AN ECONOMIC ANALYSIS OF BICYCLING IN BOSTON, MASSACHUSETTS

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1. OVERVIEW

The personal vehicle accounts for almost 90% of all commuting and travel in general, making it the most significant factor in transportation design (1). The economic principles of other means of transportation are dwarfed by the usage rates of the automobile; however the changing transportation environment indicates an increasing trend towards mass transit and bicycling in many cities around the country, Boston in particular.

Compared to European nations, the US has a fraction of the bike ridership with a significantly higher rate of injury. Ridership rates are as high as 20% in Holland and Denmark compared to just between 1.7-3% in Boston, and the risk of death is almost three times greater and more than ten times the risk of injury in Boston vs. Holland (2). A higher share of Americans commute to work via car, and the amount of time spent driving has a greater impact on obesity rates than factors such as income, education, gender or ethnicity; an additional 30 minutes spent commuting each day results in a 3% greater chance of obesity (3). The health, environmental, and financial benefits of cycling are examined in comparison with the costs of car travel.

1.1 ECONOMIC PRINCIPLES OF URBAN TRANSPORTATION

The two main forms of transportation in urban areas are car and public transit, with walking and bicycling generally representing under a quarter of all travel. Automobile travel generates three main externalities: congestion, pollution, and accidents. Congestion results in high opportunity costs to the drivers in wasted time. Pollution due to driving has damaging environmental and health effects at significant cost to both the vehicle users and other members of the community. Collisions cause financial, health and time burdens on the users. Some public transportation systems also contribute to congestion (busses and streetcars) while also requiring significant energy. Bicycling, by contract, generates just one negative externality – high accident rates. Bicyclists are both more likely to be in an accident and more likely to be hospitalized than a person driving a car.

Drivers waste an average of 47 hours in traffic congestion nationally (1). In 2003 the cost of congestion for drivers had increased 5-fold and will continue to increase as the number of vehicles on the roads grows. Without parallel expansion of roadways, which is difficult in urban areas, the increase in vehicle use will further exacerbate congestion issues.

DEMAND FOR URBAN TRAVEL

The demand curve for transportation is calculated based on trips vs. trip cost for each type of travel. If the travel costs are high, fewer individuals will make the trip. The response of ridership rates to changes in price, time, means, and purpose of travel are most significant. On average, a 10% increase in the price of ridership decreases the ride share by a margin of 3.3% (η=-0.33) (1). The time variable has a higher elasticity ($-0.4<\eta<-0.7$), which is greater for access time spent on public transportation (1). An hour spent on public transit is worth half an hour in wage to avoid, and the value of an hour of waiting is worth up 1.5 times the hourly wage to avoid. Finally, the demand for noncommuting travel has a higher elasticity than the demand for commuter travel, resulting in lower elasticity of travel during weekdays.

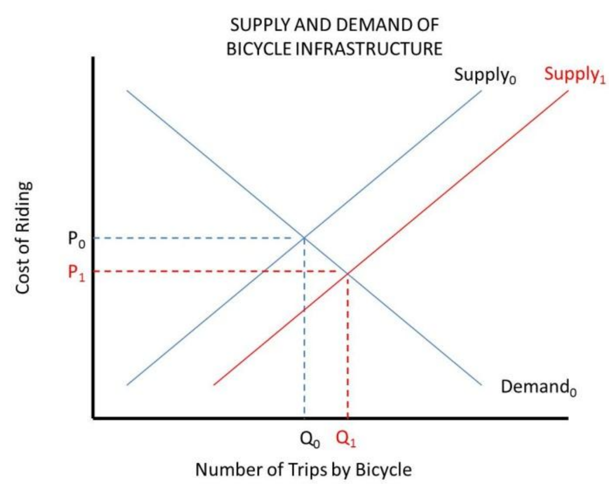
When in March of 2009 gas prices were under $2 per gallon, Americans drove fewer miles than they did during March 2008 when gas was $3 per gallon (3). Despite the lower fuel costs, residents were not driving as much – perhaps due to the costs of congestion. The demand for additional bike facilities is greatest in urban areas, where there is a great need for additional bike paths, lanes, parking and other facilities and amenities. Unmet demand for cycling results in dangerous riding conditions, as it has been experienced that commuter cyclists will often take the most direct path regardless of the bike-friendliness (5).

HEALTH AND SAFETY

Per trip, cyclists in the US have between a 7-70 times higher chance of being injured than car occupants (2). For every 100 injuries on a bike, there is an average of 1.2 deaths of bicyclists, as compared to a value of 1.07 deaths per 100 injuries for car occupants (1). Research suggests that the perceived improvements in bicycle safety have an elasticity greater than one, wherein an increase in safety measures yields an even greater increase in ridership (2) (3).

ECONOMICS OF BICYCLE INFRASTRUCTURE

The basic economic model for bicycle infrastructure indicates that if you improve the bike facilities, the perceived and actual increases in safety will encourage more riders to participate. The cost for riding decreases as the safety improves, thus making bicycling more appealing and economical and increasing the demand. The $Supply_1$ line displays a supply which has increased by increasing the bike infrastructure, thus shifting the supply. In turn more trips by bike are taken at a lower average cost (risk of injury) to the riders.



For the purposes of this research, bicycle design is divided into intersections and 'straightaways'. For the purposes of striaghtways, there are several main designs which have been utilized around the world and recently in part in Boston. A road with no bike infrastructure represents the baseline environment. The next improvement would be a painted bike lane or sharrow markings (shared lane), providing a visible barrier for protection. A physical barrier creates even better safety measures for cyclists, such as a separated bike path, multiuse lane, or protected bike lane (with a buffer between traffic and parked cars). Intersections are high-risk areas for cyclists and pedestrians alike, and the addition of bike boxes (protected areas between car stop lines and ped crossings), bike light phases, and bike markings in intersections help to reduce accidents within intersections. Intersections where cyclists are separated from traffic flow are safest, but require greater land use over marked bike paths among travel lanes.

Countless studies have been conducted which reveal that bike lanes, paths, and markings increase ridership and either lower or do not change the number of crashes (6) (7).

About one-third of all bike fatalities take place in intersections, with the highest rate of accidents from the "right hook" where a driver takes a right into a bicyclist going straight in a bike lane. Painting bike boxes and bike stripes through intersections helps to improve awareness and lower crash rates in the intersections and straightaways. Intersection safety measures include both painted and physical changes to roadway elevations and features. Physical changes such as raised cycle path crossings can result in increased ridership and improved safety rates compared to off-grade intersection crossings (7). Changes made with markings can also improve safety, with simple bike lanes resulting in lower injury and collisions rates (2).

The most significant factor in bicycle safety and infrastructure is the roadway design and utility. More severe injuries are associated with motor vehicle involvement, wider roads, poorly graded surfaces, and one-way streets. There are a wide array of traffic calming measures and designs for safety such as bike boxes, sharrows, speed bumps, road width restrictors and more.

Proper street lighting can also have significant safety benefits for cyclists and road users, decreasing rate of injury by 50% (2). Unlit roads have a higher percent of severe injuries as a result of accidents.

A cost-benefit analysis indicates that the benefits from increase cycle use are worth 4-5 times the investment costs, such that the construction of safer cycle tracks and paths has significant benefit for both the riders and community (2). A higher bike share represents less pollution, noise, and congestion and also provides the rider with a multitude of health and financial benefits. Infrastructure improvements are population-based (large population effected), require no active participation from road users, and are long-term single-action solutions – features that make the investment more promising for bike safety than an increase in fines, restrictions, and laws such as riding without a helmet.

Case studies of improvements on urban roadway infrastructure have increased ridership and generally decrease the accident rate (3) (4) (10). The addition of a dedicated cycle track or path also has the effect of lower sidewalk riding, which reduces risk of bike and pedestrian collisions. In a NYC study of a transition from no bike infrastructure to a separated cycle track, the sidewalk riding reduced three-fold down to fewer than 3% of riders. Ridership on the roadway increased more than 50% for weekday trips, and both delivery space and parking were preserved such that there was a decrease in double parking incidents (4).

Purpose-built bike-only facilities (paths, lanes, cycle tracks, etc.) reduce the risk of crashes and injuries compared with on-street or sidewalk cycling, and features such as lighting and proper paving further increase safety. The major benefit of dedicated infrastructure is the population-wide community which is affected, as compared with helmet use measures.

The difference in costs for bike infrastructure compared to vehicles is significant; in one case in LA three miles of an 8-lane interstate repaving ($75 million) was enough to over a thousand miles of paint and signage for bike lanes (6). Infrastructure to support cyclists also leads to increase in business traffic and home values. The amount of road required by bicycle facilities is also dramatically lower, as cyclists can fit 2-10 times more people per car space and require less space for parking.

2. BICYCLING IN BOSTON

Nationally, about 5% of the US workforce use mass transit as their means of transport to work. In Boston this rate among residents was 33% in 2011 and 39% among those below the federal poverty standard (2). Car commuter share in Boston in 2011 was 45.5% compared to about 87% nationally (2). Among Boston's poor (at or below the federal poverty standard), car commuter share was 29%, less than half the national average of 77% for those in poverty (2).

In Boston the 2011 average for commuter share by bike was 1.7%, more than three-times the national average and growing (2). A 2009 survey by the League of American Bicyclists pegged the percent of bike commuters even higher at 2.1%, up from 1.6% in 2008 (9). 23% of Boston residents at or below the poverty level chose to walk or ride a bicycle, compared to just 17% of total Boston residents walking or biking to work in 2011 (2).

Of the more than 38,000 trips being taken by bike every day, 20% are commuter trips (9). The total bike share of all trips (personal and work related) is approximately 3%, yet more than 20% of traffic deaths from 2000-2001 were people on foot or on bike (10). As the city works to improve bike facilities and safety measures, and more people opt to ride bikes it is likely that improved safety numbers will be experienced. Although bike traffic is highest on off-road paths, bike traffic is heavy on direct routes regardless of bike-friendliness (13). Key bicycling routes and destinations are the main factor in determining bicyclist behavior in the city, as many riders take the most direct path to their destinations.

Cyclists in Boston ride on practically any roadway accessible by car with reasonable speed limits, and on almost all surfaces accessible to pedestrians. It is illegal to ride your bicycle on the sidewalks in Boston, however there are many riders who ignore this danger. Sidewalk riding is more than twice as hazardous for cyclists than riding on the road, especially at intersections where the cyclists are moving against the flow of the adjacent traffic (6).

In 2011 the city painted its 50th mile of new bike lane on Massachusetts Ave, one of the most popular bike routes in the city and also one of the most notoriously dangerous. The City went from zero miles in 2007 to over 50 in just 4 years, and will continue to add new bike facilities in the coming years (13).

The City's Network Plan for bike growth represents a blueprint for the next 10 years to connect every neighborhood with facilities for all ages and abilities. They also plan to continue adding new parking spaces at schools, community centers, libraries, and housing facilities. In 2011 Boston adopted LEED standards for bike facilities at all new developments.

Community bike programs in Boston are putting bikes into the hands of those in poverty, having distributed nearly 10,000 bikes in 2011 and 2012. The Roll it Forward program collected, repaired, and redistributed over 1,000 bikes to youth from 2011-12, while the Bike to Market program repaired thousands of bicycles at farmers markets around the city. The Youth Cycling program provided training, riding skill-building and safety lessons for over 7,500 youth while Bike Week and Bike Friday events encouraged new and inexperienced participants to begin riding. Subsidized helmet distribution efforts were effective at providing over 5,000 helmets to the community to improve safety (13). An improvement in police enforcement of compliance by bicyclists and drivers resulted in increased awareness from both types of road users and encouraged legal road use.

2.1 BOSTON'S BIKESHARE PROGRAM - HUBWAY

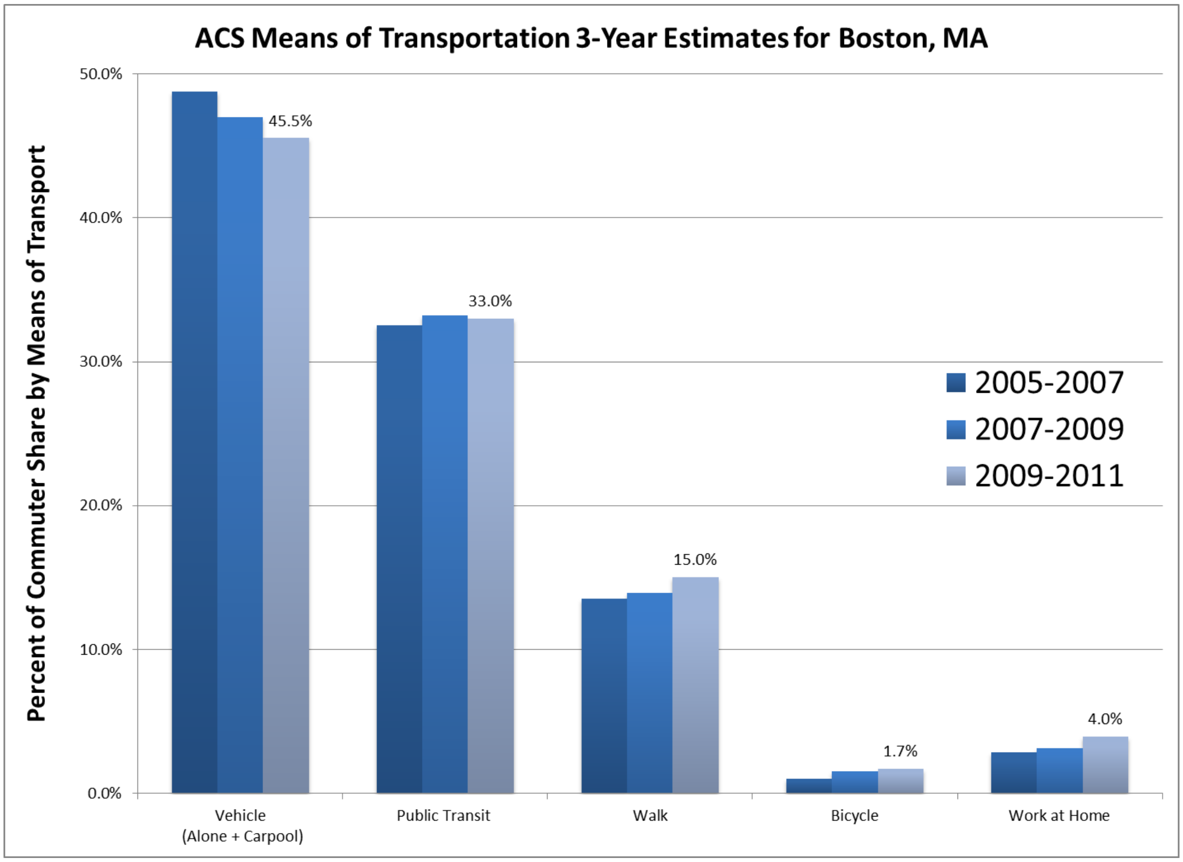
In July of 2011, the City introduced the Hubway bike share program with 60 stations and 600 bikes which could be rented for a day ($5 + usage fees), three days ($12 + usage fees), or for a full year pass ($85 + usage fees). 600 subsidized memberships were given to low-income residents for just $5 for the year. In the first year of operation, the Hubway system achieved more than 140,000 trips and attracted 3,700 memberships. With the "safety in numbers" theory, the additional use of bikes on the city streets has promoted better bicycle awareness and safety. To date, no serious injuries have occurred with riders using the Hubway system, however there are serious community concerns around several of the Hubway stations which promote riding in difficult streets without proper bike facilities. It should also be noted that the Hubway users wear helmets an average of just 20% of the time, compared with the average 50% rate among riders who own a bicycle (11).

With over 1,150 trips taken each day at an average distance of more than one mile, the Hubway system has been by all accounts an overwhelming success (13). The growth of the program continued this past summer of 2012 with the addition of new stations and bikes in Cambridge, South Boston, and communities like Jamaica Plain, Roxbury, Mattapan, and other disadvantaged areas. The City plans to expand to more than 300 stations and 3,000 bicycles over the next several years to connect the entire area along the Charles River (13).

2.2 MEANS OF TRANSPORTATION DEMOGRAPHICS

The decision to ride on a particular roadway and the related skill level of riders has a large effect on accident rates and severity levels, with young men traditionally taking more risks than other demographic groups. A cyclists' age, cycling experience, type of bicycle, and environmental factors all have contributing effects on bike safety and usage rates, and these values vary greatly by location.

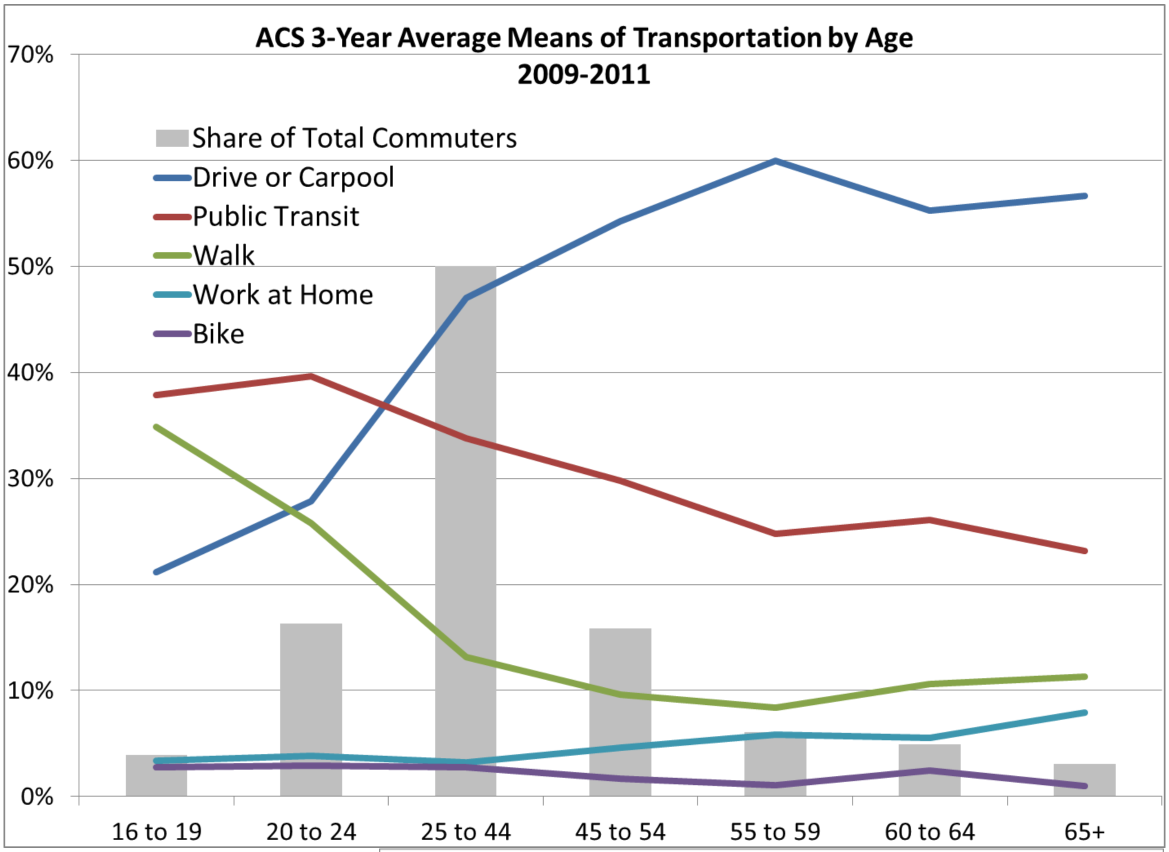
Since 2005, the bike share for commuters has increased by over 300% as the rate of vehicle transport decreased down to about 45% of total commuter trips. About half trips are made by car, one in three trips to work are made by public transportation, around one in six trips are made by walking only, and just one in fifty trips are made by bike. The rate of public transit share has been fairly level but is expected to increase as development projects are completed in the coming months and years (14). It is also anticipated that as the City constructs more bike facilities, the share of bike commuters will also increase relative to the population. Over the next 10 years it is projected that car share will decrease to just above 40%, replaced by increases in public transit share, walking, and biking.



(2)

When examining the means of transportation by age, we find a small and expected decline in bike commuter share as age increases, from about 3% for those 16-44 and about half this for those 45 and older. As age increases, the car share also increases from about 25% for those 16-24 up to almost 50% and above for those 25 and older. The public transit share decreases as age increases, as does the share of walking commuters. The older populations are also more likely to work from home.

The younger generations rely more on public transportation, walking and bicycling most as a result of not having a vehicle available for use.



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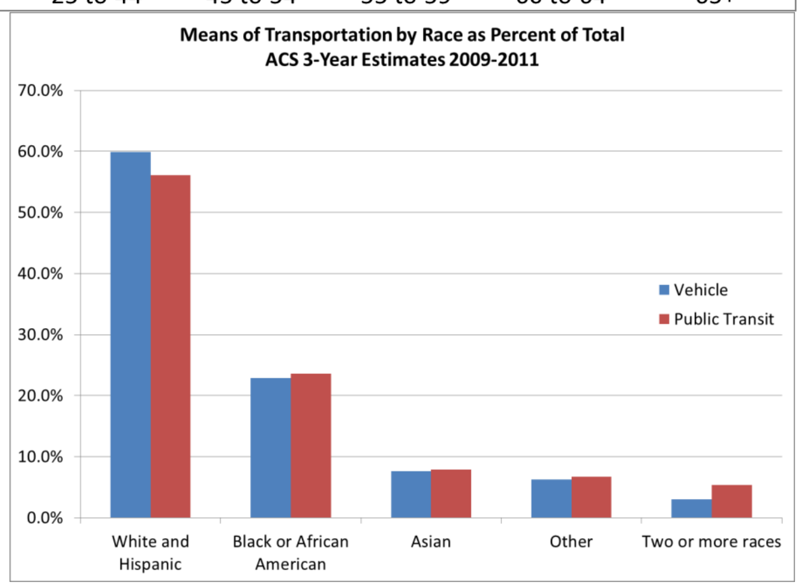
There exists a slight difference in the share of personal vehicle use as compared to the share of public transit, displaying the income inequality between the races in Boston. As a low-cost and efficient means of transportation, bicycle commuting is more popular among lower-income populations. Data were not available for the differences in bicycle ridership among races.



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2.3 BICYCLE INFRASTRUCTURE AND SAFETY

The Boston community has several districts with dynamically varied levels of bike infrastructure. Communities such as Jamaica Plain, Roxbury and Brighton have among the highest bike use rates and access to goods and services, while communities like East Boston and Mattapan are fairly isolated and restrict widespread bike use. Many communities show promise of becoming more bike-friendly with simple improvements to the roadways and bike culture. The communities with higher bike share consistently have higher accident rates, namely Brighton, Dorchester, and Roxbury. Several of the highest and lowest-rate bicycling communities are outlined below to explain the difference in facilities across the city, and the effect of facilities on bike culture and permeation.

DOWNTOWN BOSTON

The downtown area has just a few miles of bike lanes and is dominated by pedestrian, vehicle, and public transit use. Bicycling in the downtown area is generally safe due to lower travel speeds, large roads and one-way streets with generous space for travel lanes.

DORCHESTER

There are a significant number of complex intersections along major bike and car thoroughfares in Dorchester such as Dorchester Ave, Washington Street, and Columbia Road. The access to public transit in Dorchester is above average, and the MBTA Red Line provides bike accommodations during non-peak hours. There are few bike rack-equipped bus routes in the neighborhood, making combined bus and bike commuting difficult. The lack of east to west bike routes make connections to Jamaica Plain, Mattapan, and Roxbury difficult however the Neponset River Greenway and Harbor Paths make north-south connections more convenient (with some complex intersections). The infrastructure and connectivity problems and traffic conditions likely discourage less-experienced riders, yet Dorchester still has among the highest accident rates due to its large size and high rate of bike use coupled with unsafe riding practices, high traffic volumes and complicated intersections (17).

EAST BOSTON

The community of East Boston is highly isolated, accessible only by the Blue Line MBTA and by car. Within the community, bike use is low despite a relatively friendly biking environment given low traffic volumes and calm residential streets. No bike lanes, pavement markings, signage, bike parking, or bike shops were observed in the 2009 assessment by MassBike, however the community has benefited from recent investments by the City of Boston which provided bike parking and painted lanes at several locations (17). Despite the availability of public transport that supports bicycles, connectivity remains a significant issue in encouraging higher bike use. The lack of a bike-accessible route to downtown Boston and in other directions results in very low usage rates. The low crash rates are due to low rate of use in comparison with other communities.

JAMAICA PLAIN

Jamaica Plain has a large bicycling community and strong access to public transportation, bike facilities, and bicycle services and shops. Although many main thoroughfares have higher rates of speed (upwards of 35 mph) and many complex intersections and hilly areas, the availability of off-road paths and access to public transportation makes bicycling an attractive alternative in and around the area. The good connectivity to surrounding neighborhoods makes for convenient commuting to downtown, Longwood, Back Bay, and surrounding communities. The relatively high proportion of crashes is due to high use of bicycles and high traffic volumes with limited on-road bike facilities.

MATTAPAN

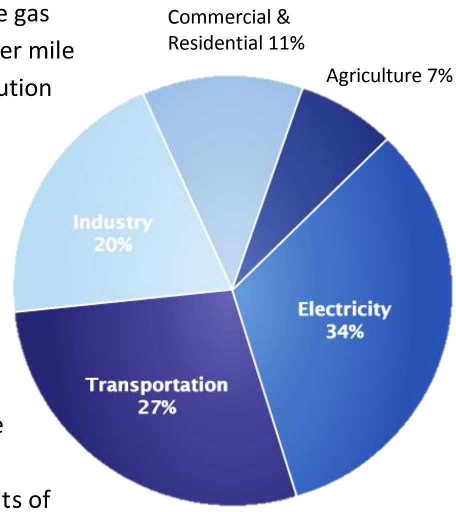
The Mattapan community, similar to East Boston, has low bicycling rates due to relative isolation from surrounding communities. Despite being one of the most impoverished communities in the Boston area, the complex intersections and high traffic volumes and travel speeds make bicycling relatively unsafe and inconvenient. Poor public transportation connections and lack of bus bike-racks make coupling bike and public transit difficult. A lack of on-road facilities, parking spaces, and bike shops and services discourage higher rates of ridership. The roadways in the Mattapan area are generally in more disrepair than most communities, and the dimensions are not large enough to permit safe bicycling in travel lanes on many streets including Blue Hill Ave, the main vehicle thoroughfare.

ROXBURY

Roxbury, similar to Jamaica Plain, has a high rate of bicycle use both as a destination for many cyclist and a thoroughfare for connections to other neighborhoods. With several colleges and hospitals in the community as well as high residential corridors and good access to public transit, Roxbury has a strong bicycling community. Streets like Huntington Avenue and Massachusetts Avenue have high use rates for both bicycles and vehicles and complicated intersections. Roadway conditions are a significant issue on Huntington Avenue, Mass Ave., and in the Southwest Corridor bike path which may discourage more riders from using the facilities. The good connectivity and access to public transportation are hampered only by low rates of bus routes with bike racks. A high concentration of college-age students and commuters results in high rates of ridership, in addition to the heavy traffic volumes in many key corridors of the community.

3. ECONOMIC EFFECTS OF BICYCLING

3.1 ENVIRONMENTAL



The environmental benefits of bicycling over car travel start with the gas consumption savings, which prevents up to 4 pounds of emissions per mile traveled. Vehicle exhaust is the largest single contributor of air pollution in the US. The exhaust from cars mixes carbon monoxide, sulfur dioxide, lead, hydrocarbons, and particulates into the air you breathe while sitting in a car, and the air you breathe walking near them or biking with them. Nationally, transportation accounts for more than a quarter of all greenhouse gas emissions (9). Vehicle emissions are highest in the first few minutes from starting while the car is still warming up – the “cold start” is responsible for up to 60% of pollution from autos (10). Since the majority of urban trips are within several miles, a significant proportion of greenhouse gasses can be prevented by traveling by bike instead of by car. As congestion due to vehicles increases time spent in traffic, the benefits of bicycling become even greater. Congestion times are increasing at a significantly faster rate than the population due to declining costs and availability of cars which is generating even greater quantities of emissions. In 1982 the average commuter wasted 5 gallons of fuel and 13 hours per year, as compared to 21 gallons and 47 hours in 2010 (almost 4-fold) despite just a 25% increase in population (11).

On one gallon of gasoline (the equivalent of 31,000 calories), a hybrid car can travel almost 50 miles. A human on a bicycle can travel upwards of 500 miles on 31,000 calories, or more than 12 times as far as one of today’s most efficient vehicles. The result is less greenhouse gas emissions or lower demands for fuel .

The manufacturing process for vehicles is very material-intensive, requiring high amounts of minerals such as aluminum, copper, lead, and nickel and manufactured steel, plastics, and rubbers. These raw materials are mined and processed around the world and shipped to global manufacturing plants, consuming massive amounts of energy along the way.

3.2 HEALTH AND SAFETY

There are a wide range of both physical and mental health benefits for bicycling. A regular bicyclist has decreased obesity, reduced risk of cardiovascular diseases, and improved respiratory function (3). Despite breathing in more than three times the amount of air than a driver, cyclists have improved respiratory function and are able to obtain a cleaner concentration of air than a driver enclosed in a car, who absorbs 60% more carbon monoxide (14). Tailpipe exhaust has been shown to contribute to certain types of cancer, heart disease, respiratory illnesses, nervous system disorders, emphysema, and birth defects. Bicycling burns between 500 to 1000 calories per hour depending on your physical condition and rate, while exercising your heart, lungs, and muscles and helping the digestive and immune systems (11). With over half adults and a growing percent of children overweight, the medical costs continue to increase to over $100 billion today (13). Most adults do not get adequate exercise which bicycling provides, and the inactivity of adults is a factor in 10% of deaths and 25% of chronic disease related deaths (3).

The Safety in Numbers theory which seems to apply in most all bicycle scenarios indicates that as ridership increases, safety will also increase. This can be seen in comparison of the US and European countries, where ridership is higher and safety is also better vs. the lower US rates. It can also be displayed between cities in the US, where standouts like Portland Oregon and New York City have experienced improved safety numbers for all forms of transportation with increased bicycle per capita ridership (4). A higher concentration of cyclists makes motorists more accustomed to the movements and habits and encourages driving more cautiously around interactions.

Mental benefits include improved well-being, self-esteem, confidence, and ability to perform active tasks.

3.3 FINANCIAL

For trips within 5 miles, cyclists can often go from A to B in the same amount of time or less than if a car had been taken. The bicycling alternative eliminates any parking charges and loss of time due to congestion when driving. There are also the long-term benefits and reliefs from cars that can provide thousands of dollars of relief for residents. With the growth of carshare programs like Zipcar, it is becoming easier to own less cars or none at all without significant restriction in activity. Capital costs and depreciation of the vehicle aside, a cyclist can save up to $4,000 a year from auto expenses.

EXPENSE	*BICYCLE*	*PERSONAL VEHICLE*
Capital Cost	$100	$10,000
Maintenance and Repair Fees	$75/yr	$1,000/yr
Gasoline	-	$500 - 1,000/yr
Insurance Premiums	-	$1,000 - 2,000/yr
License and Registration Fees	-	$0-250/yr
Property Tax		Varies

3.4 LAND USE AND URBAN PLANNING

TABLE 1 Average Customer Expenditures by Mode of Travel and Type of Establishment

Mode	Establishment	Trips per Month	$ per Trip	$ per Month	*N*
Auto	Bar	1.6	25.55	40.21	88
	Convenience	9.9	7.98	79.37	543
	Restaurant	2.2	18.74	41.16	409
	Total	4.5	13.70	61.03	1,040
Bike	Bar	4.9	14.08	68.56	42
	Convenience	14.5	7.30	105.66	63
	Restaurant	3.5	12.08	42.52	48
	Total	7.1	10.66	75.66	153
Transit	Bar	1.8	19.54	35.35	13
	Convenience	10.9	6.91	75.62	53
	Restaurant	3.5	11.52	40.68	36
	Total	5.7	10.15	58.16	102
Walk	Bar	3.1	22.17	68.42	53
	Convenience	12.6	6.13	77.34	254
	Restaurant	2.6	16.74	43.77	131
	Total	5.9	11.25	66.22	438

In addition to a ten-fold decrease in required space for bicycle facilities compared with vehicle space, the creation of bike facilities encourages riders to make more frequent trips to local stores, and also increases bike sales and the demands for bike stores and shops (26). Installing bike facilities is also significantly less material-intensive, requiring only paint and signs in many instances. A city can add new capacity for cyclists at a fraction the cost and space of new capacity for vehicles, and with similar economic benefits. Cyclists take more trips, and are using the saved money for other goods and services in their communities (26).

Cycle facilities have shown to also increase home prices in the area. The increased accessibility by this form of transportation is of great interest to families and in establishing a desirable community environment (26). The difference between a property on or near a bike path and one more than a mile away can be very significant, provided up to 10% higher property value (27).

4. UNINTENDED CONSEQUENCES

The evolution of transportation in Boston has and will continue to yield both expected and unexpected results. As we see more bike facilities installed, the use rates have been increasing and the accident rates decreasing. Bicycle infrastructure presents an economically simple form of transportation as compared with the use of a vehicle, which entails a much wider range of externalities and factors of use. The bicycle dynamics are more straightforward in that there are less associated costs and variables for determining expected behaviors. However, there are some instances where theory and actual use conflict and present unanticipated issues both good and bad.

The Vehicle Safety Act of 1966 required new safety standards for automobiles, which had just a small effect in decreasing the death rates among occupants. Additionally, this requirement was followed by a long-term increase in pedestrian and bicyclist death rates by motor vehicle accidents. Both these facts can be explained by the theory of risk compensation, wherein making it safer to operate a car entices individuals to travel at faster speeds and drive more recklessly, since they have a heightened sense of safety. The faster travel has resulted in higher accident and severity rates among other road users while preserving the occupants. Such mandated safety features have shown to at times have the inverse effect on risk-taking than they are designed for, which is one argument against a legal requirement for helmets. Requiring the use of a helmet may or may not have an effect on ridership, however the built environment is perhaps the biggest factor in determining who will use bike transportation.

The effect of creating a safer bicycling environment may be that some riders take more risks, as experienced when drivers are provided safer conditions. These improvements will enable cyclists to feel more comfortable traveling at higher rates of speed, putting more risk into potential crashes and liability for anyone else involved in a crash. That bike riders already are less responsive to signage and lights suggests that a cyclists' behavior would tend to travel as quickly as possible (26).

Building bike share also has the consequence of increasing variable peak loads for vehicles and public transit systems when bike travel is dangerous or otherwise difficult, such as in the case of a storm when these systems are already subject to increased loads and congestion issues. The result is lower average demands on the car and transit systems, but higher peaks during bad weather events. A dynamic and responsive public transit system is required to overcome swings in travel share for such instances.

An unintended consequence of the transition to more fuel efficient cars has been a reduction in the noise they emit, which is often helpful for cyclists to gauge proximity to a vehicle behind or otherwise out of sight. Hybrid vehicles are 57% more likely to be involved in a bicycle crash than a standard internal combustion vehicle (5).

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