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

Elizabeth Flanagan
School of Urban Planning
McGill University
Room 400
Macdonald-Harrington Building
815 rue Sherbrooke Ouest
Montréal, QC, Canada
Phone (207) 805-2107
Email: Elizabeth.flanagan@mail.mcgill.ca

Ugo Lachapelle, PhD
Département d'études urbaines et touristiques,
École des sciences de la gestion,
Université du Québec à Montréal,
Case postale 8888, Succursale Centre-Ville, Montréal
(Québec) H3C 3P8
Montréal, QC, Canada
Phone: (514) 987-3000 x5141
Fax: (514) 987-7827
Email: lachapelle.ugo@uqam.ca

Ahmed El-Geneidy, PhD (Corresponding author)
School of Urban Planning
McGill University
Room 400
Macdonald-Harrington Building
815 rue Sherbrooke Ouest
Montréal, QC, Canada
Phone (514) 398-8741
Email: ahmed.elgeneidy@mcgill.ca

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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-demographic backgrounds. This research assesses the geographic distribution of cycling infrastructure with regard to community demographic characteristics to assess claims that cycling investment arrives in tandem with incoming populations of privilege or is targeted towards neighborhoods with existing socioeconomic wealth. Using census and municipal cycling infrastructure data in Chicago and Portland from 1990 to 2010, we create demographic and cycling infrastructure investment indices at the census tract level. Linear regressions estimate the extent to which existing community demographics and change in demographics associated with gentrification are related to cycling infrastructure investment. In both cities, we identify a bias towards increased cycling infrastructure investment in areas of existing or increasing privilege. This paper suggests 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, planning processes may actively seek out diverse stakeholders and be sensitive to citywide community input and stated needs in future transportation projects.

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 (and cycle tracks, boulevards or other linear facilities), 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 an affluent White 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 (2014), Lubitow and Miller (2013) and Stehlin (2015), discuss underlying socio-political factors associated with gentrification, "White" cycling culture, and ongoing inequities in urban transportation networks and decision-making processes.

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. The concept of gentrification implies reinvestment in formerly marginalized communities. For the purposes of this paper, 'gentrification' refers to a measure of change over time in socioeconomic indicators (Change in Community Composition 1990-2010) associated with gentrification. Much of the dialogue surrounding inequality and cycling infrastructure focuses solely on gentrification, but this paper posits that the larger issue is whether areas with populations of privilege, either long-term or newly arrived, are correlated with greater levels of cycling infrastructure investment. To determine if communities that are already privileged capture a disproportionate amount of cycling infrastructure investment, a measure of existing 'privilege' is also included (Community Composition 2010) and considers the same variables at their 2010 levels.

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 cycling infrastructure investment indices and assess their relationship with indicators representing privilege and gentrification.

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, aggregate census tract data captured at two time points makes interpretations of whether cycling infrastructure is a cause or effect of changing community characteristics inappropriate. Regardless of whether cycling infrastructure investments are a catalyst for gentrification or whether they follow privileged populations, this paper attempts to investigate if marginalized communities are less likely to be able to attract these investments without the presence of more privileged populations.

Linear regression models provide evidence that cycling investment is related to both characteristics of privileged current demographics and to markers of gentrification, expressed through incoming populations of privilege. Given the economic, environmental and health benefits of cycling, 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 lay narratives. Newspaper articles and online media point to 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 to develop the analytical strategy.

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 (*3)* 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 often 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-effects of gentrifying communities (*4-6*). 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 (Chum, 2015).

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 (Atkinson, 2000; Chum, 2015; Freeman, 2005; Hwang and Sampson, 2014).

This paper uses a range of indicators of community composition 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. We use the term privilege to outline the fact that gentrification does not always imply an in-migration of a wealthier population, at least at the outset. Rather, gentrification can connote a change in "class," such as populations with higher educational attainment (Freeman, 2005).

Inequitable distributions of transportation investment are a classic example of environmental injustice; marginalized communities are split by highways, disproportionately impacted by air and noise pollution, or priced out of locations near convenient public transit (Bullard et al., 2004; Gibson, 2004; Bullard and Johnson, 1997). Bullard and Johnson (1997) claim that transportation benefits accrue to wealthier and more educated populations while transportation burdens, such as pollution, cost, or lack of safety, fall disproportionately on people with low socioeconomic standing and people of color. It seems that regardless of mode, American transportation systems and development trends systemically place undue burden on marginalized communities by forcing them to travel using less safe, more costly or inconvenient transportation networks.

Cycling differs from other forms of transportation because of its seemingly universal economic and health benefits. However, it also differs from other modes because of the vastly different stigmas associated with being a cyclist. Bicycles are sometimes viewed as a last resort for those unable to bear the cost of a vehicle or of public transportation. On the other hand, cycling has been adopted for recreation by the affluent and for transportation by environmentally and socially conscious millennials. As cycling becomes more and 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 (*7*)). Valencia Street in San Francisco, for example, has been a center for cycling activity and investment following a shift from a primarily working-class Latino population who cycled out of necessity to a more affluent and white population (Stehlin, 2013). This example illustrates the difference between those who cycle out of necessity and those who cycle by choice. This paper argues that it is this second group who is able to attract infrastructure investments that contribute to a more pleasant and safe riding experience.

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 (Lubitow and Miller, 2013(*8*).

Active transportation projects are sometimes used by cities to boost the local image and create an environment attractive to the "creative class" (*9*). 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 (Stehlin, 2015) 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 scarce active transportation funding.

The 2015 Building Equity report (Andersen and Hall, 2015), assembled by PeopleForBikes and the 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, a respondent 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 (*10*) 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 (*11)* 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. According to 2009 National Household Transportation Survey (NHTS) data, the national mode share for bikes, considering all respondents, is 0.68 percent. The cycling mode share among White respondents was 0.71 percent, 0.53 percent among Black respondents, and 0.76 percent among Hispanic respondents (US Department of Transportation, 2009). In Chicago, there is a strong presence of bicycle shops and groups focused on catering to or assisting riders of color or low-income through advocacy, rides, bicycle services or youth outreach, including groups like Red Bike & Green, Bronzeville Bikes, the Major Taylor Cycling Club, Blackstone Bicycles, or Working Bikes. Fewer groups were found in Portland (the Community Cycling Center being one), which could be due to the smaller presence of minority populations in Portland compared to Chicago.

These findings cumulatively demonstrate the presence of cycling culture in marginalized communities and communities of color. Presumably, this also equates to a demand for cycling amenities and safer infrastructure. To this point, Hispanic cyclists, followed by Black, are most likely to die in a bicycle crash in Chicago (1999-2011) (*12*). 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 in Chicago may be due to a lack of cycling amenities and safety elements in disinvested and marginalized communities.

This paper will discuss whether there is merit to claims that there is a disconnect between the 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 a privileged population (*9*). 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, a participant 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" (*13*).

Lubitow and Miller (*9)* 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 (*14*). 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 thus essential for successful bicycle share usage. It is possible that tourists unaware of the pricing scheme drove the average up while riding along the Lake Front path, but it would stand to reason that a similar proportion of tourists would make the same mistake on the Lake Front path in the North Side. 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 expanded the system during the summer of 2015, growing from 300 to 476 stations, but still will only serve about 56% percent of the city's population (*15*).

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 (*16-19*), 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 (Hoffman and Lugo, 2014; Lubitow and Miller, 2013; Stehlin, 2015; Hoffman, 2013; Andersen and Hall, 2015), 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. These relationships should be apparent even when controlling for distance to downtown and population density of areas.

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 cyclists' 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 linear bicycle facilities and bicycle parking. Because Chicago now has a bicycle share program, we added bicycle share stations to Chicago's index. Bicycle data matching census years as closely as possible were obtained: 1991 and 2012 for Chicago (*20*) and 1990 (*21*) and 2010 (*22*) 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” in either map were excluded. Our assumption is that the latter have required minimal physical investment.

Most of the network links represented in the City of Chicago’s 1991 cycling map are recommended with the exception of off-street trails. For this reason, the Chicago analysis is run twice. The first iteration removes routes missing or categorized as recommended in 2012. The second iteration is more conservative and assumes that everything in 1991 is recommended except for off-street trails. As will be discussed in the findings, the model remains robust for both of these iterations.

We compiled 2010 bicycle parking data for Portland (*23*) and 2012 data for Chicago (*24*), but found no reliable source of historic data. Chicago’s Divvy bicycle share program rolled out in 2013 (*25*); 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 linear bicycle facility coverage over time and by area [(km linear facilities 2010 – km linear facilities 1990)/km^2 2000 census tract area]. The bicycle data layers include off street paths and trails that do not follow vehicle roadways. A measure of bicycle infrastructure density relative to census tract size was preferred over a measure using the street network as a denominator. 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]). To normalize the different infrastructure variables with respect to citywide averages, the z-scores of each attribute were calculated and summed to generate a bicycle infrastructure investment index at the census tract level. This measure is used as the dependent variable in the regression models and reflects variation from the mean in units of standard deviation. While we refer to this as the bicycle infrastructure investment index, it is understood that monetary value was not calculated.

Gentrification and privilege socio-economic indicators at the census tract level

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 (*26*). Other studies assessed the growth in presence of coffee shops (*27*) or attendance in art festivals (*28*), both seemingly ubiquitous signs of gentrification of urban districts.

In this study, we are interested both in markers of gentrification (incoming populations of privilege) and existing privilege. Using existing literature (*4; 29-31*), we developed a set of variables associated with gentrification or privilege: percent White population; percent homeownership; percent population with some college education or higher; median household income; unemployment; age; and median home value. These are created using United States Census tract level data from 1990 and 2010 and assessed both at their 2010 levels to capture existing privilege, and as change from 1990 to 2010 to capture gentrification related associations. By using a linear regression model, the level of cycling infrastructure investment can be estimated relative to the mean with respect to the different socioeconomic indicators (independent variables). Table 1 provides definitions for the variables used in analyses as well as expected relationships.

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.

For illustrative purposes, a composite score considering changes in community composition was generated (Figure 1 and Figure 2). To normalize the analysis variables, the z-scores for each socio demographic attribute change were calculated. By summing the z-scores of each variable within each census tract, an index is achieved which identifies areas undergoing the greatest changes associated with gentrification, relative to the city mean. The index only considers change in community composition and not current conditions (existing privilege) since combining the two measures would result in double counting and over-represent areas with large change in a single variable.

[Table 1 about here]

[Figure 1]

[Figure 2]

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, and the socio-economic indicators associated with gentrification and existing privilege. Population density, distance to downtown and distance to transit are included as control variables. All available variables are initially included to test the general strength of the model. The measures for rentership and change in homeownership are removed from the final analysis due to collinearity. Several model formulations were tested and the final models represent those that achieved the best fit.

The regression models are used to test the extent of cycling infrastructure investment made in a census tract given a set of area characteristics. Since bicycle infrastructure is measured as a sum of standardized scores for linear bicycle facilities, parking and bike share stations, the relationships are described in units of standard deviations from the mean. For every unit increase in an independent variable, the model indicates B standard deviations increase in cycling infrastructure that can be anticipated within the census tract where B is the coefficient within the regression model. The standardized β coefficient helps to interpret the relative slope of each variable within the model.

Findings

A first cartographic presentation of information 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. The maps illustrate patterns of bicycle infrastructure distribution relative to areas of increasing 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. 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 (Friesen, 2015). 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. With respect to community change during the study period, Portland's median income and home values increased considerably more as should be expected considering its top ranking in terms of gentrification, 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.

[Table 2 about here]

[Table 3 about here]

Portland

The Portland linear regression model (Table 4) explores separate components of the index to provide greater insights into variations in individual components. 59.6 percent of the variance between the independent variables and our cycling infrastructure index is 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 0.286 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 87 standard deviations relative increase in infrastructure. The standardized coefficient reveals that distance to downtown (β=-0.641) has a greater impact on the predicted presence of cycling infrastructure investment than population density (β =0.181). The influence of distance to downtown and population density on investment follows what would be expected of an unbiased distribution of investments. However, socioeconomic indicators are also strong predictors of investment in the model.

Change in college education from 1990 to 2010 and 2010 unemployment are reflected similarly within the model with significance values of 0.08 and standardized β coefficients of 0.116 and 0.114 respectively. As an increase in college education is associated with gentrification, the coefficients have the expected sign with a one percent increase in college education correlated to 1.85 standard deviations greater cycling infrastructure investment. Unemployment did not follow the expected direction, with census tracts in 2010 with higher unemployment correlated to 3.45 standard deviations greater cycling infrastructure.

More strongly correlated to greater cycling infrastructure investment in the model are change in median household income between 1990 and 2010 and median household income in 2010. An increase in median household income between 1990 and 2010 of $1000 is associated with 0.04 standard deviations greater cycling infrastructure. Interestingly, census tracts with lower median household incomes in 2010 are correlated to higher levels of cycling infrastructure investment. These changes in community composition could be due to lower income areas experiencing an increase in current resident household incomes or the influx of relatively wealthier households.

[Table 4 about here]

Chicago

The Chicago linear regression models (Tables 5 and 6) include more significant variables to the model than Portland but result in a lower overall model fit with an R^2 of 0.466 for both iterations. As with Portland, the distance to downtown and population density control variables are significant indicators of cycling infrastructure investment. In the Chicago model, an increase in population density from 1990-2010 is also associated with greater cycling infrastructure investment.

A one percent increase in White population is associated with a 1.42 standard deviations relative increase in infrastructure. Because Hwang and Sampson (11) 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 reviewed 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 that 40% non-White in 1990. Its negative association with cycling investment is apparent, and brings the areas with growth in White population to the expected positive direction of coefficient.

Change in population with college education or higher influences the model in a different direction than the Portland model. Areas with growth in educated population are associated with decreased investments. But in the Chicago model, current level of education was significantly associated with the dependent variable and correlated to increased investments. This relationship suggests 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). In the Chicago model, census tracts with lower home values in 2010 but an increase in home values over the period between 1990 and 2010 are associated with greater cycling infrastructure investment. A higher rate of new residents since 2009 is also positively associated with cycling infrastructure investment. These variables reflect a similar possible explanation as in the Portland case, where cycling infrastructure is predicted to accompany neighborhoods where the existing population may be marginalized, or have low capital, and are experiencing incoming residents and rising housing values.

The standardized β coefficients indicate that proximity to downtown (β= -0.33) and current (2010) levels of higher education (β= 0.44) are the strongest predictors of greater cycling infrastructure investment. These are followed by 2010 median home value (β= -0.22), 2010 population density (β= 0.18) and change in home value (β= 0.18).

[Table 5 about here]

[Table 6 about here]

Discussion

Although the significant variables in each city's model are not identical, they do reflect similar attributes. In Portland, the model points to greater cycling infrastructure investment in census tracts that have current (2010) socioeconomic characteristics tied to marginalization (lower income and higher unemployment rates) while also reflecting incoming residents of higher education and relatively higher wealth. This suggests that gentrification is a driver in investment choices. Despite the significance in the model of proximity to downtown and population density, the presence of variables reflecting changes in community composition associated with gentrification indicates that there are disparities in Portland's infrastructure distribution.

In Chicago, proximity to downtown and population density are also important predictors of investment. In both cities, lower income or lower home value neighborhoods experiencing incoming populations with greater relative wealth are correlated with cycling infrastructure investment. College education is another shared variable, although in Portland this seems more tied to incoming educated populations and in Chicago this may be an element of existing privilege.

The role of race as a predictor of cycling infrastructure investment is unique to 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). 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 experiencing an influx of white residents are more likely to receive cycling infrastructure investment while census tracts with greater than 40 percent minority populations are associated with less cycling infrastructure investment. This paper has largely painted gentrification in a negative light with regard to the unethical way in which marginalized communities lack decision-making power and the needs of an incoming elite are prioritized over existing residents. However, gentrification can manifest positive investments to otherwise disinvested communities. 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.

Future research

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 an important issue in gentrifying neighborhoods. The inclusion of rental unit pricing changes to the analyses would be a valuable addition to this research.

Future research could expand the analyses to control for geographic or social elements that may impact the viability of cycling infrastructure investments. For instance, slope of the terrain or levels of crime may indicate where people are more likely to bicycle. While the addition of such variables will help to further develop a picture of drivers of cycling infrastructure investment decisions, the needs and desires of marginalized communities must be at the forefront of the decision-making process.

Another area for further research revolves around the role and effectiveness of advocacy groups and local government in capturing bicycle and pedestrian funding.

Handy and McCann (2010) find, through a series of case studies focused on bicycle and pedestrian funding sources, that supportive local governments and the presence of advocates can encourage the allocation of federal funding on non-motorized transportation investments. They find that regions with supportive local government also have strong advocacy bases. Cradock et al. (2009) find that nationally, at the county level, bicycle and pedestrian project implementation was less likely in counties that have persistent poverty or low education. Further research into funding opportunities and implementation patterns could provide strategies to encourage project implementation such that non-motorized investments are expected and equitably distributed, rather than an extra that needs to be advocated for.

While advocates, partnered with local government, may play an important role in capturing federal funding, they 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 at the neighborhood level.

Conclusion

This study of Portland and Chicago reveals disparities in cycling infrastructure investments across city boundaries above and beyond expected differences associated with distance from downtown and density of census tracts. In both cities, low-capital census tracts (income or home value) who would benefit most from increased cycling infrastructure for the economic, health and safety benefits, have been comparatively less likely to receive public or private investment than their counterparts. In Chicago, communities of color are also less likely to receive investment. Higher levels of educational attainment are associated with greater infrastructure investment, reflecting existing privilege in Chicago and gentrification in Portland. 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 follows needs and is equitably distributed, while not being imposed. Cycling infrastructure is relatively inexpensive, providing the possibility for widespread infrastructure implementation. With the support of existing communities, infrastructure investments in cycling could be a catalyst for breaking down historic lines of socioeconomic disparity. However, forcing frustrated communities to accept changes that may seemingly (or actually) disproportionately benefit privileged residents will not build trust in the planning process 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		
	Change in community composition 2010	**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***	Population per square meter is used to better capture the slope of the relationship with the dependent variable. Higher population density is expected to reflect an increase in cyclists and cycling infrastructure supply.
Gentrification and privilege 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 can be an indicator that gentrification may occur, followed by a switch from renting to homeownership. These are removed from the regression analysis due to multicollinearity between the rentership and homeownership variables.
	% 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 higher rate of unemployment is associated with marginalized communities and is expected to be associated with a lower level of 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 and privilege indicators	% non-White	0.010	0.446	0.179	0.107	Change in % White population	-0.323	0.643	-0.013	0.145
	% 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 3: 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	0.003
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	15.215	0.000	2.234					

Table 4: Portland cycling infrastructure investment regression model

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.819	0.531		3.424	0.001
Population density 2010	87.207	26.186	0.181	3.330	0.001
Distance to downtown (km)	-0.286	0.026	-0.641	-10.973	0.000
Change in % with some college or higher 1990-2010	1.847	1.044	0.116	1.769	0.079
% unemployed	3.445	1.925	0.114	1.790	0.076
Median income	-.020	0.006	-0.305	-3.525	0.001
Change in median income	0.036	0.011	0.265	3.363	0.001

Summary	**N**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
	149	0.772	.596	.579	1.054

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)	-0.779	0.309		-2.516	0.012
Change in population density 1990-2010	68.551	23.720	0.079	2.890	0.004
Population density 2010	99.105	17.511	0.183	5.660	0.000
Distance to downtown (km)	-0.153	0.014	-0.334	-11.193	0.000
Change in % White 1990-2010	1.421	0.364	0.137	3.909	0.000
More than 40% non-White in 1990	-0.583	0.172	-0121	-3.397	0.001
Change in % with some college or higher 1990-2010	-2.052	0.509	-0.144	-4.033	0.000
% with some college or higher 2010	4.483	0.414	0.440	10.824	0.000
% new resident since 2009	2.586	0.707	0.109	3.656	0.000
Change in median home value (per $1000) 1990-2010	0.002	0.001	0.177	4.053	0.000
Median home value (per $1000) 2010	-0.003	0.001	-0.219	-4.003	0.000

Summary	**N**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
	844	0.683	0.466	0.460	1.642

Table 6: Chicago regression model including all census tracts, a dummy variable for percent non-White population in 1990, and conservative 1991 linear bicycle facility data

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	-1.362	.0.262		-5.200	.0.000
Change in population density 1990-2010	68.546	23.718	.079	2.890	0.004
Population density 2010	99.132	17.510	.183	5.661	0.000
Distance to downtown (km)	-0.153	0.014	-.334	-11.193	0.000
Change in % White 1990-2010	1.420	0.364	.137	3.906	0.000
More than 40% non-White in 1990	-0.583	0.172	-0.121	-3.398	0.001
Change in % with some college or higher 1990-2010	-2.050	0.509	-.144	-4.028	0.000
% with some college or higher 2010	4.482	0.414	.440	10.823	0.000
% new resident since 2009	2.587	.707	.109	3.658	0.000
Change in median home value (per $1000) 1990-2010	0.002	0.001	.177	4.053	0.000
Median home value (per $1000) 2010	-.003	.001	-.219	-4.005	0.000

Summary	**N**	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
	844	0.683	0.466	0.460	1.642

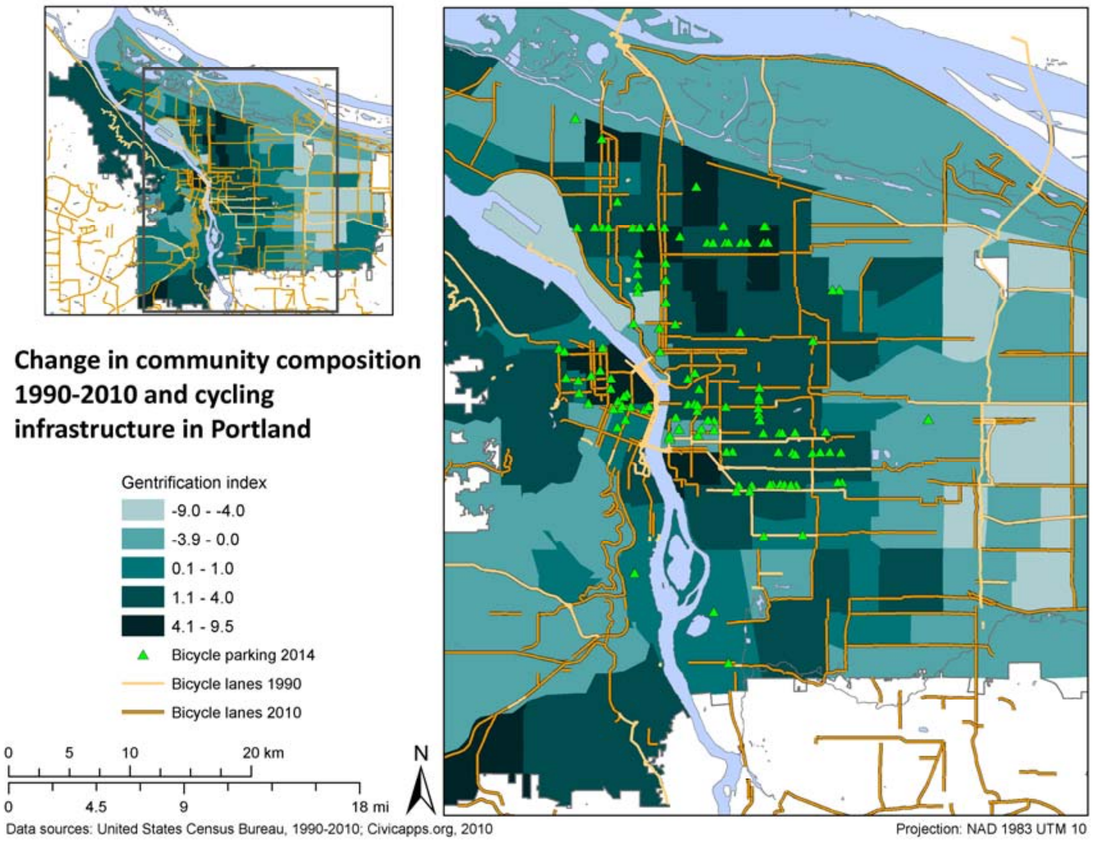

Figure 1: Change in community composition 1990-2010 and 2010 bicycle infrastructure in Portland

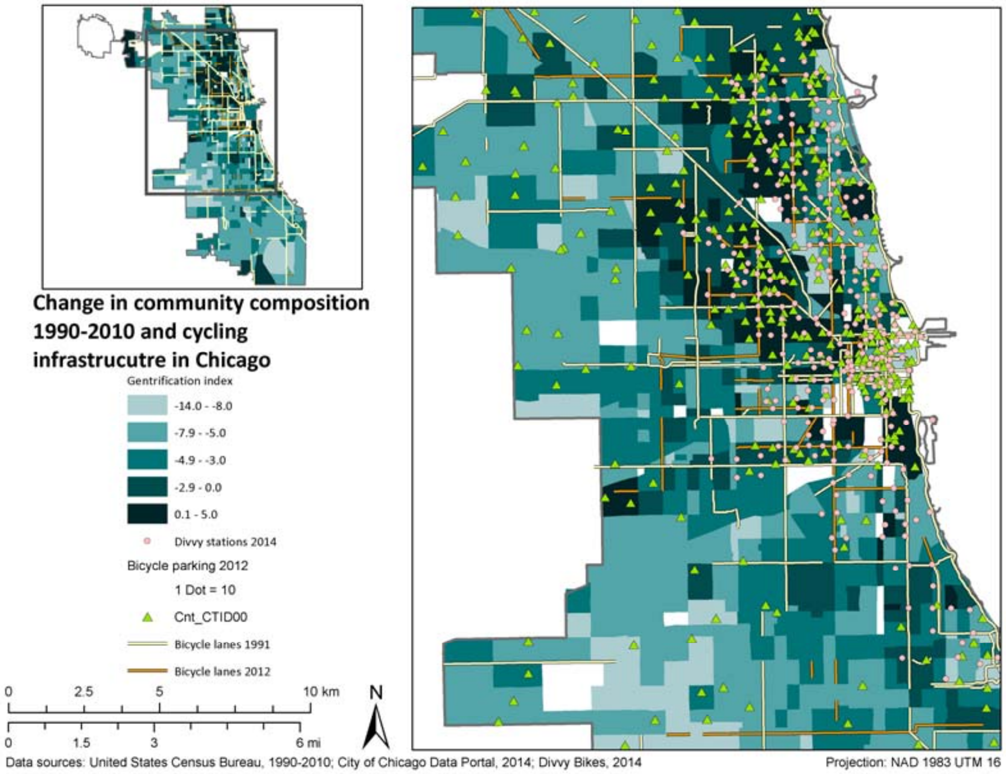

Figure 2: Change in community composition 1990-2010 and 2012 bicycle infrastructure in Chicago

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