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The Impacts of Commuter Rail in Greater Boston

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Since the 1970s, when it took over formerly private commuter rail lines in greater Boston, the Massachusetts Bay Transportation Authority (MBTA) has spent several billion dollars to sustain, improve, and operate the region's commuter rail system. Moreover, the MBTA is considering several more major commuter rail projects, most notably an almost $700 million project to extend commuter rail service to Fall River and New Bedford.

These investments have many justifications, including reducing congestion, improving accessibility to jobs in downtown Boston, revitalizing communities, and encouraging denser, transit-oriented development patterns. But have the investments had the desired effects?

To answer this question, I used Geographic Information Systems (GIS) and a network dataset to define areas within 5 and 10 minute drives of all current or former commuter rail stations in greater Boston and then to see how those areas changed between 1970 and 2000. These included 66 stations that have been open since the 1970s, 45 stations opened between 1970 and 2000, 39 stations closed since 1970, and 10 stations in the Needham commuter rail line closed from 1979 to 1987 because it could not be used while the Orange Line was being relocated to a corridor formerly used only for commuter and intercity rail. (See Appendix for a full list of stations in this study.)

In general, all these comparisons showed that investments in commuter rail had small, but generally positive, impacts on nearby areas. Specifically:

Transit Ridership: In 2000, between 11 and 21 percent of the employed adults in areas near commuter rail stations used transit to get to work, more than the 8 percent of all workers in greater Boston (which I defined as all areas within an hour's drive of downtown Boston),[1] but roughly the same as residents of areas that lost commuter rail service after 1970. Moreover, as in greater Boston, areas that had, gained, or lost transit all saw the share of people using transit to get to work drop in the 1970s and 1980s and rise in the 1990s. However, compared to greater Boston and to areas that lost service after 1970, areas that had or gained rail service lost a smaller share of riders in the 1970s and 1980s and many, but not all, gained a larger share of riders in the 1990s.

Land Use: As in the region as a whole, more than 85 percent of the land uses in areas that had, gained, or

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Eric Beaton received a Master in Urban Planning from Harvard's Graduate School of Design in 2006 and is now working as a Project Manager for the New York City Department of Transportation. This policy brief is based on "Commuter Rail and Land Use," a paper by Beaton that received the Howard T. Fischer Prize in Geographical Information Science (GIS), an annual award given to the best use of GIS by Harvard University graduate student. The full paper is available online at http://www.ksg.harvard.edu/rappaport/downloads/beaton.pdf.

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lost rail service did not change between 1971 and 1999. However, there were differences in the types of changes in each category. Most notably, between 1971 and 1999, more medium-density housing and commercial buildings were built in areas that gained commuter rail. Areas near stations that were closed also had higher rates of commercial development.

Commuter rail is most likely to impact land use patterns when it is explicitly and clearly linked to local and regional policies for land use and development.

Population Density: Areas that had, gained or lost rail service are significantly denser than the region as a whole. However, density levels do not seem to be affected by the introduction or removal of commuter rail. They did not increase significantly in areas near new rail stations and they did not decrease in areas when nearby stations were closed. While densities did not change dramatically in any area, from 1970-2000, density increased on a percentage basis most rapidly in the region as a whole, followed by areas near stations that opened in the 1990s and areas close to stations that were always open. Looking only at the 1990s, densities in areas near active commuter rail stations generally did increase slightly more than for the region as a whole. Finally, there was wide variation in densities among the different study areas and the densest areas were most likely to have a higher share of people using transit to get to work.

Income: Average household incomes in almost all areas that had, gained, or lost service are either higher or roughly equal to incomes in the region as a whole. The most affluent areas are those that have always had service or that lost service, while areas particularly close to stations that opened in the 1980s and 1990s generally have slightly lower incomes than the region as a whole. In the 1970s all areas in the study group did much worse than the region as a whole but that pattern generally reversed in the 1980s and 1990s. Higher incomes are also weakly correlated with lower transit use.

Taken together, these findings suggest that commuter rail is associated with small, but generally positive, impacts. However, data showing positive impacts in relatively dense areas that lost transit service since 1970 also suggest that at least some of these positive impacts are due to the character of areas that grew up around railroad stations before the advent of automobiles. This finding suggests that commuter rail is most likely to impact land use patterns when it is explicitly and clearly linked to local and regional policies for land use and development.

Background and Methodology

Like in many older cities, the network of towns surrounding Boston grew significantly with the railroad age, but by the 1950s, private railroads no longer found commuter rail service profitable. In the late 1950s and early 1960s, after federal legislation prevented states from forcing railroads to provide local passenger rail service, the railroads abandoned many unprofitable lines. Although the state initially responded by subsidizing some private operators, in 1973 it took over the Boston and Maine Railroad's lines, which ended at North Station and in 1976, it did the same for Penn Central's lines, which ended at South Station. Since that time, the state and federal government have spent several billion dollars to rehabilitate stations, buy new rolling stock, and upgrade tracks. The state also invested hundreds of millions of dollars in new service, opening 11 new stations in the 1970s, 9 in the 1980s, and 25 in the 1990s. In addition, ten stations were closed from 1979 to 1987 to accommodate the relocation of the Orange Line

into what had been a commuter rail corridor, and 39 stations have been closed since 1970. (See Appendix and Figure 1)

These changes make it possible to explore whether areas around stations that saw different fates changed in different ways. To answer this question, I first researched the history of each current and former MBTA station. Next, I defined the area "around" each station. In the past, this was often done by drawing an equidistant circle surrounding the station, which has the obvious flaw of ignoring actual development patterns, particularly the specific roads that provide access to the stations. Instead, I used a GIS computer program to define areas within a 5- and a 10-minute drive of each station, based on the actual street layout and speed allowed on each road and, in doing so to define areas that had gained or lost service in the 1970s, 1980s, and 1990s.

I then used the areas as ways to differentiate two sources of information. The first is data about land use provided by Mass GIS for 1971, 1985, and 1999. This information derives from a sophisticated analysis of aerial photos of the entire state, categorizing each section as a certain form of land use for each of those three years.[2] In addition, information about transit use, population density, and household income is available at the tract level from the long form of the US Census for each decade starting in 1970.[3] I imported this information into the GIS program I used to determine service areas.

Results

Public Transit Ridership: Ridership is the most obvious measure of whether commuter rail has had a significant impact on the region. The first way to assess this impact is via total ridership. Like everywhere across the United States and much of the rest of the world, public transit ridership (as measured in the U.S. Census by people using transit to get to work) fell sharply in the 1970s but, as in many regions, rebounded in the 1990s. The rebound in transit usage, however, has been uneven. Total ridership is higher in 2000 than in 1970 only in areas that have always had commuter rail service, areas that gained service in the 1990s, and areas 10 minutes from stations that closed after 1970.[4] (See Table 1) Ridership has not increased in areas near stations built between 1970 and 1990, nor in areas near stations that were temporarily closed from 1979 to 1987.

The share of commuters using transit in areas near stations that closed after 1970, for example, has consistently been higher than the share for those who live near stations that have always been open.

A second way to gauge commuter rail's impact on ridership is to examine whether an unusually high share of workers in areas with commuter rail use transit to get to work and whether the introduction or removal of commuter rail significantly affected that figure.

Transit's share of all work trips in greater Boston and most other urban areas has declined since the 1970s.While lines in greater Boston that had, gained, or lost commuter rail service all followed this general pattern, transit use in those areas was always higher than in the region as a whole. (See Table 2) However, areas with high rates of commuting by transit are not always those with commuter rail service. The share of commuters using transit in areas near stations that closed after 1970, for example, has consistently been higher than the share for those who live near stations that have always been open. Additionally, while transit use is high in some areas near stations that opened after 1970, it was high in the years before those stations opened.

While all the study areas generally followed regional trends, it does appear that the presence of commuter rail may have slightly mitigated downturns in ridership and slightly amplified upturns. Illustratively, in the 1970s and 1980s, the region as a whole lost a greater proportion of its transit riders than any of the study areas. (See Table 3) In the 1990s, the region as a whole gained back a smaller share than some but not all of the study areas, including areas that both gained and lost commuter rail service after 1970.

About 90 percent of the land in the region and in areas that either gained or lost commuter rail service had the same land use in 1999 that it did in 1971.

Land Use: As with ridership, commuter rail service has only a modest impact on land uses in areas near commuter rail stations. In fact, data in the Mass GIS database indicates about 90 percent of the land in the region and in areas that either gained or lost commuter rail service had the same land use in 1999 that it did in 1971, a figure that rises to 95 percent for 1985 to 1999. (See Tables 4 and 5)

For the 1971 to 1999 period, there were variations in how land uses changed in different areas. (See Figure 2) Many of the changes mirrored those in the region as a whole, though with certain exceptions. Compared to the region as a whole, there was a higher share of open space converted to commercial uses in areas within five minutes of a station that opened after 1970 and areas 10 minutes from stations that closed after 1970. In addition, a higher share of land was converted from open space to low-density housing in areas within 10 minutes of a closed station while a lower share of land was converted from open space to low-density housing in areas within five minutes of new stations. A lower share of land was converted from open space to medium-density housing in areas within 10 minutes of closed stations.

Many of these patterns also held for the period between 1985 and 1999. (See Figure 3) Compared to the region as a whole, more land was converted from open space to commercial uses in areas within five minutes of stations that closed and, to a slightly lesser extent, stations that opened after 1970. While no area matched the region's rate of converting open space to low-density residential uses, areas within 10 minutes of new stations had a higher rate of such conversions than any other area. In contrast, only areas within 10 minutes of a closed station saw a lower share of land converted from open space to medium-density uses than in the region as a whole.

Land use maps do not reveal whether existing structures are being used more efficiently. Vacancy rates, however, do provide that information. Those rates are slightly lower in areas that developed around commuter rail stations, whether or not that area still had active commuter rail service. However, the differences are relatively modest. In 2000, the region's vacancy rate was about 4.4 percent, while vacancy rates for areas near commuter rail stations ranged from 2.7 percent (in areas within five minutes of a station closed in the 1970s) to 4.4 percent (for areas within five minutes of a station opened in the 1990s). Somewhat similarly, in 1990, the regional vacancy rate was 7 percent while vacancy rates in areas near existing, planned, or former commuter rail stations ranged from 4.1 percent (in areas within five minutes of stations closed in the 1970s) to 7.4 percent (in areas within five minutes of a station opened in the 1980s).

Population Density: If people value commuter rail service, then more people might choose to live near commuter rail stations. If this did

occur, then the population density around stations might change in ways that were different than the region as a whole.

All the areas that had, gained, or lost rail service are denser than the Boston region as a whole. Moreover, areas that gained rail service in the 1970s and 1980s, as well as areas near stations temporarily closed for the Southwest Corridor, are significantly denser than areas near stations that have always been open, stations opened in the 1990s, and stations closed after 1970. (See Table 6)

Moreover, density turns out to be highly correlated with transit ridership, much more than the presence or absence of commuter rail. (See Table 7) Within this framework, it is not clear whether the presence of commuter rail produces more transit riders. In 2000, densities were similar in areas within five minutes of stations that have always been open, that opened in the 1990s, or that closed after 1970. The share of people in these areas using transit to get to work, however, varied widely with areas that lost service, having a lower share than areas that gained service in the 1990s, but a lower share than areas that have always had service.

Looking at rates of change, there is little evidence that the presence or introduction of commuter rail has produced significant increases in density. Rather, in the 1970s and the 1980s, densities in the region as a whole increased while densities decreased or increased only slightly in areas around commuter rail stations. (See Figure 4) In the 1990s, by contrast, densities increased in the region and in areas that had, gained, or lost rail service. But densities increased fastest in the region, followed by areas that gained service in the 1990s, and areas that always had rail service.

Income Effects: The presence or absence of commuter rail service could lead to demographic changes in areas near commuter rail stations. If rail is attractive and housing supplies near stations are limited, then areas near active stations might become more affluent. Conversely, the increased possibilities for non-auto based transportation might attract families that are relatively less well off, because car use would be a greater percentage of their income, and they have lower values of time as measured as a percentage of their hourly wage.

Neither seems to be the case. Household incomes in some areas always served by commuter rail are higher than average household incomes in the region, but incomes are lower than the regional average in some areas that gained service as well. (See Table 8) Incomes in areas that lost service are higher than in both the region and areas that currently are close to commuter rail stations. Over the last three decades, the relative rankings of the various areas generally did not change after rail service was introduced or removed.

Density turns out to be highly correlated with transit ridership, much more than the presence or absence of commuter rail.

In addition, while real incomes in the region dropped in the 1970s, they declined less sharply in the region as a whole than in areas that had, received, were going to get, or lost commuter rail service. However, in the 1980s and 1990s, this pattern reversed. Real incomes rose in the region but the growth in areas that had, gained, were about to gain, or lost commuter rail service was generally higher than in the region, suggesting that land use patterns oriented around rail stations are attractive to higher income persons, whether or not those areas are well served by rail. (See Figure 5)

Finally, there is a negative correlation between household income and transit use, though this correlation is weaker than the population

density-transit use correlation. (See Table 9) Moreover, even within this limited sample, there are outliers, most notably the region as a whole, which has much lower transit ridership than incomes would suggest. While the correlation becomes stronger if the region as a whole is excluded, it is still not as strong as the correlation between population density and transit ridership.

Efforts to increase density, reduce sprawl, and promote transit should start with local or regional land use policies and then link those policies with transportation plans.

Conclusion

The data show that development patterns are governed by the dominant forces of the day. In the late 19th and early 20th centuries, commuter rail service played a major role in shaping the land uses in the communities it served. But that does not seem to be the case today. Rather, the large investments in commuter rail have had, at best, modest positive impacts on ridership and land uses.

In contrast, some land use patterns originally created by commuter rail lines have had positive and enduring impacts. Many of those areas are often denser, more affluent, and have higher rates of transit ridership, regardless of whether they currently have commuter rail service. In fact, areas that have had service since before 1970 generally are less dense and have a lower share of commuters using transit than many areas that either gained service in the 1970s and 1980s or that lost service after 1970.

Looking to the future, this means that providing new commuter rail facilities is not likely to produce significant changes in travel and land use patterns. Increases in density, on the other hand, might result in a higher share of people using transit to get to work. The data strongly suggest that commuter rail service can encourage but not spur these changes. This, in turn, suggests that efforts to increase density, reduce sprawl, and promote transit should start with local or regional land use policies and then link those policies with transportation plans.

Endnotes

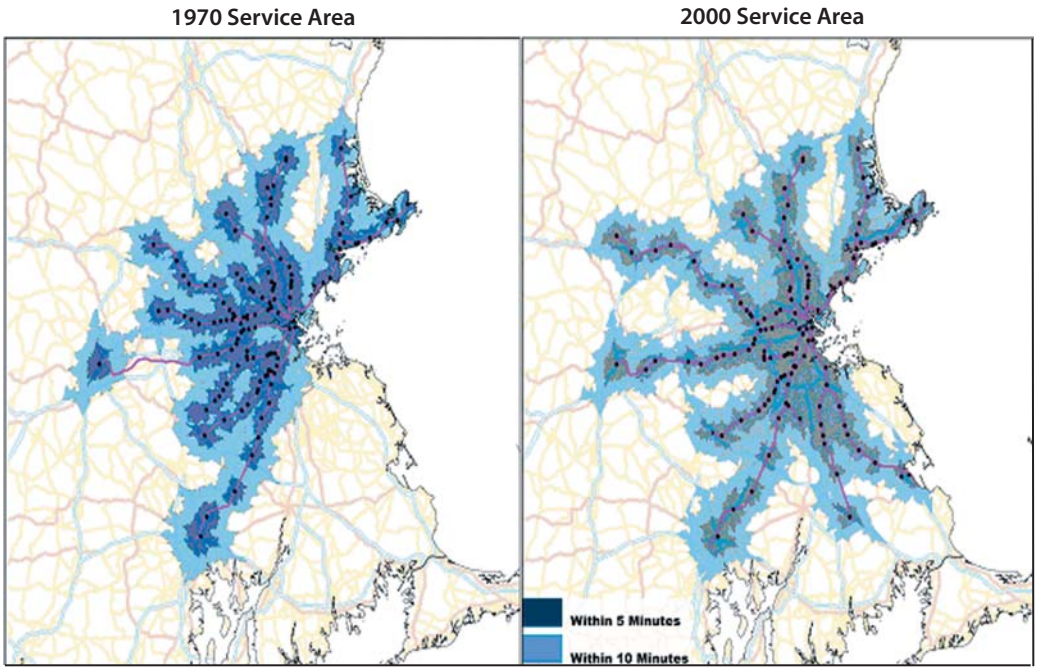
1. I used this definition of greater Boston rather than the Census Bureau's standard definitions of the region because the Census Bureau considers some areas in southeastern Massachusetts that are served by commuter rail to Boston be part of the Providence metropolitan area not the Boston metropolitan area.

2. Information on the land use data is available at http://www.mass.gov/mgis/landuse_stats.htm

3. Census data came from the US Census Long Form at the tract level, normalized to year 2000 boundaries via Geolytics brand software. More information on this process is available at http://www.gsd.harvard.edu/gis/manual/censuscd/ncdb_docs/index.htm. A more detailed explanation of the methodology is available in my longer paper, which is online at http://www.ksg.harvard.edu/rappaport/downloads/beaton.pdf.

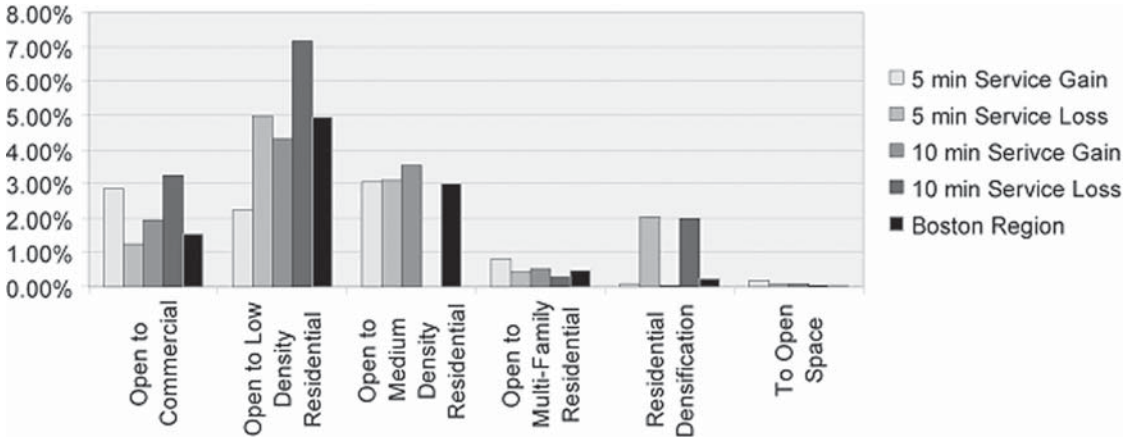
4. Note that data in this paper does not include the census tracts that are listed as being near North Station, South Station, or Back Bay station, because transit ridership in those areas would more likely be by subway not commuter rail. Farther out in the suburbs, commuter rail is the primary form of public transit available.

Figure 1: Service Areas for Rail Service



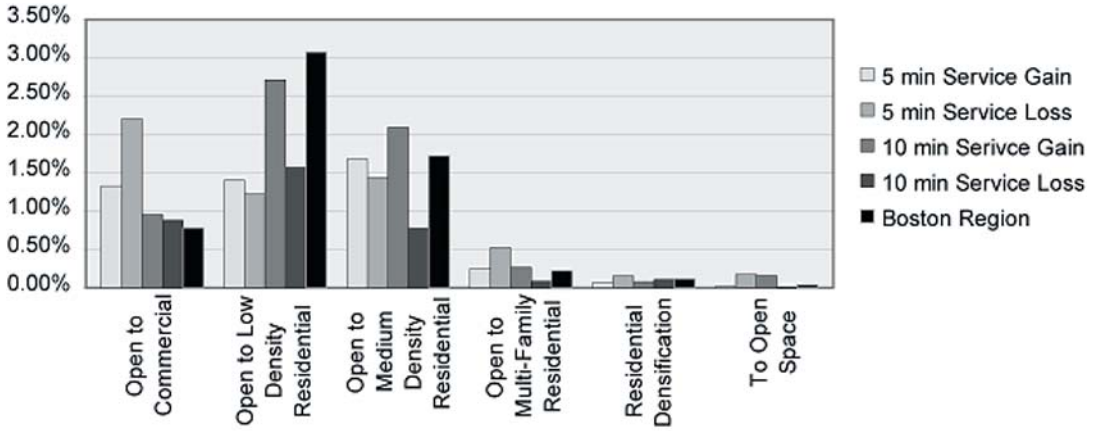
Sources: ESRI Roads Database, Mass GIS Commuter Rail Locations, Boston CTPS, and author's calculations

Figure 2: Selected Land Use Changes, 1970 - 2000



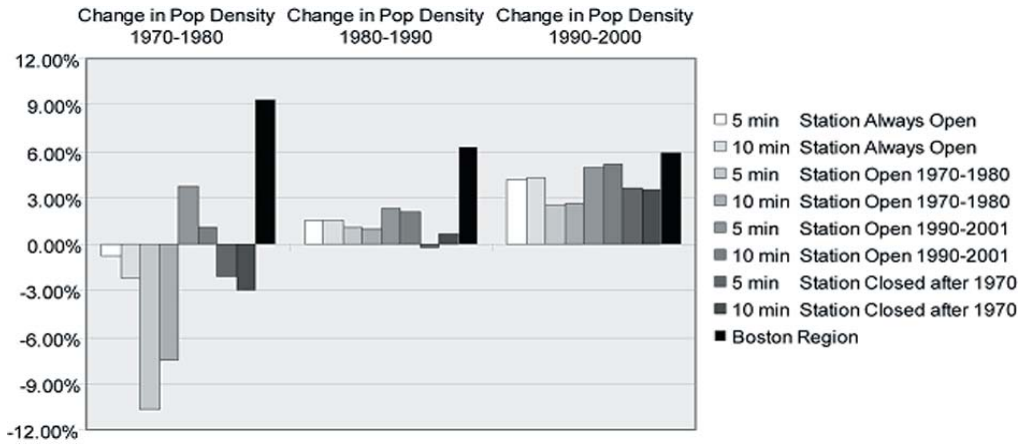
Sources: Mass GIS Land Use Database and author's calculations

Figure 3: Selected Land Use Changes, 1980 - 2000



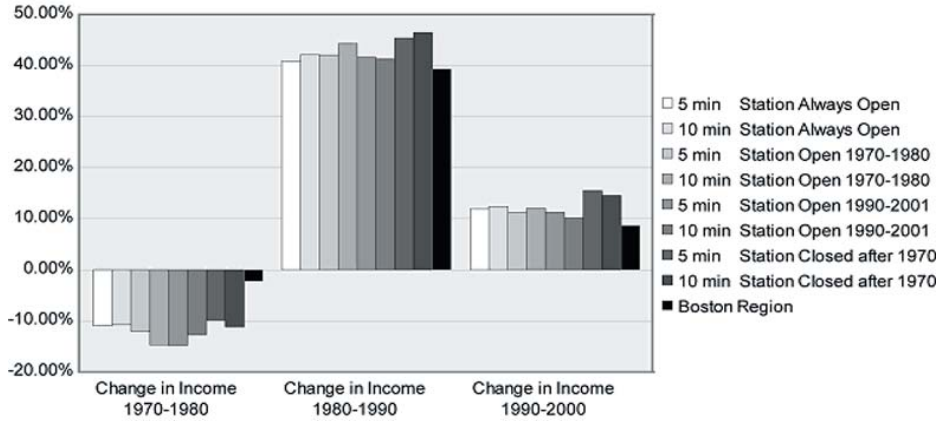
Sources: Mass GIS Land Use Database and author's calculations

Figure 4: Percentage Change in Population Density Per Decade



Sources: US Census Long Form Tracts and author's calculations

Figure 5: Percentage Change in Average Household Income, in Year 2000 Dollars



Sources: US Census Long Form Tracts and author's calculations

Table 1: Number of People Commuting by Transit (per day)

5 min	10 min	Travel By Transit 1970	Travel By Transit 1980	Travel By Transit 1990	Travel By Transit 2000	Changes in Transit Use 1970 - 1980	Changes in Transit Use 1980 - 1990	Changes in Transit Use 1990 - 2000	Changes in Transit Use 1970 - 2000
Station Always Open		282,846	263,477	273,096	306,504	-19,369	9,619	33,408	23,658
	Station Always Open	1,214,096	1,109,281	1,169,028	1,263,135	-104,815	59,747	94,107	49,039
Station Open 1970-1980		177,083	145,713	142,746	146,966	-31,370	-2,967	4,220	-30,117
	Station Open 1970-1980	523,684	468,593	485,982	513,263	-55,091	17,389	27,281	-10,421
Station Open 1980-1990		179,732	148,314	158,439	165,036	-31,418	10,125	6,597	-14,696
	Station Open 1980-1990	522,176	449,498	467,948	491,220	-72,678	18,450	23,272	-30,956
Station Open 1990-2001		169,187	164,548	167,684	185,243	-4,639	3,136	17,559	16,056
	Station Open 1990-2000	489,939	449,220	456,534	511,524	-40,719	7,314	54,990	21,585
Closed for SW Corridor		145,320	113,723	113,303	112,629	-31,597	-420	-674	-32,691
	Closed for SW Corridor	607,270	521,945	535,069	547,085	-85,325	13,124	12,016	-60,185
Station Closed After 1970		232,991	211,674	203,514	223,085	-21,317	-8,160	19,571	-9,906
	Station Closed After 1970	1,051,804	979,755	1,020,620	1,090,270	-72,049	40,865	69,650	38,466
Boston Region		2,757,360	2,487,170	2,503,170	2,748,000	-270,190	16,000	244,830	-9,360

Sources: US Census Long Form Tracts and author's calculations

Table 2: Share of People Using Transit to Get to Work

5 min.	10 min.	Travel By Transit 1970	Travel By Transit 1980	Travel By Transit 1990	Travel By Transit 2000
Station Always Open		13.5%	11.1%	9.6%	10.6%
	Station Always Open	17.0%	13.8%	12.0%	12.9%
Station Open 1970-1980		28.5%	23.2%	18.6%	19.4%
	Station Open 1970-1980	27.0%	23.1%	19.7%	20.8%
Station Open 1980-1990		29.1%	23.7%	20.3%	21.0%
	Station Open 1980-1990	27.6%	22.8%	19.4%	20.2%
Station Open 1990-2001		21,2%	17.7%	14.5%	15.5%
	Station Open 1970-1980	20.3%	16.4%	13.5%	14.7%
Closed for SW Corridor		25.6%	20.3%	17.1%	17.4%
	Closed for SW Corridor	29.0%	24.6%	20.9%	21.7%
Station Closed After 1970		18.0%	14.3%	11.6%	12.8%
	Station Closed After 1970	20.8%	17.3%	14.9%	15.9%
Boston Region		13.6%	9.9%	7.9%	8.3%

Sources: US Census Long Form Tracts and author's calculations

Table 3: Proportional Change in Transit Use, By Decade

5 min.	10 min.	Change in Transit Use 1970 -1980	Change in Transit Use 1980 - 1990	Change in Transit Use 1990 - 2000
Station Always Open		-21.89%	-15.87%	9.79%
	Station Always Open	-23.18%	-14.29%	6.45%
Station Open 1970-1980		-22.76%	-24.88%	4.17%
	Station Open 1970-1980	-16.93%	-17.50%	5.39%
Station Open 1980-1990		-22.87%	-16.81%	3.29%
	Station Open 1980-1990	-20.96%	-17.82%	4.02%
Station Open 1990-2001		-19.94%	-21.64%	6.27%
	Station Open 1970-1980	-23.96%	-21.55%	8.12%
Closed for SW Corridor		-26.05%	-19.05%	1.78%
	Closed for SW Corridor	-17.58%	-18.13%	3.83%
Station Closed After 1970		-25.88%	-22.51%	8.92%
	Station Closed After 1970	-20.81%	-15.46%	6.21%
Boston Region		-37.58%	-25.63%	4.83%

Sources: US Census Long Form Tracts and author's calculations

Table 4: Changes in Land Uses, 1971 - 1999

	5 min. Gain of Service		Loss of Service		10 min Gain of Service		Loss of Service		Boston Region	
	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole
No Change	287.99	90.21%	11.50	87.88%	506.30	89.03%	116.77	85.04%	3318.19	89.35%
Open to Commercial	9.16	2.87%	0.17	1.28%	11.16	1.96%	4.43	3.23%	57.97	1.56%
Open to Low Density Residential	7.10	2.22%	0.66	5.01%	24.56	4.32%	9.84	7.17%	184.40	4.97%
Open to Medium Density Residential	9.75	3.06%	0.41	3.12%	20.23	3.56%	0.00	0.00%	111.15	2.99%
Open to Multi-family Residential	2.65	0.83%	0.06	0.42%	3.09	0.54%	0.42	0.31%	17.67	0.48%
Residential Densification	0.28	0.09%	0.27	2.04%	0.35	0.06%	2.72	1.98%	8.11	0.22%
Residential Dedensification	0.01	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.03.	0.00%
Commerical to Low Density Residential	0.08	0.02%	0.00	0.01%	0.01	0.00%	2.93	2.13%	0.43	0.01%
Commercial to Multi-family	0.04	0.01%	0.00	0.03%	0.05	0.01%	0.00	0.00%	0.35	0.01%
Residential to Commercial	0.50	0.16%	0.00	0.03%	0.42	0.07%	0.07	0.05%	2.65	0.07%
New Road/Rail	1.05	0.33%	0.01	0.07%	1.92	0.34%	0.06	0.04%	11.36	0.31%
To Open Space	0.64	0.20%	0.01	0.09%	0.59	0.10%	0.07	0.05%	1.32	0.04%
SUM	319.25	100%	13.09	100%	568.68	100%	137.31	100%	3713.63	100%

Sources: Mass GIS Land Use Database and author's calculations

Table 5: Changes in Land Uses, 1985 - 1999

	5 min. Gain of Service		Loss of Service		10 min Gain of Service		Loss of Service		Boston Region	
	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole	Sq. Mile	% of Whole
No Change	306.54	95.12%	6.56	94.28%	53.32	93.56%	41.24	96.48%	3485.97	93.90%
Open to Commercial	4.28	1.33%	0.15	2.21%	0.54	0.95%	0.38	0.88%	29.00	0.78%
Open to Low Density Residential	4.52	1.40%	0.09	1.22%	1.55	2.71%	0.67	1.57%	114.24	3.08%
Open to Medium Density Residential	5.42	1.68%	0.10	1.44%	1.19	2.09%	0.33	0.77%	63.99	1.72%
Open to Multi-family Residential	0.79	0.25%	0.04	0.52%	0.15	0.27%	0.04	0.09%	8.28	0.22%
Residential Densification	0.22	0.07%	0.01	0.16%	0.04	0.08%	0.05	0.11%	4.27	0.12%
Residential Dedensification	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.02	0.00%
Commerical to Low Density Residential	0.01	0.00%	0.00	0.00%	0.00	0.01%	0.00	0.01%	0.44	0.01%
Commercial to Multi-family	0.06	0.02%	0.00	0.00%	0.00	0.01%	0.01	0.01%	0.19	0.01%
Residential to Commercial	0.21	0.07%	0.00	0.00%	0.03	0.05%	0.03	0.07%	1.50	0.04%
New Road/Rail	0.17	0.05%	0.00	0.00%	0.06	0.10%	0.00	0.00%	3.03	0.08%
To Open Space	0.06	0.02%	0.01	0.18%	0.09	0.16%	0.00	0.01%	1.37	0.04%
SUM	322.27	100%	6.96	100%	56.99	100%	42.74	100%	3712.31	100%

Sources: Mass GIS Land Use Database and author's calculations

Table 6: Population Density (Persons per Square Mile)

5 min.	10 min.	Population Density 1970	Population Density 1980	Population Density 1990	Population Density 2000
Station Always Open		1955.98	1940.90	1970.70	2056.66
	Station Always Open	2056.84	2012.74	2043.47	2134.96
Station Open 1970-1980		3284.13	2966.58	2998.39	3075.43
	Station Open 1970-1980	3224.06	2999.52	3030.60	3112.93
Station Open 1980-1990		3550.95	3278.08	3363.65	3510.40
	Station Open 1980-1990	3438.57	3206.11	3254.89	3383.28
Station Open 1990-2001		1808.81	1878.83	1923.11	2022.44
	Station Open 1970-1980	1702.83	1721.10	1758.83	1853.81
Closed for SW Corridor		3842.06	3478.38	3467.67	3601.97
	Closed for SW Corridor	4366.85	3989.98	3988.18	4848.47
Station Closed After 1970		1909.27	1870.60	1866.83	1937.08
	Station Closed After 1970	2343.57	2276.92	2291.80	2374.39
Boston Region		925.09	1020.26	1088.84	1158.10

Sources: US Census Long Form Tracts and author's calculations

Table 7: Population Density/Transit Use Relationship

5 min.	Population Density 2000	Travel By Transit 2000
Station Always Open	2056.66	10.62%
Station Open 1970-1980	3075.43	19.42%
Station Open 1980-1990	3510.40	20.98%
Station Open 1990-2001	2022.44	15.48%
Closed for SW Corridor	3601.97	17.37%
Station Closed After 1970	1937.08	12.78%
10 min.		
Station Always Open	2134.96	12.87%
Station Open 1970-1980	3112.93	20.78%
Station Open 1980-1990	3383.28	20.17%
Station Open 1990-2001	1853.81	14.65%
Closed for SW Corridor	4848.47	21.68%
Station Closed After 1970	2374.39	15.93%
Boston Region	1158.10	8.28%

Sources: US Census Long Form Tracts and author's calculations

Table 8: Average Household Income (Constant 2000 Dollars)

5 min.	10 min.	Average Household Income 1970	Average Household Income 1980	Average Household Income 1990	Average Household Income 2000
Station Always Open		$55.450.90	$49,365.72	$69,558.19	$77,871.28
	Station Always Open	$55,047.76	$49,145.60	$69,642.60	$66,351.36
Station Open 1970-1980		$47,760.86	$41,992.26	$59,642.60	$66,351.36
	Station Open 1970-1980	$50,572.40	$43,140.92	$62,260.37	$69,771.58
Station Open 1980-1990		$44,041.45	$37,928.42	$54,419.40	$60,416.87
	Station Open 1980-1990	$47,593.89	$41,251.91	$59,284.16	$66,371.18
Station Open 1990-2001		$46,370.72	$39,489.65	$55,923.35	$62,224.99
	Station Open 1970-1980	$49,066.03	$42,824.99	$60,514.47	$66,687.09
Closed for SW Corridor		$60,357.98	$52,113.53	$73,673.42	$81,600.14
	Closed for SW Corridor	$55,160.57	$47,148.55	$68,265.31	$76,813.49
Station Closed After 1970		$59,877.48	%53,975.68	$78,468.17	$90,637.73
	Station Closed After 1970	$57,011.30	$50,657.90	$74,186.17	$84,994.40
Boston Region		$44,236.47	$43,246.49	$60,241.43	$65,495.94

Sources: US Census Long Form Tracts and author's calculations

Table 9: Income/Transit Ridership Relationship

5 min.	Household Income 2000	Travel By Transit 2000
Station Always Open	$77,871.28	10.62%
Station Open 1970-1980	$66,351.36	19.42%
Station Open 1980-1990	$60,416.87	20.98%
Station Open 1990-2001	$62,224.99	15.48%
Closed for SW Corridor	$81,600.14	17.37%
Station Closed After 1970	$90,637.73	12.78%
10 min.		
Station Always Open	$78,535.06	12.87%
Station Open 1970-1980	$69,771.58	20.78%
Station Open 1980-1990	$66,371.18	20.17%
Station Open 1990-2001	$66,687.09	14.65%
Closed for SW Corridor	$76,813.49	21.68%
Station Closed After 1970	$84,994.40	15.93%
Boston Region	$65,495.94	8.28%

Sources: US Census Long Form Tracts and author's calculations

Appendix: Commuter Rail Stations in Greater Boston, 1970-2000

Stations Open Continuously	1970s Changes	1980s Changes	1990s Changes
Andover Attleboro Auburndale Ayer Ballardvale Beverly Deopt Beverly Farms Bradford Brandeis/Roberts Canton Junction Concord Endicott Framingham Franklin/Dean College Gloucester Greenwood Hamilton/Wenham Hastings Haverhill Ipswich Islington Kendall Green Lawrence Lincoln LIttleton/495 Lowell Lynn/Central Square Manchester Mansfield Melrose/Cedar Park Melrose/Highlands Monserrat Natick Newtonville Norfolk North Beverly North Billerica Norwood Central Norwood Depot Prides Crossing Porter Square Providence Reading Readville Rockport Route 128 Salem Sharon South Acton Swampscott Wakefield Walpole Waltham Wedgemere Wellesley Farms Wellesley Square West Concord West Gloucester West Medford West Newton Wilmington Winchester Center Wyoming Hill	**Stations Opened** Belmont Canton Center Fairmount Fitchburg Gardner Harbour (Gloucester) Morton Street North Leominster North Wilmington Stoughton Uphams Corner Waverley Windsor Gardens **Stations Closed** Arlington Beaver Brook Bedford Bellevue Charles River Cherry Brook Clematis Brook Cliquot Dover East Dedham East Foxboro East Lexington East Sudbury Farm Street Gleasondale HIghland Hudson Hyde Park Lake Street Lexington Malden Center Medfield Medway Millis Mt. Hope Munroe Needham Center Needham Heights Needham Junction Newburyport North Andover North Lexington Ordway Pierce's Bridge Roslindale Village Rustcraft Shawsheen South Sudbury Stone Haven Tower Hill Waltham Heights Waltham North Wayland West Acton West Medway West Roxbury Weston Winchester Highlands Worcester	**Stations Opened** Bellevue Chelsea Dedham Corp. Center Forest Hills Forge Park/495 Hersey Highland Hyde Park Malden Center Mishawum Needham Center Needham Heights Needham Junction Roslindale Junction Ruggles Shirley South Attleboro West Natick West Roxbury **Stations Closed** Cross Street Gardner Harbour (Gloucester) Pawtucket/Central Falls Plimpton Silver Hill Woburn	**Stations Opened** Abington Anderson/Woburn Ashland Braintree Bridgewater Brockton Campello Grafton Halifax Hanson Holbrook/Randolph JFK/UMass Kingston/Route 3 Middleborough/Lakeville Montello Newburyport Plimptonville Plymouth Quincy Center Rowley Silver Hill Southborough South Weymouth Westborough Whitman Worcester Yawkey

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