Property Value Impacts of Rapid Transit Accessibility in Boston

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ABSTRACT

This thesis evaluates the relationship between rapid rail transit accessibility and investment property values through a series of interviews, literature and report reviews, and a quantitative empirical analysis of over 1,000 investment property sales transactions. Theory tells us that within urban environments, proximity to rail transit generates value that accrues to the real estate owner. Initiatives in various municipalities across the world have attempted to tap into the value created by major projects to help finance infrastructure investment, but there has yet to be one method that is universally applied.

Major infrastructure improvements are expensive, time consuming, and challenging to deliver. While there are multiple hurdles to overcome in order to create an expansion or new rail project, finding funding sources is amongst the most difficult. A large focus of the thesis is understanding value creation along rail access nodes in pursuit of evaluating alternative financing sources. We take both a qualitative and quantitative approach to understanding the value creation, including the "announcement effect" prior to actual completion of the infrastructure project.

These issues are explored through an examination of the practices in the Boston Metropolitan Region. Specifically, we use a current, in-progress rail expansion, the Green Line Extension (GLX), to investigate the process of delivering a substantial infrastructure project and its impact on real estate value. Such projects have far reaching impacts and effects, so throughout the thesis we broaden the lens and highlight issues, ancillary benefits, and experiences of other cities that have endeavored to undertake similar projects.

Among our major quantitative findings, we observe that, within the Northwest Boston Basin (our focus area), having close proximity to operational rail rapid transit stations adds up to $48/SF, or nearly 39%, to property value, holding all else constant as best as data allows (including land use). We find some evidence that the GLX project may ultimately increase property values even more than this, as our study indicates that properties near planned GLX stations appear to have already increased substantially in value relative to otherwise similar properties subsequent to the announcement of specific planned station locations in 2008.

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We would like to thank all of the people we interviewed and met with to gather data and learn about this topic, and who allowed us to use their wisdom and insights to create this thesis.

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Introduction

This thesis will discuss the interaction between rapid transit rail infrastructure and real estate values in metropolitan areas, with a specific focus on Boston. Our instincts are that proximity to rail, within cities, creates explicit and implicit value, so this thesis will explore those concepts. In order to frame the discussion, we have researched and interviewed a wide range of sources in pursuit of understanding the process of bringing a large infrastructure project to life. When thinking about the inherent value creation, it is important to understand the process and time it takes before that value is able to be unlocked, which will be discussed in Chapter 1. Chapter 2 will focus on once the value has been unlocked, to whom does it accrue and what are some possible ways to capture a portion of the benefit to reinvest in the system? In Chapter 3, we will explore Boston as a useful example to highlight challenges that are external to a project, but important elements of the environment in which a project exists. And finally, Chapter 4 will walk through a quantitative example of explicit value created in investment properties in the Northwest Boston Basin, generally regarded as Cambridge, Somerville, and Medford, Massachusetts, based on proximity to a subway station. For the purposes of this study, investment properties are defined as multifamily, industrial, office, and retail assets. Our quantitative findings are based on an empirical sample of such property classes, and probably represent fairly well at least approximately the value impacts of similar user-owned properties. While this thesis will focus primarily on Boston, the take-aways and challenges can be applied to many cities. Additionally, we will try to draw from the experiences of other cities in support of our topic.

Why do we care about this topic? We are part of a generation that has come of age in the post-Great Recession era where cities are morphing into more dynamic places, the sharing economy is commonplace, and transportation challenges are a regular conversation starter. While trends and demographics can change, based on our current experiences, transit needs are critical to support the existing population of Boston and many other cities, so achieving a state of public transportation that meets the ongoing needs can be just as important to a city as planning for the continued growth in order to compete in the global economy.

"Seventy percent of humanity will likely live in cities by 2050. A limited number of creative, vibrant cities, however, will dominate the cultural and economic life of the planet by actively nurturing entrepreneurship and attracting the young, technology-savvy professionals who drive innovation and build new industries."[1] - Kent Larson, Director of the Changing Places research group and Co-Director of the City Science Initiative at the MIT Media Lab

Cities are growing up and becoming more vibrant, as people elect to live, work and play in the same place. "Instead of the 'bigger, better, faster, more' ethos of their parents, a slate of recent studies show that the rising Generation Y's and Millenials want 'smaller, closer, slower, more livable."[2] People are foregoing the multi thousand square foot homes in exchange for one thousand square foot lofts or condominiums. Many are getting rid of their cars or are only keeping a single vehicle for occasional use, opting instead for the convenience and affordability

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[1] Larson, Kent. "Flex Homes." Print. Rpt. in *City 2.0: The Habitat of the Future and How to Get There*. New York: TED Conferences, 2013. 914-93. Print.

[2] Stone, Rebecca Sanborn. "Guerilla Urbanism." Print. Rpt. in *City 2.0: The Habitat of the Future and How to Get There*. New York: TED Conferences, 2013. 802-95. Print.

of ride-sharing. "This move back into the city centers also coincided with the Great Recession. Those big houses and multiple cars, it turns out, were beyond many of our means."[3]

With this migration, however, are growing pains as cities try to expand as rapidly as the numbers of people trying to occupy them. Not only has this trend drawn more people to cities, but the generation coming of age is larger than our parent's generation, so there is no doubt that cities need to grow if they are to remain competitive in attracting this flood of new residents and employees - to be one of those creative, vibrant cities that dominate cultural and economic life. This influx into cities is driving housing costs up as the demand has outpaced supply. Developers are frantically constructing residential towers throughout cities trying to capitalize on this shortage. As people continue to move into cities, the public transportation infrastructure is utilized more heavily and, in many places around the world, has reached capacity. There is limited land area within current city limits, so cities are expanding outwards. Due to housing shortages, many people cannot afford to live in the center of the city so are pushed to neighboring communities. This bulging effect impacts transit as more people need to commute, although in many cases the public transit system does not serve all of the areas where residents seek to utilize the service. We have reached a critical point where improvements need to be made and quickly. Within the United States, "the [American Society of Civil Engineers] reports estimated that nearly 900,000 jobs were expected to be lost by 2020 due to the continued economic impacts of poor transportation infrastructure alone."[4]

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[3] Badger, Emily. "Share Everything." Print. Rpt. in *City 2.0: The Habitat of the Future and How to Get There*. New York: TED Conferences, 2013. 104-90. Print.

[4] Petroski, Henry. *The Road Taken: The History and Future of America's Infrastructure*. New York: Bloomsbury USA, 2016. Print, 243.

So how can we fix the system? It's a very large question and there is no right or easy answer, unfortunately. According to the same ASCE report, an "investment of $157 billion per year across all sectors of infrastructure through the year 2020 will prevent the loss of $3.3 trillion in GDP and 3.5 million jobs."[5] So can we afford to spend that much? "The total proposed for transportation infrastructure projects was $478 billion, but over six years. That's about $80 billion a year, which is about 2 percent of the total annual [federal] budget. Forty percent of that amount was already coming from the existing federal gasoline tax, and the rest of it [is expected] to come from a new tax on foreign corporate earnings held overseas."[6] So according to these estimates, we are only about 50% of the way there based on federal funding. This has to change, but the question is whether federal financing is or should be the answer. This is a question that we will explore further within the thesis. But compared to other countries, the US federal investment in public infrastructure is low. "The share of American GDP devoted to infrastructure investment is only 2.4%, compared with an average 5% in European Union countries and as much as 9% in China and other emerging economies."[7] There could be a number of reasons why the spending is varied, such as the size of the GDP, the infrastructure needs of the country, and even transparency into the truth of the number. What is clear, however, is that the US needs better rail infrastructure and there currently isn't enough money flowing from the federal government to meet all of those needs.

Many people believe that maintaining, improving and expanding rapid transit on rail is valuable for a variety of reasons, but that value is difficult to quantify. Our econometric models

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[5] Petroski, Henry, 244.

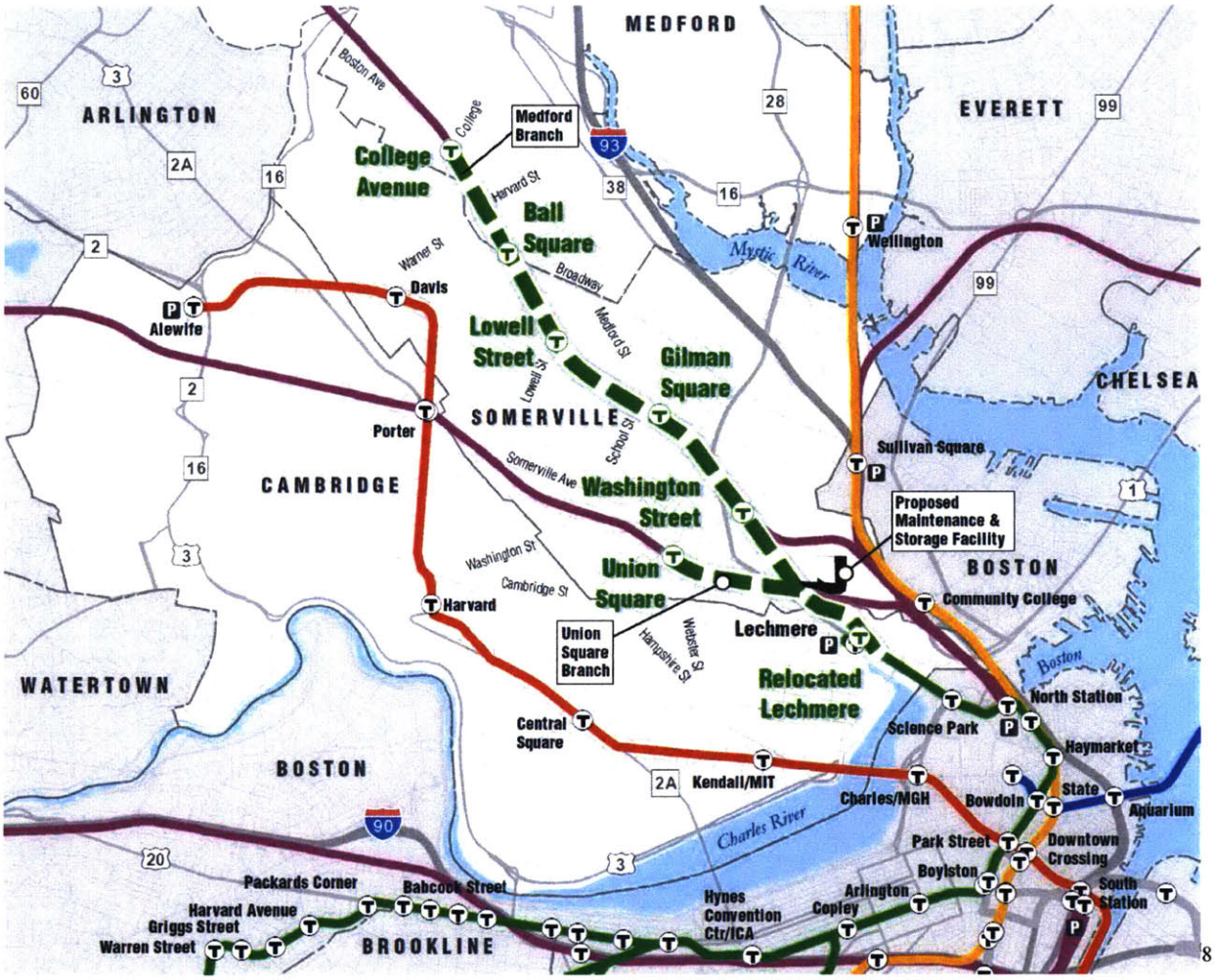
[6] Petroski, Henry, 129.

[7] Kanter, Rosabeth Moss. *Move: Putting America's Infrastructure Back in the Lead*. New York: W.W. Norton, 2015. Print,243.

suggest that proximity to transit is tied strongly to value in investment property, and a portion of that value is capitalized prior the completion of service. While there are many who benefit from subways, we believe that some of the primary beneficiaries to new rail projects developers and investors who are able to capitalize on land gaining new accessibility and value. With mature cities bulging outwards, there are limited opportunities for developers to mass enough land together within the center city limits to create a substantial mixed use development. When a new rail line is installed that improves or creates accessibility to previously underserved areas, developers have the chance to create new, vibrant, urban environments.

There are many modes through which the goals of transit investment can be achieved, whether it is rail, Bus Rapid Transit (BRT), bike networks, car-sharing services, or perhaps someday through an autonomous vehicle network. Each of these modes have varying costs and benefits as well as passenger capacities. This thesis will briefly discuss BRT in Chapter 3 as the most similar mode to rail with a substantially lower construction cost, but in general, the purpose of this thesis is not to assess a cost-benefit analysis across modes of transit.

This thesis looks at a small subset of the much larger, global issues at hand, but will use that greater landscape as a framework and lens through which to evaluate the situation. As mentioned, our focus is on Boston, and more specifically, an in-depth look at the Green Line Extension ("GLX"), which is a rapid transit rail infrastructure project that will extend high frequency service from the City of Cambridge through the City of Somerville into the City of Medford, several nearby suburbs of Boston.



As these projects are so expensive, and there isn't enough federal funding to support them, this thesis examines value capture financing as a means to support the projects. We believe that proximity to a subway line within a metropolitan region increases land value, so are interested in exploring what that value looks like and if there is a way to share the benefit to support the projects without destroying development returns and creating a disincentive for development along transit lines. It is difficult to disentangle the effect of the rail as opposed to other forces driving land values, because "you can build a transit line and still not get new

[8] "Green Line Extension Project." 2016. Web. June 2016. <http://greenlineextension.eot.state.ma.us/documents/about/ProposedMap/projectmap.pdf>.

development if any of several other things don't fall into place - including zoning, economic growth, cooperative neighbors, courageous developers, and bankers willing to lend."[9] We are going to try and understand the rail portion through both a qualitative and quantitative review.

We chose this city and this project for a number of reasons. First, Boston has one of the oldest subway systems in the United States, so it has a rich history, but also faces the challenge of having an aging system, which we will address in Chapter 3. Second, there has been substantial growth in Boston, and in general, Boston's economy is consistently among the top performing cities in the country, so we can explore various alternatives for additional funding. Third, Boston has a history of investing in infrastructure, most famously with the Big Dig, so there are numerous resources available for understanding how these megaprojects occur. And finally, fourth because the project is currently in progress and has an interesting story associated with it. It also doesn't hurt that we are students at MIT who both regularly use the Boston Area subway system and have a vested interest in the continued growth of the region.

The Green Line Extension project dates back several decades and while discussions may have been ongoing since as early as 1920, 1990 is when Massachusetts made a legal commitment to the project as a pollution mitigation for expanding the highway during the Big Dig. Due to severe cost overruns with the Big Dig, however, this project never got off the ground, despite the legal commitment, which caused the City of Somerville and the Conservation Law Foundation to file a lawsuit against the state. In 2006, as a result of the lawsuit and the support of numerous advocacy groups, the state agreed to commit substantial funding to the project.[10] At that time,

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[9] Walker, Jarrett. *Human Transit: How Clearer Thinking about Public Transit Can Enrich Our Communities and Our Lives*. Washington, DC: Island, 2011. Print.

[10] "OSPCD- Green Line Extension." *Somerville, MA*. Web. 6 July 2016. <http://www.somervillema.gov/departments/ospcd/green-line-extension>.

based on estimates in 2005, the project was expected to cost $438 million. In 2009, with more robust planning having been completed, the revised project cost estimate had increased to $934 million. In late 2011, early 2012, the cost had risen again to $1.4 billion, which included contingency money, financing charges and some changes to the designs.[11] At this point, the project team decided to pursue federal assistance and entered the preliminary engineering phase of the New Starts Program, one of the most competitive federal funding programs in the nation.[12] In fall of 2014 it was announced that the cost had increased to $2 billion due to the additions of bike and pedestrian paths as well as further structural work that had previously not been included.[13] On January 5, 2015, the Federal Transit Administration ("FTA") signed an agreement to contribute federal funds through the New Starts Program, with a commitment of $996,121,000, which was expected to cover half of the cost of the project, while the state of Massachusetts committed to match that contribution to cover the other half.[14] Several months later, in late summer 2015, the estimate was revised to $3 billion, primarily related to contract increases.[15] In December 2015, the MBTA decided to cancel its four contracts and the project went on hold while state officials worked to determine whether or not they would be able to proceed with the project or if it would need to be abandoned.[16] Over a period of 6 months the project team worked to scale back the station designs and find additional funding sources. On

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[11] Vaccaro, Adam. "The Long, Depressing History of Green Line Extension Cost Increases." Boston.com. The New York Times, 28 Aug. 2015. Web. 21 July 2016. <http://www.boston.com/news/business/2015/08/28/the-long-depressing-history-of-green-line-extension-cost-increases>.

[12] "Green Line Extension - FTA Participation." Mass.gov. Commonwealth of Massachusetts, 2016. Web. 21 July 2016. <http://greenlineextension.eot.state.ma.us/about_FTA.html>.

[13] Vaccaro, Adam.

[14] "Green Line Extension - FTA Participation."

[15] Vaccaro, Adam.

[16] Dungca, Nicole. "MBTA Terminates Deals with Current Green Line Contractors." BostonGlobe.com. The Boston Globe, 10 Dec. 2015. Web. 21 July 2016. <https://www.bostonglobe.com/metro/2015/12/10/mbta-terminates-deals-with-current-green-line-contractors/vfPRi1yVfiYd7nNWpyMz2H/story.html>.

May 9, 2016, the MBTA and MassDOT boards voted against cancelling the Green Line Extension after they were able to reduce the costs to $2.3 billion. The $300 million funding gap was being partially filled by $152 million in additional federal funds and $75 million being contributed between the City of Cambridge and the City of Somerville. The team is still working to fill the remaining $73 million gap, but as of the writing of this thesis, the project is moving forward despite the gap.[17]

In this thesis, we will walk through how infrastructure improvements move from idea conception through to completion in Chapter 1, we will look at the value that is created from the project and to whom that value accrues in Chapter 2, we will layout the current state of Boston's infrastructure and the current challenges associated with this metropolitan area in particular in Chapter 3, and then go through a quantitative review of the impact of rapid transit accessibility in the Northwest Boston Basin in Chapter 4. We hope that by combining a qualitative and quantitative perspective, we will be able to provide a more complete picture that highlights the costs and benefits of this transportation mode in order to help decision makers evaluate whether the ends justify the means of bringing new rail projects to life as well as to help real estate developers and investors understand the complexity and reality of new transit investments and their potential involvement as a means to improve project efficiency and delivery.

[17] Juul, Matt. "Transportation Boards Vote Not to Cancel Green Line Extension."Boston Daily. Boston Magazine, 10 May 2016. Web. 21 July 2016. <http://www.bostonmagazine.com/news/blog/2016/05/10/green-line-extension-vote/>.

Chapter I: The Process of Bringing Mega Infrastructure Projects to Life

In this chapter we will discuss how rapid transit rail infrastructure projects move from idea conception through to completion. These projects are extremely complex and require numerous groups of people to be involved, they require strong leadership, they are extremely expensive and difficult to finance, and as a result of these factors, can take multiple decades to complete. This substantial project timeline creates an interesting circumstance for the surrounding areas and potential opportunities for real estate developers who can, in certain cases, catalyze projects. Even without developers taking the lead on projects, it is in local real estate investors and developers' best interest for the city in which they're invested to pursue and undertake improvements and expansions to support regional growth, which can translate into higher rent, lower vacancy, and enhanced tenant credit.

Through a series of interviews and the review of relevant studies and reports, this chapter aims at bringing understanding to all the pieces that must come together to deliver a new rail project. We think it is important to understand this process because there are opportunities throughout the lifecycle to improve efficiency and generate additional value. While the analysis in Chapter 4 will aim at quantifying the value created by proximity to rail, the concept of the time value of money would indicate that the substantial time lag in delivering projects is costly, as was seen with the Green Line going from an initial estimate of $438 million to $3 billion over the course of a decade, which equates to an annual growth in cost in excess of 20%. While this thesis is not attempting to quantify the loss due to time, we believe it is important to understand the substantial process as a framework before jumping to the resulting value creation once the project is complete.

In addition to the pure cost of time associated with these projects, is the fact that during that time demographics are changing, preferences and trends are changing, technologies are changing, and the world in which we live has become so connected and impatient that taking multiple decades to solve a problem is no longer an acceptable solution. Rather than waiting for a city, state or private entity to take the lead on fixing a problem, citizens and employers can easily relocate, so whichever city gains a lead on solving these problems will likely gain a competitive advantage which will support its growth. When commuting can comprise such a substantial portion of a person's day, it can be a large factor when residents are selecting where to live and when employers are selecting where to locate.

So how do these projects get initiated? Who kicks off discussions? What we've learned is that it depends on the circumstance - some projects come from visioning exercises, some from private developers who have an infrastructure plan to support or bolster a development, while others are crafted to solve problems. This chapter will first walk through the different participants and their roles in bringing an infrastructure project to life, then discuss how projects are selected, followed by the multiple ways in which they can be financed and conclude with a short discussion of how they are completed. The primary purpose of the chapter is to outline the complexity of the system and process in order to give perspective to the resulting value creation discussed in the rest of the thesis. In certain cases, we will attempt to outline ways in which the system can be improved in pursuit of a more efficient process.

1.1 - Government Involvement

When it comes to these types of investments that are considered public goods, the government must be involved. In different cities "the government" can mean different things,

and in certain states there is much less government involvement than in others, but since this thesis is focused on Boston, we will discuss what types of government get involved in Boston infrastructure projects.

Within Boston, the rapid transit rail system is controlled by the Massachusetts Bay Transit Authority ("MBTA"), which is an Authority controlled at the state level under the Massachusetts Department of Transportation ("MassDOT").[18] Because the T, as the subway has been nicknamed, provides access to several cities and towns around Boston, no one municipality has direct control over its subway. According to Sara Myerson, Director of Planning at the Boston Redevelopment Authority ("BRA"), "Even if you think additional rail is the right thing for the City, you are still advocating to another body. Even if you say you have these capital resources to dedicate to it, you still need to appeal to the governing body."[19] There are several organizations that can assist with the T's investments, such as Central Transportation Planning Staff ("CTPS") and Metropolitan Area Planning Council ("MAPC"), which both contribute to the Boston Region Metropolitan Planning Organization ("MPO"), but these organizations are managing and planning for much more than just the MBTA.

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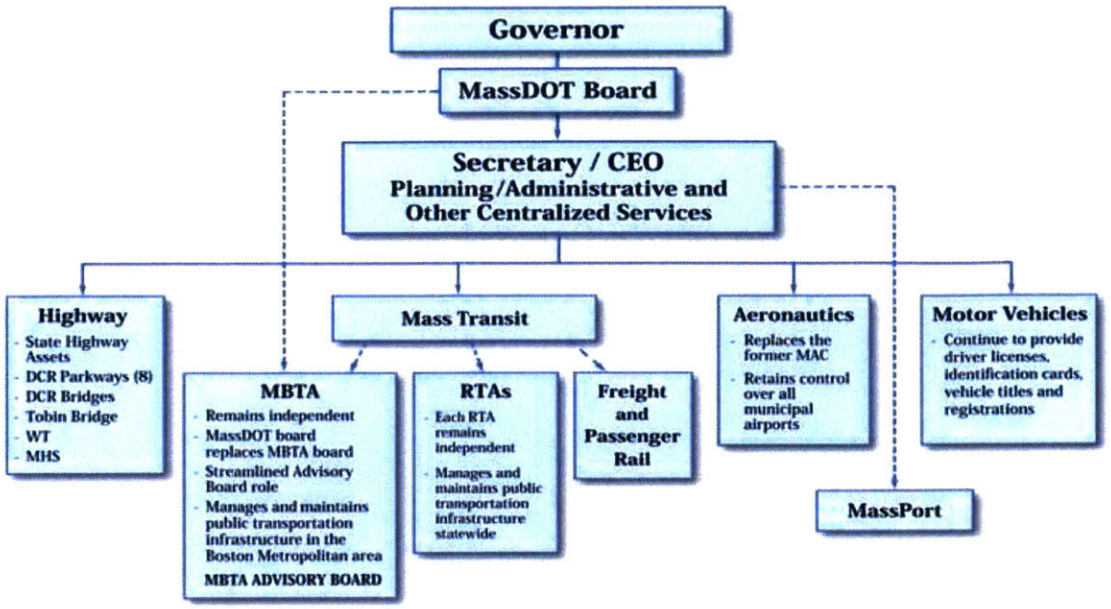
[18] "Massachusetts Bay Transportation Authority." *MBTA About the MBTA History*. Web. 05 July 2016. <http://www.mbta.com/about_the_mbta/history/default.asp?id=970>.

[19] Myerson, Sara. "Director of Planning: Boston Redevelopment Authority Interview." Personal interview. 31 May 2016.



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This chart shows the state-level transit groups and where the MBTA falls within the structure. CTPS and MAPC work through the MPO at the Planning level below the MassDOT Board.

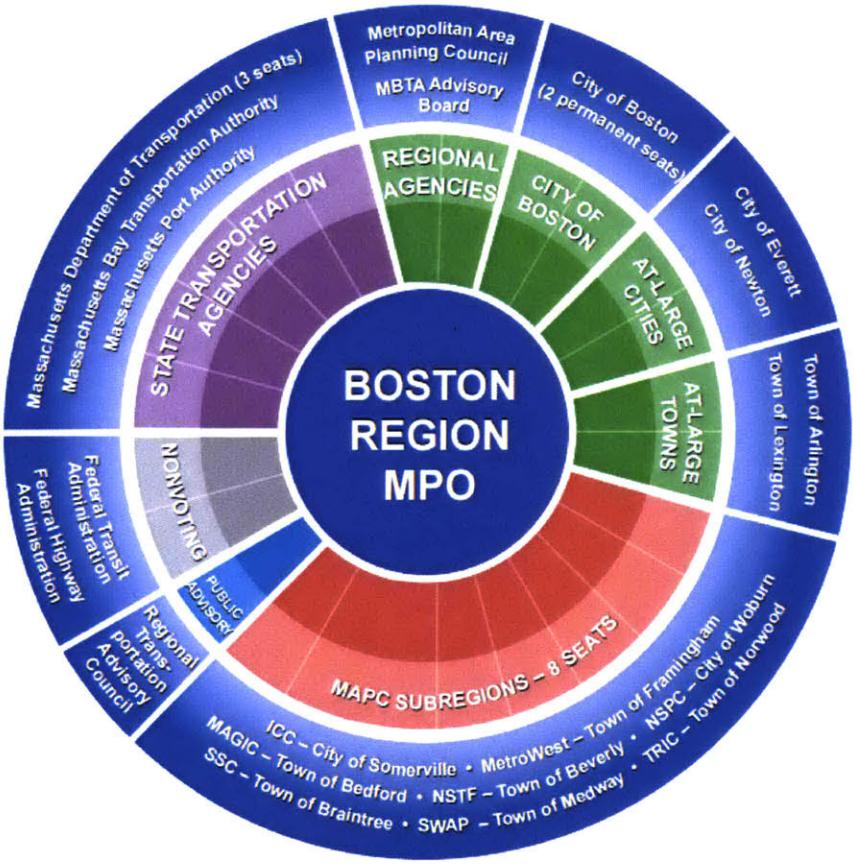
By statute, the MBTA is required to have a five-year capital plan, so each year the T engages in a public process and works with its board on a rolling five-year plan. The projects included in this plan can be funded through a number of sources. The American Recovery and Reinvestment Act of 2009 that was directed at boosting the economy after The Great Recession included several rail projects that received direct federal aid. The T can also receive funding through its own federal aid program or the state's aid program.[21] The state's funds can come through several avenues. First, the state and federal governments contribute to the MPO's annual budget - 2016's allocation is roughly $75 million. CTPS manages the expenditure of those funds

[20] Patrick, Deval, and Timothy Murray. "Transportation Reform." Governor Deval Patrick's Budget Recommendation - House 1 Fiscal Year 2012. Commonwealth of Massachusetts, 2011. Web. 21 July 2016. <http://www.mass.gov/bb/h1/fy12h1/exec_12/hbudbrief25.htm>.

[21] Davey, Richard. "Former State Secretary of Transportation Interview." Personal interview. 2 June 2016.

through several planning processes. They create a Long Range Transportation Plan, which forecasts out to 2040, and then they also construct a short range Transportation Improvement Plan ("TIP"), which is a five-year view. These plans are created and voted on by the 23-member board of the MPO, which includes state agencies, MassDOT, the MBTA, the Massachusetts Port Authority, the City of Boston, and several suburban towns (as shown in the figure below).[22]

Boston Region Metropolitan Planning Organization Member Structure



[23]

[22]Peterson, Scott. "CTPS Interview." Personal interview. 23 June 2016.

[23] "Long Range Transportation Plan." Transportation Planning for the Boston Region (2016): n. pag. Web. 21 July 2016. <http://www.ctps.org/data/pdf/plans/lrtp/charting/2040_LRTP_Chapter1_final.pdf>.

Projects over $20 million or that add capacity to the transportation network cannot be included in the TIP without first being in the Long Range Transportation Plan. These plans cover 101 cities and towns around the Greater Boston Area and include updates to intersections, complete streets or even projects such as the Green Line Extension. The MPO money is primarily designated for highway and roadway projects, but occasionally the board can elect to flex money over towards transit, which is what happened with the Green Line.[24] Second, the state has pure discretionary dollars available, so advocates and advisors will provide recommendations to the Governor about which projects should receive additional funding. Finally, the MBTA has its own budget that it can use for projects.[25] In the case of the Green Line Extension, the MPO is contributing $190 million over a six-year period from its TIP, as of the most recent estimates in June 2016.[26] The reason that there is such a wide swath of agencies that contribute to this planning and funding is to ensure equitable and coordinated investments across the entire region. The MPO advocates across the 101 participating municipalities to dedicate investments that support the entire metropolitan area, which would otherwise be competing on a project-by-project basis with the rest of the state.

So as discussed, there are multiple tiers of possible funding, and thus involvement - city, state and federal. When a project seeks to use federal money, there are strings that become attached. There are environmental studies, public participation, historic preservation, and many other items that are needed to support the project. And transportation makes up a relatively small portion of the overall federal budget.[27] But when the federal government evaluates a project, it is

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[24] Peterson, Scott.
[25] Davey, Richard.
[26] Peterson, Scott.
[27] Neumann, Lance. "Interview with Cambridge Systematics." Personal interview. 1 June 2016.

comparing projects from all over the region, Boston being in Region 1, which covers all of New England. There is a very serious matriculation process that includes an impact analysis - not purely in terms of negative impacts, but in terms of ridership or usage, economic output and benefits - and the project must demonstrate how it performs in terms of each dollar that the federal government spends. But before a project is even put before the federal government, it must pass through the state's own matriculating system. And that system can be through the MPO, but the MPO projects are also competing across the state with areas such as Western Massachusetts and Cape Cod.[28] In order for a project to receive federal funds through the MPO, however, it must go through the 3C Process, which stands for continuing, comprehensive and cooperative planning process, and is typically done through the metropolitan planning process, such as the TIP or long range plan.[29]

Once a project has successfully made it through both the state and federal matriculation processes, then there is a question of when the money comes. For the Boston projects, the federal funds go through the MPO, so even if a project has been earmarked for the funding and the money is available, if the project is not ready to spend the money when it is available, the money will go to other projects that are ready at that moment. So with the Green Line Extension, for example, even though it is budgeted in CTPS's TIP document with exact dollar amounts identified for the next six years, if the project isn't ready to spend those amounts, that money will go to other projects that were lower on the list and the Green Line will be pushed out.[30] That

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[28] Shen, Kairos. "Former Director of Planning; Boston Redevelopment Authority." Personal interview. 26 May 2016.

[29] Paiewonsky, Luisa. "Interview with Federal Transit Administration." Telephone interview. 15 June 2016.

[30] Shen, Kairos.

being said, CTPS works to manage that process and minimize any project "leap-frogging" that might happen. If a project needs to be pushed out, there is a ripple effect, and the TIP and Long Range Transportation Plan need to be updated to reflect the change, so when this happens there is a lot of communication between the project team and CTPS to try and understand the revised timing.[31] This can create additional challenges, especially for large projects that can be difficult to coordinate and time exactly. While money is typically still made available, especially for projects with strong regional significance like the Green Line Extension, the timing of receiving that money may become less certain if the project wasn't ready when the funding was initially made available, so the project team may need to delay work or find short term financing solutions to bridge timing gaps, if necessary.

While the federal government tends to be hands-off in terms of planning, and act only as a funder, the state and metropolitan governments are active participants in the planning process. But even at the city and state levels there are often multiple groups involved, whether it's a transit authority, port authority, multiple city governments, or a metropolitan planning organization. When you have this many government agencies involved in decisions, there is also, unfortunately, a lot of politics that surround these decisions. According to Lance Neumann, Chairman of the Board of Cambridge Systematics, a transportation consulting firm, "the biggest issue nationally, one of the most frustrating and significant issues that I've seen develop over the last 20 years or so in the US is a change in public attitudes about infrastructure and spending and investing. And it used to be very much a non-partisan issue… 10 years ago, or 20 years ago for sure, infrastructure financing, spending on infrastructure, raising the gas tax, was not a partisan

[31] Peterson, Scott.

issue. It was an invest in the country issue, it was a republican supporting and a democrat supporting it and it was perceived as a public good. And by and large, if we're in a recession, it's good to stimulate the economy, if the economy's growing, we need infrastructure to satisfy development… And it just - it is what it is, and it's a political issue until the public changes that."[32] In Rosabeth Moss Kanter's book on putting America's infrastructure back in the lead, she suggests "one solution to the politics is to depoliticize infrastructure decisions, as other nations have done by way of infrastructure banks, which create dedicated pools of long-term capital not dependent on taxes or yearly appropriations of funds."[33] If we could get to a point where there was enough money to maintain the current system and improve and expand it through this type of infrastructure bank, it could certainly help streamline the process, but based on the current estimates, achieving that is likely a long way off. Even with an infrastructure bank, however, there would still need to be a level of government involvement, in order to fairly distribute the money across the nation.

1.2 - Public and Private Interaction

While the public sector is heavily involved in infrastructure planning and investment, the private sector can and often does play a critical role as well. While Boston is our focus, "cities such as Chicago demonstrate that transportation and infrastructure problems can be tackled by strong public-sector leadership with a strategic vision, with the support or active partnership of the private sector."[34] The issue with partnering with the private sector is that private entities

[32] Neumann, Lance.
[33] Kanter, Rosabeth Moss, 6.
[34] Kanter, Rosabeth Moss, 213.

generally need to make a return on their investments. So when it comes to some projects, if the private sector is willing to invest and they build it and operate it with a level of tolls and ridership that makes sense, it becomes a good business enterprise for them. But there are many cases where the public sector has to be willing to make opportunity payments to cover a scenario in which traffic volumes don't meet the projections and make up the difference. Without that agreement, the private sector wouldn't be willing to take on the risk.[35]

Even if the private sector is comfortable with the financials and is ready and willing to undertake infrastructure improvements, there are still hurdles involved. In Massachusetts, there are limits on how much a private entity can be allowed to work on things that are occupied and controlled by the public. In some cases it depends on the size of the project. But if the project is supposed to benefit the public, there are safeguards in place to ensure that projects aren't hijacked for private purposes, so wading through that system can be very bureaucratic and cumbersome. With respect to the MBTA, even if a developer wanted to contribute to a project rather than control the construction, it is still not a simple task because the agency doesn't have an easy way to actually receive the money. Additionally, there is a long negotiation of the terms that can be difficult.[36] For example, the City of Somerville and the City of Cambridge have agreed to contribute financially towards the Green Line Extension. A portion of these contributions will come from developers and the other portion will come from the municipalities. But even despite there being an agreement on a contribution, there is no in-place system set up for the towns to give money to the state, so in each case, the municipalities are working through unique

[35] Neumann, Lance.
[36] Shen, Kairos.

arrangements to make this possible. Usually money just flows down from the state rather than coming back up.[37]

While infrastructure investment can be a business strategy for certain firms, within Boston the more likely form of private involvement in public infrastructure is when it is related to a commercial development project. This is likely due to the fact that Boston rail infrastructure projects are extremely complex, time consuming and costly, that unless there is a strong economic incentive to get involved, private companies would prefer to invest elsewhere. But in order to justify spending millions of dollars on rail improvements, the associated development needs to be of a certain scale to absorb those costs, so certain marquee, large land use planning exercises can drive some of the decisions as well.[38]

For example, NB Development Group is developing a 15-acre campus in the Brighton submarket of Boston which did not have any rail access, but they felt it was important to their development to improve access to their site. There was an existing commuter rail line that passed the development, so NB Development Group initiated conversations through their elected officials and eventually with the Secretary of Transportation at the time, Rich Davey, (which transitioned to Stephanie Pollack upon a leadership change) requesting that a station be built along the site.[39] The state and MBTA could not afford to build a new station, but when NB Development Group offered to cover the cost, Secretary Davey agreed to work with them on it. So while the station is being paid for entirely by NB Development Group, the state's

[37] "MassDOT Official Interview." Personal interview. 22 June 2016.
[38] Davey, Richard.
[39] Craig, Keith. "NB Development Group Interview." Personal interview. 20 June 2016.

commitment is that once it's built, the train will stop there, which adds incremental operating costs, but not much.[40]

Even when the project is taken on completely by a private developer, however, the public is involved, which can extend the time that it would otherwise take to complete due to the public process. In the case of the NB Development Group station, it took two years to move from a Letter of Intent to a Memorandum of Understanding, which laid out the terms of who was going to do what and how much things would cost. Then it took another year and a half before construction started. Because the station, upon completion, will be turned back over to the state, the MBTA required certain design elements, safety elements and construction protocols be followed. Even after the design was complete and construction was underway, there were weekly meetings between NB Development Group, MBTA Railroad Operations, MBTA Construction, Keolis, which is the operator of the railroad, and the Department of Transportation. NB Development considers it to be a public job because ultimately they are not the owners of the station but rather are a conduit to make it happen, and happen faster than it would have it they weren't involved.[41]

So while private developers can initiate and take the lead on constructing rail infrastructure improvements, the public is still heavily involved throughout the process.

1.3 - Project Selection

While private developers can initiate some rail upgrades and extensions, that is not the only source of bringing a project to life. When infrastructure is considered a public good, the

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[40] Davey, Richard.
[41] Craig, Keith.

public agencies and communities that are impacted are typically very involved. Within Boston, the BRA is a city agency that works to guide the growth and development of Boston. They do this through land use planning and working with the community to develop planning guidelines for emerging and transitioning neighborhoods in support of an overall vision for the city.[42] This ties into infrastructure because as the city is developed and different buildings are constructed with different uses, that impacts the usage of the subway system and people's commuting patterns.

The current Mayor of Boston, Marty Walsh, has initiated a citywide planning process called Imagine Boston 2030, which will be the first long-range plan the city has had in over 50 years.[43] This is considered separate from the Long Range Transportation Plan that is maintained by CTPS because Imagine Boston covers transit, but also open space and community goals. This initiative is engaging the community to source project ideas from residents and has collected over 3,700 project ideas to date.[44] According to Fred Salvucci, former Secretary of Transportation during the 1980's, "it's crazy to go and ask people what do you want, what do you want, what do you want? Everybody wants this. There is a technical logic to what you should want...and it's up to the mayor and the governor to package, to craft the packages that work. You don't expect citizen constituencies to do other than advocate their own self-interest. They are weak. They don't have any power to spare to go advocate someone else's interest so they make their point as strongly as they can."[45]

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[42] Myerson, Sara.
[43] Myerson, Sara.
[44] Imagine Boston 2030 Community Meeting. Atlantic Wharf, Boston. 6 July 2016.
[45] Salvucci, Fred. "Transportation Expert Interview." Personal interview. 7 June 2016.

Mr. Salvucci has a point. With over 600,000 residents in Boston and over 4 million residents in Greater Boston, opening up a forum for people to request projects can be opening a can of worms. While it has the potential to furnish some good, plausible ideas, it could also create a lot of noise and potentially give people false hope. But that being said, to do a public infrastructure project in the US requires holding public hearings. You have to go out into communities, you have to engage everyone and hear all points of view. The potential problem with this approach is that you can run into a small group of people that are against the project and can wreak havoc in the planning process.[46] These situations can cause substantial delays in getting the project off the ground. In some cities, the public hearings may be easier if the diverging interests at the table are not as strong, but in any mature city such as Boston, New York, San Francisco or D.C., it's not just a business community pushing for change, there are communities entrenched in among the commercial enterprises and each group might be impacted differently.[47]

Fred Salvucci's strategy of crafting a package of projects to garner support has been successful in several high-profile occasions. Mr. Salvucci worked closely on the Big Dig project during its early years of planning and advocacy. At the time, there were two large projects that had been seen as separate and had different constituencies supporting them. The state officials tied the two projects together and forced both constituencies to either support both or oppose both, and mostly people supported the projects.[48] Another example of this strategy occurred in Miami, Florida where then city Mayor, Manny Diaz "bundled a number of pending projects

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[46] Neumann, Lance.
[47] Shen, Kairos.
[48] Salvucci, Fred.

favored by various commissioners - a new baseball stadium, a streetcar system, a performing arts center, and a museum park - into a $3 billion umbrella "megaplan" to revitalize Miami's urban core...Diaz's audacious plan worked: commissioners realized that they would need to support each other's projects to get their own projects endorsed, and the megaplan was approved."[49]

When it comes to state support, there can be a variety of initiatives, requirements and politics that factor into the decisions. In some cases, projects are selected because of an implied economic payback, and other times a project will be selected because residents across the state deserve mobility, which are political decisions. There is also a goal of trying to understand inflection points in transportation and what transit will look like in the future. In general, planning exercises can be very useful if there is a realistic way to achieve the goals and strong leadership driving the process forward, but with administration changes every several years and multiple stakeholders that can have dissenting views, getting from visioning to project planning to completion can be a challenge. Especially when there are so many immediate needs to fix the current system, transit investments are usually driven by operationally, what is needed today.[50]

Overall, when it comes to an investment in infrastructure, there can be incredibly long life cycles for projects. It typically depends on the project, the political climate, the funding climate, the momentum behind it, and the advocacy around it, so it really take a lot of forces coming together to make a project happen.[51]

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[49] Kanter, Rosabeth Moss, 232.
[50] Davey, Richard.
[51] Myerson, Sara.

1.4 - Olympic Planning as a Catalyst

One potential force that can catalyze discussions and planning, is hosting a major event, such as the Olympics. Boston recently engaged in the early stages of participating in the Olympic bid process, hoping to host the 2024 Summer Olympics. While the city ended up bowing out of the bid process due to low public support, the bid had included $12.4 billion in transportation infrastructure improvements, most of which were already included in the Long Range Transportation Plan.[52] However, most had not gone through the process of being designed, selected, vetted through the public process or funded. The deadline of 2024 had the potential to bring all of the stakeholders together to actually have a conversation about infrastructure. There was an opportunity to accelerate and even expand the investment in public infrastructure instead of waiting the 25 years that it normally takes to see an improvement.[53] Absent that kind of conversation, it's hard to get a project, never mind multiple projects, moving in even a 15-year time frame. Without the Olympics, or other large catalyst as a driving force, holistic visions of substantial change are more likely to happen in small pieces and eventually those pieces might come together to create the whole.[54]

But even with the Olympics, first and foremost the infrastructure shouldn't be planned for the purpose of hosting an event, but rather should be considered an investment in the city so that it can compete in 20 years time for the companies that want to bring their employees and grow

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[52] *Boston 2024: Transportation, Accommodation + Security*. Rep. Boston 2024, 1 Dec. 2014. Web. 26 May 2016.<https://2024boston.s3.amazonaws.com/2014_1201_Boston2024_3_Transportation_Accommodation_Security_Print.pdf>.

[53] Shen, Kairos.

[54] Myerson, Sara.

their businesses there. The plan should help the city in the natural way that the city is growing and fit the Olympics around that framework.[55]

While hosting a major event shouldn't drive infrastructure decisions, the planning for one does create an opportunity to garner support for financing large projects. The $12.4 billion worth of projects have been on the books for a long time, with a few exceptions. And historically, although not guaranteed, there has been significant willingness at the federal level to provide support for these projects. That being said, lately the attitude in Congress has changed and there is less willingness to spend, but there would probably still have been some support.[56]

1.5 - Financing

Absent hosting an Olympics, infrastructure projects are still accomplished. One of the greatest challenges, however, is figuring out how to pay for them. As construction costs rise, politics pulls limited funds in multiple directions and the need to complete projects remains pressing, people have been getting creative and working to establish new techniques for financing these infrastructure investments.

The standard financing source that can no longer be the only source is through various government agencies. The gas tax in Massachusetts is 24 cents and the federal gas tax also provides some money to the state as well. Additionally, toll revenues, MBTA fare revenues or state bonds have been used. Without expanding beyond these methods, there are some ways that are being contemplated to extract more from these sources - both through increasing revenue as well as reducing expenses. For example, the state is moving to man-less tolling. This required a

[55] Shen, Kairos.
[56] Neumann, Lance.

minimal infrastructure investment and there are substantial labor savings. Once this has been fully implemented across the state, future administrations can explore using time-of-day pricing, passenger pricing, and type of vehicle pricing, which could bring in additional revenue but also incentivize certain behaviors that will benefit the environment as well as reduce congestion.[57] Another alternative would be to create high-occupancy toll ("HOT") lanes where drivers can pay a convenience fee to use the lane and get out of traffic. The counter-argument to this approach is that only the wealthy can afford to use this.[58] Although, in support of the HOT lanes, if only the wealthy use them, then the wealthy would also be contributing more than others towards infrastructure investment while still freeing up some of the capacity, which benefits everyone else for free, so there are multiple ways to view this concept.

Another tool that the state uses is compromising between projects or eliminating certain projects in order to use earmarked money for a different purpose. In the 1970's there were two additional interstate highways proposed nearby Boston which were cancelled to fund two MBTA subway projects - extending the Red Line and moving the Orange Line underground.[59] More recently, related to the Green Line Extension, the project became at risk due to the cost being substantially greater than what the state could afford, so MassDOT asked the MPO to reallocate money that had been targeted for a station, which had been proposed as the end of the line, and shift it forward to the rest of the line in order to help bridge the gap. The Green Line Extension plan was thus revised to end one stop closer into the center city.[60]

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[57] Davey, Richard.
[58] Kanter, Rosabeth Moss, 123-124.
[59] Salvucci, Fred.
[60] Bourassa, Eric. "Metropolitan Area Planning Council Interview." Personal interview. 6 July 2016.

When federal funding gets involved, probably 80% of the projects are straight-forward with 80% being funded federally and 20% being funded at the state level. But then you also have projects that get earmarked and those can sometimes get additional funding due to strong congressional support that advances bills on transportation legislation, which can include certain projects within the bill.[61]

But even with these current methods, there is not enough money to cover all of the projects that need to be done to maintain the existing infrastructure, never mind trying to expand the system. There are several concepts that people are discussing as possible new sources of funding. In London, they are constructing the Cross-Rail, and to help pay for it they are putting a surcharge on the business property tax across London, for all businesses larger than a certain threshold. The argument is that even if you're two miles from the Cross-Rail, you are benefitting because the London network as a whole is enhanced. The business community in London agreed to the assessment, which is covering roughly one third of the cost.[62]

In Chicago, Mayor Emanuel's Building a New Chicago plan, which was estimated to cost $7 billion, did not have to wait for federal assistance or require raising taxes. Funding came from efficiencies realized through office cuts, water fees, new revenue sources such as licensing to put digital billboards on city lands along highways, and a first-in-nation Chicago Infrastructure Trust fund.[63]

In Boston, the highways and mass transit have reached capacity and across the metropolitan area people are losing hours of their day due to commuting. If the capacity is not

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[61] Peterson, Scott.
[62] Salvucci, Fred.
[63] Kanter, Rosabeth Moss, 214.

fixed, "you are really kicking the economy in the stomach."[64] From Fred Salvucci's point of view, if we create an assessment district around Boston, Cambridge and Somerville and do something similar to what London did, we could say "starting five years from now, all economic growth is going to get a new assessment based on the ridership in those towns that the stations generate. And you assess it - you can assess it through the local property tax. We could do it exclusively on the business side so you don't get the voter backlash... and the proposition to the business people is, if we don't do this, you're not going to be able to grow. So doesn't it make sense to tax your growth, not your base, but your growth. And we're not going to do it in a stick up. We're going to do it prospectively. You'll know what's coming and it's five years off. People can adjust if it's five years off, and if you spread it broadly across all the beneficiaries you are not hitting one poor beneficiary who happens to be in to get a permit this week."[65] In Boston there is already a small regional contribution to the MBTA, which will be discussed further in Chapter 3, but if this program were to be expanded to help cover the costs of projects such as the Green Line Extension, it would need to come from the entire network, not just the immediately adjacent towns. As Michael Glavin, Executive Director in Somerville's Office of Strategic Planning and Community Development, said, "[it's] pretty hard to tell people who have been waiting over 25 years for something that they've been promised, by the way, now that you're finally going to get it, we're going to hit you with this, this, this and this…[it's] kind of blaming the victim."[66] There is a delicate balance, however, to increasing taxes, because at a

[64] Salvucci, Fred.
[65] Salvucci, Fred.
[66] Glavin, Michael, and Brad Rawson. "City of Somerville Interview." Personal interview. 13 July 2016.

certain point, businesses and developers will go to other cities and states that don't appear to be taking as much off the top.

Another alternative that is being explored is value capture financing. Within Massachusetts, the closest program to value capture is called I-Cubed, which stands for Infrastructure Investment Incentive Program. This program essentially gives private developers access to public bonds at very low interest rates in order to finance public infrastructure improvements related to their development. The bonds are then paid back through two means. The first is during construction, the municipality levies assessments on the developer's property, and then the second is once the development delivers, the revenue associated with the improvement will go towards covering the debt service.[67] It works very similarly to tax increment financing with the primary difference being that the project is controlled by a private entity. But qualifying for the program is very rigorous. A developer has to prove that without the proposed infrastructure improvement, the new jobs associated with the project would not have materialized in Massachusetts. And you need actual tenants lined up that are either new to Massachusetts or businesses that are expanding in Massachusetts that otherwise would not have expanded there, or businesses that might have left.[68] So with such a rigorous process, there are very few developers who qualify or even seek to qualify for this type of financing. This also doesn't solve the issue of financing infrastructure that is initiated through public planning.

Alternatively, value capture has been negotiated. For example, as mentioned, the Green Line Extension was at risk of being cancelled due to the cost being greater than initial estimates.

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[67] "Overview of I-Cubed." *The Official Website of the Executive Office for Administration and Finance*. Commonwealth of Massachusetts, 2016. Web. 08 July 2016. <http://www.mass.gov/anf/budget-taxes-and-procurement/cap-finance/i-cubed/overview-of-i-cubed.html>.

[68] Bourassa, Eric.

While eliminating the original terminus provided some relief, the project was still short by roughly $100 million. In order to push the project forward, MassDOT approached Somerville, Cambridge and Medford, the three towns through which the extension would run, and asked them to contribute and bridge the gap. Initially the municipalities were all against contributing, as cities had never been asked to contribute to infrastructure in the past. Ultimately, however, Cambridge ended up committing $25 million and Somerville committed to spend $50 million in support of the rail extension. Medford decided not to contribute.[69] Somerville and Cambridge worked with MAPC and a consultant team to try and understand and quantify the economic benefits of the green line in order to get comfortable with their contributions, which we will explore further in Chapters 2 and 4.[70] In Cambridge's case, there was already an active developer in the early stages of planning a development near the proposed station, so they were able to negotiate that half of its contribution would be provided by the developer. In Somerville, however, the expected transit-oriented-development won't occur until further into the project cycle. The $50 million contribution was a number that was negotiated between MassDOT and the City of Somerville without a clear sense of its source, but rather it represented the municipality's commitment to the project through an ambitious, but feasible amount. The expectation is that a portion of it will come from developers building large scale projects which will benefit from the future stations, but they are also evaluating their internal capital plans to determine if there are projects that can be reduced or eliminated to reallocate funds without too much collateral damage or burden on the local taxpayers.[71]

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[69] "MassDOT Official Interview."
[70] Bourassa, Eric.
[71] Glavin, Michael and Brad Rawson.

According to Fred Salvucci, "Pollack (Stephanie Pollack, the current Secretary of Transportation), presumably on behalf of Baker (Charlie Baker, the current state Governor), pulls a stick up and tells Cambridge and Somerville that if they want to see the Green Line alive they have to get some contributions from the developers who are going to benefit. I think that's abominable public policy. These development deals are real hard to put together. They represent economic growth. They represent transit-oriented development. We're all supposed to want that. It's part of the solution to the climate change challenge and after developers have been working, putting their numbers together for at least a decade in the case of NorthPoint (the development in Cambridge), to tell them at the last minute, $100 million, your money or your life, is not exactly incentive to developers to get involved in transit-oriented development in the future...if you're interested in value capture, in my view, it's absurd to hit a developer at the front end when they're at their most vulnerable financially. You can screw up their deals. Kill them and get nothing...The right way to assess, to me, would be to assess based on ridership five years after the project is complete. Right now a developer is being asked to contribute to a project and it's still conjectural. [It] hasn't been built. Nobody knows how long they're going to take ... to build it. They're taking forever in every step in this thing, so as a developer you're putting money into something and you don't know when [it] is going to open."[72]

Mr. Salvucci's concerns are certainly valid and as various agencies work to find new solutions they should tread carefully in order to avoid creating disincentives, but at the same time, we do need new financing solutions. The old way of doing things where the costs are borne by the state while the municipalities benefit without contribution just isn't going to work

[72] Salvucci, Fred.

anymore.[73] According to Brad Rawson, the head of Transportation & Infrastructure in Somerville, "we are in a frustrating position where we essentially are being asked to grit our teeth and contribute massive, massive sums of local monies. And we believe it is necessary and we intend to do it. However, are we happy about it? No, absolutely not. Yet the state of the practice needs to evolve...Massachusetts, for all our progressive values and progressive policy environment, we are behind the times in terms of value capture… Can this sound the clarion call to say there's a need for a new series of tools, expectations, transparency and predictability for all communities seeking to do these kinds of transformative investments? Because the rules of the game have changed...we cannot rely on the state government to do as much as it used to do. Local governments must be given tools to plan for, to strategize, and to propose partnerships."[74]

One possible tool at a municipal level would be to create assessment districts along new infrastructure that are likely to benefit the most from its installation. Although within Massachusetts there is a statute, Proposition Two and a Half, which puts a cap on the annual increase in property taxes that a municipality is able to receive. This creates a challenge for cities and towns which seek to use a traditional Tax Increment Financing scheme, or District Improvement Financing, as it is called in Massachusetts. With Proposition Two and a Half, an individual's property tax can increase by more than 2.5%, but the municipality cannot receive more than a 2.5% increase, so it would need to create a zone near transit that experiences a higher increase and a zone further away that experiences a lower increase, or a decrease. This is counter-productive because it adds no additional benefit to the municipality and creates artificial value bubbles within the town. There are conversations currently in the legislature discussing

[73] "MassDOT Official Interview."
[74] Glavin, Michael and Brad Rawson.

different tools for municipalities to use, such as creating an exempt district from Proposition Two and a Half, but at this point it is only just discussions and nothing is seriously being considered yet.[75]

So then the other alternative is to work with the private sector. There are a couple alternative ways in which the private sector can get involved in projects that are not initiated as part of a development scheme. The first is called Build-Operate-Transfer ("BOT"), in which a private company can undertake a project and build it at their own cost and timing risk, operate it and charge tolls, or other fees to generate revenue for a period of time, and then return it to the appropriate government agency. This has not been used in Massachusetts, but is being tested in other states.[76] The second are public private partnerships, or P3s, which can be structured in any number of ways, but essentially a developer and a public entity work together to construct the improvements. A municipality could offer a density bonus in exchange for a developer either constructing an improvement or making a financial contribution towards one. Especially in Boston, which has relatively low current zoning, there is room to go from four stories to eight stories without having too much of a negative impact.[77]

Another type of P3 which is currently being exemplified in Boston is a deal in which Boston Properties ("BP"), a development REIT, is renovating Back Bay Station, a major transit hub which houses subway lines, commuter rail lines and a bus terminal. BP held an air rights lease for a garage adjacent to the station (the garage sits over the Massachusetts Turnpike and is thus an air rights lease with MassDOT), and sought to amend its lease to allow for

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[75] Bourassa, Eric.
[76] Shen, Kairos.
[77] Bourassa, Eric.

redevelopment of the garage. MassDOT, which acts as a parent agency to the MBTA, negotiated with BP to expand the boundary of the air rights lease to include air rights over the station in exchange for renovating it. BP agreed to take the net present value of its air rights lease payments related to the garage and contribute that to renovating the station on behalf of the MBTA. BP will also take on management of the station going forward with the idea that the renovated station, with additional retail, should cover the cost of operations and maintenance. BP will participate in any profits, should there be any.[78]

"By privatizing and monetizing existing public assets, public authorities can tap deep-pocketed private investors who could provide an enormous capital influx for much-needed development, proponents [of privatizing] hope. They argue that injecting a profit motive into infrastructure management is necessary to reap efficiency gains and save money, and that monetizing assets via privatization is necessary to cover budget gaps and build for the future."[79]

However, these partnerships should be considered carefully by the state, as states can be "tempted by proposals to enter into partnership with private investors that will provide much-needed revenue to balance budgets, but at the risk of abdicating control of public property to private interests, which may or may not be wise."[80] Chicago entered into a deal in 2004 that gave many public agencies cause for concern. A group of investors purchased a 99-year lease of the Chicago Skyway, a toll road leading into downtown Chicago. On the day of the transfer, the tolls increased by 25%. Another example, also in Chicago, was the parking meter privatization in 2008. The private company quadrupled parking rates and then began billing the city for lost

[78] Schrock, Melissa. "Boston Properties Interview." Personal interview. 5 July 2016.
[79] Kanter, Rosabeth Moss, 244.
[80] Petrosky, Henry, 11.

revenue if there were street repairs or festivals. Those who are against privatizing compare it to "'selling the family silver' for short-term goals and suggested that privatization constitutes an intergenerational transfer of wealth from future citizens who will have to pay more to use assets that were previously public goods."[81]

So while private involvement can improve liquidity and help bridge funding gaps, the agreements need to be carefully considered and negotiated to protect public interests. With respect to an infrastructure project, its life-cycle is already drawn out at this point, and securing the financing is no quick or easy step. This part of the process is very critical and can make or break a project, but given new tools, there is a substantial opportunity to improve the process.

1.6 - Construction

Once the funding has been established and the project team is ready to start construction, a decade or two could have passed, and multiple design iterations, budget reviews, environmental analyses, and negotiations have happened. There is finally hope that the project will happen. But there are still several hurdles that can arise at this stage as well.

First, when the project goes to bid, prices are only fixed for so long. When projects can take decades, there will potentially be several times that a project experiences price adjustments during the process based on the costs of labor and materials. Depending on where the real estate and construction cycles are when the project is finally ready to go, bids could be 20-30% lower than expected or 10% higher than the estimates.[82] Additionally, when federal funding is

[81] Kanter, Rosabeth Moss, 244-246.
[82] Davey, Richard.

involved, there are procurement requirements. Not every contractor is eligible, so you have to ensure you meet the federal standards.[83]

There could also be multiple government goals that are packed into a project. For example, the Big Dig was divided into roughly 30 contracts because at the time, it was deemed that if the state had bid the entire $3 billion project as one contract, there would have only been two construction companies in the whole world that could have bid. But one of the priorities of the project was to distribute the economic benefit to smaller and medium-sized, local companies.[84] So while it was less efficient to do so, the project was carved up in order to meet goals beyond just accomplishing the highway construction.

Once you've gotten past these bureaucratic hurdles, these projects are subject to face the same issues as any other construction project, from finding environmental hazards in the ground, to materials being late, to weather delays and numerous other challenges. Unfortunately, until construction is complete, there are still risks associated with every project.

Summary

At each stage of the process, there can be substantial hurdles to overcome, so for a project to have a chance of reaching completion requires strong leadership. With respect to the Green Line Extension, the City of Somerville has been a strong force in keeping that project alive, although it has taken a whole team with participation across all sectors - federal, state, municipal and private - to get it to its current state, which is still not to a point of being guaranteed. While private developers can "fast-track" projects that are advantageous to their developments, those

[83] Shen, Kairos.
[84] Shen, Kairos.

projects can still take close to a decade to complete. When it comes to public transportation infrastructure, there are so many impacted parties that need to be involved, that it is hard to imagine accomplishing a major project in anything less than a decade. Although with new tools for municipalities and enhanced methods of securing financing, that is an area where efficiencies could be gained. With this chapter setting the stage, the balance of the thesis will focus on exploring ways to improve the financial constraint element of making these projects happen.

Chapter II: Value Creation

This chapter will focus on exploring the value that is created by the installation of a new rapid transit rail line. The goal of the thesis is to explore value capture as a means through which to support financing infrastructure improvements, and there are many stakeholders and beneficiaries beyond developers who receive value from a new rail line. While this chapter will discuss some quantitative measures of value, it will be more focused on a qualitative review of various methods of understanding and potentially capturing value from a variety of sources. There will be a more in depth quantitative discussion and example of value capture in Chapter 4. Value can mean many things to different people, so this chapter will discuss the various types of enhancements and detractions that are fully or partially attributable to rail infrastructure. We will try to understand how the values are shared and to whom they accrue. It is important to also understand that rail improvements are not installed in a vacuum, and there are typically numerous factors at play that contribute to the various types of value creation, such as zoning that promotes mixed-use developments. We will try to highlight some of these factors and how their interactions come together and create value.

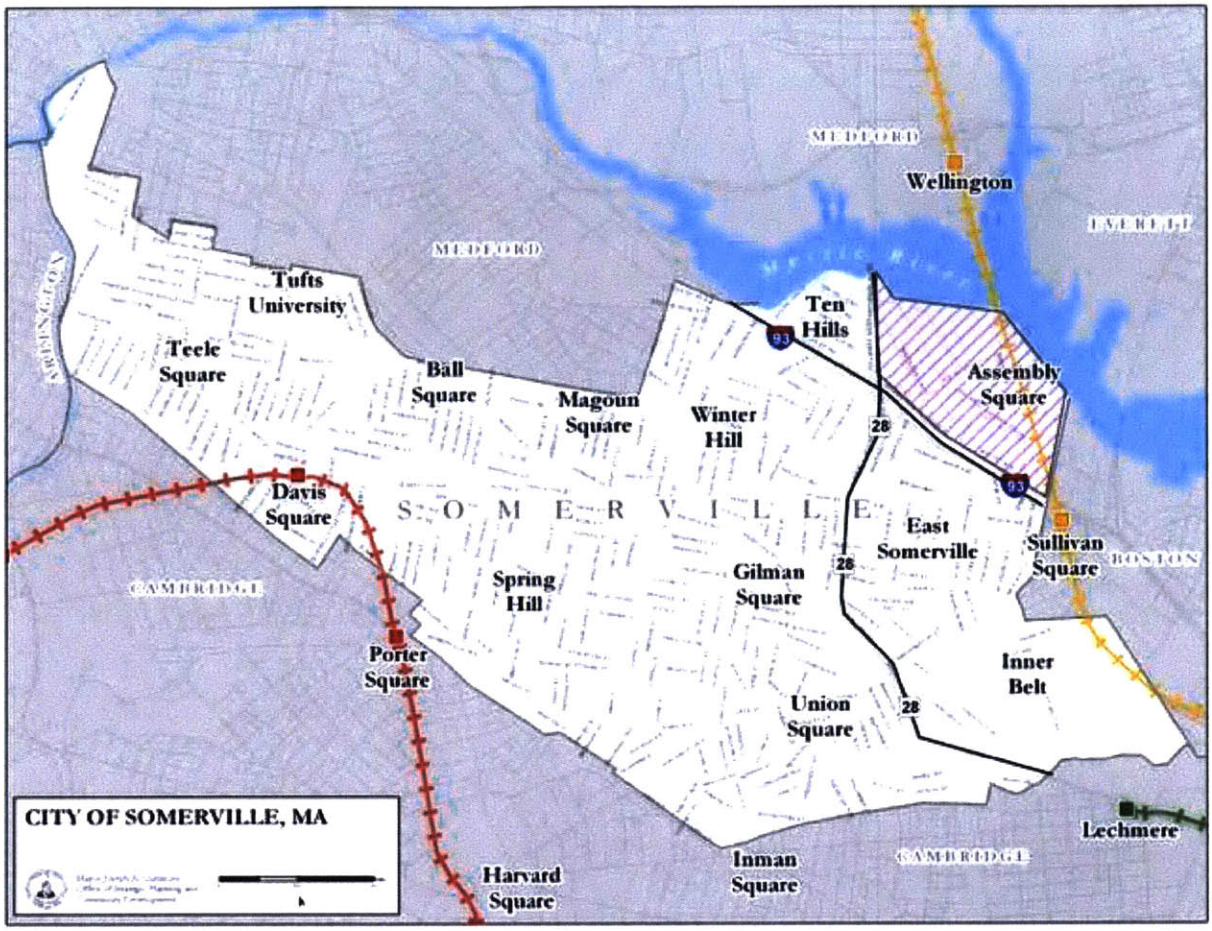
In general, we see value as accruing to three of buckets of stakeholders - private sector, public sector and the community. Within each bucket there are sub-categories, and we will try to explore those throughout this chapter. Before we do, however, it is also important to understand that different people can experience these infrastructure installations through differing lenses and where one person may experience multiple benefits, another may experience hardship. While the purpose of these types of projects is to maximize benefits and minimize hardships, the results are not unilateral. We will try and point out several examples as we explore each group of actors.

One additional factor that is worth noting is that not all infrastructure improvements are created equally, and circumstances surrounding each project can vary the resulting value creation. For example, adding a connection between two lines in a downtown, already very accessible part of a city, will create values that are different from extending rapid transit to an area that previously had none. For our thesis, we are more focused on the latter, but that's not to say that the former is any less important or valuable.

2.1 - Private Sector

When thinking about the private sector, there are a couple of main sub-groups that come to mind. The first is real estate developers, land speculators, and existing land and home owners, and the second is private businesses. As mentioned in Chapter I, real estate developers and land speculators need to be wary of and understand the time that these projects can take. Getting in too early can wipe out cash reserves that are spent holding the land while decades pass before the opportune construction time arrives. That being said, however, if timed correctly and the market remains favorable, new developments that become possible due to a rail extension providing access to a new corridor can provide strong financial returns to developers. Once developers have created new assets in a market, individuals and private enterprises have the opportunity to start new businesses or relocate or expand existing businesses and capture new audiences. These projects represent growth in a region, and that growth benefits the local commercial entities.

One prime example of this situation is with the Assembly Square T Station. Assembly Square is a 145-acre section of Somerville that is along Mystic River and has the Orange MBTA subway line cut through a portion of the area, previously without a stop, as shown in the image below.



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This area was formerly the Ford assembly plant until the 1960's. Afterwards it became an indoor mall, which failed. Then a new developer picked it up and tried to evolve it into a power center with big-box retail, which also didn't work. A third developer picked up the vacant marketplace and started to re-tenant it, at which point the developer, Federal Realty Investment Trust ("FRIT"), who would eventually undertake the redevelopment of a 56-acre portion, acquired the marketplace and began assembling additional land around it. Part of the hook for FRIT's initial involvement was that the MBTA was already considering a new station at Assembly Square. When FRIT acquired the marketplace, the design for the new station was

[85] "Squares and Neighborhoods - Assembly Square." Somerville, MA. City of Somerville. Web. 10 July 2016. <http://www.somervillema.gov/departments/ospcd/squares-and-neighborhoods/assembly-square>.

complete enough that funding had been federally earmarked to finance the construction.[86] According to Patrick McMahon, Director of Development for FRIT, "our involvement, without question, was tied to the dream, and at that point, a promise, that the T was coming."[87] However, in 2008, when the financial market crashed, all of the earmarked funding disappeared. It was uncertain to FRIT, the City of Somerville, the community and the MBTA whether the new T station would ever happen there. Between 2010 and 2011, the City, the State and FRIT worked to cobble together enough funding from various sources to bring the station project back to life. Ultimately, the sources of funding broke down as:

Federal Transit Earmark	$1 million of original $25 million
State (MPO)	$10 million
State (Other Grant Sources)	$18 million
Congressional Multi-modal Earmark	$6.26 million
FRIT	$15 million

[88]

FRIT felt that the station was such a critical element to the success of its development that it supplied a substantial contribution to help bring it back to life. According to McMahon, "the T station here is not one of several building blocks - it's one of two building blocks. There

[86] McMahon, Patrick. "Federal Realty Investment Trust Interview." Personal interview. 30 June 2016.
[87] McMahon, Patrick.
[88] "Squares and Neighborhoods - Assembly Square."

are two reasons we're here - one is the City of Somerville and their progressive vision... and the other is the T - if you take one of those two things away, we wouldn't be here."[89] So FRIT found a way to make it work with $15 million less going into the development because they felt that it was fundamental to their strategy to have the T station constructed. The entire project had been underwritten assuming they would have a transit stop, so they played with their models to the extent that they could reallocate the $15 million to the station and still have the ability to construct their vision.[90]

As mentioned earlier, these projects do not happen in a vacuum, and as Patrick alluded, the City of Somerville's progressive vision was a fundamental factor to creating value in this corridor as well. As discussed in Chapter 1, strong leadership is a necessity in achieving these types of projects, and in this case, the City of Somerville provided that leadership, with a strong private partner in FRIT to support the initiative. That leadership and progressive vision lead the City and the Mayor of Somerville to fight for the station because they understood that it would create value - it would unlock the development parcel and allow it to be of greater scale and density than it would otherwise be able to support.[91]

Another developer that felt their project was reliant upon a new transit station was NB Development Group, mentioned in Chapter 1, who agreed to pay for and construct a new commuter rail station within the Brighton submarket of Boston in support of their mixed-use development. According to Keith Craig, a member of NB Development Group's senior management team, "without creating another mode, [the development] wouldn't be successful. I

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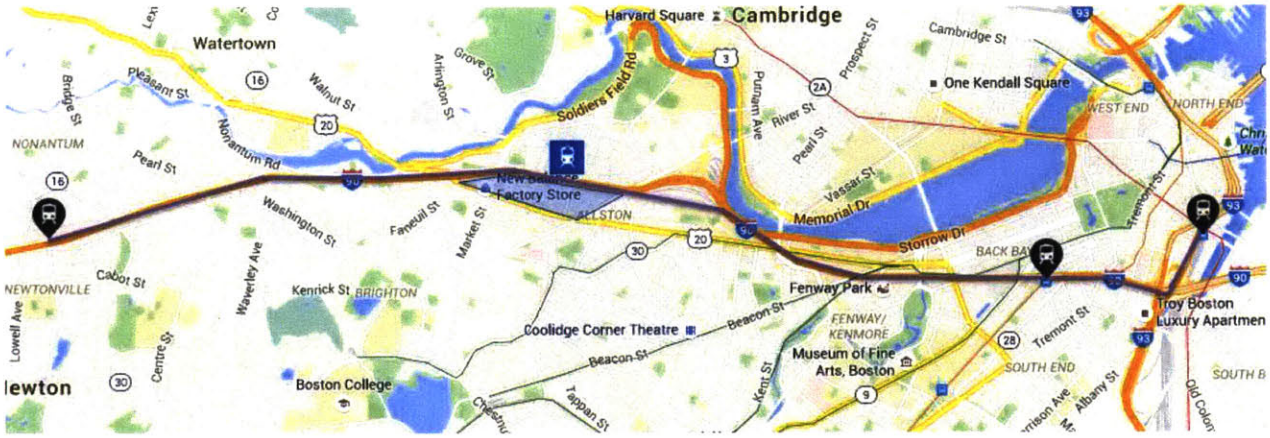
[89] McMahon, Patrick.
[90] McMahon, Patrick.
[91] McMahon, Patrick.

mean, preferably you'd have the Red Line, Green Line, or Orange Line, but the commuter rail makes sense. You're only a couple stops from Back Bay, a few from South Station, and then you've got all the [towns] out west… it'll be tough to attract the big, large space users without hard rail. Half of the development plan goes away without it...and having the train station, that kind of creates this location that people can understand - 'oh, I can see going there, I can see paying rent there, I can now understand how you get to and from' - whether it's train or car or shuttle or bus or bike or run."[92] Especially in mature cities, such as Boston, where public transportation infrastructure and the maps that support it are such a fundamental part of getting around, it makes sense that having a station can literally put your development on the map.



This is a map showing NB Development Group's 15-acre site, highlighted in blue in the Western part of Boston. The black station markers indicate the existing stations - originating at South Station on the far right, with Back Bay station shortly thereafter and Newtonville station on the far left. The distance from Back Bay to Newtonville is just shy of 9 miles, whereas the distance from Back Bay to the new NB Development station is less than 4 miles.

[92] Craig, Keith.

While NB Development Group is constructing a commuter rail station, the hope is that someday down the road, that the portion of the line close to the city would be transferred into a high-frequency line with subway-like service.[93] As the city expands outwards, the NB Development site could be a substantial growth area, and running higher frequency service may someday be required. So in this instance, the developer is investing in the rail to support its development, which in turn is expected to support future investments in the same rail. The value creation is tiered and cyclical which indicates strong growth.

The success of these two developments were reliant upon the installation of new rail infrastructure. A third developer, DivcoWest, who is in the early stages of constructing NorthPoint, a mixed-use site that sits between two different T lines, is making a financial contribution to the Green Line Extension, despite the fact that it already has access to rapid-transit. Tim Canon, a member of the acquisitions team at DivcoWest, indicated that if the site didn't have both lines, the underwriting would have been impacted, and it would have certainly changed if neither were there. Transit is something they follow closely, as tenant trends indicate a desire to be more urban and closer to more transit options. The developer's contribution in this case is tied to increased development rights that they will be awarded as the new station achieves certain milestones.[94]

In all these cases, the necessary contributions towards the various rail projects were factored into the financial analyses and were justified through robust modeling. But at the end of the day, developers pull the trigger on a development because it meets a return threshold. These

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[93] Craig, Keith.

[94] Canon, Tim. "DivcoWest Interview." Personal interview. 9 June 2016.

projects can be very risky, so in order to take on that risk, developers must be compensated, and below a certain return, the developer will just not build. In the current market that has been ripe with new developments, return margins have thinned out substantially, so developers are starting to take on substantial risk for not a huge return.[95] When thinking about value capture, and the concepts that Fred Salvucci mentioned in Chapter 1, squeezing developers even more than they already are can jeopardize entire projects. So when thinking about value capture, it's important to strive for a balance where there is a reasonable contribution, but not to the extent of destroying a project. Financial underwriting can be a moving target which relies on a vast number of assumptions. The only certainty with these models is that they will never tie exactly to what ends up happening, so it makes sense that in many of these cases, the developer contribution was a negotiated number, as opposed to formula-based. During the discussions in these three examples, the costs for new rail or new stations was known, so it came down to how much could each group justify spending based on their understanding of the benefit weighed against how thin their margins might be. Again, this ties back into a method Fred Salvucci mentioned of using retrospective value capture rather than prospective, so that all costs related to the infrastructure and the development are known, and the benefit can be quantified in terms of ridership or transactions, or another method. This is similar to a more traditional tax approach, but there could be opportunities to create a tiered value capture structure tied to the development based on ridership or sales milestones that are specifically reinvested into infrastructure.

Despite these couple examples of new rail access supporting developments, there are numerous factors other than rail that can cause development values to increase. Within the

[95] Schrock, Melissa.

Boston area, there are two submarkets that are currently exploding with development. The Seaport District has risen from a sea of parking lots to be the home of multiple millions of square feet of office and residential development over the past decade. This area of the city has been a commercial and light-industrial zone for the past couple centuries, holding a fish pier, cruise terminal, and a variety of other uses, but only recently has this frenzy of development occurred. This development is widely attributed to the Big Dig. The project provided highway access, a tunnel to the airport, and a Bus Rapid Transit ("BRT") system to the Seaport District. Once the market recovered after The Great Recession, this newly accessible market became an attractive development location. The other submarket currently ripe with development is Kendall Square. Kendall Square has been one of stops along the Red Line since the line was initially constructed. This area too has grown wildly with development over the past several years, yet there has been no change in transit, so increased access is not the key here. However, it has close proximity to MIT and Harvard, and it has historically been a strong biotech and software market, which happen to be strong parts of the economy that have been rapidly growing lately. These factors have created a niche in Kendall Square, and there was already transit access in place.[96] So while accessibility certainly helps, it was not the driving factor that spurred new development. So with this example, it is important to understand that just because there is a correlation, doesn't mean there is causation.

Beyond developers, companies who locate within these developments, along new rail lines receive value as well. There is enhanced accessibility provided by the rail which enables employees and customers to reach these establishments with greater ease. Increasing

[96] Neumann, Lance.

accessibility can help companies recruit workers, which can help grow a business. At the Assembly Square development, Partners Healthcare is consolidating 14 locations around the greater Boston area into a campus that FRIT is constructing. They chose that location because of the value that the T brought to helping their employees get to work. Additionally, the Assembly Square retail tenants have benefitted tremendously from not only the high-density environment that FRIT created, but from the T station delivering shoppers to their door steps daily.[97]

With respect to the Green Line Extension through a different part of Somerville, although much of the heavy construction has yet to start, real estate brokers are using the future station proximity as a selling point to home buyers in the region.[98] "It's well known that economies grow around train stations... and that property values increase in areas adjacent to good transit connections...From 2006 to 2011, residential property values performed 42 percent better on average if they were located near public transportation with high-frequency service."[99] In this case, the promise of the station is creating value upon which these brokers and home sellers are able to capitalize, and there is likely greater growth yet to come once the stations are constructed and operational. If residential homes are performing substantially better, it would seem that it is only fair for a portion of that benefit to go back into the system creating the value. As mentioned, however, it is unlikely that residents would vote to increase taxes to participate in a value capture strategy. There is a general distrust in the ability of the government to effectively spend the money they receive, so until we're able to achieve a situation where the cities and states can prove they are able to make good, quick use of the money, and residents buy into continued

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[97] McMahon, Patrick.
[98] "MassDOT Official Interview."
[99] Kanter, Rosabeth Moss, 178.

reinvestment in the infrastructure, it doesn't seem likely that we will be able to tap into that 42% value benefit.

2.2 - Private Sector Value Capture

So when there is clearly financial value created, is there a way to capture a portion of it to reinvest back into infrastructure in order to continue growing the region without completely stripping the developers and commercial beneficiaries of the value they received? While the I-Cubed program captures future value if a developer elects to apply for it, it is not a sustainable or reliable way to fund maintaining, improving and expanding the system. One method that has been successful numerous times within Massachusetts and across the country, according to Lance Neumann, "would be through joint development - value capture through development rights along the corridor. So you say to some private consortium, 'you build this and maybe operate it, but at least build this infrastructure, we'll give you development rights at these 6 station locations'... if you have access to the site, its value tends to go up, so you could conceivably get - I'm not sure you could get enough financing out of that to build a whole project, but you could make a contribution."[100] This strategy is similar to the concept of trading density bonuses for infrastructure projects or contributions, as mentioned in Chapter 1. This strategy should be attractive to public agencies because they could potentially receive quite large contributions without having to give up too much. Of course, adding density can put further strain on the system, but increased ridership also helps to support the system.

[100] Neumann, Lance.

Another way to think about value capture would be through land-use planning as it relates to transportation by putting a residual tax value around the land that benefits from transit and put that incremental value back into the infrastructure.[101] There have been other municipalities across the country that use a sort of tax-increment financing, but as discussed in Chapter 1, Massachusetts's Proposition Two and a Half limits the ability to utilize this sort of financing in the same way. If Massachusetts were able to implement a sort of District Improvement Financing scheme, there could be a substantial contribution that went towards transit. In most cases, these value capture districts collect on the benefit of rail into perpetuity. There is an assessment done before the rail is installed and then a percentage tax is put on the additional property value.[102] Although this usually is only ever on the commercial assets, since residents would likely not vote to approve an incremental tax on homes.[103]

With respect to capturing value from private businesses that locate in new developments along new rail corridors, there could be an arrangement made, at the state or city level that a percentage of the new business income tax generated in that area will be designated to go back into transit as opposed to general funds for the city or state, although that may create other challenges and restrict an agency's ability to invest in the area as a whole. Alternatively, for companies that relocate to the transit, there could be an incremental assessment placed on growth they experience, although that could create a disincentive to locating near transit, which would be counter-productive. The third option would be, as Mr. Salvucci suggested in Chapter 1, to assess a tax on all companies' growth across the region, as opposed to solely along new transit,

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[101] Davey, Richard.
[102] Neumann, Lance.
[103] Bourassa, Eric.

over a base and provide plenty of notice to allow companies to plan. This would provide additional funding and allow the state to capture some of the value created to invest back into the system.

2.3 - Public Sector

The public sector, meaning municipalities and state governments, receives many benefits from rapid transit rail infrastructure as well. Some of that benefit is reflected through the receipt of increased taxes generated by the private sector, as discussed in the prior section, but there are additional benefits, beyond taxes, that these agencies receive as well. Valuing transit is not a new concept. "Just look back nearly 60 years, and the story of building interstate highways serves as inspiration. Back then the country looked to infrastructure as a way of growing the economy, generating the revenue that would sustain the growing population. The Federal-Aid Highway Act of 1956 authorized the spending of $25 billion (more than $200 billion these days) for the construction of more than 40,000 miles of interstate highway over the coming decade."[104] With strong infrastructure, cities will have the capacity to grow, but only if the land-use, zoning and regulations work in concert with those growth needs.

"Public transit is worth a great deal to a city. Hidden economic value can range from as much as $1.5 million a year for the smallest of cities to a whopping $1.8 billion a year for the largest cities, according to urban economists Daniel Chatman and Robert Nolan, who analyzed 2003-07 data from 290 metropolitan areas. Their study shows that adding about four seats to rail lines and buses per 1,000 residents produces 320 more employees per square mile [of the service

[104] Lind, Diana. "Cities Without Highways." Print. Rpt. in City 2.0: The Habitat of the Future and How to Get There. New York: TED Conferences, 2013. 287-393. eBook.

area] for the central city, an increase of 19 percent. Adding 85 rail miles delivers a 7 percent increase. A 10 percent expansion in transit service by adding rail and bus seats or rail miles produces a wage increase between $53 and $194 per worker per year in the city center, and an associated 1-2 percent in the gross metropolitan product, a measure of urban economies equivalent to the gross national product for countries. These figures predate the financial crisis and Great Recession, of course, but the sheer magnitude of the effects is impressive."[105]

When thinking about the hidden economic value of public transit, it might be reducing unemployment and thus unemployment benefits, or it might be reducing the overall cost of subsidizing services for residents due to educational and employment opportunities that are now available as a result of increased mobility.[106] "The American Public Transit Association claims that every $1 invested in public transportation generates approximately $4 in economic returns, [which includes explicit tax and revenue increases, the reduced unemployment and subsidies mentioned, reduced costs of congestion, and agglomeration effects, among other things]. Their figures show that every $10 million in capital investment in public transportation yields $30 million in increased business sales, and every $10 million in operating investment yields slightly more, some $32 million in sales increases."[107] These increased sales and wages all translate into higher tax revenue that goes back into the states and municipalities, so when considering value capture options, an incremental tax on sales or business income may generate substantial revenue to reinvest in transit infrastructure. "There are also cost savings [associated with expanded transit that impact the public and private sectors]: in 2011, U.S. public transportation use saved 865

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[105] Kanter, Rosabeth Moss, 177-178.
[106] Davey, Richard.
[107] Kanter, Rosabeth Moss, 178.

million hours in travel time and 450 million gallons of fuel in 498 urban areas. Without public transportation, congestion costs in 2011 would have risen by nearly $21 billion, from $121 billion to $142 billion in the 498 urban areas," according to the American Public Transit Association.[108]

The supporters of the Green Line Extension understand that there is potentially a lot of value to be unlocked by installing the rail through Somerville, so MAPC worked with the City of Somerville and several consultants to try and understand that value. The team tried to evaluate from both a city perspective and a state perspective, what would be the impact of the Green Line Extension? When thinking about the city level, it's difficult to disentangle what jobs or housing might have materialized regardless of the T because it is a strong growth area due to its proximity to the bulging Boston downtown market. When thinking about the state level, it's hard to say that just because jobs and new residents didn't locate in Somerville, that they wouldn't materialize in a neighboring town. So to actually quantify, at both the city and state levels, jobs and housing that would not have materialized but for the Green Line Extension, is challenging. The angle that the team took was to say that Somerville is planning a substantial density increase along the new line with a mix of uses. Their argument is that without the Green Line, there won't be as much commercial growth. With housing, there is such a high demand for it, and that development could still happen, but the commercial growth becomes much harder to achieve without the rail extension. Somerville then said that if they don't get the commercial, they will need to balance the taxes with the residential constituents because of the service needs that are created by additional residents. So without the commercial to help support the additional

[108] Kanter, Rosabeth Moss, 178.

services, Somerville will not allow the development of as much housing. Taking it one step further, without the additional housing within close proximity of Boston, you also have fewer places for workers who commute downtown to live, so there's also an impact on the Commonwealth in terms of having as many workers who can fill jobs, which means you don't have as much job growth in the whole region.[109] According to Brad Rawson, "[Somerville] has been 100% clear - [the Green Line Extension] has to happen. This is not just about Somerville, this is not just about Metro Boston, this is a project of statewide significance that delivers meaningful benefits to the entire Commonwealth - not just the metro core, and certainly not just to the City of Somerville."[110] When trying to quantify the Green Line Extension value, there are clearly many angles to consider. There are both the quantitative and qualitative sides to these analyses, but both are mired with complications that create challenges when trying to isolate value that is truly attributable to a rail extension, especially when fairly capturing some of that value is the goal.

The Green Line Extension successfully captured value from the municipalities of Somerville and Cambridge. Some of the benefits outlined in the MAPC report are reduced transportation costs, improved connectivity to jobs and regional destinations, and reduced cost for maintaining road infrastructure. Additionally, the rail line, along with supportive local land-use contexts and public policy, are expected to generate pedestrian-friendly, mixed-use neighborhoods with higher density. This planned development is expected to generate an additional $3.2 billion in assessed property value by 2047, and of that, approximately $1.37 to $1.52 billion (43-47%) is directly related to the planned Green Line Extension, and is unlikely to

[109] Bourassa, Eric.
[110] Glavin, Michael and Brad Rawson.

occur without it. Based on this growth potential, the consultant team estimated the potential revenues from capturing a share of the property tax increment, as shown in the figure below. In one scenario they calculated property tax revenues generated from all planned developments in the station areas, which totaled $158 million captured over a thirty year period. In a second scenario they calculated the property tax revenues generated by only the development that is directly related to the build-out of the Green Line Extension, which yielded $67 million over the same thirty year period. Additionally, based on these estimates, the consultant team calculated the potential value that the municipalities might receive from development contributions under the same two scenarios. In scenario one, they estimated that developments could contribute $20.7 million over thirty years, whereas in scenario two the estimate was $9.7 million.

Somerville Revenue Estimates between 2017-2047

	Scenario I: All planned development in station areas	Scenario II: Only development directly related to the GLX
Property Tax Revenues	$158 Million	$67 Million
Development Contributions	$20.7 million	$9.7 million

At the state level, the Green Line Extension is expected to support close to 15,000 permanent jobs and provide $932 million in state tax revenues over thirty years, of which approximately $399 to $431 million could be attributed to the new development directly related to the line.[111] Based on this analysis, Somerville and Cambridge felt comfortable contributing $50 million and $25 million, respectively.

[111] Strategic Economics, and RKG Associates. Green Line Extension Revised Value Capture Analysis. Rep. 2016. Print.

But to take a step back, beyond the added revenue from taxes or cost savings from congestion or unemployment, the public sector also benefits from the rail extension in terms of supporting their overall goals and missions for the region. The public sector's purpose is to advocate for all of the different groups and support a range of initiatives from social equity to economic development. To support these broader goals, they pursue initiatives for improving mobility and connectivity, but also increasing sustainability and encouraging mode shift from cars into public transportation.[112] In general, if the city is to be able to grow at the level that people desire, there needs to be an accelerated investment in bringing the public infrastructure into a state of good repair so that we can think about future expansions.[113]

2.4 - Community Value

While the public and private sectors have clear, direct economic benefits that result from rail extensions, the community also extracts both economic as well as more qualitative values from these projects. When we say the community, we mean the residents that live within walking distance of the new investment, workers whose jobs are located within close proximity to the new rail, and the greater population at large. There is certainly overlap between benefits that community receives and those that public sector receives, as the public sector's purpose is to protect and advocate on behalf of the people. So reduced congestion, unemployment, and increased municipal and state revenue that can be invested in better services and infrastructure are all benefits that the community experiences as well.

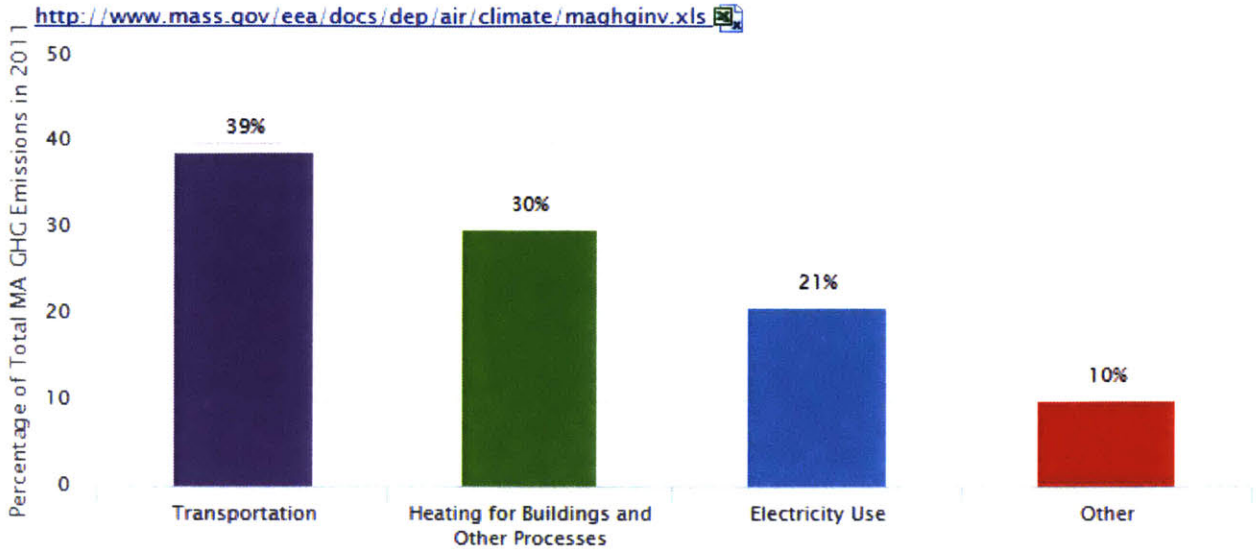
[112] Myerson, Sara.
[113] Shen, Kairos.

Before exploring granular benefits in the daily lives of the people closest to a new rail line, in the big picture, some of the largest community benefits of increased mass transit are enhanced productivity, sustainability, and health. According to several studies on urban mobility and environmental health completed in 2010 and 2011, "the average American commuter wastes a total of 38 hours in traffic per year. This amounts to 5.5 billion hours in lost U.S. productivity annually and 2.9 billion gallons of wasted fuel. For 2011, the cost of congestion in wasted time and fuel was estimated to total $121 billion, or $818 per auto commuter. Traffic congestion alone costs about $70 billion per year in time wasted, and the public health cost of pollution from that congestion is about $15 billion per year, according to Harvard School of Public Health researchers."[114] These figures are astounding, and the reduction in greenhouse gases has entered legislative discussions as well. Within Massachusetts, the Global Warming Solutions Act is pushing the state to reduce its carbon footprint 25% by 2020 (with a base year of 2008), and by 80% by 2050.[115] The largest contributing factor to greenhouse gas emissions in Massachusetts is due to transportation, as seen in the chart below.

[114] Kanter, Rosabeth Moss, 9.

[115] "Massachusetts' Progress towards Reducing Greenhouse Gas (GHG) Emissions by 2020." The Official Website of the Executive Office of Energy and Environmental Affairs. Commonwealth of Massachusetts, n.d. Web. 12 July 2016. <http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/>.

Source: MassDEP (2014). Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990-2011 with partial 2012 data
http://www.mass.gov/eea/docs/dep/air/climate/maghginv.xls



Within Massachusetts, according to Walkscore.com, seventy-two out of the 351 Massachusetts cities and towns have been ranked with a walk-score, and approximately 65% of those communities are considered "car-dependent". Fewer than 10% of those communities are considered "very walkable".[116] So with this in mind, expanding mass public transportation options should be considered a crucial investment in the planet and our future. Amending land use and zoning regulations to permit transit-oriented development goes hand-in-hand with that to concentrate density around these hubs and minimize travel.[117] So at the highest levels of understanding community benefits, increased public transit options improves the planet for everyone.

At a more micro-level, increasing transit can connect people with goods and services and jobs. Under the right circumstances, there can be new mixed-use developments that locate near

[116] "Massachusetts' Progress towards Reducing Greenhouse Gas (GHG) Emissions by 2020."
[117] Schrock, Melissa.

transit which can bring new parks, programmed open space, and amenities to a neighborhood.[118] Unfortunately, however, the current transit system within Boston isn't fully reflective of the evolving daily commuting patterns of Bostonians.[119] There are likely many people who live or work within close proximity to public transit and yet don't use it. There can be many good reasons for a person not to use transit. "It may not go where you need it to go, or at the time you need to go. Perhaps you can get there three times faster by driving, or at half the cost. You may know from experience that you can't trust your service to come on time."[120] So just installing a new line is not enough to get the mode shift and increase in ridership that public agencies hope to attract when undertaking these projects. There must be useful connections between places and thoughtful designs to try and solve for as many use patterns as possible.

With a strong public transit system, expansion can benefit the entire system and help enable growth in the region. It can promote new commercial development and job creation in areas that were previously residential, such as Somerville, where the labor force is currently 45,000 and there are only 20,000 jobs within the city limits. The Green Line Extension will enable new job growth within the city which will help reduce the outflow of workers every day, reducing congestion and allowing parents to be closer to home to be able to volunteer in their kid's school or on athletic teams, or participate in a community organization.[121] Better transit can connect people to education and employment opportunities and create upward social mobility if the less-advantaged communities have the same access.[122]

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[118] McMahon, Patrick.
[119] Myerson, Sara.
[120] Walker, Jarrett, 1.
[121] Glavin, Michael and Brad Rawson.
[122] Kanter, Rosabeth Moss, 217.

But as we discuss value increases that occur along transit and generally think of that as a positive factor, there are also negative impacts, such as growth causing displacement and gentrification. There are inclusionary policies that can help minimize these effects, but that is beyond the scope of this thesis. With respect to the Green Line Extension, there were citizens who were concerned about worsening traffic congestion both from any increased density near the stations but also from people driving from neighboring communities and parking near a station to avoid driving into the city center.[123] So when thinking about public transit as a means to reduce congestion, there can be both areas that experience improved traffic flow as well as areas that are negatively impacted.

Coming back to the concept of value capture, it is more difficult to quantify the value that accrues to the community. There are cost savings from reduced congestion, but capturing this value would likely need to be done through a sort of time-of-day tolling as explained in Chapter 1 and would be difficult to directly relate to a specific improvement. Congestion savings are also reflected in less fuel needed, so there could be an increase in the gas tax to capture any savings within a certain region. Health, productivity, and increased access are also difficult to quantify. Health savings are often not seen for decades and are difficult to attribute to one thing. Increased productivity could be reflected in a supplemental business income tax, which is similar to London's approach with the Cross-Rail, as mentioned previously. Increased access to education and employment are also measures of productivity within a region, so the same region-based business level tax may be appropriate for that as well. When the entire community and region

[123] Bourassa, Eric.

benefit from an enhanced transit system, it seems that value should be captured across the board, and the legislature should be considering several of these alternative options.

Summary

When thinking about the value of transit, it cannot be considered alone. A rail extension that does not connect to anything is useless, so in order for all of the values discussed in this chapter to be realized, the rail must be designed and located thoughtfully. The real estate development that exists or occurs around it is one of the other substantial components to the value equation. The relationship between those pieces can largely define how much value will be derived from the infrastructure, so when developers have substantial control over what opportunities are created near the transit, it seems counter-productive to squeeze as much value out of their development budgets as possible. Especially when there are several buckets of stakeholders experiencing both real and hidden economic benefits from these infrastructure projects. It seems reasonable for municipalities and state agencies to try and tap into those additional resources. Just as the federal government can no longer be considered the sole source of infrastructure financing, neither can developers.

Chapter III: Boston's Current State of Rail Infrastructure

This chapter will discuss the current environment in which rail investments exist in the Greater Boston Area. As discussed in the previous chapters, these projects do not occur in a vacuum, so it is important to understand the landscape and challenges associated with constructing a project other than things directly related to the project itself.

Boston's MBTA network has enough critical mass to be useful to a substantial number of users, but in order to support the growth of the region, there needs to be additional investment. The necessary investment is not only for expanding the system and creating new connections, but also investing in bringing the current rail and vehicles into a good state of repair, which will be a large focus of this chapter. Before the Commonwealth is able to engage in much discussion about expansion, it needs to address the existing issues. Whereas the prior chapter discussed extracting value from increased benefits that accrue to different groups as a result of new accessibility, this chapter will seek to highlight value that can be achieved or is currently being passed over through means that are not necessarily directly related to a specific project, but rather the system as a whole.

To set the stage for this chapter, we will review the MBTA's current state of affairs, including legislative reform, financial constraints, and debt and deferred maintenance, how Boston is impacted by its current landscape, and whether Bus Rapid Transit (BRT) can be a reasonable alternative to help relieve some of the issues and costs associated with rail projects.

3.1 - MBTA Legislative Reform

In the year 2000, the passage of *Forward Funding* legislation initiated the first attempt at improving the MBTA's ability to manage its budget. Prior to this bill, the T would essentially send a request to the state each year for money to cover that year's expenses.[124] This new legislation dedicated 20% of all statewide sales taxes collected in Massachusetts to the T. Throughout the 1990's, sales taxes had grown at an average of 6.5% annually, but after the dot-com bubble burst, the following decade's sales growth hovered around 1% annually, which meant that the T received only a small fraction of the expected revenue from that source. The *Forward Funding* legislation also transferred $3.3 billion in Commonwealth debt from the State to the MBTA based on projects that the state had borrowed against and funded on the T's behalf.[125] While this legislation had been initiated as a means to empower the MBTA to balance its budget and take control of its operations, it ended up providing a substantial debt burden and less revenue than expected to support it.

In 2009, the legislature passed *An Act Modernizing the Transportation Systems of the Commonwealth*, which consolidated multiple state-run transportation agencies all under the Massachusetts Department of Transportation ("MassDOT"). This act was aimed at reducing redundancies across organizations and streamlining shared services such as legal, human resources, IT, and security departments. It also enacted several cost-savings measures such as eliminating the practice of allowing workers to retire after 23 years regardless of age, moving

[124] Davey, Richard.

[125] Kane, Brian. "Born Broke: How the MBTA Found Itself with Too Much Debt, the Corrosive Effects of This Debt, and a Comparison of the T's Deficit to Its Peers." (n.d.): n. pag. *MBTA*. MBTA Advisory Board, Apr. 2009. Web. 8 June 2016. <https://www.mbta.com/uploadedfiles/Documents/Financials/Born_Broke.pdf>.

employees onto a state group health plan, and eliminating two-person operators on the red and orange lines.[126]

The most recent legislative reform aimed at improving the T's financial and operational capacities was the *Transportation Finance Act of 2013* which attempted to tackle these problems from numerous angles. The Governor at the time, Deval Patrick, proposed raising the income tax and reducing the sales tax, which would have net an additional $1.9 billion in taxes, half of which would have gone towards transportation and half would go towards education. The legislature rejected that proposal and instead opted to raise the gas tax.[127] The bill ultimately raised the state gas tax by three cents, shifted operating expenses from the capital budget to the operating budget, developed a schedule for fare increases and required regular capital planning.[128] The Act is projected to raise $600 million per year over a five year period to support transportation needs. While this is a step in a positive direction, prior to the passage of this Act, analysts estimated that the annual funding gap was closer to $1 billion per year over 20 years.[129] Without further legislative reform that dedicates a reliable revenue source towards public transit infrastructure, cities and states will need to get creative and identify their own new sources of financing to bridge the gap.

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[126] Mares, Rafael. Keeping on Track: Our Progress in Reforming and Funding Transportation since Passage of the Massachusetts Transportation Finance Act of 2013. Rep. MASSPIRG Education Fund, Mar. 2014. Web. 15 June 2016. <http://www.masspirg.org/sites/pirg/files/reports/Keeping%20On%20Track%20Vol.%20I%20-%20Final%20Web%20March%2020%202014.pdf>.

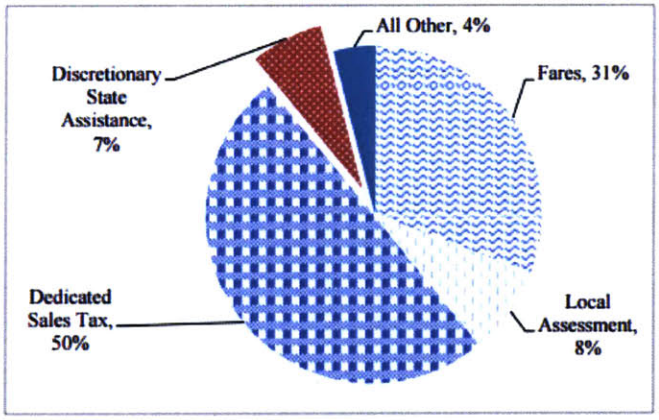
[127] Davey, Richard.

[128] Mares, Rafael.

[129] Mares, Rafael.

3.2 - MBTA Revenue Shortfalls

The MBTA has four primary sources of revenue - fares, local assessments, the 20% dedicated state sales taxes, and discretionary state assistance. The first three sources are statutorily capped, which results in the state being left to assume risk for shortfalls - a similar position that the state was in prior to the *Forward Funding* legislation. Fiscal year 2015's sources of revenue broke down as shown in the chart below, with the state bridging a gap of 7%.



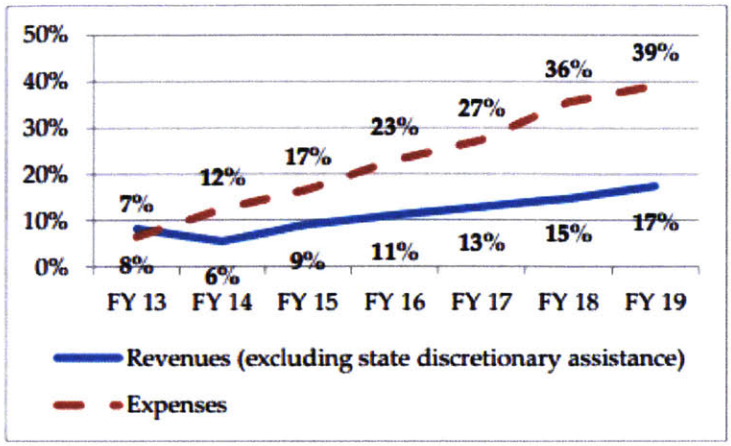
[130]

For fiscal year 2016, the state's contribution from their general discretionary funds is projected to be $200 million, which is roughly a 10% shortfall in the MBTA's $2 billion budget. Based on the current structure, the state's exposure is expected to grow to $360 million by fiscal year 2019.[131]

[130] "The End of Its Line." (n.d.): n. pag. *MBTA*. Massachusetts Taxpayers Foundation, Mar. 2015. Web. 8 June 2016. <http://www.mbta.com/uploadedfiles/About_the_T/Panel/MTFTheEndofItsLineReport.pdf>, 8.

[131] "The End of Its Line.", 2.

Year-over-Year Growth in MBTA Expenses and Revenues (FY 2012 Base)

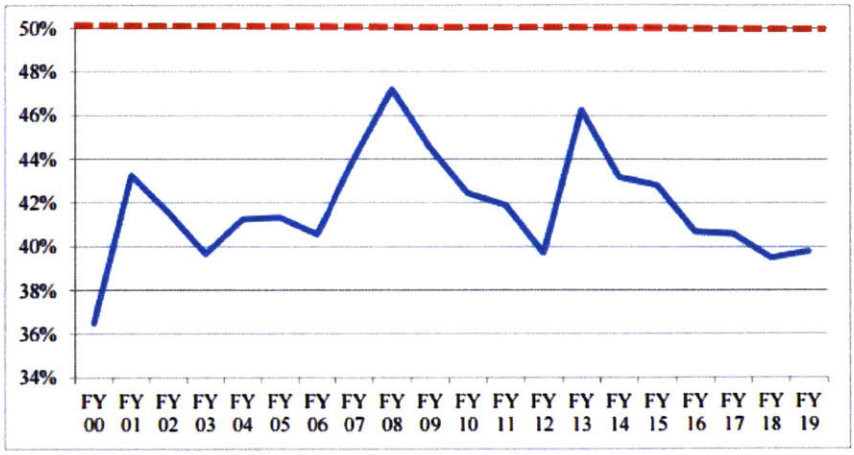


[132]

The first source of revenue, MBTA fares, account for roughly 30% of its revenue. Based on fare increases, the T reached a revenue recovery ratio, defined as total fare and other self-generated revenues divided by total operating costs, of 47% in fiscal year 2008, which is the highest ratio it has seen to date, while other comparable transit systems, including New York, San Francisco, Washington DC, and Chicago, all achieve a revenue recovery ratio in excess of 50%. However, since 2008, with expense growth outpacing revenue growth, the revenue recovery ratio has declined and is currently around 43%.

[132] "The End of Its Line.", 2.

Figure 7 – MBTA's Revenue Recovery Ratio – FY 2000 - 2019



[133]

Prior to the *Transportation Finance Act of 2013*, the T would arbitrarily enact steep fare increases when there was a need. The Act, while establishing regular formulaic increases, also capped the increase at 5% every two years. The four fare increases between 2000 and 2013, in addition to the growth in ridership, grew revenue at an annual rate of 11%, on average, during that period. Based on the new cap and a projected slowdown in growth, the total fare revenues are projected to grow by only 3.3% annually over the next five years which will reduce the revenue recovery ratio from 43% in fiscal year 2015 to an estimated 39.6% in fiscal year 2019.[134]

The second source of revenue, local assessments, are contributions that municipalities that are serviced by the T make to support its ongoing operations. In 2015 this source accounted for approximately 8.2% of its revenue whereas the 10 largest transit systems across the country receive nearly 25%, on average, from local communities. The disparity is caused by Proposition Two and a Half, which has been discussed in prior chapters, which limits the annual growth of municipal payments to the MBTA to no more than 2.5%. Part of the *Forward Funding*

[133] "The End of Its Line.", 19.
[134] "The End of Its Line.", 8-10.

legislation increased the number of towns that participate from 78 to 175, but it also froze contributions during 2001 and reduced the contribution for the following five years by $1.7 million annually. Additionally, it set a cap on the contribution to the T to the lesser of 2.5% or the rate of inflation, which was just over 1% from 2011 through 2014. Based on these changes, the average contribution is $900,000 annually, which is half of what it was in 2000.[135]

The third source of revenue is the dedicated portion of sales taxes, which makes up roughly 50% of the T's revenue. When it was initially outlined, the T would receive 20% of the sales taxes. In 2010, the state increased the sales tax rate from 5% to 6.25% and decreased the contribution to the T to 16%. There is also a statutory cap and floor to this revenue source. The distribution to the T can be no less than the previous year with a base amount in 2001 of $644 million, and can grow no more than the lesser of inflation or 3%, regardless of the total sales tax collections in any year.[136]

It seems that every time there has been positive legislation related to the MBTA, there are hurdles thrown in the way at the same time that offset a substantial portion of the benefit. While value capture strategies discussed in Chapter 2 can be beneficial tools for expansion projects, they don't address the shortfall in revenue that currently fails to cover the existing operating expenses. While this shortfall continues to exist, expanding the system becomes difficult to justify.

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[135] "The End of Its Line.", 11-12.

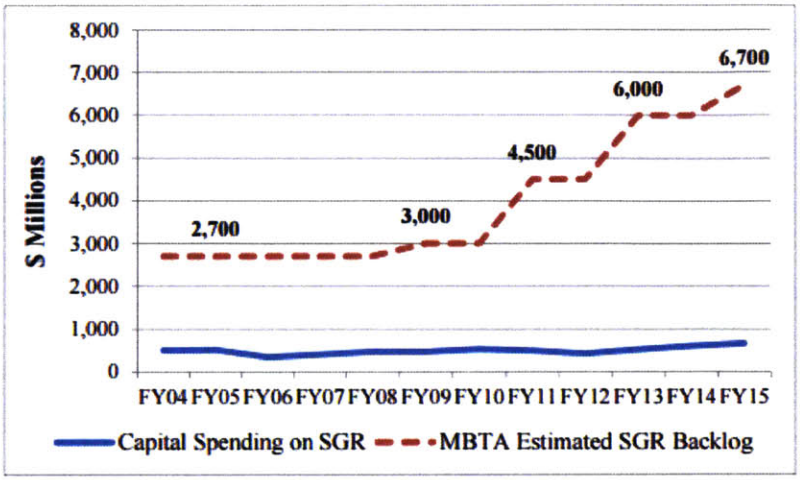
[136] "The End of Its Line.", 13.

3.3 - MBTA Deferred Maintenance and Debt

Beyond not having enough revenue to cover ongoing operations, the T needs money to address a backlog of "State of Good Repair" ("SGR") issues in addition to paying off a substantial debt burden. The current system has aged beyond its useful life and is in need of a major facelift. "In a 2006 report, the MBTA said it faced a backlog of $2.7 billion in deferred projects and would need to invest $470 million a year just to keep the system from deteriorating further. At that point in time, it would have required a total of $620 million a year to eliminate the existing SGR backlog over 20 years. 'Even with unlimited funds', the report notes, 'it would take nearly seven years to complete these backlogged projects, *during which time an additional $2.1 billion in needs would be generated* (emphasis added).'"[137] Even after this report was issued, the MBTA continued to under invest in the system and the SGR backlog increased. As of March 2015, the latest estimate is that the current backlog is $6.7 billion, although that number is probably low since there has not been a complete compilation of assets in inventory. As projects continue to remain unaddressed, they worsen, which causes the overall cost to bring the system into a state of good repair to continue to increase. As of March 2015, the MBTA could only afford to increase SGR spending by $100 million annually to a total of $600 million between 2015 and 2019, whereas current estimates are that there should be at least $800 million invested per year to maintain the system and $1 billion annually to start chipping away at the backlog.[138] These estimates are purely to bring the system to an acceptable state and don't even scratch the surface in terms of addressing expansion or growing to support the region.

[137] "The End of Its Line.", 45-46.
[138] "The End of Its Line.", 46-47.

Figure 17 – MBTA State of Good Repair Backlog, FY 2004 - 2015

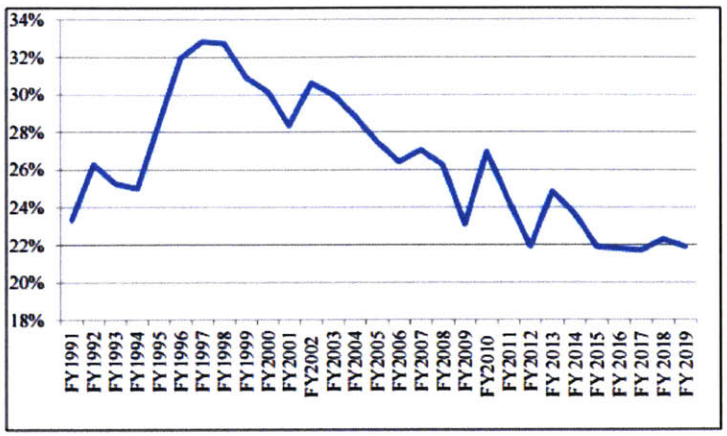


[139]

Beyond the SGR needs, "the MBTA is one of the most indebted transit systems in the United States, with $5.45 billion in outstanding debt - a figure that rises to $8.8 billion inclusive of interest."[140] Prior to *Forward Funding*, the T's debt was guaranteed by the state and the Commonwealth subsidized roughly 90% of the annual debt service. When the $3.3 billion in debt was transferred in 2000, so too did the responsibility for paying it. The cost of paying debt service, at the time of the $3.3 billion transfer, consumed approximately 31% of the T's total expenses, which is more than any other large transit agency in America. In order to manage this burden, the MBTA has refinanced and restructured its debt numerous times over the past fifteen years, bringing the debt expenditures down to roughly 22% in 2015, but in many cases, the restructurings just stretched out the obligation and deferred it to a later date, which in the long-run increases the total obligation when accounting for additional interest.

[139] "The End of Its Line.", 47.
[140] "The End of Its Line.", 13.

Figure 15 – Debt Service Expenditures as a Percent of Budget – FY 1991 to 2014



[141]

"[The] MBTA has endangered the long-term viability of both its operating budget from which future debt service payments must be allocated *and* its capital program because this outstanding debt imperils the T's ability to borrow for critical system maintenance projects."[142] So between a $9 billion debt obligation and $7 billion in backlogged maintenance, the MBTA has a $16 billion problem to solve.[143]

When it comes to the Green Line Extension, it has been no easy feat to get the funding lined up, given how thin the money to which the agency has access is stretched. The Fiscal Management Control Board for the MBTA receives constant reports on the needs of the system - the estimated backlog of the State of Good Repair needs, inventory that's constantly breaking down, the buses, the maintenance facilities - they're inundated with issues. So when they're pressed to contribute $1 billion of state money towards the Green Line Extension, that is money being taken away from projects that have already been neglected in the system and that are impacting existing riders. On the other side, though, supporters of the GLX argue that the Green

[141] "The End of Its Line.", 42.
[142] "The End of Its Line.", 44.
[143] Davey, Richard.

Line is receiving $1 billion dollars more of federal money that would not otherwise have come to the state and that this project will create more jobs, increase accessibility and is an overall great project for the Commonwealth.[144]Additionally, as of a 2015 report, the launch of the Green Line Extension is expected to generate an additional $16.5 million in fare revenues in fiscal year 2018 and increase to $21.3 million in fiscal year 2019.[145] Although these figures predated the fiscal challenges that caused the project to go on hold, there is still an expectation that much needed revenue will be added to the system with the addition of the Green Line Extension.

3.4 - MBTA Outcomes

Boston has reached and arguably surpassed a critical point for evaluating and fixing the public transportation infrastructure. "We're living in a 21st Century city, a beautiful city that everyone wants to come to. A Gateway city that, with Kendall Square and Longwood Medical Center and 50 colleges and universities that we have in the state, it seems like we should be able to support a first quality transit system that everyone can rave about, and we're just not there yet."[146] Every year there is an enormous out-migration from college students who come to Boston for their education and leave afterwards, largely because they can't find an affordable and accessible place to live.[147] Additionally, Millenials have already started moving back to the suburbs to start their families. Although, that shift is due to more than mobility challenges related to public transportation; it's also about education, housing affordability, access to open space and the ease of living, so there are many hurdles that the City of Boston and the surrounding

[144] Bourassa, Eric.
[145] "The End of Its Line.", 10.
[146] Craig, Keith.
[147] Bourassa, Eric.

metropolitan region need to address to help the Greater Boston Area continue to grow.[148] As the City of Boston approaches revisions to its master plan, neighborhood communities are vocally against adding any more density because, in the current state of things, the T is too crowded and there is too much street congestion. The communities have expressed that until the T is improved, the City shouldn't be approving growth.[149] So there is a Catch 22 - the city needs the density to justify and financially support expanding the infrastructure, but the city constituents are against increasing the density until the infrastructure is expanded and improved. Many cities would love to have the problem of too much growth, so Boston and the Commonwealth need to address these bottlenecks quickly if this metropolitan area is to remain competitive.

With all of the fiscal challenges associated with the MBTA, though, it's difficult to imagine much more significant rail development in the Boston region beyond what is currently being discussed. The realistic outcome is improving the existing infrastructure to get more service on the existing line, better maintenance to increase reliability, and new rolling stock. There are things that can be done with the current infrastructure to enhance frequency and reduce delays, but building new lines will be difficult to achieve in terms of garnering sufficient support and financing.[150]

Even with the increased funding through the 2013 legislation, which still isn't sufficient to maintain the current MBTA system, the incremental money received is not earmarked for the T or even for transportation projects around the metropolitan area. One of the pitches that helped the gas tax legislation get passed was that this would be for statewide investments, not just

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[148] Myerson, Sara.
[149] Bourassa, Eric.
[150] Neumann, Lance.

Greater Boston. Across the state there are significant equity concerns and mobility issues in rural, urban and suburban communities, even in such a small state as Massachusetts. And when raising the gas tax, Western and Central Massachusetts and Cape Cod were not interested in paying more if the tax was just going to be earmarked for improving the metropolitan area.

Additionally, coming back to the concept of value capture and considering that as a more sustainable funding source, if the state imposes some sort of District Improvement Financing and asks cities and towns to contribute to their infrastructure, Boston and the metropolitan area would be the only portion of the state that could support itself, due to its density.[151] So when considering these alternatives, there are many cases where investing in infrastructure isn't done in support of continued economic development, but rather the state and federal governments need to equitably contribute to all regions to provide mobility. Additionally, with such a substantial investment in the Boston region with the Big Dig, going back to the federal or state governments to ask for more funding becomes challenging, because there is a general sense among other parts of state and country that the Boston Metropolitan area has had more than its fair share of federal dollars and should wait its turn for the needs of other competing locations and projects to be addressed.[152] There is a balance between pursuing fairness and equity versus investing in pursuit of an overall economic impact and regional growth. Given all of the hurdles that need to be overcome in order to get a project off the ground, it is no wonder that the Green Line Extension has taken several decades to get to its current state. In order to support the growth of Boston and the metropolitan region, there needs to be a new approach to these types of projects.

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[151] Davey, Richard.
[152] Shen, Kairos.

3.5 - Rail versus Bus Rapid Transit

While process is certainly a substantial hurdle, one possible relief valve to the financial challenges is to consider Bus Rapid Transit ("BRT") as a viable alternative to constructing rail infrastructure. The most effective way to utilize BRT and have people accept it as an alternative to rail is to isolate it in a dedicated right-of-way out of city traffic. Well-designed BRT systems have stations where you enter and pay through a turnstile, the bus pulls up, and there is all-doors boarding. The bus acts like a train and the only difference is that it's on tires.[153] If it is in a segregated lane and not stuck in the same stop-and-go traffic as cars, it can be just as efficient as riding a subway and can be constructed at a fraction of the cost. With respect to its impact on surrounding real estate values, if the stations and bus lanes are fixed and the route is constructed and cannot be re-routed, proximity to a station can still be valuable to developers. It comes down to accessibility, frequency, ease of use, and creating a fixed station.

To put the cost difference in perspective, the Green Line Extension is 4.7 miles long with much of the track and right-of-way already in place and will cost $2.3 billion, or just under $500 million per mile.[154] In San Francisco, the 1.7-mile BART Central Subway Project is estimated to cost $1.7 billion or $1 billion per mile. A 2-mile section of New York's Second Avenue Line, currently under construction will cost $4.5 billion, more than $2 billion per mile.[155] Conversely, in Chicago, the city was able to construct a 16-mile BRT route for only $150 million, or just under $10 million per mile.[156]

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[153] Bourassa, Eric.
[154] Glavin, Michael and Brad Rawson.
[155] Kanter, Rosabeth Moss, 180.
[156] Kanter, Rosabeth Moss, 196.

Despite the substantially reduced cost, there are still challenges associated with BRT. According to Fred Salvucci, "The BRT doesn't give you enough capacity to make things work. It's a useful tool in some cases, but the most successful cases in the world, like Bogota, are now dying from their own success. They needed to shift to rail ten years ago. They're carrying more people than the systems can handle... I think they're at 80% unfavorable in the local polls now. This is the poster child for what a great success BRT is. We live in a democracy. You don't get elected with 80% unfavorable. So yeah, BRT is a useful technique in some corridors if you don't yet have enough demand. But in corridors that need rail, we need rail. Then you'd better admit it and you'd better figure out how to pay for it. And I think if we were skillful at the game, we could continue to get reasonable amounts of federal money. But we've got to supplement it with a lot of money."[157] Additionally, there are political challenges associated with taking away lanes from cars, which is the most cost-effective way to construct BRT within an already-developed city. Even if the BRT is adding capacity to the system, there will still be a substantial number of people who commute in cars who will strongly oppose losing a lane. While creating designated lanes and a reliable BRT may result is some mode shift, it is unclear whether it would be enough to offset the reduced car capacity. Yet another concern, especially in Boston, is the weather and does removing snow from a segregated lane create additional challenges that could potentially take the BRT out of service during severe storms.

Within Boston, there are likely several places where BRT could solve a problem sufficiently where adding rail would be prohibitively expensive. And in mature, built-out cities, there is limited land area to construct new rail, so modifying existing roadways could be the path

[157] Salvucci, Fred.

of least resistance. But as Fred Salvucci indicated, we need to be cognizant and realistic about the capacity if we are going to pursue BRT as a means to improve mobility around Boston.

Summary

In a city like Boston, accessibility and growth go hand in hand. Enhancing the public transportation infrastructure network impacts the value of the region as a whole. From a real estate development standpoint, transit oriented development has become a substantial financing source for improvements and expansions because there are synergies created by increasing access and delivering a mix of uses directly adjacent to that node. Developers have been willing to contribute to these projects and the cities, state and communities are all benefitting. But that doesn't address the backlog of financial duress associated with the MBTA. Unless developers are willing to accept responsibility for being the primary source of financing, it is in everyone's best interest to pursue a sustainable and realistic way to bring additional funding to the MBTA. That could be in the form of a business growth tax, a DIF or TIF, an incremental capital gains tax on residential properties, or maintaining the current legislation and removing some of the hurdles that handicap its potential. But in order for the region to grow, these issues must be addressed and quickly. If the Commonwealth and MBTA are unable to bring the backlog of SGR projects and substantial debt burden into a manageable state, expanding the system would be ill-advised. Given these financial constraints, the only feasible way to improve the system is through new funding sources, and capturing some of the value that the infrastructure investments create could be key to that endeavor.

Chapter IV: A Quantitative Review of the Value of Transit Accessibility in the Northwest Boston Basin

The quantitative aspect of our work is focused on investigating the property market value premium for rapid transit accessibility for investment (income generating) property in the cities of Cambridge, Somerville, and Medford, Massachusetts. This is the region of the Boston Metropolitan Area where the Green Line Extension will be located, what might be referred to as the Northwest Boston Basin. It has a degree of coherence and homogeneity, including high density development dating originally largely from before the automobile epoch, mixed land uses and mixed social and income characteristics including large numbers of students and young professionals. The analysis is based on the transaction prices of retail, office, industrial, and multifamily properties.

Increased accessibility in the form of rapid transit is thought to bring with it many benefits, both financial and otherwise. Much of Cambridge, and portions of Somerville, benefit from existing rapid transit service in the form of the Red, Orange, and Green Lines of the MBTA. However, a significant part of the region is too far from the existing transit lines to reap any substantial rewards, and an expansion of service by extending the Green Line will significantly affect this part of the region (largely but not entirely within Somerville). The newly announced collaborative funding initiative, which brings together state, local, and private actors to fund and complete the GLX represents a significant milestone for the project.

The main purpose of Chapter IV is to employ modern econometric analysis to determine the market's pricing of rapid transit accessibility for investment property within the Northwest Boston Basin, the area affected by the GLX project. Our focus on investment property is driven

by data availability. However, in fact, much of the land use in the Northwest Boston Basin is devoted to investment property. Furthermore, in principle, it is likely that the value added by transit accessibility to investment property is similar to that added to other types of properties, since fundamentally such added value derives from the greater convenience for the users of the property. In this analysis, which is based on hedonic regression models of transaction prices, we are able to analyze to some degree separately both the effect of proximity to existing service (long-time operating stations of the Red, Orange, and existing Green Lines), as well as any already-accrued value effect on properties far from the existing stations, but with proximity to the proposed future service in the form of the GLX expansion stations.

When analyzing the effect of transit on property values, one can do so in either of two scenarios: (A) flexible land use, or (B) constant land use. The former reflects the enhancement in the Highest & Best Use (HBU) of sites (impact on land value). The latter reflects only the enhancement of value of properties with their existing buildings (or same type and density of buildings) on them. In our hedonic model, we are largely controlling for property type and density (through the use of size and property type regressor variables), therefore, it's most reasonable to interpret our results as holding land use constant. This also is reasonable given the rather strong and ubiquitous zoning regulations that apply generally in the Northwest Boston Basin region.

We can lay out a theoretical foundation of our hypotheses in a simple DCF present value model. Suppose, for example, that a typical representative property without transit accessibility produces an annual benefit stream of $5 per square foot in annual net cash flow (Property Before Tax Cash Flow, or PBTCF). Applying a basic perpetuity formula assuming a 5% opportunity

cost of capital (discount rate), one can value this income stream at PV= $5/.05= $100 psf.[158] Now suppose that with proximity to a fully operational rail rapid transit station, the same property can generate $7 per square foot annually (PBTCF) in perpetuity (assuming the transit will operate in perpetuity). We can assume that the $2/SF increment in annual benefit reflects the same building (holding land use constant), and that zoning would prohibit any change in land use. Then this increase in annual benefit flow will result in a similar increase in property value from $100 (without transit) to: PV(wTransOper) = $7/.05 = $140 psf, or a 40% increment in value.

But now suppose the benefits from the transit station will not start for 8 years. That is, you can't charge the higher rent until the station will be operational in 8 years. Keeping the same OCC, the PV for such a property near a Proposed Transit station would be:
PV(wTransPropsd) = $100 + $2/.05/(1.05^8) = $100 + $40/1.05^8 = $100 + $27 = $127.
Thus, the Proposed-Station property is only worth 127/140 = 91% of the Existing-Station property, an increment of only 27% over the No-Transit property instead of the full ultimate increment of 40%. (Proposed immediately gives 27/40 = 68% of the ultimate increment.)

However, the situation could be even worse for the Proposed-Station property if there is substantial risk that the new proposed transit station will never get built. Suppose there is a 50% chance of this. Then the increment to value is only 0.50*$27 = $13.50 instead of the full $27. Thus, a 13.5% increment in value over No-Transit, and station proposal gives immediate capitalization of only 13.5/40 = 34% of the ultimate increment in value.

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[158] Geltner, D., N. G. Miller, J. Clayton, and P. Eichholtz (2014). Commercial Real Estate Analysis and Investments, Third Edition. OnCourse Learning, Mason, OH.

We use these representative numbers to present the general theoretical framework of our quantitative analysis of investment property in the Northwest Boston Basin, and the GLX project specifically. There are three general "states" of transit accessibility for investment properties within this market; no transit, or assets within the NBB (even with the GLX project) that lack proximity to transit, proposed transit, or assets that while currently located far from existing transit, are located closely to proposed transit, and assets that already benefit from existing transit (in the form of the Red, Orange, or Green Line). Within these three scenarios, we should see clear value gradients, and the relative difference among them will help us understand not only the value inherent in transit accessibility in the market, but also the relative confidence across the market of the economic benefits of the GLX to investment properties.

4.1 - Literature Review

The literature for capitalization of proximity to transit is wide and deep. The "magnitude of impact on commercial property values will vary according to:

- How much accessibility is improved
- The relative attractiveness of the locations near those stations
- The real estate market in the region"[159]

Several studies have shown that proximity to rapid transit have positive and significant relationships to commercial asset value. A survey of Washington DC's Metro noted a $2.30 (a coefficient of -.21) assessed value per square foot decrease for every 1,000 feet further from a transit station (FTA 2000) for a cross-set of commercial properties[160].A cross sectional and

[159] Parsons Brinckerhoff, T*he Effect of Land Rail Transit on Property Values: A Summary of Studies*. Research carried out for Project 21439S, Task 7 NEORail II, Cleveland, Ohio. 2001. Web. 08 July 2016.

[160] Federal Transit Administration. 2000. *Transit Benefits 2000 Working Papers: A Public Choice Policy Analysis*. Washington, D.C.: Federal Transit Administration, Office of Policy Development. 2000. Web. 07.15.2016

longitudinal survey of the Guadalupe line in Santa Clara County noted that commercial offices within a quarter mile of stations received higher rents in comparison with locations located more than three quarters of a mile from a station (Weinberger 2001)[161].

Literature on proposed or expanded rapid transit service is less prevalent, but remains a topic of interest in the field. McDonald and Osuji studied the anticipatory effects of the Chicago Midway line within residential land values (McDonald Osuji 1995). Capitalization of the upcoming expanded rail service resulted in a 17% premium in residential land values within a half mile of a station between 1980 (before commencement of construction) and 1990 (during construction, but prior to opening of the line) (McDonald Osuji 1995)[162]. A follow-up study by McMillen and McDonald subsequent to the completion of the line concluded that single-family residential properties within the impact study area of the Midway line had an aggregate increase in value of $216 million between 1986 and 1999 (McMillen McDonald 2004)[163]. Knapp, Ding, and Hopkins surveyed the effects on vacant residential land values in the vicinity of Portland's Max system and determined that assets traded within a study area within a half mile of stations were 36% higher valued following the station announcements, and assets within one mile of service were 9% higher (Knapp, Ding, Hopkins 2011)[164].

In this study we have generally two separate questions, both of which tie to the literature. One is how much value is ultimately created by the operational transit stations. The other is what

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[161] Weinberger, Rachel. *Commercial Property Value and Proximity to Light Rail: A Hedonic Price Application*. Diss. University of California, Berkeley. Fall 2011. Web. 07.15.2016.

[162] McDonald, J. and C. Osuji. 1995. *The Effect of Anticipated Transportation Improvement on Residential Land Values*. Regional Science and Urban Economics 25: 261–278.

[163] McMillen, D.P., McDonald, J.F., 2004. *Reaction of house prices to a new rapid transit line: Chicago's midway line, 1983–1999*. Real Estate Econ. 32 (3), 463–486.

[164] Knapp, G.J., Ding, Chengri, and Hopkins, Lewis. *Do Plans Matter?: The Effects of Light Rail Plans on Land Values in Station Areas*. Journal of Planning Education and Research 21(1):32-39 · August 2001. Web. 07.15.2016

proportion of that value is created prior to transit operation (using the most current data available). The literature and economic intuition suggest the proportion of the ultimate value creation likely depends on several factors which are topics addressed in earlier in this paper, such as: (i) how long between the announcement of the transit plan and ultimate operation; (ii) how certain upon announcement of plan that completion and operation will in fact ultimately occur. Generally, the transit lines in the literature followed somewhat similar time frames to our analysis of the GLX. The Chicago Midway line was discussed as early as the 1940's, but did not get widespread public support until the late 1970's, with construction commencing in 1987 and completion occurring in 1993. McMillen and McDonald studied a full timeline of transactions between 1983 and 1999, a similar time period to our study. The Westside expansion of Portland's Max System studied by Knapp, et al. was announced in 1993, and completed in 1998. Their survey of transactions fell between January 1992 and August 1996, a smaller timeframe than our study. Still, they looked at land transactions only, which are generally considered more volatile and sensitive to market fluctuations, than investment property, the asset of interest to this study. Overall, the literature suggests that increased transit access is associated with a positive increment in property value, and that increment can be found at least partly prior to the completion and operation of the line.

Also of interest is existing literature on the Green Line extension. MAPC prepared a 2014 survey entitled "Dimensions of Displacement: Baseline Data for Managing Neighborhood Change in Somerville's Green Line Corridor", which outlined the potential impacts of the GLX on residential rental affordability based on the realized premiums to existing transit stations north of the Charles River.

Table 4-1: MAPC Rent Premium Estimates

Rent Premium Estimates for GLX Station Areas						
	Current Rent Premium (P_i)		Projected Rent Increase (I_i)		Projected Rent Increase ($)	
Station	Low	High	Low	High	Low	High
Ball Square	0.89	0.93	1.29	1.34	$277	$330
College Av.	0.88	0.89	1.35	1.37	$277	$295
Gilman Sq.	1.11	1.13	1.06	1.08	$61	$84
Lowell St.	1.18	1.22	0.98	1.01	$0	$14
Route 16	0.91	0.94	1.28	1.32	$241	$274
Union Sq.	0.95	0.96	1.25	1.26	$264	$277
Washington St.	0.72	0.80	1.51	1.67	$442	$580

Dimensions of Displacement[165]

The report concluded that between 740 and 810 lower income households may become cost-burdened due to increases from 25% to 67% in rent along the corridor. Using a similar model and a broad set of Assessor's data, MAPC determined that single-family residential assessed property values within a half mile walkshed are expected to rise between 16% and 25%.[166]

Table 4-2: MAPC Potential Residential Assessment Increases

Rent Premium Estimates for GLX Station Areas								
	Current Assessment Premium (P_i)		Projected Assessment Increase (I_{GLX})		Projected Assessment Increase ($)		Projected Property Tax Increase ($)	
	Low	High	Low	High	Low	High	Low	High
GLX Stations	1.01	1.02	1.16	1.25	$40,393	$64,680	$542	$868

Dimensions of Displacement

A recent memorandum to MAPC prepared by Strategic Economics outlines the effective growth that can be expected due to new, transit oriented development within the GLX corridor. Their

[165] Metropolitan Area Planning Council. *The Dimensions of Displacement Baseline Data for Managing Neighborhood Change in Somerville's Green Line Corridor*. February 2014. Web. 07.15.2016. "Current Rent Premium" and "Projected Rent Increase" represent percentage estimate ranges based on model results.

[166] Metropolitan Area Planning Council. "Current Assessment Premium" and "Projected Assessment Increase" represent percentage estimate ranges based on model results.

work suggests that $250 million to $280 million in potential property tax revenues are dependent on completion of the line as proposed, and will not be realized otherwise. Projected development in the corridor is expected to total 5,400 residential units, 4.6 million square feet of office space, 615,000 square feet of retail space, and 210 hotel rooms.[167] This significant expansion of the commercial property stock and multifamily residential housing sets to provide sustained growth in the area beyond what our models and analysis are quantifying.

Taking these studies into mind, we pose our hypotheses. Considering the extensive academic research into transit accessibility and real estate value, we will examine the Northwest Boston Basin market premium for transit accessibility, as well as whether the planning and initial onset of construction of the Green Line extension has already had an effect on investment property values in the local market. Based on existing research, proximity to existing transit in the market should have a notable relationship to asset value and properties located in closest proximity to the proposed Green Line extension stations should have shown positive appreciation following the station announcements.

4.2 - Data

The data to be analyzed consists of 1,094 commercial and multifamily asset transactions that occurred within the Cambridge, Somerville, and Medford area between 2000 and 2016. This study period reflects data availability, but also was chosen to reflect the long-run planning timeline of the GLX project. As noted prior, the GLX began as a mitigation for the Big Dig, and substantial funding was committed to the project in the 2000's. Extending our analysis back to

[167] Strategic Economics, and RKG Associates.

the year 2000 allows greater context to the project, and brings into the sample a larger variety of transactions. The data was sourced from Real Capital Analytics, as well as a national real estate valuation and consulting firm that requested to remain anonymous. RCA is a partner of the MIT Center for Real Estate, and is a research and analysis firm focused on institutional asset transactions across a broad spectrum of real estate asset classes. RCA tracks transactions that have occurred above $2.5 million, so additional data was sourced for transactions less than this threshold amount. This data was contributed by a national real estate valuation and consulting firm that has offices across the United States in most major markets. The original dataset consisted of 160 industrial sales, 358 office sales, 442 retail sales, and 427 multifamily sales, or a total of 1,387 asset transactions. We also considered vacant land sales and hospitality properties, but a lack of transactions suggested they be left out of the study group. This larger dataset was cleaned, with transactions having non-arm's length or allocated sales prices removed, and condominium transactions were also removed. These types of transactions are considered to not be a reflection of market value or of the type of property market being studied. The final dataset consists of 1,094 asset transactions. Table 4-3 is an overall summary of the dataset. Figure 4-1 displays a histogram of log of Sale Price, and Figure 4-2 displays mean sale price of the dataset over time.

Table 4-3: Dataset Summary

Asset Type	Count of Asset.Type	Average of Land.Area.SF	Average of Bldg.SF	Average of Age	Average of Sale.Price	Average of Price Per SF
Industrial	141	44,753	30,581	75	$2,560,096	$150
Multifamily	362	16,383	26,518	98	$7,500,701	$230
Office	210	45,911	53,143	77	$13,648,293	$245
Retail	381	30,762	9,976	91	$2,605,530	$296
Grand Total	1,094	30,715	26,392	89	$6,339,192	$245

*Age is Building Age in Years

Figure 4-1: Histogram of log Sale Price

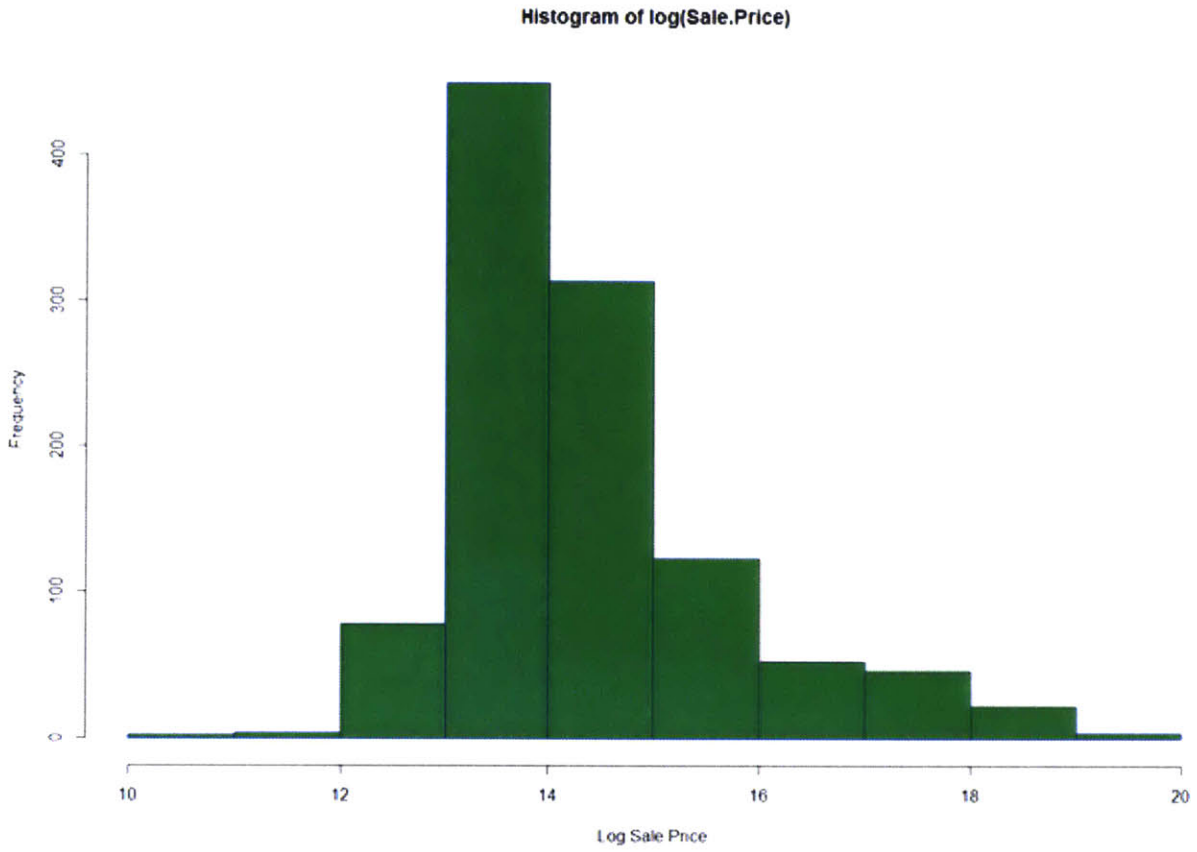
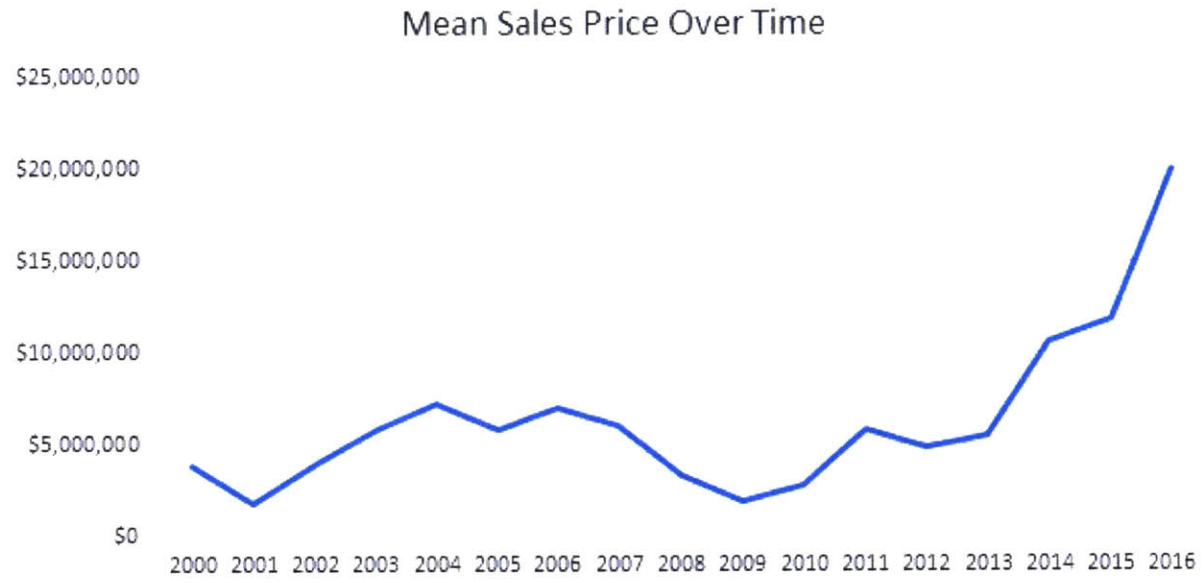


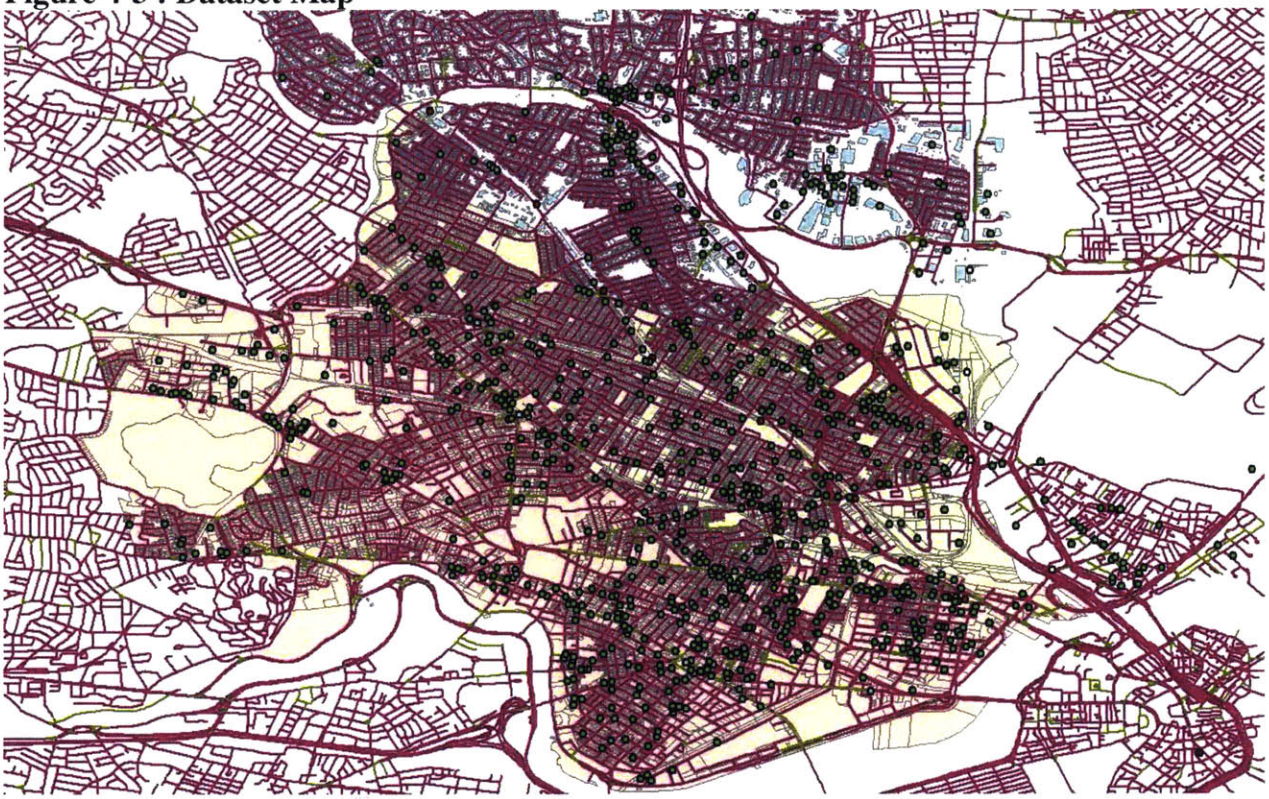
Figure 4-2: Mean Sale Price Time-Series



Once the final dataset was determined, the transactions were mapped using ArcGis software to determine their locations in relation to existing and proposed transit. Transactions and stations were plotted using latitude and longitude. For the purpose of our analysis, despite the recent shift in funding, the Route 16/Mystic Valley station was included as a potential destination, as it is still committed for eventual completion (albeit in another phase of the project).[168] Figure 4-3 displays the final study area map, with transactions in green and GLX transit stations in Red.

[168] Ruppenthal, Alex. "GREEN LINE EXTENSION: Project alive, but Medford Rt. 16 station in doubt." 5.10.2016. http://medford.wickedlocal.com/article/20160510/NEWS/160519543. Web. 07.15.16

Figure 4-3 : Dataset Map



Some overflow transactions occurred in nearby Charlestown, but were not removed from the dataset as they are effective as contributors to the control group. Distances to transit stations and the Boston CBD (defined as the Financial District) were determined using ArcGIS' OD Cost Matrix function.[169] The OD Cost Matrix function determines the distance in miles along the street network from a point to multiple destinations. These distances were compiled using the current US Streets Network.

To account for local amenities, each asset transaction's Walk Score was researched. Walk Score is a measure of pedestrian friendliness and lifestyle amenities that analyzes the

[169] "OD Cost Matrix Analysis" ArcGis.com. ESRI ArcMap. Web. 07.15.2016 http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/od-cost-matrix.htm

walkability of location using "hundreds of walking routes"[170]. The measure takes into account walkability to shopping, grocery stores, public open spaces, and cultural institutions. Walk Score has been shown in academic research to have a positive and significant relationship to asset value (Pivo Fisher 2010)[171]. Walk Score is scaled from 0-100, with higher values demonstrating superior walkability. Scores below 50 are designated as Car-Dependent. Demographic information was sourced on a Zip Code level from the 2010 US Census using Simply Map[172].

4.3 - Variable Selection and Methodology

This analysis applies an OLS hedonic regression model of property transaction price. Hedonic regression modeling is used often in real estate and urban economics, and is based on the theory that the value of an asset can be broken down into the contributing value of its characteristics ("hedonic" variables) (Rosen 1974).[173] These characteristics can be broadly categorized into the physical characteristics of each property, the neighborhood or submarket characteristics of its location, the time of the transaction, and the asset's physical relationship to transit and the CBD. The result is a form of the equation:

$$y = f(P, L, D, T)$$

where:

[170] "Walk Score Methodology". WalkScore.com. https://www.walkscore.com/methodology.shtml. Web. 07.15.2016

[171] Pivo, Gary, and Jeffrey D. Fisher. 2010. The Walkability Premium in Commercial Real Estate Investments. Real Estate Economics. Web. 07.15.2016

[172] Geographic Research, Inc. (2008). Census 2010 Data. Retrieved from SimplyMap database.

[173] Rosen, S., 1974. Hedonic prices and implicit markets: product differentiation in pure competition. J. Polit. Econ. 82, 34–55.

y is the price of the property

P is a vector of the physical characteristics of the property

L is the vector locational characteristics of the property

D is the time effects/date of the transaction

T is the property's transit accessibility measure

Physical characteristics included in our analysis are building size, land area (in square feet), age of the building on the property (in years), number of floors/stories, and a categorical variable (0/1 dummy) for asset type (multifamily, retail, industrial, and office). These were the most complete variables reported in the data. Due to the limited number of transactions within the total dataset, and lack of complete information on asset type specific characteristics such as linear feet of frontage (industrial and retail specific), ceiling heights (industrial, office, and retail), tenancy (office, retail), number of residential units (multifamily), income (all), or "Class" (all), the model must satisfy itself with the variables noted above and is estimated "pooled" over all the asset types employing categorical variables ("fixed effects") for the property reported usage type.

Locational characteristics include Walk Score, population density (persons per square mile), median household income, and the percentage of the population employed in white collar professions. Additional characteristics such as crime index and household expenditures were considered for the analysis, but due to strong multi-collinearity effects, were ultimately dropped. Distance to the CBD was also included, which is traditional in the literature, based theoretically on the classical monocentric city model, which suggests that value is greater for properties with closer proximity to the CBD.

While the transaction sample is largely cross-sectional in nature (variation over space rather than time), the data also includes a longitudinal dimension, as it spans a range of history from 2000-2016. Therefore, the model must control for the time of sale. In particular, in order to control against movements in the relevant property markets, dummy variables for the year of the transaction were created and assigned to each sale. (The dummy variable assumes a value of 1 if the sale is in the year of the dummy variable, and zero otherwise.)

Finally, a continuous distance to transit stations is assigned to each transaction to determine the price elasticity of transit in the local market. The literature suggests that either a continuous cardinal numeric value for distance to the nearest station, or else a dummy/categorical value indicative of distance to the nearest station, may be employed in studies of this type. A dummy value approach assumes that all locations within a given radius, usually defined in segments of quarter or half-miles, have effectively similar access to the transit station. In contrast, a continuous distance variable allows measurement of the elasticity of price with respect to the distance to the nearest transit station. Due to the complexities of several transit stations potentially interacting with one another (considering some transactions within our set would have radius defined locations to multiple modes of rapid transit), our primary models employ the continuous distance approach, defined relative to the nearest station. We computed both distance to existing transit only in the form of the Red Line, Orange Line, and Lechmere stop of the Green Line, as well as distance to the closest transit station including the proposed service expansion of the GLX project. Table 4-4 summarizes the descriptive statistics of the study variables.

Table 4-4: Dataset Descriptive Statistics

Descriptive Statstics

Statistic	N	Mean	St. Dev.	Min	Max
walkscore	1,094	85.785	11.235	16	99
Age	1,094	88.612	37.937	1	316
Bldg.SF	1,094	26,391.580	58,310.790	260	490,980
Land.Area.SF	1,094	30,715.290	86,944.470	740.000	1,129,510.000
Number.Of.Floors	1,094	2.515	1.734	1	24
Sale.Price	1,094	6,339,192.000	18,836,975.000	40,000	215,000,000
Pop_Density	1,094	16,466.910	5,309.793	7,006.000	23,163.300
White.Collar.Employment	1,094	1.569	0.400	0.778	2.226
Med_HH_Income	1,094	70,362.980	6,739.900	57,644	94,929
Dist.CBD	1,094	3.843	1.205	1.600	7.011
Distance.to.Closest.Transit.Station	1,094	0.626	0.352	0.001	2.104
Distance.to.Existing.Transit	1,094	0.895	0.492	0.001	2.791
Closest.Station.is.Proposed	1,094	0.415	0.493	0	1
Year2000	1,094	0.072	0.259	0	1
Year2001	1,094	0.062	0.242	0	1
Year2002	1,094	0.049	0.217	0	1
Year2003	1,094	0.039	0.194	0	1
Year2004	1,094	0.073	0.260	0	1
Year2005	1,094	0.058	0.233	0	1
Year2006	1,094	0.084	0.278	0	1
Year2007	1,094	0.085	0.279	0	1
Year2008	1,094	0.039	0.194	0	1
Year2009	1,094	0.037	0.188	0	1
Year2010	1,094	0.035	0.183	0	1
Year2011	1,094	0.047	0.211	0	1
Year2012	1,094	0.077	0.266	0	1
Year2013	1,094	0.059	0.237	0	1
Year2014	1,094	0.073	0.260	0	1
Year2015	1,094	0.082	0.275	0	1
Year2016	1,094	0.028	0.166	0	1
Price.Per.SF	1,094	245.424	215.192	11.760	3,269.230

Mean distance to existing transit across the stations is .895 of a mile, with the mean distance decreasing 30% to .626 of a mile including the proposed Green Line extension stations. The relatively large dispersion in the data around sales price, price per square foot, land area, and building area all suggest these aspects of the data to be right-skewed with a large total range. Mean Walk Score across the dataset is 85.78, which falls within the category for "Very Walkable", suggesting most locations are well within walking distance to amenities such as general goods, schools, and recreation space.

Following the selection and specification of variables, a hedonic function is applied:

$$Ln\,y = \alpha + \beta p * P + \beta l * L + \beta d * D + \beta t * ln\,Distance\,To\,Transit + \varepsilon$$

where:

$ln\,y$ = natural log of sales price

α = a constant

βp= a coefficient on the variables in P

βl= a coefficient on the variables in L

βd = a coefficient on the variables in D

βt = the coefficient for the log transformed distance to transit

ε = an error term

Two models are specified. The first is based on distance to existing, operational transit only. This model uses the determined street distance from each asset to the nearest existing transit station. The second is specified using distance to the nearest transit station, including the planned GLX service extensions. An additional dummy variable indicating whether the closest station to the sale is proposed is also included in this model to isolate the effects on price between proposed and existing service. In both instances, the coefficient for distance from transit should display negative value, as greater distance from the station should, other things equal, reduce the value of the property. Table 4-5 outlines the results of the continuous models.

Table 4-5: Continuous Model Results

	Dependent variable:	
	log(Sale.Price)	
	(1) Exisiting	(2) Proposed
log(walkscore)	0.022	0.055
	(0.115)	(0.115)
log(Bldg.SF)	0.559***	0.560***
	(0.027)	(0.027)
log(Land.Area.SF)	0.293***	0.293***
	(0.027)	(0.027)
log(Age)	-0.167***	-0.168***
	(0.027)	(0.027)
log(Number.Of.Floors)	0.117**	0.123***
	(0.046)	(0.046)
Asset.TypeMultifamily	0.564***	0.566***
	(0.065)	(0.065)
Asset.TypeOffice	0.446***	0.447***
	(0.065)	(0.065)
Asset.TypeRetail	0.516***	.0520***
	(0.056)	(0.056)
log(Pop_Density)	-0.124**	-0.118*
	(0.062)	(0.062)
log(Med_HH_Income)	-1.180***	-1.165***
	(0.275)	(0.276)
White.Collar.Employment	0.608***	0.589***
	(0.062)	(0.067)
log(Dist.CBD)	-0.312***	-0.319***
	(0.065)	(0.065)
log(Distance.to.Existing.Transit)	-0.159***	
	(0.024)	
log(Distance.to.Closest.Transit.Station)		-0.127***
		(0.026)
Closest.Station.is.Proposed		-0.153***
		(0.040)
Year Dummies	See Appendix	
Constant	20.032***	19.731***
	(3.518)	(3.525)
Observations	1,094	1,094
R^2	0.846	0.845
Adjusted R^2	0.842	0.841
Residual Std. Error	0.523 (df = 1064)	0.524 (df = 1063)
F Statistic	201.145*** (df = 29; 1064)	193.723*** (df = 30; 1063)
Note:		*p**p***P<0.01

4.4 - Results

As expected, the coefficient for transit access in both versions of the model is negative and significant. This sustains "Hypothesis (i)", that rail rapid transit proximity increases property value. In the model for existing transit only, the coefficient is -.159, while in the model including proposed transit access, it is -.127. This suggests that all else being equal, asset value increases by 1.59% with a 10% decrease in the distance from existing transit, and 1.27% with a 10% decrease in distance including proposed stations. Using our dataset mean asset value ($6,339,192) and mean building size (26,391 square feet), this suggests that a 10% change in distance from existing transit results in, all things being equal, a $3.81 change in value per square foot (and $3.04 per square foot including GLX stations). The dummy variable for whether the closest transit station is proposed is also significant, and has a coefficient of -.153, with a standard error of .039. This indicates that assets whose closest station is proposed exhibit a difference in price of 16.55% (as a percentage of Proposed-Station property value) compared to assets located in proximity to existing stations.

Physical characteristics are mostly significant, and of the expected sign. Log of building area, land area, and number of floors have positive coefficients. Log of age is negative (reflecting building depreciation). Asset type is positive and significant, with multifamily properties carrying the highest relative coefficient. Since industrial properties were the omitted category, this implies that all the other three property types exhibit a statistically significant value premium compared to industrial properties, other things being equal. (This too is to be expected.)

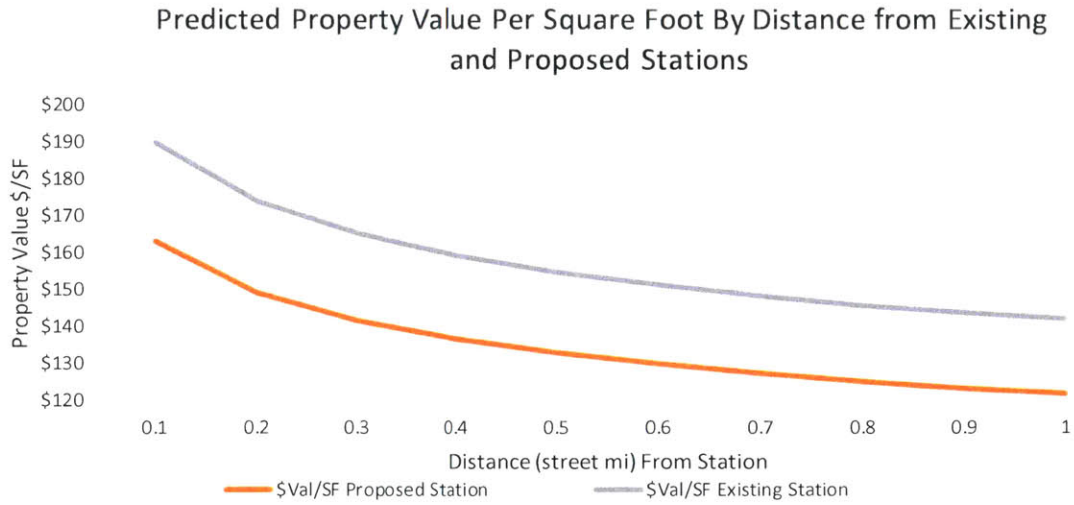
Locational characteristics had more mixed effects. The log of population density was negative, while the log of white collar employment was positive and significant. Surprisingly, the log of median household income was negative and significant, suggesting increases in

median income results in a decline in sales price. However, as previously stated, the demographic data was sourced primarily on a zip code level. As a result, demographic characteristics are likely exhibiting some effects of collinearity possibly with omitted variables. Walk Score exhibited a positive coefficient, but was not statistically significant. This is likely due to the generally high Walk Score for the dataset. As the properties are located in similar neighborhoods, there is likely consistently high walkability for the vast majority of properties. Thus, the model cannot distinguish a significant effect of differential walkability. Distance to the CBD was found to be negative and significant in both versions of the model, as predicted by the classical monocentric model. Time effects followed a general upwards trend, however with a sharp downturn during the financial crisis/recession years of 2008-10, followed by a strong recovery. The overall predictive ability of the models was roughly the same, with each model displaying adjusted R-squared of .84, suggesting the models are capturing roughly 84% of the variation in sales price in the dataset. This is a strong fit of the prediction model to the sample data.

4.5 - Conclusions of Continuous Distance Model

As hypothesized, the coefficients of the models show distance to transit is significant in the market under both scenarios. From the noted coefficients, value gradients are constructed that visually illustrate the relationship between predicted value and distance from transit. Figure 4-4 demonstrates the price gradient for existing transit (grey line) and proposed transit (orange line)

Figure 4-4:Transit Price Gradients



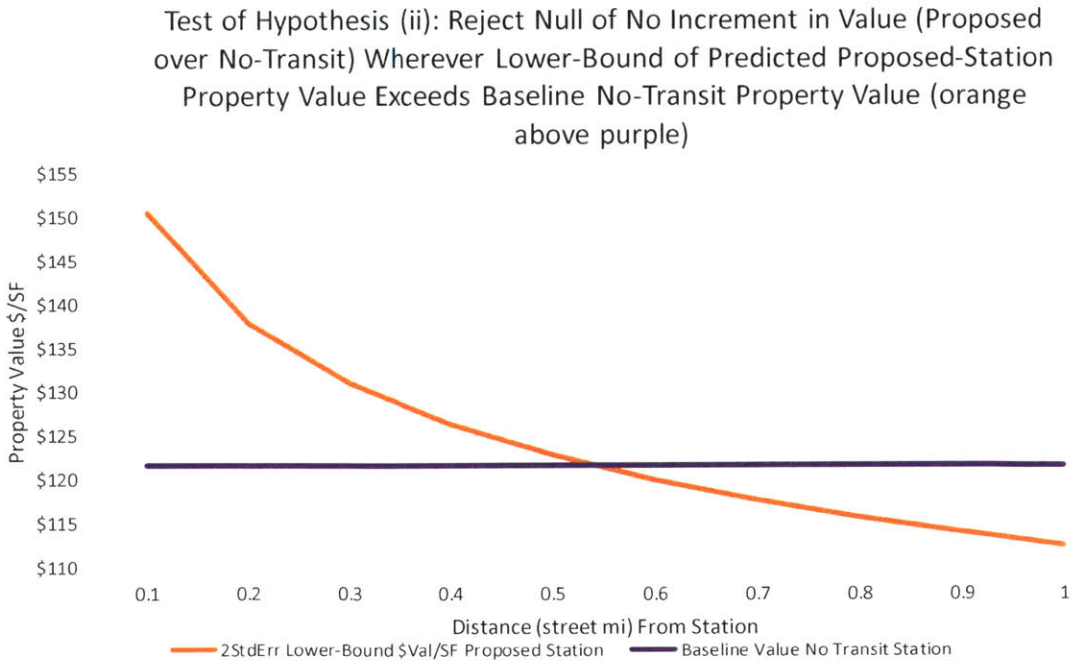
Based on average values of regressor variables

The coefficient on whether a station is proposed (the dummy variable coefficient of -.153, with a standard error of .039) shows that all else being equal, price is negatively affected by an asset being most proximate to a proposed station *as compared to being most proximate to an existing (operational) station.* This affirms a standard line of thinking, which is that a proposed station is not as valuable (in a present value sense) as an existing, presently operating station. As noted in our earlier presentation of the DCF present value model of the effect of transit station announcement and service, this difference is due not only to a "one in hand versus two in the bush" consideration, but also to the present discounted value of the transit service benefits which accrue to the property location. As stated prior, when we apply the estimated hedonic value model at the average property parameter values in our data sample, the estimated coefficient on the Proposed-Station dummy variable suggests that moving from a "proposed" station to an "existing" station adds an increment of 16.5% in the sales price of the typical property. On a per

square foot basis for a typical-size property, this amounts to a value increment of about $27/SF for a property close by the transit station.

As noted, within this study there really are two hypotheses: (i) Transit has an effect; & (ii) The proposal and planning of transit capitalizes some of that ultimate effect. Formal statistical significance of hypothesis (ii) is in the coefficient of the "Proposed" dummy-variable. If that coefficient is negative and statistically significant then we formally reject the null hypothesis of full ultimate value increment immediately upon announcement. However, that is not the correct alternative hypothesis for hypothesis (ii). To prove that, we need significance of Proposed Station- No Station difference. We can test this by looking at the 2-Standard Error bound around the dummy-variable coefficient, and tracing the lower range of that bound's implied predicted values compared to the baseline value of a property with no transit station accessibility. The gradient construction of this test is displayed in Figure 4-5.

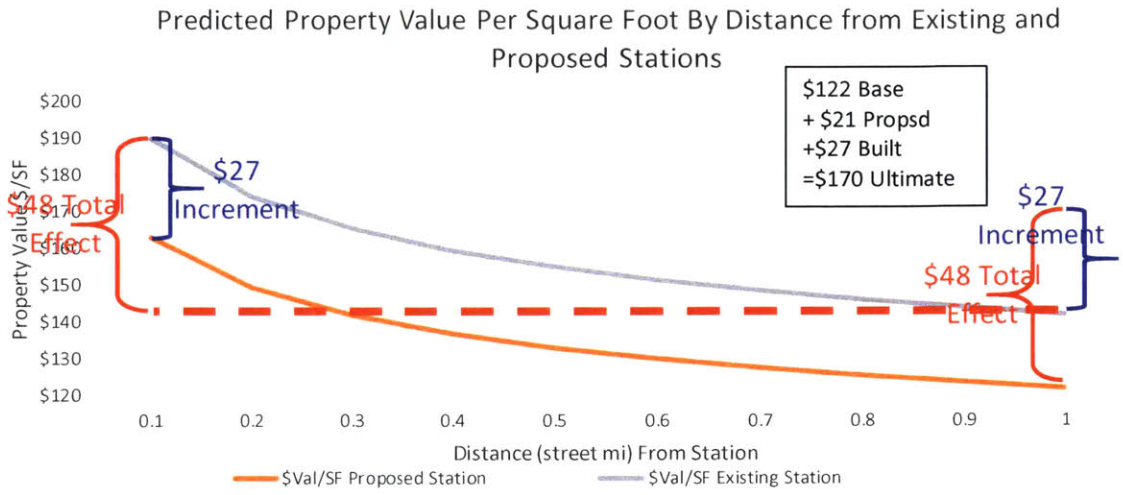
Figure 4-5: 2 Standard Error Test of Significance of Proposal Effect



Based on average values of regressor variables

With this test, we cannot reject a no-increment alternative hypothesis for distances beyond 0.5 mile. But we can show a statistically significant effect up to 0.5 mi. To demonstrate this effect, we have constructed some simple values per square foot to tease out the effect of both proposing/planning the stations (along with some start of auxiliary construction), and the eventual completion effect. As a baseline value for "no transit" we have used the point estimate of the model for the price per square foot of an average proposed transit asset (i.e. properties most affected by the GLX) at 1 mile of distance, which is $121.71 per square foot. One can assume this as the outer bound of the effect of the stations, as there are likely diminishing effects beyond a 20-minute walk from the stations. The full value of existing transit is applied as the predicted value per square foot from the existing price gradient at 0.1 of a mile ($189.92 per square foot) less the predicted value per square foot at 1 mile ($141.86 per square foot), for a total value of existing transit of $48.06 per square foot. The implied increment for station completion is estimated using the difference in value of the predicted price per square foot at 0.1 mi between existing ($189.92 per square foot) and proposed assets ($162.95 per square foot), which is $26.97 per square foot. The incremental value for proposing/planning the stations is taken as the difference in value from the total $48 per square foot price gradient, and the completion effect ($27 per square foot), which is $21.09 per square foot. This suggests that the proposal effect is approximately 17% of our base "no transit" value, and the completion effect is 19% of the base value upped by the proposed station effect. The total transit effect of $48 per square foot is 39.49% of the base "no transit" value. The proportion of the proposal effect to the total effect is 43.89%, suggesting a significant portion of value to existing investment properties from the completion of the GLX has been effectively capitalized as a result of the planning process. Figure 4-6 summarizes these effects in a chart of predicted values per square foot.

Figure 4-6: Proposal and Completion Effects



Based on average values of regressor variables

It would be presumptuous to state that completing the GLX will immediately yield an increase of 19% for all commercial properties located most proximate to proposed stations in our study area, or that all assets in proximity to proposed stations have capitalized 43% of their total benefit. The analysis applies to the average or central tendency effects, and our analysis above is using representative values, and should not be taken literally for all investment properties. Still, the models have shown the local market does place significance on proximity to transit for investment properties, and that all else being equal, completing the GLX as planned could result in substantial value growth to investment properties, with a portion of that value already being capitalized into transaction prices.

4.6- Subset Model

Using the previously described continual distance hedonic OLS model applied to our entire Northwest Boston Basin territory and our entire transaction sample, it was demonstrated

that transit access provides a substantial increment to investment property market values in the Cambridge-Somerville-Medford area. This analysis also demonstrated that completing the GLX as planned should add significant further value to investment property assets in the market, even though many of those properties have already gained value simply from the GLX stations being proposed (probably primarily properties within a half mile of the planned stations). This latter finding is consistent with what we have heard in conversations with public officials, developers, and citizens, who have said that the market has already reacted to the expanded access plan. As an official from the City of Somerville noted,

"The informal view would be that the whole market is moving in a positive direction. There are parts of the market that are moving faster than others and some of those areas obviously correlate to the transportation plan."[174]

With respect to the Green Line Extension, real estate brokers have been using the future station proximity as a selling point to home buyers in the region for some time. So it is not surprising that we find a significant value increment has already occurred for properties nearest to the planned GLX stations.

In the present section, we present a second analysis focusing more narrowly on just this question of the pre-existing value increment. Here we conduct a similar OLS hedonic regression model as used above, but on a more narrowly constrained property transaction sample and with some different study variables. The data subset employed here includes only transactions that have occurred where the asset's closest rapid transit station is a planned stop of the GLX. That is, we eliminate from the value estimation sample any properties whose nearest station was an

[174] Glavin, Michael and Brad Rawson.

existing station (of the RL, OL, or Lechmere). This results in a smaller, more tightly geographically concentrated dataset of 454 transactions. Summary descriptions for the various asset types and values can be found in table 4-6, along with summary statistics in table 4-7 and a map of the data in figure 4-7.

Table 4-6: Description of Dataset

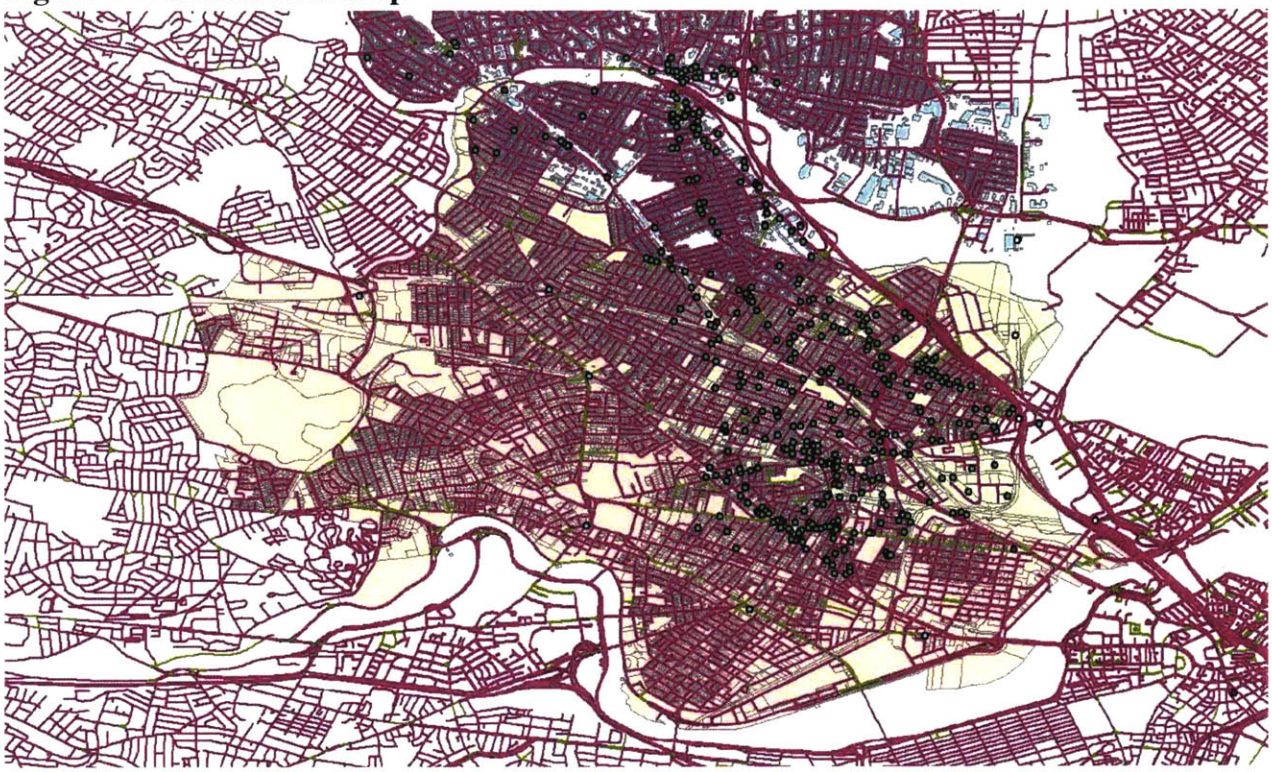
Asset Type	Count of Asset Type	Average of Bldg SF	Average of Land Area SF	Average of Sale Price	Zero to Half Mile GL	Half Mile To One Mile GL
Industrial	70	24,647	44,289	$2,265,072	31	37
Multifamily	151	14,346	10,750	$2,819,936	44	102
Office	47	22,155	34,262	$2,329,315	8	26
Retail	186	7,280	15,443	$1,151,315	93	72
Grand Total	**454**	**13,848**	**20,278**	**$1,999,973**	**176**	**237**

Table 4-7: Descriptive Statistics

Descriptive Statistics of the Subset

Statistic	N	Mean	St. Dev.	Min	Max
walkscore	454	85.304	10.635	16	95
Age	454	91.919	35.188	1	316
Bldg.SF	454	13,847.800	30,061.770	600	234,344
Land.Area.SF	454	20,278.020	51,006.460	810.000	501,375.000
Number.Of.Floors	454	2.128	1.252	1	14
Sale.Price	454	1,999,973.000	5,466,902.000	40,000	87,000,000
Pop_Density	454	16,355.690	5,763.123	7,006.000	23,163.300
Med_HH_Income	454	68,016.460	6,762.679	57,644	94,929
Dist.CBD	454	3.818	1.045	2.426	7.011
Distance.to.Closest.Transit.Station	454	0.612	0.294	0.027	2.100
Distance.to.Existing.Transit	454	1.260	0.377	0.500	2.791
Zero_to_Half_Mile_GL	454	0.388	0.488	0	1
Half.Mile_To_One_Mile_GL	454	0.522	0.500	0	1
Year2000	454	0.079	0.270	0	1
Year2001	454	0.084	0.277	0	1
Year2002	454	0.062	0.241	0	1
Year2003	454	0.051	0.220	0	1
Year2004	454	0.081	0.274	0	1
Year2005	454	0.057	0.233	0	1
Year2006	454	0.093	0.290	0	1
Year2007	454	0.077	0.267	0	1
Year2008	454	0.031	0.173	0	1
Year2009	454	0.035	0.185	0	1
Year2010	454	0.029	0.167	0	1
Year2011	454	0.042	0.200	0	1
Year2012	454	0.077	0.267	0	1
Year2013	454	0.059	0.237	0	1
Year2014	454	0.062	0.241	0	1
Year2015	454	0.066	0.249	0	1
Year2016	454	0.015	0.123	0	1
After_Station_Announcement	454	0.399	0.490	0	1
Before_Station_Announcement	454	0.601	0.490	0	1
Price.Per.SF	454	194.412	141.587	24.050	1,241.020
College.Avenue.Station	454	0.150	0.357	0	1
Ball.Square.Station	454	0.084	0.277	0	1
Lowell.Street.Station	454	0.055	0.228	0	1
Gilman.Square.Station	454	0.192	0.394	0	1
Washington.Street.Station	454	0.161	0.368	0	1
Union.Square.Station	454	0.328	0.470	0	1
Mystic.Valley.Station	454	0.031	0.173	0	1

Figure 4-7: Subset Data Map



To complete an analysis of this subset of transactions, a similar hedonic breakdown of asset characteristics is employed. The major difference between the two models is the application of categorical variables for distance bands of zero to a half mile, and a half mile to a mile, instead of linear distance to transit. Dummy variables for distance are preferred in this type of model, as they allow for clearer interaction effects in comparison with continual distance models. In the previous analysis we could not use dummy variables because the transit proximity relationship was complex, as we needed to distinguish between existing versus proposed stations. Here, with this specialized subsample, we have only one type of transit station, proposed GLX stations. Thus, we can use the more traditional categorical (dummy) variable approach.

The categorical variables were created using the same linear distances from our OD Cost matrixes outlined above. In addition, categorical variables for the individual stations are also

employed, so whether specific stations add more or less value. (The Mystic Valley/RT. 16 station serves as the reference group, that is, the suppressed category, such that coefficients of the other stations represent differences from the Mystic/Rt16 station value effect.) Transactions located in proximity to Lechmere Station are not included in this dataset. While Lechmere will be receiving a new, modern station as part of the GLX project, it does not represent a significant expansion of transit accessibility, and any effective capitalization of the new station will be hard to parse out from the premium for existing transit service. White collar employment is removed from this version due to strong multicollinearity in the model.

The subsample analysis also allows to be more nuanced in studying the effect of historical time. As noted in the introduction, the timeline of the GLX project dates back to the early 2000's, with several complications and delays altering the projected date of substantial completion. Therefore, exact longitudinal effects are difficult to pinpoint. While potential transit alternatives were being discussed in the early 2000's, the announcement of the planned stations in May of 2008[175] serves as a good comparison point for our dataset. Including an interaction term in the models on whether the transaction occurred before or after the station announcements will serve to help isolate the effective capitalization that has resulted from the project's announcement and onset. The results of the models are summarized in Table 4-8.

[175] Ryan, Andrew (May 7, 2008). "Potential Green Line stops announced in Somerville, Medford". The Boston Globe. Accessed 07.16.2016.

Table 4-8 Green Line Subset Model Results

	Dependent variable: log(Sale.Price)	
	(1) Base	(2) Before/After
log(walkscore)	-0.062	-0.074
	(0.14)	(0.14)
log(Bldg.SF)	0.420***	0.420***
	(0.04)	(0.04)
log(Land.Area.SF)	0.332***	0.331***
	(0.04)	(0.04)
log(Age)	-0.111***	-0.110***
	(0.04)	(0.04)
log(Number.Of.Floors)	0.104*	0.101*
	(0.06)	(0.06)
Asset.TypeMultifamily	0.588***	0.586***
	(0.09)	(0.09)
Asset.TypeOffice	0.186*	0.197**
	(0.10)	(0.10)
Asset.TypeRetail	0.362***	0.359***
	(0.07)	(0.07)
log(Pop_Density)	0.186*	0.189*
	(0.11)	(0.11)
log(Med_HH_Income)	0.771**	0.776**
	(0.33)	(0.33)
log(Dist.CBD)	-0.348	-0.347
	(0.29)	(0.29)
Year Dummies	Significant, see appendix	
Zero_to_Half_Mile_GL	0.220**	
	(0.11)	
Half.Mile_To_One_Mile_GL	0.142	
	(0.10)	
Union.Square.Station	0.12	0.115
	(0.25)	(0.25)
Washington.Street.Station	-0.082	-0.088
	(0.26)	(0.26)

Gilman.Square.Station	-0.033	-0.039
	(0.23)	(0.23)
Lowell.Street.Station	0.032	0.031
	(0.21)	(0.21)
Ball.Square.Station	0.108	0.1
	(0.17)	(0.17)
College.Avenue.Station	0.247	0.235
	(0.15)	(0.15)
Zero_to_Half_Mile_GL:After_Station_Announcement		0.322**
		-0.134
Zero_to_Half_Mile_GL:Before_Station_Announcement		0.137
		-0.126
After_Station_Announcement:Half.Mile_To_One_Mile_GL		0.249**
		-0.126
Before_Station_Announcement:Half.Mile_To_One_Mile_GL		0.057
		-0.116
Constant	-3.115	-3.061
	-4.528	-4.529
Observations	454	454
R^2	0.787	0.788
Adjusted R^2	0.77	0.77
Residual Std. Error	0.438 (df = 418)	0.438 (df = 416)
F Statistic	44.238*** (df = 35; 418)	41.900*** (df = 37; 416)
Note:	*p**p***p<0.01	

4.7 - Results of Subset Model

As seen in the base model output (column (1)), controlling for station level effects, location within a half mile of a proposed green line station carries a positive .22 coefficient, and is statistically significant at the 5% level. This means that all else being equal, assets within a half mile of a proposed green line station have sold roughly 24% higher (exp(.22)=1.24) than properties elsewhere in the subset study area over the timeline surveyed. The half mile to mile category in our base model carries a positive .142 coefficient, but was not demonstrated to be statistically significant. These findings are roughly consistent with our findings on the full dataset reported in section 4.5, although this suggests a somewhat higher value increment. (Recall that we previously reported a 17% impact for proposed stations.) No stations showed any statistically significant effects, with some carrying positive and negative coefficients (all relative to the suppressed Mystic/Rt16 station). The other coefficients in the base model are generally consistent with the previously developed wider market model, however, distance to CBD is not significant. This is likely due to collinearity with the station level category variables, as both serve as proxies for distance to the Boston CBD.

As shown by the coefficients in the before and after station announcement model (column (2) in the Table), the value of properties located within a half mile walkshed and a wider half mile to mile catchment area are significant and positive, *after* the announcement. The coefficients on the interactive terms for a half mile distance and up to mile distance are .322 and .249 respectively, with both significant at the 5% level. This means that properties located within a half mile of a planned station sold for 38% higher following the station announcement compared to a similar property, and assets within a half mile to mile sold for 28% more

following the station announcement. The interaction terms for before the announcement were also positive for both distance categories, but not significant. In this model, station effects were also not demonstrated to be significant. Both models demonstrated similar predictive abilities, with adjusted R-squared of .77.

The results of the model confirm the previous findings from section 4.5 that merely proposing the GLX stations has added value to investment properties (Hypothesis (ii)). However, this analysis adds some additional nuance. First, we find somewhat greater increments in value. Second, we find that the increment in value can only be clearly demonstrated to occur within a half mile of the proposed stations, unless we differentiate between the time before and after the 2008 "announcement" of specific station sites. In that latter case, the value increment extends to the half-mile-to-one-mile ring, and the increment within the half-mile ring becomes larger, at 38%. Still, using predicted values from the subset model, we can more accurately compare across the two models. Table 4-8 demonstrates predicted values per square foot within the subset model for the relevant categories for analysis.

Table 4-8: Subset Model Predicted Values Per Square Foot

Category	Predicted Value PSF	Difference	Percent Change
Within Half-Mile Before Announcement	$124.58		
Within Half Mile After Announcement	$149.90	$25.33	20.33%
"Zero" Time/Transit Effect	$108.65	$41.26	37.98%

From these values, one can see that the relative difference for price per square foot from an asset located within a half mile of a planned station before and after the station announcement is around 20%. This is similar to the value found in our prior model, and is also approximate to the value found by McDonald and Osuji in their original study on the Midway line in Chicago.

We also note the larger 38% jump is a comparison against a lower base value than we used in our prior model. As such, while the 38% jump is similar to the total percentage value change from both proposing and completing the stations found in section 4.5, they aren't really comparing "apples" and "oranges". If we apply a similar total price per square foot value addition of $48, then the subset model suggests that investment properties within a half mile of a planned GLX station have already capitalized around half of the total value to be added from completion, which provides support for our analysis in section 4.5.

In combination with the finding in section 4.5 that Existing stations add more value than Proposed stations (which is also consistent with *a priori* theory) these results suggest that the GLX project may potentially produce stations that add more value than the typical Northwest Boston Basin currently existing stations of the Red Line and Orange Line (and Lechmere). Still, as discussed previously, the process of bring a project like the GLX can be a long and hard road. Therefore, it is possible that due to the extended timeline of the project, whereby several delays have pushed completion further into the future, there may have been more time for asset values to react to the station proposals in their pricing, pushing current effective capitalization higher. Present value effects would suggest this would result in an observed lower value difference (due to additional time and risk), but our observed premium is generally similar to other studies in the literature. Likewise, as we are assuming constant land use, the model may be omitting the anticipatory highest and best use changes that come with expansion of transit accessibility, which could be pushing values higher despite the project complications. In any case, the relative increase in value does suggest that actors in the local market are strongly confident that the GLX will be completed, despite the noted struggles.

In the matter of the "chicken" and the "egg", it would seem that based on our model, value growth has anticipated the actual opening and operation of the GLX, and that value has accrued to properties most apt to capitalize on the start of service (within a half mile of a planned station). It is of interest to see if this growth continues, given the extended timeline of the project, re-engineered station designs, and uncertainty regarding final financing gaps.

4.8 - Limitations of the Models

While the models have demonstrated statistical significance for proximity to rapid transit in the Cambridge-Somerville-Medford market, there are limitations to our analysis. The most prevalent issues are potential omitted variables from the hedonic model and spatial error. With hedonic modeling of this type, while we have taken lengths to include as complete a model as possible, there are potential omitted variables that could be biasing the results of the model. By not controlling for these omitted variables, we could be over or underestimating the market elasticity and value of transit access. For example, in the continuous distance model, the value we are attributing to transit accessibility could actually reflect other neighborhood characteristics not reflected in the regressor variables that we do have. In the subset model, the increase in value attributed to the announcement of the planned stations may actually be capturing broader market effects that are coincident in time with the announcement, such as new zoning policy or additional business development. A recent paper by Sun, Zheng, and Wang demonstrates that the use of a repeat transactions model can better control for this bias, with the determined coefficient of transit elasticity declining from a baseline OLS hedonic model.[176] A further study

[176] Weizeng Sun, Siqi Zheng, Rui Wang. *The capitalization of subway access in home value: A repeat-rentals model with supply constraints in Beijing*. Transportation Research Part A 80 (2015) 104–115. July 2015. Web. 07.015.16

may include such a model, especially upon the completion and operation of the GLX, which will ultimately yield sufficient repeat sales to allow for such a model. Our dataset is inherently backward looking, which presents complications when mixing proposed and existing transit access in our price gradients. Also, while we project that value will be created through the completion of the stations as planned, we did not explicitly consider probable new developments in our model. While this is accounted for somewhat in the full-sample model, the possibility for redevelopment to a new highest and best use represents an omitted variable that could explain some of the greater increment in value found in comparison between the subset model and the full-sample model. The dataset for the subset model is based on a total of 454 transactions, which while deemed sufficiently large enough for analysis, is likely not a complete record of sales that have occurred in the market.

Another possible limitation is spatial errors within the dataset. One of the main assumptions of a regression analysis is the independence of observations. Tobler's Law states that "Everything is related to everything else, but near things are more related than distant things." This forms the basis for potential autocorrelation amongst observations in a spatial dataset. When working with spatial data, autocorrelation may occur in the spatial dimension, whereby assets with high or low values may be clustering together in space. This can result in inaccurate p values as well as spatial effects in the error term. To determine spatial error effects, we performed a Moran's I test on the final dataset, which indicated a coefficient of .047 with a p-value of exactly zero. This suggests there is likely some autocorrelation of points within our dataset. To correct for any spatial effects, a spatial lag, autocorrelation, or spatial error model could be estimated in addition to our OLS model.

When determining our distances to transit, we used ArcGIS' OD Cost matrix function. While this provides a distance in miles based on the in-place street network, it does not account for potential time-distance savings by walking routes that do not appear in the street network source data file. This could cause us to overestimate or underestimate the distances to transit in some cases, and could bias the results.

4.9 - Concluding Thoughts

Through the use of hedonic OLS models, we have studied the effects of transit accessibility on investment property within the Cambridge-Somerville-Medford area. The conclusions can be broadly summarized:

- Proximity to transit is significant in the local market. All things being equal the coefficient for distance to existing transit is -.159, which suggests that a 10% change in distance from an existing transit station results in a change in value of $3.81 per square foot.
- Moving a station from "proposed" to "existing" results in mean sales price appreciation of 16.5%, or around $27 per square foot.
- Within the subset model of assets whose closest station is a proposed extension of the GLX, properties located within a half mile of a planned station have sold at a 24% premium compared to other properties in the subset the study area, confirming significance found in section 4.5.
- The announcement of the planned GLX stations had a positive and significant impact on investment property prices within a half mile (38%) and mile (28%) of the station locations in our subset model, however these increases are compared to a lower base value than our original model in section 4.5.
- Using predicted values per square foot from the subset model, we can show that the "typical" asset value per square foot for investment properties within a half mile of a planned station have risen from $124 per square foot before the station announcement, to $149 per square foot following the announcement, a difference of around 20%.

Based on this analysis, transit access has been, and will likely to continue to be, the source of positive value in the investment property market in the Northwest Boston Basin.

Across both models we have shown that the planning of the GLX has added around 20% to asset values within the greatest area of impact, which is similar to prior literature on this subject. Likewise, the value increment from the station announcement represents around 40%-50% of the total expected value to be added, which suggests investors are very confident that the GLX will ultimately be completed as planned.

Conclusion

Almost everyone in the world interacts with some form of transit infrastructure on a regular basis. Different cities and towns have varying modes, frequencies, and scales, and most people rely on these roads, bridges, trains and boats to get around and live their lives. Unless there is a problem with the infrastructure, most people don't think about it, but rather take for granted the benefits that are derived from these projects. As residents of the Boston area, we are blessed with a transit system that does not allow us to forget about it.

The focus of much of our analysis has been on the ongoing extension of the Green Line. With the new collaborative funding initiative, the Cities of Cambridge and Somerville have committed a total of $75 million to fill gaps in the budget of the GLX. This number is backed by substantial research regarding potential assessed value and tax growth tied to new construction as a result of the GLX.[177] Our analysis indicates that additional value is expected to be created in existing properties, beyond what is created solely from new development. However, effectively capturing the value that accrues to existing properties presents unique challenges. Most notably, Massachusetts Prop 2.5 limits the ability of the local governments to raise city-wide taxes above 2.5 percent per year. The issue of effective capitalization obfuscates the timeline of when additional value is realized and makes the exact causes of property value increases difficult to identify and separate and quantify. While existing property owners in the market inherently have financial "skin in the game", the issue of fairness is notable at a municipal level.[178] Levying existing residents, investors, or business owners for additional tax revenue through a

[177] Bourassa, Eric.

[178] Glavin, Michael and Brad Rawson.

TIF or DIF would likely be difficult, especially considering the delayed time frame of the project and any negative externalities from the construction and eventual operation of the project such as noise or pollution. The proposed Chapter 40X Supplemental Infrastructure Financing for Transportation (SIFT) could potentially help solve this problem by allowing municipalities and MassDOT to perform "lookbacks" on base years for revenue increments, but has not yet been passed. Carving the cities up with TIFs or DIFs can cause management of finances to be burdensome or controversial, especially when the collected revenue is allocated away from the district or onto non-infrastructure related projects.[179]

It is because of these complications that direct development agreements, such as the $15 million contribution of FRIT to the Assembly Row project, and DivcoWest's committal of funding to the Lechmere station construction, remain the typical means of performing value capture in the broader Boston market. These types of projects depend on transit at their core, and the economics are inherently tied to having strong rapid transit accessibility.[180] For developers, management of risk and return remains of utmost importance. Providing a clear understanding of what the expectations are for all parties in regards to funding ahead of time allows investors and developers to maintain their fiduciary responsibilities. [181]

Our models have shown that proximity to transit is valuable in the Cambridge-Somerville-Medford market for investment property, and the GLX expansion will likely be the source of additional property value appreciation upon completion. The means to capture that value remain a challenge. Without the clearer-cut nature of negotiated development agreements,

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[179] Shen, Kairos.
[180] McMahaon, Patrick.
[181] Canon, Tim.

applying value capture techniques to existing properties becomes comparably difficult. As put by the City of Somerville:

"If someone's building new and going into large, large scale or large, large projects, or someone's making a big investment in existing properties where someone adds, we'll use it as an example, 51% of [the] value [of the] property, where they really become a new investor and a new developer. I think that's kind of where we think we're going to be on the fairness start- how do we treat existing owners and this question about value capture or contribution versus new development.

From there, new development, large scale development and or major renovation and reinvestment in existing properties that reach some sort of threshold, then I think it's fair for us to say to them, you're enjoying the benefit of all of this. We're asking you, through whichever product we end up using, to make a contribution to help defray some of those costs, so I think that's where we'll cut the line."[182]

This approach draws the line at scale; re-developing over a threshold amount based on the existing property value, or a large scale change in use, would result in some implementation of a value capture system. With new access, the highest and best use of many existing properties may change. If a property owner is content to maintain the existing use, seemly foregoing the economic benefits brought on by additional transit access, then the City would not assess them any penalty. However, a more profit seeking actor looking to maximize return due to the creation of value would be expected to contribute a fair share to the community. This approach balances the differing interests amongst local property owners. Using incremental values on sale

[182] Glavin, Michael and Brad Rawson.

(potentially adjusted for market inflation effects), or an exemption to local tax code caps for changes in use, could serve as a basis for such a capture technique, and could be applied within a potential DIF or special assessment district. Whatever mechanism is eventually used by the municipalities, alignment of interests amongst the state and local government, private investors, and citizenry will be crucial to the completion of the GLX. The collaborative funding initiative, which binds these groups together in a way previously unseen in infrastructure development in Massachusetts, should serve as an intriguing test of a new approach towards completing large scale transit projects.

Poor transportation infrastructure is not unique to Boston, though. In the American Society of Civil Engineers' ("ASCE") 2013 report card, "the estimated investment required to bring all infrastructure [in the United States] up to acceptable levels was put at $3.6 trillion by 2020."[183] The longer it takes us to address these issues, the larger that figure grows. While technology disruptions and innovations may help relieve some issues, we need to come up with creative financing solutions as well, to address the backlog of deferred maintenance and critical repairs or replacements across the country. We need a reliable and stable funding source so that transportation departments can plan for and depend on annual revenue to cover ongoing operations and maintenance while chipping away at backlogged projects, as opposed to the current system of triaging situations when they can't be stretched any thinner.

The current state of infrastructure is costing American households and businesses real dollars. Between increased commuting time, additional fuel use, larger vehicle maintenance bills, and higher prices for consumer goods whose distribution costs are higher, among many other

[183] Petroski, Henry, 24.

costs, the ASCE's *Failure to Act* report estimates "the nation's degrading infrastructure could cost American Households over the period from 2012 to 2040 in excess of $150 trillion, not accounting for inflation."[184] It is in everyone's best interest to find a solution that works.

As the population grows, the existing infrastructure is struggling to support the needs of today's world. While there is no doubt a need to bring the current structures into a good state of repair, there is also an urge to expand the system to a level that supports today's population and its commuting patterns. As we have seen, there have been meaningful partnerships between the public sector and private developers who believe in the synergies created between a large mixed-use development and rapid transit rail access. Infrastructure projects have successfully delivered due to a negotiated value capture contribution by developers in many circumstances. But the developers are not the only groups that benefit and receive value from that new infrastructure.

While we believe that there is substantial value that is created with new rail access for a variety of stakeholders, there are also diminishing marginal returns. At the extreme end of the spectrum, if there were public transit along every single road and stations at every intersection, the system would be so complex and stops would be so frequent, that the rail would cease to be a benefit, so at some level, adding an additional station reduces the value. Boston, and most cities, are a long way off from being concerned about reaching that apex, but with that in mind, the system needs to connect enough people to enough places to be of value.

In mature, dense, cities around the world, creating new access also means creating new value. In order to support the required growth and backlog of issues, there needs to be meaningful conversations and legislative changes that allow and promote the use of a wide range

[184] Petroski, Henry, 280.

of value capture techniques. In order to move funding conversations and infrastructure projects forward, we need strong leaders who understand the needs and the politics to educate the voting public and garner support for change. Throughout this thesis we identified several methods of capturing and extracting value that can be attributed to rail infrastructure - both explicitly and implicitly. This shouldn't be a partisan issue - an improved infrastructure network benefits the country as a whole.

There are many miles to go before we reach a state of acceptable infrastructure, but we need to start making progress towards reducing the substantial mountain of needs in the system. Developers can and do participate in that initiative, but there needs to be a larger discussion about other means to bridge the gaps. We need to come up with a sustainable way to keep investing in the future while securing the existing foundation, and in order to accomplish such a monumental task, we need all groups to participate and strong leadership to guide us there.

Q.E.D.

Appendices

Table 4-5: Continuous Model Results

	Dependent variable:	
	log(Sale.Price)	
	(1) Exisiting	(2) Proposed
log(walkscore)	0.022	0.055
	-0.115	-0.115
log(Bldg.SF)	0.559***	0.560***
	-0.027	-0.027
log(Land.Area.SF)	0.293***	0.293***
	-0.027	-0.027
log(Age)	-0.167***	-0.168***
	-0.027	-0.027
log(Number.Of.Floors)	0.117**	0.123***
	-0.046	-0.046
Asset.TypeMultifamily	0.564***	0.566***
	-0.065	-0.065
Asset.TypeOffice	0.446***	0.447***
	-0.065	-0.065
Asset.TypeRetail	0.516***	0.520***
	-0.056	-0.056
log(Pop_Density)	-0.124**	-0.118*
	-0.062	-0.062
log(Med_HH_Income)	-1.180***	-1.165***
	-0.275	-0.276
White.Collar.Employment	0.608***	0.589***
	-0.062	-0.067
log(Dist.CBD)	-0.312***	-0.319***
	-0.065	-0.065
log(Distance.to.Existing.Transit)	-0.159***	
	-0.024	
log(Distance.to.Closest.Transit.Station)		-0.127***
		-0.026
Closest.Station.is.Proposed		-0.153***

		-0.04
Year2001	0.036	0.028
	-0.087	-0.087
Year2002	0.173*	0.172*
	-0.093	-0.093
Year2003	0.203**	0.202**
	-0.1	-0.1
Year2004	0.340***	0.347***
	-0.084	-0.084
Year2005	0.351***	0.351***
	-0.089	-0.089
Year2006	0.444***	0.444***
	-0.081	-0.081
Year2007	0.418***	0.428***
	-0.081	-0.081
Year2008	0.245**	0.232**
	-0.1	-0.1
Year2009	0.015	0.016
	-0.102	-0.102
Year2010	0.181*	0.197*
	-0.105	-0.105
Year2011	0.273***	0.289***
	-0.095	-0.096
Year2012	0.458***	0.460***
	-0.083	-0.083
Year2013	0.495***	0.497***
	-0.088	-0.089
Year2014	0.690***	0.685***
	-0.084	-0.084
Year2015	0.779***	0.779***
	-0.082	-0.082
Year2016	0.936***	0.928***
	-0.113	-0.114
Constant	20.032***	19.731***
	-3.518	-3.525
Observations	1,094	1,094
R^2	0.846	0.845
Adjusted R^2	0.842	0.841
Residual Std. Error	0.523 (df = 1064)	0.524 (df = 1063)

F Statistic	201.145^{***} (df = 29; 1064)	193.723^{***} (df = 30; 1063)
Note:		*p**p***p<0.01

Table 4-9 Green Line Subset Model Results

	Dependent variable:	
	log(Sale.Price)	
	(1) Base	(2) Before/After
log(walkscore)	-0.062	-0.074
	-0.14	-0.14
log(Bldg.SF)	0.420***	0.420***
	-0.037	-0.038
log(Land.Area.SF)	0.332***	0.331***
	-0.037	-0.037
log(Age)	-0.111***	-0.110***
	-0.038	-0.038
log(Number.Of.Floors)	0.104*	0.101*
	-0.061	-0.061
Asset.TypeMultifamily	0.588***	0.586***
	-0.085	-0.085
Asset.TypeOffice	0.186*	0.197**
	-0.098	-0.098
Asset.TypeRetail	0.362***	0.359***
	-0.071	-0.071
log(Pop_Density)	0.186*	0.189*
	-0.11	-0.11
log(Med_HH_Income)	0.771**	0.776**
	-0.33	-0.33
log(Dist.CBD)	-0.348	-0.347
	-0.294	-0.294
Year2001	0.142	0.146
	-0.105	-0.105
Year2002	0.279**	0.284**
	-0.114	-0.114
Year2003	0.347***	0.347***
	-0.119	-0.119

Year2004	0.471**	0.461***
	-0.106	-0.107
Year2005	0.514**	0.522***
	-0.115	-0.115
Year2006	0.589**	0.592***
	-0.102	-0.102
Year2007	0.544**	0.543***
	-0.106	-0.106
Year2008	0.559**	0.472***
	-0.141	-0.154
Year2009	0.334**	0.175
	-0.134	-0.176
Year2010	0.401**	0.259
	-0.148	-0.179
Year2011	0.572**	0.388**
	-0.13	-0.184
Year2012	0.652**	0.481***
	-0.106	-0.161
Year2013	0.693**	0.520***
	-0.114	-0.167
Year2014	0.721**	0.545***
	-0.113	-0.169
Year2015	0.849**	0.674***
	-0.113	-0.168
Year2016	0.714**	0.548**
	-0.189	-0.223
Zero_to_Half_Mile_GL	0.220**	
	-0.107	
Half.Mile_To_One_Mile_GL	0.142	
	-0.099	
Union.Square.Station	0.12	0.115
	-0.246	-0.246
Washington.Street.Station	-0.082	-0.088

	-0.259	-0.259
Gilman.Square.Station	-0.033	-0.039
	-0.227	-0.227
Lowell.Street.Station	0.032	0.031
	-0.206	-0.206
Ball.Square.Station	0.108	0.1
	-0.167	-0.167
College.Avenue.Station	0.247	0.235
	-0.152	-0.152
Zero_to_Half_Mile_GL:After_Station_Announcement		0.322**
		-0.134
Zero_to_Half_Mile_GL:Before_Station_Announacement		0.137
		-0.126
After_Station_Announcement:Half.Mile_To_One_Mile_GL		0.249**
		-0.126
Before_Station_Announacement:Half.Mile_To_One_Mile_GL		0.057
		-0.116
Constant	-3.115	-3.061
	-4.528	-4.529
Observations	454	454
R^2	0.787	0.788
Adjusted R^2	0.77	0.77
Residual Std. Error	0.438 (df = 418)	0.438 (df = 416)
F Statistic	44.238*** (df = 35; 418)	41.900*** (df = 37; 416)
Note:	*p**p***p<0.01	

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