relative to census tract size was appropriate. Similarly, bicycle parking and

bicycle share stations were normalized by census tract area ([bicycle parking count/km^2 census tract area] and [bicycle share station count/km^2 census tract area]). Our census tract level bicycle infrastructure index is the sum of the z-scores of each indicator. It is used as the dependent variable in the regression models.

Gentrification index and census tract socio-demographics

Gentrification is a difficult phenomenon to quantify and other researchers have attempted to assess the presence and impact of gentrification in a number of ways. For instance, a recent study considers municipal structural reinvestment in previously disinvested areas by exploring Google Street View for visible cues of neighborhood change (*28*). Other studies assessed the growth in presence of coffee shops (*29*) or attendance in art festivals (*30*), both seemingly ubiquitous signs of gentrification of urban districts.

In this study, we assess gentrification as a gradient of change in community composition over time. By using a linear regression model, the likelihood of cycling infrastructure investment can be understood with respect to different gentrification indicators (1990-2010) and to current community demographics (2010).

Because census tract boundaries have changed over time, the 1990 and 2010 data were transposed using census tract relationship files to 2000 census tract geographic boundaries for ease of comparison between years. Census tracts with no household incomes or population (e.g. industrial areas such as airports) were removed. All monetary values are in 2010 dollars using adjustment values listed by the Bureau of Labor Statistics.

A gentrification index was created using United States Census tract level data from 1990 and 2010. Gentrification indicator development was based on previous research (*7; 31-33*) and measures the change from 1990-2010 for each of the following attributes: percent White population; percent homeownership; percent population with some college education or higher; median household income; and median home value. The z-scores of the gentrification variables were calculated and summed to identify areas undergoing the greatest changes associated with gentrification. Table 1 provides definitions for the variables used in analyses.

[Table 1 about here]

Distance to amenities and population density

To account for proximity to amenities as a possible influencer of cycling infrastructure investment, the distance from each census tract centroid to downtown and to the nearest rail transit facility was calculated. “Downtown” was defined as the centroid of census tracts that encompass what is generally considered the downtown area. Transit includes subway, light rail and trolley but excludes bus stops due to the possibility of stop relocations. 2010 population density and the change in population density (1990-2010) were also included in the regression models with the assumption that higher population densities will correlate to higher densities of local services, opportunities for cycling and cyclists.

Modeling

The linear regression models measure association between cycling infrastructure indexes and population density, distance to downtown, distance to nearest rail transit, gentrification index components (1990-2010) and 2010 socio-demographic conditions. All available variables were initially included to test the general strength of the model. The model was then built stepwise to include only significant variables for each city. A test of collinearity ensures that none of the variables are overly associated.

Findings

A first visual presentation of the data allows the reader to explore the data that was used in analyses. Figure 1 and Figure 2 show for each city the distribution of bicycle infrastructure and change in community composition based on the gentrification index. Here, the index is referred to as “change in community composition” because the assumption of initial disinvestment is not met (some census tracts were already reasonably privileged in 1990). The maps do, however, illustrate patterns of bicycle infrastructure distribution relative to areas of increasing or existing privilege. Upward change in community composition occurred mostly in the center and northeast of the center of Portland and most bicycle parking is located within the two highest jenks (natural breaks classifications) of change. While east-west bicycle lanes generally go far beyond those areas, more north-south lanes are found closer to the center and have been added since 1990. In Chicago, the presence of parking is broadly distributed but, as with Divvy stations, they tend to be more present in the center and north of the center. Upward change in community composition has also occurred mostly north of the center and generally closer to Lake Michigan. In both maps, census tracts with the greatest change in the opposite direction (large negative values) reflect “landing zones”, potentially due to the relocation of displaced individuals (35). These tend to be farther from the center and have received fewer new investments.

Descriptive statistics are provided in Table 2 for Portland, and in Table 3 for Chicago. As discussed earlier, because of the size of the city, mean distance to downtown is greater in Chicago. Mean percentage of non-white population, renters and unemployed is also reflected in descriptive statistics. Home value and median household income of census tracts are also on average higher in Chicago, making it a city with likely more serious affordability issues. Portland has a higher mean percentage of highly educated population and a greater percentage of new residents. During the study period, Portland’s median income and home values increased considerably more, while Chicago’s census tracts experienced on average a growth in minority population, owned units and college graduates. These differences in current conditions and in change during the study period provide two distinct cases on which to test our hypothesis. We now turn to an analysis of the factors associated with cycling infrastructure investment in each city individually, expecting that the drivers of cycling infrastructure investments may not be the same but will point to a similar conclusion.

[Figure 1 about here]

[Figure 2 about here]

[Table 2 about here]

[Table 3 about here]

Portland

A basic scatter plot (Figure 3) shows that there is a positive, non-linear correlation between the bicycle infrastructure investment index and gentrification index.

The Portland linear regression model (Table 4) explores separate components of the index to provide greater insights into variations in individual components. The model suggests that there is a relationship between the independent variables and our cycling infrastructure investment index with 58.8% of the variance explained by included independent variables. All model relationships are expressed in standard deviations relative change in cycling infrastructure per square kilometer. Distance to downtown is the most significant variable (sig.=0.000) where 1km further from downtown is associated with a 0.228 standard deviations relative decrease in cycling infrastructure. Population density is also significantly associated, with a one unit increase in density (pop./m^2) resulting in 74 standard deviations relative increase in infrastructure. Investment is influenced by distance to downtown and population density, as would be expected if distribution were based on a basic supply and demand model. However, variables associated with gentrification and current privilege are also strong predictors of investment in the model.

Two community demographic variables associated with gentrification (change from 1990 to 2010) are significant: an increase in home ownership and an increase in the population with some college education or higher. Change in college education has the greatest impact, with a one percent increase associated with a relative increase of 3.080 standard deviations of cycling infrastructure. Two variables reflecting 2010 conditions are significant in the step-wise model, both with positive coefficients: percent renter occupied units and percent unemployed. A one percent increase in current renter occupied units is associated with 1.582 standard deviations relative increase in infrastructure. At first glance, this may seem contradictory with respect to the change in home ownership variable. However, high rates of renting are a factor thought to provide a platform that attracts gentrification (33), while an increase in homeownership is associated with gentrification in later phases (7). Despite the significance in the model of proximity to downtown and population density, the strong presence of variables reflecting changes in community composition associated with gentrification and privilege indicate that there are disparities in Portland's infrastructure distribution.

Chicago

Figure 4 is a scatter plot of bicycle infrastructure investment in Chicago as a function of the gentrification index. Because of the distribution of the data, we explored different fitting methods. The LOESS curve (dependent variable is fitted to independent variable using a subset of near independent variable points to the one being estimated, hence LOcal regrESSion) provides the best-fit line and illustrates that infrastructure

investment remains consistently low until the top two quintiles of gentrification indicators, at which point investment slopes upward sharply.

The Chicago linear regression model (Table 5) provides evidence that while overall results are similar and follow the same directions, different variables were found to be associated with the bicycle infrastructure investment index. Population density and distance to downtown have the same sign while increasing population density over the study period also presents a significant relationship with cycling investments. This latter result was not identified in the Portland model. A one percent increase in the White population was associated with a 1.421 standard deviations relative increase in infrastructure. Because Hwang and Sampson (2014) found that, in Chicago, gentrification did not occur in census tracts where there was a threshold of 40 percent or more Black community concentration, we revised our initial modeling strategy to account for this. When census tracts with greater than 40 percent non-White population are removed from the analysis, a percent increase in White population is associated with a 2.624 standard deviations relative *decrease* in infrastructure and a much stronger model fit. In order to keep all census tracts in the analysis, we accounted for this threshold effect by including a dummy variable to identify tracts with more than 40 percent non-White in 1990. Its negative association with cycling investment is clearly apparent, and brings the areas with growth in White population to the expected direction of coefficient. The model suggests that within gentrifying census tracts, there is perhaps some increase of racial mixing, but it is very important to remember that regions with largely non-White populations are likely excluded from both this mixing and gentrification. Among all Chicago census tracts, areas with higher White populations or those experiencing an influx of white residents are more likely to receive cycling infrastructure investment.

This paper has largely painted gentrification in a negative light with regard to the way in which marginalized communities lack decision-making power and the needs of an incoming elite are prioritized. However, gentrification can manifest positive investments to otherwise disinvested communities such as increased amenities, safety, and commercial activity. In Chicago, communities with over 40 percent non-White population concentrations are unlikely to be able to attract investment on their own and are also unlikely to experience investment through gentrification.

A sixth variable present in both models, the change in population with college education and higher, influences the model in a different direction than the Portland model. Areas with growth in educated population are associated with decreased investments. But for the Chicago model, current level of education was significantly associated with the dependent variable and suggested increased investments. This relationship would suggest that cycling infrastructure investment is associated with current privilege with regard to education, rather than gentrification.

The other significant demographic variables for Chicago are percent new residents since 2009, median home value (2010), and change in median home value (1990-2010). Additionally, greater infrastructure investment is associated with an interesting combination of increasing density (1990-2010), high rates of new residents since 2009, relatively low median home values (2010) and increasing median home

values (1990-2010). Neighborhoods with low value housing stock may be primed for gentrification, resulting in an influx of new residents and rising housing costs.

The regression model's coefficients suggest that higher density areas and those experiencing population growth are more likely to gain additional cycling infrastructure. As with Portland, there is a positive correlation between population density and proximity to downtown, yet the strength of demographic characteristics in the models point to disparities in investment distributions throughout both cities. Predominantly White areas undergoing many of the markers of gentrification receive a disproportionate amount of cycling infrastructure investment.

Discussion

Although the significant variables in each city's model are not identical, they do reflect similar attributes. Population density and distance to downtown are clearly an important factor in the processes determining where cycling infrastructure investments are made. In the Portland model, the change in homeownership between 1990-2010 and renter occupancy in 2010 are significant, while in the Chicago model, the percent of new residents since 2009 is a significant variable. Each of these variables reflects to some degree the amount of housing turnover and mobility potential, suggesting that communities undergoing changing residential composition are correlated to higher rates of cycling infrastructure investment. College education is a common strong element between both models and a marker of gentrification that is not solely based on wealth but can point to first-wave gentrifiers.

Surprisingly, however, race was only a significant variable in Chicago. This could be due to the relatively small number of census tracts in Portland that are predominantly non-White (only 13 out of 149 have a non-White population concentration greater than 40 percent).

Finally, income (change from 1990-2010 or 2010 conditions) was not a major influencing variable in either model. In a 2005 study, Freeman (*32)* found that between 1980 and 1990, gentrifying neighborhoods throughout the United States had an upswing in household income but the trend reversed between 1990 and 2000. He suggested that this could be due to decreasing household size or to an influx of first-wave gentrifiers who are relatively poor (artists, entrepreneurs, students, etc.). If this reasoning is accurate, it could contribute to the lack of significance of income for the two models.

The findings from this study reveal a continuation of the disparities in investment that are systemic throughout North American cities. Claims that cycling investment occurred along with gentrification are supported in both cases. Perhaps most striking, though, is the role of race in the Chicago model and the improvement of the model once census tracts with greater than 40% non-White population concentrations were singled out. This clear segregation between race and cycling investment should be an indication that cities must approach active transportation infrastructure investments thoughtfully and be aware that traditional planning processes can have shortcomings.

It should be noted that the home value variable from the census only considers owner occupied units. Therefore, neither model is able to capture changes in rental prices. Low-income neighborhoods often have high rental rates and rising living costs are a major issue in gentrifying neighborhoods. The addition of rental unit pricing changes would be a valuable addition to this research.

This research addresses potential association between variables by testing for collinearity. A test of spatial autocorrelation would further improve future research to ensure that the variables are not spatially dependent.

Another area for further research revolves around the role and effectiveness of community advocacy groups. This study has attempted to quantify and reveal patterns of investment with respect to community composition attributes. It does not, however, take into account the role of community organizations and active transportation specific advocacy groups. These organizations have the potential to either contribute to or mitigate inequitable network distributions. Privileged cycling advocates may push for self-serving projects under the impression that the projects serve the common good, as discussed in the literature review. Alternatively, advocacy groups led by members of marginalized communities or that cater to a diverse group of members can promote inclusive dialogues and reveal strategies for promoting equitable active transportation networks. Further research is required to determine the effectiveness of current and past advocacy efforts in implementing just active transportation network improvements.

Finally, understanding the changes in needs of marginalized communities with respect to safer cycling infrastructure should be pursued more actively, as current use and the potential for growth in usage may help supplement alternatives to more costly forms of transportation.

Conclusion

This study of Portland and Chicago reveals disparities in cycling infrastructure investments above and beyond expected differences associated with distance from downtown and density of census tracts. As the models show, there is an association between cycling infrastructure and both gentrification and current privilege. Low-income and communities of color, who would benefit most from increased cycling infrastructure for the economic, health and safety benefits, have been less likely to receive municipal or private investment. Mitigating these disparities in the future will be challenging and require rethinking assumptions about cycling culture and planning processes. Concerted efforts must be made so that investment follow needs and is equitably distributed, while not being imposed. Forcing frustrated communities to accept changes that may seemingly (or actually) disproportionately benefit privileged residents will not build trust in institutions or a safe environment for cycling among all socio-economic groups. Rather, planners should seek to support “revitalization” efforts- bottom-up economic reinvestment- instead of the top-down impositions of economic development through gentrification.

Table 1: Linear regression model variable definition

	Independent Variables		
	2010 Conditions	**Change in community composition 1990-2010**	**Description and expected associations**
Distance (constant 1990-2010)	**Distance to downtown****	**N/A**	Distance (km) from the centroid of each census tract to the centroid of the downtown area. Proximity to downtown is expected to increase cycling infrastructure.
	Distance to transit	N/A	Distance (km) from the centroid of each census tract to the nearest CTA station (Chicago) or TriMet MAX light rail or Portland Streetcar station (Portland).
Population density	**Population density****	**Change in population density***	M^2 are used rather than km^2 so the model coefficients better capture the slope of the relationship with the dependent variable. A positive change in population density is expected to reflect an increase in cyclists and, by extension, cycling infrastructure supply.
Gentrification indicators	**% non-White[1]***	**Change in % White population***	An increase in White population concentrations is associated with gentrification.
	% renter occupied units*	**Change in % homeownership***	High rentership rates often are an indicator that gentrification may occur, followed by a switch from renting to homeownership. The change variable reflects increases in home ownership and is expected to be associated with increased cycling infrastructure.
	% with some college or higher*	**Change in % with some college or higher***	Higher educational attainment is associated with gentrification and is expected to be associated with increased cycling infrastructure..
	%new resident since 2009*	**N/A**	High mobility, whether through displacement or in-migration, is associated with gentrification and changing community composition
	Median home value (per $1000)*	**Change in median home value (per $1000)***	An increase in housing costs is associated with gentrification and is expected to be associated with increased cycling infrastructure.
	% unemployed (civilian labor force)*	**not available 1990**	A decrease in unemployment is associated with gentrification and is expected to be associated with increased cycling infrastructure.
	Median household income (per $1000)	Change in median household income (per $1000)	Increased affluence is associated with gentrification and is expected to be associated with increased cycling infrastructure.
	Median age	Not available 1990	Lower median age is associated with gentrification.
	Median age^2	N/A	Median age squared is used to reflect the non linear relationship with the dependent variable in the linear model

***indicates the variable is significant in one model**
****indicates the variable is significant in both models**

[1] It is perhaps simplistic to lump all individuals into White and non-White. However, the discussions around cycling culture, gentrification and privilege in North America have largely converged specifically around the dominance of White privilege and norms. As such, the grouping in this instance is seen as justified.

Table 2: Portland regression variables descriptive statistics

	2010 Conditions					Change in community composition 1990-2010				
	2010 Conditions	**Min**	**Max**	**Mean**	**Standard deviation**	**Change in community composition 1990-2010**	**Min**	**Max**	**Mean**	**Standard deviation**
Distance (constant 1990-2010)	Distance to downtown	0.287	15.338	6.758	3.635	N/A				
	Distance to transit	0.044	10.366	1.954	1.638	N/A				
Population density	Population density 2010	0.000	0.031	0.003	0.003	Change in population density 1990-2010	-0.000	0.012	0.000	0.001
Gentrification indicators	% non-White	0.010	0.446	0.179	0.107	Change in % White population	-0.323	0.643	-0.013	0.145
	% renter occupied units	0.036	0.830	0.397	0.191	Change in % homeownership	-0.408	0.374	0.021	0.087
	% with some college or higher	0.331	0.973	0.709	0.159	Change in % with some college or higher	-0.084	0.402	0.140	0.102
	% new resident since 2009	0.061	0.731	0.207	0.111	N/A				
	Median home value (per $1000)	36.075	810.800	325.585	129.549	Change in median home value	-64.037	575.285	217.384	97.042
	% unemployed (civilian labor force)	0.012	0.388	0.091	0.054	Not available 1990				
	Median household income (per $1000)	3.303	141.558	53.935	24.552	Change in median household income (per $1000)	-9.641	56.189	10.440	12.095
	Median age	4.090	77.690	36.377	7.289	Not available 1990				
	Median age^2	16.728	6035.736	1376.042	563.717	N/A				
Dependent variable	Cycling infrastructure index	-2.420	7.380	0.000	1.624					

Table 2: Chicago regression variables descriptive statistics

	2010 Conditions					Change in community composition 1990-2010				
	2010 Conditions	**Min**	**Max**	**Mean**	**Standard deviation**	**Change in community composition 1990-2010**	**Min**	**Max**	**Mean**	**Standard deviation**
Distance (constant 1990-2010)	Distance to downtown	0.300	25.537	10.323	4.868	N/A				
	Distance to transit	0.017	9.780	1.554	1.546	N/A				
Population density	Population density 2010	0.000	0.032	0.006	0.004	Change in population density 1990-2010	-0.031	0.015	0.000	0.004
Gentrification indicators	% non-White	0.007	1.000	0.598	0.326	Change in % White population	-0.683	0.745	0.051	0.215
	% renter occupied units	0.000	0.929	0.452	0.162	Change in % homeownership	-0.512	0.776	0.076	0.140
	% with some college or higher	0.075	1.000	0.537	0.219	Change in % with some college or higher	-0.623	0.819	0.160	0.157
	% new resident since 2009	0.000	0.758	0.174	0.094	N/A				
	Median home value (per $1000)	0.000	1453.500	267.019	181.719	Change in median home value	-654.400	884.200	118.677	164.109
	% unemployed (civilian labor force)	0.000	0.595	0.134	0.092	Not available 1990				
	Median household income (per $1000)	0.087	258.729	44.688	31.083	Change in median household income (per $1000)	-96.160	181.610	3.209	25.769
	Median age	8.800	55.000	33.128	6.109	Not available 1990				
	Median age^2	77.440	3025.000	1134.771	425.518	N/A				
Dependent variable	Cycling infrastructure index	-1.580	15.220	0.000	2.234					

Table 4: Portland cycling infrastructure investment regression model

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	-.163	.408		-.400	.690
Population density 2010	73.963	26.825	.154	2.762	.007
Distance to downtown (km)	-.228	.030	-.511	-7.539	.000
Change in % homeowner 1990-2010	2.916	1.108	.156	2.631	.009
Change in % with some college or higher 1990-2010	3.080	.954	.193	3.227	.002
% renter occupied units 2010	1.582	.601	.187	2.633	.009
% unemployed	3.990	1.887	.132	2.114	.036

Summary	**N**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
	149	0.767	.588	.570	1.064

Table 5: Chicago regression model including all census tracts and a dummy variable for percent non-White population in 1990

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	-.779	.309		-2.516	.012
Change in population density 1990-2010	68.551	23.720	.079	2.890	.004
Population density 2010	99.105	17.511	.183	5.660	.000
Distance to downtown (km)	-.153	.014	-.334	-11.193	.000
Change in % White 1990-2010	1.421	.364	.137	3.909	.000
More than 40% non-White in 1990	-.583	.172	-.121	-3.397	.001
Change in % with some college or higher 1990-2010	-2.052	.509	-.144	-4.033	.000
% with some college or higher 2010	4.483	.414	.440	10.824	.000
% new resident since 2009	2.586	.707	.109	3.656	.000
Change in median home value (per $1000) 1990-2010	.002	.001	.177	4.053	.000
Median home value (per $1000) 2010	-.003	.001	-.219	-4.003	.000

Summary	**N**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
	844	.683	.466	.460	1.642

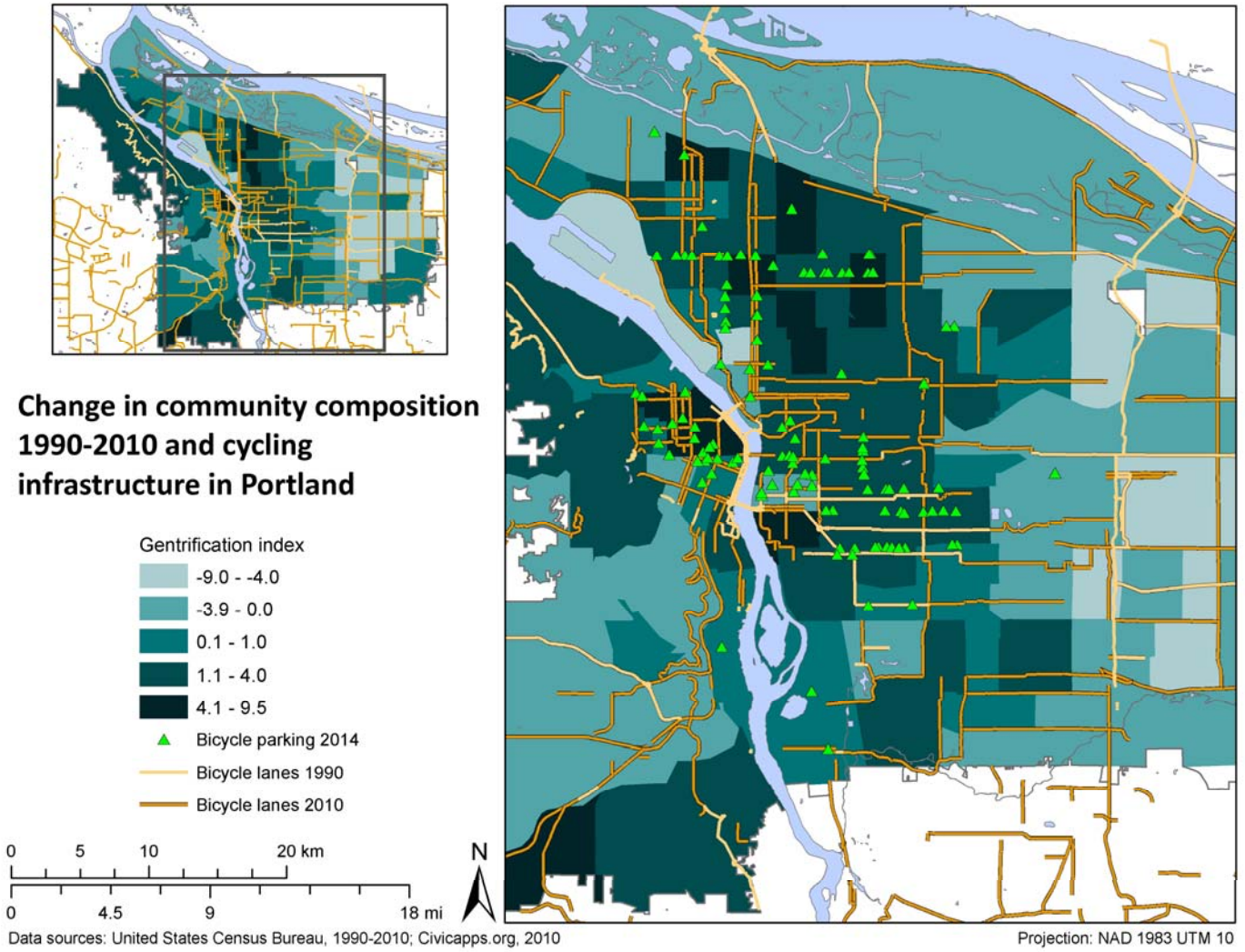

Figure 1: Change in community composition 1990-2010 and bicycle infrastructure in Portland

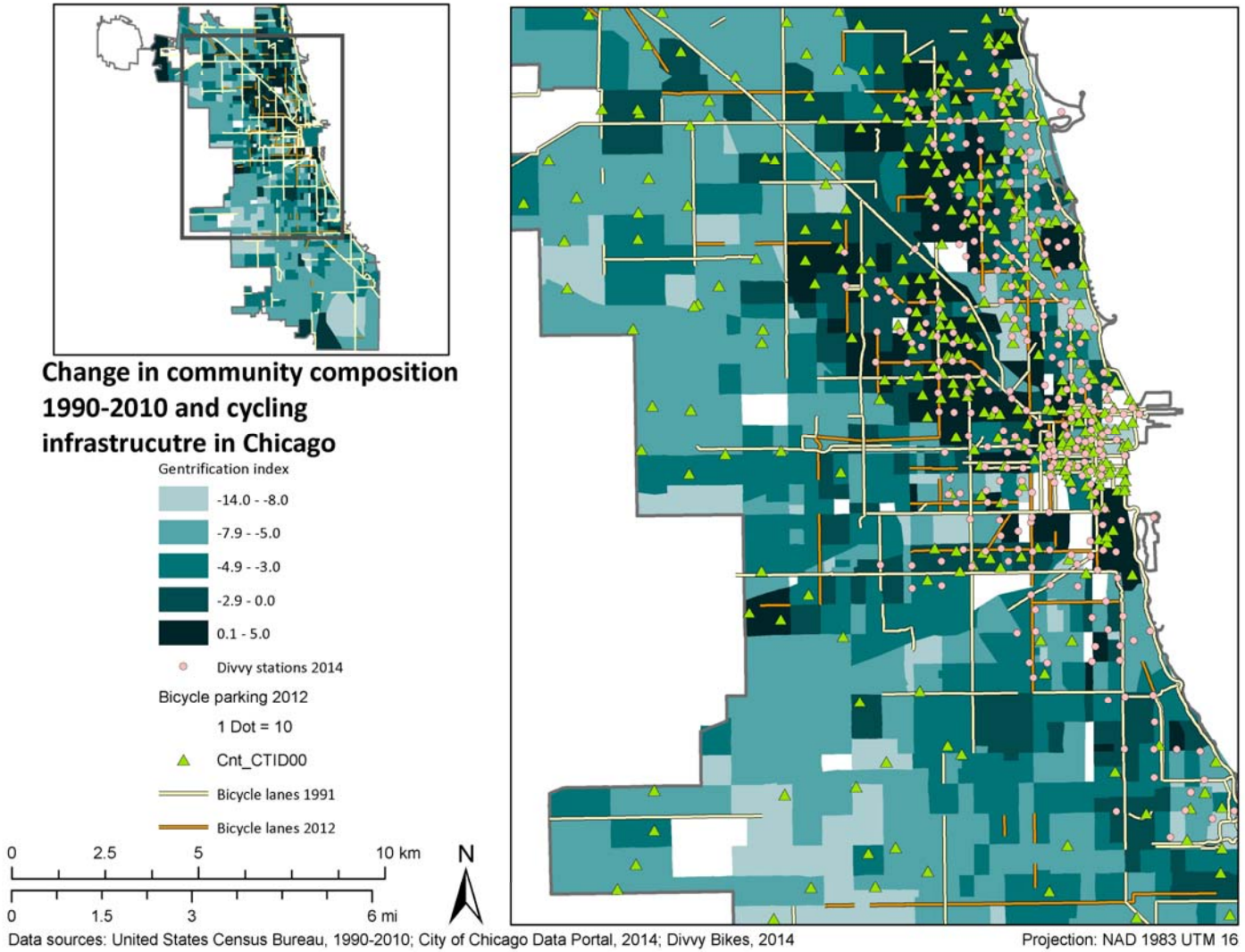

Figure 2: Change in community composition 1990-2010 and bicycle infrastructure in Chicago

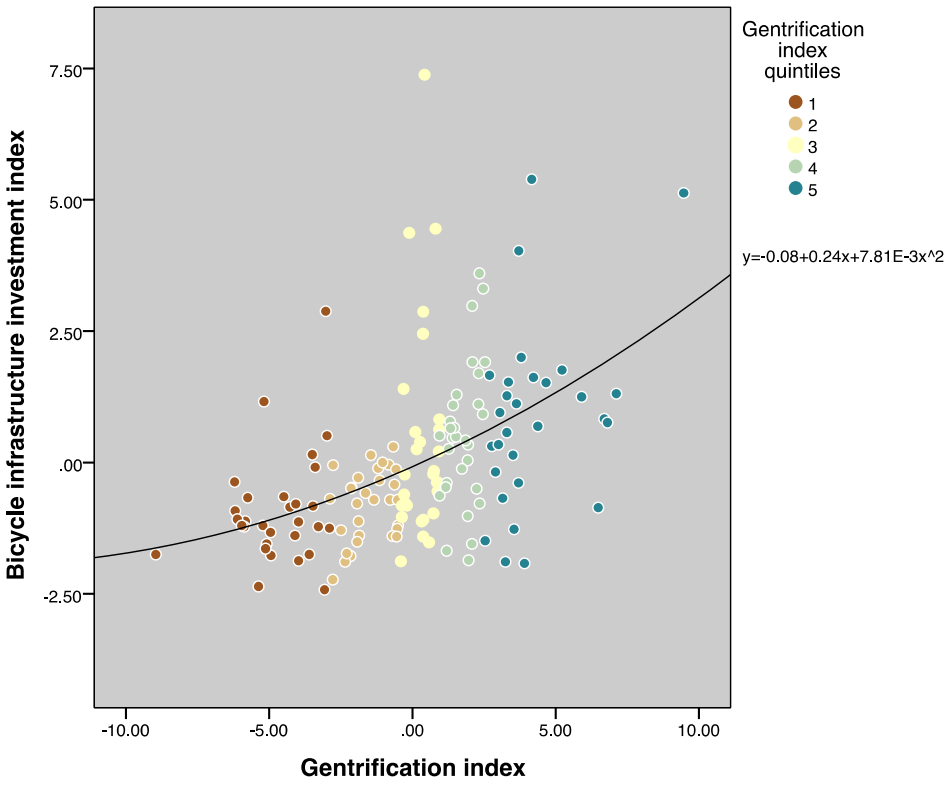

Figure 3: Scatter plot of Portland bicycle infrastructure investment as a function of the gentrification index

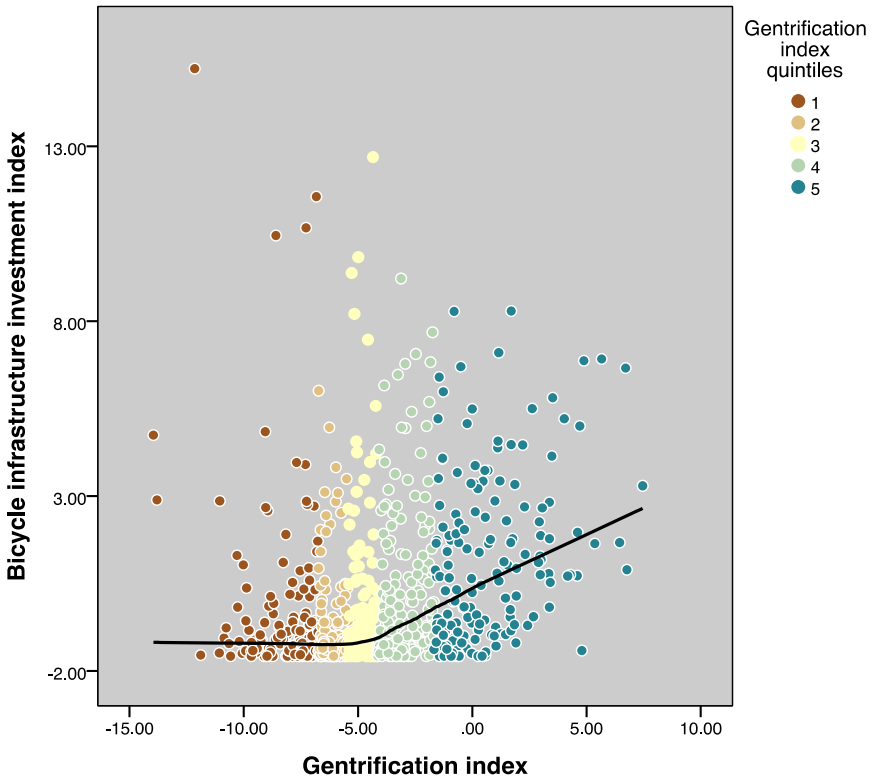

Figure 4: Scatter plot of Chicago bicycle infrastructure investment as a function of the gentrification index

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