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The Hiawatha Line:
Impacts on Land Use and Residential Housing Value

CTS Report 10-09

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16. Abstract (Limit: 250 words)

This report presents the results of an examination of the economic and land-use impacts of the Hiawatha Light Rail Line. Specifically, the report contains findings on the impact of the line on residential property values, housing investment, and land-use patterns. Property value impacts were determined through the creation of a hedonic pricing model for single-family and multi-family residential properties within a one-half mile radius of the Hiawatha Line stations. Price trends within station areas were examined both prior to and after completion of the Hiawatha Line in 2004 and in comparison to a control area of southeast Minneapolis. Housing investment trends were investigated through an examination of building permit data, also broken down into pre- and post-construction periods. Land use patterns were examined through analysis of the Metropolitan Council's seven-county land use data base. The findings indicate that construction of the Hiawatha Line has had a positive effect on property values within station areas. The effect is limited to the west side of the line; on the east side a four-lane highway and a strip of industrial land uses intervenes and eliminates any positive impact of the line. Results also show a high level of residential investment (as measured by dollar value of the investment) within station areas compared to the control area. No changes in land use patterns were detected since completion of the light rail line. This study demonstrates that completion of the Hiawatha Line has generated value and investment activity in the Minneapolis housing market.

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The Hiawatha Line Impacts on Land Use and Residential Housing Value

Final Report

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Executive Summary

The $715 million Hiawatha Light Rail Line opened in 2004, running between downtown Minneapolis and the Mall of America in Bloomington. The line is the first major investment in the Twin Cities region in what planners and public officials are envisioning as a comprehensive network of transitways to include a mix of light and heavy rail and Bus Rapid Transit. This report presents the finding of a study of economic impacts resulting from the construction of the Hiawatha Line.

Three major research questions are investigated:

- RQ1. What are the impacts on property values of proximity to a Hiawatha Line station?
- RQ2. How have land-uses changed around the Hiawatha transit stations?
- RQ3. What are the impacts of the transit stations on the level of housing investment within the corridor?

Research question 1 focuses on the impact of the line on the real estate market. Using tax assessor's data we examine trends in residential property sales before and after development of the Hiawatha Line. The assessor's data provides data on most recent sales prices as well as detailed information on property attributes. The data allow us to control for a range of variables that determine sales value in order to isolate the impact of proximity to a transit station. We examine home sales from 1997 to 2007, both within station areas and in the larger southeast Minneapolis housing sub-market which we use as a control group. We use 2004, the year the Hiawatha Line completed construction, as the break point between pre- and post-LRT. Thus, we utilize a "pretest-posttest with comparison group" design.

The second research question is an examination of how land-uses have changed around Hiawatha stations. We develop several measures of the land-use characteristics within station areas utilizing data from the Metropolitan Council covering a period between 1984 and 2005. In this analysis we focus our attention on an area defined by a ¼ mile radius from the stations. We also describe the planning efforts of the cities of Minneapolis and Bloomington that have led to rezoning to accommodate land-use changes.

The third research question focuses on the degree of investment in the housing stock that may have been induced by the Hiawatha Line. In this analysis we utilize data on construction permits issued within the city of Minneapolis from 2000 to 2007. We compare the rate and value of permits over the eight-year period, comparing station areas to comparison areas more distant from the Hiawatha Line stations.

The 17 Hiawatha Line stations are located in a diverse set of neighborhoods. The downtown Minneapolis station areas from the northern terminus (Warehouse district station) to the Downtown East/Metrodome station have little land-use diversity, being dominated by commercial land uses and having very few residential properties. The downtown stops are typically destinations for those travelling on the Hiawatha Line.

The neighborhood corridor of the line stretches from the Cedar Riverside station on the north to the V.A. Medical Center station to the south. These station areas have a greater mix of land uses (especially the Franklin and Lake Street stations) that become more residential as one moves south along the line. The neighborhood corridor stations are primarily origin stations; most of the riders using these stations begin their LRT trips at these stations. There are significant differences in the demographic (and housing stock) profiles between the Cedar Riverside and Franklin Avenue stations in the northern section of the neighborhood corridor and the stations from 38th Street south to the V.A. The northern stations have greater levels of racial diversity, lower incomes, and more multifamily housing compared to the southern stations in the neighborhood corridor. The Lake Street station occupies a middle ground both geographically and demographically.

The third identifiable subset of station areas along the Hiawatha Line is made up of the Fort Snelling station and the two airport stations. These station areas are surrounded by institutional land uses with no residential properties.

Finally, the southernmost stations of the line are in the city of Bloomington and are surrounded primarily by commercial properties, including the Mall of America. In general, the institutional and commercial station areas at the southern end of the line are destination stations (the 28th Street station is a notable exception, having park and ride facilities nearby).

Key Findings

- Single family homes sold within a half-mile radius of the station areas along the neighborhood corridor are 16.4 percent lower in price before 2004 than homes sold in the larger southeast Minneapolis sub-market. After 2004, single family homes within station areas sold for 4.2 percent more than homes in the comparison area.
- There is a significant accessibility effect for single family residential properties located within station areas west of the Hiawatha Line. Location closer to the LRT stations is associated with higher property values, an effect that extends beyond a half-mile. There is also a negative, nuisance effect for properties that are close to the LRT tracks. This effect is of a smaller magnitude than the positive, accessibility effect.
- Properties on the east side of the Hiawatha Line do not benefit from proximity to the line. This is likely due to the intervening effect of the four-lane Hiawatha Avenue and the strip of industrial land use immediately adjacent to the highway on the east. The combination of these pushes the nearest residential property close to 200 meters away from the LRT line and its stations. Furthermore, the large industrial structures create a visual barrier between the residential properties on the east and the Hiawatha Line.
- Development of the Hiawatha Light Rail Line has produced an average $5,229 price premium per single family home in the station areas. This translates to an aggregate increase in home value of $18.3 million for houses that sold in the station areas since 2004. Applied to all single family homes in the station areas, the Hiawatha Line has produced an aggregate premium of $29.4 million.
- Properties with multifamily housing located within station areas have also benefitted from development of the Hiawatha Line. West of Hiawatha, proximity to LRT stations is associated with an increase in value of roughly $350 per meter. As with single family properties, there is also a smaller nuisance effect associated with proximity to the tracks. The positive accessibility effect, however, is of a greater magnitude than the nuisance

effect, producing an overall price benefit for multifamily properties. As with single family properties, these patterns are not repeated east of the Hiawatha Line.

- Development of the Hiawatha Light Rail Line has produced an average $15,755 price premium per multifamily property in the station areas. This translates to an aggregate increase in property value of $6.9 million for multifamily properties that have sold since 2004. Applied to all multifamily properties in the station areas, the Hiawatha Line has produced an aggregate premium of $17.7 million.
- All told, the development of the Hiawatha Line has resulted in a combined price premium of $25.2 million for residential properties sold after 2004 in the station areas from Cedar Riverside on the north to the V.A. Medical Center to the south. When applying the increase in value to all residential properties along Hiawatha's neighborhood corridor, the LRT line has produced an increase of $47.1 million in residential property value between 2004 and 2007.
- There has been a significant amount of new housing construction immediately adjacent to the Hiawatha Line since 1997; 183 percent more than would be expected given rates of new construction throughout the southeast Minneapolis sub-market. Aerial photographs show fill-in construction of parcels adjacent to the line that had been kept vacant to accommodate potential widening of Hiawatha Avenue. In total, there were 67 residential properties constructed within 300 feet of the light rail tracks after funding for the Hiawatha project was announced in 1997.
- An analysis of building permits from 2000 through 2007 shows little difference between the number of building permits for station areas and for the larger sub-market comparison area. Three exceptions to this pattern exist; permit activity within a quarter mile of the Franklin Avenue station, the Lake Street station, and the V.A. station were all well above the sub-market rate for the 2000-2007 period. It is notable that station-area planning and rezoning efforts by the City of Minneapolis were completed first for the Franklin Avenue and Lake Street station areas. The greater rate of investment reflected in permit activity may be a result of completed planning processes in those station areas.
- When analyzed by value, permitting activity along the neighborhood corridor accounted for 6 percent of aggregate residential value at the quarter mile scale, compared to 4 percent for the larger sub-market comparison group. This suggests that station areas saw larger-scale building activity than the comparison area for the 2000-2007 period.
- There has been little systematic effect of the Hiawatha Line on the land-use patterns of station areas. Measures of vacancy and undeveloped land, land-use intensity, land-use type, and diversity show modest levels of change over an extended period of time from 1984 and 2005. The changes that have occurred since 2000, however, are indistinguishable in scale or pattern from those that occurred in previous years. Our data on land use extends only to 2005, just one year after opening of the Hiawatha Line. It is likely that greater land-use changes may occur in the future.

Part 1. Introduction

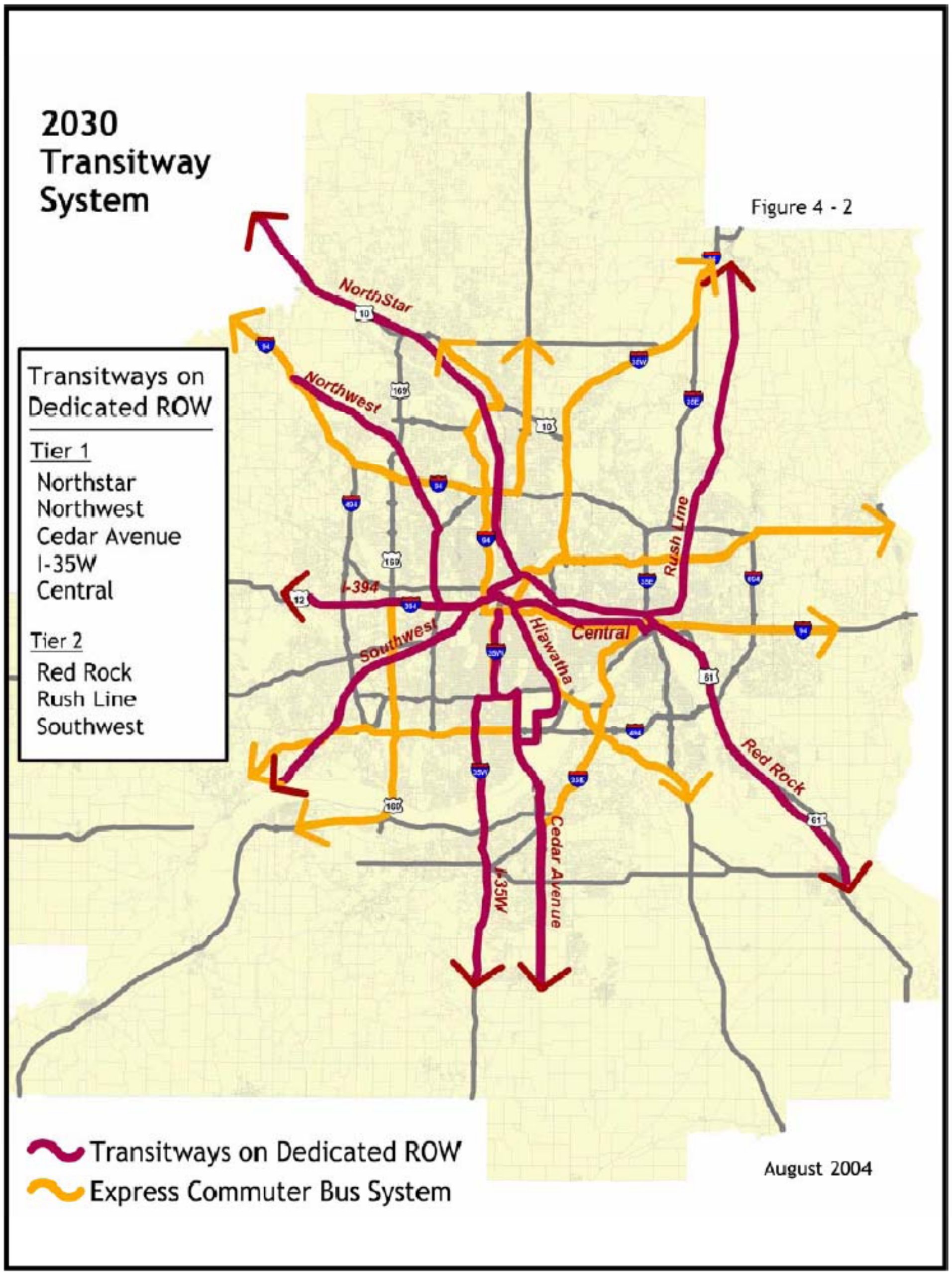
The Hiawatha Light Rail Line, extending for 12 miles between downtown Minneapolis and the Mall of America in Bloomington marks the Twin Cities' first major investment in modern transitway infrastructure. Regional policymakers envision the creation of a network of transitways that will include a mixture of light rail, heavy commuter rail and Bus-Rapid-Transit (BRT) to complement the area's road and highway system.

Given the immense public investment associated with such an effort, public officials are interested in monitoring the performance of the local transitway network. Since 2006, public officials at the municipal, county, regional, and state level have collaborated on an effort to establish and fund an on-going project of research to monitor the impacts of the transitway system. .[1] The collaborative named the effort the Transitway Impact Research Program (TIRP) has two major areas of research concern: the travel and transportation impacts of transitways, and the secondary economic and community impacts of transitways. Documenting the travel impacts of transitways is critical to planning a system that effectively addresses the region's growing mobility needs. At the same time, the investments made in creating the network of transitways is expected to generate positive impacts on economic development, jobs, housing, land markets, and land uses. The objective of the research effort is to document the impacts of transitway developments in a way that allows the lessons learned to be applied as the network is expanded. Thus, research on the economic and travel impacts of the Hiawatha Line, the first element of the network to be completed, are expected to provide lessons for the development of subsequent lines.

Objectives of This Study

The impetus for TIRP and for the careful documentation of transitway impacts comes from many sources. First, state, regional, county, and local governments in the region recognize the importance and magnitude of the public investment embodied in the region's Transportation Policy Plan, and they desire to monitor impacts in order to maximize the return on those investments. Second, the physical development associated with constructing transitways can generate political controversy, and may generate neighborhood opposition. Public agency members of TIRP are interested in documenting positive and negative effects of transitway development in order to respond to constituent concerns. Third, the Federal Transit Administration (FTA) mandates that local recipients of transit funding conduct impact studies.

Figure 1.1: 2030 Transitway system as proposed by Metro Transit



The various public agencies involved in financing and developing this transitway network are interested in monitoring the travel and the economic impacts that will result. The term "economic impacts" is used interchangeably with "community impacts" and ranges from concerns about the effect of transitway development on land values to its potential effect on neighborhood composition and land uses.

Table 1.1 below identifies a range of potential economic impacts that was considered by members of the TIRP collaborative.

Table 1.1:
Potential Economic Impacts of Transitway Development

Type of Impact	*Measure*
Economic and Business Impacts	Commercial property values
	Commercial rents
	Commercial sales
	Business start ups and closings
	Jobs
	Types of businesses
	Business confidence
Land market impacts	Land values
	Property values & property sales
Investment	Building, rehabilitation & demolition
	Public investment patterns
Housing market impacts	Residential sales and values
	Housing starts
	Investment (rehab and upgrading)
	Rents
	Vacancy rates
	Mix of housing type and tenure
	Housing Density
Land use impacts	Parcel land use
	Density of development
Community impacts	Crime patterns
	Resident and business sense of safety
	Median household income
	Neighborhood socio-economic status
	Neighborhood satisfaction

The intention of TIRP members is to produce research efforts that will:

- provide lessons learned that can be applied to other transitways as they are developed in the region;
- utilize research designs, methodologies, and data sources that can be repeated as other transitways come on-line, so that the impacts of subsequent lines may also be monitored and compared to those of the earlier lines;
- represent a model for national efforts to monitor and document the economic and community impacts of transitway development.
- Transitways cross many local jurisdictional boundaries, complicating data collection and comparability within a single transitway, let alone across different lines. The early impact studies, in addition to presenting a set of substantive

findings to members of the TIRP collaborative, are also meant to produce a set of research protocols and data collection procedures that can be used to complete the full series of studies envisioned.

- This report represents the first round of research on the transitway impacts. In this report we focus only on a few of the economic impacts identified in table 1.1. Three major research questions are investigated:

- RQ1. What are the impacts on property values of proximity to a Hiawatha Line station?
- RQ2. How have land uses changed around the Hiawatha transit stations?
- RQ3. What are the impacts of the transit stations on the level of housing investment within the corridor?

- Research question 1 focuses on the impact of the line on the real estate market. Using tax assessor's data we will examine trends in residential property sales before and after development of the Hiawatha Line. The assessor's data provides data on most recent sales price as well as detailed information on property attributes. The data will allow us to control for a range of variables that determine sales value in order to isolate the impact of proximity to a transit station. The data also allow a "pretest-posttest with comparison group" design.

The second research question is an examination of how land uses have changed around Hiawatha stations. We develop several measures of the land use characteristics within station areas utilizing data from the Metropolitan Council covering a period between 1994 and 2005. In this analysis we focus our attention on an area defined by a ¼ mile radius from the stations. We also describe the planning efforts of the cities of Minneapolis and Bloomington that have led to rezoning to accommodate land use changes.

The third research question focuses on the degree of investment in the housing stock that may have been induced by the Hiawatha Line. In this analysis we utilize data on construction permits issued within the city of Minneapolis from 2000 to 2007. We compare the rate and value of permits over the eight-year period, comparing station areas to comparison areas more distant from the Hiawatha Line stations.

The results are presented in the sections to follow. We begin with a discussion of the research design and description of the data used and design decisions made in conducting this research.

Then we provide information on the station areas, in order to typologize station areas. The property values analysis is presented in part 4, land use in part 5 and housing investment in part 6. Part 7 is a documentation of the steps taken to conduct this research. Anticipating that studies like this one may also be conducted for the Central Corridor, the Northstar, and other transitways coming to the region in the near future, we have attempted to document the steps taken to gather and prepare the data necessary to answer these three research questions. The final chapter is a summary of the important research findings.

Part 2. Hiawatha Project Narrative and Research Design

Hiawatha Project Narrative

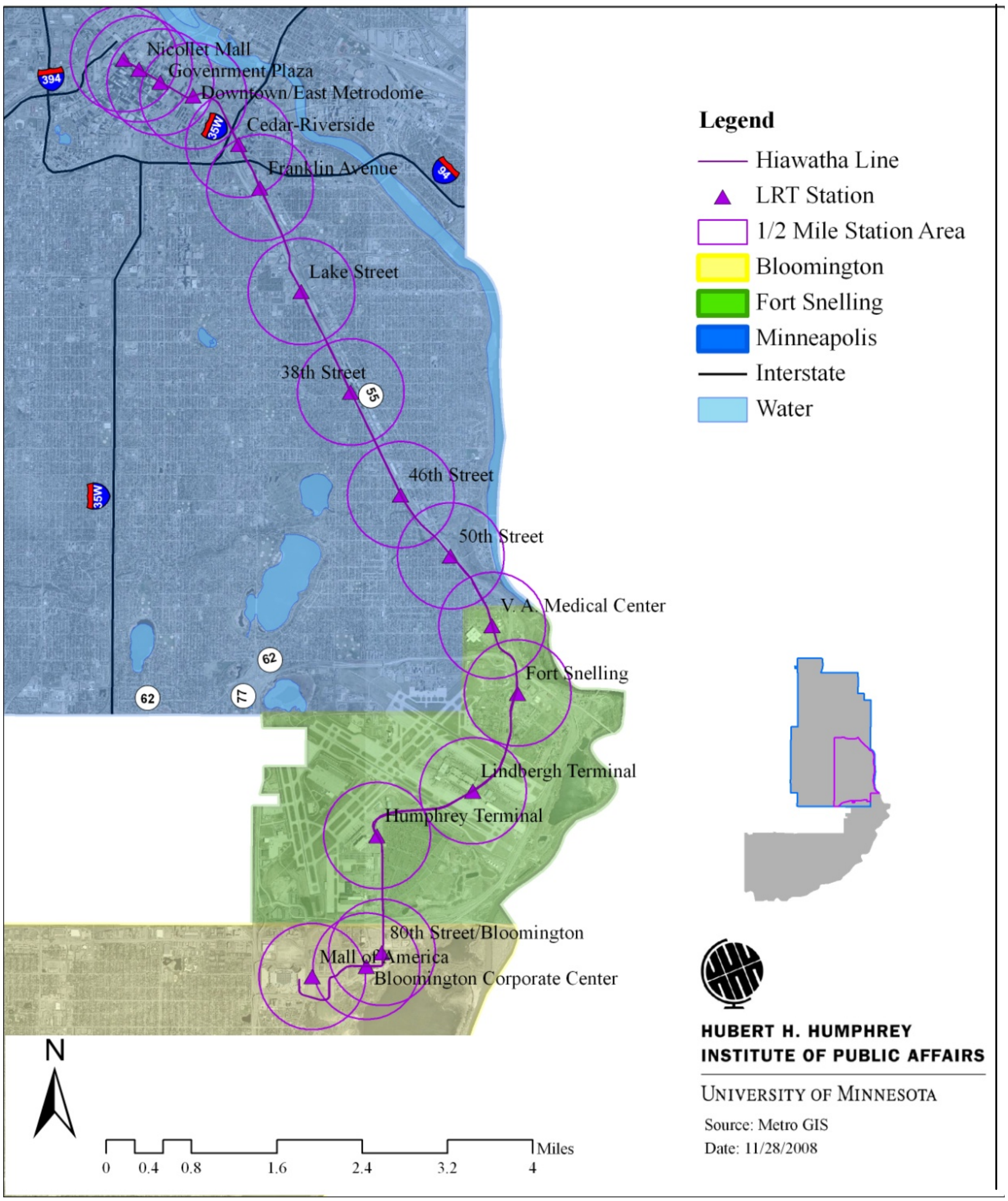
Background

Light rail transit in Minnesota has been heavily debated and has received varying degrees of support over the last 25 years. In 1998 and 1999 support for light rail progressed to the stage that state and federal funds were granted to the Hiawatha Light Rail Line connecting the airport and Mall of America to downtown Minneapolis. From its inception, the Hiawatha Line has been characterized by a significant amount of cooperation between public agencies at all levels of government.

The Hiawatha Light Rail began construction in 2001 and started service in 2004. It consists of 17 stations along 12 miles of track (Map 2.1). The northern terminus of the line is at the intersection of Hennepin Avenue and 5th Street in downtown Minneapolis, and the southern end of the line is at the Mall of America in Bloomington. Two of the stations service terminals at the Minneapolis-St. Paul international airport where the line travels in a 1.4 mile tunnel. Thirteen of the station platforms are served by a total of 46 bus routes to provide timed transfers. Fares for bus and rail transportation are interchangeable. Ticketing is based on the “honor system” and fares can be purchased at train platforms. Compliance is ensured by random checks and the issuance of $180 fines for unticketed riders. During rush hours (6am-9am and 3pm-6:30pm) the trains run every 7.5 minutes with trains arriving on 10, 15 and 30 minute schedules for day time, evening, and late night respectively (Metropolitan Council, 2007a).

One of the goals for light rail in the Twin Cities metro area is to reduce or slow the growth of traffic congestion. In 1990 30% of the freeway lanes in the region were congested. By 2000 congestion of metro area freeway lanes had grown to 60%. A 2004 survey of metro residents listed traffic congestion as the number one problem in the area. Goals for the entire transit system are to increase ridership by 50% between 2005 and 2020 and to double ridership by 2030. The Metropolitan Council has moved to expand the regional bus system and to develop dedicated transitways for bus and light rail in order to meet future ridership goals (Metropolitan Council, 2005).

Map 2.1: The Hiawatha Line and stations



History

For the past 25 years the Minnesota state government has struggled with the idea of light rail transit, going through periods of both support for and prohibition of planning. The first public expenditure dedicated to light rail in Minnesota came in 1988 when the State Legislature appropriated $4.17 million in matching funds for the planning, design and construction of light rail. During the initial stages of the Hiawatha Line there was some uncertainty as to whether the corridor would contain a Bus Rapid Transit line (BRT) or light rail, with much of the decision hinging on how much funding was available (Blake, 1997). In 1998, with the backing of the Ventura administration, the Legislature approved $40 million in funds for the Hiawatha Line. Another $60 million was appropriated for the line in 1999. In September of 2000 the Metropolitan Council submitted a grant application to the Federal Transit Administration (FTA). In January of 2001 the FTA approved the grant and awarded $334.3 million to the Hiawatha project (Office of the Legislative Auditor, 2002).

In order to construct the Hiawatha Light Rail Line, Highway 55 needed to be reconstructed to make enough room for both automobile traffic and rail. The reconstruction plans for Hwy. 55 went through various iterations for 30 years prior to work starting. The final design created a four-lane divided highway between Interstate 94 and Highway 62. The construction cost for road work totaled $100 million and occurred in two phases. The first phase was 1988-1990 and between 32nd and 46th streets. The second phase was 1999-2002 and finished the remainder of the road between 46th street and Highway 62 (Minnesota Department of Transportation, 2007).

Funding and Construction

The original plan for the Hiawatha Line called for a total cost of $675 million. A last - minute realignment of the line directly to the Mall of America,· and the construction of a transfer station increased the price by $39.9 million (Angelo, 2005). Ultimately, $715.3 million in public financing was required to build the line. Funding came from many levels of government, including the county, regional, state, and federal agencies. Table 2.1 below lists the funding amounts and sources for the project (Metropolitan Council, 2006).

The Mall of America management was initially inclined to allow a light rail station on mall property, but was unwilling to pay for construction. Mall owners had spent $2 million building a bus transfer station when the mall was built and did not foresee light rail as bringing in much additional business (Olson, 2003a).

Construction of the line began January 17, 2001 and service began on June 26, 2004. The final stretch of the line from the airport to the Mall of America opened Dec 4, 2004 (Metro Transit, 2007).

Table 2.1: Funding amount and sources for Hiawatha Line

Source	**Amount (millions)**
FTA New Starts	$ 334.3
State of Minnesota	$ 100.0
Metropolitan Airports Commission	$ 87.0
Hennepin County	$ 70.0
Federal Congestion Mitigation Air Quality	$ 49.8
Transit Capital Grant	$ 39.9
State of Minnesota In-Kind	$ 20.2
Hennepin County In-Kind	$ 14.1
Total	**$ 715.3**

Source: Metro Transit

The Metropolitan Council is the grantee of federal transportation funds and is responsible for federal regulatory compliance. The Hiawatha Project Office was created to manage project construction. The Minnesota Department of Transportation was responsible for the mainline construction and contracted with Minnesota Transit Constructors to build the line. The Metropolitan Airports Commission was responsible for the components of the line within the airport boundary and contracted the station and tunnel construction to Obayashi-Johnson Brothers (Office of the Legislative Auditor, 2002).

The rail fleet currently consists of 27 cars, a three car expansion from the original 24, each with integrated electric drive motors built by Bombardier Corporation of Canada. Individual trains consist of two cars, one facing each direction. Each car is 94 feet long, weighs 107,000 pounds, and has room for 66 seated and 120 standing passengers. Cars have built in luggage and bicycle racks and are fully compliant with the requirements of the Americans with Disabilities Act.

Initial projections for Hiawatha Line operating costs were approximately $16 million per year. Sixty percent of the cost would be shared between Minneapolis and Hennepin County with the remainder paid for by the state (Olson, 2007b). The 2006 operating cost was projected to be $19.85 million (Metro Transit, 2007).

Ridership

Prior to the opening of the Hiawatha Line there was much public doubt about the success of LRT in Minnesota. There were concerns about how well the line would function, ridership, and the possibility of additional traffic problems and car-train collisions (Peterson, 2004). In order to create ridership the rail line offered free rides during its opening weekend and neighborhood celebrations and activities at each of the rail stations (Blake, 2004).

In the first year the line served nearly 3 million passengers, exceeding the pre-construction forecasts by 58%. Ridership has grown steadily since the line opened with 7.9 million and 9.4 million riders in 2005 and 2006 respectively (Metropolitan Council, 2007b, 2007c). As of 2007, an average of 28,146 riders used the Hiawatha Line every weekday (Metropolitan Council, 2007b).

The majority of Hiawatha riders use the line to commute to and from work, and 40% of passengers have not previously used public transit (Metropolitan Council, 2006). The Metropolitan Council estimates that half of Hiawatha Line riders would drive alone if transit were not an option (Metropolitan Council, 2007b).

The increase in ridership led Metro Transit to add new rail cars to the fleet in 2007, bringing the number of cars to 27. The addition of new cars allowed an increase in train frequency during peak periods and allowed the maintenance of service levels when trains were taken out of service for repair or upkeep. Each additional car cost $3.15 million (Metropolitan Council, 2007c).

Research Design

As described in Part 1 of this report, there are three overarching research questions that we will analyze. The first is whether and to what degree residential property values have increased due to the proximity of light rail stations. The second is whether and to what degree new investment in housing, through new construction and renovation/rehabilitation has been spurred by the Hiawatha Line. Finally, we also examine whether the line has led to significant changes in land use in the areas surrounding the stations. In order to answer these questions, five major research design issues were considered:

1. Defining the pre- and post-Hiawatha time periods.
2. Determining the time frame for the analysis.
3. Defining "station areas" or the area in which to look for economic impacts.
4. Establishing comparison neighborhoods (areas similar to the station areas but not proximate to the light rail line).
5. Aggregating the economic effects across all of the stations, or differentiating stations on the basis of pertinent characteristics.

Defining Pre- and Post-Hiawatha Periods

This research focuses on the effects of the Hiawatha Light Rail Line on several housing and land market outcomes. In order to conduct such an analysis we need to determine exactly when the hypothesized effects of the light rail line would begin to manifest themselves. Would changes in the housing market wait until construction of the line was completed? Or would noticeable market reactions occur earlier, when full funding was secured or when construction began?

One approach to this question is to attempt to document the point in time when the Hiawatha Line became widely known among residents of the Twin Cities, known enough that individual property owners and potential buyers might begin to factor the line into market negotiations. Such an analysis assumes the determination of the "intervention point" – the moment that differentiates the period prior to the line from the period after the line. This is not so straightforward considering that development of the line took more than 15 years, and that funding for the line was received over an eleven-year period. Because we are looking at market responses to the line, we must be able to judge when the line could reasonably be expected to produce such impacts. Landowners and developers would have been aware of the line for many years and would be anticipating its completion and acting accordingly. By 2000, over $100 million had already been appropriated by the Minnesota legislature for the construction of the Hiawatha Line. Final funding was received in January of 2001 when the Federal Transportation Agency (FTA) awarded $334.3 million to the project. On the other hand, if awareness was not widespread among the home buying public, then we would not expect to see an impact on values or investment patterns. Even the start-date for construction (January 2001) might be too late since most of the funding had been in place for years prior to groundbreaking.

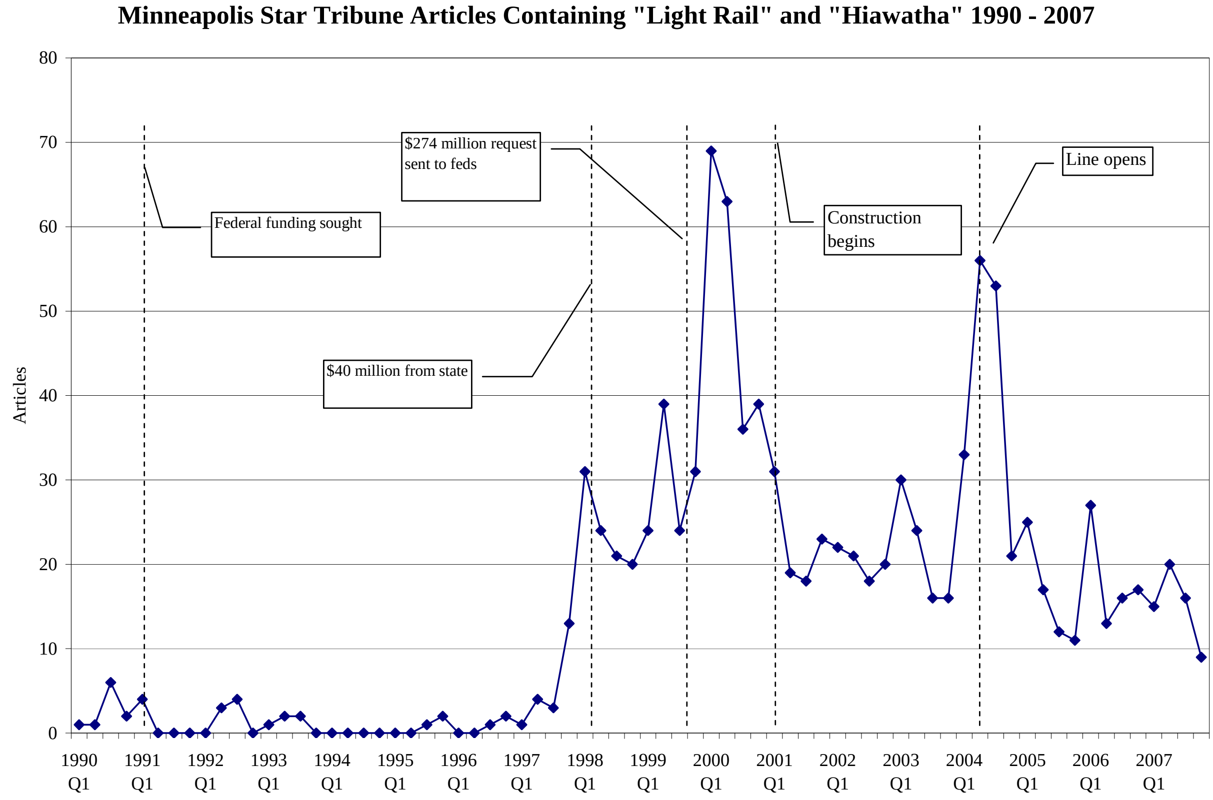
It is clearly possible that property owners and land developers began to act in anticipation of the final announcement of full funding for the project. As described above, the idea of the Hiawatha Line had been around for more than a decade, and in fact, the Minnesota legislature had appropriated $40 million in matching funds as early as 1988. Real progress on the project, however, took place during the Ventura administration when the legislature made major appropriations in both 1998 and 1999. If this is the point at which the project became a "real" possibility in the eyes of developers and land owners, then land use and housing market changes may have begun to occur prior to 2000.

Figure 2.1 presents data on the number of newspaper articles in the Minneapolis daily paper (the *StarTribune*) containing the phrases "light rail" and "Hiawatha" both. The y-axis represents the number of newspaper articles in the given three-month period relating to the Hiawatha Line. The x-axis charts quarter-years beginning in first-quarter 1990 and going through the fourth quarter of 2007. This provides some empirical evidence of the degree to which the line was in the public consciousness at any given point in time.

As the figure shows, there were very few newspaper accounts of the Hiawatha Line prior to the last quarter of 1997. In fact, prior to 1997, the Hiawatha Line appeared in the *StarTribune* at a frequency of less than once per month, and for several consecutive quarters did not appear at all. A sharp spike upward occurs in 1998, however. In the first quarter of 1998, 31 newspaper articles appeared dealing with the Hiawatha Line, roughly one article every three days. This level of attention is maintained for two years, through the end of 1999. Whether this increase in attention is significant enough to trigger a market response is unknown, but this period might constitute the point at which public consciousness of the Hiawatha Line became significant enough to trigger land market activity.

A larger spike in newspaper attention to the Hiawatha Line occurs in the first half of 2000. For this six-month period, newspaper articles pertaining to the Hiawatha Line appear roughly three out of every four days. This is the year before the start of construction. Newspaper accounts decline during the construction period, though they remain elevated well over the pre-1998 level. A last spike occurs in 2004 as the system comes on-line and begins carrying passengers. During the three years of operation, newspaper attention has maintained itself at an average of almost 20 articles per quarter, or roughly one every four to five days.

Figure 2.1: Newspaper accounts of Hiawatha Light Rail Line



On the basis of this analysis, we estimate that market effects may begin manifesting themselves as early as 1998, though a more conservative hypothesis might place the point in the year 2000.

Determining the Time Frame for the Analysis

The establishment of an intervention point helps determine how far back to go to collect data. Ideally, we would like to have data for periods prior to the intervention in order to establish pre-Hiawatha trends against which to compare the post-Hiawatha conditions. Thus, we look to collect data going back for several years prior to 2000. This is possible for some data and not for others. Our analysis of land use patterns, for example, allows us to go back as far as 1990. The housing permit data, however, goes back only as far as 2000. Our analysis of property values is based on data sets that go back to 2002, but these contain historical information that goes back much farther. In all cases, we have opted to use data that provides as much historical information as possible. We are constrained by the availability of relevant data in our ability to establish conditions and trends prior to the emergence of the Hiawatha Line.

Defining "Station Areas"
We expect land use and housing market impacts to occur in proximity to station areas, hypothesizing that access to the line is an amenity that will be capitalized in market transactions and will lead to changes in land use. Our analysis here requires us in some cases to define the area in which we expect to see results.

We have adopted a flexible approach to defining station areas. Some of our analyses, most importantly the property value analysis, allows us to determine the changing market effects at any given distance from the station. The land use and housing investment analyses, however, require the definition of a study area. For the analysis of land use changes we consider the City of Minneapolis comprehensive plan that establishes the optimum size of Transit Station Areas as "approximately ½ mile in radius." The draft plan also differentiates between the anticipated impact of rail at ¼ and ½ mile (City of Minneapolis, 2000). The literature on Transit-Oriented-Development (TOD) that establishes an area of 600 feet from the station as the modal size of a TOD. The City of Minneapolis has secured federal funds to assist with TOD development within 1,500 feet of a light rail station (City of Minneapolis, 2005). This places the study area halfway between a ¼ mile and ½ mile radius from the station. Thus, we use both study-area-sizes in most of the following analyses.

In order to understand investment in residential properties over the study period parcel level building permit data was obtained from the city of Minneapolis for the years 2000 through 2007. While the permit data obtained from the city contains many attributes, this analysis was concerned only with the location of the property, the date of permit issue, and reported value of new construction and remodeling projects. New construction and remodeling were not considered separately as both types of construction reflect property investment. As with other monetary values used in this report, the value of building permits were deflated to constant year 2000 dollars. The ratio of residential parcels granted building permits compared to total residential properties and the total value of residential building permits compared to total residential property value were calculated for individual years and study areas. An additional analysis compared the total permits and investment from 2000 to 2007 for each station area.

Establishing Comparison Neighborhoods
(areas similar to the station areas but not proximate to the light rail line)
Similar analyses of the impact of light rail transitways have utilized 'control neighborhoods' or areas that are similar to the station area on important dimensions, but that do not share proximity to the light rail line. This allows the researcher to eliminate larger, citywide trends in property values as an explanation for the changes seen near the line. It may also allow the comparison of market effects of the light rail transitway compared to other types of transportation corridors such as bus rapid transit or automobile corridors.

The choice of 'control neighborhoods' is always difficult because of the many potentially relevant characteristics that could be taken into account. It is virtually impossible to find neighborhoods identical in all respects to the station areas, except for proximity to the stations. We have opted for two strategies to establish spatial comparisons for the Hiawatha Line station areas. The first is to define an additional band of territory immediately outside of the station areas. Since our most expansive definition of station area is the land within a ½ mile radius of a given station, our first comparison area is the land that lies between a ½ mile and a ¾ mile radius. These areas typically share most neighborhood characteristics with the station area but are outside the presumed influence of the light rail station.

Our second approach, used in the property value analysis, is to use the entire southeastern portion of the city of Minneapolis as a comparison area. This allows us to examine trends along commercial corridors, automobile corridors and other sub-areas to the market trends occurring along the Hiawatha Line. We use the analysis in Adams and Van Drasek (1993) that identifies this area as one of the 17 discrete housing sub-markets within the Twin Cities as a justification for this approach. Part 4 of this report will provide more information on the southeast sub-area.

Aggregating the Economic Effects across All of the Stations, or Differentiating Stations on the Basis of Pertinent Characteristics

As previously mentioned, the Hiawatha Line consists of 17 different light rail stations in neighborhoods as diverse as downtown Minneapolis, mixed-use areas around Cedar Avenue and Franklin Avenue, the predominantly single family residential neighborhoods surrounding 38th Street and 46th Street in Minneapolis, the largely institutional settings of the Fort Snelling and airport stations, and finally the largely commercial areas surrounding the Bloomington stops.

The three economic outcomes we examine in this report, residential property values, housing investment, and land use changes, are likely to vary according to the nature of the neighborhoods surrounding the stations. Thus, it makes little sense to examine the Hiawatha Line as a single entity and simply aggregate results across all station areas. Instead, we are likely to learn more about the impacts of the line if we are sensitive to the difference among station areas. Thus, we endeavor to classify station areas by type and to segment our analyses according to these classifications. Part III of this report presents the analysis we conduct in order to arrive at the classification scheme.

Part 3. A Classification of Station Areas

The 17 Hiawatha Line has stations are located in a diverse set of neighborhoods with a diverse set of land use characteristics. It is quite likely that the impacts of the development of the light rail line that we are interested in, including the impact on residential property values, housing stock, and land use, will be strongly mediated by the physical and social characteristics of the station areas. Thus, it is necessary to analyze the station areas in order to categorize the distinct Hiawatha stations according to appropriate dimensions.

Literature on Station Areas

Previous studies of property value impacts of light rail stations have either implicitly or explicitly acknowledged the important range of stations types that exist. Perhaps the most obvious distinction made is between downtown station areas and all others (see, e.g., Cervero, R. and J. Landis, 1997). Some analysts have divided larger transitway lines into segments defined by neighborhood or geographic characteristics and examined impacts within those segments (Getzlaff and Smith, 1993; Lewis-Workman and Brod, 1997). The most developed typology of station areas is provided by Bollinger and Ihlanfeldt (1997) who offer a five-way categorization:

- High-intensity urban node; central business district and areas with high-intensity commercial use
- Mixed-use regional node; stations serving regional shopping and office centers
- Commuter station; stations serving as points of service origin for commuters
- Community center; stations that ‘function as centers of activity for several surrounding neighborhoods
- Neighborhood station; serving low- or medium-density neighborhoods.

While the distinction between the community-center and neighborhood stations described above is somewhat difficult to see, Bollinger and Ihlanfeldt have produced a typology that is more refined than a simple downtown/neighborhood dichotomy. The Bollinger and Ihlandfeldt typology is based on the prevailing land use surrounding the station area and on how the station area is used either by riders or by residents living in the immediate vicinity.

A sensitive classification of station areas is important given the potential mediating influence that surrounding land uses or neighborhood characteristics may have on the economic impacts of station development. In the pages that follow we examine three dimensions of the light rail stations along the Hiawatha Line in an effort to construct a typology of stations by which to organize our subsequent analyses; the physical and land use change, the demographic and social characteristics of residential neighborhoods, and the ridership patterns associated with each station. We begin with a physical description of each station area and its immediate surrounding area.

Physical Description of LRT Stations

Warehouse District/Hennepin Avenue

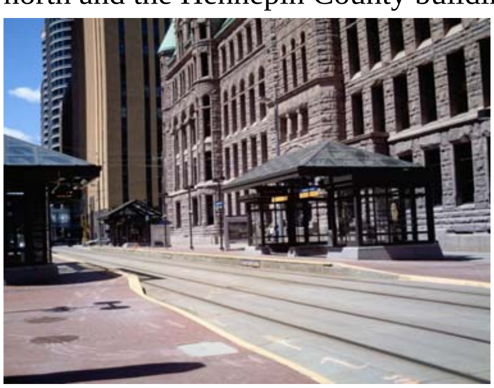
The Warehouse District/Hennepin Avenue station is currently the northern terminus of the Hiawatha Line and one of the four downtown stations. The stop is on the edge of downtown, where downtown transitions into the Warehouse entertainment district. The station is surrounded by the entertainment options. In the immediate vicinity there are a number of restaurants and bars, the Hennepin Center for the Arts, the Target Center, and the new central library. Hennepin Avenue is served by several regional bus lines. This is the downtown stop that is closest to the new residential land uses emerging in the Warehouse District, though the nearest of these is several blocks away.

Nicollet Mall

The Nicollet Mall station is near the heart of the Minneapolis downtown commercial office space district. The stop is bounded by very high-density commercial office buildings. This station also serves the Nicollet Mall shopping district that extends south on either side of the mall for several blocks. There is no residential property in the near vicinity of this stop. Riders can access this station fairly easy from all directions. Nicollet Mall is a bus-only mall, thus many regional bus lines converge there, providing light rail users with a large variety of connecting transit options.

Government Plaza

The Government Plaza station is located directly between Minneapolis City Hall to the north and the Hennepin County building to the south. Similar to the other downtown stations, Government Plaza station is enveloped by high density commercial land uses and there is no residential land use in the immediate surrounding area. According to the Metropolitan Council the station is designed artistically to reflect the principles of representative government. There are bus connections within a walking distance from this station.



Downtown East / Metrodome

The Downtown East / Metrodome station is located next to the Metrodome at the edge of the downtown district. The Metrodome is a multi-sport facility, hosting the Minnesota Twins baseball team and the Minnesota Vikings football team. The University of Minnesota's baseball team plays some games in the Metrodome in the early spring and the University's football team plays its home games there. Both the Twins and the University's football teams have new stadiums under construction, while the Vikings are also investigating plans for a stadium elsewhere. There are a number of bus connections from this station as well. The majority land use around this station is medium density commercial with scattered residential uses located approximately five blocks south of the station in the Elliot Park neighborhood, and in condominium buildings along the Mississippi River to the north. Washington Avenue, two blocks north of the station is also beginning to develop a range of residential and commercial properties. The new Guthrie Theatre complex and the Hennepin County Medical Center are both within walking distance from the station.

Cedar-Riverside

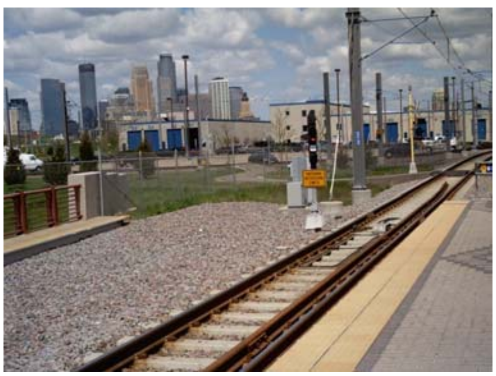
The Cedar-Riverside station area marks the beginning of the 'neighborhood' station areas after one leaves downtown. It is separated from downtown by Interstate 35W, thus its

neighborhood is located to the north and east of the stop. There is essentially no pedestrian access to the station from the west and south because of I-35 and I-94. The station itself is isolated, tucked behind the Cedar-Riverside towers and a public housing high-rise complex, two blocks from Cedar Avenue. The station platform sits behind a non-descript one story, gray building, and is impossible to see even one block away. Complicating pedestrian access to the area is the large amount of "indefensible space" between the towers and the numerous dead end streets in the area surrounding the station. There are also a number of loading docks, dark corners and chain link fences in the area that contribute to perceptions of security risk, especially at night.

The Cedar-Riverside station currently serves residents of the afore mentioned high-density residential developments, as well as other more distant residents of the Cedar-Riverside neighborhood and the University of Minnesota's West Bank campus. Bus service does not connect with the Cedar-Riverside station. Passengers wishing to transfer to or from a train must walk past the above mentioned security concerns in order to rendezvous with bus transportation on Cedar Avenue. The platform is artistically designed with a Somali textile pattern, which reflects the area's ethnic diversity.

Franklin Avenue

After pursuing a largely eastward path from downtown Minneapolis, the Hiawatha Line turns southward to the Franklin Avenue station. It is at this point that the Hiawatha Line begins to track Hiawatha Avenue, Highway 55. The Franklin Avenue station is not especially accessible to pedestrians, but it is well served by connecting bus routes. Franklin Avenue is a major east-west commercial corridor on the near south side. The station is located where Franklin Avenue and Hiawatha Avenue intersect. The intersection is dominated by industrial land uses and commercial properties as well as by a complicated intersection design. Land use to the north and south of the station platform are industrial or semi-industrial and not pedestrian friendly.



More distant from the station itself is a band of multifamily residential land use. The station sits at the center of a confluence of major and minor roads creating an island effect and limiting pedestrian access and neighborhood integration. As seen with the Cedar-Riverside station, the Franklin Avenue platform is accessible from the surrounding areas, but there may be a psychological barrier due to a break in the urban fabric immediately surrounding the station. The station platform is elevated and as a result is somewhat removed from the surrounding streetscape.

Lake Street/Midtown

The Lake Street station is accessible to pedestrians, but the surrounding land is not well suited to pedestrian traffic. There are many commercial and retail businesses in the immediate station area, but they are predominantly auto-oriented with large parking lots that create a barrier to pedestrian traffic. The area to the southwest of the station platform is pedestrian friendly and dominated by single family homes. Similar to the Franklin station, the Lake Street station is elevated and not integrated into the surrounding area. However, riders can either take the elevators or escalators down one level to make bus connection to their destination. The most dominant land use surrounding this station is commercial. This area is newly revitalized and currently contains many locally owned ethnic shops and restaurants.

38th Street

The 38th Street station is located along the Hiawatha Avenue, which is a busy industrial

corridor. This station is at ground level and incorporates a bus stop and "kiss and ride" where automobile passengers can be dropped off. The station does not have parking so automobile access is limited to passengers getting rides. The area west of the LRT tracks has good access to the station and is predominantly residential. There is also a local restaurant and bar located next to the station. The area immediately east of the tracks is dominated by a four-lane divided highway, heavy rail, many blocks of grain elevators and other industrial uses. The elevators and associated heavy-rail tracks may provide a barrier to residential areas farther east of the light rail station. It is relatively easier to get to the station for the riders who are coming from the west side of the station compared to those coming from the east side because of the large Hiawatha Avenue in the middle. The 38th street station has a number of bus connections to transport people to a variety of destinations.

46th Street

The 46th street station is similar to the 38th station in many aspects. The platform is at ground level and incorporates a bus stop and kiss and ride layout. The predominant land use west of the platform area is single-family residential. This station is easily located and highly accessible to the residents in the areas. East of the light rail tracks is Hiawatha Avenue (State Highway 55) and auto oriented businesses. The 46th street station area is significantly less industrial than the 38th street station area. There is a newly constructed multi-family housing development across Hiawatha Avenue, east of the station. The 46th street station also has many bus connections.

50th Street/Minnehaha Park

50th street/Minnehaha Park station is also located along Hiawatha Avenue. This station is surrounded by the Minnehaha Park to the East and high end single family residential uses to the West.

V.A. Medical Center

The V.A. Medical Center station is located adjacent to the V.A. Medical Center. The dominant land use in the surrounding area is institutional land use and a small percentage of single-family residential to the northwest of the station. Flanked by the V.A. medical Center and its large parking lot to the west, highway 55 to the east, Highway 62 to the south, it has very little access for those who wish to walk to the station.

Fort Snelling

The land use surrounding the Fort Snelling station is institutional. This is another station with park and ride lots and these lots are heavily utilized by riders. There is no residential land use within the immediate area, thus, most riders access this station via cars then take the light rail to their destinations.

Lindbergh Terminal

The Lindbergh Terminal is the main terminal of the Minneapolis-Saint Paul International Airport. This is an underground station and is connected to ticketing, baggage, rental vehicles and the transit center by a short walk. A fare-free zone connects the Lindbergh and Humphey terminals.

Humphrey Terminal

The Humphrey Terminal station is located just outside of the Humphrey Terminal of the Minneapolis-Saint Paul International Airport. This terminal is connected to car rental, ticketing and baggage claim by a walkway. The station area land use consists of the airport and the national cemetery.

Bloomington Central

The Bloomington Central station is surrounded by a mix of commercial land uses and semi-vacant land. Reflections condominiums is a new transit oriented development located adjacent to the station platform. The HealthPartners headquarters is located in an existing office tower southwest of the station. There is relatively little residential property within half a mile radius from the station, but development plans already approved would add much more high-density residential property to the immediate area.

28th Avenue

The 28th Avenue station in Bloomington is only a quarter mile from the Bloomington Central station. As a result, the surrounding areas for these two stations are essentially identical. The 28th Avenue station is currently surrounded by a number of surface parking lots. Some of these are devoted to 'park and ride' for the station. The 28th Avenue station is the third station with a park and ride lot. Currently, a permanent park and ride lot is under construction. When it is completed, there will be approximately 1,500 spaces available for light rail and bus riders.

Mall of America
This station is the southern terminus of the Hiawatha Line. It is located adjacent to the Mall of America and at the lower level of the mall's parking lot. This multi-modal station has many bus connections to various other parts of the metropolitan area. The major land use in the surrounding area is commercial. Approximately one third of the land within a half mile radius is vacant, but there are well-developed plans for increased commercial density in the area.

Typologizing Station Areas

We explore the possibility of typologizing station areas using three data sources; land use characteristics, census data, and ridership data. Our land use data (described more fully in part 5) provide 10 categories of land use for each station area in 2005. Our census data exploration focuses on the racial and income characteristics of station area residents and housing stock characteristics with station areas. Finally, we look at ridership data to determine whether station areas are primarily origin or destination stops.

Land Use
Below we profile the 17 Hiawatha Line stations according to various metrics and at two scales (quarter-mile and half-mile radius). Table 3.1 shows summary information for each of the stations based on land use in 2005. Station areas are arrayed in the table beginning at the northern terminus of the line in downtown Minneapolis and ending at the southern terminus at the Mall of America in Bloomington. The final column of the table contains a measure of land use mix for each station. For the summary purposes of table 3.1, we simply use one index of land use mix, taken from Ramanjani (2002). This measure, the land use diversity measure, takes the value of 1.0 if there is a perfect mix of land uses with the area and the value of 0 if there exists one exclusive land use.
The data reported in table 3.1 show significant differences in land use characteristics across the station areas. Most of the station areas have very little undeveloped land. Ten of the 17 station areas have either no undeveloped land or such land accounts for less than 1 percent of the total area in 2005. The three Bloomington station areas (28th Avenue Station, Bloomington Central Station, and Mall of America Station) have the highest percentages of land undeveloped. The Bloomington Central Station has the highest percentage of undeveloped land within a one-quarter mile radius (18.25%) and the Mall of America has the highest percentage of vacant land within the full half-mile radius (31.67%). Among the rest of the station areas only Franklin Avenue and Lake Street have sizable amounts of vacant land. Downtown Minneapolis and the four stops from the Veteran's Medical Center to the Humphrey Terminal of the airport have no vacant land.

Table 3.1: Station area land use

Land Use Statistics by Hiawathat Line Station Area - 2005

Station Area	Percent land ¼ m	Percent land ½ m	Land use intensity# ¼ m	Land use intensity# ½ m	Predominant land uses ¼ m	Predominant land uses ½ m	Land use index* ¼ m	Land use index* ½ m
Warehouse district	0.00%	0.05%	477	1280	83% Comm. 8% Indus.	59% Comm. 14% Indus.	0.184	0.391
Nicollet Mall	0.00%	0.00%	535	1313	85% Comm. 11% Inst.	70% Comm. 15% Inst.	0.156	0.278
Government Plaza	0.00%	0.00%	392	1160	70% Comm. 25% Inst.	68% Comm. 16% Inst.	0.163	0.291
Downtown East Metrodome	0.00%	0.81%	60	451	69% Comm. 26%Inst.	49% Comm. 18% Inst.	0.169	0.484
Cedar Riverside	1.67%	2.17%	39	328	46% HW 23% MF Res.	24% MF res. 24% HW	0.417	0.509
Franklin Street	5.06%	2.99%	46	397	22% HW 22% Indus.	31% MF res. 16% HW	0.545	0.624
Lake Street	8.70%	5.38%	32	302	38% Comm. 21% Inst.	21% Indus. 21% SF res.	0.514	0.59
38th Street	0.95%	0.60%	109	495	51% SF Res. 21% Indus.	67% SF res. 10% Indus.	0.41	0.366
46th Street	1.95%	0.87%	109	420	45% SF Res. 15% Indus.	61% SF res. 14% Rec.	0.526	0.388
50th Street	0.99%	0.25%	41	223	44% Rec. 39% SF Res.	44% SF res. 32% Rec.	0.299	0.38
V.A. Medical Center	0.00%	0.00%	7	131	67% Inst. 25% HW	30% Inst. 23% SF res.	0.203	0.41
Fort Snelling	0.00%	0.00%	x	x	76% Inst. 16% HW	51% Inst. 24% Rec.	0.193	0.31
Lindbergh Terminal	0.00%	0.00%	x	x	100% Airport	97% Airport 3% Inst.	0	0.032
Humphrey Terminal	0.00%	0.00%	x	x	67% Airport 33% Inst.	70% Airport 30% Inst.	0.111	0.111
28th Ave. Station	9.31%	10.47%	x	x	71% Comm. 13% Rec.	30% Comm. 23% Rec.	0.294	0.587
Bloomington Central Station	18.25%	18.24%	x	x	61% Comm. 18% Vacant	36% Comm. 18% Vacant	0.326	0.555
Mall of America	15.07%	31.67%	x	x	75% Comm. 15% Vacant	46% Comm. 32% Vacant	0.22	0.361

= Ratio of built square footage to area square footage
* = Formula taken from Handy et al. 2002

For most station areas there is little different in the amount of vacant land whether using the quarter- or half-mile radius. The major exception to this is the Mall of America where the percent vacant land doubles when one moves from the quarter- to half-mile scale. For Franklin Avenue and Lake Street, the percent vacant decreases slightly as the study area is increased from the quarter- to the half-mile radius.

Table 3.1 also presents data on land use intensity. The numbers shown in the table represent the building square footage within the station area per square foot of land

within the station area. This is essentially an aggregate floor ratio area (FAR) for the entire ¼ mile- or ½ mile-radius station area. The data show, predictably enough, that the downtown Minneapolis station areas are characterized by very intensive land use, when compared to the residential station areas from Cedar Riverside to 50th Street.   In terms of land use intensity, the Downtown East / Metrodome station area is closer to the station areas from Cedar to 50th Street than it is to the other downtown stations. The institutional station areas from the V.A. Center show very little intensity because of the large amount of station area devoted to airport use. The station areas from Humphrey Terminal south could not be measured for intensity because of the lack of available square footage data. Qualitative observation suggests that these areas are unlikely to show intensive land use because of the large amount of vacant land and transportation infrastructure.
Predominant land uses along the line define four separate clusters. The first two exist at both ends of the line - station areas that are overwhelmingly commercial. In downtown Minneapolis and in Bloomington commercial office space dominates the station areas, whether measured at the quarter- or half-mile scale. The commercial uses around the Mall of America station are, of course, retail in nature. The third cluster is a string of station areas from Cedar Riverside south to 50th Street that are significantly residential, although Franklin and Lake both have significant non-residential land uses as well. The final cluster is made up of four stops from the V.A. Medical Center to the airports that are primarily institutional in nature.

The final measure of land use characteristics focuses on the degree to which there is a mix of different land use types within a station area. While we present one index of land use mix in table 3.1, it is also possible to draw conclusions about mix by looking at the predominant use at each station. Compare, for example, the Nicollet Mall station area and the Franklin Avenue station. The two most-dominant uses in the Nicollet Mall area account for 96% of all land with the quarter-mile radius and 85% within a half-mile. For Franklin Avenue, the two most prevalent land uses account for less than one-half of the full station area, both at the quarter-mile and half-mile scale. The land use diversity index reflects these differences. The index for Nicollet Mall is the lowest (reflecting very little diversity) outside of the airport stations, while the Franklin Avenue station records the highest diversity index.

The diversity index separates the downtown and institutional stations, with very little diversity of land use, from the rest of the station areas.   The greatest diversity is seen in the Cedar-Riverside, Franklin Avenue, and Lake Street station areas. For all station areas except 38th and 46th Street, the degree of land use diversity is greater at the half-mile scale than it is within one quarter-mile of the light rail stop. Both the 38th Street and 46th Street station areas incorporate large single family neighborhoods at the half-mile scale, and this reduces the overall mix of land uses when moving outward from the station.

Figure 3.1: Residential land uses by station area (1/2 mile)

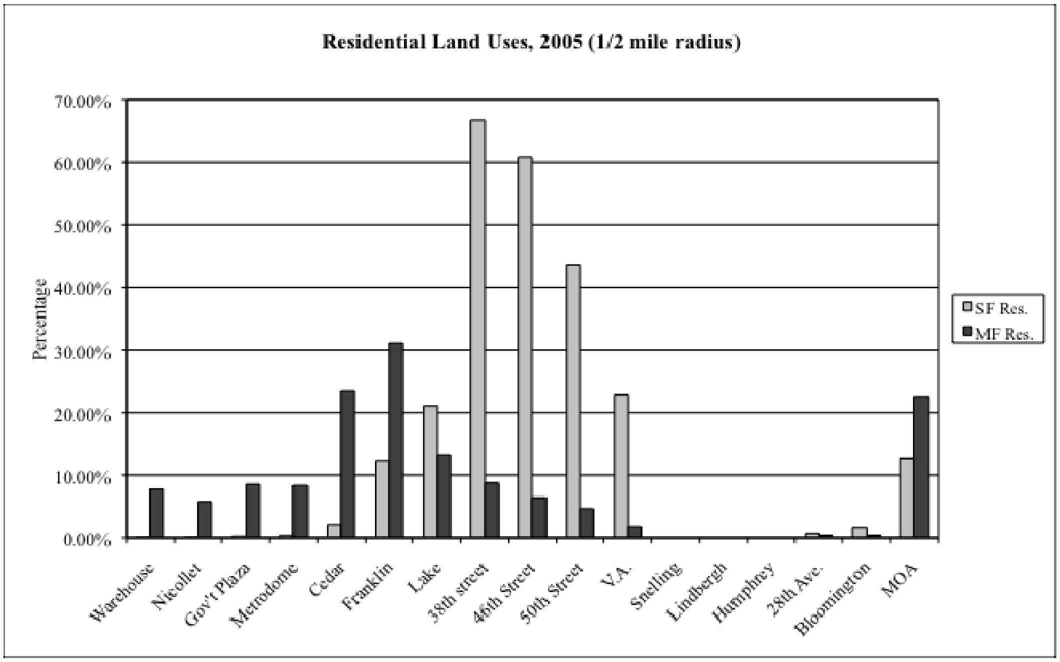


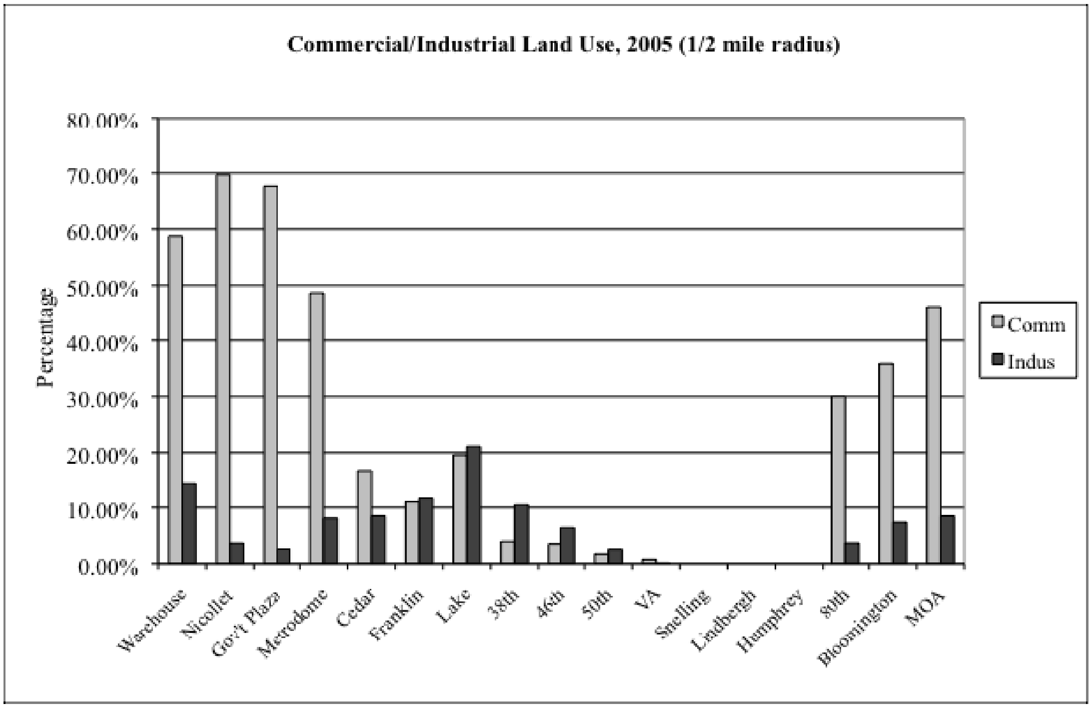
Figure 3.1 shows the prevalence of residential land uses within the station areas in 2005. There is little difference in the pattern whether one defines station areas using a half-mile radius (figure 3.1) or a quarter-mile radius (not shown). The highest prevalence of residential land use is located in the middle segment of the line with little to no residential at the two ends of the line (this is especially true using the quarter-mile radius).

In virtually all cases, the percentage of station area land devoted to residential uses increases when one moves from the quarter-mile to the half-mile scale (the 50th Street station being the only exception).

Figure 3.2 presents the distribution of commercial and industrial land uses within a half-mile radius from the stations for 2005. Commercial land use is heavily concentrated at the two ends of the line. One-half to two thirds of the acreage within a half-mile of the downtown Minneapolis stations are given over to commercial uses, while one-third to one- half of the land at the southern end of the line is commercial. This pattern is repeated at the quarter-mile scale, though the proportion of commercial land is higher at both the Minneapolis and Bloomington nodes.

Generally, there is little industrial land within the stations areas of the Hiawatha Line. Most of the industrial land that exists along the line is located in the neighborhood section of the line. This is, for the most part, the industrial strip that parallels Hiawatha Avenue and the line from Cedar to 46th.

Figure 3.2: Commercial land uses by station area (1/2 mile)



Figures 3.1 and 3.2 confirm that from a land use perspective, there are four distinct segments of the Hiawatha Line. Two of these segments exist at either end of the line, downtown Minneapolis and the Bloomington stops. These stations areas are dominated by commercial development, including office space and retail. In between these two commercial nodes is a stretch of six stops that are characterized by a mix of land uses from Cedar through the Lake Street stations and then residential land uses from 38th through the 50th Street stations. Finally, the stops from the VA station through the airport stations are dominated by institutional land uses and very little if any residential or commercial uses.

Census Housing and Population

As the land use characteristics analysis shows, there are only five station areas with significant residential land uses. The rest of the stations along the line are located in areas with very little housing; the predominant land uses are devoted to commercial or institutional uses. Thus, when attempting to classify station areas according to demographics, we focus on the six stations (located in a continuous alignment in the middle of the line) with significant residential land uses that make up the neighborhood corridor. These station areas are Cedar Riverside, Franklin Avenue, Lake Street, 38th Street, 46th Street, and 50th Street.

Table 3.2 presents the basic housing and population figures for the half-mile station areas within the neighborhood corridor. The large number of housing units and the high population totals for the Cedar-Riverside and Franklin Avenue stations areas reflects the greater number of apartment buildings in those station areas.

Table 3.2: Station area population and housing

Neighborhood Station Area Population and Housing		
Station	Total Population	Total Housing units
Cedar-Riverside	10,741	4,552
Franklin	13,186	5,546
Lake Street	3,179	1,230
38th Street	5,740	2,364
46th Street	3,325	1,516
50th Street	3,839	1,651

Figure 3.3 shows that over 60 percent of the housing units within the Cedar-Riverside and Franklin station areas are in buildings with 20 or more units. The Lake Street station area has a more mixed housing profile, while the 38th Street to 50th Street stations are dominated by single family homes.

Figure 3.3: Units per structure by station area in neighborhood corridor

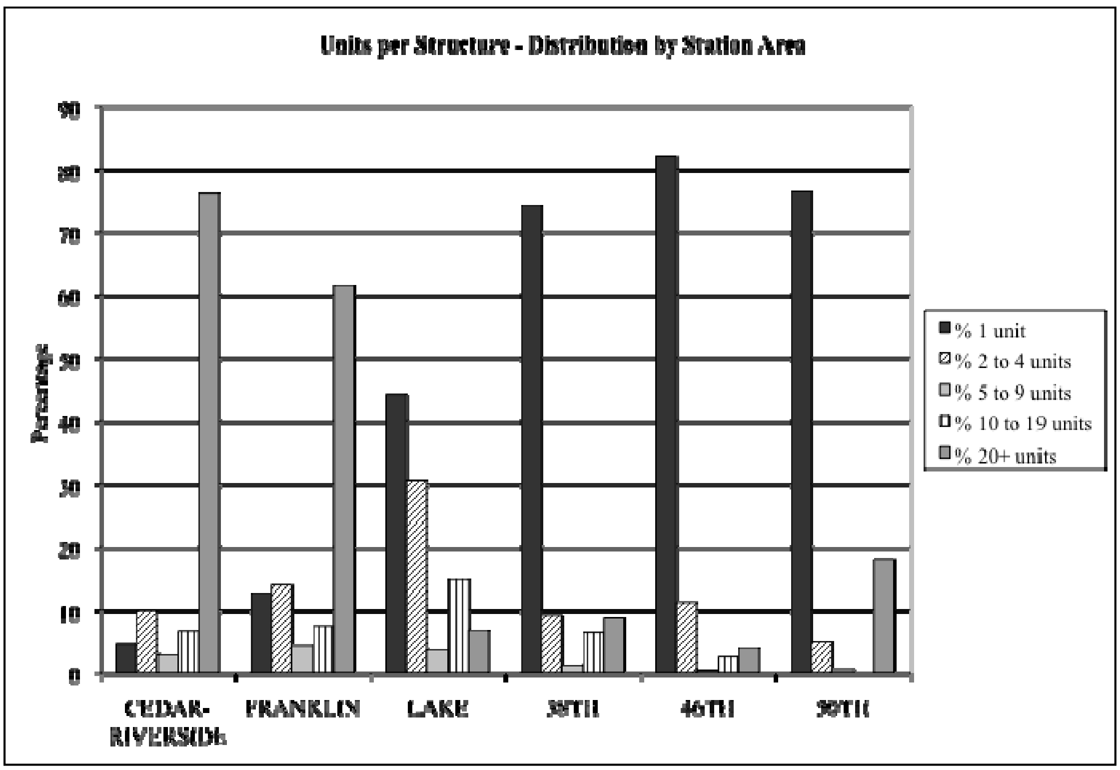


Figure 3.4 shows that the differences in housing stock among stations areas within the neighborhood corridor are echoed by differences in the racial makeup of the population. The station areas in the northern end of the neighborhood corridor (Cedar to Lake) have a much greater level of racial diversity than the three southernmost neighborhood station areas. Less than half of the populations within the Cedar, Franklin and Lake Street station areas are white, compared to more than 60 percent for the 38th Street station area and more than 80 percent for the 46th Street and 50th Street station areas.

Figure 3.4: Racial composition by station area in neighborhood corridor

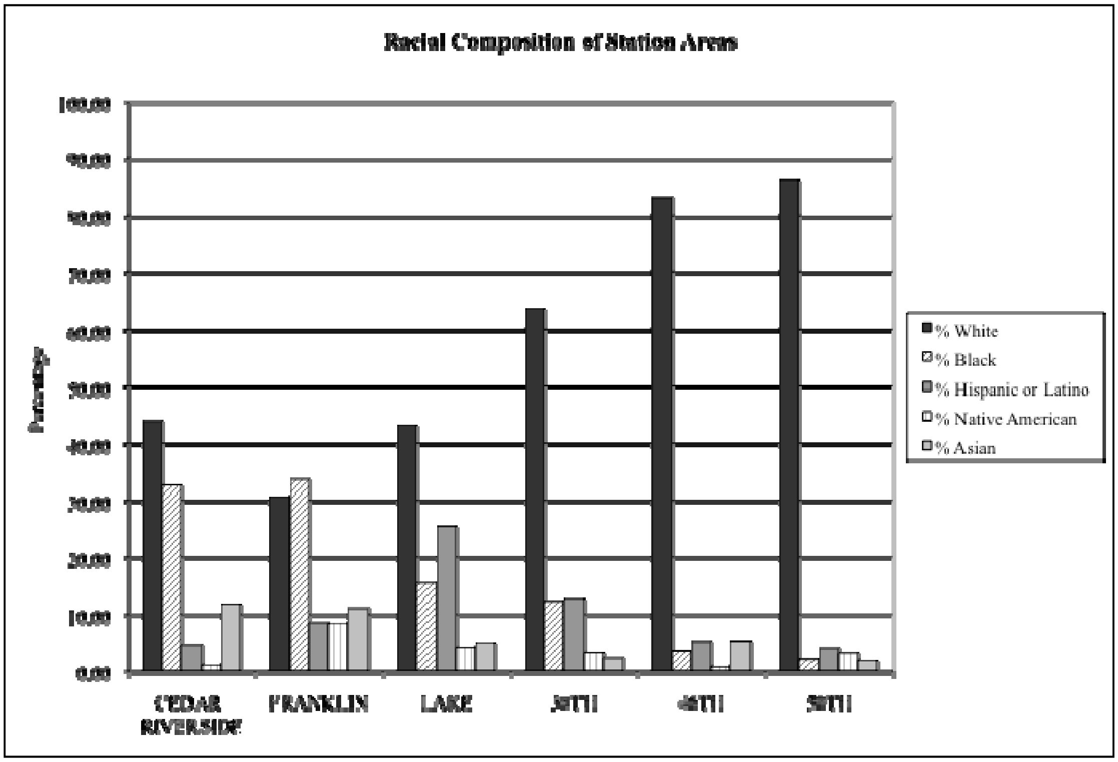
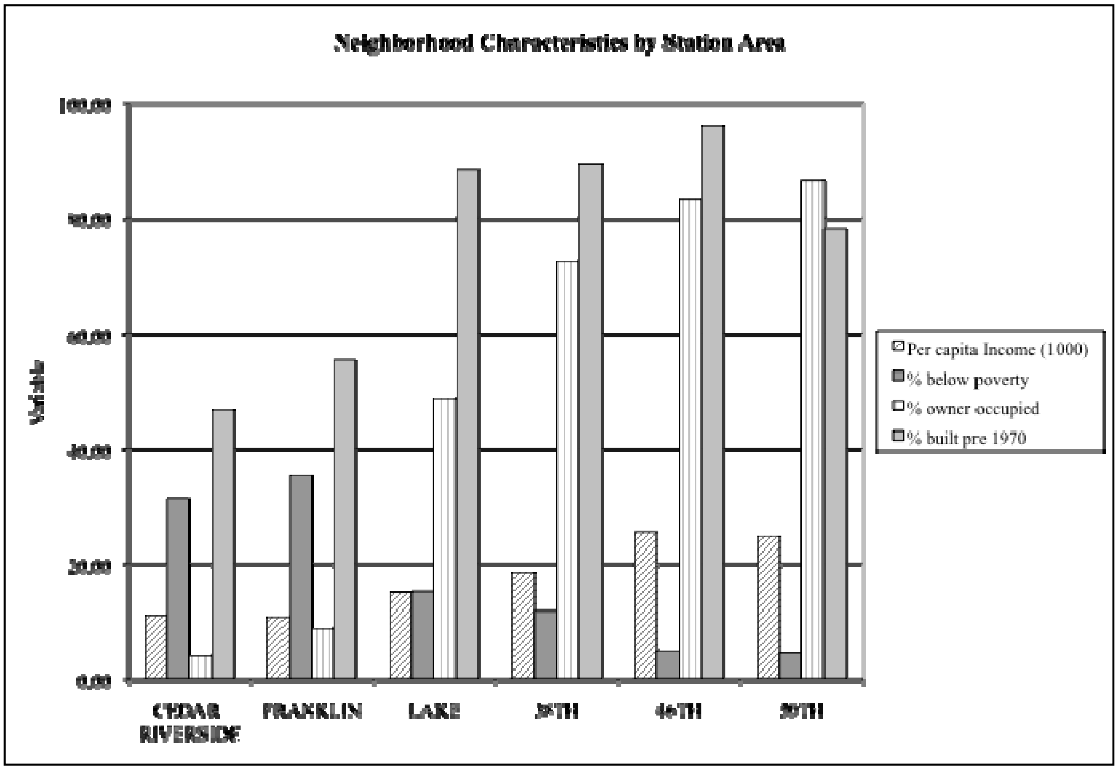


Figure 3.5 shows other differences across station areas within the neighborhood corridor. Per capita income within station areas is higher among the southern station areas, though in this case the Lake Street station is more similar to the southern stations than it is to the Cedar and Franklin stations. The amount of poverty within station areas declines significantly as the line moves south. The Cedar and Franklin areas have much greater poverty rates than the other station areas. Owner-occupied housing is higher within the southern neighborhood stations than it is in the Cedar and Franklin areas, with the Lake Street station area again occupying a middle ground.

Figure 3.5: Neighborhood characteristics by station area in neighborhood corridor

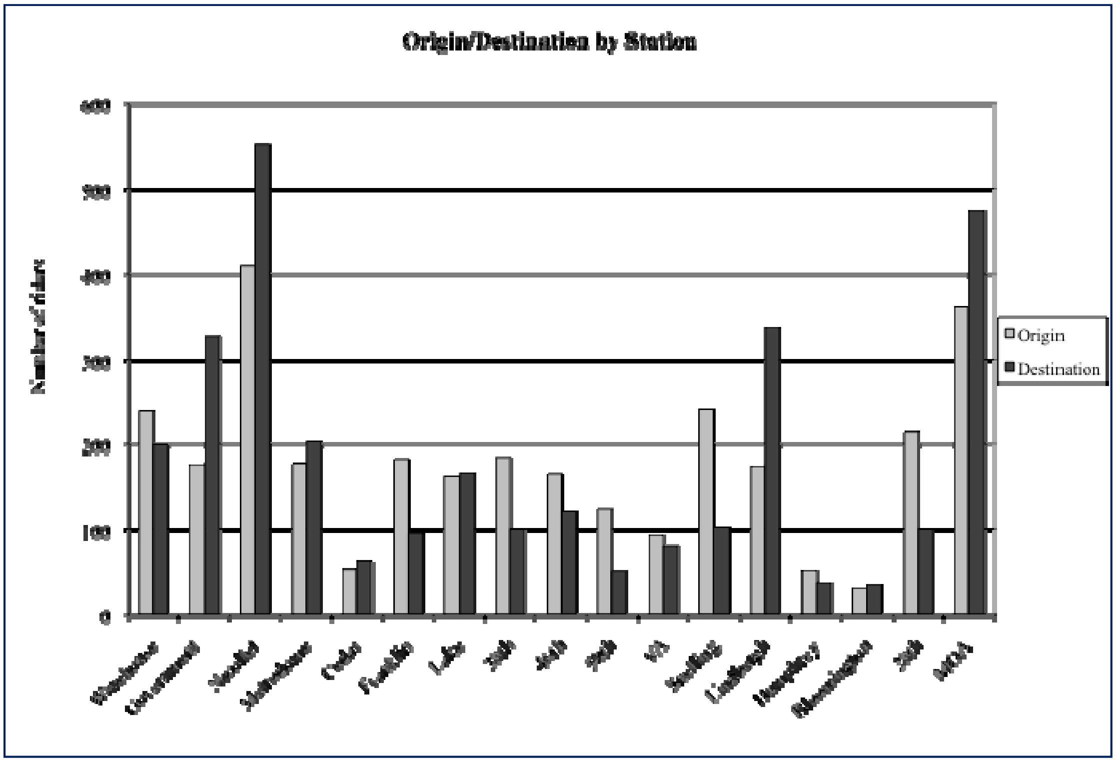


Trip Origin/Destination

Our final analysis of station area differences is an examination of ridership, specifically whether stations are primarily origin or destination stations. In early 2006, the Metropolitan Council conducted the *Transit Rider Travel Survey* (Metropolitan Council, 2006). Surveys were handed out to riders at each transit station in the Twin Cities' area during both peak and off-peak time periods. One of the main goals of the survey was to update the mode choice models that are an integral component of the regional travel forecast model. Consequently, the survey was designed to identify characteristics of the trips being taken by each individual rider. The characteristics include: origin, destination, trip purpose and mode of access.

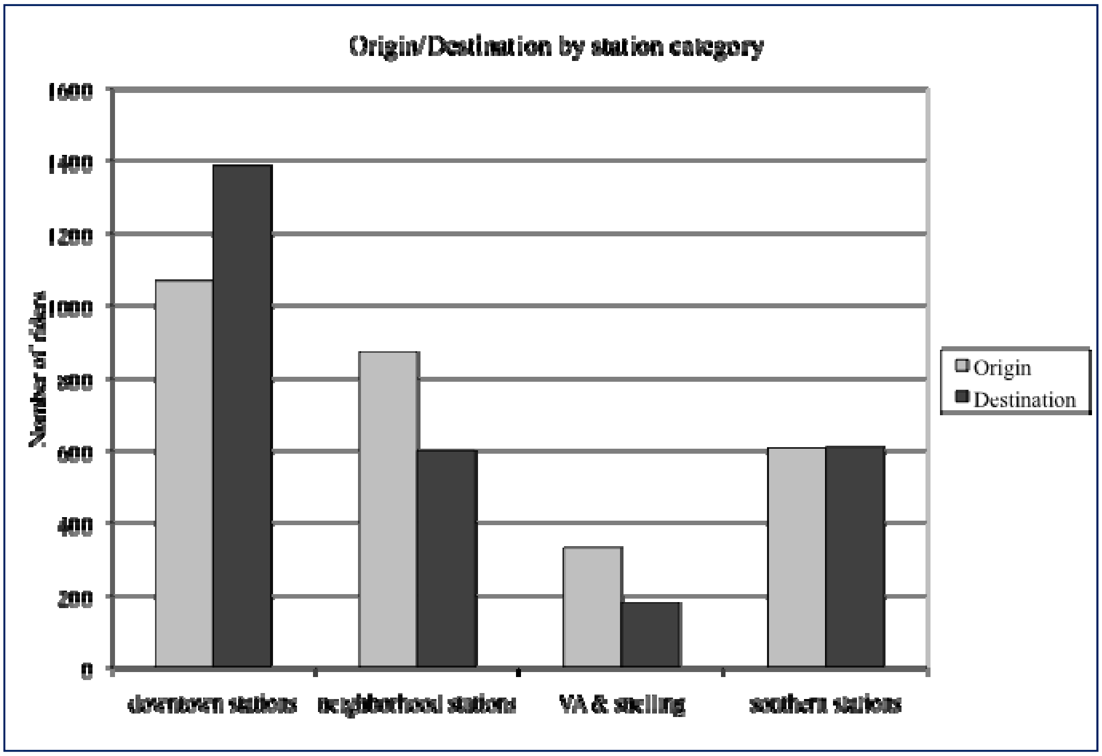
Figure 3.6 presents the data on origin and destinations by station. The first noticeable pattern in the data is that station areas at either end of the line are the busiest. Second, of the nine stations that are significantly more origin than destination, six are located in a stretch in the middle of the line from Franklin Avenue to Fort Snelling. The large destination stations are the Mall of America and the airport on the south, and Government Plaza, the Nicollet Mall, and Metrodome stations to the north. Exceptions to this general pattern are the Warehouse District station in Minneapolis which seems to be serving as an origin station to people living in the growing number of housing units being built in that part of downtown Minneapolis, and the 28th Avenue station in Bloomington which has a park and ride lot and serves as the origin station for many commuters from the south metropolitan area. Indeed, the 28th Avenue station may well fit the Bollinger and Ihlandfeldt "commuter station" category (see discussion on page 14).

Figure 3.6: Trip origins and destinations by station



By aggregating the data into four geographic clusters, we see that the downtown Minneapolis stations are primarily destinations for riders of the Hiawatha Line (see figure 3.7). Those using the stations within the neighborhood corridor more often begin their trip at those stations. The station areas at the south end of the line are more evenly divided, although there is specialization within those station categories.

Figure 3.7: Trip origins and destinations by station category



Summary

Our analysis of the Hiawatha Line station areas has highlighted important differences among stations. In terms of land use, it is possible to identify four types of station areas. At both ends of the line there are station areas with very little residential land and a predominance of commercial land uses. There is little land use mix in these areas as well. From Franklin to 50th Street, the line runs through areas with greater land use mix and much greater levels of residential land use. Finally, there are four stops from the V.A. Hospital through the airport with little or no residential and commercial uses that are dominated instead by hospitals, cemeteries, and airports.

Within the neighborhood corridor that begins at the Cedar-Riverside station and extends through the 50th Street station, there are significant and generally consistent demographic differences between station areas. Per capita incomes decline the farther north one goes within the neighborhood corridor, while poverty and racial diversity increase. The housing stock, too, changes within the neighborhood corridor as one moves northward, going from almost exclusively single-family housing to a housing stock dominated by multifamily apartment buildings in the Cedar and Franklin areas.

The data on how these stations are used by riders also suggests important differences. The downtown stations are typically destinations, while the neighborhood corridor station areas are typically used by riders beginning their journeys. There is an even split between origin and destination uses at the institutional and Bloomington stations.

While it is unclear whether and in what ways the differences among station areas are related to the economic impacts that are the subject of this study, the diversity among station areas suggests at the very least that a careful examination take account of these differences. Because two of our three main research questions relate to housing market effects (the impact of the line of property values in spart 4 and the impact on housing investment in part 5), we focus our analysis in parts 4 and 5 on the station areas within the neighborhood corridor. In our analysis of land use changes (part 6) we examine all of the station areas along the Hiawatha Line.

Part 4. Analysis of Property Values

In this section we examine the effect of proximity to the Hiawatha Line on residential property prices in Minneapolis. First, we analyze home sales over an extended period (10 years) that includes time prior to construction of the line and several years post-construction. Second, because of the alignment of the light rail line in Minneapolis along a highway and industrial corridor, we expect and test for differential impacts east and west of the line. We use a spatial hedonic pricing model that controls for several structural and location aspects of the residential properties in our sample. On the west side of the LRT in particular, we find both an accessibility effect of proximity to stations and a nuisance effect of proximity to the track. Through comparing our treatment area to a control area to adjust for recent fluctuations in the housing markets, we are able to estimate the housing value premiums generated by completion of the line.

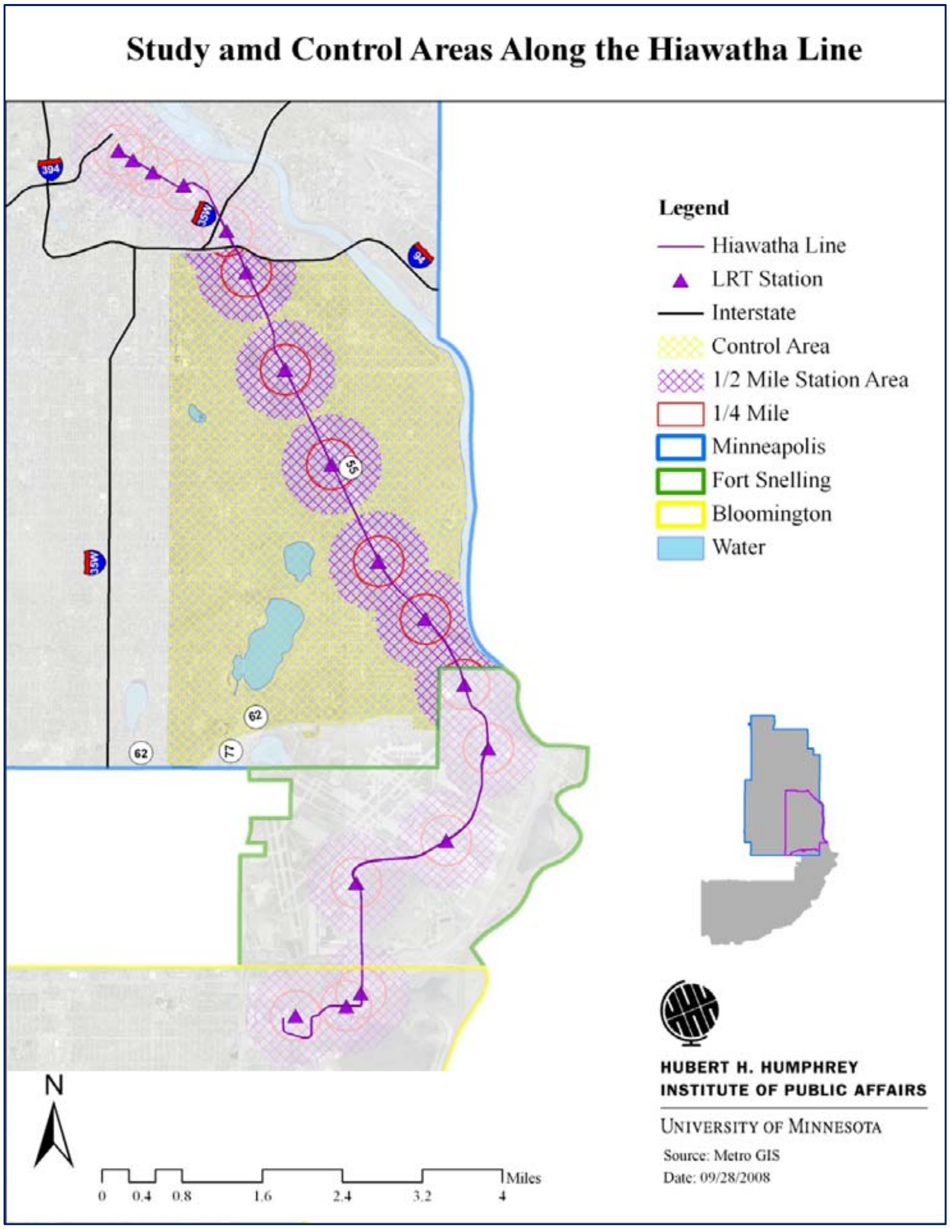
The northernmost stations are located in the downtown Minneapolis area and southernmost stations are located at the Minneapolis-Saint Paul International Airport, the Bloomington corporate center, and the Mall of America. These station areas, at either end of the line are dominated by large-scale commercial development or institutional land uses, with few, if any, residential properties. Furthermore, structure attributes were unavailable for properties outside Minneapolis, thus, these properties are excluded from the analysis. Because the majority of residential properties are located on the mid-section of the line, we focus our attention on the seven station areas that cut through neighborhoods on the southeast side of the city of Minneapolis (see Map 4.1), along Hiawatha Avenue- State Highway 55.

The southeast part of Minneapolis constitutes a separate housing sub-market within the Twin Cities. This area housed Scandinavian immigrant settlers before 1900, and it retains its character as a "working class and lower-middle-class area of modest housing and quiet tastes." The sub-market is a cul-de-sac, dead-ending at the river, the airport, and the Fort Snelling national cemetery. Because of this, argue Adams and Van Drasek, the movement of population out toward the suburbs has been constrained and housing turnover is minimal. Thus, we consider the residential sales activity throughout this sub-market; defined as southeast

Minneapolis from the river on the east to Chicago Avenue on the west, Franklin Avenue to the north and south to the city limits as a type of control area, against which to compare housing premiums within station areas (Map 4.1).

Consistent with the current literature, station areas are defined as land within a one-half mile radius from the LRT stations, each equal to 0.79 square miles (506 acres) in size. However, the spacing of the station areas along the Hiawatha Line is such that in all but three cases, the half-mile station areas overlap each other. In those cases without overlap, there is less than one-quarter mile distance between station areas.

Map 4.1: Study and control areas



Since the Hiawatha LRT line is the first major investment in modern transit infrastructure in Minneapolis, we believe that the work presented here provides the foundation for anticipating and rationalizing the externality generated by the LRT in the Twin Cities area. This study is especially timely given that state and federal funding has been provided for other transitways in conjunction with the Hiawatha LRT line. Furthermore, this study complements and contributes to the limited literature on time- and location-differentiated impacts of the LRT by linking to issues concerning the role of LRT in neighborhood revitalization, real (as opposed to nominal) property value capital gains, and housing affordability. Ultimately, the current research provides a framework for understanding and evaluating the impact of future investment and economic development in any potential transit supportive corridor.

Literature Review

Property Values

Depending on data available, various studies show that Light Rail Transit (LRT) systems can have either positive or negative impact on property value. Intuitively, they should increase property values if they increase riders' accessibility to work and recreation, and the preponderance of evidence indicates that this has happened. However, light rail lines may decrease property values if they generate pollution and induce crime. Accordingly, there have been mixed results about the extent to which LRT systems affect home prices and property values..

The impact of a LRT system on property value has been the largest in St. Louis County, outside of St. Louis City. In Garrett (2004), he distinguishes the nuisance and accessibility effects of LRT system on single-family homes within a one mile radius of the station areas between 1998 and 2001, by measuring distance to track and accessibility respectively. Within a 445 meter radius of the LRT station, he finds that there is a $45.91 per meter decrease away from the station. This means that a property located 100 meters away from the station will have a price premium of $15,837.77 ($45.91 * 444-1000) over one that is located 445 meters away. But between 451 and 701 meters away from the station, home prices actually increase at a rate of $22.80 per meter. Due to relatively small nuisance effect that he finds in the analysis, the author concludes that the accessibility effect of the LRT system outweighs the nuisance effect.

Using mainly census data, Dueker and Bianco (1999) use an *ex post facto* multiple group pretest posttest design. The treatment group used here is the Portland's east-side LRT corridor, and the control group is a parallel bus corridor. In order to measure travel behavior changes in each corridor, census years 1980 and 1990 are used as the pre- and post-periods, with the 1986 opening date of the east-side LRT in the middle as the study's treatment. They estimate that a single-family house that is valued at $82,800 (median price of housing in sample) at an LRT station would decrease in value at $34.80 per meter up to a distance of 122 meters (400 feet) away, at $32.08 per meter up to a distance of 182 meters (600 feet) away, and at $29.01 per meter up to a distance of 244 meter (800 feet) away. Furthermore, they show that zoning land around rail stations for multifamily housing helps to concentrate multifamily housing density, but the effect of LRT alone on multifamily housing development is not strong in and of itself.

Other studies such as Chen et al. (1998) and Al-Mosaind et al. (1993) have also illustrated significant decline in price gradient. Chen et al. (1998) show both the positive accessibility effect (measure by distance to LRT station) and negative nuisance effect (measure by distance to LRT line) in Portland, using prices of single-family homes sold from 1992 to 1994. In particular, they use a 700 meter LRT station radius, as they claim that the standard bus walking distance of 400-500 meter underestimates LRT's attraction. They find that the positive effect dominates the negative effect, which implies that a declining price gradient is produced as one moves away from the LRT stations for several hundred meters. Home prices decrease as distance from the station increases, but they do so at a declining rate. Specifically, at 100 meters away from stations, there is a $32.20 per meter decrease in price for an average price house at $85,724.

Al-Mosaind et al. (1993) is another study of LRT impact on single-family homes in the Portland area. Using sale prices of homes during 1988, two years after the opening of LRT operation, they estimate two models. The first regresses home prices that are within 1000 meters of the stations, with a variable that specifies ones that are within 500 meters. Those within the 500 meter radius command a $4, 324 price premium. In the second model, using a 500 meter boundary of Manhattan distance (also called 'network distance' – the walking distance between two locations), they find that home prices drop at rate of $21.75 per meter away from the station.

The magnitude of the impact of LRT is not always as profound as suggested by the above studies. In a recent study of Buffalo's Metro Rail, Hess and Almeida (2007) use 2002 assessed values for residential properties that are within a half-mile radius of the stations. The authors find that property values increase by approximately $7.58 for every meter closer to the stations. Distinguishing Euclidean and Manhattan distances, they find that straight line distance from the stations is a more significant predictor of property values than walking distance.

Landis et al. (1993) analyze three light-rail systems in California: Sacramento, San Diego, and San Jose using 1990 single-family home sale prices. Of the three systems, the only case with positive results is the San Diego Trolley, with price dropping $2.72 per meter away from the station. The authors argue that even though San Jose's average home prices actually declined with proximity to station (at a rate of $1.97 per meter), the value of the LRT system is underestimated due to the lack of accessibility and land use diversity. Also, they note that since Sacramento's system is less efficient and that its freeways are less congested, it is not surprising that it has no significant impact on property values.

In a study of Portland's LRT line and several other heavy rail lines, Lewis-Workman and Brod (1997) analyze LRT station areas that are one mile apart, using cross sectional data in 1995. In general, they conclude that transit access increases assessed property values as long as properties are within 1.6 kilometer (1 mile) but more than 610 meter (2,000 feet) from the major roadway and transit line. In particular, they find that property values increase by approximately $2.49 for every meter ($0.76 for every foot) closer to light rail within the range of 762 to 1609 meter (2,500 to 5,280 feet) to transit. In addition, holding everything constant, homes 305 meters (1,000 feet) closer to transit are worth about $760 more than other homes. Overall, they acknowledge that there is a smaller property value effect of distance to station in Portland than for BART (in the San Francisco Bay Area) or MTA (in New York City). This is probably the result of lower performance service in Portland and the lower property values generally in the Portland region compared with San Francisco and New York City.

In a detailed study of light, heavy, and commuter rail transit, and bus rapid transit (BRT) in Los Angeles County, Cervero and Duncan (2002a) separately analyze the impact of such transit systems on multi-family housing, condominiums, single-family housing, and commercial property, using Metroscan 2000 data. In particular, they find that single-family homes within a half- mile radius of the Metro LRT Blue Line command a 3.4% premium, which is inferred from $13,351.50 of value-added by the LRT line. As for the Green Line, they find a 1.8% discount. Cervero and Duncan (2002b) replicate the L.A. study in San Diego County, analyzing the impact of light and commuter rail transit using Metroscan 2000 data. They find that the San Diego LRT has very little positive impact on single-family homes. Specifically, only the South Line has a price premium of 0.6%, which is inferred from $6,774.8 of value-added by the LRT line.

Multi-Family Homes and Condominiums

In terms of sales prices of apartments and other multi-family housing units in Los Angeles County, Cervero and Duncan (2002a) find no evidence of significant price premiums or discounts from the presence of the LRT system. According to the same study, they find that condominiums within a half-mile radius of the Blue Line show a 6.2% discount, equivalent to $14,174 value subtracted because of the LRT line. That effect might change with more recent data, as new data would capture the effect of the Blue Line in connection to the revitalization of downtown Long Beach.

As for San Diego County, Cervero and Duncan (2002b) find that overall, residential properties within a 0.5 mi radius of the LRT stations command positive price premiums even though only one LRT line yields significant results. Specifically, multi-family homes and condominiums near the East Line command a 17.3% premium (equivalent to a value-added of $104,827) and a 6.4% premium (equivalent to a value-added of $11,917), respectively.

Cervero and Duncan (2002d) conducted another study with 1999 Metroscan data to analyze the effect of LRT proximity to residential (including rental properties and condominiums) sale prices in Santa Clara County. Parcels within a quarter-mile of the stations command a 9% per square foot premium, which means that given the mean parcel value of $20.30 per square foot, proximity translates to a 45% premium on average.

Hedonic Pricing: Functional Form of Model

In this section we discuss new developments in the hedonic pricing literature within the transit research area. In particular, the body of work we reference here alleviates some of the problems of the traditional hedonic model.

To estimates an implicit price for light rail transit (LRT) and housing attributes, we put home value as a general function *f* of:

$$p_h = f\,(S_i, N_i, L_i, E_i) \qquad \textbf{(4.1)}$$

for

S_i = the set of i structural characteristics
N_i = the set of i neighborhood/environment characteristics
L_i = the set of i location specific characteristics
E_i = the set of i economic characteristics

so that the demand for housing is a function of its structural characteristics, neighborhood, location and economic characteristics of the household. As such, the general pricing formula 4.1 is consistent with consumer demand for a good that is based on income and preferences of the consumers, and the quality of the good. Lancaster (1966) expresses the price of a good as a combination of hedonic (component) prices, each corresponding to the good's characteristics, so that it is equivalent to the consumers' shopping observations when comparing prices among slightly differentiated goods.

If we restrict the function f to be linear, specification returns coefficients that can be interpreted as the implicit marginal/shadow prices of the characteristics of the good. In our case, this simply measures the change in home price, with respective to a one unit change in a particular attribute, equal to $dp_h/df(\cdot)$. But this is rather unrealistic and allows for arbitrage in a sense that the goods are divisible and can be repackaged (Rosen 1974). To allow flexibility by not imposing any functional form, we can use the Box-Cox transformation, starting with:

$$g(p_h, \lambda) = \beta_1 h(\mathrm{X}, \eta) + \frac{\beta_2 h^2(\mathrm{X}, \eta)}{2} + \epsilon \qquad \textbf{(4.2)}$$

where

$g \equiv$ BC transformation $= \begin{cases} \frac{p_h^{\lambda}-1}{\lambda}, \lambda \neq 0 \\ ln\, p_h, \text{o/w} \end{cases}$
$h \equiv$ another BC transformation
$\beta_i \equiv$ vectors of parameters, I = 1,2
$\epsilon \equiv$ error

Note that above quadratic form is a standard Taylor expansion of degree 2. In this way the analysis allows for interaction effects from the explanatory variables. Several studies have compared sales prices of single family homes with both linear semilog ($\lambda = 0, \eta = 1$) and double-log ($\lambda = 0, \eta = 0$) functional form to estimate attributes coefficients, where the linear semilog indicates the percentage change in housing price with respect to a unit change in any of the attributes (this assumes that housing attributes affect home price exponentially, so that the coefficients are calculated as $\frac{d \ln p_h}{df\,(\cdot)}$) and the double-log indicates a percentage change in housing price associated with a percentage change in any of the attributes.

The above pricing models and applications are static, meaning that they do not take spatial or temporal functional interdependence into consideration. Can and Megbolugbe (1997) develop a spatial hedonic model to capture the spillover effects of home sales by introducing a spatially autoregressive (SAR) term as an explanatory variable, using single-family housing transactions for Dade County, Florida data in 1990. This way the prices of the most recent sales of similar properties are considered in estimating the market value of a property, controlling for differences in their structural attributes and neighborhood characteristics. The influence of prior sales is hypothesized as an inverse function of distance: the lesser the distance between a prior sale and the property of question, the more influence that prior sale will have. In comparing the SAR result to traditional hedonic regression, they find that the explanatory power of the model increases by at least 14%. Following Can and Megbolugbe (1997), Haider and Miller (2000) apply the above SAR technique in their analysis, but they first use Moran’s I autocorrelation statistics to establish the existence of spatial autocorrelation. Using freehold property in Greater Toronto Area sold in 1995, they assume that housing values are not correlated if separated by a distance greater than 2 kilometers (=1.24 miles) or if sales are more than 6 months apart (an arbitrary length of time). When comparing the explanatory powers of the models, they find that the SAR model improves the non-spatial model by about 5.3%.

In order to allow for household and spatial heterogeneity, Hess and Almeida (2007) conduct a study of the impact of the LRT system by differentiating census track income groups and location (separated by LRT track and by station). They then are able to group the stations with significant results into three groups based on median household income, from which they conclude that proximity to LRT stations has a positive impact on property values in higher income station areas, whereas it has negative impact in lower income areas. Also, the authors separate impact of the location and the proximity of the stations (using Euclidean and Manhattan distance respectively).

Studies such as Chen et al. (1998), Al-Mosaind et al. (1993), Weinberger (2001), and Cervero and Duncan (2002c) use dummy variables to indicate distance to LRT stations (see also, Cervero and Duncan, 2002a; 2002b; and, 2002d). Chen et al. (1998) omit the results from a preliminary regression that incorporates a dummy variable to separate those observations within and beyond 700 meters (=0.435 mile) of an LRT station, as the dummy turn out to be statistically insignificant. For the regression using only observations within 700 meters of an LRT station, two additional variables are used to separate the accessibility effect and the nuisance effect, the straight-line distance between each house and its closest station and the shortest distance between each house and the line. Similarly, Al-Mosaind et al. (1993) find that all housing attributes are significant when a dummy that distinguishes homes within and beyond 500 meters is used.

In term of nonresidential values, Weinberger (2001) studies the relationship between commercial office rental rates and sales prices, and proximity to LRT in Santa Clara

County, CA. Using lease transaction data from 1984 to 2000, he finds that the highest premium is found for properties that are within 0.4 kilometer (0.25 mile) of the LRT stations. Beyond the 0.8-kilometer (0.5-mile) boundary (which is roughly an upper limit on a comfortable walking distance), he finds no statistical relationship between the distance from transit stations and the rents for those properties. Cervero and Duncan (2002c) conduct a similar study using Metroscan 1998-1999 data and find that within a 0.25 mile radius of LRT station, commercial properties command an average price premium of about $19 more per square foot.

Analysis

Methodology and Data

The data set used in our residential property analysis includes parcel data from MetroGIS and structural data from the City of Minneapolis. Typically, the estimation of a hedonic pricing model is straightforward, as defined earlier by equation 4.1. The robustness of the model then depends on the number of observations available, the quality of the data, and the exogenous variables available, so that the specification of the model is determined after we examine the raw data. The parcel data and structural data were joined in ArcMap 9.2 (ESRI), analyzed for distance parameters, and all monetary values were adjusted to constant year 2000 dollars.

Table 4.1 displays the number of observations available for analysis. For the purpose of this table only, we regard any parcel as “Residential” if its land use has been residential at any given point in the land use description (available from 2005-2007). Consequently, the actual number of observations we use in our analysis may be lower as this depends on whether or not a parcel is residential when it is sold. This means that we have to assume that given a structure’s age has not changed. If its age is less than that given by subtraction of the sale date from 2007, and if its land use has not changed from 2005-2007, then its land use is that which is listed in the 2007 data set. Given that we are only studying parcels that are sold recently, there is a high probability that land use has not changed significantly over such short period of time. Also, we focus on properties that are sold for more than $1 and have all relevant structural information. Lastly, we take repeat sales into account and distinguish the data between single-family homes from multifamily homes. Taking all data inconsistencies into account, the number of observation we end up using is dramatically different than what is available (see descriptive statistics below).

Since the impact of proximity to the LRT pre- and post-completion is our research focus, we only include properties that were sold between 1997 and 2007. Also, we distinguish the treatment area of our study, the station area, from the control area, the sub-market. But as our study area overlaps the Minneapolis-St. Paul International Airport, it is impossible for us to separate nuisances related to noise generated by the LRT and the airport. A four-lane highway and the adjacent industrial corridor parallel to the Hiawatha LRT line add an additional and more prominent complicating spatial factor to our analysis. Together the Highway 55 (Hiawatha Avenue) and industrial land uses create a minimum separation of 194 meters between the station platforms and the nearest residential properties on the east side. Residential properties on the west side of the track are directly adjacent to the light rail tracks and stations without significant spatial separation. In some cases the closest single-family residences west of the Hiawatha Line are only 20 meters from light rail tracks compared to 194 meters on the east.

Table 4.1: Residential transactions in the study area, 1997-2007

Hiawatha Area Residential Sales Volume					
Residential Data	**Total**	**Sold***	**Sold After 1997****	**Sold After 2001**	**Sold After 2004**
Sub Market	28167	18808	13674	10029	6193
Hiawatha East	8915	5693	3946	2825	1417
Hiawatha West	19252	13115	9728	7204	4479
Station Area	6750	4396	3269	2413	1479
Station Region – I	64	20	17	13	7
Station Region - II	1505	947	731	547	330
Station Region - III	5181	3429	2521	1853	1142

* This is the number of parcel with non-zero sale year and sale price greater than $1, and it does not include any double-counting. For example, a parcel sold in 2000 and 2003 will only be counted once.
** This is the number of parcels sold in 1997 and after and it does not include any double-counting.

Given that the highway and industrial barriers may significantly diminish any positive accessibility effects that might be generated by proximity to the LRT stations, we expect to find a significant nuisance effect of proximity to the highway and the industrial corridor both prior to and after construction of the LRT line. Thus, in the analysis to follow, we estimate separate effects for properties east and west of the Hiawatha LRT, as well as for pre and post opening of the line.

Following the general functional form of equation 4.1, we have:

$$\begin{aligned} \text{sale val}_i = \quad & \beta_0 = \beta_1 \text{ year built} + \beta_2 \text{ lot size} + \beta_3 \text{ gross buil} \\ & + \beta_4 \text{ total bath} + \beta_5 \text{ total bedr} + \beta_6 \text{ home} + \beta_7 \text{ post 04} \\ & + \beta_8 \cdot W \cdot \text{coms} + \beta_9 \text{ dist to st} + \beta_{10} \text{ dist to track} \\ & + \beta_{11} \text{ dist to cbd} + \beta_{12} \text{ wst hiwtha} \\ & + \alpha o \ (S_i \ x \ L_i) + \epsilon \end{aligned}$$

where the set of β and α are coefficients, and ε is the error term. With slight abuse of matrix notion, the operator specifies the element-wise multiplication. In particular, the set of structural variables S_i in equation 4.3 includes the structure's year built (*yr blt*), total land area squared footage (*lot size*), total building area (*gross buil*), number of bathrooms (*total bath*), number of bedrooms (*total bedr*), homestead status (*home*), and a dummy for the property being sold after 2004 (*post 04*). The set of location variables used, [illegible], includes comparable sales of properties sold within the past four months and are within 0.75 miles radius to a particular property (*coms*), distance to closest LRT station in meters (*dist to st*), distance to LRT track (*dist to track*), distance to central business district (*dist to cbd*), and a dummy for the property located on the west side of Hiawatha (*wst hiwtha*). The matrix *W* is the set of weighted distances of comparable sales and β_8 is the spatial correlation coefficient, as defined in Can and Megbologbe (1997). In addition, we include quadratic distance terms as well as their interactions with the dummy variables to increase flexibility of the model. All distance measures are in terms of the Euclidean metric.

In this setup, the accessibility effect of the LRT stations is captured by all the *dist to st* terms, while the nuisance effect of the LRT track is captured by all the *dist to track* terms. A more precise measure of accessibility would be a calculation of Manhattan distance (or walking distance using the street network) rather than straight-line distance. Calculation of Manhattan distance was not possible in this study. Therefore we acknowledge that the accessibility effect of the LRT stations is subjected to unobservable measurement error, in the same way that we cannot observe certain housing attributes such as view and building quality.

Using comparable sales as an exogenous variable creates an endogeneity problem in the model and therefore a maximum likelihood estimator (MLE) is used. To provide the iteration with an initial coefficient vector, we perform iterated feasible general least square (FGLS) for the sub-market and fixed effect general least square (GLS) for the station area. The purpose of using these methods instead of ordinary least square is to mitigate the effects of heteroskedasticity in the error structure. In the GLS estimation, we impose group heterogeneity of the stations that are captured by constant terms instead of pooling together the observations. Due to the small size of the sample, instead of a by-station fixed effect analysis, we perform a station-region fixed effect analysis. The first region is Downtown, the second is Cedar-Riverside Station to Lake Street Station, and the last is 38th Street to VA Station. The reason for this division is based primarily on land use and demographic composition. The downtown station areas contain very few residential properties and are instead dominated by large commercial office-space properties. The three station areas from Cedar-Riverside to Lake Street have more residential properties, but contain a wide mix of land uses, housing tenures, ethnic/racial demographics, and income. The stations areas from 38th to the VA station are more homogeneously single-family residential, middle-income, and white.

We test several variations of the model above. First we include time fixed effect dummies for sale year, and find that source estimates for structural attributes yield “incorrect signs”. This is true for both sub-market and station area data. Secondly we shifted the 2004 time dummy to 2000, the year during which the Hiawatha Line construction was announced. The difference in the resulting estimates, when compared to our original model formulation, is insignificant. Lastly we test the alternative of using a random effect model for the station area data, and find that individual station regions fixed effects are correlated with the other regressors. As a result, we use a fixed effect model for the first stage initial estimation for the station area.

Analysis of Single Family Homes

We first report the findings using the entire submarket to provide a benchmark for comparing the findings from the station areas. Our initial focus is on single-family homes.

Descriptive Statistics for Sub-Market

Table 4.2 summarizes the sales data we use in the analysis. There are 14,943 sales in the sub-market between 1997-2007, 4405 are from the region east of Hiawatha Avenue and 10538 are from the western region. Thus, we expect that the results of the sub-market analysis would be dominated by the results from the west. In general, home prices in our control area are about 13% lower than the overall city average of $175,632 while the properties are about 6.5% smaller in gross building square footage and 10% smaller in terms of lot size. Home prices on the east and west sides of Hiawatha are 13% and 13.5% lower than the city average respectively.

Table 4.2: Summary of home sales, 1997-2007

Single Family Home Sales Characteristics - 1997 to 2007								
	Minneapolis (49312 Sales)		Sub Market (14943 Sales)		East Hiawatha Sub Market (4405 Sales)		West Hiawatha Sub Market (10538 Sales)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sale Value	175632	131536.70	152971	55887.24	152193	60583.66	151988	53895.20
Sale Year	2002	2.92	2002	2.94	2002	3.00	2002	2.92
Year Built	1928	20.52	1928	17.30	1922	15.01	1930	17.68
Lot Size	5835	1786.06	5543	1231.88	5616	1459.12	5514	1127.07
Square Feet	1292	549.39	1158	351.40	1141	393.82	1165	332.71
Homestead	87.8%	0.33	91.9%	0.27	92.8%	0.26	91.5%	0.28

The timing of sales also has significant impact on the prices. For those homes that are sold prior to 2004, prices are 20% lower than the city average while those sold after are only 1.7% lower. More specifically, on the east side of Hiawatha, homes sold before 2004 are 20.6% lower than city average while those sold after are only 0.48% lower. The averages on the west side are similar to those of the city.

Results

For the initial estimates, we test the ordinary least squares (OLS) estimates (not displayed here) of this study area for heteroskedasticity and multicollinearity using Breusch-Pagan's and Cameron-Trivedi's tests, and variance inflation factors (VIF) respectively. Such problems of OLS are indeed present, meaning that the robustness of our model should increase with a different functional form, as well as by removing some dummy interaction terms. But in order to allow intuitive interpretation of the marginal effects of the estimates, we keep all our exogenous variables and estimate the model with FGLS rather than using a Box-Cox transformation. The resulting maximum likelihood (ML) estimates are displayed in Table 4.3.

Table 4.3: **Maximum likelihood regression model of single-family home sales in the sub-market**

ML Parameter Estimates
Sub-Market Single Family Homes

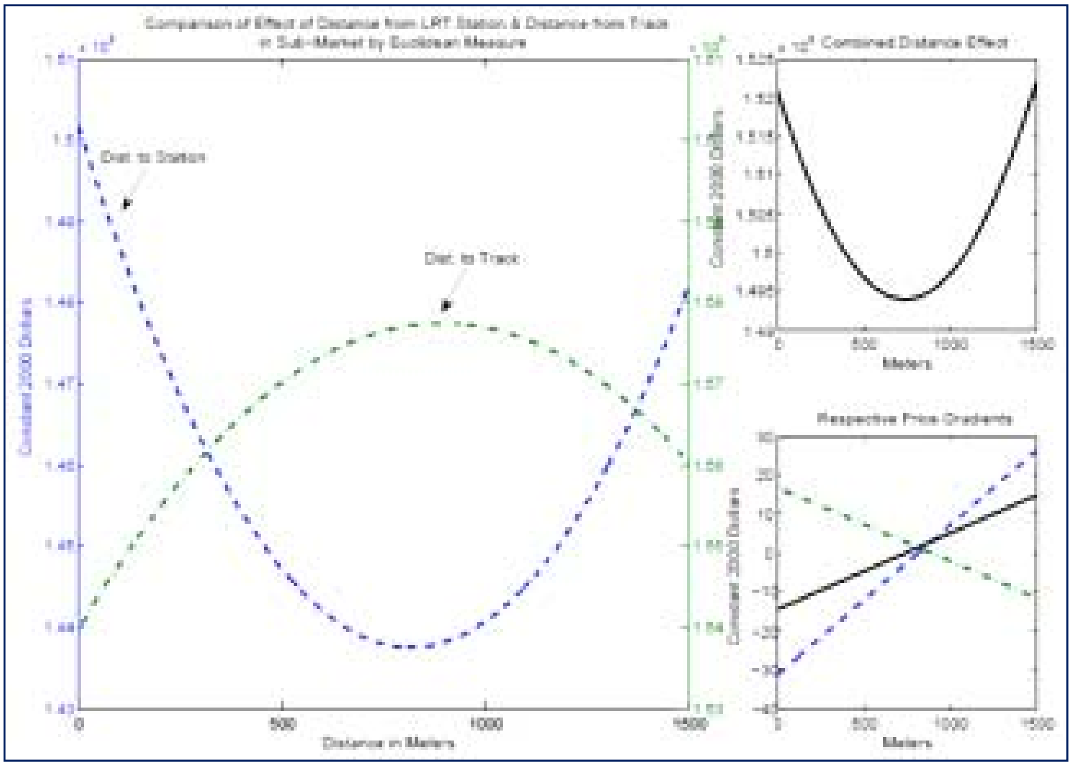
Variable	Coef.	Std. Err.	z
weights	0.5935043	0.0102455	57.53*
year_blt	255.9754	19.23671	13.31*
lot_size	4.650835	0.250831	18.54*
gross_buil	55.72911	1.153843	48.3*
total_bedr	1366.975	417.3267	3.28*
total_bath	9512.967	542.849	17.52*
home	15234.18	1058.771	14.39*
dist_to_st	-33.70275	12.84068	-2.62*
dist_to_st_2	0.0192617	0.0064561	2.98*
dist_to_tr~k	11.16629	9.9377	1.12
dist_to_tr~2	-0.0041958	0.0057572	-0.73
dist_2_cbd	2.63469	0.2034083	12.55*
wst_hiwtha	-9276.409	3849.129	-2.41*
wst_trk	-1.603732	10.52565	-0.15
wst_trk_2	-0.0023119	0.0060882	-0.38
wst_st	23.74589	13.44709	1.77
wst_st_2	-0.0124509	0.0067664	-1.84
post_04	20755.93	2714.356	7.65*
trk_04	-4.471223	8.544113	-0.52
trk2_04	0.0031223	0.0048839	0.64
st_04	3.564486	10.37166	0.34
st2_04	-0.002534	0.0051797	-0.49
constant	-569896.3	36446.09	-15.64*

Number of obs = 14943
Wald Chi(22)= 21369.25
Prob > chi2 = 0.0000
* Significant at 5% level

The estimated structural coefficients here are all statistically significant with plausible magnitudes and the hypothesized signs. This means that our results are consistent with household preferences since the coefficients measure household's marginal willingness to pay for the corresponding housing attributes. Note that most of the variables added for curvature and interactions are not statistically significant. This insignificance is as expected because those terms are only included in the model to improve the explanatory power of other exogenous variables, they provide very little information on the impact of the LRT since we anticipate it to diminish outside the station area.

The effects of proximity to LRT station and track (evaluated at means of all the exogenous variables using above estimates) are displayed in Figure 4.1 to substantiate our hypotheses of the impact of LRT. Specifically, home prices are graphed as functions of distances, holding all other exogenous variables at their mean values. The positive price gradient (which is equivalent to negative rate of change in home prices or negative marginal effect of distance) of the accessibility effect extends to about 800 meters away from the station, while the nuisance effect persists 100 meters longer.

Figure 4.1: Accessibility and nuisance effects in the sub-market



This finding supports our choice of the size of our treatment area, since the impact of the LRT line dissipates after 800 meters away from the stations and the track. From the graphs of the respective price gradients (derivatives of the home price functions) we see that the accessibility effect of the LRT stations starts at around $30 per meter while the nuisance effect of the LRT track starts at $-16 per meter. As it turns out, the marginal benefits and marginal costs of proximity of the LRT line do not deviate much from these rates.

The effects of proximity to LRT station and track on properties sold after 2004 are displayed in Figure 4.2. The nuisance effect of the LRT track here has lowered after LRT (from -$20 to -$10), as compared to prior (displayed in Figure 4.3), possibly because the LRT line acts as a buffer for properties on the west side from the Hiawatha industrial corridor.

Figure 4.2: Accessibility and nuisance effects in the sub-market, post 2004

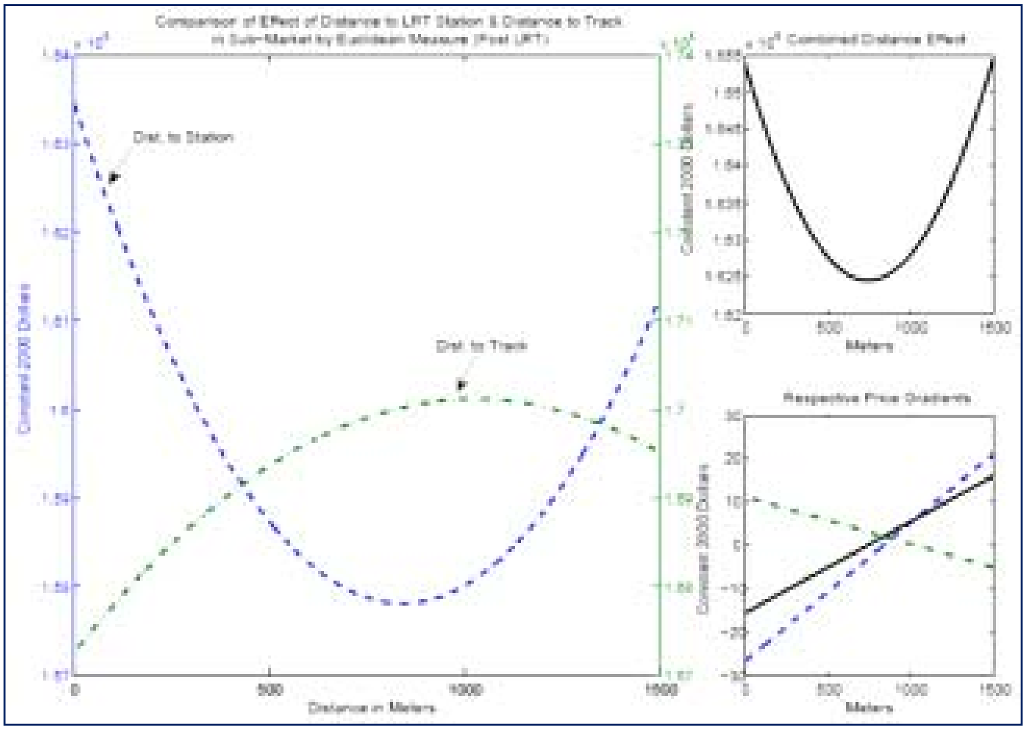
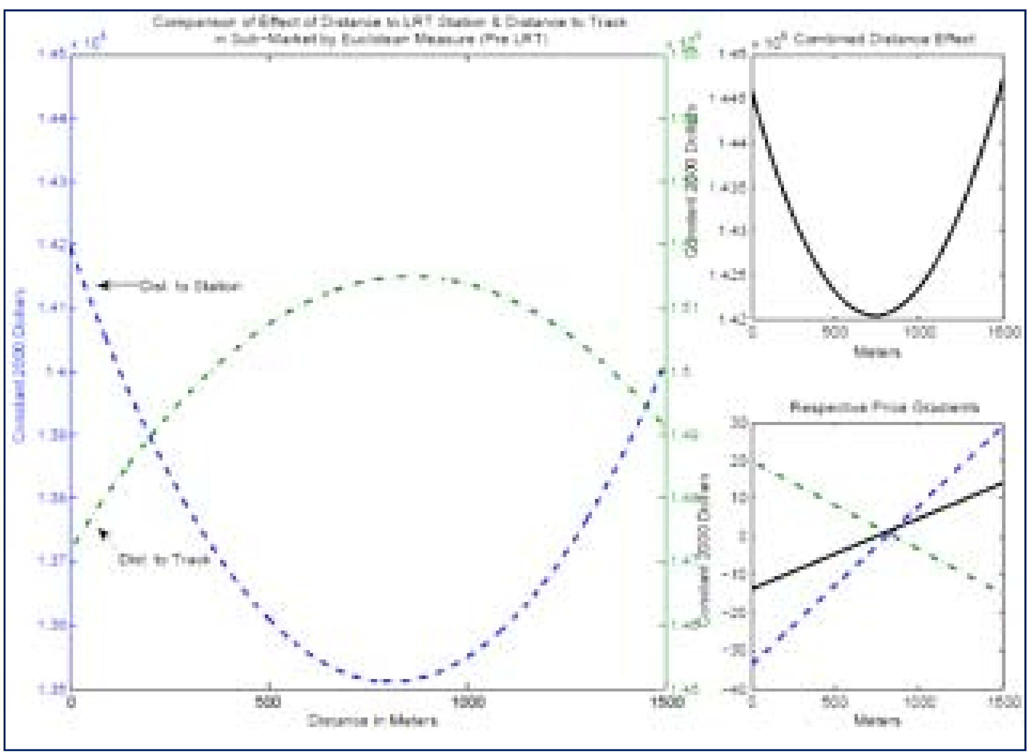


Figure 4.3: Accessibility and nuisance effects in the sub-market, pre 2004



Descriptive Statistics for Station Area

To provide more meaningful estimates and more robust inferences for the impact of proximity to the LRT line, we now focus on properties within the half-mile radius station areas. A summary of the data is reported in Table 4.4. In the station area, there are only 3514 sales and 2424 are from the west side. Here, homes are about 8.9% lower in value than in the sub-market while being about 5.5% smaller in terms of squared footage. Home prices on the east and west sides of Hiawatha are 7.9% and 9.3% lower than the sub-market average respectively.

Table 4.4: Single family home sales within station areas, 1997-2007

Single Family Home Sales Characteristics - 1997 to 2007						
	1/2 Mile Station Area (3514 Sales)		East Hiawatha 1/2 Mile Station Area (1090 Sales)		West Hiawatha 1/2 Mile Station Area (2424 Sales)	
	Mean	Std. Dev.	Mean	Std.Dev.	Mean	Std. Dev.
Sale Value	138492	45230.83	139914	51556.54	137853	42051.99
Sale Year	2002	2.91	2002	2.92	2002	2.91
Year Built	1925	16.88	1921	15.44	1926	17.24
Lot Size	5568	1221.14	5595	1332.19	5556	1167.87
Square Feet	1088	349.62	1107	393.95	1079	327.46
Homestead	90.9%	0.29	91.3%	0.28	90.7%	0.29

Also relevant here is the timing of sales. For those homes that are sold prior to 2004, prices are 16.4% lower than the sub-market average while those sold after are 4.2% higher. More specifically, on the east side of Hiawatha, homes sold before 2004 are 15.9% lower than sub-market average while those sold after are 5.2% higher. Again, due to the number of observations on the west, the averages on the west side are similar to those of the sub-market.

Results for Station Area

We initialize our analysis for this study area by exploiting the panel structure of our data using GLS, in order to eliminate the problem of groupwise heteroskedasticity that arises from neighborhood heterogeneity (see Table 4.5).

All the structural coefficients are again statistically significant, with plausible magnitudes and the anticipated signs. Since these are the estimates for the station area, some of the distance-location-time interaction terms have become significant, adding to the explanatory power of the model. Comparing the coefficients for the post LRT dummy, the realized housing premium is **$5229 per home**, which then translate to about **$18,374,284** (this is the difference between the station area and the sub-market coefficients *post_04*, multiplied by the number of observations sold in the station area) for the entire area. Accordingly, the perceived housing premium is **$29,422,908**, when we take all single-family housing units into account.

Table 4.5: Maximum likelihood model for single family home sales within station areas

ML Parameter Estimates

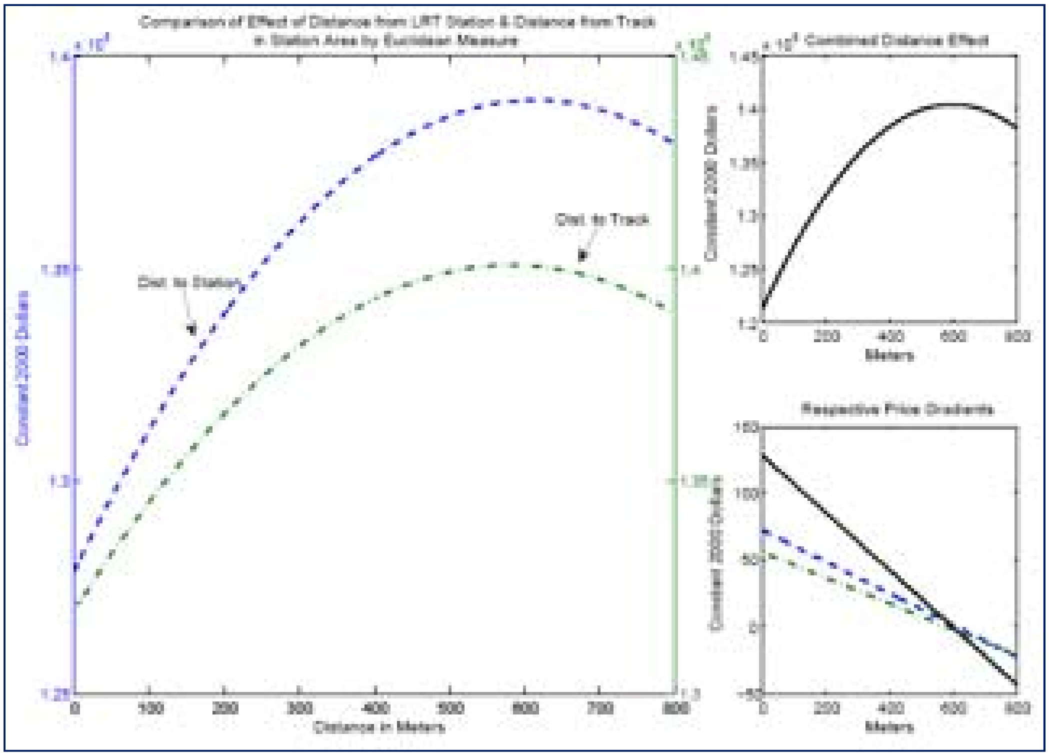
Station Area Single Family Homes

Variable	Coef.	Std. Err.	z
weights	0.5352484	0.0196714	27.21*
year_blt	308.9175	33.34414	9.26*
lot_size	.618245	0.4483795	3.61*
gross_buil	38.72193	2.108739	18.36*
total_bedr	3724.168	785.0668	4.74*
total_bath	8297.783	1040.579	7.97*
home	.4457	1812.944	7.97*
dist_to_st	214.2122	53.36338	4.01*
dist_to_st_2	-0.1656413	0.0476348	-3.48*
dist_to_tr~k	20.68746	31.95794	0.65
dist_to_tr~2	-0.0118954	0.035042	-0.34
dist_2_cbd	.988319	0.320526	6.2*
wst_hiwtha	74627.18	13293.44	5.61*
wst_trk	36.90982	33.64298	1.1
wst_trk_2	-0.0506211	0.0373303	-1.36
wst_st	-282.7826	55.68533	-5.08*
wst_st_2	0.2322198	0.050406	4.61*
post_04	25984.81	10252.37	2.53*
trk_04	-49.7517	26.78909	-1.86
trk2_04	0.0623913	0.0316449	1.97*
st_04	46.24097	44.36946	1.04
st2_04	-0.0654558	0.0419402	-1.56
constant	-706454.5	64664.13	-10.92*

Number of obs = 3514
Wald Chi(22)= 3361.75
Prob > chi2 = 0.0000
* Significant at 5% level
Wald chi2(21) = 2182.21
Prob > chi2 = 0.0000
Log likelihood = -41622.75

In the second model we present here distinguishes properties east and west of Hiawatha and pre- and post-2004. We observe that the negative externality of the industrial corridor in this treatment area is overwhelming: the further a property is away from Hiawatha 55, the higher priced it is. On average, the cost of the negative accessibility effect starts at $75 each meter away from the stations and the nuisance effect costs around $50 per meter away from the track (Figure 4.4).

Figure 4.4: Accessibility and nuisance effects in station areas



Our full model, however, is one that examines property values before and after construction of the line, and separates the effects west of the line from those that take place east. Figures 4.5 and 4.6 present the finding for properties east of Hiawatha after construction of the line (4.5) and before (4.6).

We hypothesized that the results on the east side of Hiawatha might be overwhelmed by the negative externality generated by the industrial corridor. The analysis shows that this is indeed the case. From Figure 4.5 and Figure 4.6, we observe that the opening of the LRT line has had no impact on the residential properties to the east of Hiawatha. There is a decline in values as one approaches the line, both pre and post 2004.

Figure 4.5: Accessibility and nuisance effects in station areas east of Hiawatha, post 2004

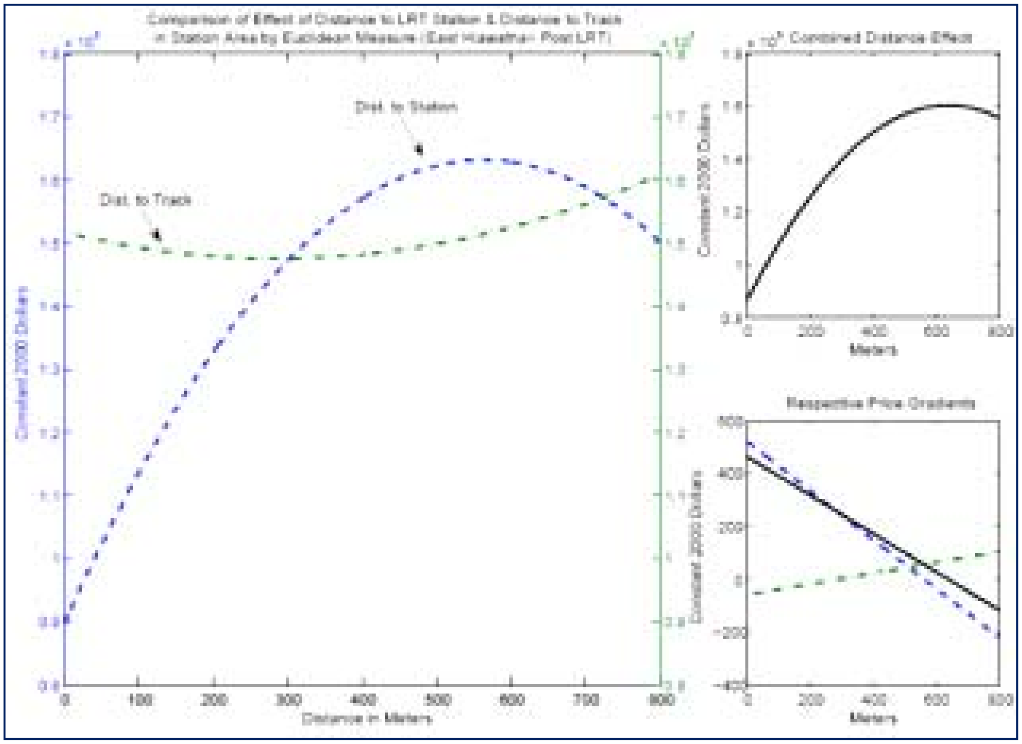
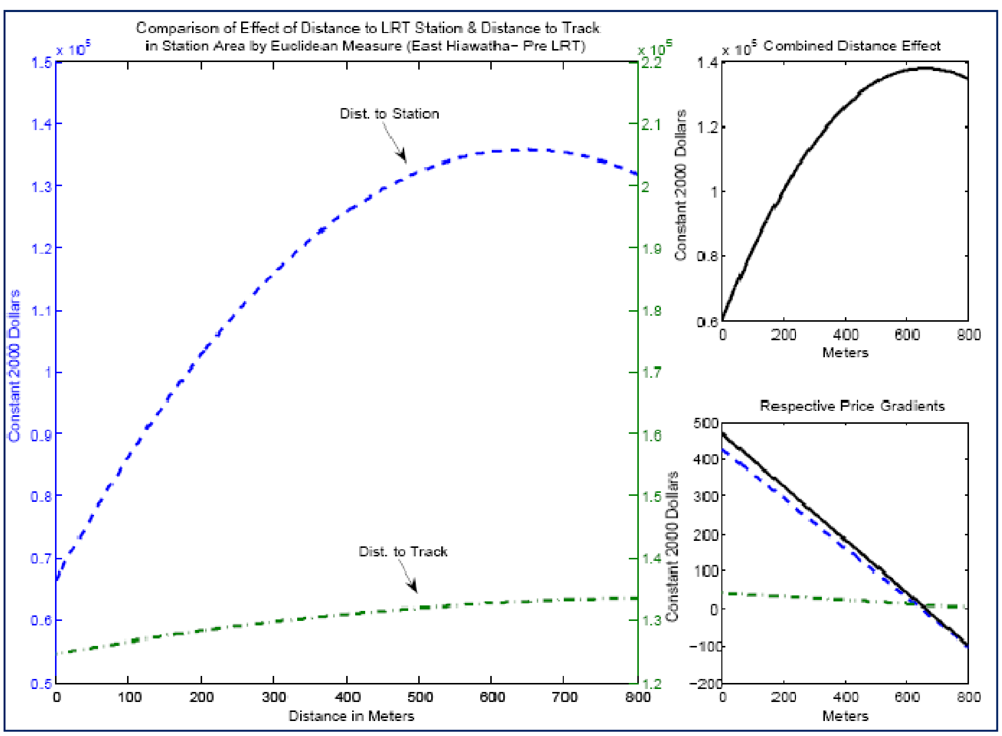
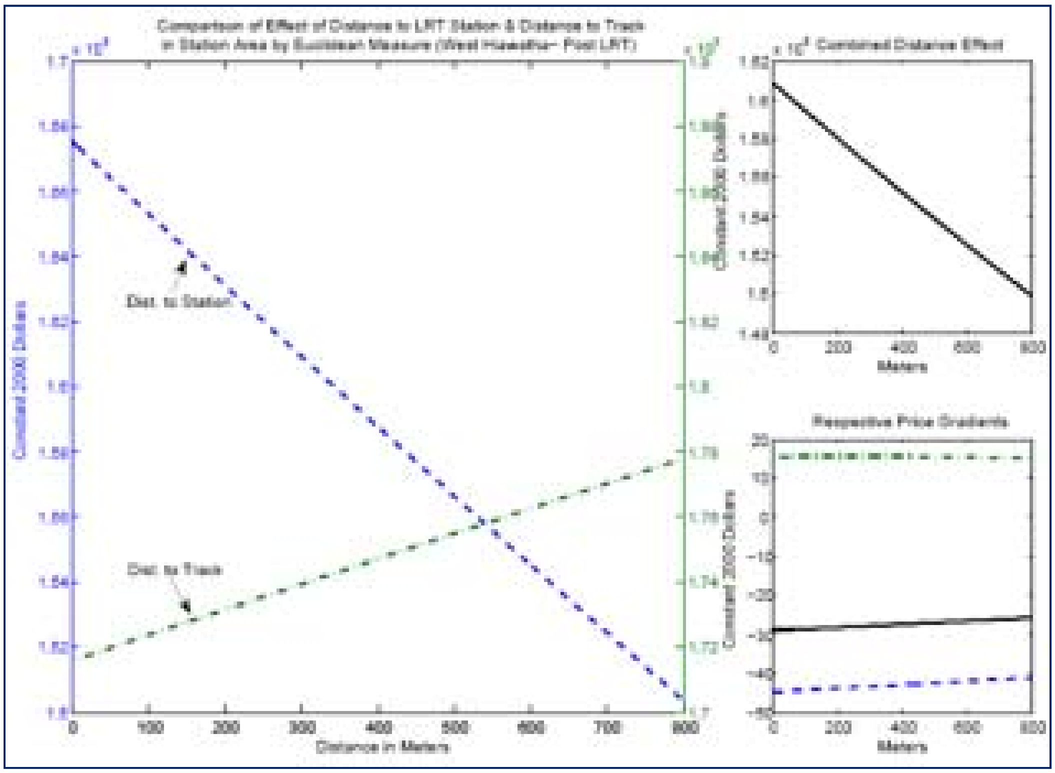


Figure 4.6: Accessibility and nuisance effects in station areas east of Hiawatha, pre 2004



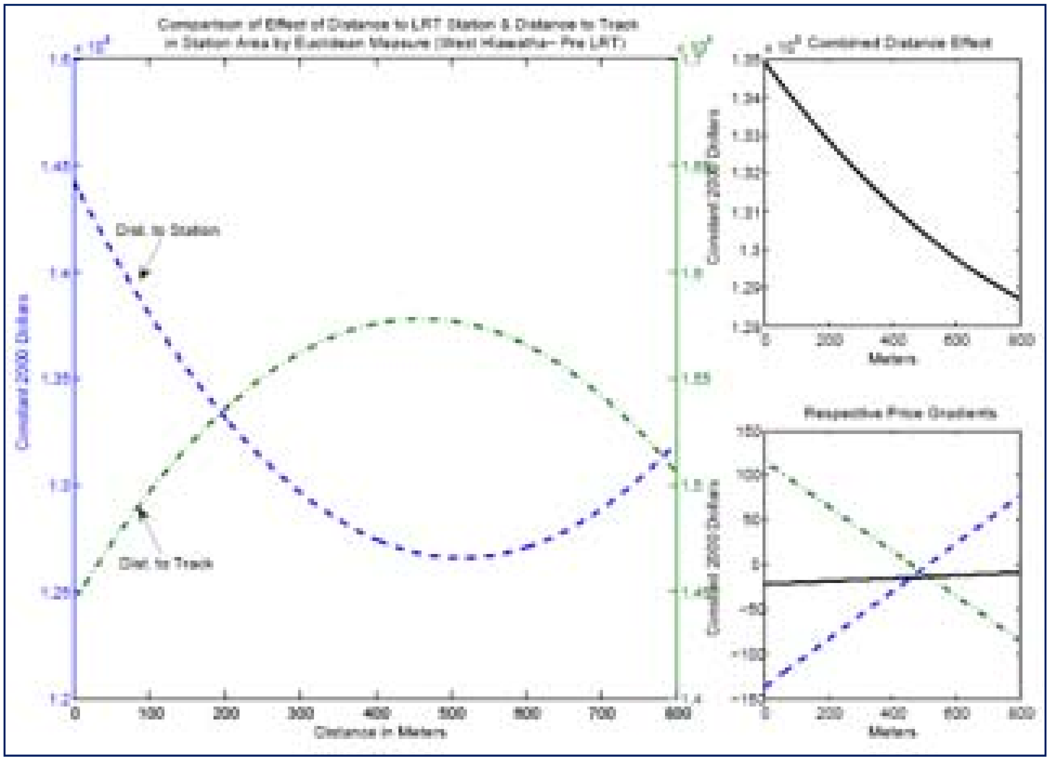
The findings for properties west of Hiawatha are shown in figures 4.7 (post-2004) and 4.8 (pre-2004). Households with properties located west of Hiawatha enjoy some marginal benefit of proximity of the LRT stations and a significant reduction in the marginal cost of the LRT track.

Figure 4.7: Accessibility and nuisance effects in station areas west of Hiawatha, post 2004



Comparing Figure 4.7 and Figure 4.8, we observe that although there is a reduction in the marginal benefit of proximity (from $140 per meter to $45), the radius of this effect has been extended from 500 meters to beyond the treatment distance of 800 meters.

Figure 4.8: Accessibility and nuisance effects in station areas west of Hiawatha, pre 2004



Analysis of Multi-Family Homes

As in the analysis of single family properties we begin by looking at the entire submarket, then examine those findings for the post 2004 period and the period preceding the completion of the line.

Descriptive Statistics for Sub-Market

Table 4.6 is a summary of the data used. There are 2041 sales of multifamily homes. Again, we expect that our results will be dominated by the west side because there are only 537 sales from the east. Here, home prices in our control area are about 11% lower than the overall average while being about 6% smaller in gross building square footage. Also, the average age of a home is at least five years younger on the East side of Hiawatha. It should be noted that at the time of data analysis, available parcel and structure datasets does not include any significant condominium developments in Minneapolis. Consequently, this analysis significantly underestimates the impact of numerous existing and newly constructed condominium developments in the study area.

Table 4.6: Multi-family home sales characteristics, 1997 to 2007

	Minneapolis (8844 sales)		Sub Market (2041 sales)		East Hiawatha Sub Market (537 sales)		West Hiawatha Sub Market (1504 sales)	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Sale Value	**188640**	**98903.59**	**167088**	**67364.25**	**180221**	**66505.66**	**162399**	**67069.60**
Sale Year	**2002**	**2.85**	**2002**	**2.87**	**2002**	**2.98**	**2002**	**2.83**
Year Built	**1918**	**24.19**	**1919**	**22.38**	**1923**	**21.65**	**1917**	**22.43**
Lot Size	**5609**	**1931.94**	**5570**	**1473.55**	**5836**	**1535.07**	**5477**	**1440.08**
Square Feet	**2107**	**683.71**	**1981**	**553.00**	**1907**	**558.28**	**2008**	**548.90**
Homestead	**56.6%**	**0.50**	**62.6%**	**0.48**	**69.6%**	**0.46**	**60.1%**	**0.49**

Results for Sub-Market

The OLS estimation of our first model reveals the presence of heteroskedasticity and multicollinearity. We therefore adopt the same approach as in the case of single-family homes. The resulting ML estimates in Table 4.7 show that many of the problems associated with multicollinearity have been alleviated.

The estimated structural coefficients here are all statistically significant with plausible magnitudes and "correct" signs. Note that most of the variables that are added for curvature and/ interactions are insignificant. Just as in the case for single-family homes, we do not expect them to provide much information on the impact of LRT since we anticipate it to diminish outside the station area.

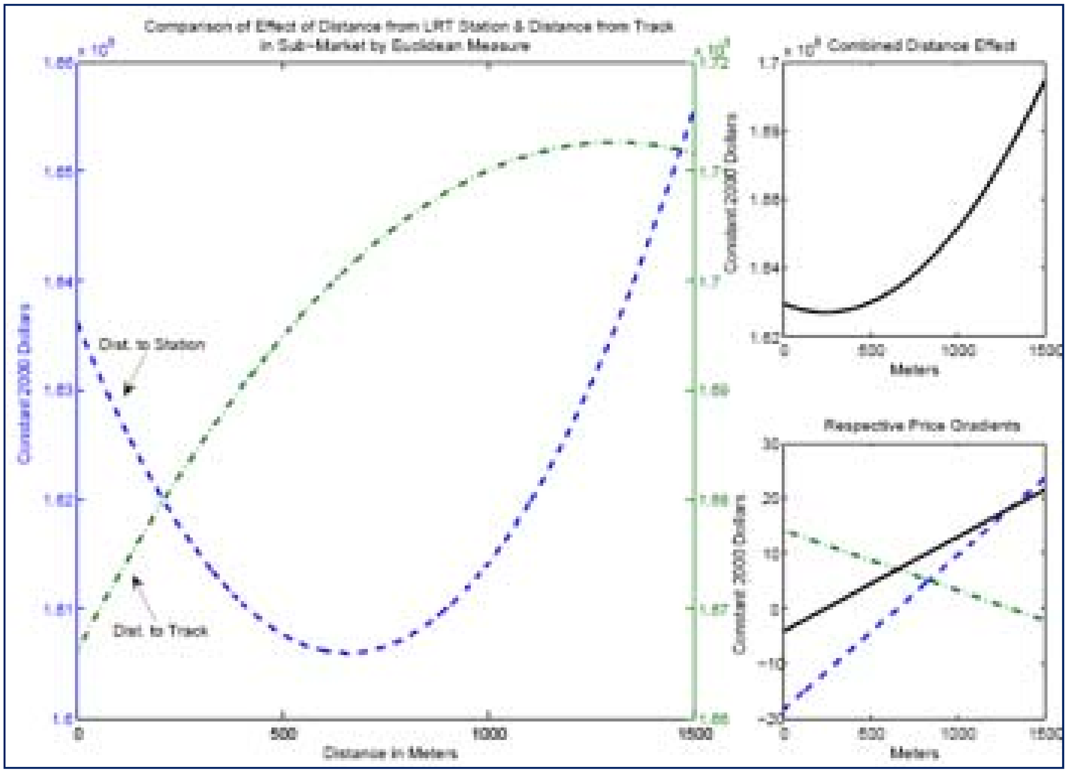
Table 4.7: Maximum likelihood model for multi-family homes within the sub market

ML Parameter Estimates			
Sub-Market Multifamily Homes			
Variable	Coef.	Std. Err.	z
weights	0.4534636	0.0235375	19.27*
year_blt	322.6445	56.52461	5.71*
lot_size	3.68829	0.8112416	4.55*
gross_buil	30.96162	2.619544	11.82*
total_bedr	6730.835	1108.365	6.07*
total_bath	4861.726	2379.129	2.04*
home	8045.561	2304.238	3.49*
dist_to_st	-1.981943	50.29799	-0.04
dist_to_st_2	-0.0023552	0.0267662	-0.09
dist_to_tr~k	-22.35965	38.34636	-0.58
dist_to_tr~2	0.0206841	0.0234449	0.88
dist_2_cbd	5.028886	0.8355896	6.02*
wst_hiwtha	-13391.42	14797.51	-0.9
wst_trk	43.27052	42.15885	1.03
wst_trk_2	-0.0321595	0.0252861	-1.27
wst_st	-21.32866	54.59281	-0.39
wst_st_2	0.0155536	0.0286229	0.54
post_04	23554.91	11201.84	2.1*
trk_04	-6.937036	36.75685	-0.19
trk2_04	0.0008676	0.0215788	0.04
st_04	24.29239	45.05732	0.54
st2_04	-0.0060538	0.0230363	-0.26
constant	-676739.5	108963.3	-6.21*

Number of obs = 2041
Wald Chi(22)= 1813.30
Prob > chi2 = 0.0000
* Significant at 5% level

The effects of proximity to LRT station and track are displayed in Figure 4.9. The positive price gradient extends to about 700 meters away from the station, while the nuisance effect is extend to about 1250 meters away. The nuisance effect here is more persistent than the case for single-family homes, possibly because any negative externality generated by the line is more visible and audible from multilevel apartment buildings. From the graph of the combined distance effect, we see that the nuisance effect is dominant.

Figure 4.9: Accessibility and nuisance effects on multi-family housing within the sub-market



The respective proximity results for properties sold before and after 2004 (see Figures 4.10 and 4.11) are similar to those from the case of single-family homes, except that we find a negative accessibility effect after the opening of the LRT line. As explained earlier, this analysis does not capture any of the condominium activity in the market, thus any implicit benefit of proximity to the LRT stations in this case may be dominated by the increased traffic congestion around the station areas.

Figure 4.10: Accessibility and nuisance effects on multi-family housing within the submarket, post 2004

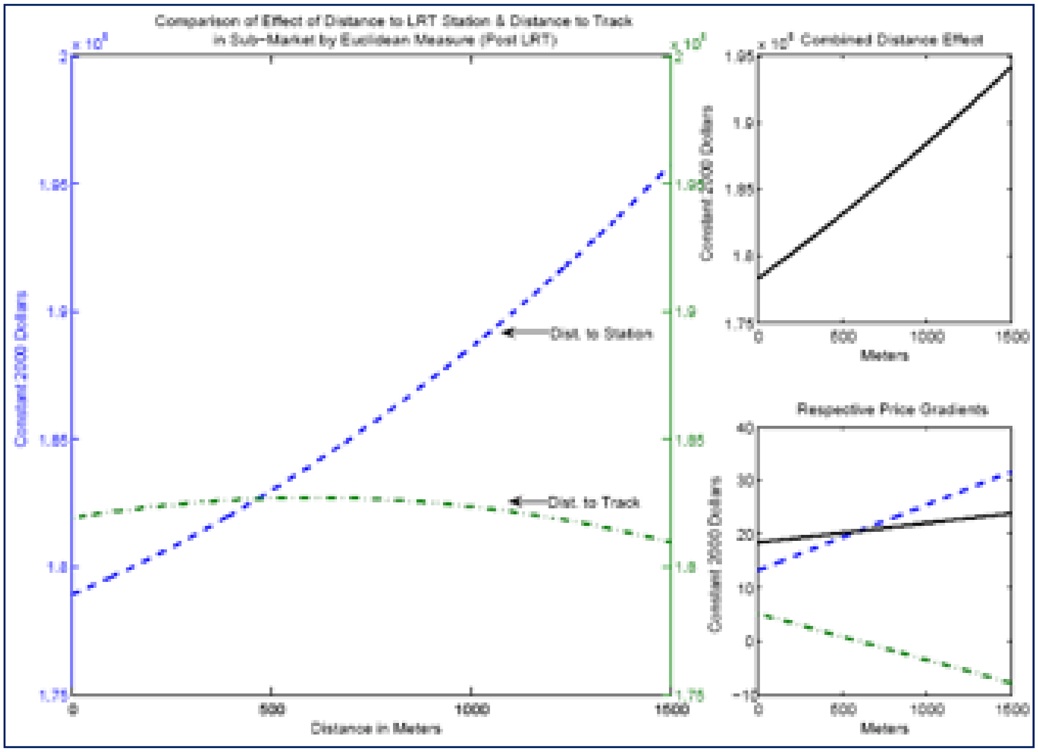
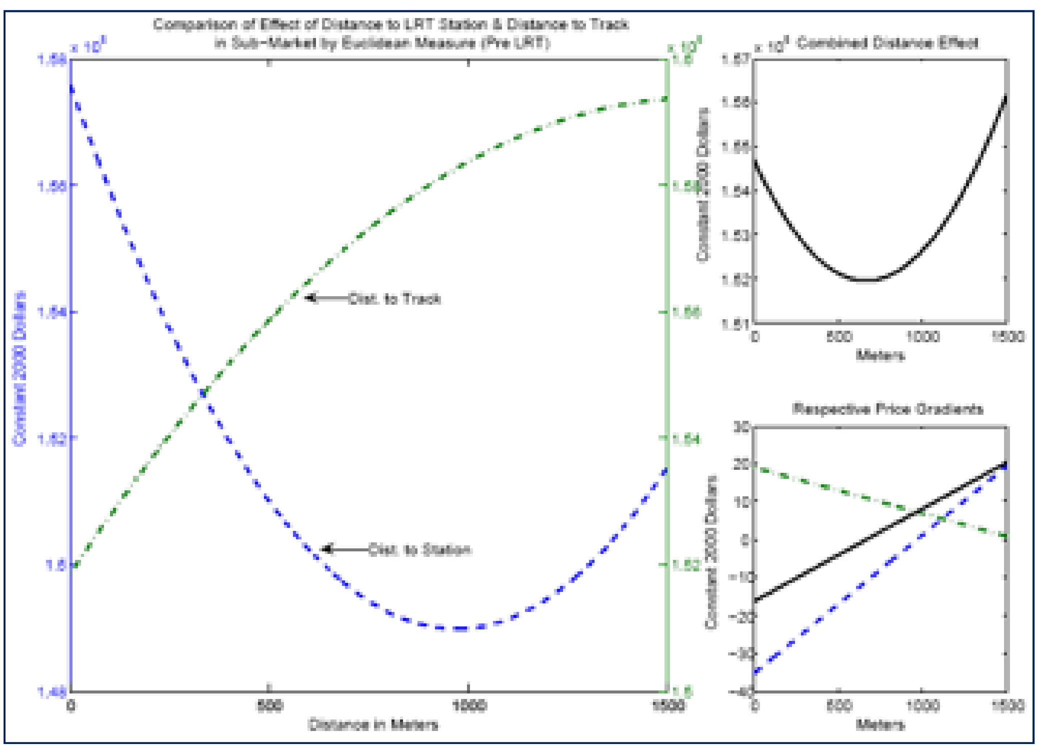


Figure 4.11: Accessibility and nuisance effects on multi-family housing within the submarket, pre 2004



Descriptive Statistics for Station Area

Again, we estimate this study area by using a MLE. In the station area, there are only 438 sales and among these, 272 are from the west side. Here, home prices are about 2.5% lower than in the sub-market and are about 5% larger in terms of lot size. Almost all structural estimates are statistically significant, except for lot size. A summary of the data is displayed in Table 4.8.

Table 4.8: Multi-family home sales within station areas, 1997-2007

Multi-Family Home Sales Characteristics - 1997 to 2007						
	1/2 Mile Station Area (438 Sales)		East Hiawatha 1/2 Mile Station Area (166 Sales)		West Hiawatha 1/2 Mile Station Area (272 Sales)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sale Value	162882	63826.51	171416	58042.43	157674	66679.87
Sale Year	2002	2.87	2002	2.91	2002	2.81
Year Built	1919	24.36	1924	25.45	1916	23.26
Lot Size	5853	1995.45	5758	2053.68	5910	1960.68
Square Feet	1923	546.39	1829	478.93	1980	576.81
Homestead	61.9%	0.49	70.4%	0.46	56.8%	0.50

Results for Station Area

Again, due to data limitations, we find that many of the distance measures are not statistically significant (Table 4.9). The estimated structural coefficients here are all statistically significant with plausible magnitudes and "correct" signs. Comparing the coefficients for the post LRT dummy, **the realized housing premium is $15,755 per home**, which then translates to **$6,900,598 for all properties sold in the area**. Accordingly, **the perceived housing premium is $16,731,586, when we take all multifamily housing units into account**.

Table 4.9: Maximum likelihood model for multi-family sales within station areas

ML Parameter Estimates

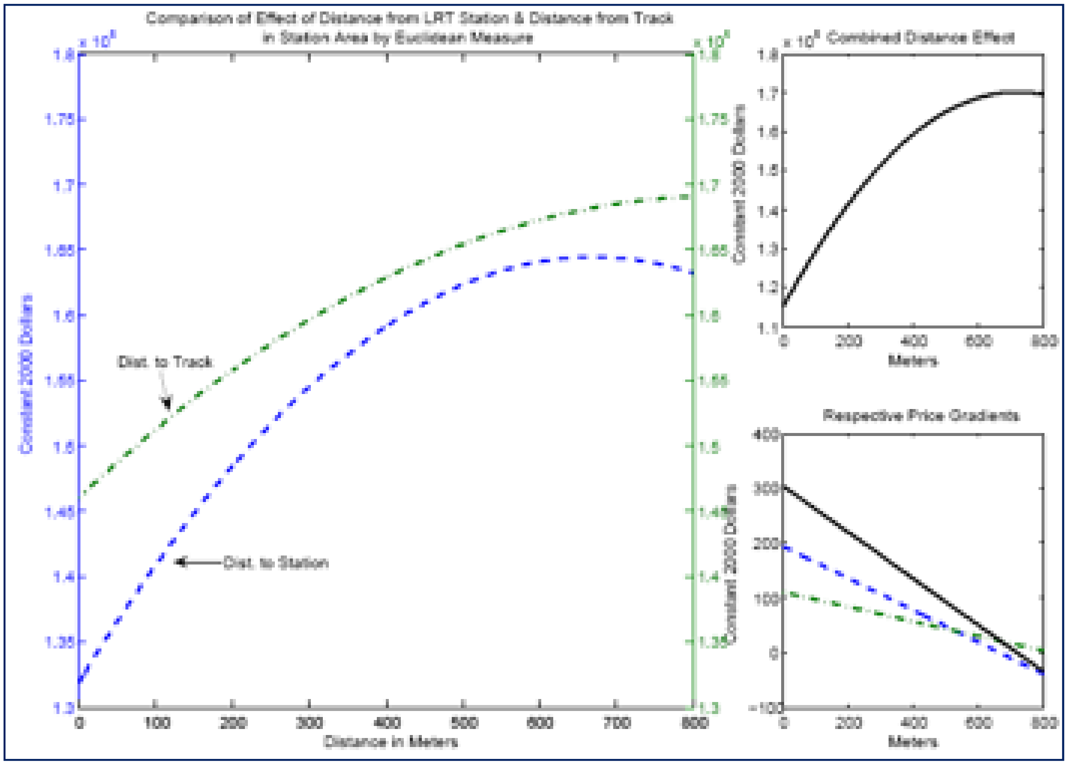
Station Area Multifamly Homes

Variable	Coef.	Std. Err.	z
weights	0.514856	0.0470734	10.94*
year_blt	436.3302	104.272	4.18*
lot_size	2.168085	1.344502	1.61*
gross_buil	26.74118	5.737085	4.66*
total_bedr	7248.979	2282.59	3.18*
total_bath	15989.64	4613.235	3.47*
home	38.78379	4674.158	0.01
dist_to_st	407.2879	211.4936	1.93
dist_to_st_2	-0.3226288	0.1867188	-1.73
dist_to_tr~k	60.82834	132.1163	0.46
dist_to_tr~2	-0.0470403	0.1414106	-0.33
dist_2_cbd	4.339361	1.464225	2.96*
wst_hiwtha	117973	61711.62	1.91
wst_trk	-92.89845	151.1334	-0.61
wst_trk_2	0.1059865	0.1653942	0.64
wst_st	-384.4637	239.9641	-1.6
wst_st_2	0.2972451	0.2141289	1.39
post_04	39309.7	49656.22	0.79
trk_04	146.267	122.6672	1.19
trk2_04	-0.145521	0.141602	-1.03
st_04	-200.9164	211.2457	-0.95
st2_04	0.1846639	0.1938699	0.95
constant	-1036523	211523.7	-4.9*

Number of obs = 438
Wald Chi(22)= 457.51
Prob > chi2 = 0.0000
* Significant at 5% level
Wald chi2(21)= 2182.21
Prob > chi2 = 0.0000
Log likelihood = -41622.73

Similar to the results from the case of single-family homes, we find that the negative externality of the industrial corridor overwhelms any benefit of proximity to the LRT. On average, the cost of the negative accessibility effect starts at $200 each meter away from the stations and the nuisance effect costs around $100 per meter away from the track (Figure 4.12). As before, the type of the structures being analyzed here are more susceptible to any negative externality generated by the corridor, hence the magnitudes of marginal costs are larger.

Figure 4.12: Accessibility and nuisance effects for multi-family housing within station areas



Figures 4.13 and 4.14 show the results for multi-family properties east of Hiawatha. Although we do not find any positive accessibility effect associated with proximity to the LRT stations on the east side of Hiawatha for reasons addressed before, we find that the LRT line has ameliorated some of the negative externality generated by the industrial corridor.

Comparing Figures 4.13 and 4.14, we observe that there is a reduction in the negative proximity effect to major traffic intersections of the corridor, from -$800 to -$400 per meter. Even though the LRT line has increased the nuisance effect in this case, the combined price gradient graph shows that overall, there is a $150 per meter reduction in the negative impact of the corridor after the opening of the LRT line. This means that the implicit marginal benefit of the LRT line outweighs the implicit marginal cost of the industrial corridor in general.

Figure 4.13: Accessibility and nuisance effects for multi-family housing in station areas east of Hiawatha, post 2004

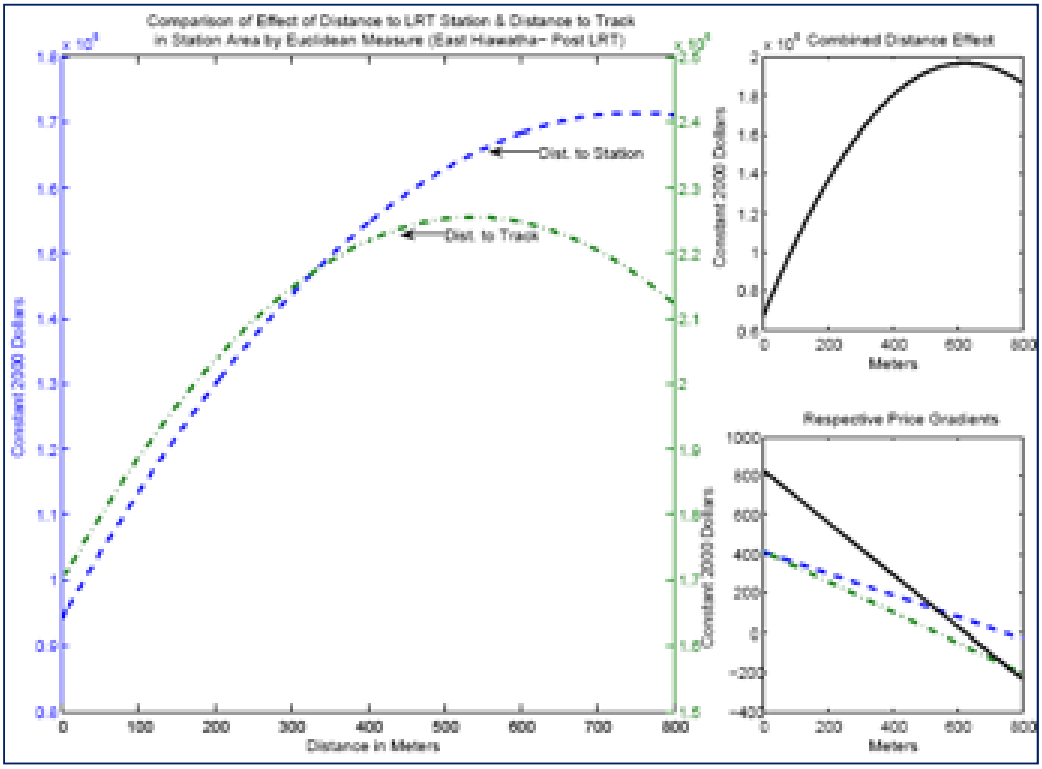


Figure 4.14: Accessibility and nuisance effects for multi-family housing in station areas east of Hiawatha, pre 2004

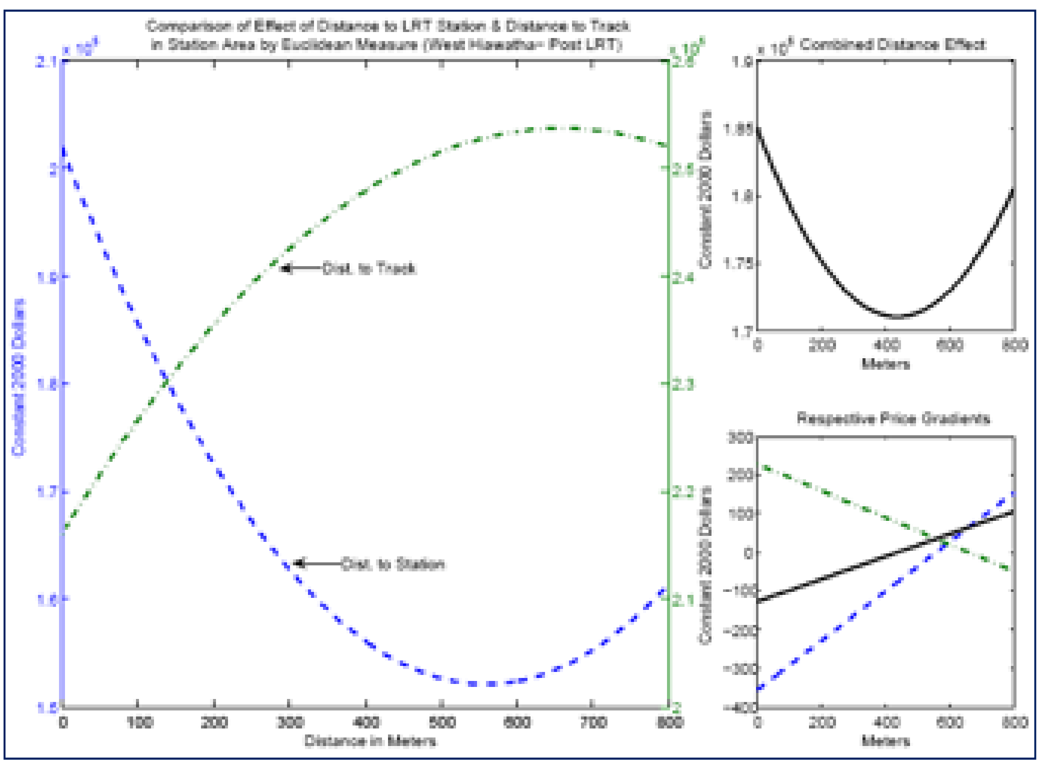


Figure 4.15 and Figure 4.16 report the impact of the LRT line on the west of Hiawatha. In this case, the LRT line has generated a positive accessibility effect, at a price gradient of $350 per meter. The combined price gradient confirms once again that even though the line has created a nuisance effect in this study area, the overall marginal benefit outweighs any associated costs.

Figure 4.15: Accessibility and nuisance effects for multi-family housing in station areas west of Hiawatha, post 2004

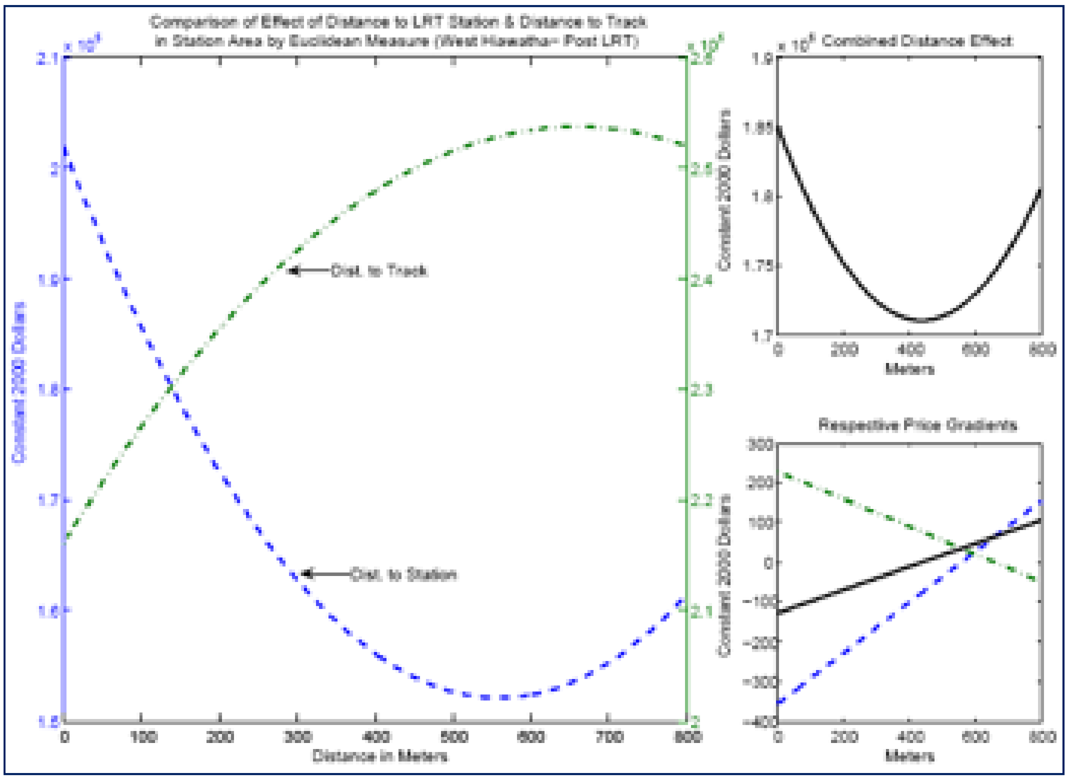
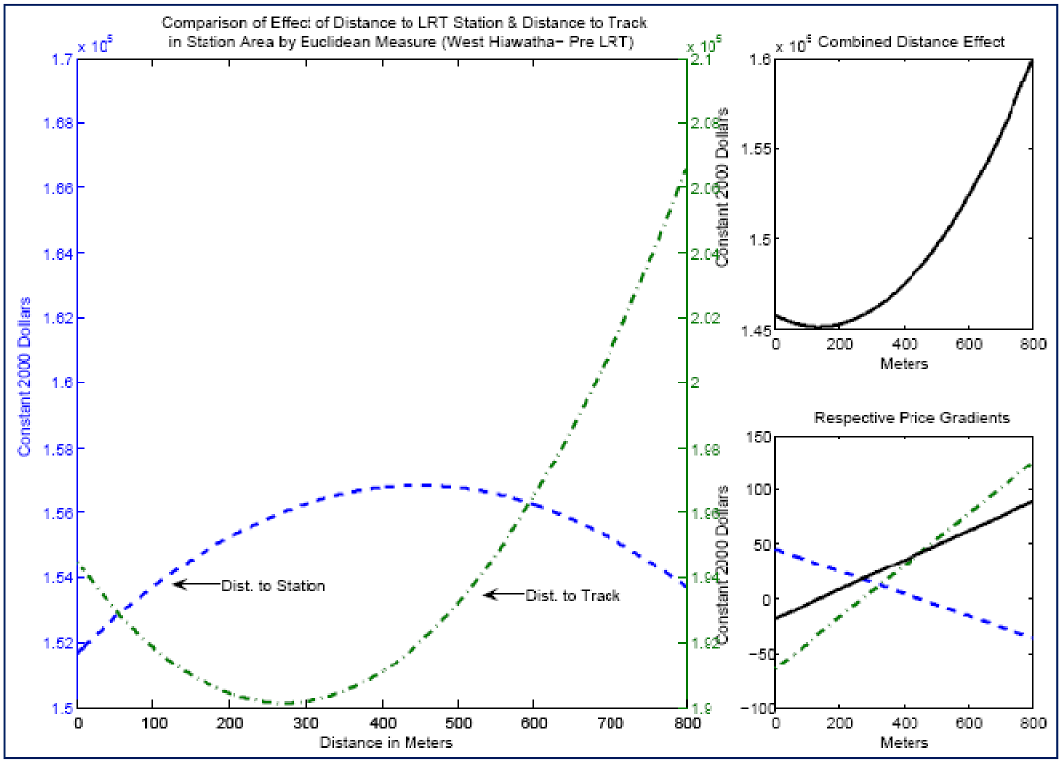


Figure 4.16: Accessibility and nuisance effects for multi-family housing in station areas west of Hiawatha, pre 2004



Conclusion

In this analysis we demonstrate that the Hiawatha LRT line in Minneapolis has had predictable impacts on residential property values. The impact of the LRT on property values is a function of proximity and location, evaluated through a hedonic pricing model. We demonstrate that the significance of the positive and negative externalities of the LRT depends on location. The alignment of the Hiawatha Line is such that a four-lane highway and industrial corridor overwhelm any positive effects of the placement of LRT stations east of the line. West of the line the story changes, with significant value gradients extended outward from the stations. This general pattern holds for both single-family and multifamily residential sales.

By extending our study period to several years prior to the opening of the line, however, we find that in most cases these patterns existed prior to the completion of LRT. The completion of the line altered the basic pattern slightly, extending the positive price gradient (or accessibility effect for distance to station) in the case of single-family homes and mitigating the nuisance effect. For multifamily homes on the west side of the line, completion of the LRT created an accessibility effect where one had not existed previously. **Overall, the completion of LRT has generated $18,374,284 worth of housing premium for single-family homes, and $6,900,598 for multifamily homes.**

Part 5. Housing Investment

In parts 5 and 6 of this report we examine the degree to which the development of the Hiawatha Line has stimulated investment in the housing stock and changes in land use within station areas. Housing investment and land use changes are the result of both market factors that induce different investment patterns and government regulatory changes allowing land use conversions. The actions of local government in rezoning station areas is an important first step in facilitating the development and land use changes that might be induced by addition of a transitway. Thus, before we look at the data on construction and land use in the next two sections, we briefly summarize the efforts of the City of Minneapolis and the City of Bloomington to plan for and accommodate development and land use change along the Hiawatha Line.

Local Planning Efforts

Minneapolis Policy

The Minneapolis neighborhood station areas are well developed communities with established neighborhood characters. In contrast to the Bloomington station areas that had very little existing residential property within station areas, the Minneapolis areas incorporated thousands of housing units and a mix of commercial and industrial land uses as well. This diversity makes the planning process complex due to the need to incorporate the perspectives of many stakeholders with different visions of how each neighborhood should look in the future. The station area planning process in Minneapolis has proceeded slowly. In mid to late 2001 the City of Minneapolis embarked on Station Area Master Plans around the Lake Street, Franklin Avenue, Cedar-Riverside and 46th Street stations. While these station area plans were adopted prior to the opening of light rail construction, the majority of planning and rezoning was not complete until well after the opening of the Hiawatha Line. It is likely that the delay in the planning process has affected development in the area and the rate of land use change that has taken place.

Table 5.1 lists the status of station area planning processes in Minneapolis. The City completed station area master plans for Lake Street, Franklin Avenue and Cedar-Riverside, and 46th Street in 2001. Several of the station areas, however, had no updated master plans by the time the Hiawatha Line opened in 2004. None of the station areas had made it as far as a rezoning study when the line opened. Rezoning studies have been completed for the Franklin Avenue and the 38th Street station areas since the line opened.

Actual rezoning of the land surrounding light rail stations is taking place in a two-stage process. In 2005 the City applied Pedestrian Overlay Districts to each of the station areas. This step created incentives for pedestrian oriented development and prohibited automobile-related uses. The second stage of rezoning in the station areas will focus on the “primary” zoning. Rezoning has been completed for the Lake Street and Franklin Avenue station areas (in 2005 and 2007 respectively) and for the western portion of the 38th Street station (in 2008). Rezoning for 46th Street and the 50th St./VA station area are currently underway.

Table 5.1: Summary of planning efforts along Hiawatha route

Minneapolis Hiawatha Area Planning			
Station Area	**Action**	**Goals**	**Date**
Lake Street	Station Area Master Plan	•Creating new business, housing & amenities	5/18/01
Franklin Ave & Cedar-Riverside	Station Area Master Plan	•Future mixes of new business, housing, & amenities •Improvements to the pedestrian environment •Improving the accessibility and fit of the stations with the neighborhood	12/11/01
46th Street	Station Area Master Plan	•Focus on land use, urban design, infrastructure & amenities •Aims to create new mix of businesses and housing •Improve pedestrian infrastructure and guide density around transit stations	12/11/01
Franklin Ave	Station Area Rezoning Study	•Immediate zoning changes for imminent development projects •Greater development rights and higher density •Zoning changes for future development •Change zoning to restrict expansion of non LRT-friendly uses •Pedestrian/commercial environment, mixed use buildings and higher density housing •Reduction of auto-oriented businesses	3/26/07
38th St	Station Area Rezoning Study	•Rezone area around 38th street station for redevelopment activities and private investment •Pedestrian "overlay" zone around LRT stations •Regulation and incentives for development •Prohibition of auto-oriented businesses •Analysis of existing zoning and recommendations for changes	9/13/07
Cedar-Riverside	Small Area Draft Plan		In Development
Minneapolis	2008 Draft Comprehensive Plan		In Development

Despite the lack of progress in rezoning individual station areas along the neighborhood corridor prior to completion of the line, the City did take steps to integrate special design and zoning guidelines for station areas into is Comprehensive Plan. In 2002 the Minneapolis City Council and the Metropolitan Council approved Transit Station Areas (TSAs) as a land use category.

TSAs are defined as areas that have unique opportunities for "investment in development that maximizes the benefits of transit such as multi-family housing, high employment work places, and other uses with high pedestrian traffic." (City of Minneapolis Comprehensive Plan, 2002). One of the city goals for TSAs is to grow density and encourage a land use mix in TSAs that support ridership and benefit users of transit. TSAs will incorporate design standards for bicycle and pedestrian friendly travel with direct connections to transit. In order to support transit ridership, bicycling and walking in TSAs, the city will limit the amount of parking available for automobiles (City of Minneapolis, 2002).

Transit Station Areas are not uniform geographic areas. In general, TSAs extend approximately ½ mile from a station in order to keep walking trips to and from stations to 10 minutes or less. The highest densities within service areas are designed for the first ¼ mile from stations. It is intended that the main methods of transportation in TSAs will be transit, bicycle and walking. In order to serve those using non-automobile transportation the development efforts will focus on multi-unit residential buildings and office/retail space. Retail development will focus on neighborhood scale businesses that cater to transit riders such as flower shops, coffee shops and drycleaners (City of Minneapolis, 2002).

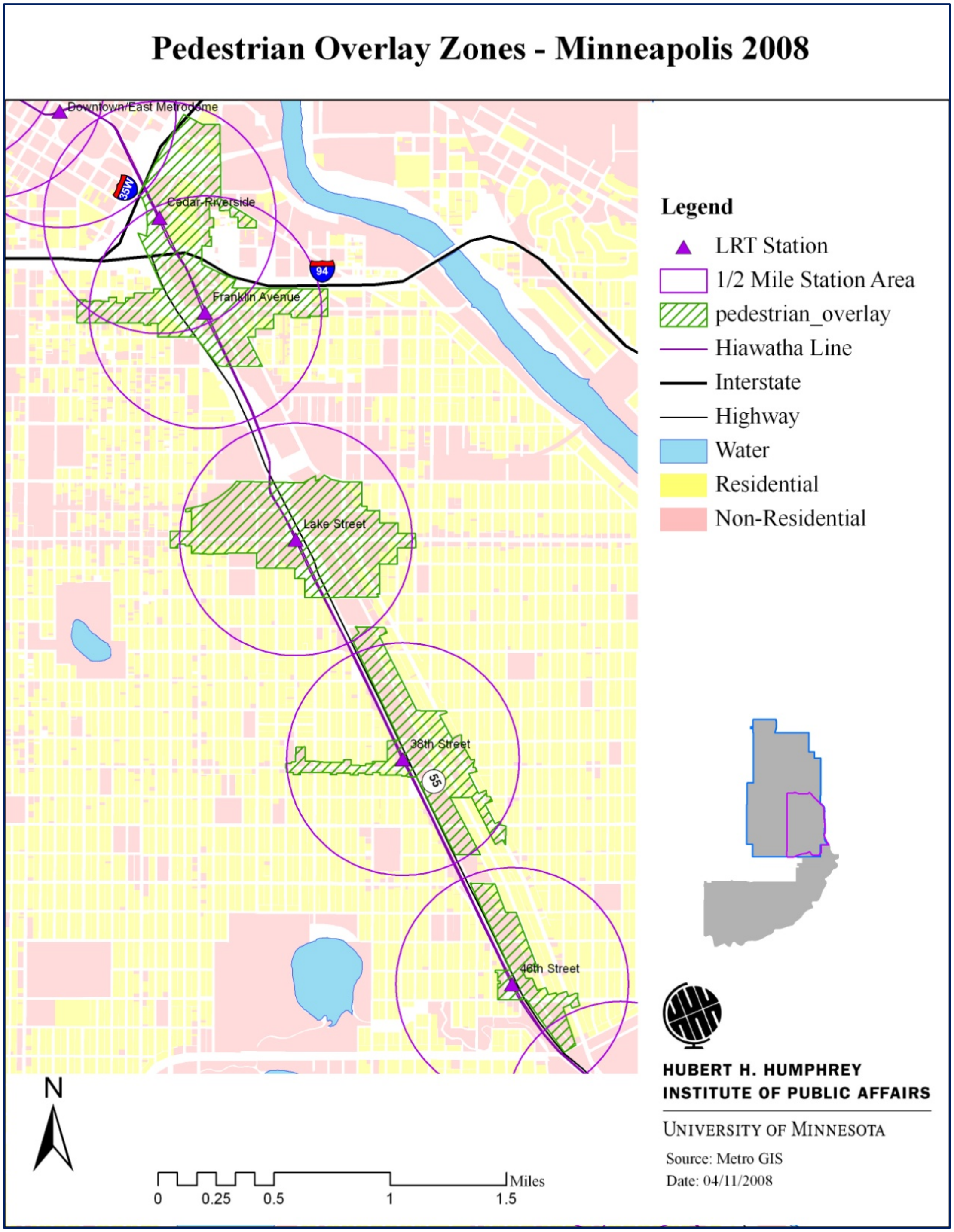
Implementation of TSA plans will require the integration of development with transit stations and a concentration of density and land use mix. Blending new higher density development with the surrounding area will be necessary to preserve existing neighborhood character. Because of the focus toward transit, TSAs are areas targeted for land uses that value convenient access to downtown Minneapolis (City of Minneapolis, 2002). TSA's exist for all of the station areas along the neighborhood corridor of the Hiawatha Line.

Pedestrian Oriented Overlay Districts (Map 5.1) in Minneapolis are established in order to "preserve and encourage the pedestrian character of commercial areas and to promote street life and activity by regulating building orientation and design and accessory parking facilities, and by prohibiting certain high impact and automobile-oriented uses" (Minneapolis City Ordinance 551.60). The overlay district prohibits drive-through and auto-oriented businesses such as commercial parking lots and self-service storage. There are also restrictions on the size and location of accessory parking lots on individual properties.

Beyond the planning-related preparations for the station areas, the City of Minneapolis has several subsidy programs aimed at increasing density and transit use in the areas near LRT stations.

In October of 2005 the City of Minneapolis issued a Request for Proposal (RFP) for the Metropolitan Council Hiawatha Light Rail Transit Land Assembly Fund. The fund was created through a federal grant to assist with the creation of transit oriented development projects within 1500 feet of Hiawatha LRT stations. The fund made $3.5 million available for the purchase of properties on which to site TOD projects. Projects awarded funding required at least 20% matching funds (City of Minneapolis, 2005).

Map 5.1: Pedestrian overlay zones along the neighborhood corridor



The overarching program is the **Great Streets neighborhood business district program,** a geographically based business development program aimed at LRT station areas and commercial corridors. The Great Streets program utilizes the Capital

Acquisition Revolving Loan Fund and the Community Economic Development Fund to foster transit area development.

The **Capital Acquisition Revolving Loan Fund** is a financing mechanism primarily designed to help assemble large parcels of land from several smaller properties in order to facilitate the development of new commercial, mixed residential, mixed income & multi-family housing.

The **Community Economic Development Fund** (CEDF) is designed to provide funding for economic development and area related technical assistance in order to meet the following goals:

- Enhance quality of life through physical revitalization
- Retention and provision of neighborhood employment
- Expansion of tax base
- Housing stabilization

The CEDF prioritizes station area development and assistance into 3 categories based on neighborhood characteristics and severity of identified problems. The goal for the Cedar-Riverside station area is to *intervene* to address serious economic and social problems. For the stations from Franklin Avenue and 50th Street the goal is to *support* trends of neighborhood resurgence. Finally, the goal for the VA Medical Center station area is to *monitor* the strong market-based development activity taking place.

Bloomington

In 2004, the year the Hiawatha Line completed construction, the City of Bloomington began an effort to 'reguide' an area they call the "Airport South district." The city completed the reguiding in 2005 and rezoned the district HX-R (High Intensity Mixed Use - Residential) in the same year. Recognizing that the Hiawatha Line represents a significant public investment and benefit the city wanted to increase density in this district and prevent the underutilization of land in the area. There are three components to the city's zoning approach to this area:

1. For commercial uses the minimum Floor to Area Ratio (FAR) was increased to 1.5
2. A minimum residential density of 30 units/acre was set
3. Surface parking is not allowed, only below ground parking allowed.

The effort to shape a district within the Bloomington station areas that is self-consciously "transit oriented" has already led to important land use changes. The Bloomington Central Station development's proximity to light rail caused the developers to re-scope the project to become significantly transit oriented. The developers had originally planned for less residential and a different location for the buildings. With the realization that light rail could be an amenity the developers added more residential units and repositioned the buildings to take advantage of the light rail station.

Housing Investment

Construction of the Hiawatha Light Rail line contributed significantly to a residential building boom in south Minneapolis. New construction and land use change was an integral part of the pre-construction planning for Hiawatha. Before construction started it was estimated that 7,000 homes would be built in surrounding neighborhoods by 2020. Construction estimates turned out to be conservative as 5,400 new units were complete or under construction by 2005 and permits for an additional 7,000 units had been processed by city governments. Initial analysis found that there was an 84% increase in sales price in the Hiawatha corridor compared to a 61% increase for the larger area (Met Council, 2006).

The most significant development in Bloomington is the Reflections condominium project at Bloomington Central Station. When completed the project will be a 50-acre multi use development with 75,000 square feet of retail, 2.5 million square feet of office, 1,000 residential units, and a 375 room hotel (McGough Companies, 2008 http://www.bloomingtoncentralstation.com). Because of market conditions between 2006 and 2008 no new phases of the development have started construction. Much of the available land in Bloomington's Airport South district is slated for the Bloomington Central Station development, therefore, the majority of development around light rail in Bloomington is tied to Bloomington Central Station.

As illustrated in Map 5.2, there is a cluster of new construction in south Minneapolis occurred along the western side of the Hiawatha Line. In fact, using both a ½ mile and ¼ mile radius area around the stations, the number of newly constructed residential structures is significantly higher than would be expected if all of the new construction in the submarket were evenly distributed spatially. We calculated the relative percentage of surface area and percentage of submarket construction for the ¼ mile and ½ mile areas and for a ¼ mile band following the light rail tracks. Using these proportions, the expected amount of construction was estimated assuming an even distribution of construction throughout the sub-market area. New construction, however, was not distributed evenly throughout the submarket. As table 5.2 shows, the ½ mile station area had 68 percent more new construction than expected; the ¼ mile station areas had 73 percent more, and the ¼ mile track buffer had 183 percent more (see Table 5.2 and Figure 5.1).

Shortly after funding was announced for the line in 1997 there was a flurry of residential construction on vacant parcels adjacent to what is now the LRT tracks on the west side of Hiawatha Avenue. With the LRT funding in place and construction about to move forward there was no longer an incentive to keep viable parcels vacant for potential freeway construction. In total there were 67 residential properties constructed within 300 feet of the light rail tracks between 1997 and 2000. Of the 67 properties, 45 are single family residential, 20 are townhouses, and two are apartment buildings.

Map 5.2: New building along the Hiawatha neighborhood corridor

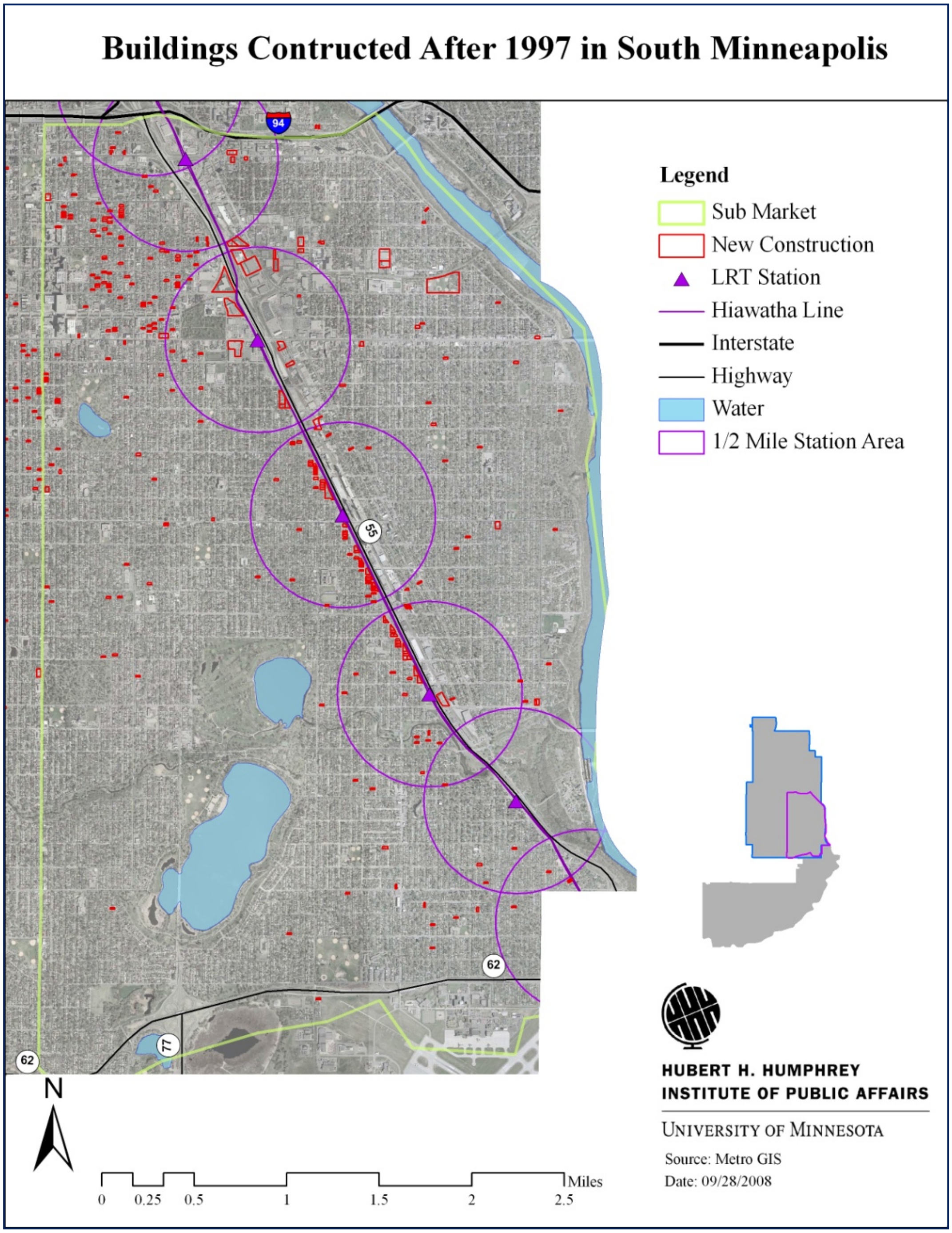


Table 5.2: New construction within station areas, 1997-2007

Relative Distribution of New Construction in Minneapolis			
	1/2 Mile Station Area	1/4 Mile Station Area	1/4 Mile Track Buffer
Buildings Built After 1997	141	38	119
Percent of Submarket Construction	47%	13%	40%
Statistically Estimated Construction Activity	84	22	54
Additional Construction Due to LRT	57	16	65
Percent Overrepresentation	40%	42%	55%

Figure 5.1: Actual construction within station areas compared to expected

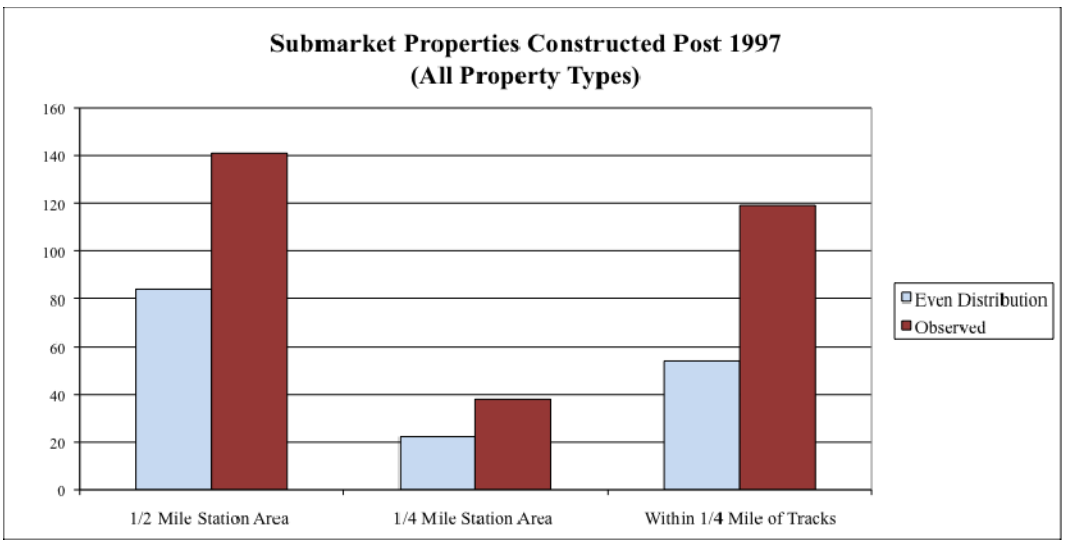
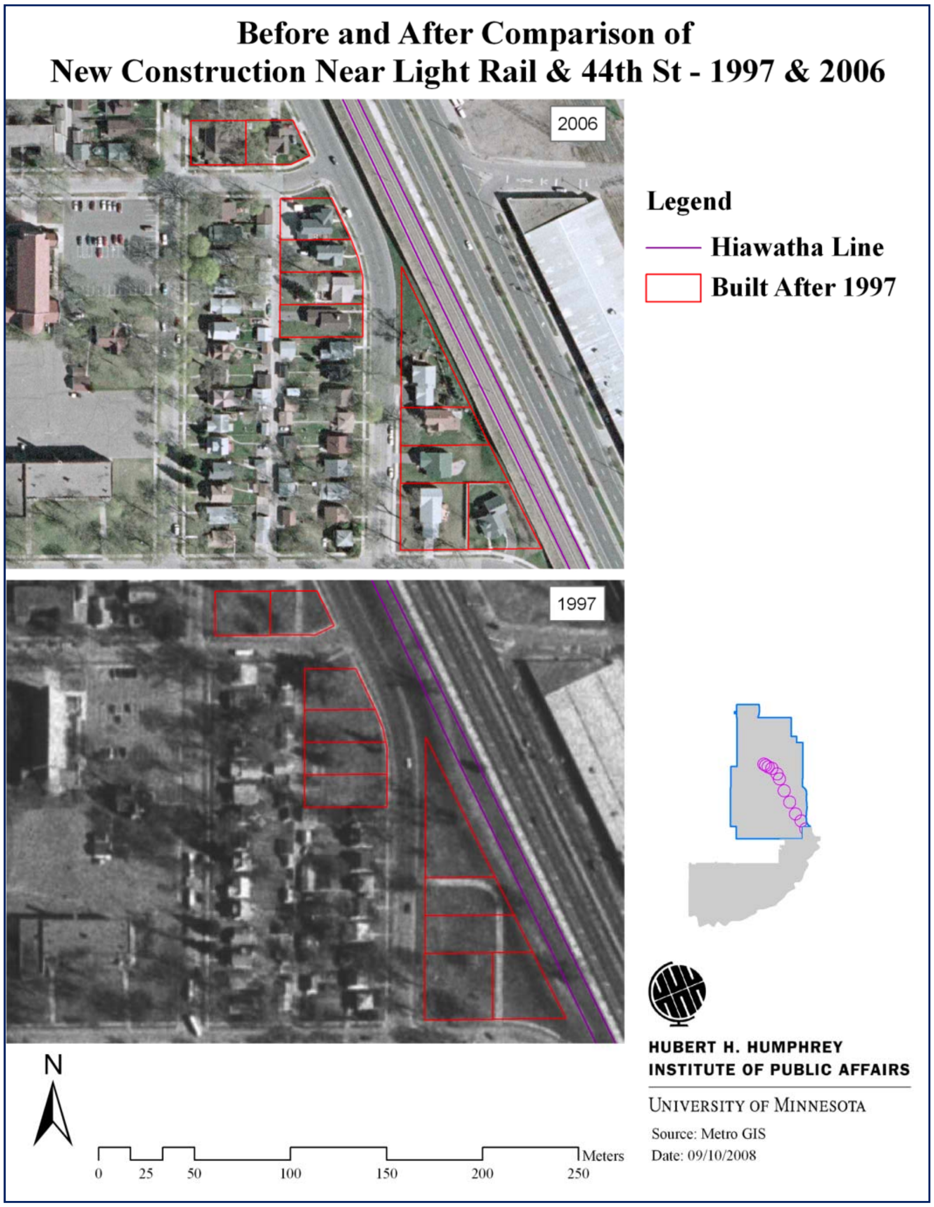


Table 5.3: Selected Hiawatha corridor developments in Minneapolis, 2000-2006

Recent Hiawatha Corridor Developments				
Name	Date Complete	Number of Units	Cost	Mixed Use
Hiawatha Square - 3801 28th Ave S	July 2004	16 1-2 bedroom market rate apartments	$149,000 - $210,000	1100 sq ft retail
Hiawatha Commons - Timbercraft - 5sites alont LRT line; 35th, 36th, 39th, 40th, 41st	:000	35 3 bedroom market rate townhomes	$180,000 - $210,000	
Many Rivers East - 1400-1500 Franklin	August 2003	50 affordable apartments		9000 sq ft retail
Hiawatha Court - 2530 E. 34th St.	Spring 2005	45 1-2 bedroom market rate condos	$160,000	
Minnehaha Place Condomuniums - E 53rd and Minnehaha	August 2005	90 studio - 3 bedroom market rate condos	$131,900 - $224,900	
Village in Philips - 16th Ave E. & 24th St	Early 2005	28 townhomes and community land trust units; 36 condos	$135,000 - $185,000	
Many Rivers West - 1400-1500 Franklin	January 2006	28 affordable apartments		
Oaks Hiawatha Apartments - 4540 Snelling	July 2005	61 Studio - 2 bedroom market rate apartments	$607 - $1327/ month	
42nd Street Lofts - 42nd St. & Dwight Ave	Ph. 1 March 2005	7 market rate 1-2 bedroom live/work lofts		

Source: City of Minneapolis

Figure 5.2: Development of vacant parcels along Hiawatha Line

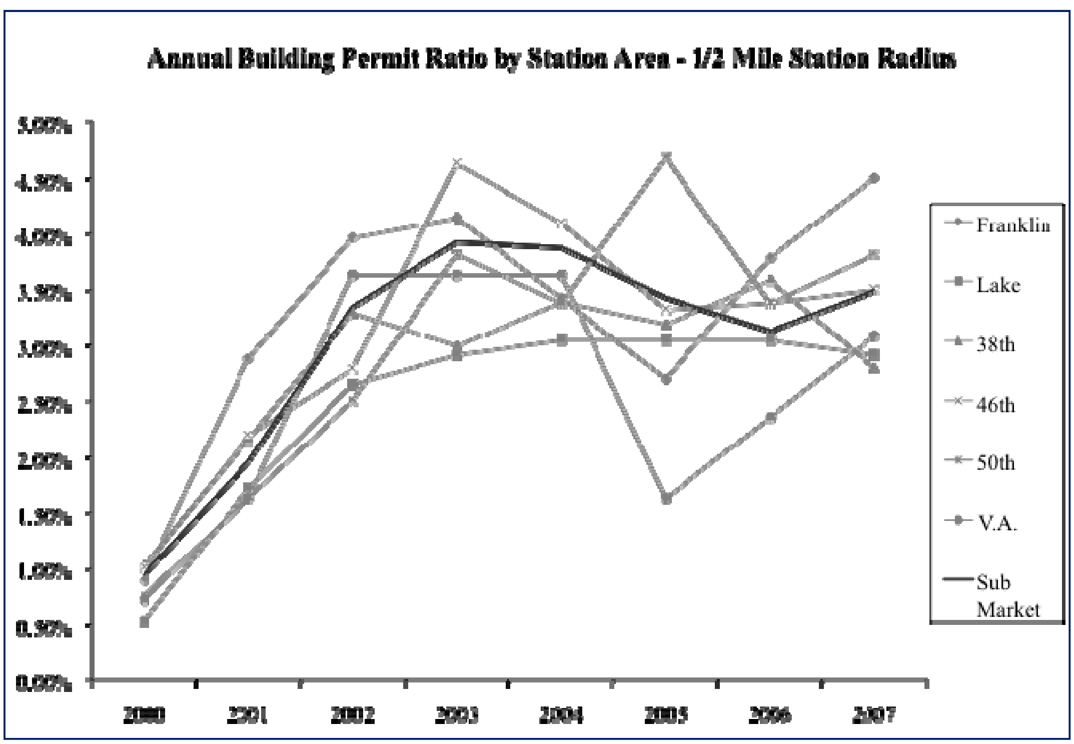


Permit Analysis

An analysis of building permits was conducted in order to gain a more systematic understanding of property investment in LRT station areas. Parcel level building permit data was obtained from the city of Minneapolis for the years 2000 through 2007. While the permit data obtained from the city contains many attributes, this analysis was concerned only with the location of the property, the date of permit issue, and reported value of new construction and remodeling projects. New construction and remodeling were not considered separately as both types of construction reflect property investment. As with other monetary values used in this report, the value of building permits were deflated to constant year 2000 dollars. The various permit ratios were calculated for each year and each individual station are at the ¼ mile and ½ mile radius as well as the larger sub-market area.

The first step in understanding property investment was to quantify the number of parcels receiving building permits in a given area and year. The analysis is predicated upon a hypothesis that a high percentage of properties with building permits in a given area is reflective of a higher level of property investment in that area. A simple ratio was calculated for the number of properties issued permits in a given area or time period against the total number of parcels in that area. Since the number of parcels is constant over time for this analysis all change is tied to the number of building permits.

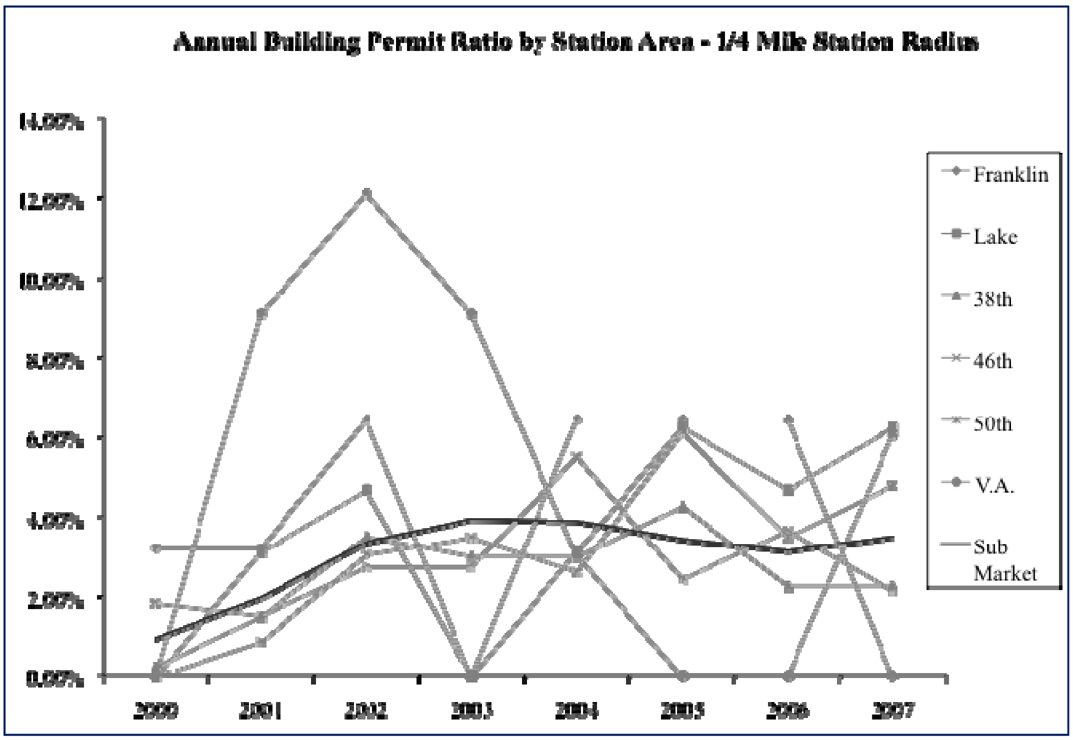
Figure 5.3: Annual building permits within half-mile station areas



The station areas experienced an increase in permit activity over the time period during which construction of the Hiawatha Line was taking place. The annual number of permits has roughly held steady since 2003. But, we cannot attribute this pattern to the LRT line because this pattern is exactly mirrored in the larger sub-market of southeast Minneapolis. The sub-market area saw an increase in the proportion of properties issued permits from 2000 to 2003 followed by a decrease to 2006 and a small rebound in 2007.

Overall, between 1 percent and 4 percent of residential properties in the submarket area are granted building permits in any given year. In general, the permit ratios of individual station areas are more chaotic than in the submarket area because of the smaller number of parcels in station areas. Within the ½ mile station areas, the pattern is similar to the larger submarket area, but the 46th, 50th, and Franklin Avenue station areas showed higher levels of permit activity in 2003, 2005, and 2007 respectively (Figure 5.3).

Figure 5.4: Annual building permits within quarter-mile station areas



Analysis of permit activity within the ¼ mile station areas is significantly more dynamic than the ½ mile station areas and the larger submarket. There is some evidence of a higher rate of investment activity within the ¼ mile range for some station areas than was seen at the ½ mile range (Figure 5.4). The most significant permit activity was in the V.A. station area between 2001 and 2003 with over 12 percent of residential properties pulling building permits in 2002.

When all residential station areas along the LRT line are considered, the year-to-year volatility becomes less pronounced. Notably, permit activity at the ½ mile station level is lower than the sub-market in all years except 2001 and 2006. The ¼ mile station areas only outpaced the submarket in 2002 and 2005. Overall, the station area residential properties saw roughly the same number of building permits as the rest of the submarket in any given year (Figure 5.5).

When all years and individual station areas are considered, the permit activity in the ½ mile areas is very close to that of the surrounding sub-market. Franklin Avenue is the only station area to see increased permit activity at both the ¼ and ½ mile radii compared to the sub-market. In addition to Franklin, Lake and the V.A. area have proportionally more activity than the sub market at the ¼ mile level (figure 5.6).

Figure 5.5: Annual building permits, all station areas

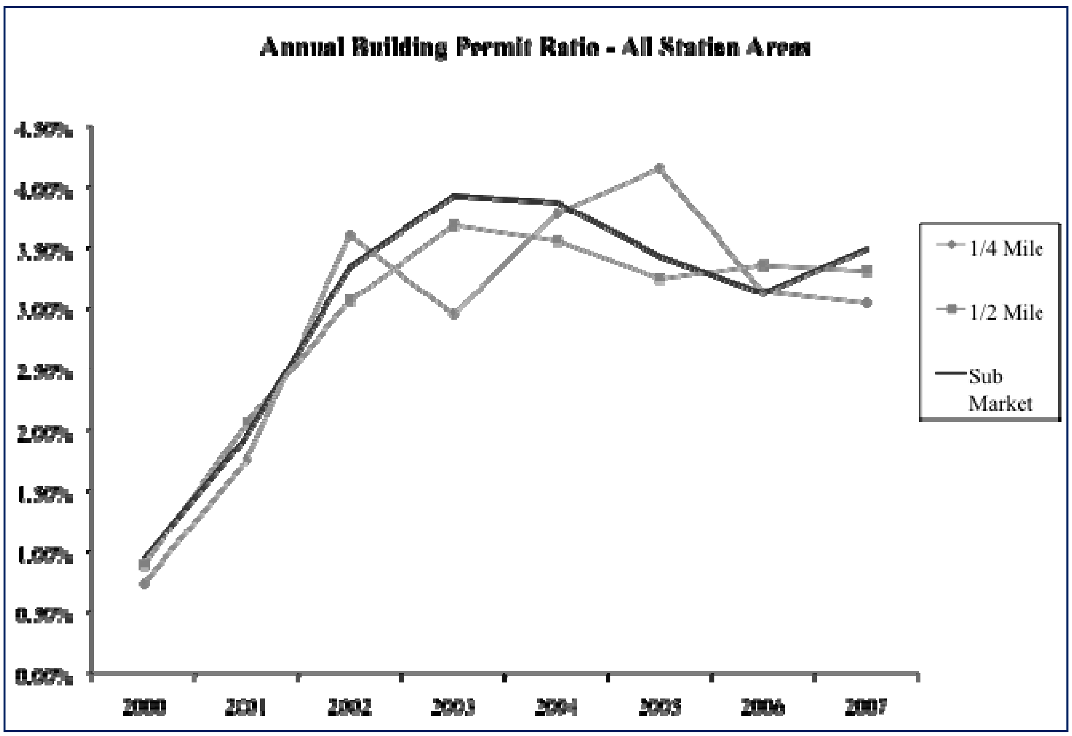
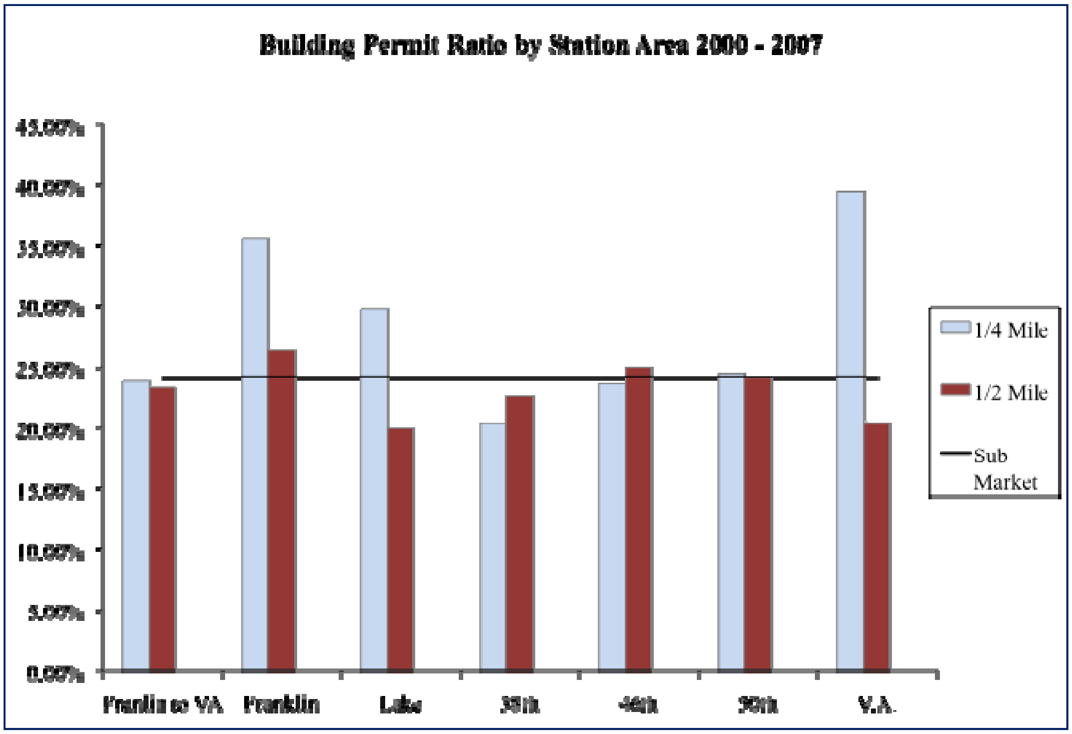


Figure 5.6: Permit activity by station area, compared to sub market

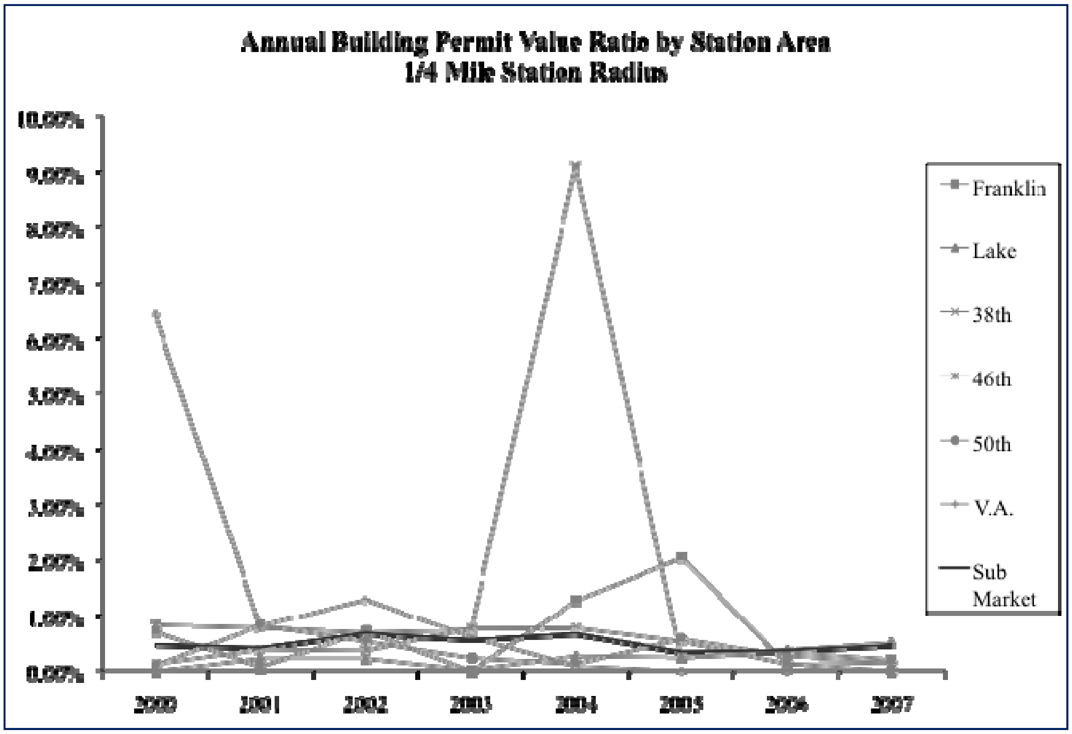


We repeat this analysis using the value of permits issued rather than simply the number of permits. In this analysis we calculate the ratio of permit value to the aggregate estimated market value within a given station area. The ratio of total value of permits issued to aggregate estimated market value allows an analysis of the relative value of investment in a given area over time. A higher ratio indicates that new construction and remodel values are a higher percentage of overall neighborhood market value.

Our findings in this analysis would vary from those of the previous analysis if the value of permits issued (and therefore the extent of work being done) within the station areas were systematically larger or smaller than for the sub market as a whole. Investing a high percentage of property or neighborhood value may be indicative of an area becoming more desirable.

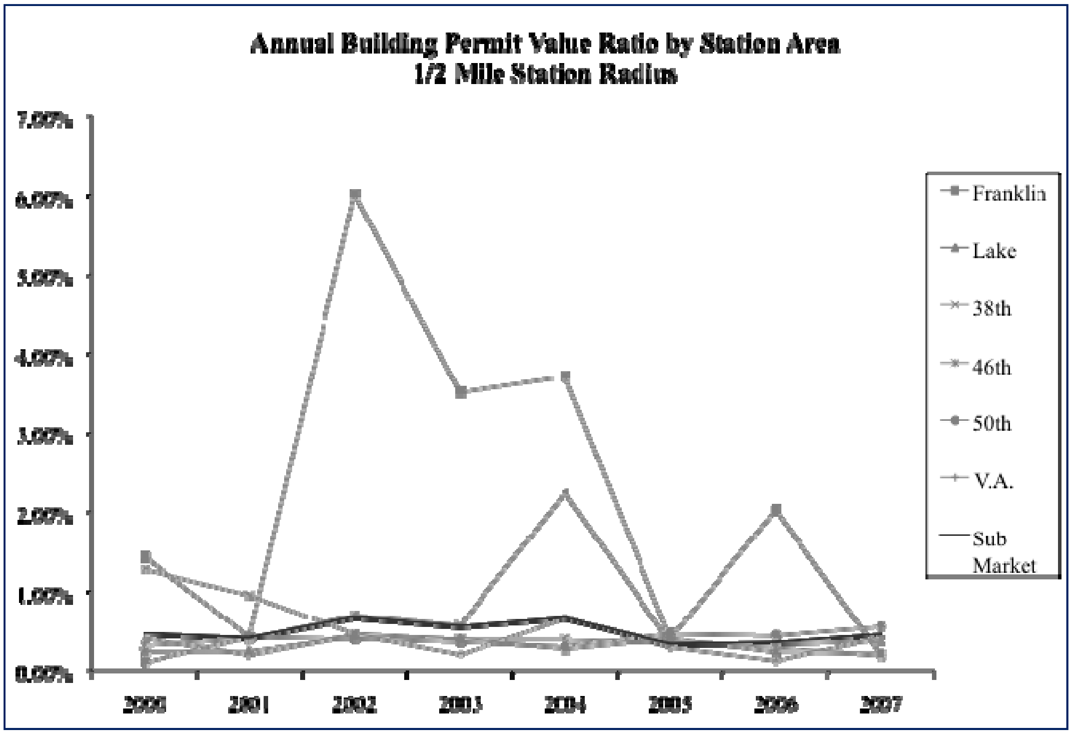
At the quarter-mile radius stations show a wide range of housing investment over the years studied. Most of the investment in the quarter-mile station areas is less than 0.5 percent, but the most notable exception was investment worth more than 9 percent of the aggregate value within the 46th Street station area. The Franklin Avenue area enjoyed a significant investment in 2004 and 2005 when investment climbed well past the areas historically low levels. The VA station area experienced relatively high levels of investment in 2000 and 2002 (Figure 5.7). The Franklin Avenue and Lake Street station areas were the first planning and rezoning efforts to be completed by the City of Minneapolis. The higher rate of investment at those stations may be a result of the completed planning process in those station areas.

Figure 5.7: Annual permit value by quarter-mile station area



Station areas at the half- mile radius again roughly reflected the surrounding sub-market with a few important exceptions. In 2000, 2002, 2003, 2004 and 2006 the Franklin Avenue station area had building permit value ratios much higher than the surrounding area and other individual stations. 38th and 46th Streets also had high investment ratios, though significantly less than Franklin (Figure 5.8).

Figure 5.8: Annual permit value by half-mile station area



When all stations are considered, the half-mile station areas showed proportionally more investment than the surrounding submarket in every year except 2007. The quarter-mile radius station areas were below or very close to the submarket in every year except 2004 when investment spiked to nearly six times the submarket level (Figure 5.9). This spike reflects the dramatic increase in the value of building permits in the Franklin Avenue station area in 2004.

In order to conduct the value analysis for the entire study period, an annual average for the area-wide estimated market value was calculated, weighted by the area's proportion of permits in a given year. For all years between 2000 and 2007 the submarket saw just under 4 percent average investment (i.e., the value of permits averaged just less than 4 percent of the aggregate property value in the sub-market). The average value for all station areas and all years was higher than the surrounding submarket. The highest value above the submarket was the Franklin Avenue station at the half-mile level and the 46th Street and VA quarter-mile station areas (Figure 5.9).

Figure 5.9: Annual permit value, all station areas

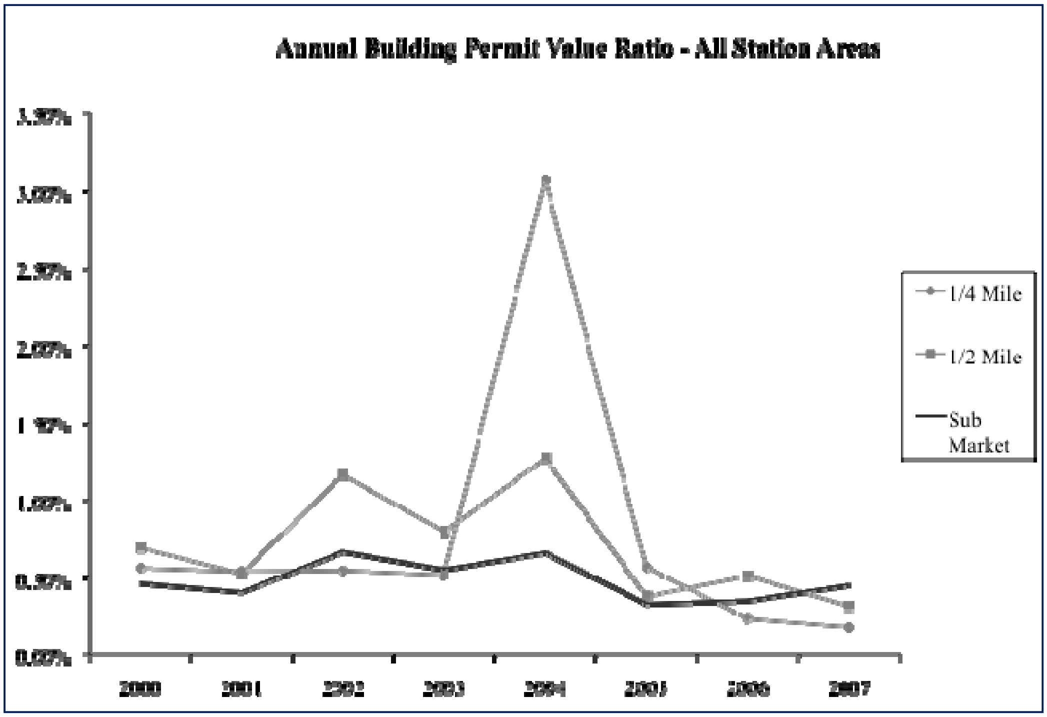
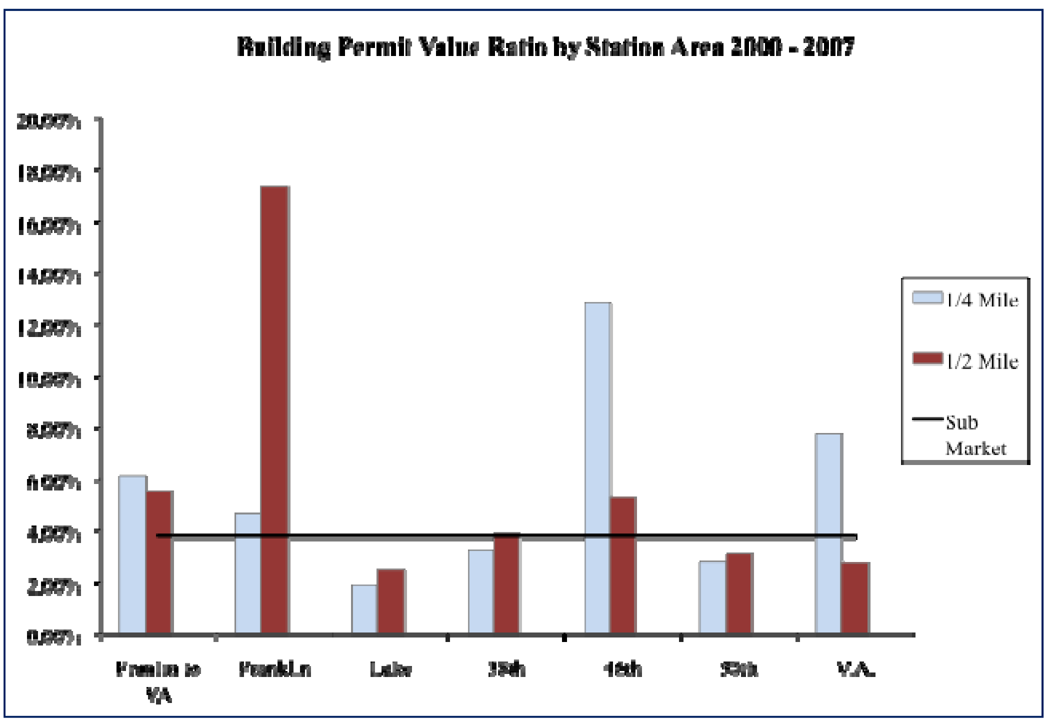


Figure 5.10: Permit value by station area, compared to sub-market



In the initial stages of the analysis it was discovered that in 2007 the value of construction projects in the quarter-mile V.A. station area was greater than the entire market value of the area. Further investigation revealed that a $5 million condominium project was in the planning phase, but was never built. In this instance there was a clear intent to invest in station area real estate, but it is likely that widespread housing market trends curbed projects that would have otherwise been built. Even though the project in question reflects intent to build, the property was removed from this analysis because the project was so large that interpretation of finer details became impossible.

Conclusion

There is significant variability in building-permit activity within station areas along the Hiawatha Line. When measured as the percentage of parcels receiving permits, the activity within station areas mirrors the permitting activity within the larger sub-market. However, when measured by value, there is a clear pattern of greater activity within station areas compared to the sub-market control area. Overall, residential construction projects near light rail stations were a higher proportion of individual property values than their submarket counterparts. Within the Franklin Avenue, 46th Street, and V.A. station areas the differences are large.

Part 6. Impact on Land Use

In this section of the report we examine how the development of the Hiawatha Line has affected land use in the areas surrounding the stations. Specifically, we examine four ways in which land use might be altered as a result of light rail station development.

- The amount of vacant and undeveloped land parcels might decline as a result of station-area investment. In this scenario, land owners may see economic benefits in developing vacant parcels that were not in evidence prior to the light rail station being developed. This type of land use change is a reflection of the greater investment activity generated by the line.

- The intensity of land use may increase. This may occur as a result of the first scenario, i.e., the development of previously vacant parcels. It may also occur as the result of subdivision of parcels, or more intense development of existing built-parcels.

- The development of a light rail station may shift the predominant land use in the surrounding area. In this scenario, perhaps greater commercial opportunities in the area surrounding the station might spur redevelopment and shifts away from other uses. Alternatively, more housing might be built at these nodes, given the greater transportation access the neighborhood acquired with the development of the station.

- Development of a light rail station may alter the mix of land uses in the station area. Here the expectation is for less dramatic land use change than in the previous scenario. Rather than shifting the predominant use, light rail station development may simply change the mix of uses. Given the general stability of land uses over time, this is perhaps a more reasonable expectation for the short term impact of the transitway.

Land uses change as a result of new development pressures being set off within the land market. But the degree to which such changes occur is constrained by local land use regulations; zoning and local area planning can facilitate or impede land use change. Thus, we also examine the degree to which the cities of Minneapolis and Bloomington have accommodated land use changes by adjusting land use plans and zoning regulations along the Hiawatha Line.

Literature Review

The relationship between land use and travel behavior, or between land use patterns and transportation systems is reciprocal. As Calthorpe (1993, 53) argues, land use patterns form the foundation for estimates of “travel cost, time, and investment factors.” Supportive land uses can enhance alternative transportation modes just as other patterns may inhibit all but automotive travel choices. Thus, when investments in light rail transit, for example, are made by the public sector, it is important to examine the degree to which land use configurations are supportive of such developments and whether changes to land use occur in tandem or as a result of such transit investment. Indeed, Calthorpe (1993, 55) argues that “land use and transit systems *must* be planned together” (emphasis added). When transit is added to an already-developed landscape as in the case of the Hiawatha Line, planning for land use change must accompany transit development.

A model of land use supportive of transit has evolved among city planners. Transit-oriented development (TOD), as the model is called, stresses a mix of land uses, moderate- to high-density development, a walkable street grid, a centrally located commercial node or corridor, all within proximity to transit access.

Krizek (2003) defines land use mix as “the synergy created when banks, restaurants, shops, offices, housing, and other uses locate close to one another, allowing for decreased travel distances between origins and destinations”. Therefore, it is important for us to analyze the relationship between the establishment of the transit stations and the surrounding land use, as such analysis ultimately adds to our understanding of how the land-market has changed.

There is, to our knowledge, little previous research on the impact of light rail development on land use patterns. Studies that focus on land use mix and changes in land use have been conducted in the context of different research questions.

Methods

In many studies of urban form, a range land use mix indexes is used, depending on the research objectives. We utilize some existing land use mix measures that are most applicable and mathematically intuitive. Again, we focus here on how land use has changed over time, not on how concentrated a particular land use has been. Knaap and Song (2004) use the following two types of indices to regress land use mix on the age of the neighborhood in Washington County, the western portion of the Portland, Oregon, metropolitan area:

1. Mix-Actual: acres of commercial, industrial, and public land uses in the neighborhood divided by the number of housing units; the higher the ratio, the greater the land use mix.

2. Mix-Zoned: acres of land zoned for central commercial, general commercial, neighborhood commercial, office commercial, industrial, and mixed land uses in the neighborhood divided by the number of housing units; the higher the ratio, the greater the mix.

In a related study of the Portland area examining the relationship between travel mode choice and the local built environment, Rajamani et al. (2002) capture the degree of land use mix in their Logit model by calculating the land use diversity:

$$\begin{aligned}
\text{Land use mix diversity} &= 1 - \frac{|\frac{r}{T}-\frac{1}{4}| + |\frac{c}{T}-\frac{1}{4}| + |\frac{i}{T}-\frac{1}{4}| + |\frac{o}{T}-\frac{1}{4}|}{3/2} \qquad (6.1)\\
&= \begin{cases} 1 \text{ if there exist perfect mixing} \\ 0 \text{ if there exist one exclusive land use} \end{cases}\\
r &= \text{acres in residential use (single and multi-family housing)}\\
c &= \text{acres in commercial use}\\
i &= \text{acres in industrial use}\\
o &= \text{acres in other land uses}\\
T &= r + c + i + o
\end{aligned}$$

Without loss of generality, we write the above formula for N number of uses:

$$\begin{aligned}
\text{Land use mix diversity} &= 1 - \frac{\sum_{i=1}^{N} |\frac{x_i}{T} - \frac{1}{N}|}{2(N-1)/N} \qquad (6.2)\\
T &= \sum_i x_i
\end{aligned}$$

Mathematically, the formula calculates the absolute deviations from the proportion of perfectly mixed land use. The closer the index is to one, the less deviation there is.

A second way to deal with land use is to use the information entropy of a random variable because uncertainty of an event can be viewed as the diversity of land use mix, based on percentage of the types of different uses. Formally, the information entropy quantifies the information contained in a piece of data: it is the minimum average message length, in bits, that must be sent to communicate the true value of the random variable. This can also be viewed as a measure of average expectation of realization of an outcome.

$$\begin{aligned}
E(I(x_i)) &= \sum_i^N p_(x_i) log_2 \frac{1}{p_(x_i)} \qquad (6.3)\\
I &= \text{self-information}\\
x_i &= \text{land use type } i\\
N &= \text{total number of land use type}\\
p_(x_i) &= \text{percentage of land use } i
\end{aligned}$$

Since the above expression is not bounded by 1, Cervero (1989) normalized it by $1/\log_2 N$ and introduced it as the land use entropy. With the expression being an index taking on values between 0 and 1, it is a compatible measure of land use mix to the diversity index (6.3). Just as before, a measure of 1 yields complete heterogeneity in land use while a measure of 0 yields homogeneity in land use.

We should note that the above formulation does not seem intuitive to use for measuring land use mix, as entropy is based on Information Theory, measuring the spread of information. Here we do not try to justify the reason for using such index; we simply consider its value-added as an alternative measure of land use mix.

A third index that is applicable here is the Simpson's index (1949):

$$\text{Simpson diversity} \quad = \quad 1 - \sum_{i}^{N} p_i^2 \qquad (6.4)$$

where p_i is the percentage of land use i, out of N total land use types. This formula is intuitive in representing the probability of two individuals among a population being different because it is derived from counting principle[6.2]. However, it may be less efficient when using it to measure land use mix in different control areas because it is a number between 1/n and 1. This means that we cannot compare this index with the others (which have a lower bound of zero) for land use mix at one point in time, but it could be use to confirm or refute any changes in land use mix over time.

One concern that can be raised about the indices above is that they do not measure the degree to which a given land use comes in contact with other uses. Cervero and Kockleman (1997) develop an index to measure the dissimilarity/integration of land use for a set of discrete choice models in the San Francisco Bay Area. The Dissimilarity Index is described below:

$$\begin{aligned} \text{Dissimilarity Index} \quad &= \quad \text{Mix Index} = \sum_{k=1}^{K} \frac{1}{K} \sum_{i=1}^{8} \frac{X_{ik}}{8} \qquad (6.5) \\ K \quad &= \quad \text{number of center hectare considered} \\ X_{ik} \quad &= \quad \begin{cases} 1 \text{ if central hectare's use differs from neighbor hectare} \\ 0 \text{ otherwise} \end{cases} \end{aligned}$$

When two central hectares share some neighboring hectares the index is similar to equation 6.1 in that 0 indicates homogeneous land use and 1 indicates complete heterogeneity. Note that the key feature here is that the neighborhood is of fixed size. This means that in order to apply this index, one must identify the center(s) of interest and choose the size of blocks (of the center and its surrounding). Use of this index requires fixing the size of blocks which may be difficult in areas of topographical or geographical complexity.

When using the Dissimilarity Index, Kockleman (1997) includes both a general mix use (of commercial including industrial and office uses, residential, educational, and outdoor recreational) and a detailed mix of 11 uses to study urban form in the San Francisco Bay Area. The author finds that the detailed mix overcomplicates the model and performed worse than the general mix model. That is, increasing the number of land use types overcomplicates calculations and does not increase the robustness of the analysis.

Cervero and Landis (1997) conduct a quantitative analysis using discrete choice models, predicting the probability of land use change and the growth rates of residential and non-residential land use, pre- and post-Bay Area Rapid Transit system. Here we do not attempt any regression analysis for land use, simply because of the lack of the number of observations available in order to make our findings statistically significant. Also, we find that our analysis is as informative without having to deal with any endogeneity problems that may arise from the regression model.

Data

The analysis of land use changes around the station areas is based on two data sets. The first is land use data collected by the Metropolitan Council of the Twin Cities. Generalized land use classification exists for the entire seven-county area for the years 1984, 1990, 1997, 2000, and 2005. Land uses are classified into one of 10 categories based on aerial photos. Digital aerial photography and direct conversion via GIS have improved the accuracy of the data beginning with the 1997 survey, though accuracy is not 100%. The Metropolitan Council states that “even though the overall accuracy has improved with these enhancements, it is important to understand that the support data (i.e., parcels) have limitations that affect the accuracy of the resulting land use data. The accuracy of the land use data is also dependent on other factors such as image quality, interpretation, and thoroughness.” (Metropolitan Council, 2005).

The Council has also added land use categories since 1997, providing for a more refined classification scheme. We have converted data from 2000 and 2005 to conform to the broader categories used in the previous surveys in order to analyze a consistent set of land use classifications over time. Table 6.1 lists the land use classifications used in this analysis. We use these data to examine how land uses have changed around station areas since development of the Hiawatha Line.

Land Use Categories

- Residential –Single Family
- Residential – Multi Family
- Commercial
- Industrial
- Public/Institutional
- Airport
- Recreational
- Vacant/Undeveloped
- Highway
- Water

We use the indexes described above to analyze land use change around the station areas. That is, using the land use data from the Metropolitan Council we calculate four indices of land use mix; the diversity index from Ramjani et al. (2002), Cervero’s (1989) land use entropy index, the Simpson index, and the dissimilarity index (from Cervero and Kockleman (1997).

The second data base used in this analysis is the parcel-level data from Metro-GIS. This data base includes information on the parcel and on the physical structure for each parcel in the metropolitan area. These data are available on an annual basis since 2002. These annual observations allow for a finer-grained longitudinal analysis than the more sporadic land use data, though the data do not incorporate as many observational years prior to the development of the light rail line.

The third data set used was the structure specific attributes from the city of Minneapolis. For the Intensity analysis presented here we used gross square footage of a given structure divided by the square footage of the parcel. This data was not available for Bloomington so intensity was not calculated. Qualitatively, however, the area of Bloomington in question is underdeveloped and policies are in place to increase the density in this area substantially.

Finally, our analysis of land use policy changes in Minneapolis and Bloomington is based on interviews with city planners and developers/land owners, as well as a review of planning documents for the various station areas along the line.

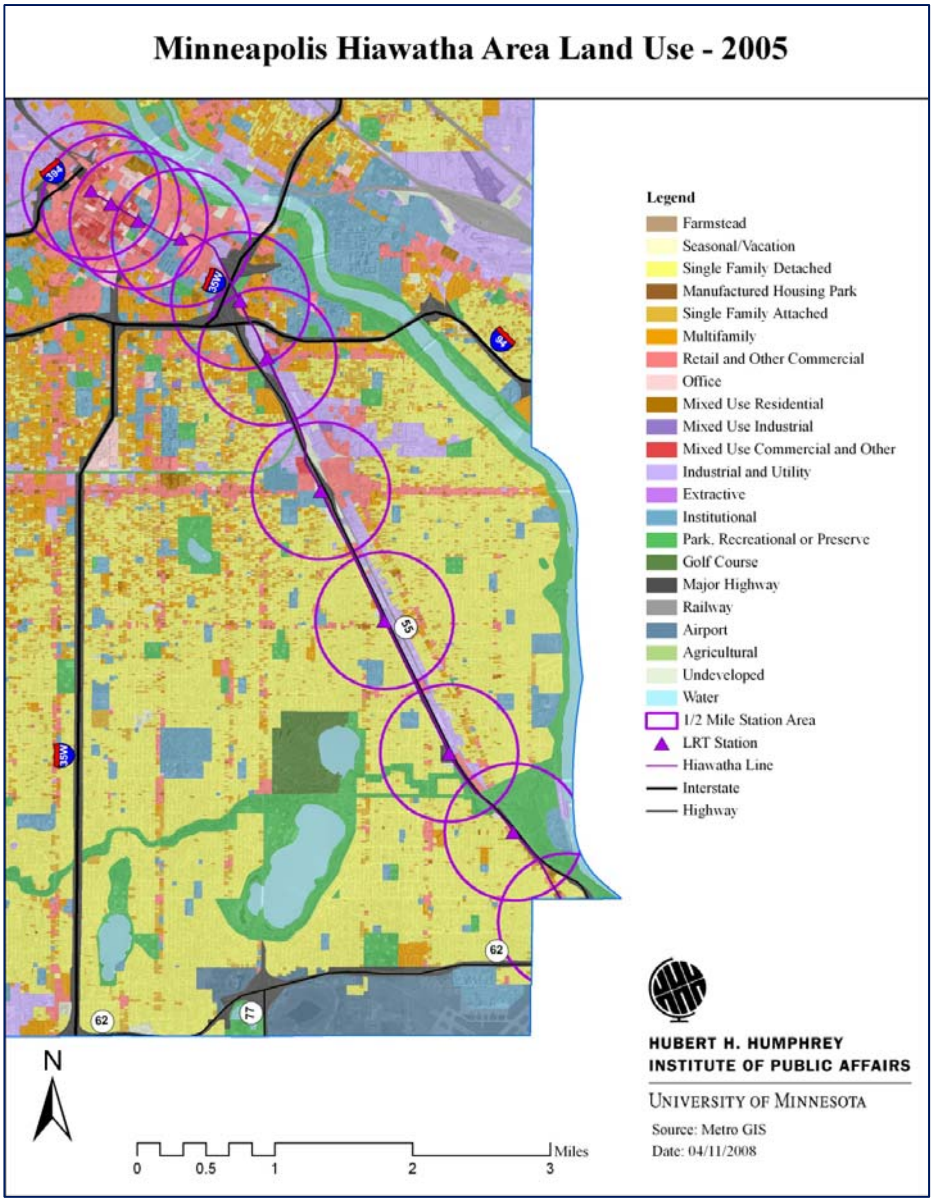
As elsewhere in this study, station areas are defined by a half-mile radius from the station and by a quarter-mile radius. Because the land area defined by a half-mile radius is four times that defined by a quarter-mile radius, localized land use changes may be swamped if the study area is defined by the half-mile radius. Furthermore, Calthorpe (1993) indicates that the typical transit-oriented-development (TOD) project is within 2000 feet of a transit stop, i.e., midway between one-quarter and one-half mile. Use of the quarter-mile radius will allow us to measure land use changes that might be directly associated with transit-oriented development, while analysis at the half-mile radius will capture broader land use changes that might be induced by TOD.

Analysis

In Part 3 we profiled the 17 Hiawatha stations according to land use characteristics. We found that station areas divide into four different types based on land use characteristics. The north and south ends of the line are dominated by commercial districts of downtown Minneapolis and the Bloomington "Airport South" district (including the Mall of America). Just north of the Bloomington stops are four stations that are located in areas that are characterized by land uses that are either substantially or completely institutional. These are the two stops at the Minneapolis-Saint Paul International Airport, and the Fort Snelling and V.A. Hospital stations. Finally, there is a neighborhood corridor that runs from Franklin Avenue south to 50th Street.

Using land use data at five points in time allows us to establish the base rate of land use change along the corridor, and to assess the impact of the line on land use. In effect, the longitudinal analysis will be a time series that will compare land use prior to and after development of the Hiawatha Line. Our conservative estimate of the 'intervention point' for this analysis is to use construction of the line (2004) as the point at which we expect change to begin occurring. If we take this as the intervention point, then our land use data provides us with four time points pretest (1984, 1990, 1997, and 2000) and one observation posttest (2005).

Map 6.1: Land use along the Hiawatha Line, Minneapolis 2005

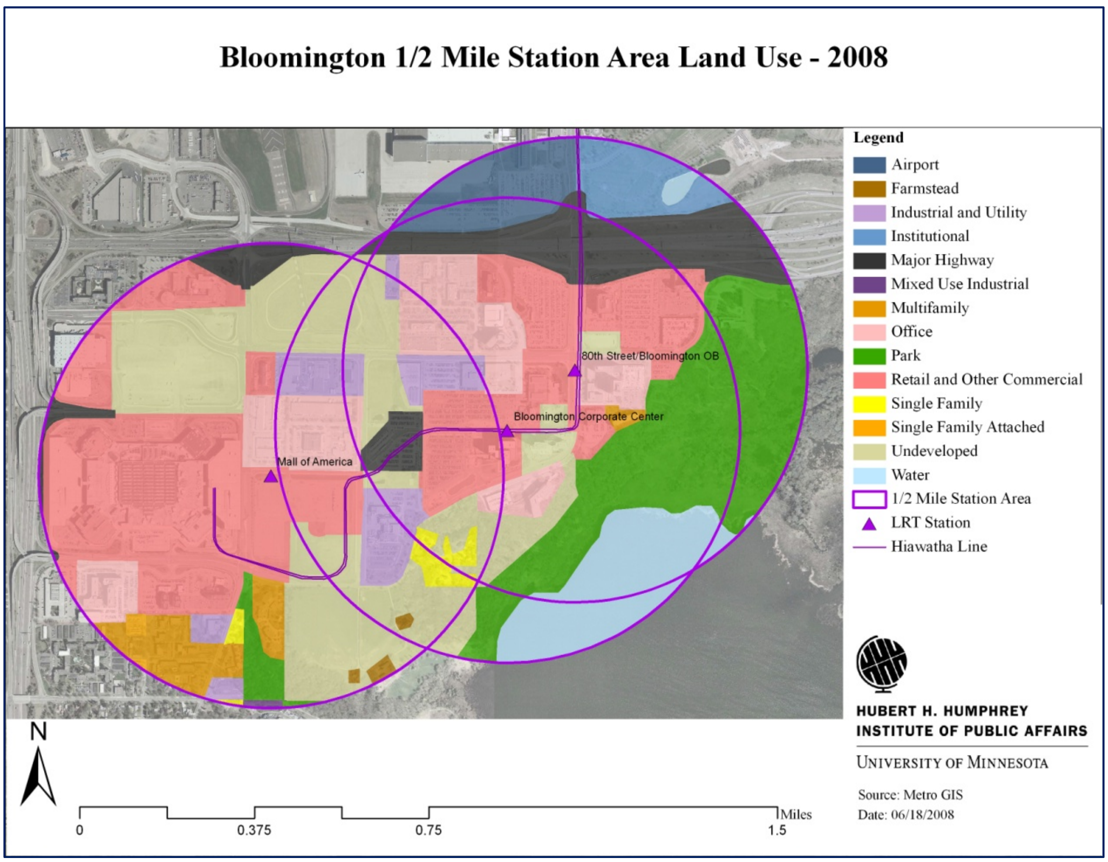


Bloomington

We begin by looking at land use changes in the Bloomington section of the line. Currently, three transit stops lay within the city of Bloomington; the 80th Street station, the Bloomington Central Station, and the southern terminus of the line, the Mall of America. The triangular area within which these stops are located is bounded by the Minnesota River and the river bluffs to the south and east, Interstate 494 and the Minneapolis-Saint Paul Airport to the north, and State Highway 77 / Cedar Avenue to the west. The area includes, of course, the massive Mall of America development.

At the time of the construction of the light rail line, there were significant amounts of undeveloped land in the area. Development was somewhat constrained by the airport to the north which limited residential development and dictated allowable heights and land use under the runway paths. Before 2005, this area was dominated by commercial land uses with lower floor-area ratios (FARs), and there was little residential land use.

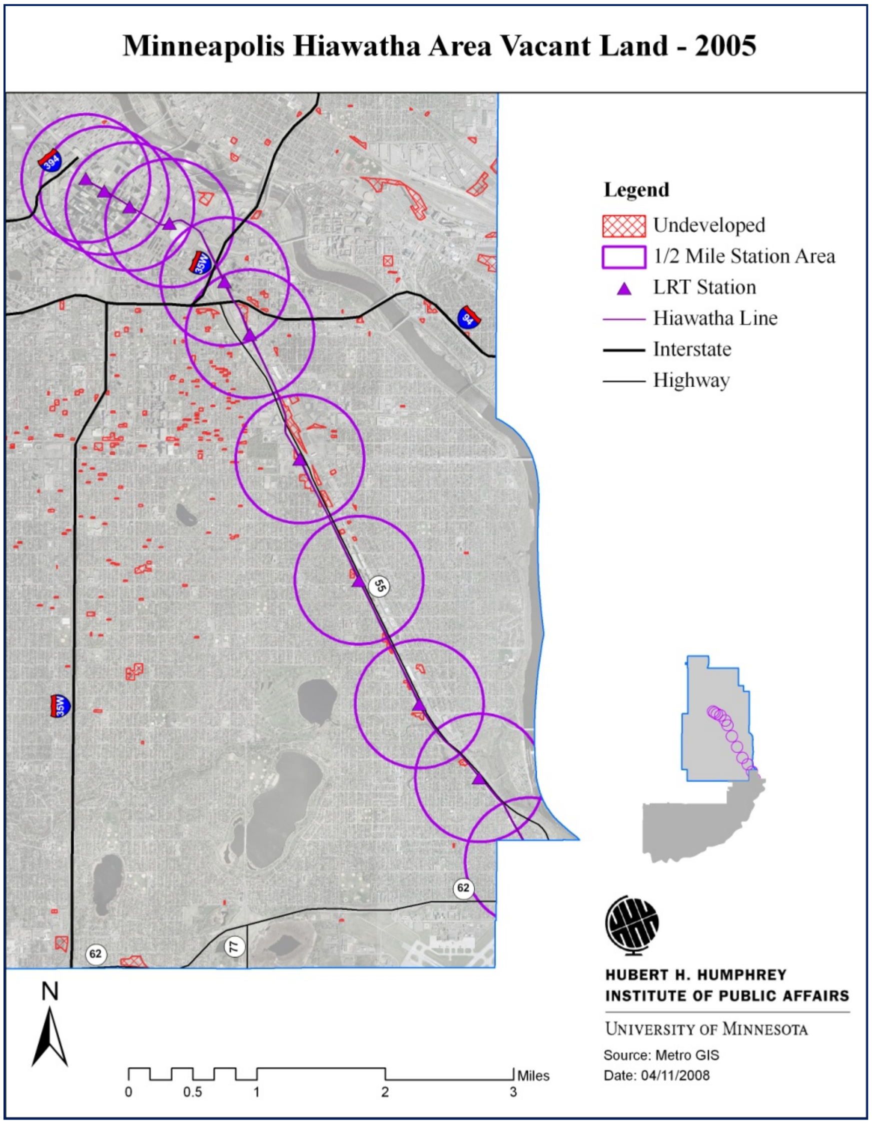
Map 6.2: Land use along the Hiawatha Line, Bloomington 2008



Development of a new runway at the Airport in 2005 resulted in significant changes in the area. A runway protection zone (RPZ) extends southward through the Bloomington South Airport District to American Boulevard (formerly 80th Street). Possible obstructions must be cleared, including three hotels, gas stations and other facilities. In addition, because of heightened noise due to the air traffic induced by the new runway, 161 residential units, ninety two of which were multi family, were purchased and demolished. The RPZ area was rezoned for office development.

Significant amounts of underutilized land remain in the Airport South district. Many of the lots are temporary long term airport parking legal under conditional use permits. There is clearly a desire on the part of developers and Bloomington to develop underutilized parcels, but current (2008) market and economic forces make development unfeasible.

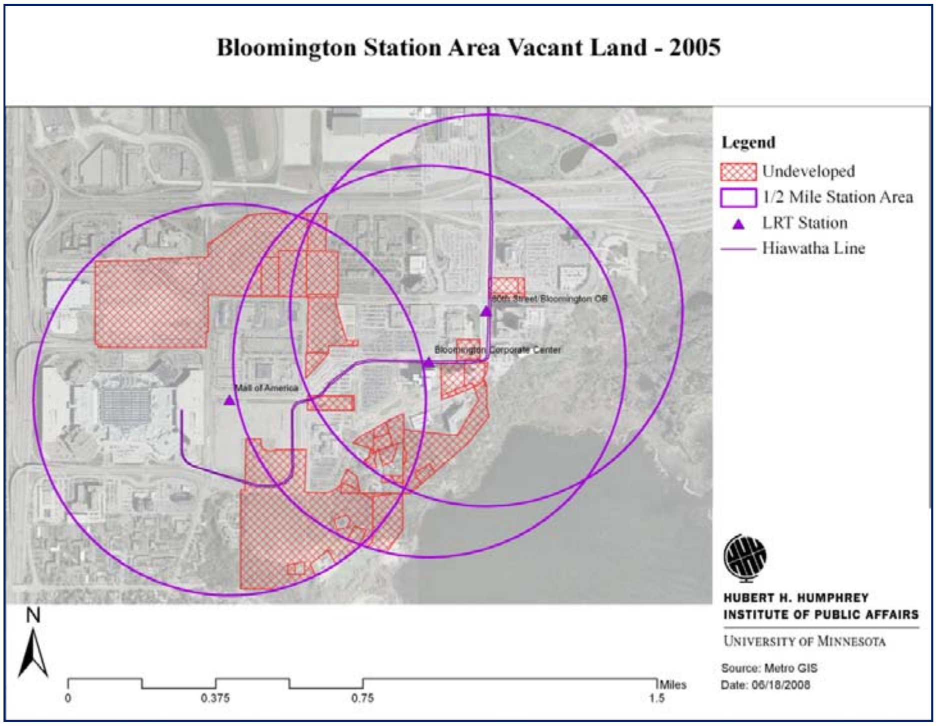
Map 6.3: Vacant land along the Hiawatha Line, Minneapolis 2005



Vacant Land

We measure land use change in four general ways. First, we measure the change in the percentage of land that is vacant and undeveloped. Our hypothesis is that the Hiawatha Line will result in land development that will reduce the amount of vacant and undeveloped land within the station areas. This is the most basic of our measurements and change is imputed regardless of the type of development that occurs on previously vacant land.

Map 6.4: Vacant land along the Hiawatha Line, Bloomington 2005



Maps 6.3 and 6.4 show significant differences in the amount of undeveloped land across station areas. Most of the station areas, in fact, have very little undeveloped land. Ten of the 17 station areas have either no undeveloped land or such land accounts for less than 1 percent of the total area in 2005 (see tables 6.1 and 6.2). The three Bloomington station areas (80th Street, Bloomington Corporate Center, and Mall of America) have the highest percentages of land undeveloped. The Bloomington Corporate Center has the highest percentage of undeveloped land within a one-quarter mile radius (18.25%) and the Mall of America has the highest percentage of vacant land within the full half-mile radius (31.67%). Among the rest of the station areas only Franklin Avenue and Lake Street have sizable amounts of vacant land. Downtown Minneapolis and the four stops from the Veteran's Medical Center to the Humphrey Terminal of the airport have no vacant land.

For most station areas there is little different in the amount of vacant land whether using the quarter- or half-mile radius. The major exception to this is the Mall of America where the percent vacant land doubles when one moves from the quarter- to half-mile scale. For Franklin Avenue and Lake Street, the percent vacant decreases slightly as the study area is increased from the quarter- to the half-mile radius.

Table 6.1: Vacant land in half-mile station areas, 2005

Vacant land in station areas, 1984 – 2005 (1/2 mile radius)						
Station Area	1984	1990	1997	2000	2005	2k-'05 Δ
Warehouse district	2.84%	6.91%	4.18%	1.26%	0.05%	-1.21%
Nicollet Mall	2.46%	3.83%	0.99%	1.67%	0.00%	-1.67%
Government Plaza	1.58%	0.55%	0.32%	1.55%	0.00%	-1.55%
Downtown East - Metrodome	0.45%	0.24%	1.03%	3.10%	0.81%	-2.29%
Cedar Riverside	0.27%	0.27%	1.13%	5.31%	2.17%	-3.14%
Franklin Avenue	0.00%	0.00%	1.89%	6.03%	2.99%	-3.04%
Lake Street	5.61%	4.06%	2.96%	6.20%	5.38%	-0.82%
38th Street	6.32%	6.32%	3.45%	2.71%	0.60%	-2.11%
46th Street	5.17%	4.31%	2.60%	1.97%	0.87%	-1.10%
50th Street	0.40%	0.40%	0.73%	0.93%	0.25%	-0.68%
V.A. Medical Center	0.85%	0.85%	0.91%	6.25%	0.00%	-6.25%
Fort Snelling	0.00%	0.00%	0.00%	0.80%	0.00%	-0.80%
Lindbergh Terminal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Humphrey Terminal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
28th Ave. Station	19.93%	9.12%	0.84%	6.30%	10.47%	4.17%
Bloomington Corporate Center	24.64%	17.81%	5.93%	12.13%	18.24%	6.11%
Mall of America	27.60%	47.09%	12.68%	15.87%	31.66%	15.79%
All Stations	5.13%	5.93%	2.46%	3.75%	3.80%	0.04%

Table 6.2: Vacant land in quarter-mile station areas, 2005

Vacant land in station areas, 1984 – 2005 (1/4 mile radius)						
Station Area	1984	1990	1997	2000	2005	2k-'05 Δ
Warehouse district	4.15%	6.41%	0.00%	0.00%	0.00%	0.00%
Nicollet Mall	4.15%	0.00%	0.00%	0.00%	0.00%	0.00%
Government Plaza	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Downtown East - Metrodome	0.00%	0.00%	0.96%	0.00%	0.00%	0.00%
Cedar Riverside	0.00%	0.00%	3.61%	4.56%	1.67%	-2.89%
Franklin Avenue	0.00%	0.00%	1.14%	13.29%	5.06%	-8.23%
Lake Street	13.78%	4.48%	3.60%	7.40%	8.70%	1.30%
38th Street	11.15%	11.15%	6.29%	4.49%	0.95%	-3.54%
46th Street	11.22%	9.32%	7.76%	6.97%	1.95%	-5.03%
50th Street	0.00%	0.00%	1.12%	0.99%	0.99%	0.00%
V.A. Medical Center	0.52%	0.52%	0.52%	17.91%	0.00%	-17.91%
Fort Snelling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Lindbergh Terminal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Humphrey Terminal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
28th Ave. Station	33.08%	11.34%	0.00%	1.86%	9.31%	7.45%
Bloomington Corporate Center	13.43%	9.66%	2.65%	12.80%	18.25%	5.45%
Mall of America	43.37%	72.16%	9.14%	9.11%	15.07%	5.96%
All Stations	8.13%	7.99%	2.42%	5.03%	3.53%	-1.50%

Between 2000 and 2005 for both station sizes, V.A. Medical Center and the three most southern stations encountered the most change in vacant land use. The V.A. Medical Center station reduced its vacant land by 6.25 percentage points and 17.91 percentage points in the half mile radius and the quarter mile radius buffers, respectively. In contrast the MOA, Bloomington Central, and 28th Avenue stations experienced increases in vacant land use.

Figure 6.1: Changes in vacant land within quarter-mile station areas

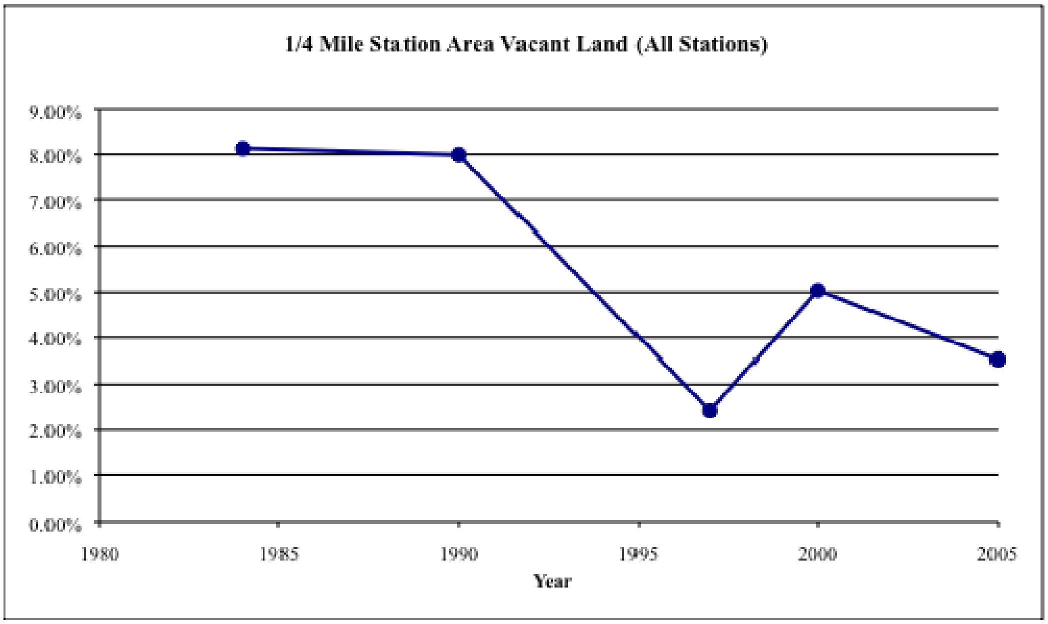
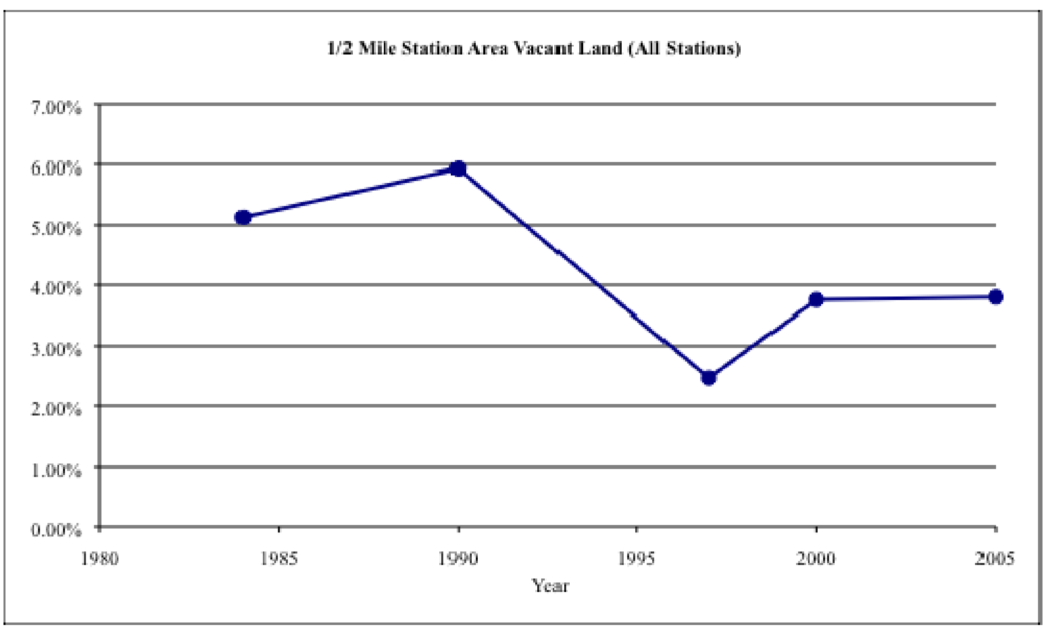


Figure 6.2: Changes in vacant land within half-mile station areas



In 2005, the percentage of vacant land remain about the same for the half-mile radius, except for the MOA station—which is 31% vacant at the half-mile scale and only 15% vacant at the quarter-mile.

Overall, vacant land decreased along the line from 2000 to 2005. It is important to note that while there was a change in vacant land in the downtown station areas, the market forces in the urban core incorporate far more than light rail. The Bloomington station areas, on the other hand, show an increase in vacant land from 2000 to 2005. Bloomington's increase in vacant land is likely due to the redevelopment taking place that requires demolition of underused and obsolete parcels. The neighborhood stations of South Minneapolis underwent a decrease in vacant land between 2000 and 2005, partially due to the construction of light rail freeing up land held by public agencies as part of a right of way for future highway construction. It is difficult to discern any overall and consistent pattern across all station areas.

Intensity

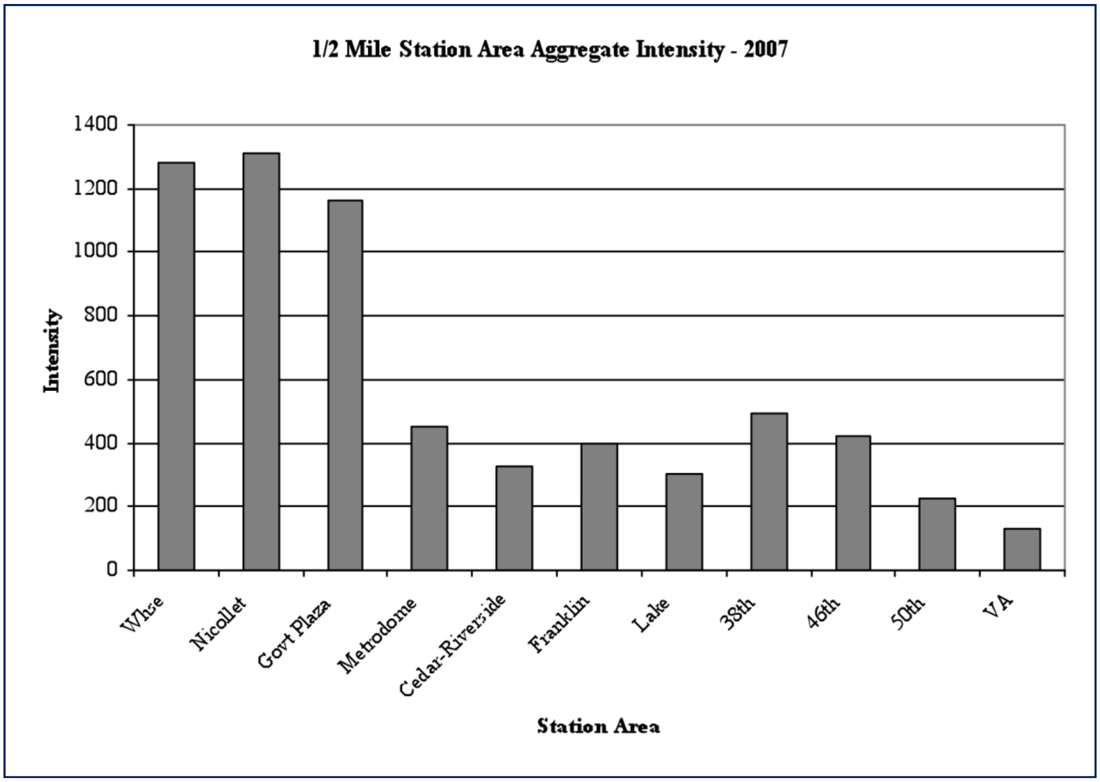
Our second measure of land use change focuses on the intensity of land use. Though the development of previously-vacant land (examined in our previous analysis) can be seen as an indicator of intensification of land use, our measure of land use intensity is a more direct and comprehensive measure of the degree to development is concentrating around station areas. We calculate an intensity-of-use ratio for each parcel and for each station area. This is defined for each parcel as the ratio between the square footage of the built structure and the square footage of the land parcel. The land use intensity measure for each station area is the ratio produced by the sum of each factor for each parcel;

$$\frac{\sum_{i=1}^{n} \mathrm{B}_i}{\sum_{i=1}^{n} P_i} \qquad (6.6)$$

where B = building square footage for parcel *i*, and
P = parcel square footage for parcel *i.*

Figure 6.3 presents data on land use intensity. The data show, predictably enough, that the downtown station areas are characterized by very intensive land use, especially when compared to the station areas from the Downtown East/Metrodome station to 50th Street. The Downtown East/Metrodome and Cedar-Riverside station areas have a lower than expected intensity measurement due to the high number of surface parking lots and freeways in the area. The 50th Street and VA Center stations show the lowest intensity use. The 38th street station area has the highest intensity measure south of Government plaza, perhaps due to the relative lack of large parking lots and other open spaces.

Figure 6.3: Land use intensity within half-mile station areas

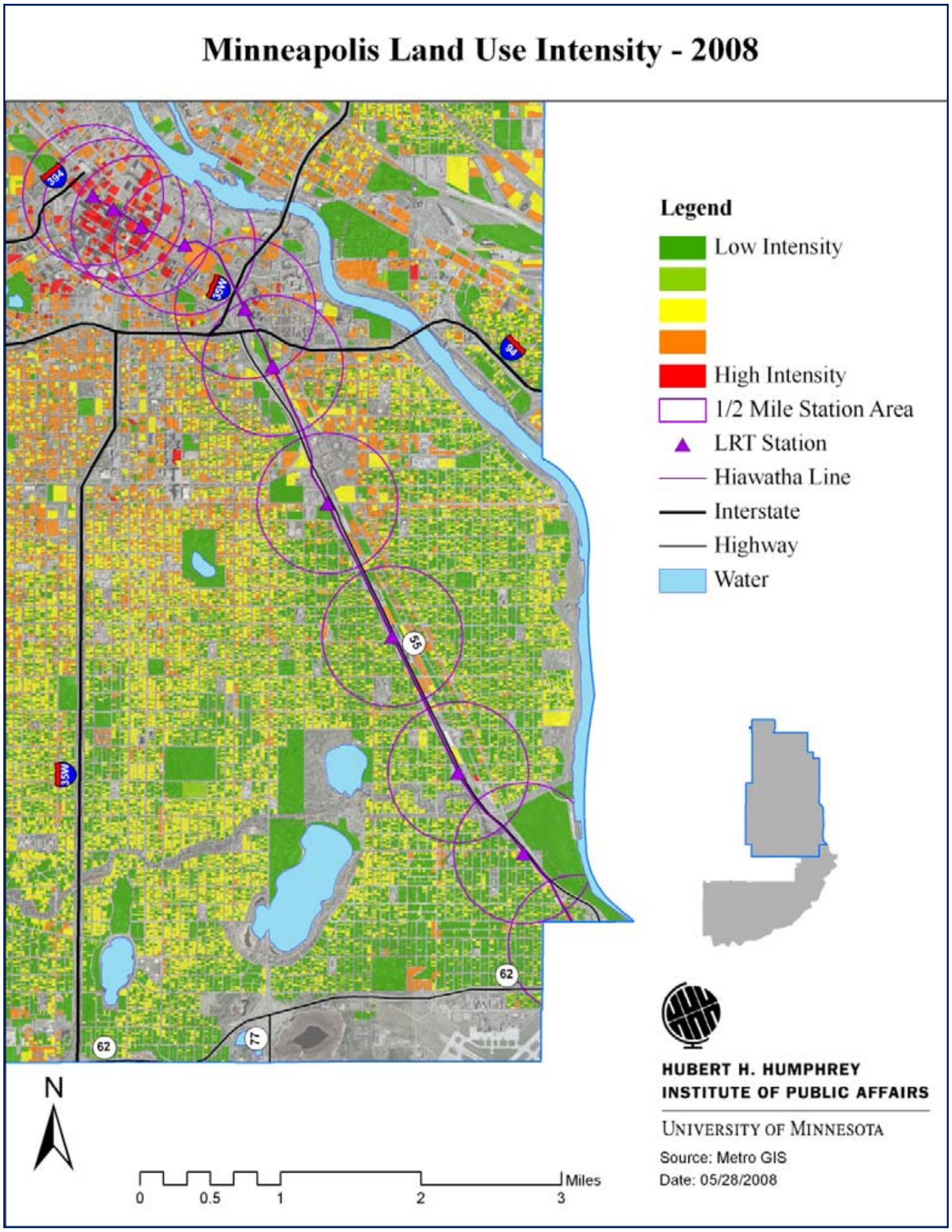


Map 6.5 shows the spatial distribution of land use intensity along the Minneapolis portion of the Hiawatha Line. Outside of the downtown area the majority of the intense land use along the Hiawatha corridor is along the east side of Hiawatha Avenue or north of Lake Street. South of Lake Street there is very little land use intensity on the western side of Hiawatha. The eastern side shows a long narrow band of high-intensity land use that corresponds to industrial and warehouse uses as well as numerous grain elevators.

If the Hiawatha Line were inducing greater land use intensity around station areas we would expect to see a negative correlation between land use intensity and distance to station area for buildings constructed (or modified) since 2004.

Unfortunately, our data on land use intensity includes very few buildings constructed after the completion of the Hiawatha Line in 2004. As a result we are unable to document significant pre- to post-LRT changes in land use intensity. At best, these data can serve as baseline for further investigation at a later date.

Map 6.5: Land use intensity along the Hiawatha Line, Minneapolis 2008



Predominant Use
Our third measure of land use change is to examine predominant land uses, noting whether the primary land use characteristic of the station area has changed over time. This measure is simply a ranking of land uses by percentage of land area.

There are total of 10 main land use types (see detailed definitions in Appendix A) that we are considering in our analysis. Using the half-mile radius, the predominant type of land use along the entire line for all five time points is single-family residential (see table 6.3).

Table 6.3: Predominant land use within half-mile station areas

Land Use for all station areas - 1/2 mile radius					
Land Use	**1984**	**1990**	**1997**	**2000**	**2005**
Residential - Single Family	19.63%	19.53%	17.26%	17.23%	17.17%
Residential - Mulit Family	4.84%	4.84%	6.51%	6.81%	7.46%
Commercial	13.75%	13.36%	18.75%	18.35%	16.85%
Industrial	11.74%	10.91%	7.00%	6.72%	6.58%
Public / Institutional	16.95%	16.95%	17.92%	15.15%	14.49%
Airport	14.71%	14.71%	14.78%	14.11%	14.15%
Recreation	6.92%	6.88%	7.52%	9.44%	9.49%
Vacant	5.13%	5.93%	2.46%	3.75%	3.80%
Highway	4.07%	4.63%	5.56%	6.18%	7.75%
Water	2.25%	2.25%	2.23%	2.26%	2.26%

Using the quarter-mile radius definition of station area, we see that commercial land use is the most prominent since 1990 (see table 6.4). Public and institutional land was the largest category in 1984, though by less than one percentage point over commercial land. Since then there has been a significant increase in the relative prominence of commercial land. Commercial land is now almost twice as prominent as any other single land use category within a quarter-mile radius of Hiawatha station areas.

Table 6.4: Predominant land use within quarter-mile station areas

Land Use for all station areas - 1/4 mile radius					
Land Use	**1984**	**1990**	**1997**	**2000**	**2005**
Residential - Single Family	12.12%	11.95%	10.16%	10.16%	10.03%
Residential - Mulit Family	3.53%	3.52%	5.05%	5.13%	5.59%
Commercial	19.29%	20.73%	30.44%	31.22%	30.16%
Industrial	13.10%	11.84%	6.43%	6.17%	5.72%
Public / Institutional	20.23%	20.18%	19.59%	16.77%	16.67%
Airport	11.21%	11.19%	11.35%	10.97%	10.97%
Recreation	6.55%	6.44%	7.52%	5.99%	5.89%
Vacant	8.13%	7.99%	2.42%	5.03%	3.53%
Highway	5.84%	6.15%	7.05%	8.55%	11.43%

Importantly, however, these changes in the predominant land use along the line occurred prior to the completion of the line. Most of them occurred well before even full funding of the line. Thus, it is not possible to tie these changes to the development of the Hiawatha LRT.

Table 6.5 shows the predominant use for each station area over the five time points of the study (the top two land uses are listed for each station). There is remarkable stability for the quarter-mile radius. Only two station areas show a change in the predominant land use over the study period, the Metrodome station and Franklin Avenue. For the

Metrodome station area the predominant land use shifted from industrial to institutional and then to commercial.

Table 6.5: Predominant land use by quarter-mile station area

Predominant land uses in station areas, 1984 – 2005 (1/4 mile radius)					
Station Area	1984	1990	1997	2000	2005
Warehouse district	54% C 26% I	67% C 14% Inst.	84% C 8% Hwy	83% C 8% Hwy	83% C 8% I
Nicollet Mall	68% C 22% Inst.	73% C 22% Inst.	83% C 14% Inst.	85% C 12% Inst.	85% C 11% Inst.
Government Plaza	62% C 21% Inst.	62% C 21% Inst.	75% C 23% Inst.	71% C 25% Inst.	70% C 25% Inst.
Downtown East - Metrodome	51% I 39% Inst.	51% I 39% Inst.	49% Inst. 47% C	71% C 26% Inst.	69% C 26%Inst.
Cedar Riverside	50% Hwy 33% R-mf	50% Hwy 33% R-mf	46% Hwy 21% R-mf	46% Hwy 22% R-mf	46% Hwy 23% R-mf
Franklin Avenue	34% I 28% Hwy	34% I 28% Hwy	27% I 23% Hwy	22% R-mf 22% Hwy	22% Hwy 22% I
Lake Street	36% C 29% I	45% C 29% I	43% C 22% I	36% C 20% Inst.	38% C 21% Inst.
38th Street	55% R-sf 24% I	55% R-sf 24% I	49% R-sf 22% I	50% R-sf 22% I	51% R-sf 21% I
46th Street	58% R-sf 20% I	55% R-sf 22% I	45% R-sf 17% I	45% R-sf 17% I	45% R-sf 15% I
50th Street	52% Rec. 44% R-sf	52% Rec. 44% R-sf	51% Rec. 42% R-sf	48% Rec. 40% R-sf	44% Rec. 39% R-sf
V.A. Medical Center	89% Inst. 8% R-sf	89% Inst. 8% R-sf	89% Inst. 8% R-sf	69% Inst. 18% V	67% Inst. 25% Hwy
Fort Snelling	87% Inst. 8% Hwy	87% Inst. 8% Hwy	86% Inst. 9% Hwy	79% Inst. 8% Hwy	76% Inst. 16% Hwy
Lindbergh Terminal	100% Air	100% Air	100% Air	100% Air	100% Air
Humphrey Terminal	66% Air 34% Inst.	66% Air 34% Inst.	67% Air 33% Inst.	67% Air 33% Inst.	67% Air 33% Inst.
80th Street	44% C 33% V	69% C 16% Rec.	78% C 16% Rec.	79% C 11% Rec.	71% C 13% Rec.
Bloomington Corporate Center	57% C 28% Rec.	64% C 24% Rec.	64% C 32% Rec.	73% C 13% V	61% C 18% V
Mall of America	43% C 43% V	72% V 15% C	85% C 9% V	84% C 9% V	75% C 15% V

All of these shifts pre-date completion of the Hiawatha Line. The predominant land use around the Franklin station shifted from industrial to multifamily housing to roads and highways. Only the last of these took place during the period when construction of the Hiawatha Line occurred.

There is similar stability at the half-mile scale. Only the Cedar-Riverside station area saw a shift in the predominant land use at this scale, shifting from predominantly multifamily housing to highways and back to multifamily housing. These shifts occurred both prior to the period of LRT construction and during construction.

Table 6.6: Predominant land use by half-mile station area

Predominant land uses in station areas, 1984 – 2005 (1/2 mile radius)					
Station Area	1984	1990	1997	2000	2005
Warehouse district	44% C 40% I	49% C 28% I	61% C 15% I	58% C 16% I	59% C 14% I
Nicollet Mall	51% C 29% I	56% C 21% I	73% C 14% Inst.	69% C 15% Inst.	70% C 15% Inst.
Government Plaza	52% C 21% I	53% C 20% I	71% C 20% Inst.	70% C 16% Inst.	68% C 16% Inst.
Downtown East - Metrodome	35% I 29% C	35% I 29% C	48% C 23% Inst.	50% C 17% Inst.	49% C 18% Inst.
Cedar Riverside	30% R-mf 27% Hwy	30% R-mf 27% Hwy	25% Hwy 23% Inst.	24% Hwy 22% R-mf	24% R-mf 24% Hwy
Franklin Avenue	34% R-mf 17% Hwy	34% R-mf 17% Hwy	32% R-mf 16% Hwy	30% R-mf 16% Hwy	31% R-mf 16% Hwy
Lake Street	34% I 30% R-sf	34% I 30% R-sf	29% I 21% R-sf	23% I 21% R-sf	21% I 21% R-sf
38th Street	71% R-sf 12% I	71% R-sf 12% I	65% R-sf 12% I	65% R-sf 11% I	67% R-sf 10% I
46th Street	69% R-sf 14% Rec.	69% R-sf 14% Rec.	60% R-sf 14% Rec.	60% R-sf 14% Rec.	61% R-sf 14% Rec.
50th Street	48% R-sf 36% Rec.	48% R-sf 36% Rec.	45% R-sf 34% Rec.	44% R-sf 33% Rec.	44% R-sf 32% Rec.
V.A. Medical Center	53% Inst. 25% R-sf	53% Inst. 25% R-sf	51% Inst. 24% R-sf	36% Inst. 23% R-sf	30% Inst. 23% R-sf
Fort Snelling	74% Inst. 13% Air	74% Inst. 13% Air	72% Inst. 13% Air	57% Inst. 24% Rec.	51% Inst. 24% Rec.
Lindbergh Terminal	97% Air 3% Inst.	97% Air 3% Inst.	97% Air 3% Inst.	97% Air 3% Inst.	97% Air 3% Inst.
Humphrey Terminal	69% Air 31% Inst.	69% Air 31% Inst.	70% Air 30% Inst.	70% Air 30% Inst.	70% Air 30% Inst.
80th Street	31% Rec. 24% C	32% C 30% Rec.	35% C 30% Rec.	36% C 23% Rec.	30% C 23% Rec.
Bloomington Corporate Center	30% C 26% Rec.	37% C 24% Rec.	47% C 27% Rec.	45% C 15% Rec.	36% C 18% V
Mall of America	56% C 28% V	47% V 37% C	67% C 13% V	64% C 16% V	46% C 32% V

Land Use Mix

Our final look at land use change is to measure the degree of diversity in land use within the station areas and to chart changes across the five time points. As described earlier various indices have been developed to measure land use diversity. We calculate three of these and apply them to the station areas along the Hiawatha Line; Ramanjani's diversity index, Cervero's entropy index, and the Simpson index. In addition, we use a simpler measure of mix, the percentage of a station area's land that is accounted for by the two most prevalent land uses.

Tables 6.5 and 6.6 present the data on the most prevalent land uses at each station over the study period. So for example, in 1984 the top two land uses accounted for 80 percent of the land within a quarter-mile of the Warehouse district station (table 6.5). In 2005, the two largest land uses accounted for 91 percent of the station area. This suggests a trend toward less land use diversity over the study period, although examination of the table shows that this change occurred entirely within one time period – between 1990 and 1997. There has been no change since construction of the LRT line. At the half-mile scale the pattern is different; the top two land uses in the Warehouse station area accounted for 88 percent of the land in 1984 but only 73 percent in 2005. This suggests an increase in land use diversity over time. Again, however, virtually all of this change occurred prior to 2000, indicating that it is not related to the development of the LRT line.

The Franklin Avenue station area (in 2005) has a much greater mix of land use; the two most prevalent land uses account for less than one-half of the full station area, both at the quarter-mile and half-mile scale. But for this station area, too, there has been no change in the level of diversity since 2000. Overall, the data in tables 6.5 and 6.6 show a range of diversity between station areas, and some change over time. However, there is no systematic change in land use diversity that can be convincingly connected to the development of the Hiawatha Line.

Tables 6.7 through 6.9 provide the year-by-year, station-by-station diversity index numbers at the quarter-mile scale for the diversity, entropy, and Simpson indices. These indices reinforce the distinction between the downtown and institutional stations, with very little diversity of land use, from the rest of the station areas. At the quarter-mile scale we see a decline in the diversity of land use around the downtown Minneapolis station areas. This pattern, that takes shape over the 20 years of the study period, is not seen at the half-mile scale where the diversity indices show little change over time in the downtown stations (data not shown).

The greatest diversity is seen in the Cedar-Riverside, Franklin Avenue, and Lake Street station areas. For all station areas except 38th and 46th Street, the degree of land use diversity is greater at the half-mile scale than it is within one quarter-mile of the light rail stop. Both the 38th Street and 46th Street station areas incorporate large single family neighborhoods at the half-mile scale, and this reduces the overall mix of land uses when moving outward from the station.

Overall we are unable to identify significant changes in land use at either the quarter-mile or half-mile scale that can be attributed to the development of the Hiawatha Line. Though the previous analysis of new construction (part 5) identified small scale concentrations of new construction along the Hiawatha Line, the larger scale analysis of quarter-mile and half-mile stations areas showed no larger systematic changes in land use in the corridor. There are two plausible explanations for the lack of findings. First, our last observation for the land use data is 2005, only one year after completion of the Hiawatha Line. This interval may be too short to allow for much significant land use change. Given zoning restrictions, the process of changing land uses is typically a prolonged one. Applications for and approval of zoning variances require a significant amount of time to work their ways through the system. Thus, it is reasonable to expect that the first changes to manifest themselves in a given station would be investments that do not require land use changes and the regulatory approval that those changes require.

Table 6.7: Land use entropy by quarter-mile station area

Land Use Entropy: 1/4 Mile Station Area					
	1984	1990	1997	2000	2005
Warehouse District	0.74	0.62	0.35	0.38	0.37
Nicollet Mall	0.56	0.64	0.49	0.37	0.38
Government Plaza	0.70	0.70	0.44	0.48	0.49
Metrodome	0.71	0.71	0.62	0.65	0.57
Cedar Riverside	0.71	0.71	0.74	0.75	0.73
Franklin Avenue	0.84	0.84	0.85	0.91	0.88
Lake Street	0.91	0.83	0.82	0.89	0.87
38th Street	0.82	0.82	0.74	0.74	0.72
46th Street	0.72	0.73	0.84	0.79	0.78
50th Street	0.63	0.63	0.51	0.58	0.62
V.A. Medical Center	0.27	0.27	0.24	0.53	0.54
Fort Snelling	0.43	0.43	0.45	0.54	0.63
Lindbergh Terminal	*	*	*	*	*
Humphrey Terminal	0.93	0.93	0.91	0.91	0.91
80th Street	0.73	0.58	0.42	0.44	0.60
Bloomington Central Station	0.75	0.68	0.50	0.52	0.60
Mall of America	0.73	0.58	0.39	0.37	0.46
All Stations	0.94	0.94	0.89	0.91	0.91

Second, our review of the rezoning efforts of the City of Minneapolis (summarized at the beginning of Part 5), indicated that for many of the station areas the small area planning and rezoning process had not been completed. Large scale land use changes will have to await the rezoning process, a process that remains on-going for many of the station areas.

Table 6.8: Simpson land use index by quarter-mile station area

Land Use Simpson Index: 1/4 Mile Station Area					
	1984	1990	1997	2000	2005
Warehouse District	0.63	0.52	0.28	0.30	0.30
Nicollet Mall	0.48	0.41	0.29	0.26	0.27
Government Plaza	0.55	0.55	0.38	0.44	0.44
Metrodome	0.58	0.58	0.54	0.43	0.45
Cedar Riverside	0.63	0.63	0.71	0.71	0.71
Franklin Avenue	0.75	0.75	0.81	0.83	0.82
Lake Street	0.74	0.69	0.74	0.79	0.77
38th Street	0.62	0.62	0.69	0.68	0.67
46th Street	0.61	0.62	0.74	0.74	0.73
50th Street	0.54	0.54	0.57	0.61	0.64
V.A. Medical Center	0.19	0.19	0.19	0.49	0.49
Fort Snelling	0.23	0.23	0.25	0.37	0.38
Lindbergh Terminal	0.00	0.00	0.00	0.00	0.00
Humphrey Terminal	0.45	0.45	0.44	0.44	0.44
80th Street	0.66	0.48	0.36	0.36	0.47
Bloomington Central Station	0.58	0.53	0.49	0.44	0.56
Mall of America	0.61	0.44	0.26	0.28	0.41
All Stations	0.86	0.86	0.83	0.83	0.83

Table 6.9: Land use diversity index by quarter-mile station area

Land Use Diversity Index: 1/4 Mile Station Area					
	1984	1990	1997	2000	2005
Warehouse District	0.53	0.51	0.35	0.36	0.36
Nicollet Mall	0.43	0.40	0.37	0.38	0.39
Government Plaza	0.48	0.48	0.35	0.36	0.37
Metrodome	0.48	0.48	0.39	0.38	0.40
Cedar Riverside	0.49	0.49	0.52	0.53	0.51
Franklin Avenue	0.58	0.58	0.63	0.70	0.65
Lake Street	0.66	0.59	0.65	0.70	0.66
38th Street	0.59	0.59	0.57	0.58	0.56
46th Street	0.57	0.56	0.69	0.63	0.63
50th Street	0.39	0.39	0.33	0.39	0.44
V.A. Medical Center	0.27	0.27	0.29	0.44	0.42
Fort Snelling	0.37	0.37	0.38	0.49	0.44
Lindbergh Terminal	*	*	*	*	*
Humphrey Terminal	0.20	0.20	0.20	0.20	0.20
80th Street	0.48	0.48	0.38	0.41	0.52
Bloomington Central Station	0.50	0.49	0.36	0.45	0.47
Mall of America	0.48	0.48	0.39	0.39	0.40
All Stations	0.76	0.76	0.70	0.73	0.73

Conclusion

There has been little systematic effect of the Hiawatha Line on the land use patterns of station areas. Measures of vacancy and undeveloped land, land use intensity, land use type, and diversity show modest levels of change over an extended period of time from 1984 and 2005. The changes that have occurred since 2000 however, are indistinguishable in scale or pattern from those that occurred in previous years. Our data on land use extends only to 2005, just one year after opening of the Hiawatha Line. It is likely that greater land use changes may occur in the future.

Few regulatory changes had been put in place by the city of Minneapolis by the time the line opened. While this may have constrained the rate of land use change, there are several additional reasons to believe that significant land use changes will emerge only after some time has elapsed. The development market changed significantly in 2007 with the advent of the financial crisis and the housing crash. Even without the constraints of a poor market, however, it would normally take years for developers to identify attractive sites for investment, assemble the necessary land, and secure financing and approval for the large scale projects that would alter land uses in the vicinity of station areas.

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