THE HIAWATHA LINE: SOCIAL AND
ECONOMIC IMPLICATIONS OF LIGHT RAIL
TRANSIT IN MINNEAPOLIS, MN ON SINGLE-
FAMILY DWELLINGS.

A RESEARCH PAPER SUBMITTED TO THE
GRADUATE SCHOOL IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
MASTER OF URBAN AND REGIONAL
PLANNING

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MAY 2013
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Introduction

The Midwest has seen widespread planning for the implementation of various rapid transit systems throughout the last decade. It has become increasingly clear to municipalities in large metropolitan areas that transit options other than highway and the outdated standard bus systems of the last half-century are desperately needed.

Light rail transit has existed in several different variations throughout the history of the United States, and has become the dominate form of urban rail transit since the expansion of subway and commuter rail systems in the 1970’s. In the Midwest, cities are increasingly turning to urban rapid transit systems as a source of economic and social revitalization.

This paper builds on the overwhelming significant works that have been conducted throughout the last several decades on economic impact of rapid transit systems, and contributes to the emerging analysis of social impacts of transportation in the social and transportation related sciences. This paper will expand on other works by including estimates of alternative transportation facilities, comparing the influence of rail-based infrastructure to the familiar Midwest highway infrastructure. Building on these existing works, regression models formulated to estimate the extent of the impact that LRT has on social and economic forces. These issues are explored in an area
of the country that is relatively new to rail-based transit, and lacking published research-
Minneapolis, MN. The findings from this research largely confirm other research,
demonstrating an observed increase in property values of single-family dwellings in
relation to proximity to LRT stations, as well as the temporal effect of these impacts.
However, an even higher observed increase in relation to critical highway infrastructure
was found. This research also indicated that LRT infrastructure in Minneapolis, MN does
not play a significant role in impacting socioeconomic position of neighborhoods that
surround rail stations. This is in contrast to highway infrastructure, which continued to
play a significant role in influencing socioeconomic position in study area neighborhoods
after LRT was built in Minneapolis.

This paper is structured in the following manner. First, an introduction to existing
literature is presented, followed by a brief overview and description of the study area. For
the social implications, a generalized linear regression model is formulated and the
results are presented. For the economic implications, a semi-logarithmic hedonic
regression model is formulated, and the findings are presented to the reader. The results
of the social implications regression model show built-environment influences on
socioeconomic position in relation to distance to properties within proximity to light rail
transit stations on the Hiawatha line. The results of the economic implications hedonic
regression model show price and distance influence on single-family residential
properties between the first year of operation in 2005, and after 5 successive years of
operation in 2010. The paper finishes with a discussion of the results, and the
implications to future transportation planning and public policy decisions.
Literature review

Analyzing the impact of rapid transit stations is not a new concept in urban planning. Since the 1970’s, many studies have emerged that analyze various transportation systems in several different cities using a variety of different methods to understand the influence that transportation systems have on their immediate neighborhoods, as well as the underlying causes. This paper has focused on two dynamics within transit neighborhoods: social and economic. These two dynamics are not mutually exclusive, there are some similarities in how they can both be described. The economic impact of transit stations describes a relationship in which the transportation system is influencing residential property values, as described in terms of monetary value. The social impact of transit stations is more abstract, and is best summarized as the relationship in how the transportation system is influencing the socio-demographic characteristics (income, education, employment, etc.) and is described in terms of the impact on the sum total of these characteristics. The later of these two dynamics has been researched in various levels of details, while the former has attracted less interest from researchers.

One of the oldest, and oft cited, works in research which analyzes the various impacts that transit stations have on surrounding neighborhoods is the *Evidence of Land*...

This study sought to understand the evidence behind the transit planning agencies rationale that the high initial costs of transit systems would be offset by the large amount of public benefits they created. At this time in the history of U.S. transit planning (1970’s), many agencies advocated that the construction of new transit systems would create, reorder, and enhance existing neighborhoods above and beyond what would have normally occurred had the transit system not been built. However, Knight and Trygg thought that these statements brought more questions than answers:

- Will a transit system promote an attraction of wealth or population from other regions?
- Do different transit technologies have different land use impacts?
- What different physical and policy settings have a significant bearing on these impacts?
- Can a regions development be focused or its average density increased by transit?
- Will declining central business districts be strengthened, or will suburbanization be increased by a new transit system?
- How quickly will any purported impacts appear?

Knight and Trygg found, through examining existing literature, that despite detailed reviews of various transit systems such as BART and Toronto, little transfer of wealth from other regions was occurring. In addition, in Toronto where a $15 billion increase in tax assessment occurred over a 10 year period, $10 billion was directly attributed to the transit system that was built. However, the studies failed to identify other factors that may influence the development within central business districts. When
compared to other Canadian cities within the same time period, many of them with no transit or plans for developing transit in the future, experienced similar or larger growth rates within their central business districts. At the time of Knight and Tyrgg’s study, they found no studies examining the impacts between alternative modes of transit. The authors called for an increase in the amount of research that should be devoted to identifying the impact differences between commuter rail, subway, light rail, and express bus. However, the authors acknowledged that there were not enough cases present in (1970’s) North America to compare the impact advantages of various transit system types. In many respects, the United States today is in a similar position, surface based rail transit (light rail) is the predominate method of new transit systems being developed in the United States, there are very few examples of its alternative, Bus Rapid Transit, that exist in a pure and complete form.

Knight and Tyrgg found that there were four factors that are important determinants of the degree of impacts that new transit systems exhibit:

- Local government policies that encourage the desired development must exist for success.
- Regional development trends will continue to influence the extent of impact.
- There must be sufficient amount of available land for infill development.
- The development of the site will be constrained to local environmental factors (river, slope, etc.).

Knight and Tyrgg end their paper with a warning to planners to avoid claiming that transit systems will provide massive gains in property tax revenue, or will
significantly improve regional growth. While rapid transit will not automatically
revitalize and reshape our existing cities and neighborhoods, rapid transit can provide
many benefits, but planners must be willing to learn the true role of the transit system and
the other factors that must be in place to ensure a successful community transformation
(Knight and Tyrrg, 1977).

Another paper, *The Blue Line Blues: Why the Vision of Transit Village May Not*
and Banerjee, sought to understand the real barriers to growth around transit stations on
the blue-line corridor in Los Angeles, CA. The authors sought to demonstrate that social,
economic, and institutional barriers can continue to inhibit Transit Oriented Development
(TOD) despite strong ridership growth within the corridor. Loukaitou-Sideris and
Banerjee found that the Blue line was placed in an area of non-functional land in Los
Angeles County, and prior to construction had no positive physical characteristics to help
promote the desired change. The line avoided connecting existing commercial centers
and weaved between the back lots of industrial areas, an exception was two bus terminals
in downtown Los Angeles and Long Beach. The Blue Line had violated two of the
fundamental rules of mass transit: connect people and activities. The authors also found
that there was not sufficient density within close proximity of transit stations. Typically,
the land surrounding the stations was left undeveloped, and density increased as the
distance from the transit station increased.

The stations were highly inaccessible for neighborhoods where blue-line transit
stations were located, lacking any type of feeder or shuttle bus transit service to bring
potential riders to the station. Additionally, many stations were only accessible by vehicle
and once arrived, lacked any type of sufficient park and ride or kiss and ride capability. The absence of viable methods of accessing the transit line in general, contributed to the failure of this particular line. Despite 10 years of operation, the line had not contributed to any significant new development near or around transit stations within the inner city of Los Angeles.

Like Knight and Tyrgg, they found that despite the planner’s best efforts, little in the way of significant community changes will occur unless changes to local policy occur. Among these include:

- Regional planning that links various communities, rather than one attraction to another attraction.
- An urban design plan that treats the transit station as a part of the community.
- Identification of assets or the promotion of enterprise zones to stimulate developments.
- Community involvement.
- Powerful economic incentives to attract new development.
- A public agency that leads and coordinates several different agencies to achieve these goals (Loukaitou-Sideris and Banerjee, 2000).

Much of the literature has been in agreement that transit systems alone cannot influence enough impact, by themselves, to significantly improve communities or transform the economic and social vitality of the entire region. How we measure the social and economic effects of transit stations is important to understanding how planners and researchers are determining the success of a given transit corridor.
When it comes to understanding the social impact of transit corridors, the literature is relatively scarce, and much of the research has focused on the analysis of independent, tract-level socio-demographic data to analyze these changes. While these methods are ideal for determining the change in individual attributes of socioeconomic position, they fail to capture the holistic nature of what socioeconomic position is: a combination of several different attributes that determine a neighborhood's position relative to the region. Similar to a scenic view, it is difficult to gain an appreciation of the totality of the scene if the viewer only focuses on the individual tree, and ignores the mountain in the background and the stream running through the forest.

Determining the social impact of transportation is an increasingly emerging field of study in transportation related research, and is constantly evolving. However, social impact analysis takes a back seat when compared to the abundance of information on economic and environmental impacts of transportation, and transit specifically. In assessing the social impacts, there is no definitive agreement in the academic or public policy world about what is considered a social impact. Additionally, there has been no agreement in the academic world as to what are the most appropriate ways to assess social impacts. Many qualitative and quantitative methods that have been used academically, and the analysis scale has involved macro and micro level analysis, while overlapping with approaches that have commonly been used in the assessment of economic, health, and environmental impacts of transportation.

In the United States, the social impact of transportation is of relatively minor consideration. It is of no surprise that, when compared to the United Kingdom and Europe, there has been more volume in this area of study, especially with public policy
support through the passage of the Equality Act of 2010 and the 2011 Public Sector Duty which requires the consideration of several social and/or equity impact concerns. Several considerations of what social impact actually means, classified into the following (Markovich and Lucas, 2011):

1.) Fatalities and injuries
2.) Noise levels and nuisance
3.) Air pollution and air quality
4.) Accessibility
5.) Personal safety and security
6.) Aversion behaviors
7.) Public safety (dangerous cargo)
8.) Community severance
9.) Forced relocation
10.) Uncertainty of construction
11.) Visual quality
12.) Historical and cultural resources
13.) Physical fitness
14.) Intrinsic value

Social impacts of transportation have several meanings, and take into consideration a broad set of considerations related to the wellbeing of neighborhoods and their residents.
This paper will focus on the accessibility and noise-related nuisance/health impacts of the transportation because these have had a clear place in transportation planning, geography, and research.

The notion of transportation accessibility, moreover, the physical access to transportation facilities may be the most highly researched component of social impact of transportation. In the United Kingdom, transportation has largely been regarded as a social policy issue, and there have been clearly established links between lack of access to transportation and the exclusion of those people from various social capital (i.e. jobs) (Farrington, 2007).

Other research has noted that social impact is much more than income-based measures and that if income was purely associated with social impact, then the impacts of transportation would be relatively modest. In this sense, someone who is of high income can still be social impacted through exclusion. Social exclusion by transportation is defined as a person’s access to work, education, healthcare, shops, recreation facilities, welfare, finance, and housing- access to (effective) transportation play’s a dominate role in determining a person’s access to the social resources above. Transportation planners should try to reduce social exclusion, by increasing social inclusion and ensuring equal opportunity to engage and integrate into society (Preston and Rajé, 2007).

Other research has focused on health related quality of life issues, which blur the line between social impact and health impact. One can easily construe that benefits to health impact a person’s social well-being. Studies have found that transportation related noise has been perceived as a nuisance and increases the stress found in one’s life (Bundesamt für Umwelt, 2007). Several studies linked the environmental exposure of
transportation related noise to the development of adverse health outcomes, and leads to severe social impacts on neighborhoods which are adjacent to or within close proximity of transportation facilities (Standsfeld and Matheson, 2000).

Noise and proximity are easily quantifiable, many studies have used a combination of survey data with established databases on health and transportation. A significant portion of the population reported noise annoyance with traffic. When comparing traffic-noise annoyance with health status, negative associations were found to be present with all health-related measures except for general health. In addition, composite health scores indicated that high traffic-noise resulted in a lower composite health score. This was present in males and females, but more prevalent in women than men. The evidence that the impacts of environmental exposure to transportation related noise can have significant impacts on clinical outcomes of health and as a result impact a person’s overall quality of life (Dratva, et al., 2009).

Several studies have analyzed the economic impact of transit stations. This impact has been primarily expressed in terms of the total impact on the price of residential or commercial property values. Questions arise as to the appropriate methods for determining this and the necessary attributes modeled to determine the extent to which various hedonic principles influence the value of a homes or business that surround the transit station.

Gatzlaff and Smith (1993) studied the value of residences near Miami Metrorail stations over the current lifetime of the system. The system had been experiencing a 15% lower ridership than projected prior to the system being built. In their review of existing literature, they found two major issues with the method of analysis:
1. Many factors, in addition to transit, may be occurring simultaneously.

2. Effects on localized properties near transportation enhancements develop over a long period of time.

Other studies indicated that transit service may increase the value of adjacent properties by providing better access and visibility, or could negatively affect adjacent properties because of associated or perceived nuisances of noise, pollution, construction disruption, property isolation, etc.

Gatzlaff and Smith utilized a hedonic methodology to control for some of the other land use factors, and were able to quantify price changes as a result of the announcement of the development of the Miami Metrorail system. The model assumed the property value is a function of local and property specific characteristics and attributes. Gatzlaff and Smith used eight hedonic variables to describe these characteristics:

- Total living area of residence in square feet.
- The parcel lot size.
- Age of the property in years at the time of sale.
- Index of residential property appreciation.
- Distance from the Miami MetroRail transit station.
- A dummy variable that describes if the property was built prior to 1980 or not.
- The distance of properties selling before and after the announcement of the Metrorail expansion.

They found weak evidence of any effect on residential values that were due to the announcement of the development of the Miami Metrorail system. A similar weak
influence on residential property values was also demonstrated, however the impact varied depending on more affluent neighborhoods.

Finally, Gatzlaff and Smith found that the entire system appears to have only had a marginal impact on overall residential property values. They further concluded that the system had little effect on increasing the accessibility of residents to goods and resources demanded at the time (Gatzlaff and Smith, 1993).

Chen et al. (1997) studied the proximity effect of transit stations using Portland’s MAX light rail transit system in their study *Measuring the Impact of Light Rail Systems on Single Family Home Values: A Hedonic Approach with GIS Application*. They, like multiple studies before them, acknowledged that the physical attributes of the house itself, neighborhood attributes, locational attributes, and fiscal and economic externalities played an important role in the determination of housing prices. In addition, they also acknowledge that existing literature has found inconsistent results in how rapid transit systems are affecting residential property values, with some studies finding positive results, others negative, and several which were inconclusive (including Gatzlaff and Smith). Chen et al used a dummy variable to indicate if the property was within or outside a 700 meter distance of a MAX LRT station, but was excluded from the final results because the attribute lacked any statistical significance. Final attributes used in Chen et al’s study were age of house, lot size, house size in square feet, house size squared, number of bedrooms, number of bathrooms, number of fireplaces, corner lot, presence of basement, presence of attached garage, median household value for census, single family zoning, distance to nearest park, distance to central business district, distance to LRT line, distance to nearest LRT, located in Portland, built in 1993, and built
in 1994. Their study utilized significantly more variables than the previous study in Miami. The more statistically significant variables they modeled will have resulted in better predictions of the influence that proximity to transit stations has on residential property values.

Chen et al. found that the MAX LRT system in Portland had a positive effect on accessibility factors, and a negative effect on single-family home values as a result of noise nuisances associated with mass transit systems. This study suggested that planners should find ways to decrease the nuisance affect by finding creative solutions to mitigate noise, increased pedestrian and automobile traffic, attraction of “undesirable groups”, and the physical division of neighborhoods by the LRT line itself (Chen and Deuker, 1997).

Sherry Ryan in her report Property Values and Transportation Facilities-Finding the Transportation- Land Use Connection (1993) analyzes many of the previous literature and seeks to understand why there is so much variation between the results of empirical research using regression modeling of land-use effects near transit-station properties differs and the theoretical expectations of transportation systems. Ryan summarizes that when transportation facilities provide travel time savings, and are accurately measured, the expected property values tend to be consistent with the perceived transportation access relationship. However, many researchers do not adequately capture the changes in travel time because too many properties that are too far away are included in the sample, and the results thus indicate no significant change in property values. Ryan indicates that property value changes as a result of the implementation of transportation systems should be more directly correlated with
changes in travel time, rather than the distance of residents and employers from the respective transportation facility.

Ryan warns future researchers that the distance from a transportation facility may not accurately estimate property value changes, and suggest that the proximity effect for rail based transit is within 0.33 miles of the station, and within 1 mile from highway facilities. She suggests that properties near transportation facilities that have accrued significant travel time savings will force the land-market to appropriately buy up these properties. Ryan asserts that planners need to have a clear understanding of the relationship between transportation facilities and travel time changes. She concludes that this is imperative in the design of transportation systems as rail solutions should link existing activity centers rather than to expect these systems to attract concentrations of activity (Ryan, 1993).

Despite warnings from Sherry Ryan’s paper that transportation researchers should focus on travel time reductions as the basis for independent variables when measuring the impact on area property values, existing literature following her report has continued to focus on the proximity effect of transportation systems. However, some variations in the type of independent variables have been enhanced.

Hess and Almeida, in their report, *the Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York* (2007) attempt to show how accessibility benefits have accrued for transit station properties in a declining, rustbelt city. In their study, they assumed that as distance increased from the transit station, accessibility benefits decreased. Hess and Almeida have introduced a new variable which they describe as the walking distance to the transit station, versus the
“straight line” distance. The primary difference between these distance measures the walking distance from the transit station requires the calculated distance using the street network, versus the straight line distance assumes a fixed radii around the transit station.

They conclude that the street network distance has less of an impact on property value than the straight line distance. According to the authors, this indicates that the local market forces favor general proximity to transit, rather than actual walking distance, or driving distance (the network assumes that sidewalks follow the street network). In absence of the street network versus the straight line distance measure, the Hess and Almeida study only added to the growing body of research which has indicated that there is a relatively weak, but generally positive influence on residential property values near transit stations. The authors found that in general, proximity to transit stations can increase the value of homes in Buffalo, NY by $1,300 to $3,000, or 2-5 percent of the median home value. Like previous literature, the authors indicate that planners cannot claim that transit systems will unequivocally increase property values and automatically lead to the revitalization of depressed neighborhoods (Hess and Almeida. 2007).

In the Impact of Railway Stations on Residential and Commercial Property Value (2007) Debrezion et al. used two different methods of determine proximity to rail and bus based transit systems. This study presented an analysis of 4 different types of rapid transit systems: heavy rail, commuter rail, light rail, and bus rapid transit. The researchers utilized three different types of models, linear, semi-log, and log-linear specifications. Like previous reports, the authors followed hedonic principles and included parcel, local, and regional characteristics that would impact the property values near the transit station. The authors conclude that in general, railway stations can expect to have the highest
degree of influence of property values, and of all the transit stations commuter rail
stations exhibited a significantly higher impact on property values than any of the other
transit stations included in the study. This study used two measures of distance, a ¼ mile
buffer from the station, and in departing from the existing literature, a more global effect
by analyzing a continuous measure of distance from the transit station. The authors
found that on average, commercial properties sell or rent 12.2 percent higher than
residential properties in the same distance range, with a gap of 4.2 percent for residential
properties and 16.4 for other commercial properties.

When utilizing the continuous measure, the impact from the transit station is 2.3
percent higher for residential properties than it is for commercial properties. The authors
of this study also included proximity to highway infrastructure, and stated that if these
measures are omitted from the study that significant variable bias will occur. The
exclusion of highway accessibility as a variable in the model will cause the researcher to
overestimate the impact that transit stations have on area property value (Debrezion, et
al., 2007).

The final study by Cervero and Kang, *Bus Rapid Transit Impacts on Land Uses
and Land Values in Seoul, Korea* (2009), is unique in that it analyzed only BRT, and
sought to understand how the system was changing land-use factors within the transit
corridor. Like Debrezion, Cervero and Kang analyzed the impact on the commercial and
residential property values. Cervero and Kang noted that the results of the BRT-only
study were consistent with rail-based transit improvement studies, and noted that it is not
transit “hardware” that will influence land use, but rather quality of service and (like
Ryan) the travel-time savings of taking transit versus a personal automobile.
The authors found that within 300 meters, there was a significantly higher impact on commercial and property value, but also found that outside of 30 meters from the transit system, no nuisance effects could be empirically detected. The authors note that this is most likely due to the BRT design enhancements that were integrated into the system during development (Cervero and Kang, 2009).

The proximity effect of transit stations has had a long history in transportation research, and planning of various systems. The empirical results of transit across the world has varies from study to study, and most likely is attributed to individual planning mistakes that occurred during the development of transit systems that performed poorly. Regardless, several researchers have indicated that the straight line distance and proximity only measures will result in significant attribute bias, and the exclusion of accessibility to other transportation accessibility will almost certainly result in inflated values for localized station proximity impacts. Multiple studies indicate there is significance between the type of transit system and the extent of impact, overall the same trends are present regardless of the type of transit system.

This study will attempt to replicate existing literature by using appropriate local, neighborhood, and regional attributes that have been shown to influence residential property values the most, but also heed researchers warning and include other transportation facility accessibility independent variables to reduce the station proximity bias effect.
Context: The Hiawatha Light Rail

Minneapolis and Saint Paul, commonly referred to as the “Twin Cities”, has a diverse history of mass transit dating back to 1880. Like many cities in the Midwest United States, the last 50 years has seen this system transition to a bus-only service that has steadily failed to meet the level of service demanded of it in the 21st century. The Hiawatha corridor follows Minnesota highway 55, and was selected as the present location of the Hiawatha Light Rail Transit line. In 2004, the Hiawatha LRT system opened to the public with twelve miles of light rail line connecting three of the largest activity centers in the Twin Cities region: Downtown Minneapolis, Minneapolis/Saint Paul International Airport, and the Mall of America in Bloomington, MN. The path to building the Hiawatha LRT was not an easy one, and the system was frequently met with political opposition. Opposition was not only because of its price tag but also because of concerns that the LRT system would not attract any riders in an automobile oriented city (see Map 1).

Between June, 2004 and December, 2005 the Hiawatha LRT served 10.9 million customers- 65% higher than initial projections. The Hiawatha LRT is used frequently for transportation to Downtown Minneapolis, the Metrodome, Target field, University of Minnesota, eleven neighborhoods, Minnehaha Park, MSP International Airport, Mall of America, and the VA Medical Center. Nearly half of all riders on the Hiawatha LRT are
Map 1. The Hiawatha Corridor with study area neighborhoods and stations
new to transit - an indication that the population is willing to use mass transit and abandon their automobile.

Prior to 1985, the original plans along the Hiawatha corridor called for an 8-lane, below grade highway that would connect into Downtown Minneapolis and the existing highway network. With the passage of the 1969 National Environmental Policy Act, residents of neighborhoods that would be affected halted the construction of the eight lane highway. When the Environmental Impact Study was presented in final form in 1985, the proposed plan included a scaled down highway with restricted 40 MPH speeds and a LRT line running alongside it. The 1985 plan called for the LRT system to connect Downtown Minneapolis to MSP International Airport and recommended a further extension to the Met Stadium (now Mall of America).

From 1985 to 1999, the proposed Hiawatha LRT line running along state route 55 was stalled and threatened in various ways. While the original Environmental Impact Statement recommended the construction of LRT, it did not provide any answers on how a proposed rail line would be funded. One of the most significant steps taken during this period to fund the LRT line was the formation of the Hennepin County Regional Rail Authority’s LRT plan, which included several lines beyond the Hiawatha LRT route. While a Draft Environmental Impact Statement was prepared, it led to no record of decision and the report was shelved.

In 1997, the Minnesota Department of Transportation began studying the concept of creating a dedicated right of way bus lane in the space reserved for the Hiawatha LRT. While Minnesota DOT had the money available to spend on dedicated bus ways, it did not have the funding to begin construction of rail-based transit. Before plans for bus ways
were complete, an infusion of funding from the federal government made possible the LRT portion of the project, and was followed by the first installment of state funding in 1998. In 1998, Minnesota DOT amended the original 1985 Environmental Impact Statement, which would cover the extension of the line to the Mall of America, originally not included in the final 1985 Environmental Impact Statement.

From 1999 to 2001, the Minnesota Department of Transportation began its preliminary engineering phase of the project. Minnesota DOT was designated as the project management firm, and in a unique twist would become the designer and the builder, which increased the importance of preliminary design documents. Between 2001 and 2004, construction began on the Hiawatha LRT corridor before the final design was completed. In the middle of summer 2004, the Hiawatha LRT line opened to the public with great fanfare.

The organization of the implementation of the Hiawatha corridor was a major challenge for several agencies within Minnesota, and represented the largest megaproject that the State of Minnesota had ever undertaken. The Metropolitan Council served as the federal grantee, the owner of the system, and the final decision maker. MetroTransit, the existing operator of the Twin Cities bus service, would become the operator of the new Hiawatha LRT. The Minnesota Department of Transportation was the constructor, and served as the owner of the right of way (along with Hennepin County). The Metropolitan Airports Commission was placed in charge of the tunnel and airport stations. The Hiawatha Project Office served as the primary coordinator for the project and as well as project management for the system. The corridor management committee and community advisory committee was tasked with coordinating policy and public input. The Cities of
Minneapolis and Bloomington provided support and coordination for land use, downtown utilities, and contra-flow bus lanes.

The Hiawatha LRT lane had several estimates of operating and maintenance costs throughout the several iterations of the environmental impact statements. In 1985, the estimates for operation and maintenance were $6,980,000, or approximately $14,500,000 in 2000 dollars. The newly adjusted operations and maintenance costs were adjusted to reflect $15.127 million in 2004, $15.581 million in 2005, and $16.049 million in 2006. In 2004, MetroTransit adjusted the operating costs to reflect $11.544 million in 2004, $16.570 million in 2005, and $17.437 million in 2006. The source of funding these costs came from: fare revenue, state funding, Hennepin county funding, and air quality funding.

In 1999, the Minneapolis Community Development Agency initiated the Hiawatha LRT Corridor Transit-Oriented Development Market Study, which identified 4 catalyst stations (with recommendations on where to focus initial investments for neighborhood development): Downtown East, Lake Street, 46th Street, and Bloomington stations.

At the Downtown East station, the study indicated 2.7 million square feet of commercial space and up to 1,500 new residential units that could be absorbed in a 20 year period. At the Lake Street station, 150,000 square feet commercial space and 1,250 new residential townhouses and apartments were identified. At the 46th Street station, the reconfiguration of 160,000 square feet of commercial and industrial could be transformed into 149,000 square feet of new commercial and up to 1,000 new residential units.
The study also indicated that the light rail transit improvements would enhance property values and help spur new community development activity, but this development might take longer to occur. Of the 7,000 new housing units that were envisioned to be built prior to 2020 near the 4 catalyst stations, more than 5,400 units were completed or under construction, and the City of Minneapolis was in the process of permitting 7,000 additional units (it is unclear how many are vacant, or if the new housing units were attracting residents from outside the metropolitan area).

The “Hiawatha Before and After” indicated nearly 850 new housing units to be completed between 2007 and 2009 near the Downtown East station, between 50,000 and 150,000 square feet of retail, and 150-450 new housing units to be completed near the Lake Street station. At the 46th Street station construction had started on over 500 new residential units and the expansion of over 145,000 square feet of retail. The Bloomington Central Station recorded the largest impact with the construction of a 5-phase project that would see 1,100 new housing units, 9,000 jobs, 2 million square feet of office, a hotel, and 75,000 square feet of new retail.

While the study indicates that community transformations and additions to employment have occurred, it was unclear as to the level of displacement of lower socioeconomic position residents and how much new employment the region added, as opposed to shifting employment from one area in the region to another (MetroTransit, 2010). This paper will seek to help identify the level of impact in social and economic realms that has occurred as a result of the Hiawatha Light Rail Transit corridor.
Like many Midwestern cities, Minneapolis is not exempt from declining or stagnant growth throughout its history. From 1900 to 1950, Minneapolis experienced steady and fairly rapid growth, a trait that is also shared with peer cities in the Midwest. From 1950 to 1990, Minneapolis experienced a steady decline in population, and in the last two decades its population has remained fairly stagnant. This is in contrast to Hennepin County where population has steadily increased from over 200,000 people to nearly 1.2 million people in 2010 (see Figure 1).

![Figure 1. Population, 1900-2010](image)

The City of Minneapolis’s educational attainment for the population 25 years and older in the categories of bachelor’s degree and graduate or professional degrees was 28.1% and 16.5% of the population respectively. This was significantly higher than the national percentage during the same year, which was 17.7% and 10.4% respectively. The unemployment rate in the City of Minneapolis was 2.2% higher than the national unemployment rate for the 2010 year at 9.1% of the civilian labor force. For those in the labor force, the largest occupational sectors were management, business, science, and arts occupations at 47.3%, sales and office occupations at 22.6%, and service occupations at
17.6%. Minneapolis’s management, business, science, and arts occupations were 11.9% higher than the national average is this category. However, Minneapolis lagged behind the nation in sales and office occupations by 0.4% and service occupations by 7.4%. In 2010, the median household income in Minneapolis was $46,508, which was just under the national median household income of $50,046.

In 2010, 16.9% of all families in Minneapolis were below the poverty level, this was higher than national estimates for the same year at 11.3% of all families. Minneapolis displayed a relatively impressive 15.2% of workers commuting to work using public transportation, in contrast to the national estimate where only 4.9% of workers used public transportation to get to work (U.S. Bureau of the Census).

Both the Hiawatha and Healthline rapid transit systems have enjoyed reasonable amounts of success in terms of pure ridership. In 2005 (first full year of operation), the Hiawatha line had a total ridership of 7,901,668, by 2011 the number has increased to 10,400,864 (see Figure 2).

![Figure 2. Hiawatha ridership 2004-2011 (thousands)](image-url)
The Hiawatha LRT route connects two major destinations in Minneapolis: the Mall of America and Downtown. In addition, Minneapolis- St. Paul International Airport is another major destination between these two points, with two stations at Lindbergh Terminal and Humphrey Terminal. Fare between these two airport terminal destinations is provided free of charge to those needing to make connecting flights while inside of the airport.

The Hiawatha line serves major residential neighborhoods between Fort Snelling Station and Cedar-Riverside Station, this area will be the focus this paper on the social and economic impacts of the Hiawatha line (Map 2).
Map 2. Hiawatha line study area single-family dwellings
Methodology

This paper presents two different sets of methods for assessing the social and economic impact that light rail transit stations have on surrounding neighborhoods. This section of the paper will be broken down into the two respective elements that constitute this paper for the greater sense of logic in its presentation.

The data for this study is provided from the following:

- U.S. Bureau of the Census, 2000 Decennial Census of Housing and Population
- U.S. Bureau of the Census, 2005-2009 American Community Survey
- U.S. Bureau of the Census, 2006-2010 American Community Survey
- U.S. Bureau of the Census, Topologically Integrated Geographic Encoding and Referencing products
- City of Minneapolis Assessors Office
- City of Minneapolis Geographic Information Systems Business Service
- Minneapolis Metropolitan Council MetroGIS

Assessing the Social Impact

Previous research has used single socioeconomic measures, such as income or poverty level, to describe transit stations proximity effect on surrounding neighborhoods. Evaluation of the transit station impacts has utilized census tracts as the primary scale
of analysis in statistical studies. While the use of census tracts as surrogates for neighborhoods has had a history in the social sciences (Park, 1916 and Suttles, 1972) the use of block-group can provide researchers with a more detailed statistical picture of the effects of proximity to transit stations. The uses of single-variable measures do not provide a comprehensive picture of the socioeconomic characteristics of a particular area.

The goal of this paper was not to develop a new index of measuring the socioeconomic conditions, but to use an existing composite socioeconomic index to better determine the impact a transit station has on the surrounding areas social characteristics. This study selected the Modified Darden-Kamel Composite Socioeconomic Index as the measure of socioeconomic conditions in a neighborhood because of index’s performance in evaluating disparities between neighborhoods (Darden, et al., 2009). The Darden-Kamel Composite Index was modified to be used at the block-group level instead of the tract level, and variables were changed slightly to match new variable definitions the U.S. Census Bureau enacted in 2010.

The modified Darden-Kamel Composite Index used in this study incorporates nine variables to calculate a Composite Socioeconomic Index (CSI) which are defined as follows:

- **Percentage of residents with university degrees.** This is the percentage of the population 25 years and older with at least a bachelor’s degree.

- **Median household income.** This is the median household income of the total family members.

- **Percentage of managerial and professional positions.** This is the percentage of workers sixteen years and older at the top of the occupational hierarchy based on
the occupational classification system used by the U.S. Bureau of the Census in 2000 and 2009. In 2010, the percentage of management, business, science, and arts occupations was used to reflect the change in the occupational classification system.

- **Median value of dwelling.** This is the median value of the specific owner-occupied housing units.
- **Median gross rent of dwelling.** Median rent is the contract rent plus estimated average monthly costs of utilities.
- **Percentage of homeownership.** This is the percentage of all housing units that are owner occupied.
- **Percentage below poverty.** This is the percentage of all individuals below the U.S. poverty threshold at the time the time recorded.
- **Unemployment rate.** This is the percentage of all civilians sixteen years and older who were looking for work. For the 2005-2009 and 2006-2010 American Community survey, the unemployment rate for census tracts were coded for each block-group due the unavailability of this data at this scale.
- **Percentage of households with vehicles.** This is the percentage of households with a vehicle available.

The modified Darden-Kamel Composite Index sorts and ranks respective Urban Rapid Transit Area’s block groups according to their overall socioeconomic position (SEP). The Composite Socioeconomic Z-score Index was calculated using the following formula:
where \( CSI_i \) represents the composite socioeconomic Z-score index for block group \( i \), the sum of Z scales for the SEP variables \( j \), relative to the Urban Rapid Transit Area SEP; URTA represents Hennepin County, Minnesota; \( k \) represents the number of variables in the index; \( V_{ij} \) represents the \( j \)th SEP variable for a given block group \( i \); \( V_{JURTA} \) represents the mean of the \( j \)th variable in the Urban Rapid Transit Area; and \( S(V_{JURTA}) \) represents the standard deviation of the \( j \)th variable in the Urban Rapid Transit Area.

The z-scores for the original variables that characterized the block groups were calculated to standardize the contribution of each variable to the Composite Socioeconomic Index. This was calculated by subtracting the mean value of the variable for the block group from the mean value of the variable for the entire Urban Rapid Transit Area. Then this value is divided by the standard deviation of the specific variable for Urban Rapid Transit Area. To ensure that percentage below poverty and unemployment rate captured a depreciating effect on the composite score for each block group, these values were multiplied by -1 before being added to the composite index. Block groups which did not include values for all of the variables were eliminated from inclusion, with the exception of when median gross rent was $0 where owner-occupied housing for the same block group equaled 100%.

These values were then aligned with the appropriate Federal Information Processing System (FIPS) number where they were input into GIS for spatial analysis. Around each transit station within the respective Urban Rapid Transit Area, 0.25, 0.5, and
1.0 mile buffers were drawn around them to intersect the appropriate data at the correct time and space (i.e., T1 represents 2000, T2 represents 2005-2009, and T3 represent 2006-2010). Using a spatial-temporal analysis technique, a one-way ANOVA test was then performed to determine the extent of the change of the mean values across time (2000, 2005-2009, and 2006-2010) and across space (0.25, 0.5, and 1.0 miles). This analysis is presented in the following hypothesis:

H₀: The proximity to transit stations does not influence the socioeconomic position of transit neighborhoods.

H₁: The proximity to transit stations does influence the socioeconomic position of transit neighborhoods.

However, using this type of analysis will only help the researcher determine if there is a statistical significant relationship occurring that is beyond random chance. If the spatial-temporal analysis confirms a significant relationship, an analysis using the 2006-2010 Composite Socioeconomic Index will be used to build a generalized linear regression model.

Using ordinary least squares regression, the following function will be used:

\[ S = f(P_r, H, L, N) \]

Where the dependent variable S is the Composite Socioeconomic Index value using the 2006-2010 American Community Survey. There are 4 vectors in the function, which are: Pr, the vector of variables that measure the proximity of properties to the transit stations; H, the vector of variables that describe property characteristics; L, the vectors that measure location amenities; and N, a vector of variables that describe neighborhood characteristics.
• **Station Proximity (Pr).** This measures the distance (in feet) from each residential parcel to the nearest transit station. This measure consists of two methods: straight line and network distance. The straight line distance is the “crow-flight” distance from the parcel to the transit station, while the network distance is the distance using the existing street grid to the transit station.

• **Property characteristics (H).** These are the attributes to single-family residential type dwellings within the study area. This includes lot area, age of house, number of bedrooms, number of bathrooms, and number of fireplaces. Dichotomous variables indicate presence of a basement, detached or attached garages. Parcels which did not contain values for all of these attributes were eliminated from the study.

• **Location amenities (L).** These attributes include variables that describe city-wide access, and the parcels proximity to these. This includes the proximity to the central business district, proximity to the nearest park, and distance to limited-access highway facilities.

• **Neighborhood characteristics (N).** These variables include neighborhood characteristics, including property crime rate, and violent crime rate.

Because the independent variables possess various units of measurement, to assess their collective impact on the dependent variable, the standardized partial regression coefficient was used for each independent variable to assess their impact on the dependent variable.
Assessing the Economic Impact

In order to assess transit station influence on surrounding property values alone, the following semi-logarithmic hedonic regression model is used:

\[ P = f(Pr, H, L, N) \]

Where the dependent variable \( P \) is the natural log of the assessed property value in U.S. Dollars. There are four vectors in the function, which are: \( Pr \), the vector of variable that measure the proximity of properties to the transit stations; \( H \), the vector of variable that describe property characteristics; \( L \), the vectors that measure location amenities; and \( N \), a vector of variables that describe neighborhood characteristics.

- **Station Proximity (Pr).** This measures the distance (in feet) from each residential parcel to the nearest transit station. This measure consists of two methods: straight line and network distance. The straight line distance is the “crow-flight” distance from the parcel to the transit station, while the network distance is the distance using the existing street grid to the transit station.

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Because the independent variables possess various units of measurement, to assess their collective impact on the dependent variable, the standardized partial regress coefficient was used for each independent variable to assess their impact on the dependent variable.
Findings

The social impact of proximity to Hiawatha light rail transit stations

The initial results of converting several independent measures of social characteristics to a composite index showed that a majority of the higher SEP neighborhoods resided in the southeastern section of the study area near the 38\textsuperscript{th} and 46\textsuperscript{th} Street stations. Most of the lower SEP neighborhoods resided in the northwest section of the study area near the Franklin Avenue and Lake Street stations. Most of the higher SEP neighborhoods surround the southern section of the study area and the eastern section of the study area, which are comprised of several local and regional parks to the south, and the Mississippi River to the east. Many of the lower SEP neighborhoods of the northwest section of the study area, which reside closer to the I-35W corridor t forms a physical boundary to the west of the study area (see Map 3).

Initial analysis of the spatial and temporal socioeconomic characteristics of neighborhoods within close proximity of transit stations was performed using 3 common variables that describe social characteristics: education (percent of the population 25 years or older with a bachelor degree of higher), occupation (percent of workers 16 years and older in management and professional positions), and income (median household
Map 3. Composite SEP of neighborhoods along the Hiawatha Corridor
income). When analyzing education, no statistical significance was found at the 0.25 and 0.5 mile factors. However a statistically significant score of 0.011 was found at 1.0 mile.

At 1.0 mile, educational attainment was found to increase from 2000 to 2010 (Figure 3). When analyzing occupation and income, no statistical significance was found to be present at any of the 0.25, 0.5 or 1.0 mile factor levels.

**Figure 3.** Temporal analysis of educational attainment

Education, occupation, and income were also analyzed spatially using time as factors. The spatial analysis was found to be more statistical significance than the temporal analysis.

In Minneapolis, when analyzing education, statistical significance was revealed between education and proximity to light rail transit (LRT) stations at the p < 0.05 level for the respective factor of 2000, 2005-2009, and 2006-2010. In addition, the author found that as the distance to the LRT stations increased the percentage of residents with bachelor degrees or higher decreased (Figure 4).

When analyzing the percentage of managerial and professional occupational within proximity to LRT stations, with factor levels of 2000 and 2005-2009, there was no statistical significance spatially, however at the 2006-2010 factor levels, there was a
Figure 4. Spatial analysis of education

![Graphs showing spatial analysis of education](image)

statistical significance of $p < 0.05$. Additionally, the author found that as distance increased from the LRT station, the percentage of population in managerial and professional occupations decreased (Figure 5).

When analyzing income at the 2000 factor level, there was no statistical significance when ran against distance from transit stations. However, at the 2005-2009 and 2006-2010 factor levels, statistical significance of $p < 0.05$ was found. In addition, the author found that income decreased as proximity from the LRT stations increased (Figure 5).

Figure 5. Spatial analysis of occupation (left) and income (center and right)

![Graphs showing spatial analysis of occupation and income](image)

Social characteristics are the sum of several different variables, and individual attributes such as income alone or education alone often do not realistically represent the
population’s socioeconomic position. This study utilized a composite socioeconomic index score to spatially and temporally analyze social conditions in the same method used to compare baseline socioeconomic conditions previously.

When analyzing the changes across time and using distances of 0.25, 0.5, and 1.0 miles as factors, the analysis found that no statistical significance when using a composite measure of socioeconomic position. This was in contrast to some marginally statistical significance that was found when utilizing base socioeconomic position characteristics at the p < 0.10 level. However, research should continue to analyze temporal changes in socioeconomic position as not enough time may have passed since construction was finished on the Hiawatha line in late 2004.

Statistical significance was found when analyzing the spatial changes of proximity to transit stations using the three time periods as factors (2000, 2005-2009, and 2006-2010).

The author found encouraging results using spatial analysis, where statistical significance of p < 0.05 for all factors was discovered. The spatial analysis found an identical appreciating SEP as distance to LRT stations increased (see Figure 6). This was in sharp contrast to baseline socioeconomic characteristics analyzed previously for Minneapolis.

With encouraging results in hand, a regression model of the 2006-2010 Composite Socioeconomic Index was built with several built environment characteristics. Because the American Community Survey collects data over a 5-year period, it was impossible for the author to get data that was collected at the same time period for explanatory model characteristics. Because of this, 2010 data collected by the
Figure 6. Spatial analysis of Hiawatha Corridor composite socioeconomic index

City of Minneapolis and its regional entities was used for the built environment characteristics. The American Community Survey data for the 2006-2010 collection period was used because it was the most recent data at the time, and included data from the 2010 period.

Several hundred model iterations were conducted to find the strongest possible model fits using the explanatory built environment characteristics. The final model was selected for low multicolinearity using the Variance Inflation Factor (VIF) as the primary indicator, high variable significance, and the highest adjusted r-squared value to determine the overall model performance at explaining the relationship between the Composite Socioeconomic Index and its potential explanatory variables.

The final model presented an adjusted R-square value of 0.677, which indicates that the selected explanatory variables are responsible for 67.7% of the total impact on socioeconomic position in single-family dwelling units that lie within 0.50 miles of the Hiawatha LRT line. This indicates a moderately strong model, with the selected variables accounting for 2/3 of the relationship between CSI and the built environment. However, additional variables accounting for 1/3 of the relationship are still missing, and more detailed analysis should be conducted to understand where additional influence is being
generated in the study area (Table 1).

<table>
<thead>
<tr>
<th>Model</th>
<th>R-square</th>
<th>Adj. R-square</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 CSI Model</td>
<td>0.677</td>
<td>0.677</td>
<td>3,698</td>
</tr>
</tbody>
</table>

When comparing the standard residuals of the model to the model probability, the fitted curve was normal (see Appendix A: CSI histogram of standard residuals). This indicates that the model is not biased in any particular direction. This was further confirmed by analyzing the Jarque-bera statistics which did not indicate statistical significance (see Appendix B: CSI Generalized regression model diagnostics). As a final test, the standard residuals were plotted, which revealed some structure, but no structure suggesting that a non-linear model was ideal over a generalized linear model (see Appendix C: CSI residuals plot and Appendix D: CSI Standard deviation map).

The final model indicated that parcel lot size, land-value, violent crime, and access to transportation were important variables. However, neither this model, nor any of the model iterations returned any statistical significance in the relationship between the straight-line or network distance to Hiawatha LRT stations in the study area. The parcel level variables, lot size and land value, indicated significant associations with composite socioeconomic index. The size of the parcel lot had a negative contribution to socioeconomic position, indicating for every square foot decrease in lot size was associated with a decrease of .000957 to the composite socioeconomic index.

Violent crime, specifically instances of aggregated assault in neighborhoods, had the most influencing effect on composite socioeconomic index. The negative relationship indicates instances of violent crime, specifically aggravated assault, in neighborhoods can decrease the CSI value for the area by -0.18.
The final variable that returned significant results was the relationship between composite socioeconomic index and distance to limited-access highway facilities that surround the study area. Several distance measures to multiple limited-access highway facilities were analyzed, with the 45th and 47th street ramps to I-35W generating the most significance (Table 2). This revelation indicates that there is some relationship between socioeconomic position and transportation access, with proximity to highway facilities negatively affecting socioeconomic position. Land-value was the only positive contribution to socioeconomic position, with increases in land-value resulting in increases in socioeconomic position. All variables reported a variance inflation factor less than 7.5, indicating low levels of multicolinearity between each of the independent variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Sig.</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot size (ft²)</td>
<td>-0.000957</td>
<td>0.000040</td>
<td>0.000</td>
<td>1.4895</td>
</tr>
<tr>
<td>Land value</td>
<td>0.000118</td>
<td>0.000004</td>
<td>0.000</td>
<td>1.8170</td>
</tr>
<tr>
<td>Neighborhood aggravated assaults</td>
<td>-0.182840</td>
<td>0.004300</td>
<td>0.000</td>
<td>1.3210</td>
</tr>
<tr>
<td>Distance to I-35W- 45th &amp; 47th Street ramps</td>
<td>-0.003496</td>
<td>0.000085</td>
<td>0.000</td>
<td>1.0207</td>
</tr>
</tbody>
</table>

The economic impact of proximity to Hiawatha light rail transit stations

The economic impact of the Hiawatha light rail transit line focuses on the impact to single-family dwelling total estimated values that are within 0.50 miles of a station. The total estimated value consists of the land and building value of the individual parcel. The actual figures used in the hedonic regression model are the natural log of the total estimated value, which will help reduce the bias associated with large values in
regression modeling. This analysis provides an insight into the temporal changes in economic influence that the Hiawatha line has had on single-family residences within the study area. The analysis looked at two time periods: 2005 and 2010. The year 2005 is significant in that it represents the first full year of operation of the Hiawatha light rail line. The total estimated value of the property is the assessed value of the property for the analysis year. This is the expected value of the property in a fair-market, as opposed to the sale value being a snap-shot of the value at the time the property was sold. The hedonic properties of this analysis focused on station proximity values (straight-line and network distances), property characteristics, location amenities, and neighborhood characteristics. The first step in the modeling process was to identify the base-model characteristics. These characteristics are composed of individual property components that are expected to have the most influence on the total estimated value of the property. This statistical technique only highlights the relationships and extent of the relationship between variables, and does not necessarily prove causation. This study indicates that specific characteristics of properties, such as the network distance to the Hiawatha line, has a strong association with the total estimated value of the single-family properties. The results from this regression can be interpreted to mean that the market, en mass, has responded to the Hiawatha line by awarding higher values to properties within close proximity to a transit station. Furthermore, it can be demonstrated that the economic value of the Hiawatha line has continued to increase as evidenced by an increasing association between 2005 and 2010, even though the process of causation is uncertain.

The network distance was chosen as the final measure of transit station proximity. The study area consists mostly of the traditional street grid pattern of the early 1900’s,
and the author assumed that the sidewalk network was adjacent to the street network. Two model types were run, one with straight distance measures to transit stations and one with network distance measures to transit stations. In all model iterations when using the two distance measures independently of each other, higher overall model results were found (and the standardized parameter estimates) of network distance to transit stations were higher in 100% of cases.

In 2005, as expected, the model indicated that property characteristics had the most influence on the total value of the structure. The square feet of the first floor, and especially the second floor, contributed the most value to the structure. The total lot size was the third highest parameter estimate that contributed positively to total value, with the number fireplaces, finished basement square feet, and number of ¾ bathrooms contributing to total value respectively. The age of the structure contributed negatively to the total value of the home.

Neighborhood amenities appeared to also contribute to the total value of the structure, with instances of all violent crimes and the number of arsons in respective neighborhoods contributing negatively to the total value of the property.

While this report spatially defined the study area neighborhoods as within 0.50 miles of a transit station, it recorded two transportation access options. Several model iterations using various limited-access freeways access within the region were analyzed. After eliminating variables due to multicolinearity, the 45th and 47th street on-ramps to I-35W recorded significant contribution to the total value of the home. This finding is significant, as it indicates that vehicular access to the interstate system is valued higher in the market, than access to the Hiawatha light rail (Table 3).
In 2010, the model returned many of the same associations that were indicated in 2005, with a few notable exceptions. Minnehaha park reported a significant increase in positive contribution to total estimated value, a difference from the contribution reported in 2005. More value was placed on proximity to the Minneapolis Central Business District, but this contribution was still negative in nature to total estimate value. Of significant interest to this paper is the revelation that from 2005 to 2010, the market value of proximity to Hiawatha light rail transit stations increased slightly, indicating that the market is placing more value on access to rapid transit. However, the access to 45th and 47th street on-ramps of I-35W more than doubled during this timeframe, highlighting the ever increasing importance of vehicular access to the I-35W corridor in Minneapolis (Table 3).
<table>
<thead>
<tr>
<th>Variable name</th>
<th>Standard Coefficients</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>beta</td>
<td>Sig.</td>
</tr>
<tr>
<td>Constant</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Network distance to nearest Hiawatha LRT station</td>
<td>0.080</td>
<td>0.000</td>
</tr>
<tr>
<td>Structure age</td>
<td>-0.191</td>
<td>0.000</td>
</tr>
<tr>
<td>Ground floor square feet</td>
<td>0.285</td>
<td>0.000</td>
</tr>
<tr>
<td>Second floor square feet</td>
<td>0.521</td>
<td>0.000</td>
</tr>
<tr>
<td>Finished basement square feet</td>
<td>0.095</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of ¾ bathrooms</td>
<td>0.037</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of fireplaces</td>
<td>0.132</td>
<td>0.000</td>
</tr>
<tr>
<td>Parcel lot square feet</td>
<td>0.103</td>
<td>0.000</td>
</tr>
<tr>
<td>Total number of all violent crimes</td>
<td>-0.046</td>
<td>0.003</td>
</tr>
<tr>
<td>Total number of arsons</td>
<td>-0.069</td>
<td>0.000</td>
</tr>
<tr>
<td>Straight distance to Minnehaha park</td>
<td>-0.512</td>
<td>0.000</td>
</tr>
<tr>
<td>Straight distance to Minneapolis Central Business District</td>
<td>-0.491</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Straight distance to I-35W 45th and 47th Streets ramp</strong></td>
<td><strong>0.167</strong></td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.637</td>
<td></td>
</tr>
</tbody>
</table>

2010

| Constant                                                | 0.000                 |
| Network distance to nearest Hiawatha LRT station        | 0.085                 | 0.000 |
| Structure age                                           | -0.132                | 0.000 |
| Ground floor square feet                                | 0.281                 | 0.000 |
| Second floor square feet                                | 0.467                 | 0.000 |
| Finished basement square feet                           | 0.115                 | 0.000 |
| Number of ¾ bathrooms                                   | 0.051                 | 0.000 |
| Number of fireplaces                                    | 0.106                 | 0.000 |
| Parcel lot square feet                                  | 0.104                 | 0.000 |
| Total number of all violent crimes                      | -0.354                | 0.000 |
| Total number of arsons                                  | -0.067                | 0.000 |
| Straight distance to Minnehaha park                     | 0.204                 | 0.000 |
| Straight distance to Minneapolis Central Business District | -0.263              | 0.000 |
| **Straight distance to I-35W 45th and 47th Streets ramp** | **0.380**            | **0.000** |
| Adjusted R²                                             | 0.680                 |       |
Discussion and conclusion

The utilization of Analysis of Variance (ANOVA) in the study is significant only in that it will determine if a pattern has developed that could not be attributed to random chance. Results were also consistent in that when using a distance of 1.0 mile as the factor against all time periods for the variable education, the ANOVA test determined that there was a marginally significant pattern occurring. As time increased, the percentage of residents with bachelor degree’s increased as well within a 1.0 proximity of transit stations. With the type of analysis performed, it is impossible to determine if this was a result of the transit station proximity impacts, or other neighborhood improvements that may have caused a shift in education concentration.

The spatial analysis of transit neighborhoods provided much more encouraging results than the temporal analysis of transit neighborhoods. Each of the neighborhoods recorded decreasing values as distance increased from the transit station before construction, but also in the years following the completion of the Hiawatha LRT.

Hiawatha line neighborhoods saw decreasing percentages of education, managerial and professional occupations, and median household income were found as distance increased from transit stations, only the percentage of residents with bachelor degrees or higher saw increases in concentrations within the 0.25 mile buffer from the transit station. Managerial and occupational positions were only significant for the 2006-
2010 factor, and household income showed a slight decrease between 2005-2009 and 2006-2010 factors, suggesting that other regional and local forces may be contributing to a change in neighborhood socioeconomic position. Additionally, concentrations of managerial and professional positions suggest a more skilled workforce is residing within close proximity to transit stations.

When utilizing a composite socioeconomic index (CSI) of socioeconomic position, the social impact analysis found results that were largely different than using basic characteristics of socioeconomic position independently. There was no statistical significance when conducting a temporal analysis using distance as the factor. This may be attributed to the relatively short period in time that has passed since the completion of Hiawatha line, when this is coupled with the worst economic recession in U.S. history, residents may be unwilling to relocate with so much market uncertainty.

Results were found that were largely opposite of utilizing basic characteristics of socioeconomic position independently. The social impact analysis found a positive correlation when using CSI as the method of determining neighborhood socioeconomic position in that as distance increased from the transit station, the CSI value also increased. This was found to have occurred regardless of the time factor that was used to run the ANOVA test against.

The relationship between socioeconomic position and the built environment factors raise several interesting points about the emerging analysis of social impacts and transportation. While it is not surprising to see that land value provides a net benefit to socioeconomic position, the revelation that access to high infrastructure provides a net negative to socioeconomic position. Additionally, the fact that there was no observed
significance between proximity to LRT stations and socioeconomic position raises an interesting question proposed in the beginning of this paper. Does access to transportation provide an increase in social position? This research finds that transportation access cannot provide immediate benefits to socioeconomic position, and the observed results from this research cannot confirm Farrington’s premises that lack of transportation access excludes those of a lower SEP from important life chances. This is further demonstrated by the fact that the highway accessibility measure returned a negative contribution to the composite index, indicating that closer access to this I-35W was contributing to a decline in socioeconomic position.

This leads to the second question proposed in the determination of the social impacts of transportation facilities. Are nuisance factors from transportation facilities effecting social position? This research finds support in this area of transportation and social impact. Previous research has confirmed that highway noise can lead to significant health related quality of life reductions (Dratva, et al., 2010). While further data may be necessary to confirm the presence of significant nuisance effects, this would seem a logical hypothesis as to the reason why this transportation facility is having a negative contribution to socioeconomic position. It should be noted that this study area included parcels that were within close proximity to LRT facilities, and the highway transportation measure was taken as an alternative transportation accessibility measure.

Further research is recommended to include more health and nuisance related measures to determine the extent that these factors could be affecting socioeconomic position.
This research is by no means a closed book on the social impact effects of transportation facilities. This area of analysis is still very much evolving within the academic and professional body. Changes in social dynamics are much more difficult and complex to change than economic dynamics. There could be significant temporal effects of transportation facilities on social dynamics, and the 5 year study period this research analyzed may simply not have been enough time to determine if there is an impact actually occurring or not. Minneapolis may not be an ideal candidate location to analyze the socioeconomic impacts of transportation, and a city with a robust, more established transportation system may be a better candidate to perform a significant longitudinal study. Nevertheless, this research has demonstrated that there is an association between the built environment and socioeconomic position occurring, and there is evidence that transportation may be a factor in the social justice debate.

There are several interesting results from the analysis of the economic impact of the Hiawatha LRT on single-family dwelling units along this specific corridor. This research found that in 2005, for every meter closer to a LRT station within 0.50 miles the value of the dwelling increased by $1.08. This was found to have increased slightly by $0.01 in 2010, accounting for a $1.09 increase for every meter closer to an LRT station for single-family dwelling units within 0.50 miles. The effect of Hiawatha LRT stations confirms existing literature that there is indeed an economic impact occurring between LRT and property-values, however, this impact remains small, accounting for just under $1,000 for properties within the closest proximity to the LRT station.

It is interesting to note that the impact of limited-access highway facilities accounted for a greater impact. For 2005, for every meter closer to the I-35W 45th & 47th
street on-ramps, there was a $1.18 increase in property value, up to 0.50 miles from an LRT station. In 2010, this impact increased significantly to $1.46. It is generally difficult to assess what construction projects may have influenced the dramatic rise in economic impact on the I-35W corridor from 2005 to 2010. One possible source of this greater influence is the completion of the Saint Anthony Falls Bridge that had collapsed in 2007 and was subsequently rebuilt in 2008. Another sharp increase in economic impact was the distance to Minnehaha Park, the location of the Minnehaha Falls and a popular recreation area in the Twin-cities. In 2005, for every meter closer to the park, there was a rise of $0.60 for properties within the LRT neighborhood study areas. This impact increased greatly to $1.23 in 2010 for every meter within the LRT neighborhood study areas. It is difficult to assess a particular reason why this occurred, and there could be several factors from crime to construction that could possibly effect this.

Other research has acknowledged that there are significant background effects that have taken place over the last decade as they pertain to LRT implementation (Golub, et al., 2012). One major background effect is the financial crisis that occurred between 2007 and 2012, and the associated housing bubble bursting in the years leading up to and beyond the financial crisis. The placement of the corridor itself is of particular interest, and in Minneapolis it appears that the intent was to link the Downtown with major attractions and productions in the area (i.e. VA Hospital, MSP International Airport, and the Mall of America).

Does LRT have an economic impact on surrounding neighborhoods, and if so what is the extent of impact? This research found that the presence of LRT has a net benefit on surrounding single-family dwelling units, and this was found to occur
regardless of significant background effects. Although it should be noted that the increase between 2005 and 2010 was very slight, and this could have been caused by a multitude of reasons. One the reason of interest why the net increase from 2005 to 2010 is small is a limitation in the scope of this research. LRT has been found to have significant effects on commercial properties and spawning Transit Oriented Development projects (Golub et al., 2012). Single-family dwelling unit are usually not what is envisioned in the standard typology of TOD development, and the scope of this project, along with the longitudinal considerations should be expanded to assess the impact on high-density residential, commercial, and mixed-use properties, along with their new development on vacant land and land that was of a previous use.

Nonetheless, the results of this study indicated significant public policy benefits in areas that have a large number of single-family dwellings. The results from this study indicate that there was a net benefit to single-family dwellings, and that as a result it can be interpreted that the real-estate market places value on proximity to Light Rail Transit. As a result, planners should understand the effect that this might have in neighborhoods that have a large degree of single-family dwellings considering new LRT construction. By understanding the influence of LRT on neighborhoods, planners can better understand and take advantage of valuation increases as a result of transit expansion. Increases in land-valuation in new-LRT corridors can have significant impacts on property acquisitions for public projects, as well as significant impacts on affordable housing and future transportation projects.

The impact of LRT has significant effects on affordable housing, as indicated in the social impact analysis. The initial social impact analysis indicated that land-value had
a significant association with socioeconomic position, and it is unlikely that transit alone provided an increase in SEP. It is much more plausible that any benefits to SEP are the result of displacement of lower SEP individuals by higher SEP individuals. As a result, this knowledge underscores the importance for those involved in community development and affordable housing to become engaged in the process early before land-valuation results in significant displacement of lower SEP persons.
Bibliography


Appendix A: CSI histogram

CSI Standard Residuals Plot
Appendix B: CSI OLS regression diagnostics

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<th>OLS Diagnostics</th>
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Appendix C: CSI standard residuals plot
Appendix D: CSI standard deviation map