Equity, Accessibility and Transit Use in large American cities

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ABSTRACT

The case for public transit is often justified for its role in reducing greenhouse gas emissions, curbing urban sprawl, and reducing society's dependence on the automobile. Urban transit could also be instrumental in enhancing accessibility of the transportation disadvantaged groups and therefore it could act as a key tool in promoting equity and social justice in the society. Interestingly enough, transit's role in promoting equity is often overlooked as a reason for investing in public transit.

This paper presents a study of transit mode split in ten large Metropolitan Statistical Areas in the United States using Census Tract (CT) data extracted from the 2000 Census. Its purpose is to study public transit ridership in select US cities to determine if transit is catering to the accessibility needs of the transportation disadvantaged groups, such as low-income households.

This paper draws on urban form (density, distance to the CBD), local economic health (income, unemployment, poverty, residential vacancy rate, average housing value), racial composition (% African American, % Hispanic), and auto-ownership (% of 0-vehicle households, average number of vehicles per household) to explain transit ridership at the CT level. The analysis reveals that urban form, transit supply, and poverty proxies, such as racial composition, are strong predictors of transit use in American cities. The study also shows that in large American cities, transit riders are predominantly poor individuals, who are often African Americans or Hispanics. This implies that race and poverty determine, to a great extent, transit ridership in the US.

BRIEF LITERATURE REVIEW

Public transit was first developed in big cities as a means of transporting large numbers of people and had a profound effect on urban form as it enabled urban growth. While many households in the post-war period were able to afford at least one car, a significant number of the population could not. Such individuals, some being very poor, continue to reside in the central city and rely on transit. It is therefore not surprising that public transit has become more of a social equity issue than an urban transportation issue.

In a research paper published in the Berkeley Planning Journal in 1999, Garrett and Taylor point out that, in many U.S. cities, the vast majority of transit users are poor. As transit agencies seek to attract more riders, they frequently subsidize expensive rail systems to serve the wealthy suburbs at the expense of central city bus networks. The authors regard this practice as a subsidy to the rich which could have detrimental effects on the quality of life in inner cities (1).

In the United States, the issue of equity is further complicated by the issue of race. It is a lamentable fact that many poor inner cities are populated mostly by African Americans and other visible minorities and these people tend to be the primary users of public transit because they are often unable to afford a car (2). The correlation between income and ethnicity is so strong that one researcher was able to show that the racial composition of a CT is a better predictor of transit use than spatial location, population density or any other measure of urban form (3). Furthermore, as documented in a Brookings Institute report on the 2000 U.S. Census, the African American communities tend to be segregated to a much greater extent than any other ethnic group. It should therefore come as no surprise that transit agencies should find themselves in court defending against charges of civil rights violations when they reduce to transit service to inner-city neighborhoods (4).

Often a trip by public transit usually takes much longer than the same trip made by car (5). This finding implies that the poor have to spend more time traveling than the non-poor. This leads to an unexpected situation where transportation advocates recommend subsidizing car purchases in the name of equity.

Researchers analyzing the latest US census have observed dramatic differences between cities in different regions of the country. The urban areas of the south and west are experiencing explosive economic and population growth, while the cities of the northeast and Midwest are barely growing or are, in some cases, shrinking (6). From a transportation perspective, the cities of the northeast are older and achieved their current form and size in the first half of the 20th century, when transit was the primary mode of urban transport. The cities on the west coast, meanwhile, experienced much of their growth during the latter half of the 20th century. During this period, the private car dominated travel patterns. As such, this paper anticipates some variation in equity, accessibility and transit use patterns between the regions.

DATA AND METHODOLOGY

This research was conducted using US Census data. Ten consolidated metropolitan statistical areas (CMSAs) were selected in a manner that ensured adequate representation from most regions of the United States, though the choice of study areas is rather ad hoc. From the northeast, New York, Philadelphia and Baltimore-Washington were selected. From the south, Miami and Houston were chosen. Chicago and Detroit represent the Midwest and Los Angeles, San Francisco and Seattle represent the West Coast. The CMSA's are usually much larger than the city for which they are named since they include all suburbs and most bedroom communities. CMSAs, rather than individual cities, were chosen for this analysis because a large city has important effects on travel-behavior and socio-economic development that extend many miles beyond the official municipal boundary.

This research focuses on social justice (equity) and the use of public transit. A large number of socio-demographic indicators were selected to be compared with the transportation data contained in the census. The two most important dependant variables were the percent of trips to work made by transit and the average commute time for a CT. The census collects information on mode of travel to work. The socio-demographic variables were then used as independent variables in regression models of transit mode split. The intent here is to investigate the significance of correlations between transit use, race and income that has been discussed in the literature. Separate models of transit use were estimated for each CMSA.

Linear regression models were estimated using the percentage of work trips in a CT made by public transit as the dependent variable. Twenty variables describing CTs were selected as possible explanatory variables. The variables were selected based on how well they describe zonal characteristics that were thought to influence transit use, such as income, ethnicity, demographics, and urban form. Descriptions of these variables are listed in Table 1.

For each of the 10 CMSAs, 20 variables were entered into a stepwise regression algorithm to determine which ones were the most significant. Coefficients having a p-value greater than .05 were not included in the model. Once the significant variables were identified, they were then tested for multicollinearity using variance inflation factors (VIF) and matrices of variance proportions. Variables that were strongly linked to others were removed from the model.

At the end of the process, only 12 variables remained in the ten models and no single model contained more than 6 explanatory variables (see Table 2).

FINDINGS

The analysis made it possible to classify U.S. cities into three main groups: New York City, "Typical" cities, and "Atypical" cities. In this section, the ten cities and three groupings are examined in detail. In addition, findings reported in this section correspond to work trips only.

Group 1: New York City

Greater New York, with a population of over 21 million people, constitutes the largest CMSA in the country. The five boroughs of the actual city of New York display characteristics which are unique in the United States. First, the average population density is extremely high and many individual CTs have densities greater than 50,000 people per square mile. Second, transit accounts for 20% of all work trips in the entire CMSA and this rate is by far the highest of all cities studied. Within the City of New York, the transit mode share of each CT is even higher, almost always above 30%. Third, a scatter-plot of income vs. auto-ownership reveals two distinct trends (Figure 1). A large set of points follow a steep upward slope suggesting that the number of cars/household increases with the increase in household income. But there is another set of points for which the slope is less steep, suggesting that auto-ownership increases at a much lower rate with income. This trend demonstrates that many wealthy people in New York choose not to own cars perhaps due to abundant supply of reliable and efficient public transit services. Hence transit use is universal throughout the New York City and is not restricted to low-income areas.

The unusual features of New York can be explained by its urban form and its extensive transit network. The island of Manhattan is the major employment centre in the New York CMSA and is accessible only by bridges and tunnels, all of which are bottle-necks for traffic and contribute to severe highway congestion leading to higher-than-average commute times. In addition, New York's subway network is the largest in the US and reaches nearly every corner of the City. The severity of traffic congestion combined with the good transit supply result in above-average travel times and transit mode shares.

New York is an exception to the general trend that transit use is dictated largely by income. Despite having one of the highest average median incomes and the lowest rates of poverty of all the cities studied, transit use in New York is nearly twice as high as in its closest competitor, Chicago.

In the regression models, New York displays trends similar to most other cities in the study. Increasing rates of auto ownership and increasing distance from the central city will cause transit mode share to decline. An increase in population density or proportion of African Americans in a CT is accompanied with an increase in transit mode share. Another important determinant is whether or not the CT is close to a subway station. CTs that are inside or touching the one-mile buffer subway buffer generally have higher rates of transit use than those CTs not touching the buffer. As expected, median residential property values are positively correlated with proximity to transit, probably as a result of the many affluent neighborhoods in New York that are well-served by public transport.

Group 2: Typical Cities

Typical cities are the ones the ones where transit ridership consists primarily of ethnic minorities. Such cities exhibit higher levels of racial segregation and incidence of poverty in the central areas.

Chicago

The Chicago CMSA is the third most populous in the U.S. after New York and Los Angeles and has the second-highest rate of transit use (12 % of all work trips). Chicago is quite similar to New York in that it displays very high population densities in certain regions, larger than average commute times and an extensive public transit network. Indeed, high rates of transit use persist quite far beyond the central city. Furthermore, transit use is not strongly tied to race, although the percentage of African Americans in a CT is a more significant predictor in Chicago than in New York. Chicago does not display New York's dual trends in income vs. auto-ownership, and rates of transit use are highest in the central city areas. These areas also tend to have the largest proportions of African Americans and the highest rates of poverty.

The variables that explain transit use in Chicago are similar to those in New York. In Chicago, the percentage of households without a car replaces the average number of autos per household variable and is positively correlated with transit use. The proportion of African Americans, population density and the proximity to subway stations are all positively correlated with transit use as well. The percentage of the population with university degrees is also positively correlated with transit mode split.

Philadelphia

Philadelphia is an example of "urban decay" in America. The African American population is concentrated and segregated in low-income CTs near the central city. These CTs exhibit high rates of transit use. Transit represents a small share of commute trips originating in more affluent suburbs, although overall, the transit mode share is 10% which is the third highest in the country.

In the regression models, Philadelphia displays the same trends as New York and Chicago. One interesting difference is the significant role of residential vacancy rates in predicting transit use. An increase in vacancy rates is likely to increase transit use through the fact that CTs with a high number of unoccupied dwellings are likely to be poorer.

Baltimore-Washington

This region bears many similarities to nearby Philadelphia. Racial segregation and poverty in the central cities are prominent features. Baltimore and Washington report high rates of transit use within the actual cities while the surrounding suburbs report low rates.

All the typical statistical trends apply. The proportion of African Americans and Hispanics, auto ownership and proximity to subway stations all contribute to rates of transit use.

Los Angeles

Los Angeles (LA) has the highest proportion of Hispanics and the highest average poverty rate of all the cities in this study. It also has the unique distinction of having the highest average number of cars per household. Despite the fact that Hispanics tend not to be segregated and ghettoized to the same extent as African Americans, there is evidence of segregation of Hispanic communities in LA. About 12% of CTs in the CMSA are over 80% Hispanic (Figure 2a) and some of these CTs are concentrated in the impoverished central city. These same CTs display the highest rates of transit use and this trend classifies LA as a Group 2 city.

Until recently, Los Angeles' transit service was provided entirely by buses. However, in recent years the city has embarked on a fairly aggressive subway construction program. The overall transit mode split is 5.3% and is the third lowest amongst the cities researched.

Transit mode split in LA is explained primarily by auto-ownership rates and population density. The proportion of Hispanics and the distance from downtown are also found to be significant predictors.

Miami

Like LA, Miami is notable for its significant Hispanic population. The poverty rate is about the same; however the connection between ethnicity and poverty is not as obvious in Miami. In addition, Miami's Hispanic population occupies a large swath of the CMSA as opposed to the isolated regions visible on the map of LA. Approximately 16% of CTs in the Miami CMSA are more than 80% Hispanic (Figure 2b), suggesting segregation of the Hispanic population.

Transit use in Miami is essentially limited to a few central city CTs. Rates of transit use are positively correlated with the percentage of no vehicle households and the percentage of African Americans living in a CT. The proximity to subway stations and the distance to downtown are also significant predictors of transit use.

Detroit

Detroit is the only Group 2 city that relies solely on buses to provide public transit. Accordingly, transit's mode share in Detroit is the lowest of all the CMSAs in the study – 2.2%. Detroit also suffers from extreme segregation of the African American population with 17% CTs having African American populations exceeding 80% of the total (see Figure 2c). The same CTs tend to have high rates of poverty and are the only ones where rates of transit use are not negligible.

There are only three dimensions of transit use in Detroit: percentage of no vehicle households, percentage of African Americans, and the unemployment rate in the CT. All are positively linked to transit use, suggesting that only the poor use public transit.

Group 3: Atypical Cities

Atypical cities do not show a strong link between poverty and ethnic minorities, or between transit use and ethnic minorities. In addition, the level of racial segregation in atypical cities is less than what has been observed in typical cities.

Houston

This CMSA has the third highest proportion of Hispanics after Miami and LA. The difference here is that the population is less segregated than in the other two cities. Although the rate of poverty is the third highest, it does not appear to be as strongly associated with the ethnic composition of a CT. Like Detroit, Houston's public transit service consists entirely of buses, yet the transit mode split is somewhat higher at 3.5%.

In Houston, the proportion of Hispanics is negatively correlated with transit use. This trend runs counter to that observed in other cities, where concentrations of ethnic minorities are good predictors of increased transit use. Transit mode split in Houston depends upon auto ownership, distance to CBD and population density. The income factor expresses itself in the model through average house price - which displays a negative correlation with transit use, and residential vacancy which is positively correlated with transit use.

Seattle

Seattle is markedly different from all other cities discussed so far. With 3.5 million people, it is the smallest of the 10 CMSAs. It also has the smallest proportions of African Americans and Hispanics, neither of which are segregated to any detectable degree. Its public transit service consists of a bus network complemented by commuter rail. Nevertheless, Seattle reports 6.8% mode share for transit and this value places it above four of the ten cities included in the study.

Some independent variables in the transit use model, such as distance to CBD, auto ownership and percentage of African Americans display the same patterns as those observed in all other cities. The appearance of the black (African American) variable is surprising considering that African Americans comprise fewer than 5% of the region's total population.

Two explanatory variables are unusual: the percentage of bachelor degrees and the percentage of workers, both of which are positively correlated to transit use. This may be due to the structure of Seattle's economy which is built around high-technology sectors requiring a highly educated population. Many of these university-educated workers live in or near the central city (see Figure 3) where public transit is a viable travel option.

San Francisco

The San Francisco CMSA has a small African American population but a large number of Hispanics. There is little evidence of segregation among either group (Figure 2d) however there is a tendency for CTs with large percentages of African Americans or Hispanics to have higher rates of poverty, especially on the Oakland side of the bay. These CTs, however, are not the only places where public transit plays a significant role. Most of the actual city of San Francisco - which is quite affluent - displays high rates of transit use. Part of the explanation for this may lie in the fact that San Francisco is well served by the BART subway system.

Transit use in the San Francisco area depends primarily upon auto ownership and distance from downtown San Francisco. Population density and the nearby presence of a subway station also had a significant impact on transit use. Percentage of working population is positively correlated with transit mode split. This may be due to the distribution of employment in the Bay area. It is possible that major employment centers are located in regions well-served by transit. This is certainly the case for downtown San Francisco.

Most importantly, San Francisco is the only CMSA where race variables do not appear in the transit use model. In spite of this, rates of transit use in the region are the same as those in Philadelphia and Baltimore-Washington, both of which suffer from extreme racial segregation. This finding indicates that the San Francisco CMSA could be the “healthiest” urban area in this study, at least from an equity standpoint.

GENERAL TRENDS

Some trends are common for all cities. It appears that the most important predictor of transit use is the amount of auto ownership. All models include either the average number of vehicles/household or percentage of no vehicle households as a statistically significant predictor. A sharp decline in transit use is often correlated with an increase in the number of cars per household.

Second, race variables - either African American or Hispanic – appear in all transit use models except for San Francisco and the correlation is positive in all cities except Houston. This finding supports other research (2, 3) which has shown that race is an important factor in travel behaviour in American cities.

The third most prevalent explanatory variable is the distance to CBD, which appeared in 8 out of 10 models. Due to historical urban growth patterns, transit tends to be a viable transportation option in the compact inner cities. The overall supply of transit service in suburban areas is less than the supply in central cities. Therefore, transit mode split declines with the increase in distance from the CBD.

Fourth, the proximity to subway stations is a significant variable in cities with a subway system. This suggests that fast transit service plays an important role in attracting people to public transit. In fact, there exists a good linear relationship between transit mode split and the length of the subway network (see Figure 4). Cities without subway systems return lower transit mode splits among the cities studied.

The results of the regression models can be interpreted by exploring the relationships between variables. We suspect that the race and auto-ownership variables displace income in the models. Indeed, scatter plots of race and auto-ownership vs. median household income reveal strong non-linear correlations. Increase in income is associated with an increase in average number of vehicles per household and a decline in the percentage of African American population.

With respect to equity and travel behaviour, some general trends are shared by all cities. The most obvious trend is the strong positive correlation between auto ownership and household income. Only New York displayed a slight deviation from the norm.

Another trend which is evident in most, though not all, CMSAs is the cyclical variation of average commute time as the distance to the CBD increases. In New York, Philadelphia, Detroit, Chicago and Miami, the average commute time of CTs located close to the CBD is low. However, commute time increases significantly for CTs located only a few miles further away from CBD, after which the commute times decline again. The commute times again begin to increase many miles from the CBD. Usually a peak is observed followed by a final decrease which typically begins about 40 miles from downtown.

An explanation for this pattern may lie in the relationship between commute time and household auto-ownership. In most cities, as the number of autos per household increases, the commute time declines. However, it has been observed that beyond 1.8 vehicles per household, average commute times start to rise again. Commute time, therefore, appears to be dependent upon the interaction of several factors.

As has been documented elsewhere, a trip by transit takes more time than the same trip made by car (5). The high rates of transit use and traffic congestion in the central city therefore imply longer commute times for people who do not live in the immediate vicinity of their place of work. As rates of transit use and congestion decline with increasing distance from downtown, it is natural that commute times should decrease. But at a certain distance, employment and population densities become so low that travel times to work must increase. Regions where this occurs are predominantly the outer suburbs where the wealthy inhabitants can afford two or more cars. At even greater distances from the central city, the CBD ceases to be a significant employment centre. People in these essentially semi-urban CTs tend to work locally and are unlikely to experience traffic jams so their commute to work takes less time.

CONCLUSIONS

This paper divides the ten large CMSAs into three categories. New York is in a league of its own. Its population density and rate of transit use are much higher than in all other cities. The correlation between income and transit use is weak, which implies that transit ridership does not comprise only of poor. Furthermore, a plot of auto ownership vs. income reveals two distinct curves indicating that even those who could afford to own vehicles choose not do so. The average commute time in New York is significantly higher than that of the other cities in the study. Many CTs less than 20 miles from the CBD (defined as lower Manhattan) display commute times in excess of 40 minutes.

Typical US Cities: These CMSAs - which include Baltimore-Washington, Philadelphia, Detroit, Chicago, Miami and Los Angeles – have poor downtown regions populated largely by visible minorities. These central city neighborhoods display the highest rates of transit use, which is strongly correlated with income and race. The actual rates of transit use within this category vary considerably. In Chicago, 12% of work trips are made by transit while in Detroit the rate is close to 2%. The commute time plots exhibit a cyclical pattern.

Atypical Cities: This category includes Houston, Seattle and San Francisco. Atypical cities are difficult to generalize. These cities have low population densities and the racial segregation of poor is not as obvious or as severe. Finally, there is no discernible pattern in commute time variation with distance in such cities, perhaps because employment is more uniformly distributed throughout the urban regions.

In general, there are three factors that predict transit use in American cities: income (correlated with race), urban form and transit supply. Note that explicit measures of income do not appear in the models. However, variables such as auto ownership and racial composition are strongly correlated with income and are used as proxies in the models. Other tract characteristics like vacancy rate, unemployment rate and median house price are also good measures of the economic well-being of a neighborhood and are therefore included in some models.

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Table 1 – Explanatory variables in an OLS model of transit use

Variable Name	Definition
AVG_NUMB	Average number of automobiles per household
MEDIAN_INC	Median household income in the census tract
SUBWAY_1MI	1 = Touching or contained in 1 mile buffer around subway station 0 = Not touching or contained in 1 mile buffer
BLACK1	% of the tract population that is Black
POPULATIO1	Population density (persons per square mile)
BACHELORS	% of the tract population possessing at least a bachelor's degree
NO_VEH_HU	% of tract households which do not possess a private vehicle
DISTANCE_C	Distance from central business district (miles)
WORKERS	% of population 16 years and older employed
SINGLE_MOT	% of population who are single mothers
MEDIAN_OWN	Median tract residential property value
F2_UNITS_A	% of residential units that are attached to at least 1 other unit
RENTAL_HOUSING	% of tract housing that is rental housing
VACANCY	Tract residential vacancy rate
PERCENT_FE	% of tract population that is female
POVERTY	% of tract population living in poverty as defined by the U.S. 2000 census
HISPANIC	% of tract population that is Hispanic
UNEMPLOYMENT	Tract unemployment rate as defined by the U.S. 2000 census
F_CHILDREN	% of tract population 18 years or younger
MEDIAN_REN	Median rent of the census tract

Table 2 – Results of regression models

City	New York	San Francisco	Seattle	Detroit	Chicago	Miami	Philadelphia	Washington-Baltimore	Los Angeles	Houston
Race										
BLACK1	x		x	x	x	x	x	x		
HISPANIC								x	x	x
Economic										
VACANCY							x			x
MEDIAN_OWN	x									x
UNEMPLOYME				x						
WORKERS		x	x							
BACHELORS			x		x					
Urban Form										
POPULATIO1	x	x			x				x	x
DISTANCE_C	x	x	x		x	x	x		x	x
Transportation										
SUBWAY_1MI	x	x			x	x	x	x	x	
AVG_NUMBER	x	x								
NO_VEH_HU			x	x	x	x	x	x	x	x
Adjusted R-squared	**.856**	**.724**	**.690**	**.701**	**.742**	**.780**	**.776**	**.737**	**.763**	**.667**

x – positive correlation

x – negative correlation

Figure 1 – Income vs. Auto-ownership in New York City

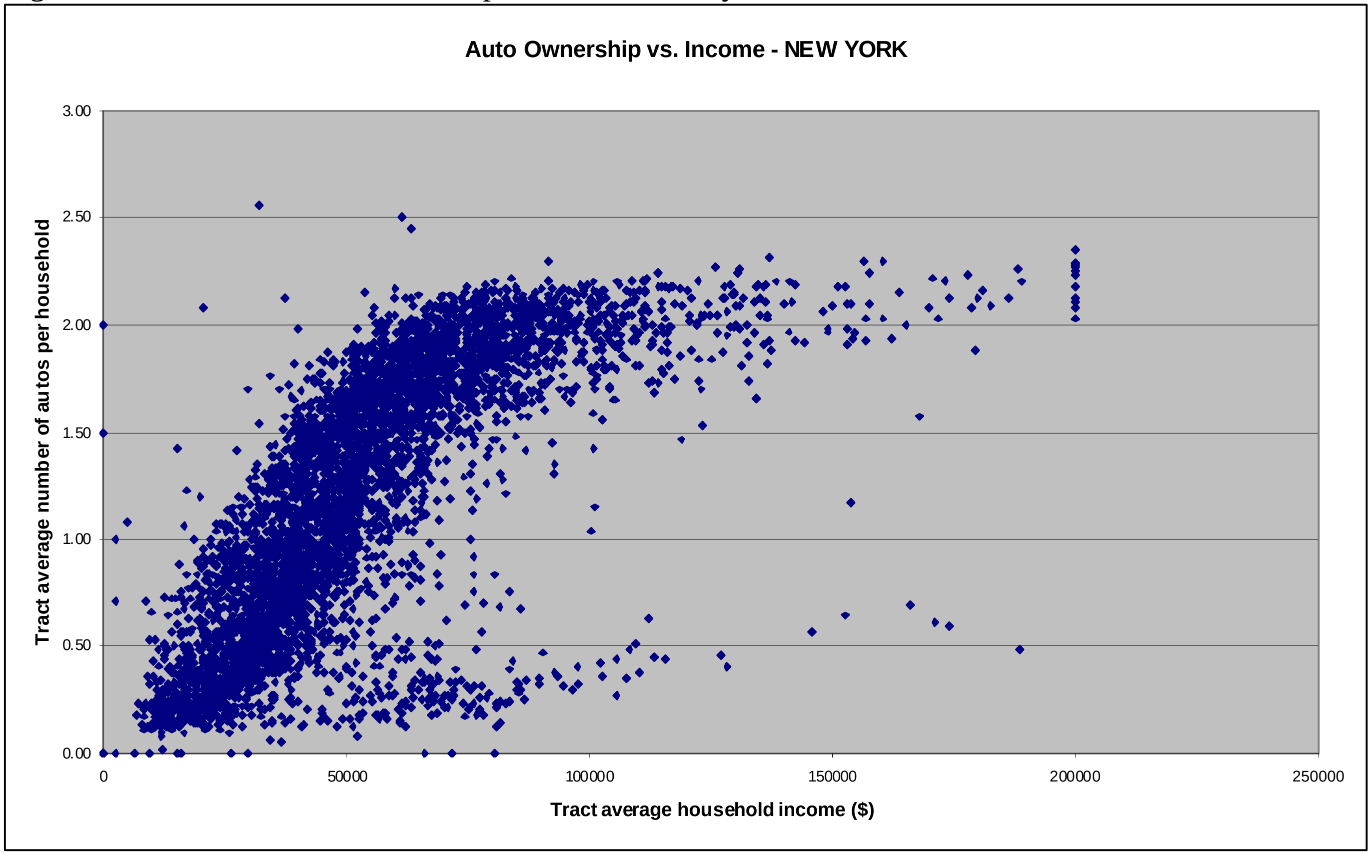
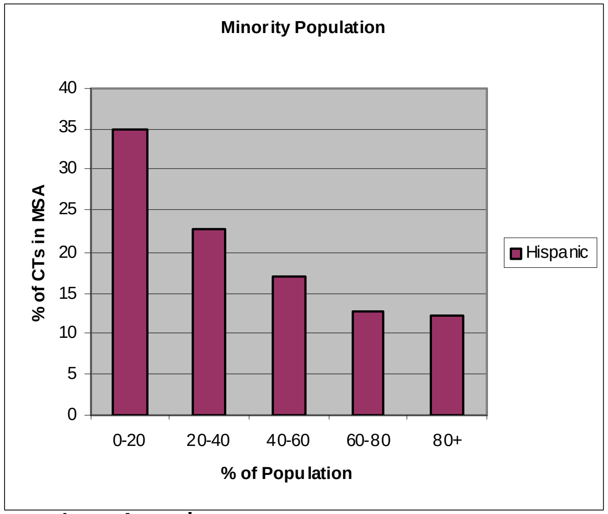
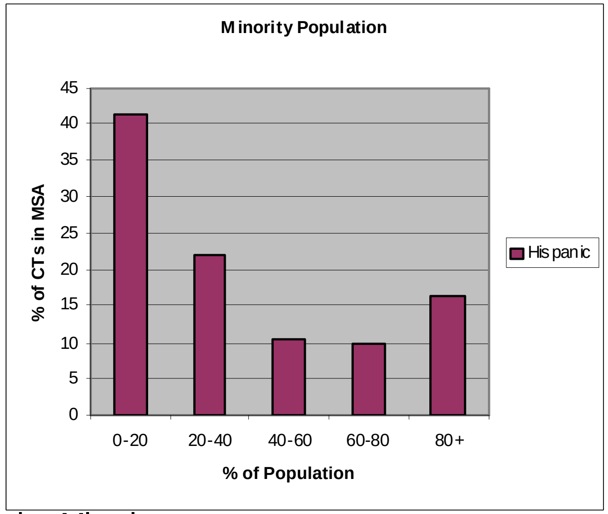


Figure 2 – Evidence of racial segregation in selected U.S cities



a – Los Angeles



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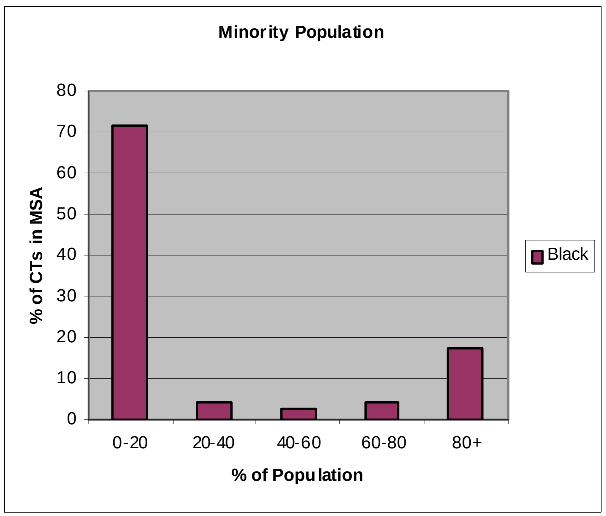

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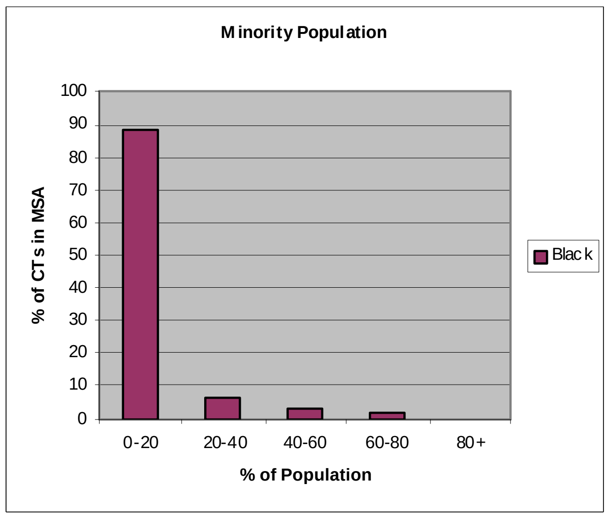

d – San Francisco

Figure 3 – Map of university-educated population in central Seattle

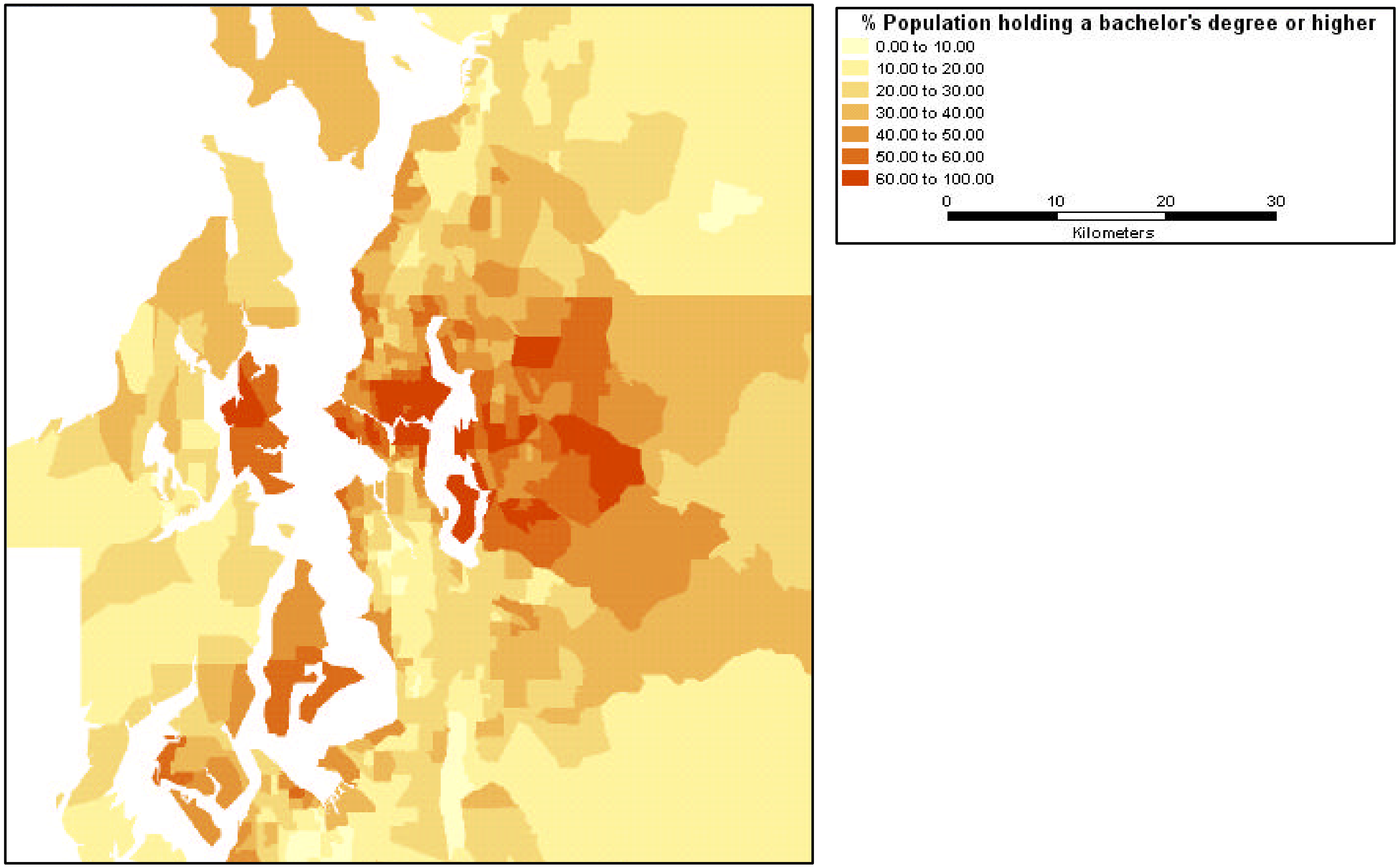

Figure 4 – Relationship between transit mode split and subway system extent