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Changing Bike Mode Share Between Time Periods For Suffolk County, MA

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CHANGING BIKE MODE SHARE BETWEEN TIME PERIODS FOR SUFFOLK COUNTY, MA

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David Wiosna
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ABSTRACT

This thesis looks at the impact of new bikeways on the rate of bicycle commuting among census tracts in the city of Boston, MA. Data from 2000 and averages from 2009-2013 are compared. Bikeways are negligible in the year 2000, but many were built after implementation of new policy in 2007. Data for 2009-2013 is interpolated into a common zonal scheme using 2000 census tract boundaries. Regression analysis is performed on socio-demographic and new bikeway variables. Results indicate that new bikeways are likely not cause of greater bike mode share in city of Boston.

CHAPTER I

INTRODUCTION

Bicycle commuting in the U.S. is on the rise (Pucher et al. 2011). The percent of all trips made by bike went from 0.6 percent in 1977 to 1 percent in 1990. Nationwide, this increase may seem insignificant; this increase translates into some 300,000 more workers regularly commuting by bike. In many cities, the increase was much greater. In Chicago, the percent of workers who commute by bike quintupled between 1990 and 2009 (Pucher et al. 2011). Measuring where this rise will happen is important in planning possible future bicycle facilities and infrastructure. One such measure of bicycle ridership is the rate of those who commute to work by bicycle. While this measure of commuting does not necessarily reflect all needs of cyclists – it excludes those who ride for recreation or schoolchildren riding to school – it does capture a significant population and their needs.

Those who commute do so for a variety of reasons (Plaut 2005). For some riders, especially those who are recreational cyclists, riding confers health benefits (Aytur et al. 2011). Others commute for economic reasons (Pucher and Buehler 2006). Cycling is also beneficial to the environment, as the activity burns no fuel (Sneiderman 1999). Bicycling can have positive effects on the areas that people ride in as well, e.g. increased real estate values (Racca and Dhanju 2006).

However, the rate at which people decide to commute by bike is largely influenced by other factors: climate (Winters et al. 2007); topography (Pucher et al.

2011); gender (Moudon et al. 2005); social factors like the influence of peers (Handy et al. 2010); the built environment (Daniel and Rietveld 2004; Cervero and Duncan 2006; Rybarczyk 2012); and the presence or lack of proper infrastructure (Dill and Carr 2003; Krizek 2009).

Bike infrastructure or bikeways are features of the built environment that aid cyclists' transportation needs. They provide a relatively safe space to ride and create recognition of the legality of the choice to commute by bike. Bikeways can include variations of on-street bike lanes (buffered, protected, cycle track), off-street paths, marked routes and "bike boulevards," sharrows, and other creative variations on these (American Association of State Highway and Transportation Officials).

The role of bikeways has been studied with regard to their effect on bike mode share – the percentage of people who commute by bike. Some studies use simple roadside traffic counts. These counts provide rudimentary bike count data along one or more routes, but provide no indication of the share of people commuting by bike (Parker et al. 2011). Other studies have often used detailed local or regional travel survey data to calculate the number of riders (Krizek and Johnson 2006). These local travel surveys provide a rich data source for the regions that undertake them – often larger cities. Other studies use widely available census data (Krizek et al. 2009; Parkin et al. 2008). These census data are often from decennial censuses, providing a long-term view of change in bike mode share (Krizek et al. 2009).

A shorter time span view of changes in bike mode share is possible with American Community Survey (ACS) data. Collected every year, ACS data samples Americans nation-wide on a variety of topics including means of transportation to work.

Using ACS data, I am able to find more fine-grained before and after nuances of the effect of new bike infrastructure on bike mode share. I attempt to answer the questions: Does implementing new bikeways impact the rate of bike mode share? And if so, do different types of bikeways have greater impacts than others?

One example of a city in which there has been much new infrastructure built and implemented is the city of Boston, MA. Starting in 2007, then mayor Thomas Menino began Boston Bikes to improve the state of cycling in the city by adding new bikeways in the form of various bike lanes and a few cycle tracks (Boston Bikes 2015). Before the implementation of the Boston Bikes program, Boston was considered by some measures to have the worst cycling experience of major American cities (Boston Bikes 2015). Before 2007, there was less than a mile of bike lane. As of 2013, there were 73.7 miles. Indeed, it would seem that the new program has had a significant impact on the rate of bicycle commuting in the city. City-wide, the rate of bicycle commuting in 2000 was .9% (TranStats). During the average of the years 2009-2013, this number climbed to 2.3% (ACS). However, one cannot assume that this was all due to the impact of the new program and its huge increase in bikeway mileage.

In this thesis, I seek to understand the role (if there is one) of new bikeways on the rates of bike mode share for census tracts in the city of Boston. Nationwide, there has been considerable new investment in bike lanes in major American cities. Boston is no exception. However, it may also be that the concomitant rise in bike mode share in these same cities may be due in large part to a sea change in attitudes toward bicycle commuting in the U.S. overall. Where once the bicycle was all but written off as a valid form of transportation, more and more Americans are choosing to bike to work – regardless if a city's infrastructure accommodates them.

CHAPTER II

LITERATURE REVIEW

Bicycle commuting – and the problems it faces – is a many-faceted and much-studied issue. The choice to commute by bike, and it is often framed in terms of choice in the American and Canadian contexts, is often perceived as a choice to commute by bike despite several hindrances. In the U.S. and Canada, many commuters have the means to afford other forms of transport, although poverty and income sometimes force a worker to commute by bike (Pucher and Buehler 2006). Often, it seems that biking is a choice among those who could afford otherwise, but have made a conscious choice to commute by bike. However, this is not to say that there are no factors that engender or inhibit bicycle commuting: there are several.

2.1 Benefits of Bicycle Commuting

Much literature exists to establish the benefits of commuting by bicycle. These benefits serve as "push" factors causing indecisive commuters to give greater consideration to biking as a commute choice. Since the hurdles to bike commuting in the U.S. are so difficult to overcome, advocates will illustrate the benefits of cycling in a number of arenas.

One such benefit is the obvious potential health benefits. Commuting by bike provides aerobic exercise often (depending on length of commute) equal to the Center for Disease Control's (CDC) weekly guidelines for "moderate intensity" adult physical activity minimum. The CDC recommends either 150 minutes per week of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity plus 2 days per week of whole-body muscle strength training (CDC Physical Activity). At the moderate level (riding a bike under 10mph, average adult cruising speed), this equates to 30 minutes each day during a 5-day workweek. Unless commuters live within 2.5 miles or less of their workplaces, they will fulfill the moderate-intensity recommendation just by biking to work everyday. Often, biking necessitates finding alternate routes to avoid high vehicle traffic areas or to circumnavigate barriers like freeways.

The health benefits of biking are well documented (Oja et al. 2011). Children and adults who regularly bike are significantly more fit than those who do not (Cooper 2006). Men who bike to work are less likely to be obese or overweight (Wen 2007), women who biked to work had generally better health (Huy 2008). Many of these studies focus on European outcomes, where cycling to work is generally already at a higher rate than in the U.S. Americans' increasingly sedentary lifestyles are likely to see even more dramatic health benefits than their European counterparts.

Even relatively limited amounts of exercise have positive health outcomes. While biking to work (or for recreation) is often not of the "vigorous" type of physical activity (CDC), small physical investments reap large health dividends. People who bike to work tend to be healthier and stay healthy. For example, Germans undertook the "Trimm-Dich" (literally, trim yourself) campaign in the 1970s to improve the health of all citizens of West Germany. Cycling was much encouraged as a piece of this fitness regime. After the rise of automobile commuting in West Germany and other European countries like The Netherlands and Denmark and a fall in bicycle commuting, Trimm-Dich brought about a resurgence in the rates of bicycle commuting. As a result, rates of obesity fell and

Germans' overall health improved (Mörath 2005). Today, cycling is the "preferred transport mode" among European Union adults at 8% union-wide (European Cyclists' Federation).

Another benefit is the personal economic savings of commuting by bike. While some bike commuters have no choice but to bike as there is no adequate public transit where they live and they cannot afford a car on their own, especially among recent immigrants to the U.S. (Chatman and Klein 2009), many bike commuters choose to bike for the savings it affords them (Pucher and Buehler 2006). These savings can come at the residence/origin-end, i.e. not having to buy and maintain a vehicle, but they can also come at the workplace/destination end in the form of not paying for parking, tolls, and in some European contexts, congestion pricing.

This car parking avoidance is likely significant in Boston proper. A very old city by American standards, it predates the founding of the country by over 100 years. As such, its streets have an irregular pattern; many are very narrow and not straight and parking in the city can be prohibitively expensive. In 2013, a pair of tandem parking spaces in Boston's Back Bay neighborhood sold at auction for $560,000 (Johnston 2013). Of course, Back Bay is among the most sought after real estate in Boston, but this illustrates the overall difficulty of parking a car in Boston. In the aftermath of severe winter snowstorms (of which there several in the abnormally brutal winter of 2014-15), residents who shoveled out their own on-street parking spaces used lawn chairs and other items to declare temporary ownership of these spaces in a phenomenon known as "dibs." Boston's previous mayor, Thomas Menino, allowed dibs up to 48 hours after a snowstorm (Capps 2015). In a city where parking is this tenacious, removing the burden of finding a parking spot is a significant incentive to find alternate modes of transport, whether it is biking or another mode.

Beyond parking savings, bicycle commuting is cheaper too because a bike is naturally cheaper to purchase and maintain than an automobile. It is unlikely that the price of gasoline will fail to continue to rise as worldwide demand increases and supply is limited by how much oil can be extracted from the Earth. Bicycle commuting side steps the need for gas entirely. One simply never has to fill up a bike; maintenance is restricted to changing tires and occasional drive train repair. As of this writing, the cost of a yearly "tune up" for a bicycle at a popular Grand Forks, ND bike shop was $70 (personal communication, Ski and Bike Shop, March 8, 2015). It is not difficult to calculate yearly savings in choosing to commute as much as possible by bike. For every mile a commuter can stay out of their own vehicle, it equates to money saved in terms of gas consumption and maintenance (regular or otherwise). For those who have a real choice to commute by bike, the economic savings can be significant.

Not only do individual bike commuters see economic benefits from bike commuting, but cities and some businesses see benefits as well. In cities, where maintaining, improving, and building new streets is a significant portion of budgeting, real savings can be realized with bike infrastructure. Building one new mile of bike lane was estimated to cost $445,000 compared with $571 million for one new mile of Doyle Drive in San Francisco (People for Bikes). Doyle Drive in San Francisco was slated for a massive rehabilitation. Moving the same amount of people by bike would save the city considerable amounts of money. Obviously not everyone can bike and most cities will need to make space for both, but having more cyclists means having less vehicle traffic.

With cyclists having significantly less destructive impact on road surfaces because of their low relative weight and smaller size, it is likely that cities would save on regular maintenance on roads and surfaces (e.g. potholes) and need to build less new lanes to accommodate automobile congestion with more bicycle commuters.

Some evidence suggests that businesses and real estate owners benefit from bike commuters, specifically bike lanes running in front of shops and homes. Among Manhattan retail business, the presence of a bike lane increased sales (NYC Department of Transportation 2011). This is perhaps a result of slowing down traffic which causes more potential customers (especially those on bike or on foot) to stop and enter an establishment rather than pass by. Other findings indicate the rise in real estate values in parcels adjacent to bike lanes (Racca and Dhanju 2006). The presence of bicycle commuters seems to increase value in cities as they become destinations rather than places to merely drive by.

Another benefit of bicycle commuting is the often cynically overlooked benefit to the environment. Bicycle commuting burns no fuel (at least not any hydrocarbons). The actual commute therefore does not emit any CO_2 or other emissions for which vehicles play a major part (Maniates 2001). Of course, bikes have to be built, shipped to the consumer and so on, all likely burning some kind of fossil fuel. It is also worth noting that biking burns human energy which might need to be replaced in terms of consuming more calories. However, at average cruising speed, an adult cyclist uses as much energy as a typical light bulb (Sneiderman 1999).

This makes biking one of the most efficient forms of transport available (in terms of energy use). For those looking to make a positive environmental impact, biking is a definite way to do so. Cities like Shanghai currently suffering from frequent bouts of smog could see reduced pollution with fewer commuters using automobiles and more commuters using bikes. As the gap in perception of climate change narrows between scientists and the general public, perhaps more commuters will seek to lessen their own carbon footprint through their means of transport (Hansen et al. 2012).

2.2 Factors Affecting Bike Mode Share

There are many factors that contribute to rates of bike mode share in cities. Some of these are beyond an individual city's control, e.g. climate and topography. Other factors can be influenced by cities themselves, e.g. policy choices, especially those related to bike infrastructure (Hull 2008). Although these factors can explain much of the bike mode share in any given city, or why one city might have more bike commuters than a similar city, it is possible that changes in attitudes to bicycle commuting are a significant factor in themselves.

One factor beyond a city's control is climate. Climate and weather are intuitive rationales for why one city might have a low bike mode share and another a rather high mode share. Potential commuters will often cite inclement weather as a reason not to ride (Winters et al. 2007). It follows that one would seek other modes of transport in a normally sunny city suddenly beset with a thunderstorm. Bicycle commuting makes one particularly exposed to the elements compared to driving or taking transit. Cities with frequent severe weather events can indeed stymie would-be cyclists.

Climate is another intuitive factor. As biking can be a strenuous activity, riders will often heat up on a commute. This of course would be exacerbated by a hot climate such as that found in the southeastern U.S. (Parker et al. 2011). One might also think that a particularly cold climate like that of Minneapolis would deter cyclists as well (Spencer et al. 2013). The literature suggests that there is no climate in the U.S. that strictly prohibits bicycle commuting. There are many commuters in cold Minneapolis and hot and humid Miami, and many in rainy Seattle.

Although it might be true that hubs of high cycling rates tend to found in mild northern Europe (Heinen et al. 2010), it is not outside the realm of possibility to increase cycling rates in warmer parts of that continent. Recent work in Seville, Spain has increased bike mode share there considerably (Walker 2015). Similarly, rates of bike commuting in southern U.S. cities typically lag behind their northern and western counterparts, but this may be due more to lack of planning and policy choices than climate. Miami, FL has a relatively high bike mode share among U.S. cities and yet is among the hottest and most humid.

Although some climates may be more favorable to biking (relatively mild northern Europe), there does not seem to be any climate in the U.S. that is totally inhospitable to biking. People will commute by bike and evidently make concessions for the climate they live in. Riders in the south may have to bring along extra clothes to put on once they get to work if they have gotten too sweaty. Northern riders may need to invest in extreme winter apparel. Climate seems to be an obstacle that can often be overcome.

Another factor in the seemingly intuitive category is that of topography, i.e. hills and slopes. It should stand to reason that flatter areas would incentivize biking. This may be true in the European theater, but in the U.S. this seems to have little bearing (Pucher et al. 2011). Hilly San Francisco has a high bike mode share but is often recalled in the

American conscious as a hilly place; one pictures the urban switchbacks of Lombard Street. However, the sometimes-steep hills of San Francisco are not impediment enough to its cyclists. Boston is a city that once had hills, but many have been removed or torn down and used as landfill in the bay. Many of these hills still exist in the names of neighborhoods like Beacon Hill.

Societal factors can play role in the decision to commute by bike as well. If one's friends and peers bike to work, one is more likely to do so (Handy et al. 2010). How one perceives the act of riding a bike and how one views cyclists in general also affects the decision to commute by bike. In cities where biking is seen as purely recreational, commuters are less likely to use a bike in their daily commute. The perception of biking in much of the U.S. is along these lines: roads are considered the domain of cars. Economic factors of individuals will also affect their decision to ride or not. Among these socio-economic groups is college students, who are more likely to ride than other groups of society, perhaps because of budget or relative ease of biking (League of American Bicyclists 2013).

Perhaps obvious is the likelihood of commuting by bike among low-income individuals who may be unable to afford a car (Handy et al. 2010). However, as workers are increasingly distanced from their workplace, biking will become more difficult for this sector of society as long commutes can detract from choosing to bike (Boschmann 2011). Long commute distances can make for a nearly impossible bike commuter, especially with transporting children or running additional errands.

Race plays a role as well (Handy et al. 2010). Although African Americans often live in central cities with well-connected streets bike mode share among this segment of the population remains low. However, at this time, little has been done to explore why this phenomenon exists. Initial research indicates that African Americans view the same obstacles to biking as whites (Bratman and Jadhav 2014).

An important role in this study and in others is that of gender. Gender differences play a huge role in bicycle commuting in the U.S. (Moudon 2005). A severe gap exists in rates of bicycle commuting among men and women. As of the ACS 2013 5-year estimate data, 73% of bike commuters were men. This large disparity is attributed to many factors (Garrard et al. 2008). Since women are considered less likely to take risks, it follows that they are less likely to engage in the risky behavior of biking. In the U.S. biking to work is often perceived as being dangerous so commuters who wish to avoid risk are less likely to bike. Not only are cyclists exposed to traffic dangers but also crime. For the same reason that women are less likely to walk alone at night, they are also less likely to bike. Rape and sexual assault harm women in vastly greater numbers than men, and the fear of such attack may induce women to seek safer modes of transport.

Fortunately, it seems that there is strength in numbers, as the more women ride, the more are attracted to riding (Garrard et al. 2008). Also, women are more likely to ride where there is sufficient infrastructure to do so. An increase in infrastructure in the form of bikeways makes all riders feel safer (Rybarczyk 2012) and therefore more women choose to ride.

There are also different societal expectations for women worldwide (Heesch et al. 2012). In the U.S. at least, although women still face discrimination based on appearance, this is less of a hurdle than it would be in other countries. It may seem silly to an outside reader, but considerations of appearance can make or break a woman’s decision to bike.

In areas where laws mandate wearing a helmet, women may actually ride less because the helmet will negatively affect hairstyling. Male riders often cannot understand this hindrance but women riders must face it every time they ride. Women riders are more likely to receive “cat calls” and other unwanted verbal solicitations than men, often determined by choice of clothing (Steinbach et al. 2011).

With all these pressures against women riding, it is understandable that the gender gap in the U.S. is so high. In countries where the overall rate of biking to work is high, the gender gap is much smaller. So where biking is seen less as an active choice and more as a humdrum daily activity, the gender gap decreases and sometimes women even outnumber men (Buehler 2011).

2.3 The Built Environment

Much of the assumption behind this thesis revolves around the impacts of the built environment with regard to bike mode share, especially the component of built environment comprising bike infrastructure. Built environment, although perhaps a vague term, can have many connotations in the context of the choice to commute by bike. It can include notions of city population density and building type or land use (Handy et al. 2002).

As one might imagine, mixed-use development with short distances between residence and workplace tends to increase bike mode share (Cervero 2002). Also a greater connectivity between streets or other potential routes increases network connectivity and therefore bike mode share as well. Cities with regular grid patterns tend to more greatly engender this type of connectivity (Cervero 2002). Cities (and especially suburbs) with far-flung and poorly connected streets serve as barriers to bicycle commuters.

The increasingly attractive option (to urban planners at least) of mixed-use and even transit-oriented development can be a boon to bicycle commuters who now have less distance to travel to work and less overall traveling distance throughout the day on cumulative trip chains. Mixed-use development also encourages more biking and walking among the elderly, who are at special risk of negative health consequences due to decreased physical activity (Marottoli et al. 2000).

Simple population density is also an important predictor of bike suitability. Greater population density means that more people tend to live closer to their workplaces and a high enough population density also tends to result in the disincentive to car ownership and driving (Cervero 2002). This last feature is certainly true in the Boston area with its at-times exorbitant parking prices.

2.4 Bikeway Types

An important aspect of the built environment that is germane to this thesis is the bikeway. The bikeway is the most visible and obvious of implemented bike infrastructure. Other features of bike infrastructure include bike traffic signals and bike racks. This thesis concerns itself with the bikeway.

Bikeways are any designated paths or routes for the use of bicycles, and sometimes they share space with pedestrians. Bikeways come in many different forms (Boston Bikes 2015, American Association of State Highway and Transportation Officials (AASHTO), Dill and Carr 2003). Different geographic areas and jurisdictions may use different terms for the same feature, or classify features as a single type which might fall into two different categories elsewhere. The terminology in this thesis seeks to most closely resemble that used by the city of Boston.

Among the most easily recognized is the humble bike lane. As the name implies, a bike lane is an on-street painted lane designed to give cyclists a share of road space explicitly for their use. These lanes are just paint, so they do not offer any increased protection to riders from cars, which can swerve in and out of bike lanes, park in bike lanes, and cross over bike lanes to make a turn at an intersection or driveway. Bike lanes are relatively cheap to construct, using mostly paint (and often some signage). Some bike lanes run along the side of a street while some are in the middle. Some bike lanes run with traffic, with one bike lane on each side, some are contra flow and run counter to the flow of vehicle traffic (often on a one-way street). Bike lanes can vary in width, although in practice they are often not much wider than 1 or 2 cyclists riding side by side.

Another form of the bike lane is the buffered bike lane. This is like a bike lane but with a painted zone of exclusion on one or either side of the bike lane itself. This often small strip running parallel to the bike lane itself provides protection to cyclists from vehicle traffic in the form of a distance buffer. Cars have more space and time to react to cyclists who feel less vulnerable to a bit more “breathing room.” The buffered bike lane’s increased distance can also ameliorate the danger of getting “doored” – a cyclist being struck by an opening driver side car door while traveling alongside parked cars. At full tilt, a cyclists hitting an open car door is not unlike hitting a wall, and serious injuries do occur.

A step up from the buffered bike lane is the so-called cycle track. This is a bike lane with some kind of physical separation between the bike lane and vehicle lanes but is still at the same grade as the street itself. This separation can be in the form of something relatively impassable (by automobiles) like bollards, a concrete curb or wall, or even common U.S.-style concrete highway dividers. Other times this cycle track's protection comes in the form of a line of semi-permanent road cones or other similar pylons. The cycle track provides an extra layer of protection from motorists and prevents abuse of the bike lane by parking cars and delivery vehicles. Although the physical barrier along a cycle track is not totally impenetrable by a typical car, its physical presence is enough to discourage any would-be bike lane violators from crossing over (and possible damaging their own vehicle in the process).

Yet another degree of separation from vehicle traffic comes in the form of the shared use path. Known by many names, the shared use path is for the use of cyclists and pedestrians. This path is often found in areas like parks and along waterways and often serves a recreational purpose more than a utilitarian transportation option. A shared use path is totally separated from the street. It is not at the same grade level and there is often a strip of lawn, grass, or even trees between the path and the street. The shared use path provides the greatest sense of separation from vehicle traffic. These paths are often indicated as appropriate routes for "beginners" on city-issued bike networks maps, e.g. Boston.

Lastly, there is the broad category including variations on a shared-space regime. This last category includes "sharrow," on-street bicycle diagram markings indicating that cyclists are legitimate users of the road space although not giving them an actual lane. Another such shared type of bikeway is the bicycle boulevard, a designated bicycle route that often takes advantage of quiet side streets. The bicycle boulevard is not exclusively for the use of bikes; bikes share the space with cars, who are supposed to respect them. Finally there are other forms of designated routes consisting of road-side signage indicating a preferred bike route; there is no on-street lane or on-street painting of any kind.

2.5 Effects of Bikeways

The literature on the effect of existing and new bikeways suggest that there is a pretty clear positive relationship between building new bikeways and increased bike mode share, both locally (Parker et al. 2011) or citywide (Dill and Carr 2003). While it seems intuitive to argue that building more infrastructure for bicycle commuters would increase their numbers, it is still important to find this link.

Controlling for socio-demographic variables, it appears that building new bikeways significantly increases bike commuting. Cities that have built more infrastructure tend to have greater rises in bike mode share (Buehler and Pucher 2011). Many major American cities have made significant investments in bike infrastructure in the last decade. For example, from 2000 to 2010, Minneapolis increased the total kilometers of lanes and paths from 39km to 70km (Pucher et al 2011). Boston increased on-street bike lanes from less than 40 yards to 73 miles (Boston Bikes 2015). For each additional linear mile of bike lanes per square miles of city area is associated with an approximate increase of one percentage point in the share of bike commuters, even when controlling for rainy days, automobile ownership, and other variables (Dill and Carr 2003).

Also, increases in bike mode share tend to be centered around areas where new bikeways have been built. In Minneapolis, increases were greatest from 1990 to 2000 in areas centered around newly constructed bikeways (Barnes et al. 2006). This finding was later reinforced in the Minneapolis area on the traffic analysis zone (TAZ) level (Krizek et al. 2009). Again, this study found that the greatest increases in bike mode share occurred along new bikeways. This holds true in the twin cities metro despite its relatively low population density. Boston's metro area population density is much greater than Minneapolis, especially when population weighting is taken into account (U.S. Census).

These increases also seemed to be greater along bike lanes instead of bike paths. Since bike lanes tend to run along urban streets, this could explain the greater impact of bike lanes over the more recreational bike paths. Since bike paths tend to run in more park areas, it is less likely that people commuting to work would use them when they ride. In recent years, the rate of people commuting by bike to work has increased significantly in the U.S., so too has the total miles of bikeways. Although research has shown that an increase in bikeways (especially bike lanes) tends to lead to an increase in bike mode share, it is also possible that there is a bit of a chicken and egg problem going on. That is, bikeways could have been implemented due to pressure from bicycle advocacy groups, from people who were already commuting to work (Buehler and Handy 2007).

2.6 Datasets

The research on bike mode share has many data sources. Many use various iterations of U.S. Census data (Handy et al. 2010, Aytur et al. 2011, Dill and Carr 2003, Wesley and Garrick 2011, Pucher et al. 2011, and Krizek et al. 2009). Sometimes this data uses supplemental census, Census Transporation Planning Package (CTPP) data, or

ACS data. These samples vary in size and method of collection. Notable to bike commuting is the fact that the decennial longform census gathered information in April, a month when some American cities are still warming up after a cold winter and others are drenched in rain and hot. The newer ACS takes its data all year and may underreport for some cities some years and over report other cities. Although biking to work can be done independent of climate, it stands to reason that a sample would capture the greatest number of bike commuters during months with hospitable weather.

Other studies make use of datasets similar to the U.S. census on an international level (Parkin et al. 2008, Pucher and Buehler 2008). Other studies use travel surveys (Pucher et al. 2011, Winters et al. 2007, Handy et al. 2010, Joo and Oh 2013, Ritchie 1998, and others). Although custom surveys and large national-level travel surveys may provide the most detailed information on the habits and needs of bike commuters, they are by their very nature typically one-off creations, difficult to generalize across other geographic areas. Census data is collected nationally and while it is usually not valid at very small geographic levels, or suppressed due to confidentiality (i.e. census blocks), a census provides a generalizable data source across all geographic areas so that results in one area can be compared to another.

CHAPTER III

DATA AND METHODS

The focus of this thesis is the city of Boston and people who commute by bike. All the data except for the bikeway shapefile were provided by various iterations of the U.S. Census. I compare bikeway data to demographic census data in order to analyze the effect of bike mode share using multivariate regression before the implementation of bike lanes and after and discuss the peculiar geography of the Boston area and its relationship to the rise in bike mode share over the study time period.

3.1 Study Area

Boston is a large metropolitan area in the northeastern U.S. in New England. It is one of America's oldest major cities, with a storied history dating back to 17th century Puritan settlers from England. Boston lies along the east coast with water on many sides. To its east and north lies Boston Harbor (Fig. 1). Along its northern border with the city of Cambridge (home to both Massachusetts Institute of Technology (MIT) and Harvard University) runs the Charles River which empties into Boston's inner harbor. Across the harbor to the northeast of the downtown area lies East Boston and Logan International Airport, both parts of Boston proper. Boston extends south, filling up the rest of Suffolk County of which it is by far the largest part. The only other cities in Suffolk County are, from west to east, Chelsea, Revere, and Winthrop. The Neponset River marks part of the south and eastern borders of Boston and Suffolk County with Norfolk County. A strange bit of geography is the enclave of Brookline in Norfolk County that is surrounded by

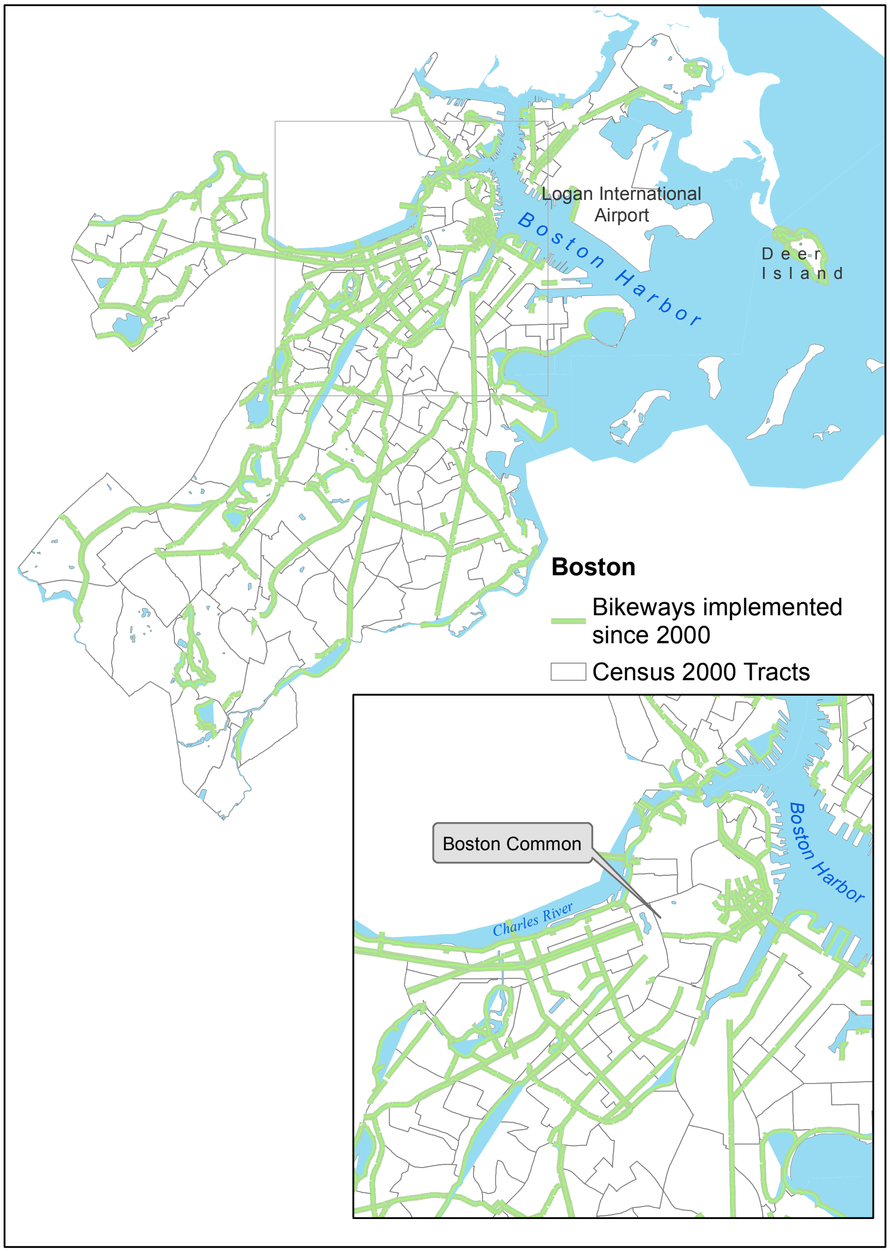

Figure 1. Census Tracts (2000) for the city of Boston with current (2013) bikeways

Suffolk and Middlesex counties, resulting in Boston having a very thin neck of land along the Charles River in the north connecting the western neighborhoods of Allston and Brighton with the rest of Boston. The Boston metropolitan statistical area includes, from south to north, Plymouth, Norfolk, Suffolk, Middlesex, and Essex counties, MA, and Rockingham and Strafford counties, NH (U.S. Census 2013).

Boston is known in the U.S. as rather congested city and the home of “The Big Dig” (Salvucci 2003). It is believed that part of the tortured nature of Boston’s streets is its relatively old age and lack of urban design in its early history. Boston was once a city of hills, originally called “Trimountain” after a three-summited hill around which the original settlement appeared (The Shawmut Project 2010). This original settlement on the narrow Shawmut peninsula grew over the centuries and gradually filled in much of the surrounding harbor by leveling off the hills within the city. This infill led to the creation of the celebrated Back Bay area with its regular grid streets, and later laid the ground for Logan Airport area, among others.

This piecemeal addition means Boston has no one regular grid pattern as one might find in street layouts of much of Manhattan or many younger American cities. As mentioned earlier, Boston is a nightmare for parking a vehicle, with exorbitant off-street parking prices and narrow streets, the latter much the darling of pioneering urbanist Jane Jacobs in Boston’s North End Neighborhood (Jacobs 1961). These narrow streets and car dominance in intervening years served to create a seemingly dangerous and inhospitable cycling environment in Boston. As of this writing, Boston’s rate of 2.3% is actually above the U.S. averge of 1.3% (ACS 2013-2009 5-year estimates). However, this rate is lower than other large American cities like Minneapolis (4.5%) and pales in comparison to juggernauts like Portland, OR (6.1%) (The League of American Bicyclists 2013). For a large, dense, and progressive city like Boston, this number is probably lower than this mix might give elsewhere.

One factor that likely accounts for much of the bike mode share in Boston is the presence of college students. Boston is by no means a "college town" and the literature point out the positive influence college students have on bike mode share (Heinen et al. 2010). Boston does have a significant college student population in 2000 (Fig. 2) with several colleges in Boston proper and more in the Greater Boston area again in 2013 (Fig. 3). This influence cannot be underestimated. Cities which might otherwise have low bike mode share can receive a significant bump with the presence of large, dominating college on the landscape. A perfect example is Tallahassee, FL, which hosts the University of Florida. Surrounded by cities with low bike mode share, Tallahassee (and nearby Gainesville, FL) has higher bike mode share than its southern location might suggest due to the large student population and proportion of college students to the total population. Boston has a large college presence, but it is not dominated like the city with the highest bike mode share among cities over 50,000, i.e. Davis, CA.

Perhaps because of its peculiar geography, Boston has earned a reputation as a terrible city in which to commute by bike. It earned Bicycling Magazine's title of "Worst Biking Cities" three times from 1999 to 2006 (Zezima 2009). This ugly reputation spurred the city to introduce Boston Bikes in 2007, a major policy initiative designed to increase the level of bicycle commuting in the city primarily through the implementation of more bike infrastructure. Before 2007, there were virtually no bike lanes in the city,

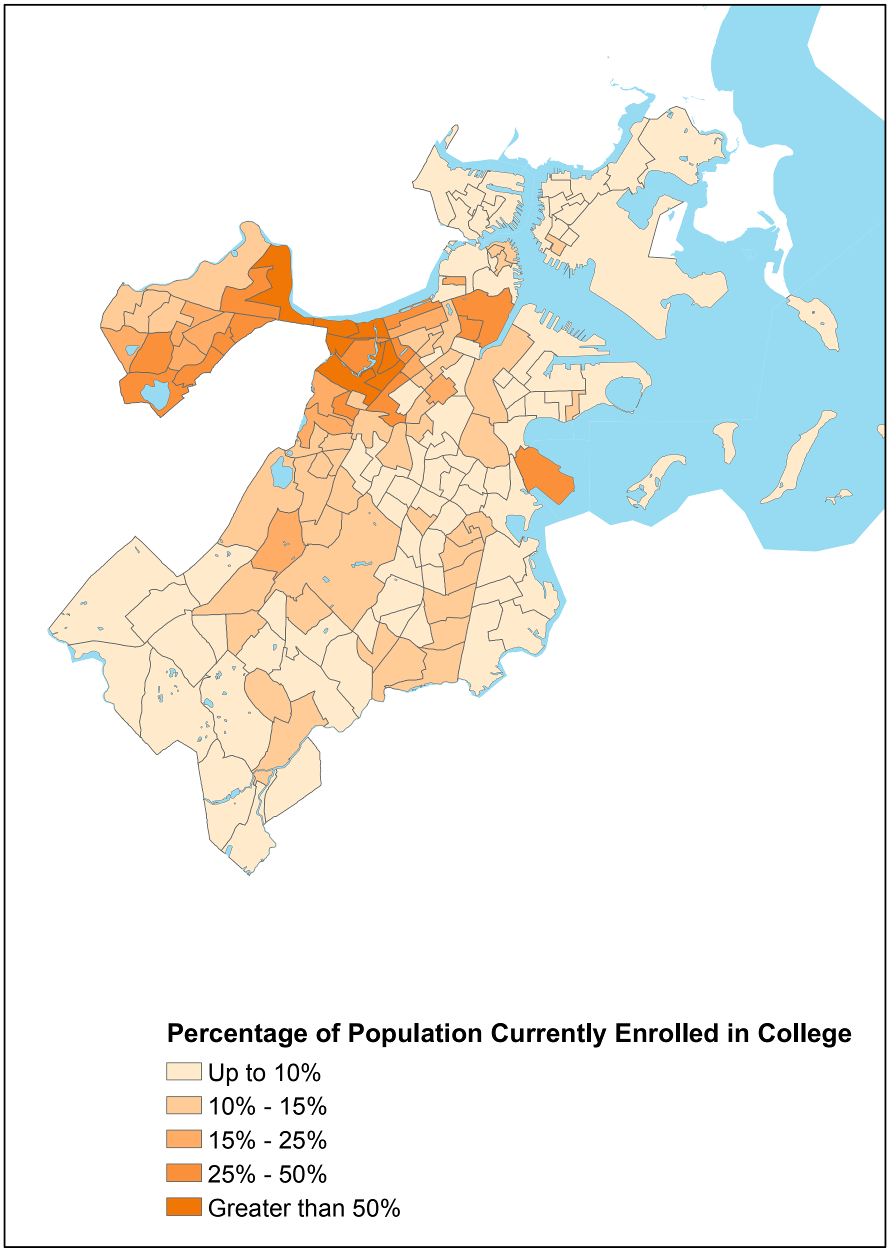

Figure 2. College Students 2000

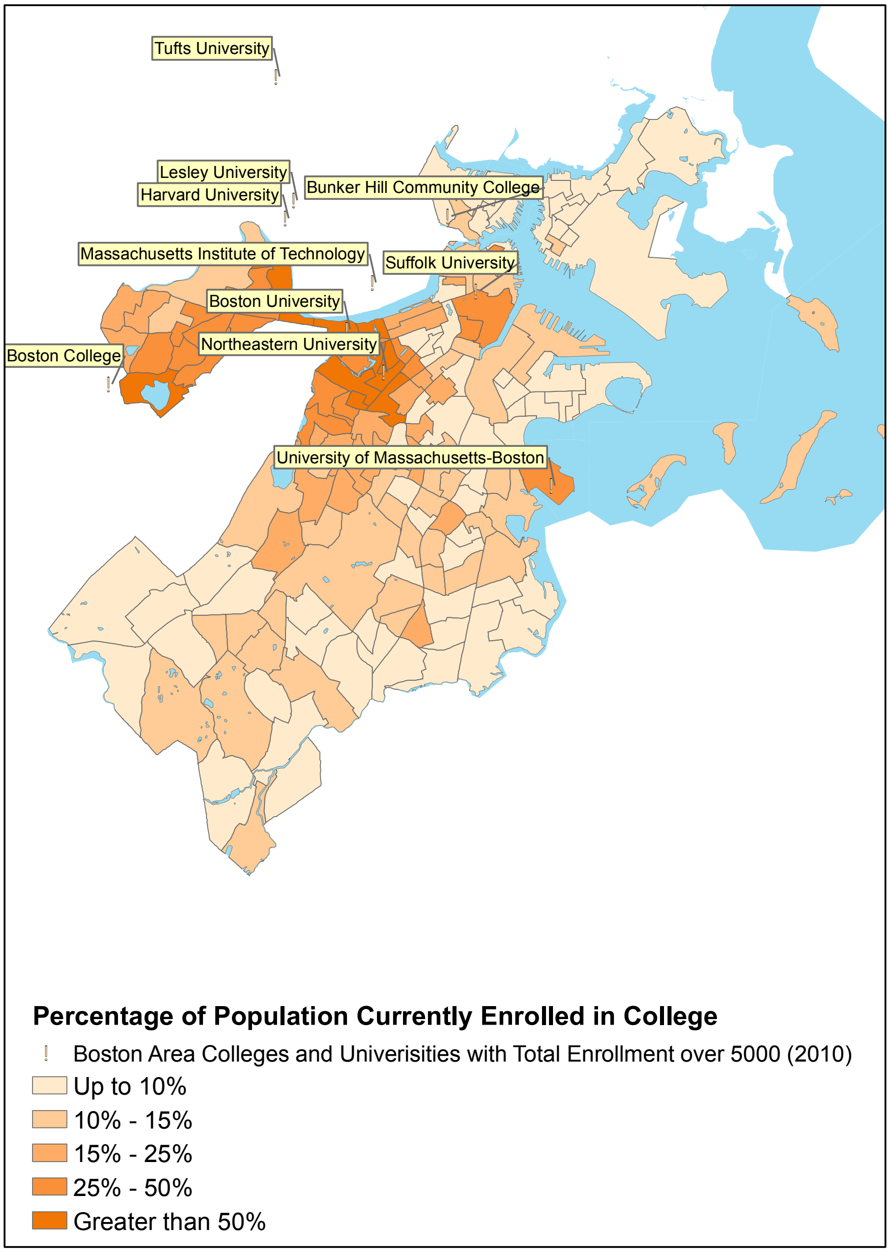

Figure 3. College students 2009-2013 with area colleges

although some off-street shared use paths, like the path in the Charles River Esplanade date back to the 1980s – although these tended to be built strictly for recreational use and did not often connect workplace and residence (Boston Bikes 2015). However, I have included these earlier shared use paths as part of the model to explain bike mode share in the 2009-2013 data.

This thesis is concerned with the city of Boston proper and its constituent census tracts. Since data for bike commuting are available regularly down to the census tract (and sometimes at block group level), this is the geography I have chosen to split up Boston into areas of geographic analysis. However, some changes to census tracts were made between 2000 and 2010, the last year that census tracts were redrawn. Several tracts were simply renumbered after aquatic portions of those tracts were removed. Other tracts were split or merged (U.S. Census Relationship Files).

I aggregated tracts that had significant population change to reflect 2000 tract boundaries. I calculated rates of bike mode share using simple proportional areal interpolation on 2009-2013 5-year ACS estimate data. Tracts that had been split were rejoined and their raw numbers summed and then divided by total commuters to produce rates.

3.2 Data

The data for this thesis were furnished by the U.S. Census for demographic and mode share data. I collected data for 2000 from CTPP via TranStats, transportation-oriented data sources under the auspices of the U.S. Department of Transportation which uses census-based data. 2009-2013 estimate data was compiled by the ACS available at the Factfinder website. I downloaded and tabulated these data and calculated my own percentages for each tract for both time periods (after accounting for tract changes) for the following variables: percent college students, percent earning below the poverty level, percent reporting their race as black alone, percent of households without access to a vehicle, percent commuting by bike, percent with a bachelors degree or better, and the age groups consisting of under 19, 20 to 34, 35 to 54, and 55 and older.

These variables best reflect previous findings in the literature as having greater impact on bike mode share. The most obvious is college students, who commute by bike in outsized numbers. I thought including black alone was at first unusual as one's race should have no bearing on transport mode. However, upon reviewing the literature, black commuters are indeed much less likely to commute by bike than whites, although the reasons for this are beyond the scope of this thesis.

I obtained data for bikeways from Boston Bikes with a data dictionary included. The bikeways are recorded by their type, length, year of implementation, location, preferred uses, and other features. This bikeway data came in the form of an Esri geodatabase.

I first categorized the bikeways into 5 groups, with group 1 being the most desirable for bike commuters with regard to perception of safety and ease of use and group 5 being the least of these (Table 1). I split the bikeways into different categories so as to find any differences between the type of bikeway built and its effect on bike mode

Table 1. Boston bikeway types

Category	Included Bikeway Type(s)
1	Off-street shared use paths
2	Cycle tracks
3	Buffered bike lanes
4	Bike lanes
5	Shared road space

share in its respective tract. Total length (in meters) of each category of bikeway (Table 2) was calculated for each census tract and these lengths were included in the 2009-2013 model as their own respective variables.

Table 2. Boston bikeway lengths

Bikeway Category	Total length in meters for all Boston
1 - Off-road paths	84783.87
2 - Cycle tracks	2115.58
3 - Buffered bike lanes	7138.27
4 - Bike lanes	104310.90
5 - Shared road space (sharrows, etc.)	60172.02

3.3 Methods

This thesis uses methods found in the literature. First the data needs to be prepared for analysis and then an appropriate tool of analysis must be selected.

In order to prepare the data for use in this study, I first had to compile all the necessary data and aggregate it where necessary to account for census tract boundary changes between 2000 and 2010. I took raw numbers of estimates for the 2009-2013 data and either added it to the other tract which made up the previously larger 2000 tract or multiplied proportionally to derive 2013 numbers in 2000 tract boundaries. With all tract boundaries the same, analysis can proceed with a uniform zonal scheme. However, most tract changes were nominal in nature due to new treatment of water areas. Tracts that once had significant portions of their areas literally in water had these areas removed. I can assume that these changes are insignificant to analysis since no one lives on the water.

Once the data was aggregated, I ran regression models to look for relationships between the independent variables described above and the percentage of bike commuters and the share of bike commuters who are male and female (Table 3). I ran models for each time period using the variables listed below using linear multivariate regression (Dill and Carr 2003). I chose this method of regression, as all the variables were continuous. Other travel survey-based studies had used forms of logistic regression

Table 3. Regression models

Time period	Independent variables	Dependent Variables
2000	Percent college students Percent bachelors or better Percent earning below poverty level Percent without access to vehicle Percent black alone Percent under age 19 Percent 20-34 Percent 35-54 Percent 55 plus	Percent bike commuters Percent of bike commuters who are male Percent of bike commuters who are female
2009-2013	Percent college students Percent bachelors or better Percent earning below poverty level Percent without access to vehicle Percent black alone Percent under age 19 Percent 20-34 Percent 35-54 Percent 55 plus Category 1 bikeways Category 2 bikeways Category 3 bikeways Category 4 bikeways Category 5 bikeways	Percent bike commuters Percent of bike commuters who are male Percent of bike commuters who are female

where bike commuting is the choice of the individual participant, rather than a rate of a geographic area.

I performed this series of linear regression using IBM's SPSS software. I calculated rates of bike commuting for both time periods for all bike commuters and the relative proportion of bike commuters who were male and female. I entered independent variables for the 2009-2013 time period both with and without the bikeway category variables to glean if there was in fact any effect of the bikeways.

Finally, I calculated overall changes in bike mode share in each census tract. Each tract's percent change in bike mode share was calculated in terms of standard deviations with the formula $SD=(N\cdot p\cdot(1-p))^{(1/2)}$ where N is the total population of the tract and p the proportion of commuters who are bike commuters (Krizek et al. 2009). In this equation, standard deviations of greater than 1 are considered to be significant.

CHAPTER IV

RESULTS

The results of the analysis for this thesis prove to be a bit confusing as they contradict earlier research. Namely, it seems that bikeways cannot be said to have had any significant effect on bike mode share, no matter the type. However, this could be because of error in analysis, or in something peculiar about the Boston as study area scenario.

4.1 Bike Mode Share

I produced a series of descriptive maps based on the data used in the analysis. I calculated bike mode share for 2000 (Fig. 4) and 2009-2013 (Fig. 5), percent of bike commuters who are male for 2000 (Fig. 6) and 2009-2013 (Fig. 7), percent of bike commuters who are female for 2000 (Fig. 8) and 2009-2013 (Fig. 9), and ratios for both 2000 (Fig. 10) and 2009-2013 (Fig. 11). Areas of high bike mode share tend to be concentrated along the northwestern side of the city, notably across the river from both MIT and Harvard and near Boston University. Little surprise, then, that these areas would have high bike mode share. Finally, I also produced a map of changes in bike mode share by tract between the two time periods in terms of standard deviations (Fig. 12). Interestingly, this last map seems to have recorded significant increases throughout most of the city except for a strip along the southeastern edge, one of the typically economically disadvantaged areas.

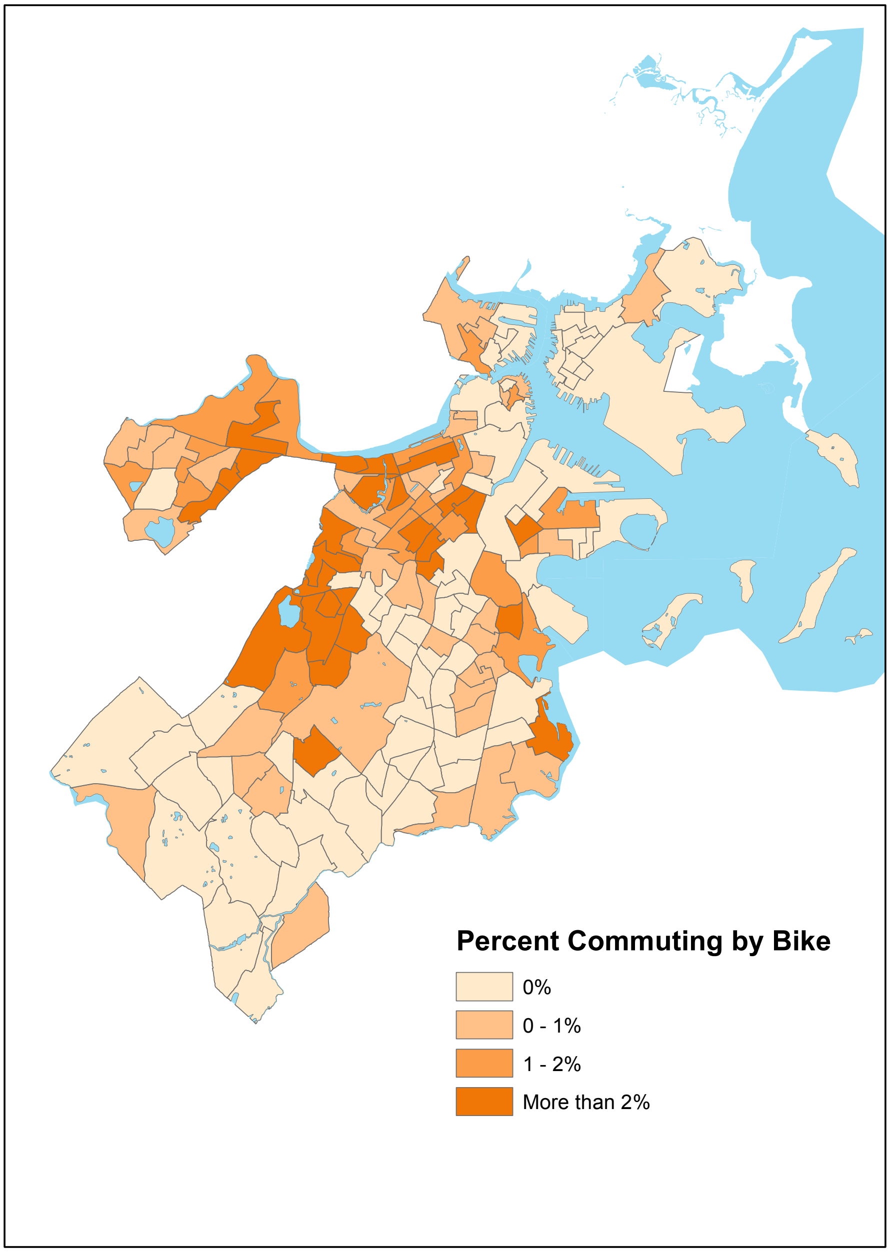

Figure 4. Bike mode share by tract 2000

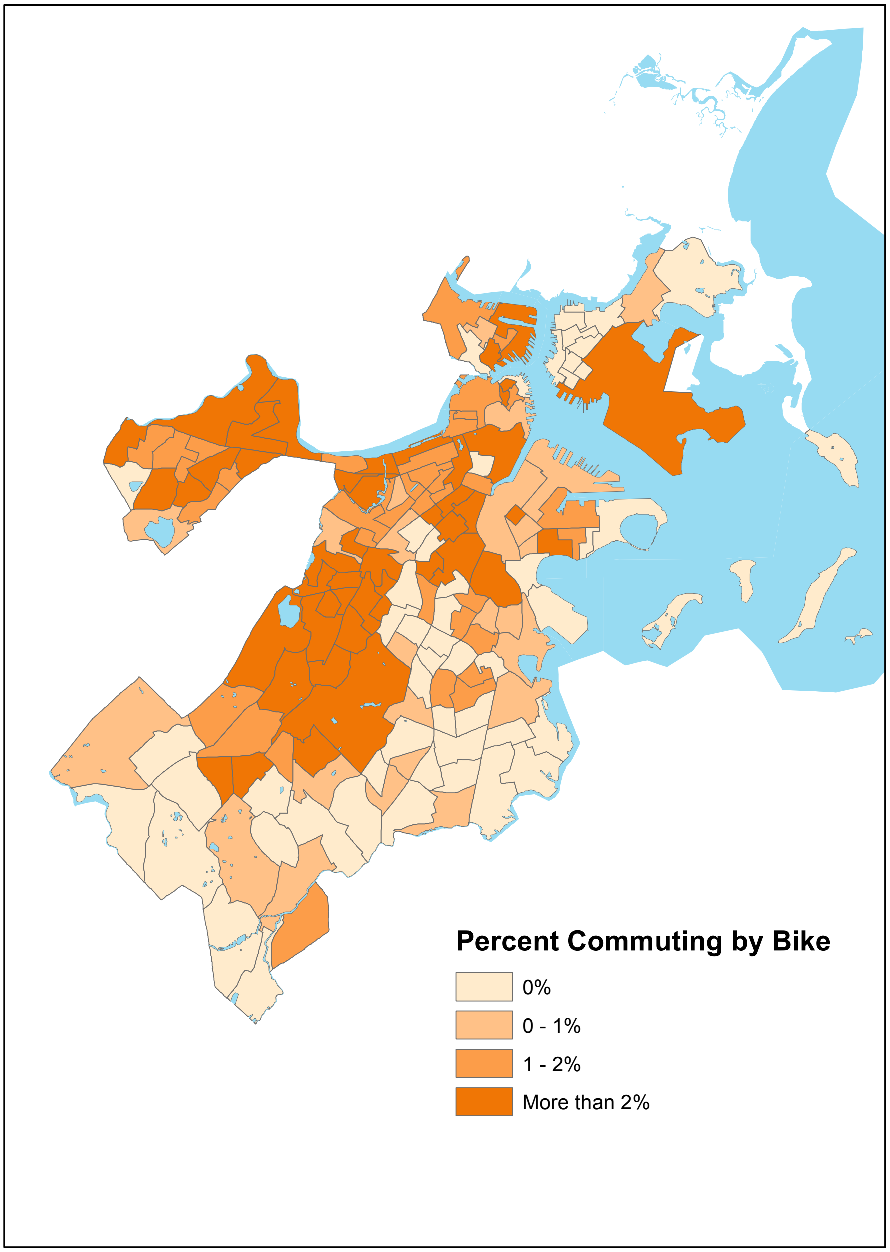

Figure 5. Bike mode share by tract 2009-2013

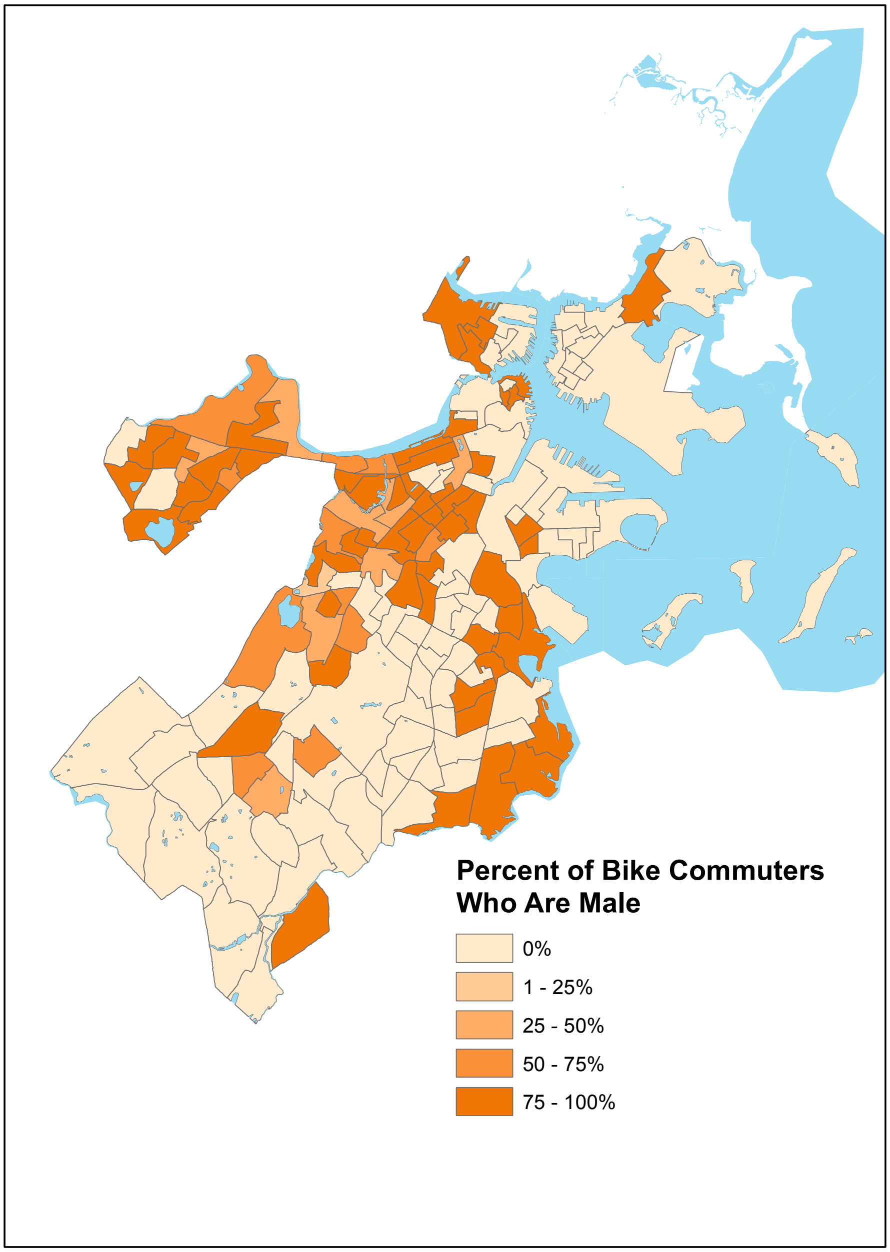

Figure 6. Male bike commuters by tract 2000

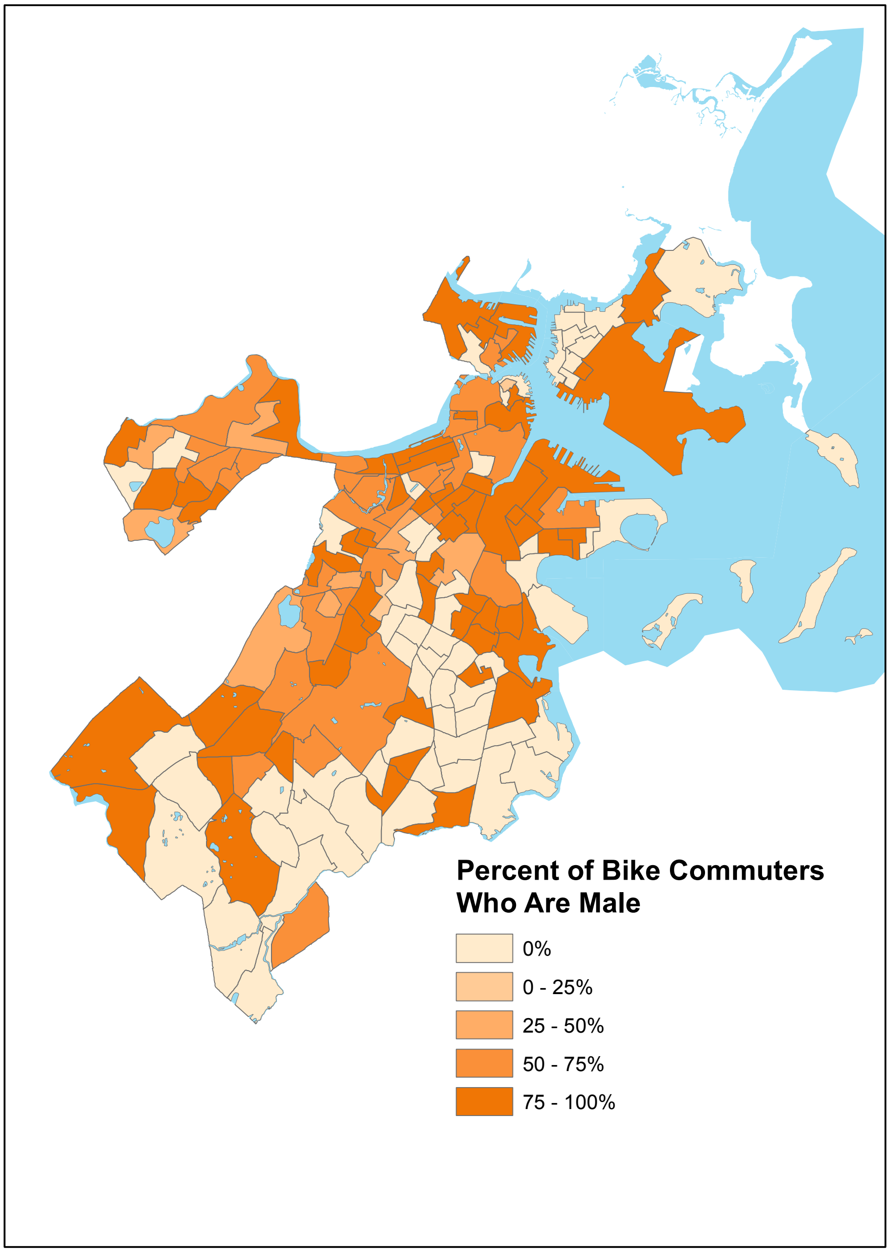

Figure 7. Male bike commuters by tract 2009-2013

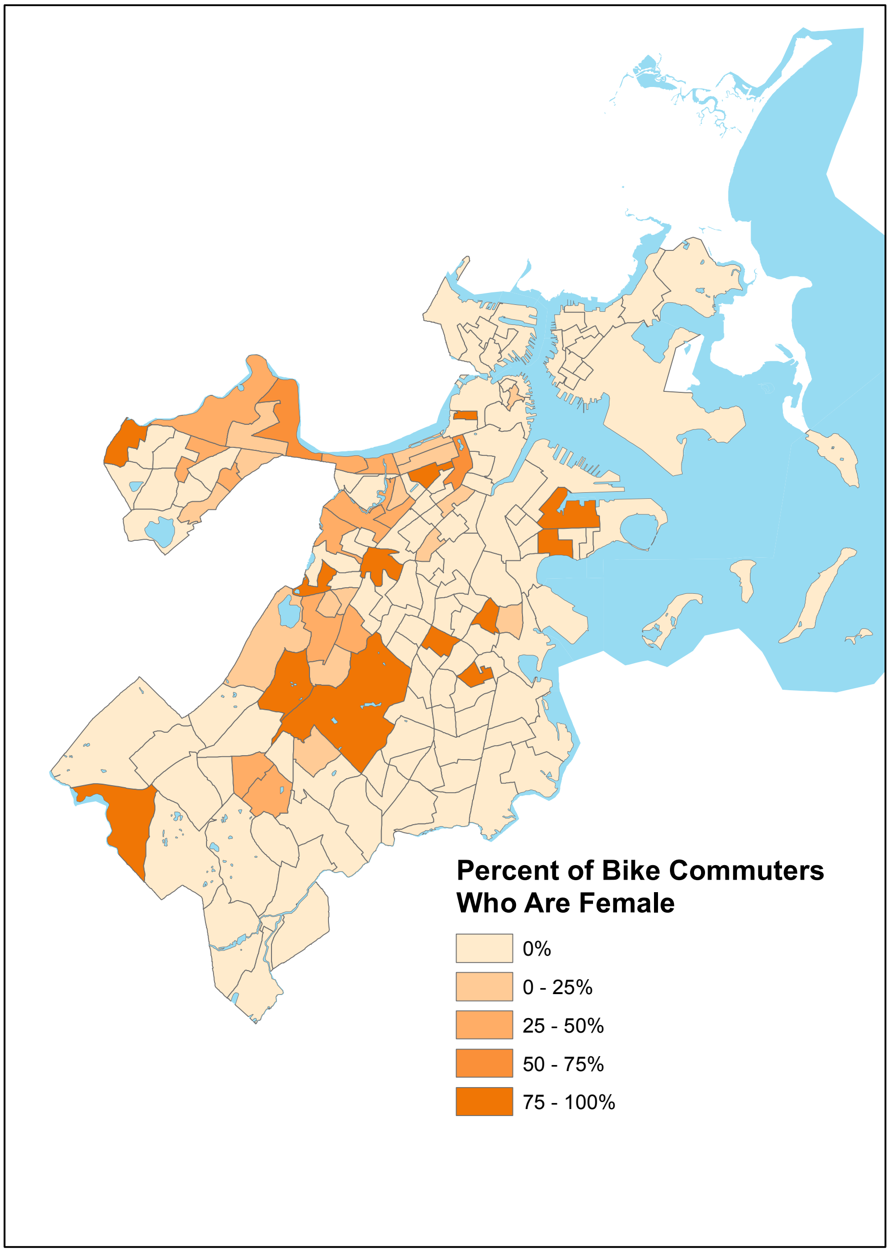

Figure 8. Female bike commuters by tract 2000

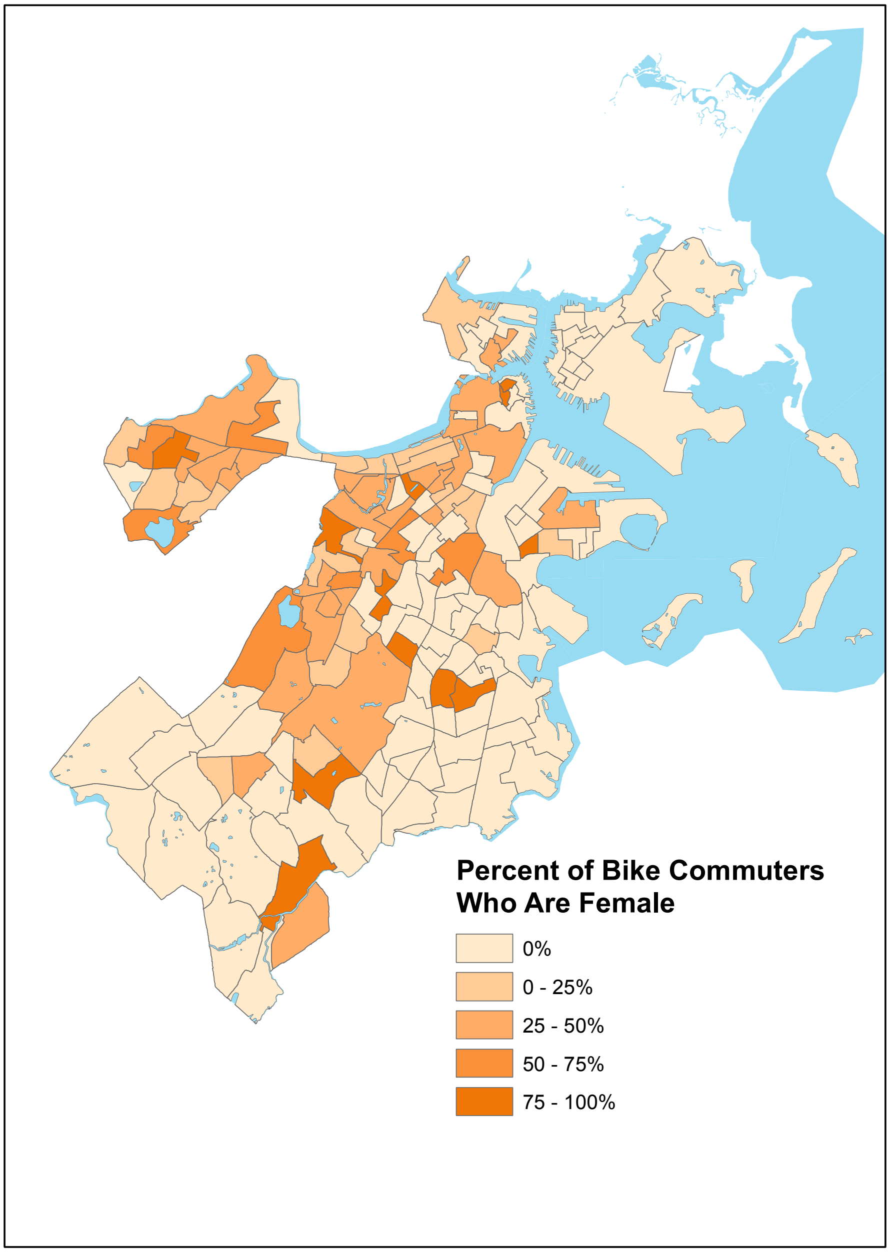

Figure 9. Female bike commuters by tract 2009-2013

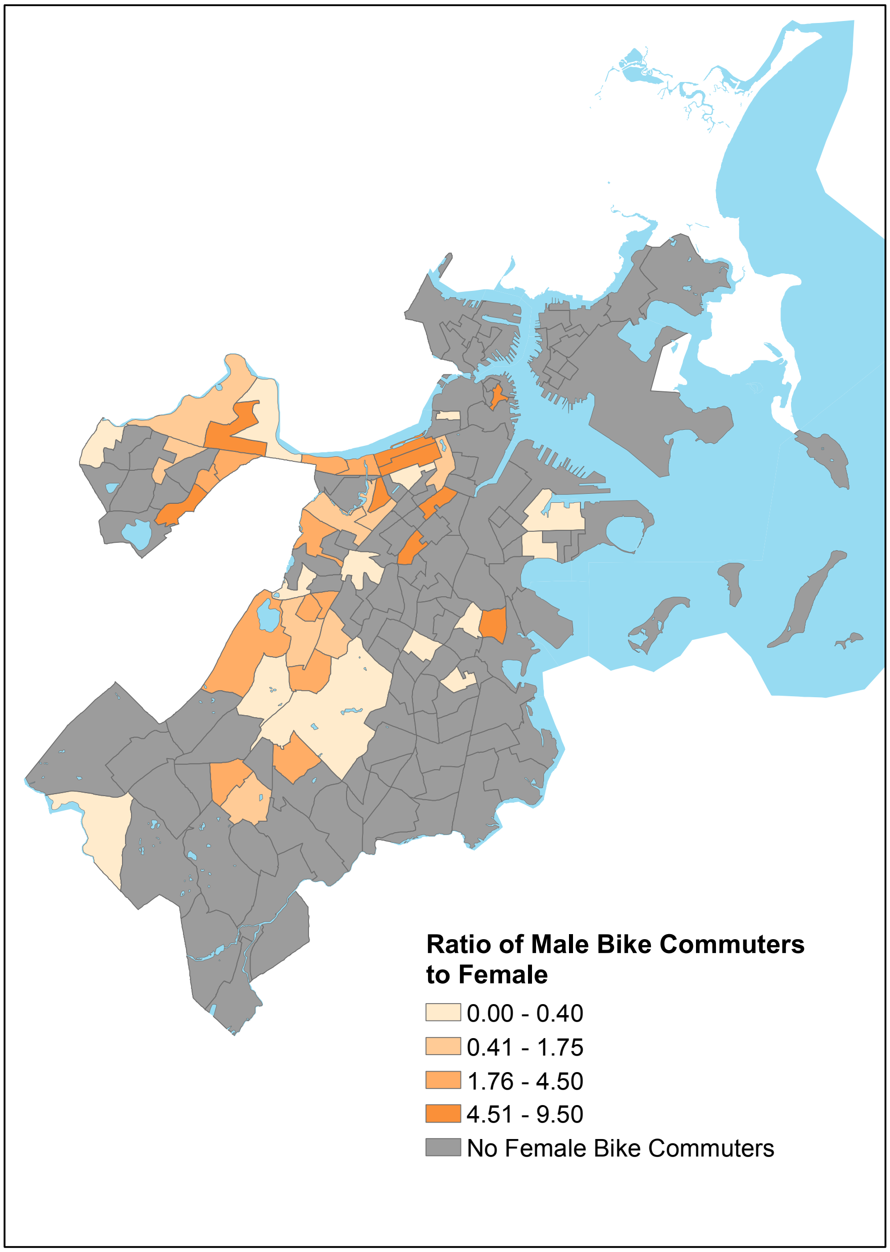

Figure 10. Ratio of male to female bike commuters 2000

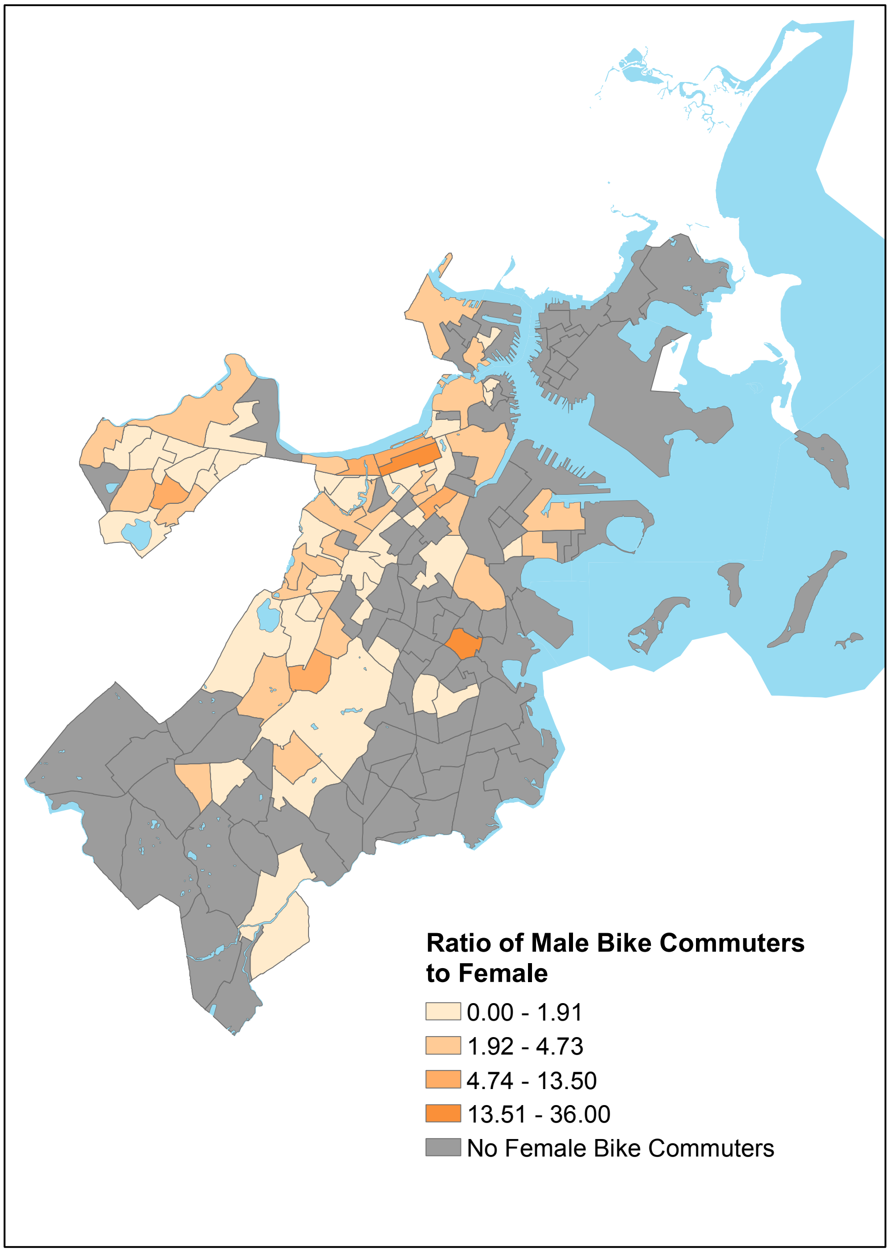

Figure 11. Ratio of male to female bike commuters 2009-2013

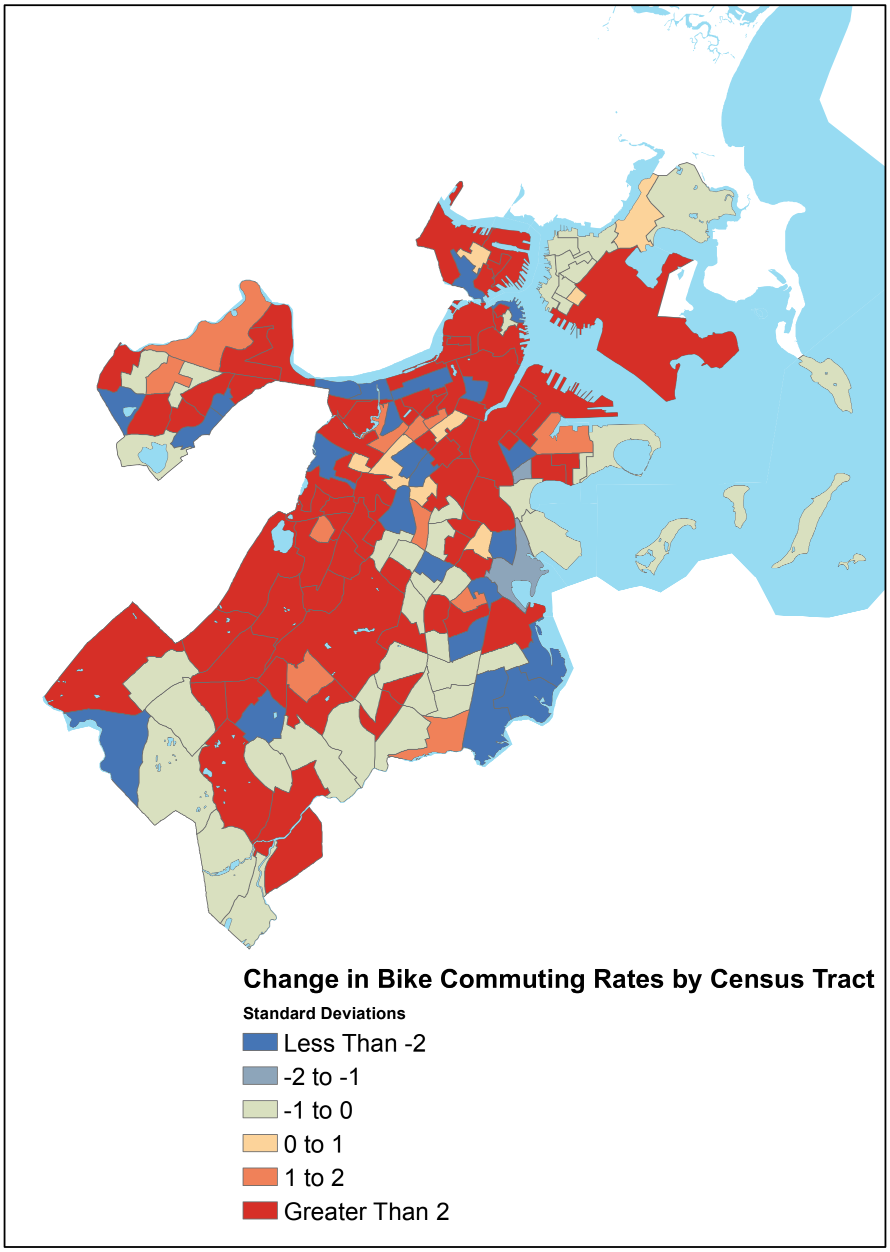

Figure 12. Bike mode share changes by tract, 2000 to 2009-2013

4.2 Regression

The results of the regression analysis indicate that there are indeed significant independent variables in the models. However, the amount and type of bikeways are not significant in the appropriate time period (2009-2013). This thesis reiterates the findings of earlier analyses that found the college student effect. Boston's large student population shows up in these models as well. Other significant variables included certain age groups, poverty status, and bachelor degree rates (Table 4). These were indeed the only

Table 4. Multivariate Regression Significant Variables

Year	Variable	Standardized Coefficient (b)	Significance
2000	Percentage Current College Students	.402	.003
	Age 35-54	.369	.004
2009-2013	Below poverty level	.308	.020
	Percentage with bachelors degree or higher	.332	.017
	Age 19 and under	-.317	.015

significant findings. All other variables, including the bikeways, were not statistically significant ($p>.05$). Of the significant variables, college students had the highest standardized coefficient at .402 and the under 19 age group had a negative coefficient at -.317. The various regression models returned changing adjusted R^2 values, suggesting meaningful change (Table 5). It is interesting to note that the 2009-2013 model without bikeways actually yielded a higher adjusted R^2 value than if bikeways had been included.

Table 5. Adjusted R^2 values for selected independent variables

Year	Dependent Variable	Adjusted R^2
2000 (no bikeways)	Percent bike commuters	.162
	Male bike commuters	.024
	Female bike commuters	.005
2009-2013 (with bikeways)	Percent bike commuters	.168
	Male bike commuters	.025
	Female bike commuters	.025
2009-2013 (without bikeways)	Percent bike commuters	.184
	Male bike commuters	.035
	Female bike commuters	.035

CHAPTER V

DISCUSSION AND CONCLUSIONS

It would seem based on the results of the regressions that bikeways have little to no effect on the rates of bicycle commuting among Boston's census tracts. Whereas previous studies indicate, "If you build them, people will come" (Dill and Carr 2003), this analysis indicates that Boston was going to see a surge in bike mode share regardless of whether the city implemented new bikeways or not. This increase occurred in tracts with the best bikeways (category 1) and even in those with the worst (category 5). Perhaps college students have no preference for the type of bikeway they use, so long as there is one, and nearly all tracts in Boston have at least some kind of bikeway facility by 2013. This distribution of bikeways may also reflect well thought out planning on behalf of city bike planners.

In the context of the current American biking "boom" where cities like Chicago have quintupled their rates of bike mode share since 1990 (Pucher and Buehler 2011), it would be difficult for a city like Boston to not have increased bike mode share during this time. This represents a sea change for American cities. Where once, commuting to work by bike was seen as an activity merely for those who had no alternative, now biking has become something of a lifestyle or environmental choice for those who might wish to eschew the car-dominant culture prevalent in the U.S. for nearly a century. It is unlikely that bike mode share will start to go down anytime soon, even if the price of gasoline remains low for an extended period. There are so many other incentives to bike to work (health, saving money, etc.) that it has become the rational choice for an increasing number of people, and especially an increasing number of women.

There is perhaps a chicken and egg problem going on then with bikeways and bike mode share. Of course, cyclists will use bikeways when they are made available (Parker et al. 2011), but that doesn't mean that a new bikeway will cause more total cyclists to choose to ride to work instead of taking other modes. It seems likely then, that there are those in Boston and in other American cities who are making the choice to ride their bicycles to work regardless of the presence or absence of suitable bike infrastructure. At some point, commuters have become aware of the greater and greater benefits of biking to themselves and to society as a whole and have made that choice, hoping that policy makers will catch up with them

It seems that in Boston, at least, policy makers are finally starting to take notice of cyclists and their needs by implementing the Boston Bikes program to much acclaim, dragging Boston's reputation as one of the worst cities to bike in, to at least something respectable. Perhaps because of this policy implementation, the gender gap in Boston's biking community narrowed as much as it did. Perhaps without action, that gap would have remained the same. Since women have been reported in the literature to more likely gravitate to bike infrastructure (and to avoid riding at all in its absence), one could argue the case that the new bikeways in Boston are effectively closing the gender gap in that city. This is good news, since it represents a move towards normalcy for biking as a legitimate mode of transport, not just the realm of thrill seekers and fitness heads. In areas where more women bike, more people (of both genders) tend to bike. The presence of female bike commuters is an indicator of a robust and safe bicycle transportation network; they are something of the canary in the coal mine. If the policy had no other effect than to increase the rate of women bicycle commuters, then it is certainly laudable, as this provides more options for about one half of the people. The fewer people driving alone, the less congested Boston will be.

Americans have come a long way in their attitudes toward bicycle commuting in the last 25 years, and it is likely that Boston is no exception. Although the regression analysis does not indicate a significant impact due to new bikeways, there are more bicycle commuters in Boston anyway.

5.1 Limitations

This thesis has several limitations. The nature of the data present a significant challenge to successful analysis. I began with all of Suffolk County, as it was a convenient delineation for which to download census data and I was able to obtain a detailed shapefile and attribute table for Boston's bikeway network. Unfortunately, the Boston bikeway network covers only the city of Boston. While this covers nearly all of Suffolk County, save for three smaller communities in the northern portion of the county, this bikeway network does not include the significant neighboring areas of Brookline, Cambridge, or Medford, all major sources of college students in the Boston area.

Of course, not all bike commuters in the Boston area need be college students. Indeed there are other significant predictor variables in the models such as certain age groups, poverty level status, and the related but different status of having a bachelors degree or better. Omitting these crucial areas from the analysis probably hampers my ability to fully account for all factors in the Boston area because commuters do not stop once they hit a city's limits. Perhaps a more robust study would include the entire MSA or at least counties adjacent to Suffolk County. This would be nearly the same size as the MSA itself, but it would omit the counties that lie in New Hampshire.

In addition to geographic scope, another significant limiting factor to this thesis is the nature of sample data. While commuting data is not suppressed at the census tract level, it often has high margins of error, especially for the "modes less travelled" like bicycle commuting. When sample data is imputed, census statisticians can only work with what they are given, so one person reporting bicycle commuting on a survey form must naturally represent others who were not included in the survey. This could very easily turn into over reporting. Fortunately, census tracts in Boston are typically densely populated and biking to work is often a valid commute choice, so it is more likely to have accurate responses to survey questions, although there were still plenty of tracts with 0 bike commuters in 2000.

Another issue is the shifting temporal nature of the 2009-2013 estimate data. Since this data is the average of a 5-year span, we might be seeing even lower levels than if a study were done that only included the year 2013. Unfortunately, that level of temporal detail is unavailable at meaningful geographic scale. One could analyze a selection of cities based on single year estimates, but in order to analyze within a single city along tract lines, one needs a fuller dataset, hence the 5-year estimate.

Perhaps it could go the other way as well with a relative spike in bike commuting in 2009 tapering off by 2013, although in aggregate this looks like a rise. This is certainly a plausible scenario given the economic recession which hit the U.S. beginning around

2008-2009. With people out of work, it is likely that many would have had to choose cheaper transport options, the bike being one of them. However, if one is unemployed completely, one is unlikely to be considered a commuter as there is obviously nowhere to commute to.

A limitation in methods is evident in this thesis again due to the nature of the data. Although I can perform regression models for the time periods 2000 and 2009-2013, I cannot perform a linear regression on the change between these two time periods, as these data do not represent longitudinal data. I am left then with running two different time period regressions and identifying significant standard deviations from period to the next. This method indicates where bike mode share has increased (or decreased) the most, but it cannot answer as to why. I can non-statistically infer that the increases evident in the Boston area on the northwestern side are due to an increased density of bikeways (if there indeed is one), but this is as far as I can go.

A limitation in methods may also arise from the aggregation of bikeways by census tract. I calculated the total length for each of the five categories of bikeway for each census tract. This method assumes that having more linear miles of bikeways in a tract (or neighborhood) will induce people there to commute by bike. This method does not take the destinations or connectivity of these bikeways into account. It is likely that having more bikeways means that there are more bikeways that actually go somewhere meaningful, however it is possible that this simple summing method includes bikeways which are merely loops or do not serve anyone. I excluded tracts where there were too few total commuters for analysis (notably Deer Island), but this had no effect on regression results. What this research cannot say is that new bikeways have no effect on bike mode share, but that bike mode share is not necessarily higher in one part of town with high quantities of bikeways versus another part of town with less bikeways.

5.2 Future Research

Future research on this geographic area is a must. It should include neighboring cities so as to "catch" the impacts of the colleges in those cities. Boston is something of a college town, and an analysis without all the nearby colleges is missing something. To that end, future research would need to compile bikeway networks for all of Suffolk county (not just Boston) and at least the cities of Brookline, Cambridge, and Medford.

In these locales one will find Boston College, MIT, and Harvard, and there more large schools as well. When I wanted to display area colleges, I downloaded data from the U.S. Geological Survey (USGS) which had a huge point shapefile of college and university locations in the U.S. There are so many in the Boston area that I narrowed down the display to only those with a total enrollment over 5000. This criterion excluded several small colleges around Boston and in the city itself. Perhaps a viable new variable would be distance from residence (or tract) to any college, although this would probably just be collinear with college student status (college students usually live near colleges).

In addition to the geographic location of college students, built environment might be important in a study of Boston's bike mode share distribution. Previous research has looked into density and variety of urban land use (Cervero 2002). Building a variable that is concerned with the built environment may prove fruitful in Boston. However, this study limits itself to urban Boston itself and excludes surrounding suburbs. It is interesting to note that while both Jamaica Plain with relatively high bike mode share and Dorchester with relatively low bike mode share were both developed at the end of the

19th century as streetcar suburbs – neighborhoods with high dependence on commuting by streetcar to the city center (Warner 1962). It is likely that the built environment is similar in both of these areas including total length of bikeways, although the populations that live in them may be quite different along socio-demographic lines.

Future research might also include weather-related variables. As of this writing, the winter of 2014-2015 has been one of the snowiest in Boston's history. It is likely that having the streets choked with snow for so many days of the year likely caused many would-be bike commuters to seek other modes of transport. Although previous research seems to indicate that overall climate does not have a significant effect, perhaps increasingly frequent extreme weather events will create more disruptions to bike commuters.

Another point of future research should be the standardization of bikeway types. For this thesis, I provided my own categorization of bikeways based preference found in literature. However, the naming conventions for these bikeways are not always consistent across jurisdictions. What might be buffered bike lane in one locale might qualify as cycle track in others. This kind of standardization is also necessary for the good of public who will need to be able to advocate for increased bikeways and need the correct terminology.

Of course, future research could include repeating this same study when an updated dataset has come out. Perhaps one could use data from right before the bikeway building boom in the Fall of 2007 and another year in the future, perhaps 2020. Having a start date closer to the area of interest might lend some accuracy to the study as before and after analysis would capture rates immediately before policy and bikeway implementation. In this thesis, the start date is approximately seven years prior to any action being taken. It is possible that a lot could happen in seven years to affect bike mode share regardless of bikeways.

APPENDIX

APPENDIX A

A. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pctbike	157	.00	10.77	.8577	1.34997
pctmalebike	86	.00	100.00	74.9505	35.05870
pctfemalebike	86	.00	100.00	24.6746	35.46913
pctcollegestudents	157	1.25	94.40	14.8465	15.60098
pctbelowpoverty	157	2.35	69.59	20.4856	12.57041
pctbachorbetter	157	2.81	84.30	30.4298	20.61141
Pctblackalone	157	.0	91.6	25.041	27.5530
pctnovehicle	156	3.57	74.22	35.0571	15.68628
pct19andunder	157	1.10	59.14	23.6759	11.35819
pct20to34	157	10.45	80.63	32.3333	13.41467
pct35to54	157	1.42	62.38	26.4482	7.13124
pct55plus	157	1.75	33.70	17.5426	6.35429
pct2013bike	157	.00	12.97	1.7321	2.29628
pct2013malebike	107	.00	100.00	72.1644	31.17563
pct2013femalebike	107	.00	100.00	27.8356	31.17563
pct2013collegetudents	157	2.39	94.55	17.9572	17.80009
pct2013belowpoverty	157	.58	84.09	21.1054	13.29405
pct2013bachelorsorbetter	157	1.40	91.58	37.7817	23.41773
pct2013blackalone	157	.00	92.97	24.9263	26.55643
pct2013novehicle	156	.18	15.83	2.8656	2.23067
pct2013under19	157	1.40	56.38	21.2094	9.85656
pct2013age20to34	157	12.13	75.37	34.6626	14.11691
pct2013age35to54	157	1.90	38.87	24.2690	7.58551
pct2013age55plus	157	1.07	46.41	19.8590	7.04408
cat1	156	.0000	6977.092547	543.48636391	998.480162284
cat2	156	.0000	1235.860000	13.561395194	115.576150548
cat3	156	.0000	2473.660000	45.758167198	231.241524923
cat4	156	.0000	5995.334001	668.65965436	975.092079508
cat5	156	.0000	2498.138425	385.71804921	495.871889844

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