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Impact of Twin Cities Transitways on Regional Labor Market Accessibility:
A Transportation Equity Perspective

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16. Abstract (Limit: 250 words)

This study evaluates the impact of the Hiawatha light rail line on job accessibility for the economically disadvantaged, seeking to further understanding of transit's role in promoting social equity, and to identify commute flow changes among low-wage workers. The results will inform more equitable transit polices and improvements in the future.

Numerous studies find spatial mismatch is an impediment to employment for low-wage workers. While transit is recognized as a tool for improving outcomes, results of empirical research are mixed. Several studies find positive relationships; others fine none.

The study examines changes in jobs accessible by transit throughout the service day. We utilize Geographic Information Systems (GIS) map analysis, summary statistics and regression analysis. Regression models estimate before- and after-LRT accessibility as a function of distance to the nearest transit stop, location within the immediate area of a light rail station or other transit premium stop, and of various demographic variables.

We examine shifts in actual home-to-work commute flows using the Longitudinal Employment and Housing Database (LEHD) Origin-Destination Matrix. We employ GIS map analysis, summary statistics and regression analysis. Regression models estimate shifts in where individuals commute from *and* to as a function of distance to the nearest transit stop at both ends of a commute, location within the immediate area of a light rail station or other premium transit stop at both ends of a commute, and of various demographic variables.
The report makes recommendations for applying our method to future transitways. Policy implications are discussed.

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Final Report

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Executive Summary

The Hiawatha light rail line opened in 2004 as part of a series of long-range transit planning activities in the Twin Cities region beginning the 1990s. Central to these transit plans is a system of transitways, defined by the Metropolitan Council's 2030 Transportation Policy Plan as including "bus and rail transit that enable fast, reliable travel times and an improved passenger experience on high-demand corridors in the region." This metro-wide transitway system has been expected to improve regional mobility and accessibility by providing reliable and rapid service, yet many have questioned who benefits from this type of investment.

The goal of this research is to evaluate the impact of the Twin Cities transitways on job accessibility for all workers, with a specific emphasis placed on the socio-economically disadvantaged. Approaching the issue from a transportation equity perspective, we seek to further understand transit's role in promoting social equity and its role in influencing relocation behaivor of workers and employers. The results will inform more equitable transit investiments and polices in the future.

The study begins with a review of existing research on spatial mismatch and the influence of transit on employment outcomes of low-wage workers. Numerous studies find spatial mismatch to be a significant impediment to positive employment outcomes for the poor and transportation disadvantaged. While transit is generally recognized as a potentially valuable tool for improving such outcomes, the results of empirical research are mixed. Several studies find positive relationships, and several others fail to find any relationship. It should be noted that many of the studies considered deal with welfare recipients, rather than low-wage workers, and none deals specifically with transitways as opposed to transit service in general.

The study examines definitions of poverty, and concludes that low-income Twin Cities residents (by any definition) use transit at considerably higher rates than do higher-income residents. In addition, low-income transit riders tend to have different transit use patterns than higher-income residents, particularly in terms of what times of day they ride.

The study examines changes—between "before LRT" and "after LRT" observations—in jobs accessible by transit throughout the major periods of the service day. In examining changes in job accessibility, we make use of Geographic Information Systems (GIS) map analysis, summary statistics and a set of negative-binomial regression models. These last estimate before- and after-LRT accessibility as a function of distance to the nearest transit stop, location within the immediate area of a light rail station or other transit stop with a high service level, and of various demographic control variables.

Results from the accessibility models illustrate what was possible at the starting point of the analysis, and what became possible after the opening of the Twin Cities' first modern transitway. Possibilities—or impossibilities, however, do not necessarily equal realized gains or losses. To address this issue, commute flow models are developed to examine shifts in home-to-work commute flows using the Census Bureau's Longitudinal Employment and Housing Dynamics (LEHD) Origin-Destination Matrix. We employ GIS map analysis, summary statistics and three ordinary-least-squares regression models to investigate commute flow changes. The regression models estimate changes in the number of workers who commute between each orgin-destination block group-level pair as a function of distances from each pair's home (origin) and work (destination) ends to the nearest transit stop, relative locations of each pair's home and work ends to the region's transit system (i.e., whether the home and work ends are located in the LRT station areas, the areas with bus-LRT connections, or the areas served with regular bus services) , and various demographic control variables at each pair's home end.

Based on these analyses, several conclusions were made:

- Spatial mismatch exists in the Twin Cities: major concentrations of low-wage workers and low-wage jobs are scattered throughout many different areas of the region and frequently do not match up.
- Significant, positive changes in low-wage transit employment accessibility were evident after the introduction of light rail transit. Large areas of accessibility gains were found around light rail stations, along bus routes that connect with light rail and especially those high-frequency LRT-connected bus routes.
- In several neighborhood station areas along the Hiawatha line, and in the areas surrounding bus stops offering a light rail connection, we find significant increases over and above regional trends in numbers of low-income commuters commuting to both downtown Minneapolis and suburban Bloomington station areas, and to areas surrounding bus stops offering a light rail connection. These results suggest that low-wage workers relocated closer to light rail, and that low-wage employers did as well. These findings support the conclusion that accessibility gains have led to realized gains for economically disadvantaged workers in the region. They also show needs to provide adequate quantities of affordable housing along transitways and to address jobs-housing balance along transitways, but most likely more at the corridor level than at the station area or neighborhood level.
- We find that the impacts of the Hiawatha line extend well beyond station areas. The prominence in both accessibility and commute flow analyses of bus routes offering light rail connections—many of which are otherwise unremarkable—speaks to the regional impact of light rail.
- In sum, the Hiawatha light rail line offers compelling evidence of the power of transit to advance social equity.

Despite these positive findings, there is still concern over who benefits, and to what degree. While many of the benefits to low-wage workers appear large, many of the same benefits appear even larger for high-wage workers. Because of the importance of spatial mismatch concerns that exist not only in this region but in others as well, conducting similar evaluations to other transitways is recommended. In such a process, this study of the Hiawatha line can assist in improving the planning process of future transitways to ensure transit realizes its full potential as a social equity promoter.

Chapter 1: Introduction

Public transit is more than a means of transportation: it serves as a key component in addressing poverty, unemployment, and equal opportunity goals [1-3].For low-income families, automobile ownership is far from universal, access to reliable vehicles is even less commonplace, and continually decentralizing job opportunities along with skyrocketing gas prices have left them more transit-dependent than ever. To help low income individuals get and keep jobs, equitable and efficient transit is a must.

In the Twin Cities metropolitan area, significant and long-range transit planning activities have been ongoing since the late 1990s. Central to these transit plans is a system of transitways, defined by the Metropolitan Council's 2030 Transportation Policy Plan as including "bus and rail transit that enable fast, reliable travel times and an improved passenger experience on high-demand corridors in the region." [4] Improvements include the five-year old Hiawatha light rail transit (LRT) line, the Northstar commuter rail line which began revenue service in November 2009, the Central Corridor LRT and the Cedar Avenue bus rapid transit corridor, as well as other transitways at various stages of the planning and/or Federal Transit Administration (FTA) New Starts grant application process. The metro-wide transitway system is expected to improve regional mobility and accessibility by providing reliable and rapid services to major destinations in the Twin Cities area.

Sponsored by the Minnesota Department of Transportation, the recent Access to Destinations Study found that the addition of the Hiawatha LRT line has drastically decreased travel times to locations near the Mall of America and the airport from downtown Minneapolis [5]. But, who benefits from these travel time savings? Does the Hiawatha addition make entry-level job opportunities more accessible to low-income individuals, thereby contributing to improved transportation equity? Answering these questions requires in-depth investigation into the concentration of poverty, the spatial distribution of entry-level jobs, commuting characteristics of low-wage workers, impact areas of transit improvements, and their spatial and statistical interactions.

Infused with a transportation equity perspective, the overarching goal of this project is to evaluate the impact of Twin Cities transitways on job accessibility of economically disadvantaged population. The evaluation can help us understand the role of transit in promoting social equity, identify the latent demand for commuting among working poor, and inform equitable transit policies and improvements. More specifically, the project has the following objectives:

- To empirically evaluate the impact of the Hiawatha LRT on low- income individuals' access to suitable job opportunities (see Chapter 4).
- To empirically examine whether there has been relocation of households as well as reorientation of employers to take advantage of the Hiawatha LRT (see Chapter 5).
- To develop a generalizable approach and to collect baseline data to be used for future evaluation of planned transitways and other available transit modes in the Twin Cities area (see Chapter 6).

The study area of this project includes the seven-county Twin Cities metropolitan region. The project employs data from various sources, including yearly, block-level residential and workplace area characteristics data as well as home-to-work commuting flow data from the Longitudinal Employer-Household Dynamics (LEHD) database; socio-demographic data from the Census; and transit network information of all modes from Mtro Transit and other transit service providers.

This project report is organized as follows:

- Chapter 2 contains a literature review on the impact of transit on job accessibility of low-wage workers, pertaining specifically to the spatial mismatch phenomenon between low-wage workers' residential locations and job locations.
- Chapter 3 identifies the population groups that are particularly relevant to this study, e.g., low-income individuals, low-wage workers, etc. More specifically, the chapter includes a discussion of definitions concerning poverty, low-wage workers and transit-dependency and maps showing the spatial distribution of the population groups of particular relevance to this study.
- Chapter 4 describes a before-and-after analysis of job accessibility changes in the Twin Cities metro area. Multiple indicators are generated to evaluate accessibility by transit to low-wage, high-wage, as well as all jobs before and after the operation of the Hiawatha LRT in 2004. The before-and-after accessibility changes are illustrated using maps and modeled using regression. To further illustrate the impact of the Hiawatha LRT on job access of low-wage workers, changes of job accessibility in transit-dependent and poverty concentration zones are compared to the overall region-wide job accessibility changes.
- Chapter 5 presents a before-and-after analysis of changes in the home-to-work commuter flow in the Twin Cities metro area. The commuter flow changes between home and work near the Hiawatha LRT are compared to the changes in other transit-served areas to illustrate if low-income households and low-wage businesses are relocating to take advantage of benefits provided by the Hiawatha LRT. Regression models are estimated to achieve a more accurate quantification of the LRT-associated relocation behavior.
- Chapter 6 summarizes the study's methodology, describes how the study's approach could be generalized to other corridors and lists data sources that are necessary for future examination of the planned transitways and in the Twin Cities or in other areas. The chapter restates the inherent limitations of the approach, and offers suggestions for improving it for future analysis of other transitways or repeated analysis of the Hiawatha line.
- Chapter 7 provides conclusions derived from the analysis results and offers discussion of the policy implications of this study.

Chapter 2: Literature Review

Planners, policymakers and the public have long struggled to increase access to employment for the socio-economically disadvantaged, especially since John Kain formulated the spatial mismatch hypothesis in his 1968 Quarterly Journal of Economics paper [6]. In its simplest form, the mismatch hypothesis states that racial discrimination in the suburban housing market, exacerbated by the decentralization of jobs to suburbs and limited transportation options, contributes to poor employment outcomes for African American urban residents. Kain's hypothesis reflects the interrelated facets between race, space and labor market processes in a novel way and has stimulated research and debate in a wide range of social science disciplines [7]. Over time, the spatial mismatch literature has evolved in relation to economic restructuring, immigration, continuing suburbanization, and welfare policy changes in the United States. The field has seen a shift of the study population from African Americans to other specific population groups such as Latinos, low-income single mothers, welfare recipients and immigrants. There is also an increasing recognition that spatial mismatch is deeply embedded in social structures and labor market processes. Emerging concepts from the recent literature include "modal mismatch" – employment inaccessible to carless residents in cities with auto-oriented land use patterns (e.g., sunbelt cities developed after the age of automobile) [2, 8, 9],"skill mismatch" – employment functionally inaccessible to geographically proximate but poorly educated residents[10-12], and "social mismatch" – mainstream labor market disconnected with the socio-economically disadvantaged due to their sparse social networks [13, 14].

Spatial mismatch arguments provide an important framework for understanding issues related to job access among low-income, transit-dependent population. The topic is particularly relevant for this project given its focus on the role of public transit in connecting low-wage workers to entry-level jobs. This chapter includes three sub-sections:

- The first section briefly reviews existing planning and policy solutions addressing the issue of spatial mismatch (including policies related to land use, economic development, transportation, and housing) and offers reflections on lessons, tactics, and promising practices that future policy and planning initiatives may take when considering the spatial mismatch problem.
- The second section provides a detailed review of transportation-related policies targeted to mitigate jobs/housing spatial mismatch and improve job access for low-wage workers, as well as a detailed review of the empirical literature studying the impact of transportation-related mobility improvements on job access of low-wage workers (including both private and public transportation-related improvements).
- The third section provides a brief summary of this literature review chapter.

2.1 Existing Policies Addressing Spatial Mismatch: Past Failures and Future Promises

Spatial mismatch has inspired policies around three main strategies: helping urban poor move to suburban locations, attracting adequate jobs to the city centre, and improving transportation mobility of low-wage workers [15]. Concerning the three strategies, straightforward policies have been generated respectively, including suburban housing policy, land use management or place-based economic development, and transportation policy (as illustrated in Table 2.1).

Table 2.1: Existing Planning and Policy Solutions for Addressing Spatial Mismatch

Problem element	Countermeasure	Existing planning and policy solutions
Job suburbanization	Bringing jobs back to cities	*Land use* ▪ Urban containment, e.g., urban growth boundary ▪ Mixed use developments, e.g., smart codes, overlay zoning practices. *Economic development* ▪ Place-based economic development strategies, e.g., urban renewal programs, enterprise zones. ▪ Public financing tools, e.g., new markets tax, tax increment financing.
Lack of affordable suburban housing	Helping urban poor move to suburbs	*Housing* ▪ Demand-side rental assistance programs, e.g., Section 8 certificates, Moving to Opportunity voucher program, and Gautreaux. ▪ Supply-side affordable housing programs, e.g., fair-share housing, Hope VI, scattered-site public housing program, inclusionary zoning practices.
Limited transportation options	Improving transportation mobility of low-wage workers	*Transportation* ▪ Public transit improvements, e.g., reverse commute services. ▪ Private mobility improvements, e.g., car-purchase-assistance programs.

Hundreds of empirical studies have examined the effectiveness of the policy interventions listed in Table 2.1 for addressing the issue of jobs/housing mismatch among the socio-economically disadvantaged population. A review of these empirical studies shows that most policy responses to spatial mismatch have failed to improve employment outcomes of disadvantaged jobseekers:

- Regions with compact and mixed land use patterns do not show lower levels of spatial mismatch between urban minorities and their economic opportunities;
- Inconsistent empirical evidence is found on the effectiveness of existing transit programs for increasing employment participation;
- Car ownership is found to play a significant role in improving employment outcomes, but few private mobility programs exist in the U.S. and even fewer programs are empirically examined;
- For housing and economic development policy programs, a vast majority of studies on these programs suggest few, if any, employment effects for disadvantaged workers.

Readers are referred to Appendix A for detailed description and analysis of existing empirical evidence on the subject. A further exploration of potential factors underlying current policy failures suggests that divided, and often conflicting, attentions are paid to inner-city job creation, poverty de-concentration and transportation improvements without acknowledging their interconnected roles. Although federal government moneys and guidelines underlie all of existing approaches for addressing the spatial mismatch problem, these approaches do not constitute a concerted, coordinated attempt. It seems that, if planners and policy makers are to create wining opportunities in the war against spatial mismatch, they must not only invest more but also invest smartly. Divided attentions and diverging priorities are likely to generate conflicting solutions that counteract each other's effects and starve government of its already limited resources. It is time to put traditional sector-specific interventions to rest and promote cross-sector partnerships and solutions. Promising practices that have great potential of generating integrated, cross-sector solutions are discussed in Appendix A, including incorporating the housing + transportation affordability assessment tool in rental assistance programs, consolidating FTA, HUD and NGA's welfare-to-work activities, bundling enterprise zone programs with transit-oriented development strategies and affordable housing policies, etc.

In addition, various social, economic, political, and cultural causes and consequences associated with spatial mismatch are so intrinsically complex and politically explosive as to defy simple solutions that fix the spatial dimension only. There is little question that disadvantaged families are in desperate need of job proximity, but whether job proximity can benefit them hinges on a chain of cooperative actions by employers, developers, landlords, tenants and sometimes others. Planners and policymakers must use a more appropriate set of approaches to address spatial mismatch; these approaches must pay more attention to non-spatially-related barriers to employment (e.g., skill mismatch, child care burdens and lack of social support), extend beyond simple matters of neighborhood diversity and mobility, emphasize community integration, and appreciate various stakeholders' behavioral mechanisms. Promising practices that have great potential of addressing non-spatial, social barriers to employment are also discussed in Appendix A, including workforce development, social marketing campaign, asset-based community development and workforce development, etc.

2.2 Transportation Mobility and Job Access of Low-Wage Workers

Transportation determines how people move from place to place. People who have access to reliable and rapid transportation such as private vehicles can easily commute between home and work even if home is physically far away from work. Therefore, the issue of job access on many levels is a problem of transportation mobility. The availability of reliable and rapid transportation (either private or public) directly impacts the level of job accessibility in cities and metropolitan regions.

Across the nation, surveys of low-income individuals or welfare recipients suggest lack of reliable transportation to be a significant barrier to employment success [16, 17]. Additional studies confirmed relatively low levels of auto ownership and that existing transit systems in the U.S. typically fail to accommodate low-income job seekers' complicated travel needs as many entry-level jobs require working late at night or on weekends when conventional transit services in many communities are either reduced or non-existent [3, 18, 19].

The well-documented evidence on "uneven access to job opportunities" had led to a series of planning and policy efforts in addressing the transportation problems of low-income residents and welfare recipients. At the federal level, the Job Access and Reverse Commute (JARC) program was established under the Transportation Equity Act for the 21st Century (TEA-21) in 1998 to specifically address the unique transportation challenges faced by welfare recipients and low-income persons seeking to get and keep jobs. Under TEA-21, funding for JARC grants was authorized at $150 million annually beginning in Fiscal Years 1999 till 2005. In 2005, another landmark bill, Safe, Affordable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), authorized a total of $727 million for JARC grants from FY2006 through 2009. At the regional level, many state agencies and metropolitan planning organizations (MPOs) have sponsored studies examining whether improvements to existing transportations systems (with a primary focus on transit systems) could contribute to urban poor and welfare recipients' employment success. Examples include the New Jersey WorkFirst Study, New York Tri-State Region Access-To-Jobs Plan, etc. These studies typically conclude with recommendations such as expanding transit/para-transit services, increasing distribution of public transportation information and initiating programs to assist car purchases and maintenance.

Despite high expectations that transit improvements would positively affect employment status for low-income persons, empirical evidence has been inconsistent. First, there is strong evidence that reverse commute transit services are ineffective in meeting the transportation needs of unemployed single mothers, a population group deeply affected by spatial mismatch [2]. Women constitute 85 percent of the adults on welfare and the majority of female welfare recipients are single mothers [13]. Chapple (2001) conducted in-depth interviews with 92 women on welfare in San Francisco and found that low-income women with children tend to seek jobs close to home [13]. . As transit riders, such women face time-consuming commutes, which are not compatible with their parental responsibilities and employment constraints. Their time poverty makes reverse commutes too costly to sustain [13]. Second, employment benefits associated with transit improvements are often predicted but not empirically demonstrated [20]. Only a handful of rigorous studies exist examining the impact of transit improvements on employment outcomes of disadvantaged population groups. As summarized in Table 2.2, these studies reach conflicting conclusions. While studies in Los Angeles, CA found a positive effect of transit accessibility on employment outcomes [21, 22, 23], studies in other regions show little or no association between transit availability/quality and employment participation [19, 24, 25, 26, 27].

At least three explanations have been used to explain the inconsistency in the empirical literature on the effectiveness of transit for increasing employment participation among low income population. *First,* some researchers have attributed the inconsistency to the inherent difficulties in determining the effectiveness of transit mobility programs for socially disadvantaged groups, which include having no accepted performance measures and an inability to control for intervening factors that affect such population groups' employability. *Second,* it has also been noted that, as low-wage workers benefit from increased job access, they have the opportunity to purchase an automobile, which would end their reliance and use of public transit and thereby increase the difficulty in assessing the impact of transit services on job seeking and retention. *Third,* many researchers also concede that the inconsistency in the empirical literature to some extent reflects the ineffectiveness of U.S. transit services in meeting the transportation needs of disadvantaged groups, especially the needs of unemployed single mothers. The lack of high-quality transit service in the U.S. has greatly diminished the attractiveness of distant suburban jobs for low income populations. While the JARC program is a landmark improvement in US transit history, the improvement it makes is insufficient to bring U.S. transit systems to the tipping point past which transit can serve as a viable substitute for the automobile. Given the US context, it is difficult to empirically detect the role of transit availability and quality in influencing employment participation.

Table 2.2: Review of the Empirical Literature on Transit and Employment

Author, Year	Study Area /Population	Methodology	Key Findings	Transit impact
Kawabata 2003	1,518 welfare recipients in Los Angeles, CA in 1999-2000	Multinomial logit regression of employment outcomes	Transit-based job accessibility increases employment probability for auto-less welfare recipients.	Yes
Ong, and Houston 2002	565 carless, single women welfare recipients in Los Angeles, CA in 1999-2000	Logistic regression of employment outcomes	Transit service level at residences moderately increases employment probability.	Yes
Yi 2006	2,008 individuals age 16-64 in Houston, TX in 1995	Multinomial logit regression of employment status	Transit accessibility increases employment probability and the positive effect is higher for captive transit riders than choice riders.	Yes
Sanchez 1999	449 census block groups in Portland and 409 in Atlanta in 1990	Two-stage least squares regression of average employment levels	Transit-based job accessibility positively influences employment levels for Atlanta block groups but not for Portland block groups.	Partially
Thakuriah and Metaxatos 2000	40,000 female welfare clients in northeastern Illinois area in 1998	Multinomial logit regression of job tenure	Auto and transit-based job accessibility positively influence employment retention for female clients with high school or higher educational degrees but not for non-high-school-graduates.	Partially
Cervero, Sandoval, and Landis 2002	466 welfare recipients in Alameda County, CA in 1992-1993	Multinomial logit regression of employment status changes.	Car ownership is much more important than transit service quality in getting people off welfare and into gainful employment.	No
Sanchez, Shen, and Peng 2004	190,405 welfare recipients in Atlanta, Baltimore, Dallas, Denver, Milwaukee, and Portland MAs in 1999	Multinomial logit regression of recipients' case status.	Of transit and employment access variables, none performed consistently and in no cases were there statistically significant coefficients with the expected signs.	No
Bania, Leete et al. 2008	Welfare leavers in Cuyahoga County, OH in 1998-2000	Logistic/OLS regression of employment status, earnings and work hours	Auto and transit-based job accessibility shows no significant association with any of the job outcomes.	No

A significant body of research also exists on linking private auto transportation to job seeking and retention [8, 28, 29]. The consensus is that car ownership is a far more powerful predictor of whether people will find a job than the availability and quality of transit services. In addition, private mobility improvements may be more cost-effective than transit improvements to bridge welfare recipients and suitable job opportunities, given the dispersed distribution of entry level jobs in many U.S. metropolitan areas [30]. However, there is increasing recognition that excessive auto use has negative societal consequences such as sprawling development patterns, declining social capital, and deteriorated environmental quality. Thus, promoting car ownership among low-income population may not receive much public support. There has also been the concept of welfare queen perpetuated by President Regan during his campaign for president in 1976. The story portrays a woman who drove a Cadillac and received mass amounts of benefits from the government by using aliases, false husbands, and excessive children. This story was widely reported to be exaggerated or all together false but it has shaped some of the perceptions of people on welfare. Currently, many states limit vehicle ownership for welfare recipients, forcing them to drive only older, more unreliable cars and thus contributing to the problem of getting to work. In California, for example, state regulations limit welfare participants to vehicles with values no greater than $4,650.

2.3 Summary

In summary, planners have long identified the issue of spatial mismatch but thus far have not consistently succeeded in solving this problem. Previous efforts to solve the question of spatial mismatch through relocating the urban poor to the suburbs, attracting more jobs to the central city, and improving transportation and mobility for low-wage workers, have been consistent and led to mixed results.

Spatial mismatch theory is useful in underscoring the importance of utilizing a transit equity perspective when evaluating the benefits of the Hiawatha light rail line. In addition, this project can further the literature on planning's many attempts at addressing spatial mismatch for low-income residents. By understanding what benefits are garnered for low-income residents who utilize the light rail line to access employment opportunities, we can better determine whether transportation mobility policies are effective.

Chapter 3: Defining the Impact Population

This project uses a transportation equity perspective to evaluate the benefits of the Hiawatha light rail transit line. Before we can understand the impacts of public transit, it is important to have a clear understanding of which groups are considered economically disadvantaged. This includes a thorough study of the official definition of poverty as well as other commonly identified groups such as low-wage workers and the transit-dependent. This chapter will begin with an overview of the debate surrounding current poverty thresholds, as well as discuss how to define low-income and transit dependent populations. Lastly, it will provide geographic information as to where low-income and transit dependent residents live within the Twin Cities metropolitan area and show the spatial distribution of entry-level jobs.

3.1 Defining Poverty

Poverty can be defined simply as economic deprivation [31]. However, social scientists have long debated how to measure poverty and what income level constitutes economic deprivation. The official government definition of poverty employs on the use of setting a specific poverty threshold. Mollie Orshanky of the Social Security Administration is responsible for developing the first poverty threshold in 1965. The threshold has its theoretical roots in the concept of minimum subsistence and the methodology is based on a calculation of an economical food budget [32]. Orshanky created separate poverty thresholds for different family sizes and based on the sex of the head of household [33]. Orshanky also differentiated between farm and non-farm households based on the theory that farm households could provide a percentage of their food budget through gardening or farming instead of paying for this out of their income. Thus, their poverty threshold was originally calculated at sixty percent of the non-farm threshold [33]. In 1965, the Bureau of the Budget recommended Orshanky's measurement to be used to define poverty for statistical and planning purposes [33]. This threshold continues to be the primary method for quantifying poverty.

Modern calculations for determining the poverty threshold closely resemble Orshanky's original poverty line. However, there have been a few, mostly minor, changes to the methodology since that time. In the years immediately following the adoption of the poverty line, the Social Security Administration expressed concerns that the perception of poverty would likely change as levels of living standard rose due to economic activity [33]. Furthermore, Orshanky's original poverty threshold differentiated non-farm households from farm households, with the farm households needing only 75% of the income of other households. The United States Department of Agriculture heavily objected to this differentiation. In 1969, two changes were made to the poverty measure. The first change was an agreement to use the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) to adjust the poverty thresholds based on changes in inflation. In addition, the farm poverty threshold was increased to 85% of non-farm poverty thresholds [33].

In 1979, an additional change was made to the poverty line, also concerning the use of the Consumer Price Index. This change was based on the Bureau for Labor Statistic's 1978 introduction of an additional Consumer Price Index. The new index, the Consumer Price Index for All Urban Consumers (CPI-U) was broader than the previous version. Although Fisher (1992) was unable to locate documentation that explained why this change had been made, in 1979, CPI-U was chosen as the standard for adjusting for inflation.

The most recent changes to the poverty thresholds occurred in 1981. The differentiation between farm and non-farm poverty thresholds was eliminated, as was the distinction between female-headed households and other households. The last change made in 1981 was to increase the largest category of family sizes from "seven or more" members to "nine or more" members [33]. Despite these minor changes, the poverty threshold has remained virtually unchanged since the original calculations by Orshanky.

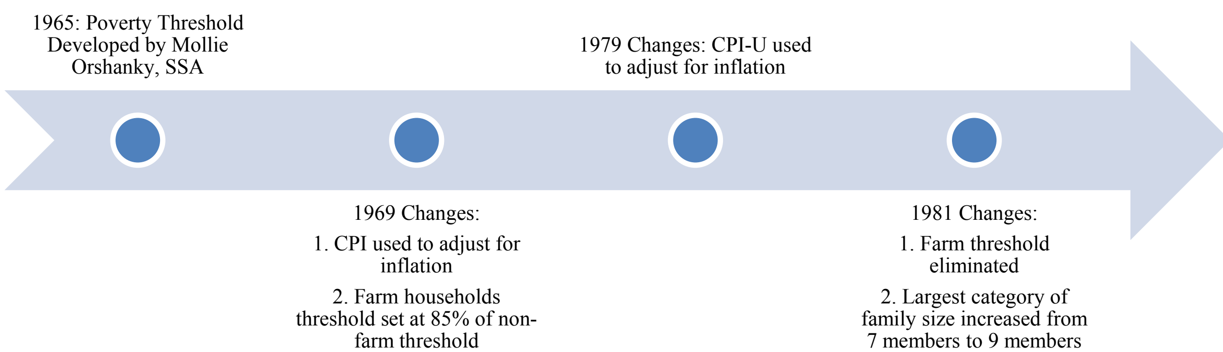

Figure 3.1. History of the Federal Poverty Threshold

Orshanky's poverty line has been under increasing criticism. Critiques have long requested an updated measure to more accurately calculate the scope of poverty in the United States. Critics have found fault specifically with Orshanky's methodology of basing the poverty line on a food budget. The National Academy of Science report (1995) has cited six major changes in household budgets since 1968 that prove the Orshanky methodology inaccurately reflects poverty status today. These include the increased labor force participation of mothers and associated increase in child care costs for America families, rising health care costs, changing demographic and family characteristics, a change in the standard of living, and changes in government policy regarding poverty that have affected disposable income and poverty status. Lastly, the report notes that the variation amongst different geographic locations within the United States is not accurately captured in the current poverty line [31]. All of these changes have resulted in food accounting for a smaller portion of the average household's budget. In 1968, food accounted for one third of budgetary expenses. Today, that proportion has decreased to one fifth [33].

Because the official poverty measure is viewed as being inadequate, researchers and policymakers have been forced to rely on other standards to measure and identify low-income populations. For public housing purposes, the Department of Housing and Urban Development (HUD) defines "low-income" as households whose income is within eighty percent of the median income for the area and "very low-income" as fifty percent of the median income. Although designed for public housing income limits, researchers frequently use these terms to identify low-income populations.

3.1.1 Application to the Twin Cities Metropolitan Area

Figure 3.2 shows the percent of population living below the poverty line by block groups in the Twin Cities Metropolitan Area based on the 2000 U.S. Census. The 2000 Census uses income from the previous calendar year, 1999, to determine poverty status. In 1999, the poverty line was $13,410 for a family of three with one member under the age of 18. (Poverty thresholds for other types of households are available online from the US Census Bureau and can be downloaded at: http://www.census.gov/hhes/www/poverty/threshld/thresh99.html) To determine the total number of people living in poverty, the Census sums the number of people in poor families and the number of unrelated individuals with incomes below the poverty level.

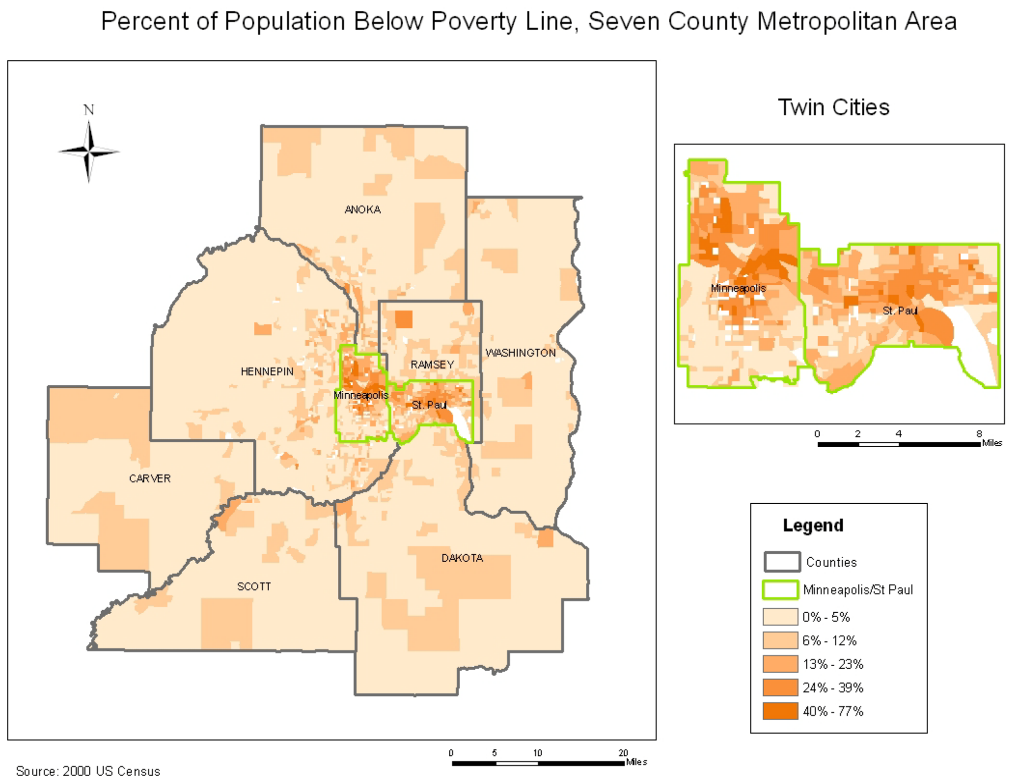

Figure 3.2. Percent of Population Below Poverty Line

The boundaries of the central cities of Minneapolis and Saint Paul are outlined to show the disparity between suburban block groups and those that are within the central cities. The majority of the block groups in the areas outside of Minneapolis and Saint Paul have the lowest concentrations of poverty with fewer than five percent of the population living in poverty. Almost all of the block groups with the highest concentrations of poverty can be found within these two central cities. This map demonstrates that the majority of those living in poverty live in either Minneapolis or Saint Paul.

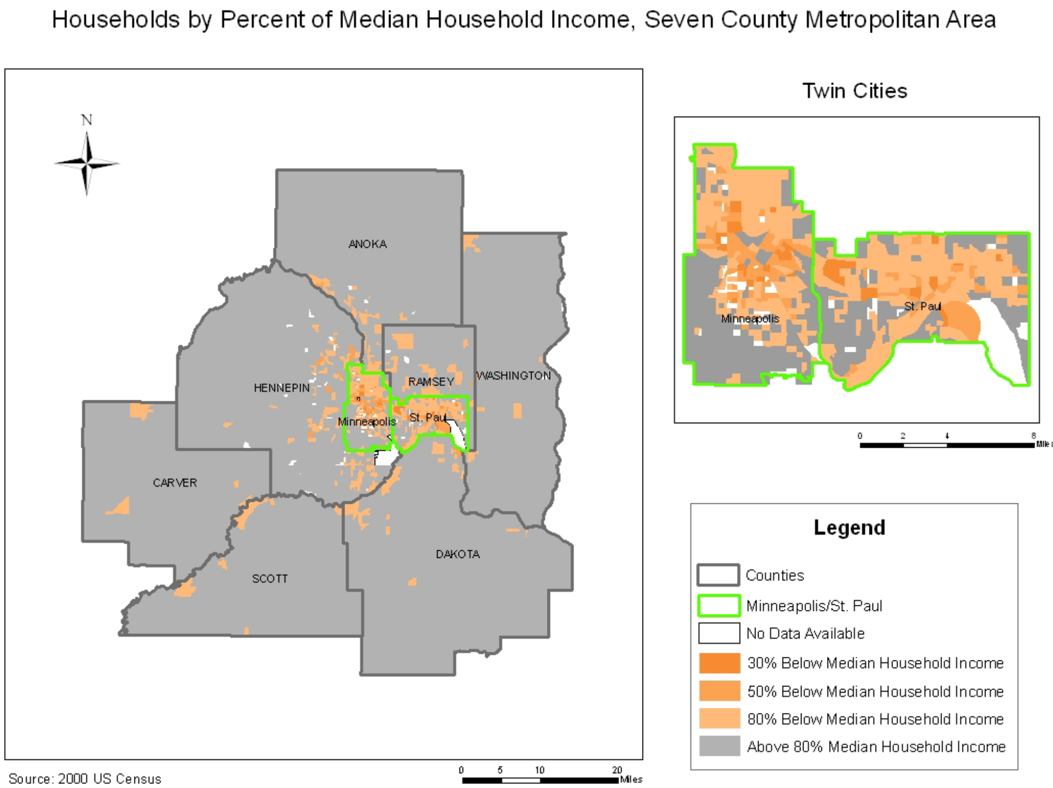

Figure 3.3. Households by Percentage of Median Household Income

Figure 3.3 shows the median household income of block groups in the seven-county metropolitan area by their percentage of the median household income for the Minneapolis-St. Paul Metropolitan Statistical Area (MSA) based on data from the 2000 US Census. Only block groups that are considered “low-income” at eighty percent of the median household income are highlighted. Those that are not defined as low-income are shown in gray. Again, the majority of the areas outside of Minneapolis and Saint Paul have only small pockets of low-income block groups. The Twin Cities themselves have the majority of the low and lowest-income block groups in the region.

3.2 Defining Low-Wage Workers

While the general definitions of poverty and low-income population are useful to this project, given the specific research aim to assess the impact of public transit systems on job accessibility, defining low-wage workers and transit-dependent population groups are particularly relevant. Conceptually, “working poor” refers to individuals who maintain regular employment but remain in relative poverty. Quantitatively defining this population has proven to be a more difficult task. Multiple standards exist for how many hours worked per hour constitutes “working” and similarly, researchers use multiple benchmarks for household income to define “poor” [34].

According to Working Poor Families Project (WPFP), working poor refers simply, to low-income individuals and families that struggle to meet basic needs [35]. Although their work focuses specifically on the plight of low-income families, their definitions can be a useful benchmark. The organization considers all adults over the age of fifteen in a family who work a combined 39 weeks or more in a twelve month period or adults with a combined work effort of 26 to 39 weeks and one unemployment adult looking for working as "working"[35]. In addition, WPFP uses incomes less than 200 percent of the poverty threshold as a benchmark for low-income. In 2006, the poverty threshold for a family of three with one child under 18 was $16,227. Earning less than $32,454 for that family would be considered low-income [36, 37]. Based on these definitions, there were approximately 9.6 million low-income working families in the United States, of which 2.5 million were considered to be in poverty based on official federal government definitions [36].

Despite their tenuous financial situation, low-wage workers are often passed over for federal benefits because they are not considered to be officially living in poverty. In the book *The Working Poor*, David Shipler (2004) labels this population as an "invisible" group: invisible both to policy makers and the public media. According to the WPFP, not only does federal policy fail to meet the education and skill needs of low-wage workers, but the federal government also has very limited data that captures the overall conditions of low-income working families [35]. Without this data, it is nearly impossible to focus investments to target this segment of the population.

3.2.1 Application to the Twin Cities Metropolitan Area

Figure 3.4 displays one variable in helping to identify low-wage workers in the Twin Cities Metropolitan Area, the percentage of households in each census tract living below 150% of the poverty threshold. Again, the highest concentrations are within the boundaries of Minneapolis and Saint Paul while the majority of the suburban areas in the metropolitan region have lower concentrations. The exception is large portions of Carver and Scott Counties, where there are slightly higher concentrations of households.

One of the biggest criticisms that the WPFP had of the federal government's role in assisting low-income working families is that the limited amount of data available to identify this group and their needs. The census only provides two categories related to the poverty threshold: households who live below 150% of the poverty threshold and households that live above 150%. WPFP, on the other hand, identifies households earning less than 200% of the poverty threshold as being low-income. Therefore, the existing data fails to capture those households that earn between 150 and 200% of the poverty threshold. Furthermore, while data exists on the households based on the number of members who are working, the census does not combine that information with earnings information. Therefore, it is incredibly difficult to identify those households that are considered to be working poor.

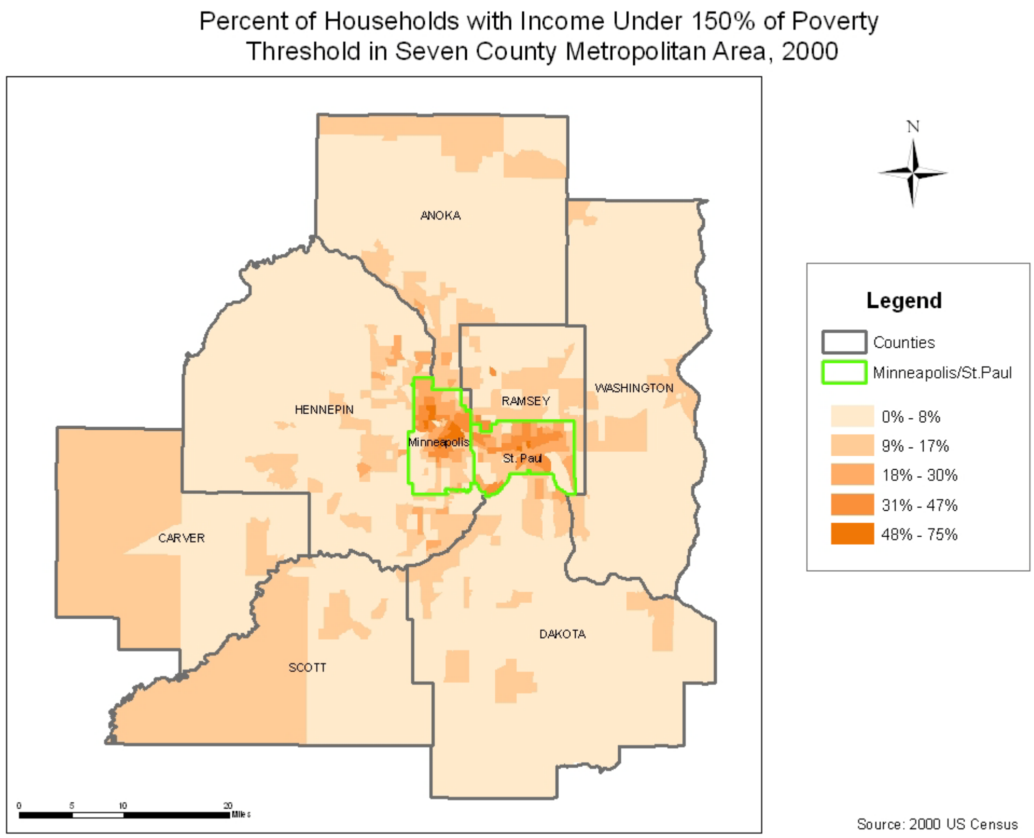

Figure 3.4. Percentage of Low-Income Households

3.3 Defining Transit-Dependency

In addition to low-wage workers, it is also important for this research to define and identify transit-dependent populations. According to Guiliano (2005), this group can be characterized simply as those who are unable, unwilling, or cannot afford to own or drive a private vehicle. Because they are dependent on public transit, this group has a lower level of mobility than the general population, which has three serious consequences [18]. First, unlike those with access to private automobiles, the transit-dependent are less able to travel to areas with lower prices and are forced to pay higher prices for goods, services, and medical care. Second, they have lower levels of access to jobs, as described extensively by the spatial mismatch theory [5]. Third, compared to the general public, low-income population often spend a higher percentage of their income on transportation.

3.3.1 Transit Dependency Index

Understanding where transit-dependent populations live in the metropolitan area is incredibly useful when choosing where to make transit investments. Although the Census provides data on the individual variables that attribute to transit-dependency, there is no question that determines dependence on public transit [38]. Therefore, we need new methods to aggregate this information and locate spatially where transit dependent people live within our metropolitan area.

The Transit Dependency Index was built using four variables: percentage of households with no vehicle, percentage of households that are low-income (using 150% of the median income as a threshold), and percentage of block groups with high youth or elderly populations. Each variable was given a different weight, based on its relative importance in reliance on transit. Households with no car were of the highest importance, since these households do not have any access to private transportation. Low-income households, defined as being 150% or less of the median income, were given the second highest weight. The lowest weights were given to elderly populations and youth. Elderly was weighted slightly higher, because Travel Behavior data from the Metropolitan Council indicates that youth use transit less. The index ranges from 0 to 100, with 100 being the highest possible score.

TDI = (% of households with no car * 0.4) + (% of low-income population * 0.3) + (% of elderly population * 0.2) + (% of youth population *0.1)

Utilizing the spatial interpolation of the Kriging method which displays data continuously, the overall patterns of areas with high transit-dependency are more easily distinguishable.

The highest concentration of transit-dependent populations resided within Minneapolis and Saint Paul. Even within Minneapolis and Saint Paul, there were distinct spatial patterns. In Minneapolis, the northern and central areas had much higher transit dependency levels than the area near the Chain of Lakes. Central Saint Paul also had a higher transit dependency index than the outlying regions of the city. There were also outlying areas that had high levels of transit-dependent populations. This is especially evident in the western region of Carver and Scott Counties.

The individual maps can help provide some idea of why regions scored high or low on the Transit Dependency Index. For example, Minneapolis had the highest concentrations of households with no car. Because it was given such a high weight, this immediately ensured that Minneapolis would have a higher index. The majority of households in the suburban block groups had at least one car per household (95-100%). This is true even for low-income households. Furthermore, Minneapolis and Saint Paul also had the highest concentrations of low-income populations, which was given a higher weight as well.

Looking at the two age variables is particularly interesting. The youth population was located primarily in the suburban areas, with the exception of North Minneapolis. North Minneapolis has a high concentration of youth residents. The elderly population is primarily concentrated in inner ring suburbs, located directly surrounding Minneapolis and Saint Paul, but not very high concentrations within these core cities. Also important to note is the high number of elderly residents in the western region of Carver County, which may be part of the reason this area has such a high TDI overall.

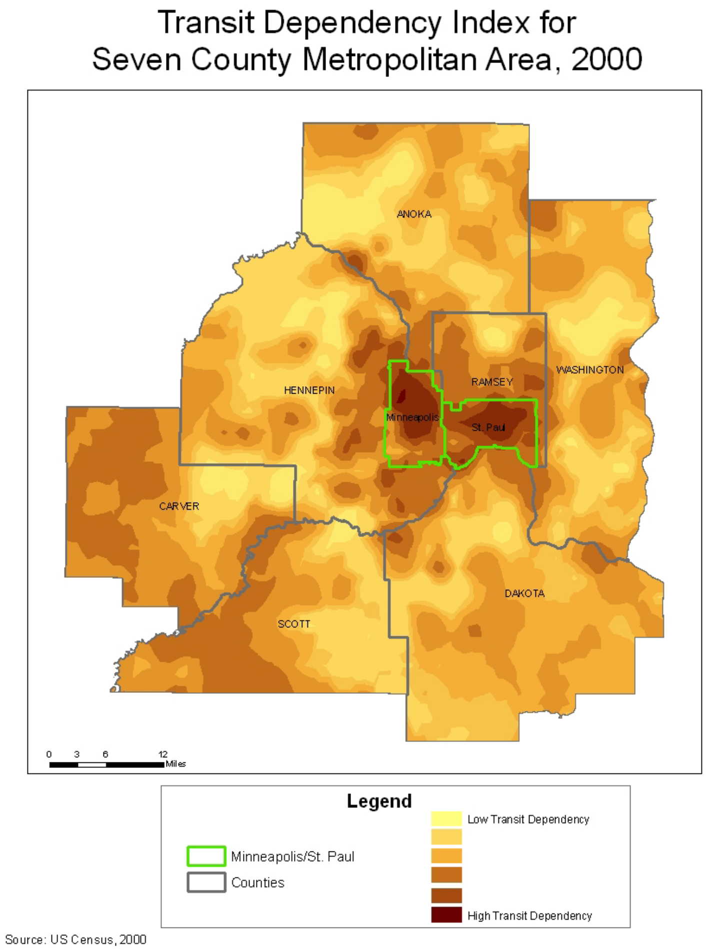

Figure 3.5. Transit Dependency Index

3.3.2 Application to the Twin Cities Metropolitan Area

The Metropolitan Council has two datasets that can be useful in identifying transit-dependent populations in the Twin Cities metropolitan region. The Metropolitan Council administered the 2000 Twin Cities Metropolitan Area Travel Behavior Inventory (TBI). TBI is composed of four parts: *Home Interview Survey, External Station Traffic Counts, External Station Origin/Destination Survey*, and *Highway Speed Survey*. The most applicable to this project is the Home Interview Survey, which includes detailed demographic information on the households in the Twin Cities metropolitan area and also includes a 24-hour travel diary [39]. This dataset surveys households in twenty counties surrounding the cities of Minneapolis and Saint Paul. A total of 6,219 households completed the survey, representing 0.5% of the population in the twenty-county region [39]. This survey was last conducted in 1990 and the Metropolitan Council plans on administrating another survey in 2010. Although this is a comprehensive dataset and includes information on both public transit users and those who do not use public transit, it has one primary limitation. The survey follows the same timeline as the decennial census, in that it is only conducted every ten years. Because of this, some of the data may become outdated before new data are published.

Table 3.1: Mode Choice by Household Income for Commuting Trips

Income Category	Walk	Bike	Driver	Passenger	Public Transit	Other
Less than $15,000	7.1	15.5	61.9	7.1	7.1	1.2
$15,000 - $30,000	7.3	2.0	80.6	4.9	4.6	.6
$35,000 -$60,000	6.5	1.2	83.6	5.5	2.9	.3
$60,000 or above	5.2	.5	87.0	4.7	2.2	.4

(N= 7,680 trips) (Unit: percent)

Table 3.2: Mode Choice by Household Income for Non-Commuting Trips

Income Category	Walk	Bike	Drive	Passenger	Public Transit	Other
Less than $15,000	12.4	5.4	52.3	22.4	6.7	.7
$15,000 - $30,000	7.2	1.5	68.4	19.8	2.4	.6
$35,000 -$60,000	5.9	1.2	66.7	24.1	1.2	.9
$60,000 or above	4.7	1.0	67.6	25.1	.8	.8

(N=30,383 trips) (Unit: percent)

Tables 3.1 and 3.2 represent the percentage of all trips by mode choice for households, based on their income levels and separated between commuting trips (trips to work or home) and non-commuting trips (all other destinations). Overall, public transit represents a very small portion of total trips although this option represented a high percentage of trips made by lower-income populations. The lower-income households were also much more likely to walk to their destination or bike there.

Table 3.3: Time Distribution of Public Bus Trips

Income Category	Early AM	AM Rush	Mid-Day	PM Rush	Night	Total
Less than $15,000	2.6	15.8	48.7	30.3	2.6	100
$15,000-$35,000	4.0	31.3	31.8	27.8	5.1	100
$35,000-$50,000	3.1	38.3	12.8	41.8	4.1	100
$60,000 or more	1.8	40.7	8.8	46.9	0.9	100

(N=30,383 trips) (Unit: percent) Source: Metropolitan Council TBI 2000

There is significant variation in how low-income use public transit, compared to populations with higher incomes. The above table includes information only for public transit trips. The vast majority of public transit trips for the higher-income group were made during either morning or afternoon rush (between 6 and 9:00am and between 3 and 6:30pm: the periods when frequencies are generally and highest when and Twin Cities Transit providers charge higher rush-hour fares). The lower-income group made many more non-rush hour trips. This shows a disparity between the way low-income populations and higher-income populations use public transit.

The Metropolitan Council also administers the Transit Ridership Survey. The most recent survey from 2006 provides socio-economic data of transit riders and can also help identify the proportion of riders that can be considered transit-dependent. However, the survey does have limitations, as it is an on-board survey, meaning data are collected from individuals riding the bus or light rail. Therefore, the data can only provide information on those people for whom transit is available and who are already riding transit. However, the data are more recent than the TBI survey results. The following tables summarize the socio-economic and demographic characteristics of Metro Transit riders.

Table 3.4: Transit Rider Frequency

Number of Trips	Frequency	Percent
5 or more days a week	111,149	63.9
2-4 days a week	43,944	24.2
1-4 days a month	11,536	6.3
Less than 1 day a month	4,713	2.6
First time using this route	4,570	2.5
Not answered	803	0.4
Total	181,715	100.0

(N=181,715 transit users) Source: Metro Transit Ridership Survey 2006

Guiliano (2005) considered riders who used transit at least one time a week to be "regular users". Based on the survey, "regular users" accounted for the vast majority of transit users (88.1%). Furthermore, a large percentage of respondents used transit far more frequently than what would qualify them as a "regular user", with over half of the respondents riding transit five or more days a week.

The survey data are helpful in identifying transit-dependent populations and learning more about this group. Therefore, we defined "frequent users" as those who rode transit five or more days a week. "Regular users" is based on Guiliano's definition and include those who rode transit 1-4 days a month and those who rode transit 2-4 days a week. Lastly, the "occasional" user was defined as those who responded that this was their first time using this route and those who said they used transit less than one day a month.

Table 3.5: Cross-Tabulation of Number of Vehicles and Transit Use Frequency

	Number of Household Vehicles				**Total**
Type of Rider	**0**	**1**	**2**	**3 or more**	
Frequent User (5 or more days a week)	26.6%	32.2%	28.9%	12.4%	100%
Regular User (in between)	23.4%	31.7%	30.5%	14.3%	100%
Occasional User (less than 1 day a month)	21.9%	28.7%	32.1%	17.2%	100%

Source: Metro Transit Ridership Survey 2006

Access to a private vehicle is an important characteristic of transit-dependent populations. Overall, most of the transit riders had at least one vehicle in their household. Frequent riders, however, were the most likely to respond that they did not have a vehicle in their household. This data can be misleading as the survey question asked how many vehicles the household had. This does not mean that the vehicle is available as another member of the household could have primary access. Furthermore, this question does not take into account whether or not the respondent has a well-functioning automobile, can afford to maintain the automobile, or is able to pay for gasoline.

Table 3.6; Cross-Tabulation of Household Income and Transit Use Frequency

Type of Rider	Less than $15,000	$15,000 - $35,000	$35,000 - $60,000	$60,000 or more	Total
Frequent User	17.2	27.4	21.3	34.0	100
Regular User	19.9	25.3	18.4	36.4	100
Occasional User	18.8	25.2	15.4	40.6	100

(N=24,612 Riders; Unit: percent) Source: Metro Transit Ridership Survey 2006

There was substantial variation in the income levels of the survey respondents. However, a greater number of frequent users had higher levels of income rather than lower levels.

Table 3.7: Cross-tabulation of Age and Transit Use Frequency

Type of Rider	Under 18	18-24	25-44	45-64	65 and over
Frequent User	3.1%	20.5%	45.4%	29.5%	1.4%
Regular User	3.0%	24.3%	44.0%	25.6%	3.2%
Occasional User	3.2%	21.6%	44.9%	28.3%	2.1%

Source: Metro Transit Ridership Survey 2006

There was also substantial variation in the age of survey respondents. However, the young and elderly are the segments of population that are most important to identifying transit-dependent people as they are most likely to be unable to drive. According to the survey, these age groups represented a very small proportion of the sample. Only 4.5% of frequent riders were either too young (under 18) or too old (65 or older) to drive.

3.4 Work Area Characteristics in the Twin Cities Metropolitan Area

The following maps, Figures 3.6 and 3.7, contain information about the work area characteristics of the Seven-County Metropolitan Area by block group. The total number of jobs for each block group is listed. These maps are meant to illustrate the change in work area characteristics before the Hiawatha Light Rail line was constructed (2002) and after (2006). In both maps, the Hiawatha Light Rail line is shown in red.

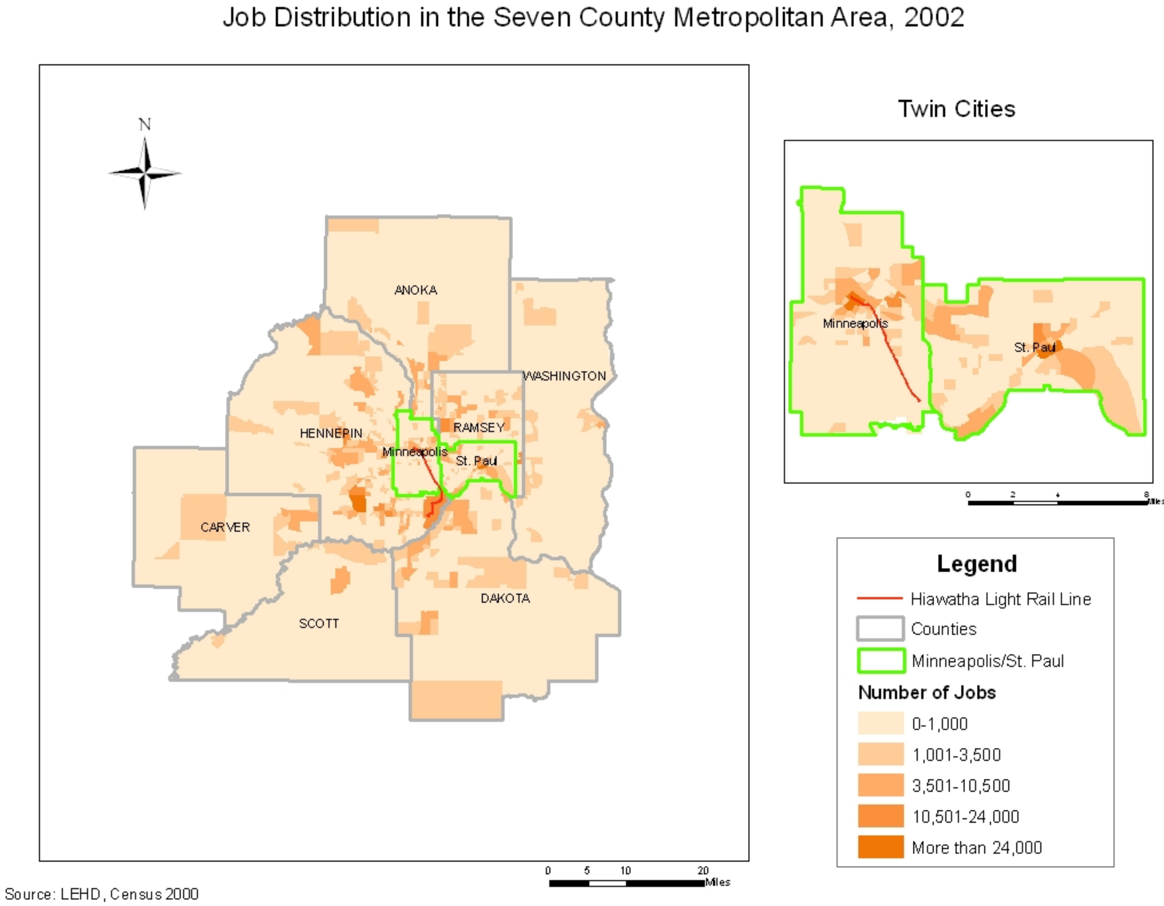

Figure 3.6. Job Distribution in 2002

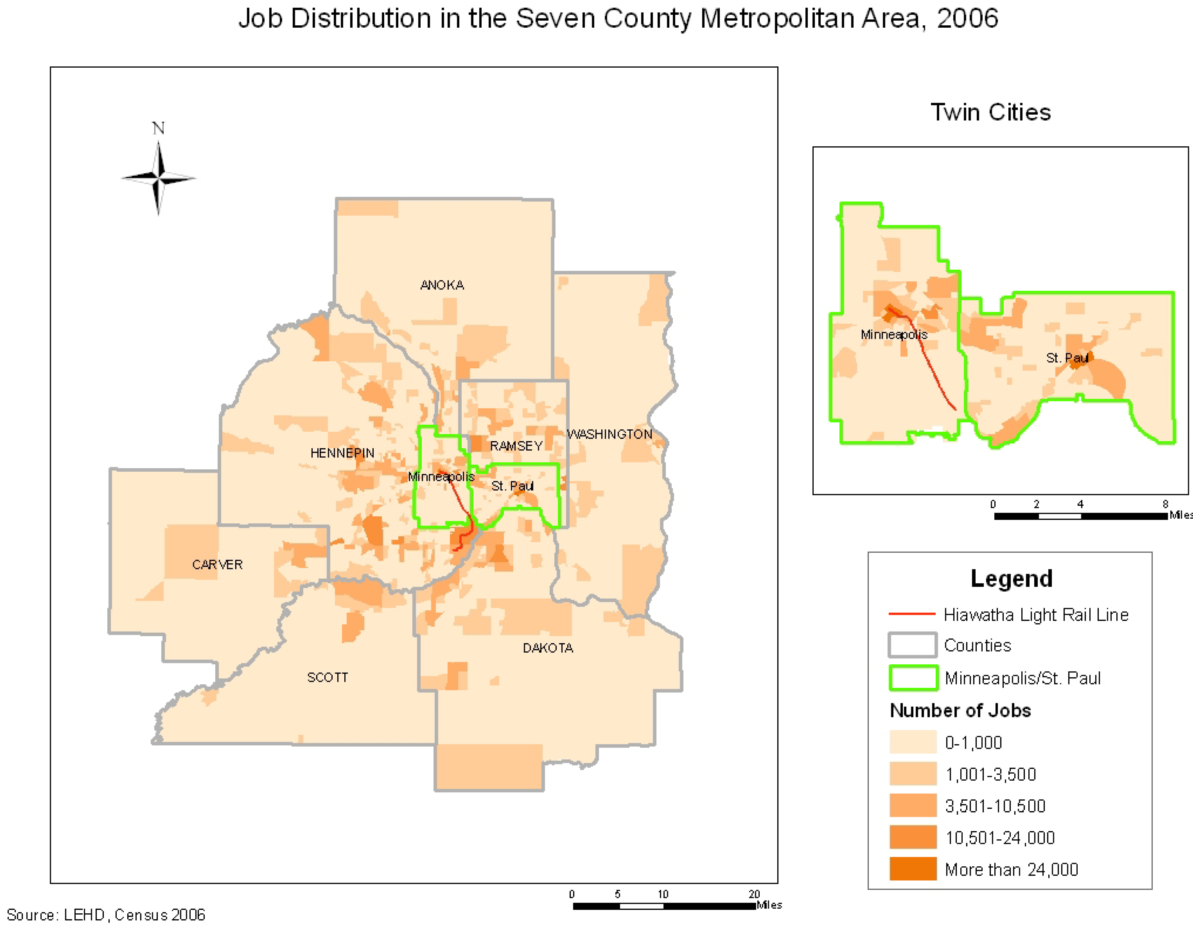

Figure 3.7. Job Distribution in 2006

Figures 3.8 and 3.9 show the spatial distribution of the low wage jobs in the Twin Cities metropolitan area. (Low Wage is defined as $1,200 a month or less. This income category is the lowest category created by the U.S. Census Bureau, Local Employment Dynamics.) There does not seem to be significant variation between 2002 and 2006. Figure 3.11 helps emphasize the changes by showing a percentage change in total jobs between 2002 and 2006.

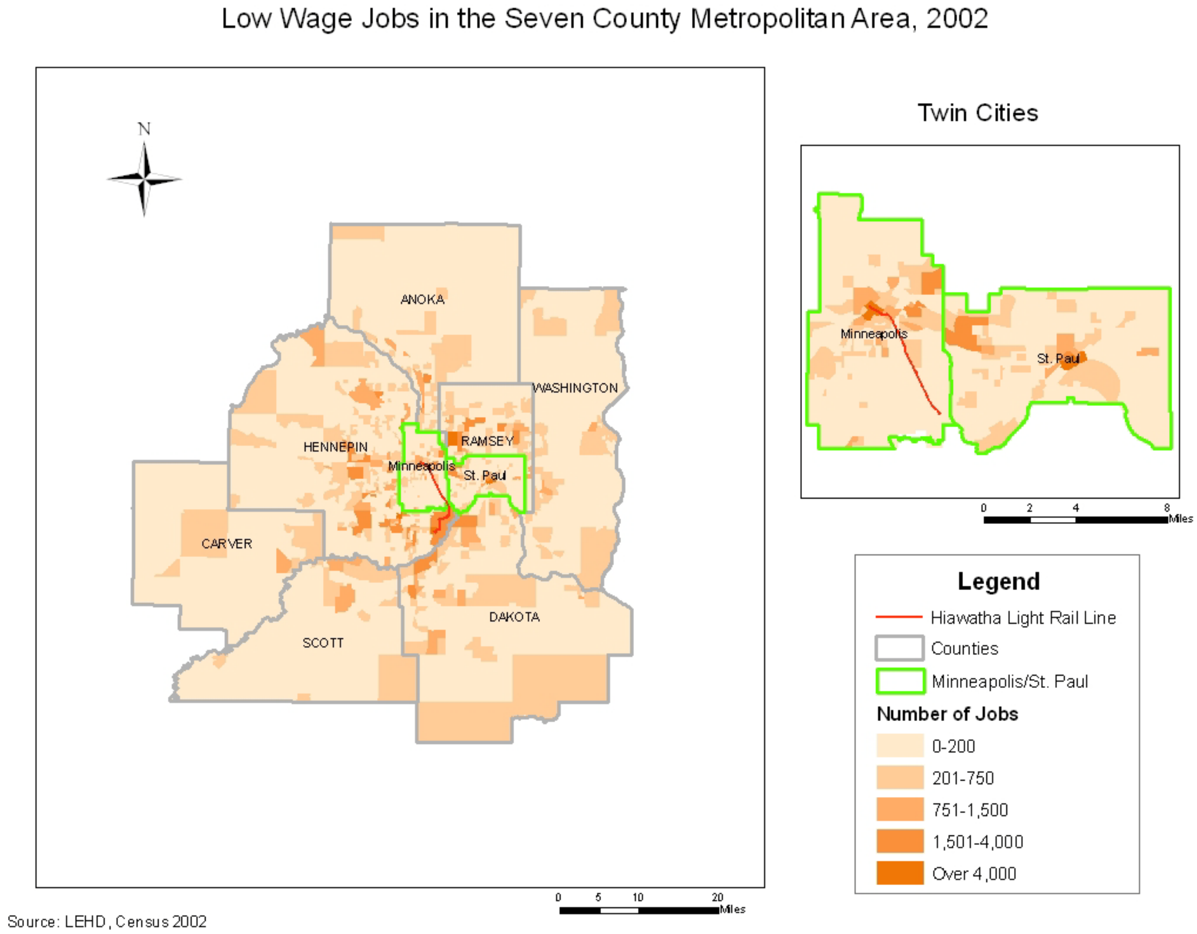

Figure 3.8. Low Wage Job 2002

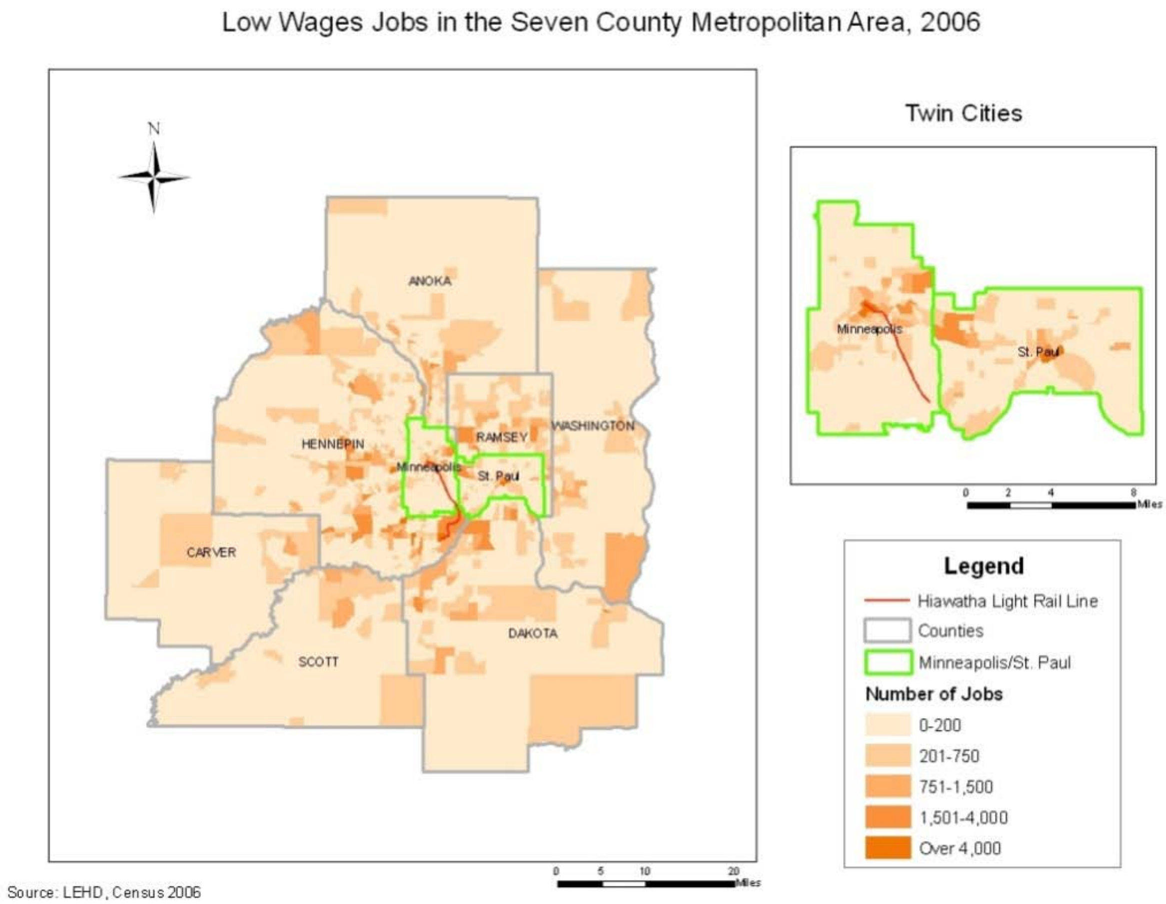

Figure 3.9. Low Wage Jobs 2006

Figure 3.10 shows the percentage change in total jobs between 2002 and 2006. To make it easier to read, this map only differentiates between census block groups that had any job loss and those that had any gain in number of jobs. This gives a clearer picture of the spatial distribution of the change in number of jobs, although it does not provide information on the extent of that change. Many of the block groups that had a gain in job were outside of Minneapolis and Saint Paul, particularly in Carver and Dakota counties. In Hennepin County, it is interesting to note that Bloomington, located at the end of the Hiawatha Light Rail line to the south of Minneapolis, experienced a loss in jobs.

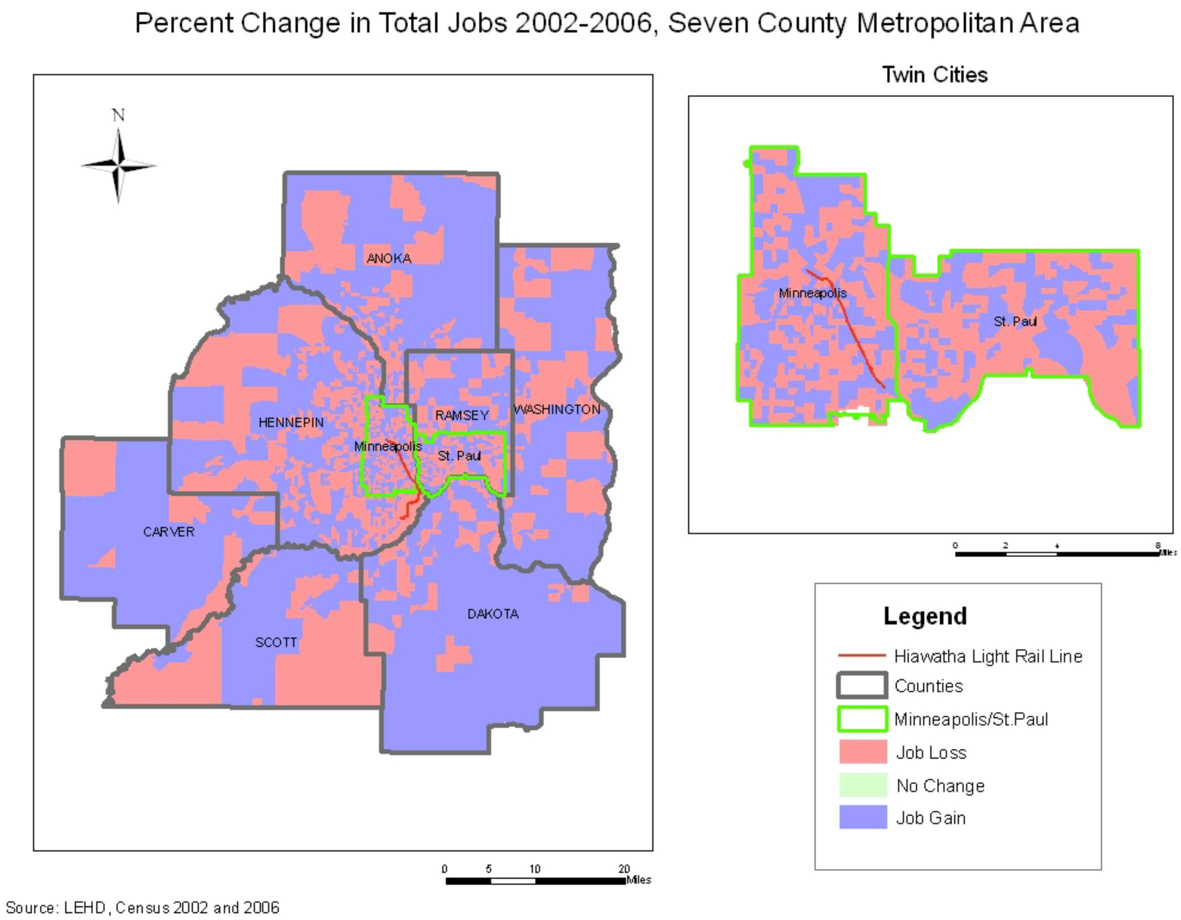

Figure 3.10. Percentage Change in Total Jobs 2002-2006

The following chart demonstrates the change in number of jobs by county. Although Hennepin County has the highest number of overall jobs, it experienced very little change between 2002 and 2006. In Anoka and Ramsey, the counties as a whole lost a percentage of jobs between 2002 and 2006. Scott County, which appears to have even distribution of areas with job growth and job loss, actually had 26.03% gain in number of jobs. Carver, Dakota, and Washington Counties also gained jobs, although by a smaller percentage.

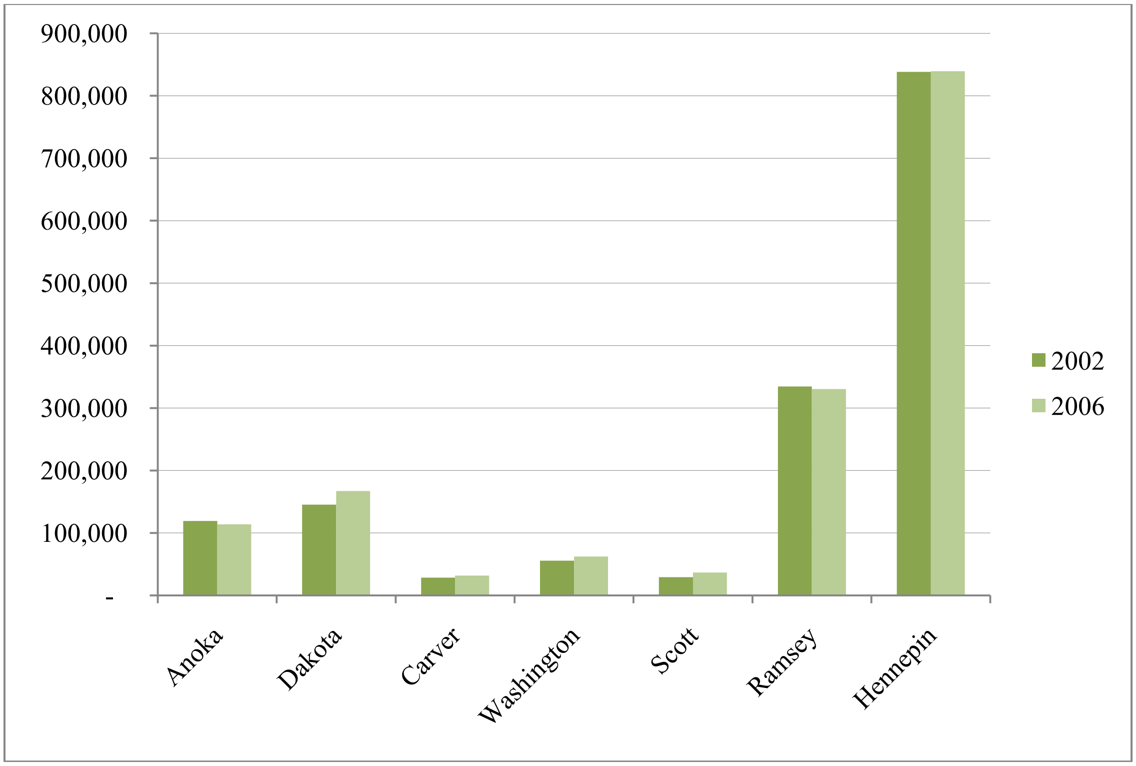

Figure 3.11. Number of Jobs by County, 2002-2006

Table 3.8: Change in Number of Jobs by County, 2002-2006

	Anoka	Dakota	Carver	Washington	Scott	Ramsey	Hennepin
Percent Change	-4.56%	15.01%	11.26%	12.09%	26.03%	-1.20%	0.12%
Unit Change	-5,430	21,811	3,205	6,726	7,557	-4,008	1,006

3.5 Summary

There is a significant need to create a new framework for identifying low-income and transit-dependent populations. These definitions must be broadened in order to accurately portray the scope of economic need in the United States. Researchers and policy makers have advocated for different solutions: from utilizing a relative measure to focusing primarily on measures of economic self-sufficiency rather than economic deprivation.

In 2009, Senator Chris Dodd and Representative Jim McDermott introduced the Measuring American Poverty Act of 2009 in an attempt to modify the current poverty threshold. Instead of relying on the food budget method used by Orshanky, the new measurement would be based on the necessary minimal income to purchase basic necessities (food, clothing, and shelter) and also include an additional amount for personal items [39]. Based on previous recommendations, the new measure would include income assistance sources and will subtract additional expenses that are not currently taken into account. Another feature differentiating this new measure and the current measure is that the new measure will account for geographic differences in cost of living [39].

In summary, the data available for this project does not provide a complete understanding of the transit needs of low-income and transit-dependent populations in the Twin Cities metropolitan area. More data, especially from local sources that can be collected on a frequent basis, is needed in order to gain accuracy in both defining and spatially locating low-income and transit-dependent populations. This is necessary not only for a better understanding of these populations but also to help strategically target investments that will improve their quality of life.

Chapter 4: Accessibility Analysis

The Hiawatha light rail line greatly reduces the amount of time it takes to travel between a number of areas in the Twin Cities metropolitan area. However, neither fast travel, nor any other kind of travel for that matter, is an end in and of itself. It is a means to the end of getting from the place where one is to a place where one wants to go. In other words, the more places one might want to go that can be reached by a trip of a certain length, the more potentially useful that trip is. This is the heart of accessibility: the amount of stuff you can get to in a certain time period.

Concentrations of jobs low-wage workers are likely to be qualified for are not uniformly distributed throughout the metro area. Precisely where those concentrations of jobs are in relation to light rail stations plays a major role in determining the usefulness of the Hiawatha line to low-wage workers. In addition, locations of jobs can move—it is possible that shifts in the real estate market brought on by light rail transit may lead to changes in the concentrations and types of jobs available near Hiawatha stations.

This chapter examines accessibility to low-wage, high-wage and all jobs before and after the implementation of light rail. A combination of map-based spatial analysis and statistical analysis is used to explore these changes throughout the transit service day.

4.1 Methodology

This research applies a cumulative opportunity approach to generate job accessibility measures. The cumulative opportunity approach counts the number of jobs that can be reached within a predetermined travel time (in this project, we initially use 15, 30, 60 and 90 minutes). Originally, the study also considered a gravity-based approach, which calculates accessibility using functions of two components: (1) the travel cost from the origin zone to the destination zone and (2) the number of entry-level opportunities at the destination zone. In this project, we considered the following gravity function:

Accessibility = sum of all blocks {number_of_jobs * exp(-0.1*travel_time_min)}

As discussed earlier, low-wage workers ought to benefit significantly from the addition of Hiawatha. Due to data limitations, it is difficult to identify what job opportunities are suitable for low-wage workers. As the LEHD database categorizes jobs into three groups based upon average monthly earnings (i.e., <=$1,200; $1,200-$3,400; and >$3,400), this research uses the low category—jobs with average monthly earnings lower than $1,200—as a proxy for the low-skilled jobs that low-wage workers are most likely to be qualified for. At an individual level, such a proxy would be suspect—it is not difficult to think of exceptions in either direction—but at a regional level, it offers a reasonable measure of jobs for which low-wage workers are likely to be qualified.

As transit service levels change throughout the service day, accessibility measures were produced for each hour from 5:00am to 9:00pm on weekdays, creating a total of 16 one-hour, metro-wide snapshots of job accessibility by transit. To show changes in job accessibility by transit before and after the Hiawatha line, we describe the pre-Hiawatha condition using the 2000 transit network and 2002 employment, and the post-Hiawatha condition using the 2005 transit network and 2006 employment data. Again, data imperfection prevents us from using the same years of data on the transit network and employment distribution.

In addition to the actual pre- and post-Hiawatha scenarios, two hypothetical scenarios were produced at the early stage of this project with the intent of isolating the accessibility effects of transit system changes in general and the implementation of light rail service in particular. The first scenario included two "real" observations combined in a hypothetical manner, producing its accessibility figures from the 2005 transit network laid over the 2002 employment data. Though the resulting accessibility figures clearly never actually existed, they were thought to offer a window on what accessibility changes could be attributed solely to transit system changes, as job location changes were taken out of the equation. The second scenario actually laid a purely hypothetical transit system—specifically the 2000 system with the sole addition of Hiawatha—over the actual 2002 employment data. This scenario was intended to provide a more focused analysis of what accessibility changes could be directly attributed to the implementation of light rail.

The two hypothetical scenarios were dropped from the final analysis for two reasons. First, the post-LRT transit/pre-LRT jobs scenario produced results only minutely different from the actual post-LRT transit/post-LRT jobs scenario. The small amount of additional information it offered was not considered worth the additional complexity required to include it in the final analysis. Second, upon further consideration, several theoretical problems appeared with the pre-LRT transit plus rail/pre-LRT jobs scenario. Most critical among these was the fact that more than half of all light rail passengers transfer to or from a bus route at at least one end of their light rail trip. Many of these transfers depend upon bus routes which were re-routed to serve light rail stations. These connections would be missed by the second hypothetical scenario. In general, due to the interconnected nature of the transit system, we decided that attempts to analyze it as anything less than a unified network were likely to produce distorted results.

For illustration purposes, Figures 4.1 through 4.4 present absolute accessibility values for each of the four scenarios originally considered for inclusion in the analysis. In comparing Figure 4.1 to Figure 4.2 and Figure 4.3 to Figure 4.4, very little difference can be seen between the before and after actual scenarios and their corresponding hypothetical scenarios.

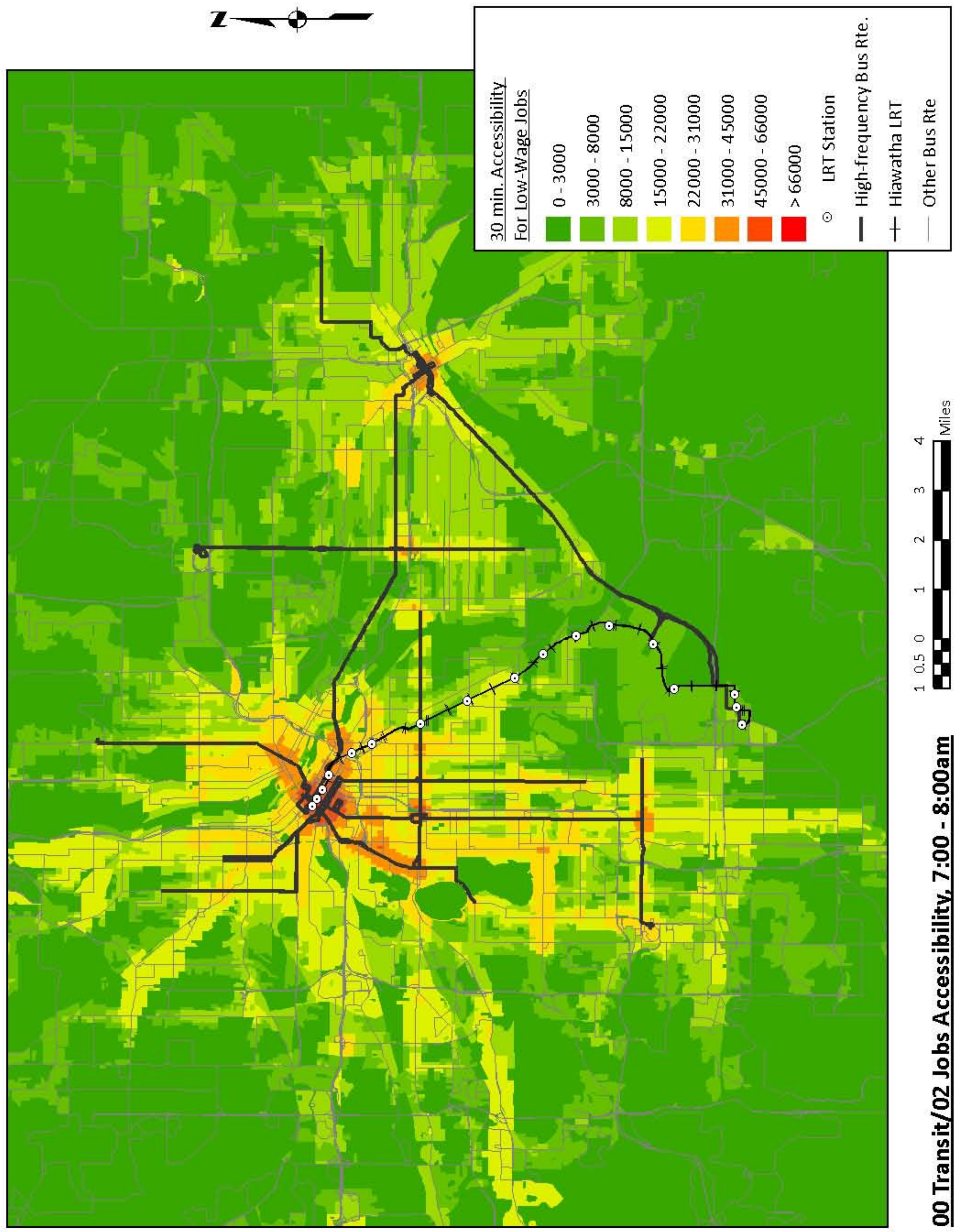

Figure 4.1. 30-min Accessibility, 00 Transit/02 Jobs

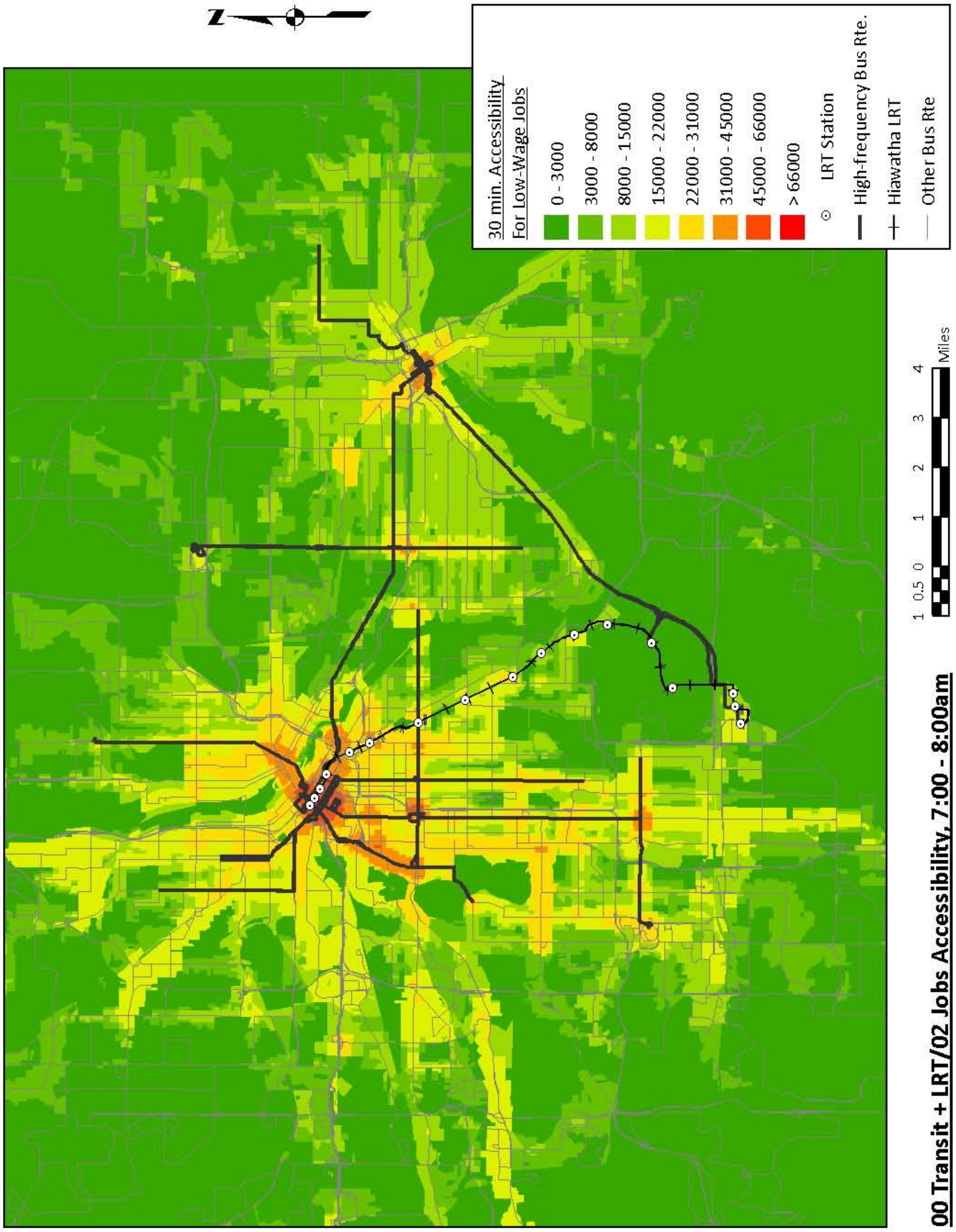

Figure 4.2. 30-min Accessibility, 00 Transit + LRT/02 Jobs

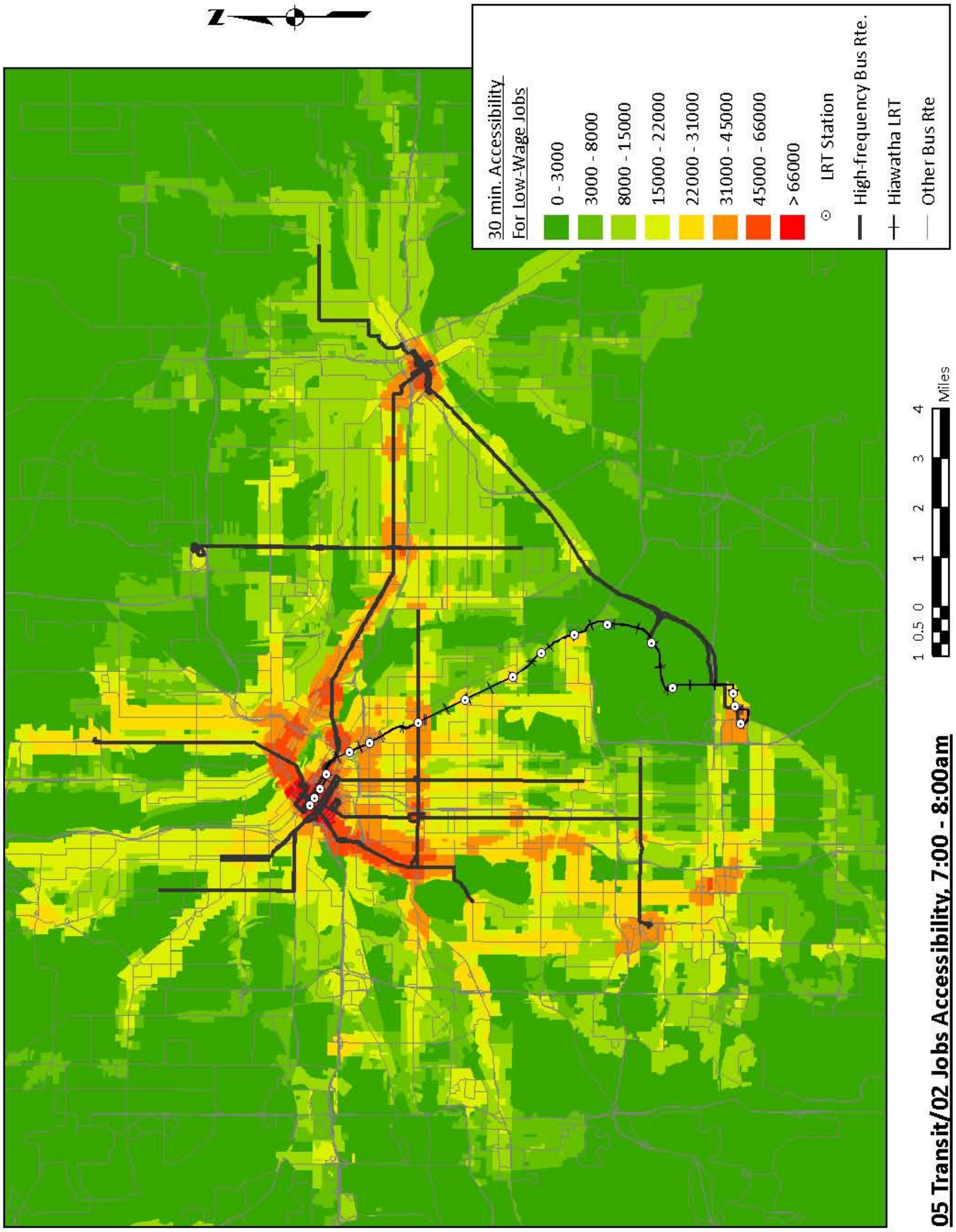

Figure 4.3. 30-min Accessibility, 05 Transit/02 Jobs

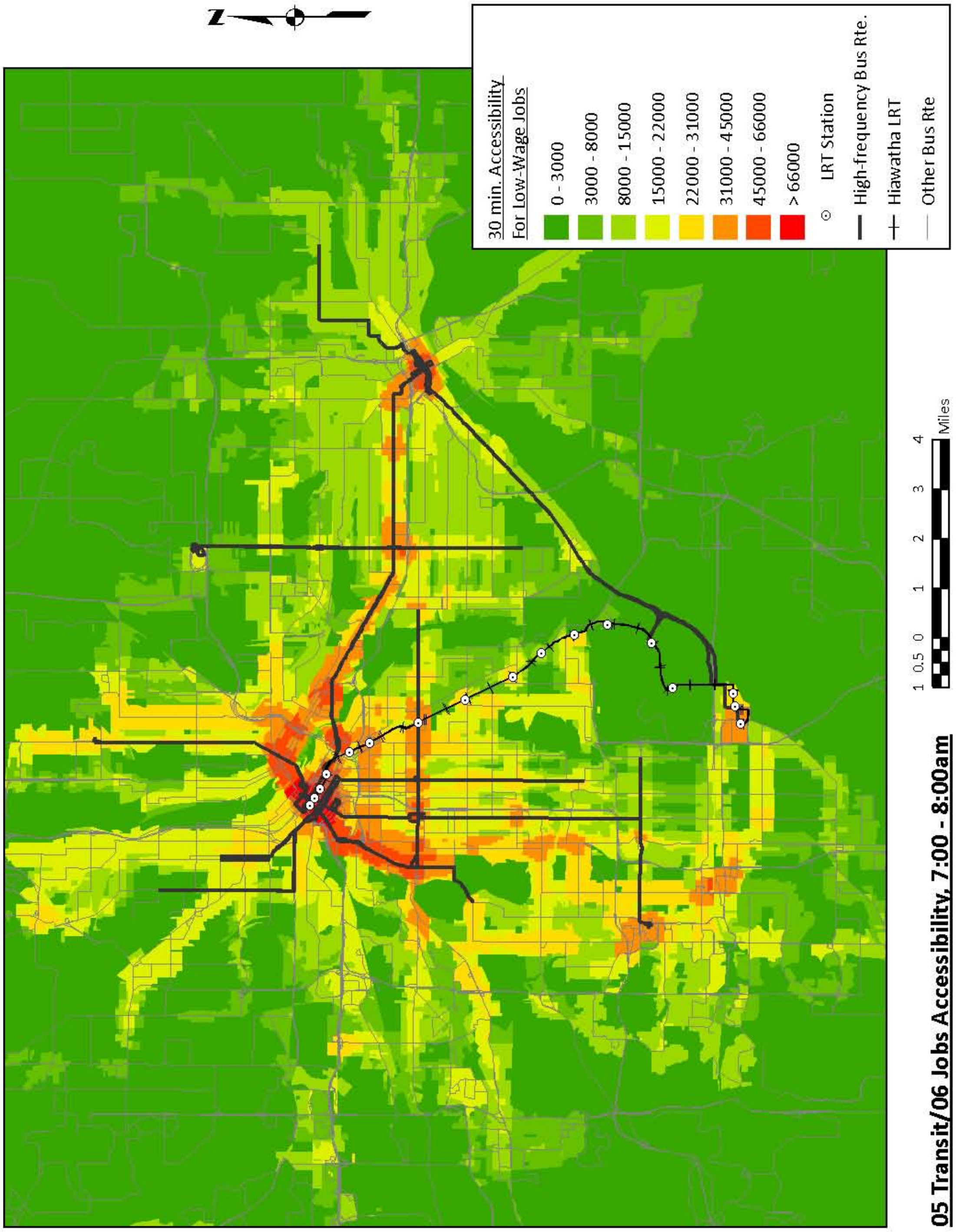

Figure 4.4. 30-min Accessibility, 05 Transit/06 Jobs

As this process—even for only the two actual, cumulative opportunity scenarios carried through to the final stages of analysis—would yield no less than 384 accessibility snapshots (16 hours X 4 cutoff times X 3 income groups X 2 points of observation), discussion here focuses on the 30-minute cutoff for reasons of clarity and brevity. In addition, several simplifying assumptions included in the original cumulative accessibility model used to produce the dependent variables may make the 30 minutes cutoff least subject to errors of simplification:

The accessibility model assumes a maximum walking distance distance of only 0.25 miles. This assumption is likely to skew the results of the 15 minute cutoff, since most passengers accessing light rail stations from very short distances would likely walk. Given the time spent walking to the nearest bus stop, waiting for a bus to arrive and finally traveling aboard the bus, such a short walk would save time for most passengers. In addition, given the average waiting times (headway/2) of most Twin Cities bus routes, half or more of the 15-minute cutoff would likely be spent simply waiting for a bus to arrive.

For technical reasons, the accessibility model assumes all transit trips include either 0 or 1 transfers. This is likely to skew the results of the 60-min and 90-min cutoffs because long transit trips often require multiple transfers. This is particularly true in our research context as many local bus routes in South Minneapolis and Bloomington are now oriented to provide feeder-distributor services for the Hiawatha line.

These simplifying assumptions, while limiting the interpretation of our findings, do set the bar relatively high for any accessibility gains found to be related to transit system changes. This in turn lends strength to any positive results, as the assumptions are stacked against them.

In order to gain a complete picture of how the Hiawatha LRT line may influence the job accessibility of low-wage workers, this research employs both spatial and statistical analysis techniques when analyzing accessibility changes before-and-after the Hiawatha line. The following two sections describe findings from the two types of analysis.

4.2 Map Analysis of the Before-and-After Accessibility Changes

Prior to creating statistical models describing changes in accessibility and residential/business location behavior before and after the introduction of light rail transit, Geographic Information System (GIS) software was used to produce maps describing 2002 and 2006 concentrations of both low-wage workers and low-wage jobs. Maps describing accessibility changes throughout the transit service day were also produced. Though their results are less concrete and less easily generalized across other areas of the city than those of the statistical models, these maps allow the quick recognition of geographic patterns in accessibility changes and location shifts. The maps described in the following section also played an invaluable role in informing the development of the regression models described later in the report and help show the process of research development.

4.2.1 Locations of Low-Wage Workers and Jobs

The maps in Figures 4.1-4.4 show the numbers of low-wage workers and jobs in Twin Cities in 2002 and 2006 at the census tract level[41]. Though these maps do not directly show employment accessibility, the information they convey shows how many low-wage workers and jobs are actuallyin areas where transit accessibility gains are like to have an impact on them. In addition, comparisons of the 2002 and 2006 maps offer clues to any relocation of low-wage workers and/or job which may have taken place after the opening of light rail service, whether due to attractiveness of improved transit, displacement by more powerful groups attracted to improved transit, or to some other cause.

First of all, these maps make it clear that spatial mismatch exists in the Twin Cities. Though some areas that are home to many low-wage workers also offer large numbers of low-wage jobs, most have one and not the other, or neither. This pattern puts special emphasis on effective transit as a much-needed means of promoting social equity in the region. As may be seen from both maps, large numbers of low-wage workers live near the Cedar-Riverside, Franklin Avenue and Lake Street-Midtown stations. It is difficult to see clear shifts between the two years, but the pattern clearly remains after the opening of the Hiawatha line. This observed pattern would seem to run counter to concerns that the implementation of light rail service may have led to the displacement of low-income residents due to gentrification of neighborhoods offering easy access to light rail stations. On the place of employment end of the relocation question, job distribution maps in Figures 4.3 and 4.4 do not indicate any notable differences in job distribution before and after the Hiawatha LRT line. However, both downtown Minneapolis and the Mall of America area in Bloomington make up significant concentrations of low-wage jobs, suggesting that, with its high travel speeds, the Hiawatha line may offer a powerful remedy to the spatial mismatch problem at least at the corridor level. Of course, while the maps offer valuable insight into this issue, the home-to-work commuter flow analysis discussed in Chapter 6 will offer greater precision about population/employment changes.

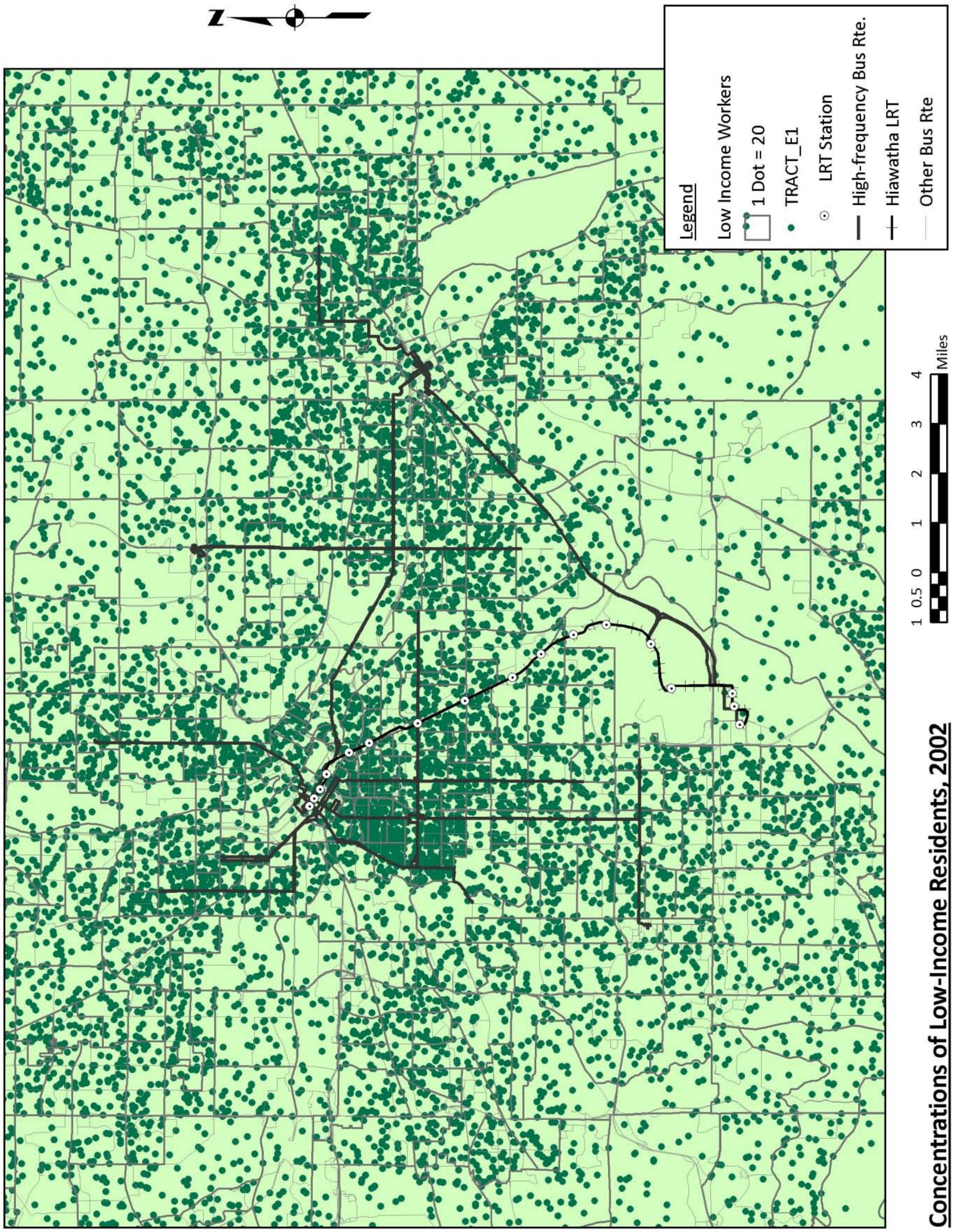

Figure 4.5. Concentrations of Low-Income Working Residents, 2002

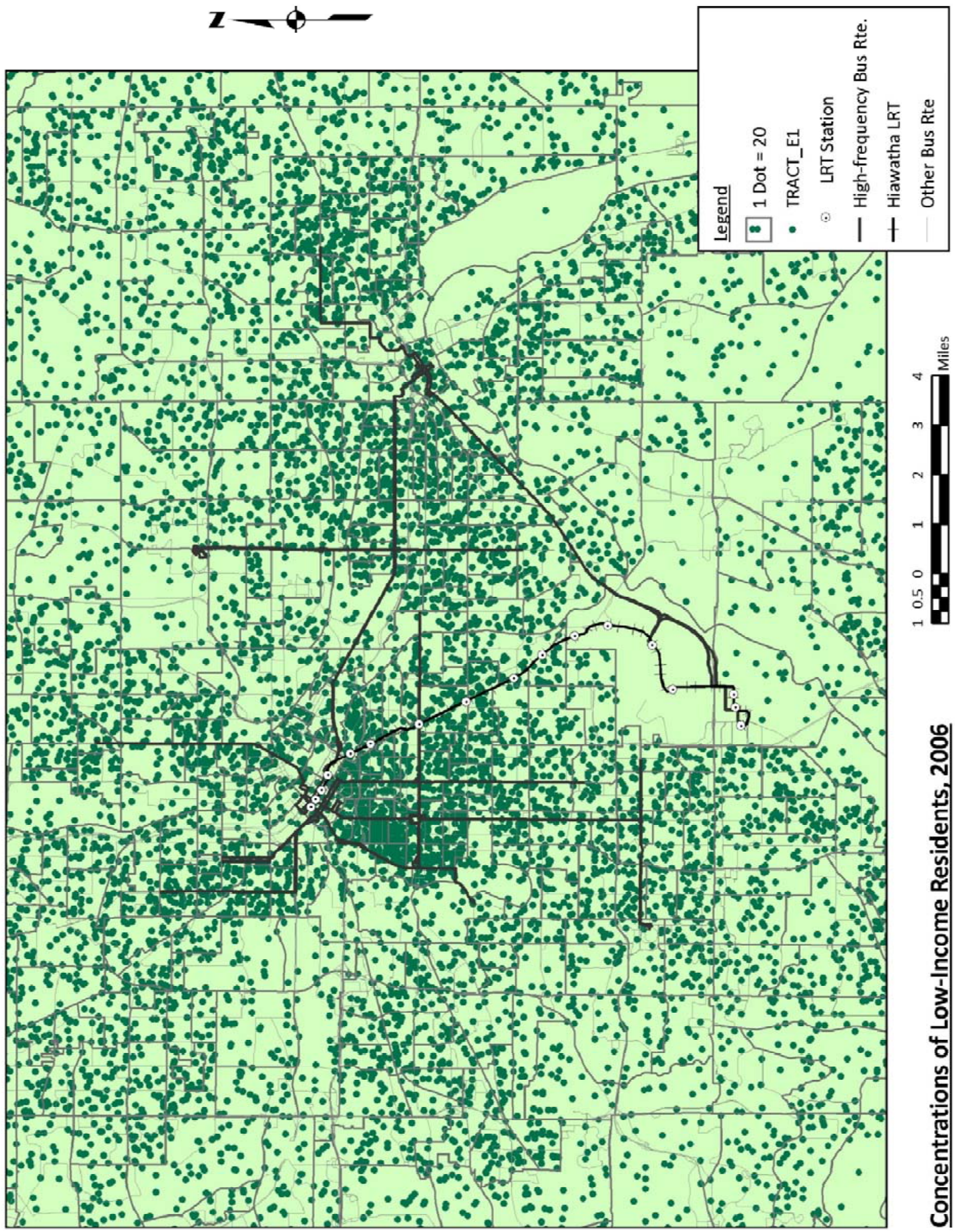

Figure 4.6. Concentrations of Low-Income Working Residents, 2006.

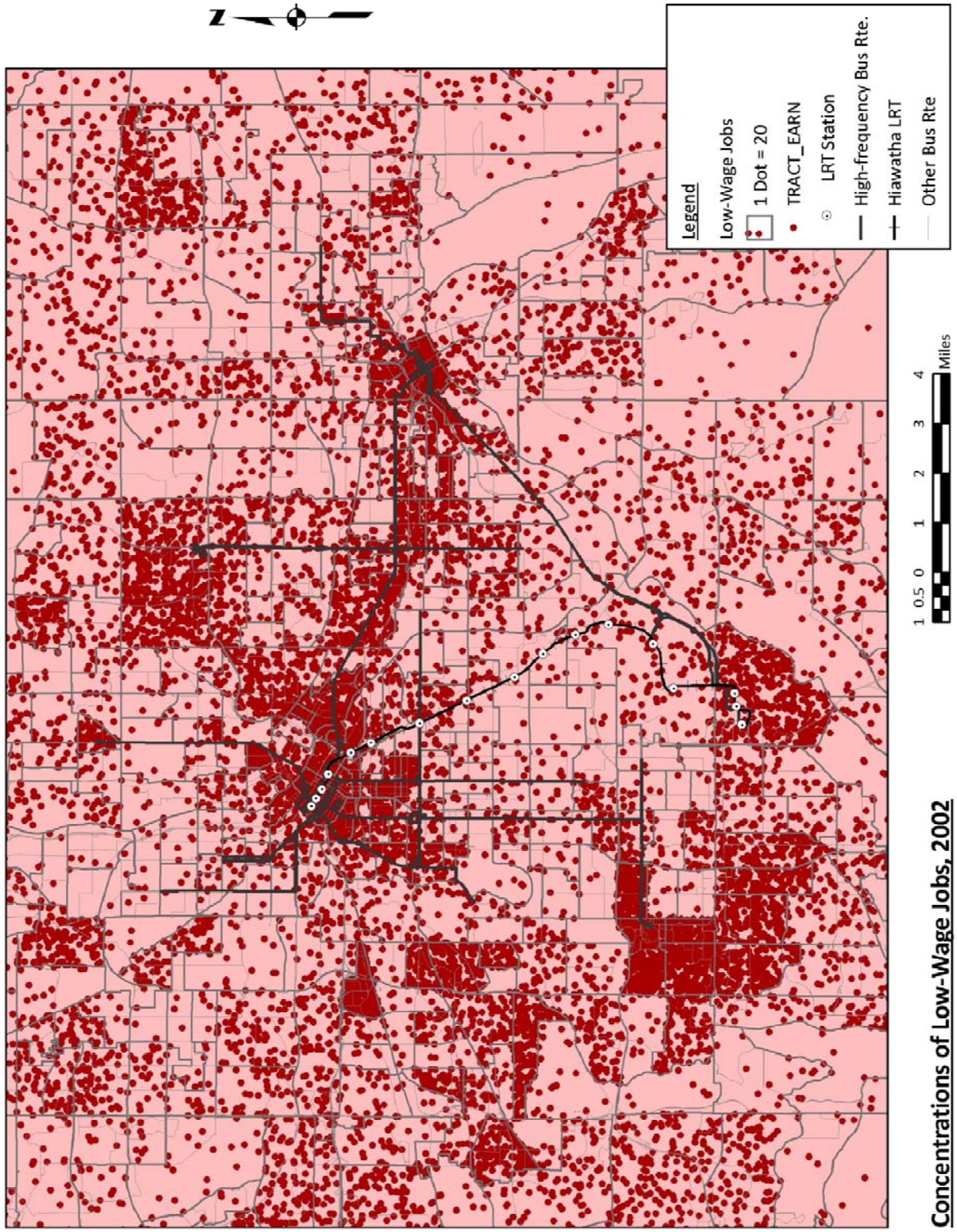

Figure 4.7. Concentrations of Low-Wage Jobs, 2002

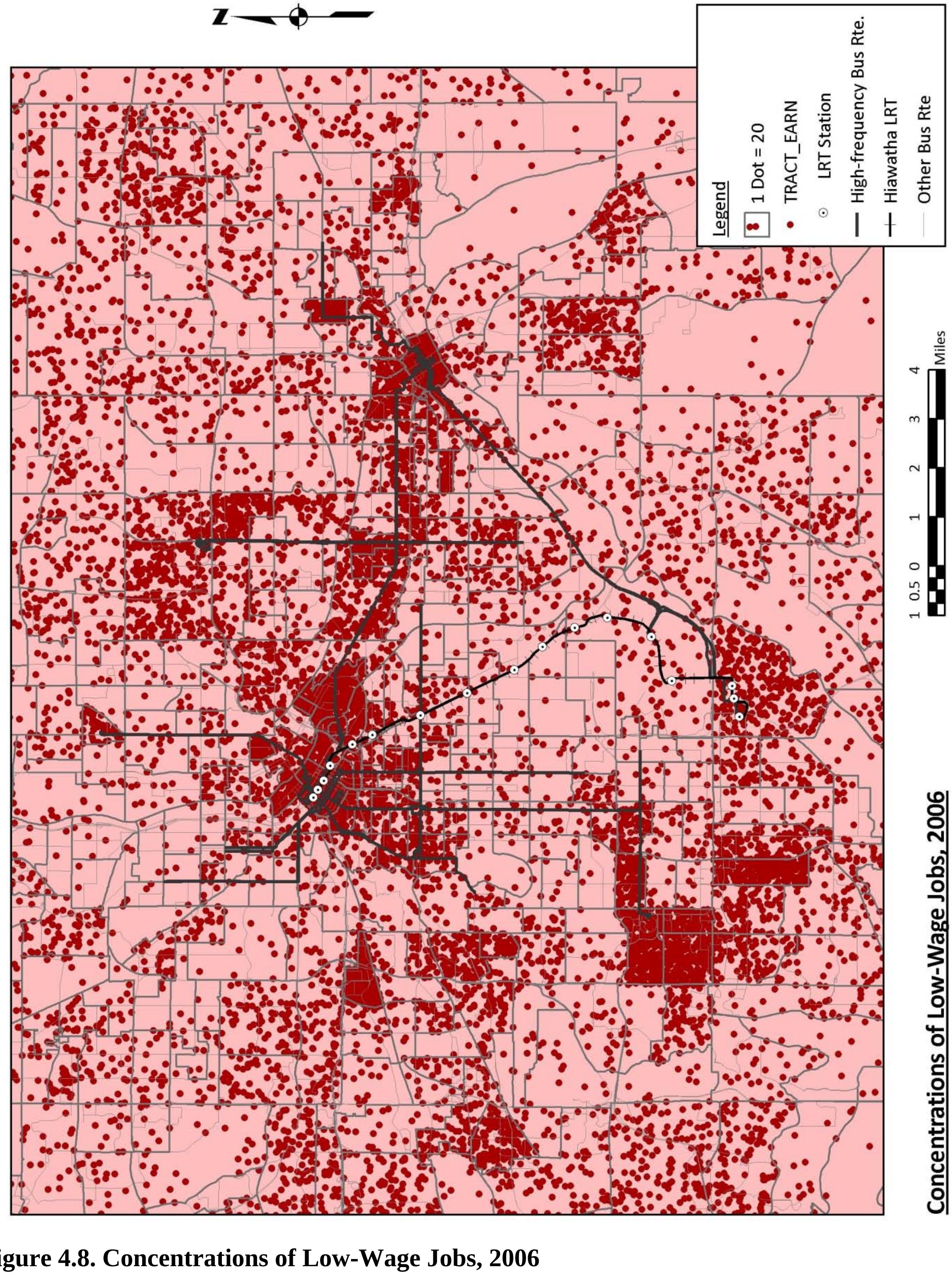

Figure 4.8. Concentrations of Low-Wage Jobs, 2006

4.2.2 Changes in Low-Wage Employment Accessibility Throughout the Service Day

The following maps deal with changes in 30-minute cumulative accessibility for low-wage jobs by transit before and after the Hiawatha addition. Though this only represents one of many accessibility measures under consideration in the study, it offers a convenient, quickly interpreted description of the changing situation for the target population. In all maps of this series, green areas represent census blocks experiencing either no change or a net accessibility loss, while yellow, orange and red areas represent census blocks experiencing a net accessibility gain; darker, more intense colors stand for greater gains and losses. Though maps were produced and analyzed for each hour of the service day from 5:00am to 9:00pm, only the hours 5:00am—6:00am, 7:00am—8:00am, 12:00pm-1:00pm, 5:00pm—6:00pm, and 8:00pm—9:00pm are shown here for the sake of clarity. These service hours provide snapshots, so to speak, of the early morning, morning peak, mid-day, evening peak and late evening periods of the service day. Based on the differences between them, they represent reasonable archetypes of these service periods.

Right from the start of the series, several things become apparent:

- There is a major change in localized transit accessibility to low wage jobs over the study interval;
- Major accessibility gains occurred along the Hiawatha corridor;
- While major gains in low-wage employment accessibility were not confined to this corridor, most seem to have occurred either along bus routes included in the high-frequency network of all-day 10-15-minute headways (such as the 16 and the 21), or along other bus routes which connect with high-frequency routes, especially those connecting with the Hiawatha LRT line (such as the 22).

Tables 4.1 and 4.2 list the bus routes with light rail connections. Table 4.1 shows all routes other than the large number of relatively limited service, often peak-only limited stop and express routes which connect in the downtown zone. Table 4.2 lists those downtown, limited-stop and express routes which connect with Hiawatha and make stops more than a quarter mile and less than 30-minutes scheduled journey time from their light rail connections (3-8) The minimum quarter-mile distance was chosen based on the assumption that light rail access trips of less than a quarter mile will be made on foot, even in cases where a bus connection was available. Given the short walk involved and the waiting time for a bus, the walking trip would almost always be faster. In keeping with the regional scope of the study, *all* transit low-income employment accessibility changes are included in these maps, whether directly connected with the the Hiawatha line or not. As the Twin Cities' transit system functions as a network, rather than merely a collection of individual routes, it is impossible to tell from these maps exactly how much of the observed accessibility change is due to Hiawatha. (Even the blocks surrounding light rail stations may benefit from bus system changes at connection points or employer relocations.) However, while accessibility gains many miles from the nearest station may have little to do with Hiawatha, the large accessibility gains observed along many connecting local routes likely do, For example, large gains appear along route 22 to the south of its 38th Street light rail connection; these gains do not continue at nearly the same level to the north of that connection, where a transfer to light rail would not be an option for a trip downtown. Frustrating as it may be, all that can be said of bus-corridor accessibility gains in circumstances between these two archetypes is that the truth lies somewhere in between.

Table 4.1: Selected Bus Routes Connecting with Hiawatha

Station	Route	Description
Downtown Zone	3	Mpls - St Paul via Como Ave
	4	New Brighton - Southtown via Mpls & Lyndale Ave
	5	Brkln Ctr - MOA via Chicago Ave
	6	U of M - Southdale via Mpls, Hennepin Ave
	7	Plmth - 34th Ave S via Mpls, Midtown
	9	Glenwood Ave - 46St LRT
	10	Central Ave - Northtown via University
	11	Columbia Ave - 4th Ave S
	12	Uptown - Opus via Hopkins
	14	Robinsdale - Bloomington Ave via W Broadway
	16	Mpls - St Paul via University
	17	Minnetonka Bvd - Washington St NE via Uptown
	18	Mpls - S Bloomington via Nicollet Ave
	19	Olson Mem Hwy - Brkln Ctr via Penn Ave N
	22	Brkln Ctr - VA via Lyndale Ave N & Cedar
	25	Northtown - Lake of the Isles
	39	Wells Fargo - Childrens Hospital
	50	Mpls - St Paul via University Ltd
	61	E Hennepin Ave - Arcade St
	94	Mpls - St Paul via I-94 Exp
Cedar - Riverside	7	Plymouth - 34th Ave S via Mpls & Midtown
	22	Brkln Ctr - VA via Lyndale Ave N & Cedar
Franklin Avenue	2	Franklin Ave - 8th St SE via Riverside Ave & U of M
	8	Franklin Ave LRT - Franklin Ave SE
	9	Glenwood Ave - 46St LRT
	22	Brkln Ctr - VA via Lyndale Ave N & Cedar
	25	Northtown - Lake of the Isles
Lake Street - Midtown	7	Plymouth - 34th Ave S via Mpls, Midtown
	21	Uptown - St Paul via Lake & Selby
	27	I-35W - Lake St LRT
	53	Uptown - St Paul via Lake & Marshall Ltd
38th Street	14	Robinsdale - Bloomington Ave via W Broadway
	22	Brkln Ctr - VA via Lyndale Ave N & Cedar
	23	Uptown - Highland Village vi 38th St
46th Street	7	Plmth - 34th Ave S via Mpls, Midtown
	9	Glenwood Ave - 46St LRT
	46	46th St - Highland Village
	74	46th St LRT - Sunray via 7th St
	84	Rosedale - Sibley Plaza via Snelling Ave
	436	Eagan - 46th St LRT via Mendota Hgts
	446	Eagan - 46th St LRT via Mendota Hgts
50th Street	None	
VA Medical Center	22	Brkln Ctr - VA via Lyndale Ave N & Cedar
	515	Southdale - VA via MOA
Fort Snelling	None	
Lindbergh Terminal	54	St Paul - MOA via W 7th
Humphrey Terminal	None	
Bloomington Central	None	
28th Avenue	54	St Paul - MOA via W 7th

Table 4.1 (Continued): Selected Bus Routes Connecting with Hiawatha

Station	Route	Description
Mall of America	5	Brkln Ctr - MOA via Chicago Ave
	54	St Paul - MOA via W 7th
	415	MOA - Eagan via Mendota Hgts
	440	MOA - Apple Valley
	441	MOA - Apple Valley via Eagan
	442	MOA - Apple Valley via Burnsville
	444	MOA - Savage via Eagan & Burnsville
	445	MOA - Cedarville via Eagan
	515	Southdale - VA via MOA
	538	Southdale - MOA via York Ave, Southtown & 86th St
	539	France Ave - MOA via Penn Ave, Normandale & 98th St
	540	Edina - MOA via Richfield & 77th
	542	84th St - MOA via 76th & American Blvd

Table 4.2: Downtown Minneapolis Express Bus - LRT Connections

Route	Description
133	Bloomington Ave - Mpls via Chicago Ave Ltd
134	Cleveland Ave - Mpls Ltd
135	Grand Ave - Mpls via 35th & 36th Ltd
141	New Brighton - Mpls Ltd
144	Snelling Ave - Mpls Ltd
146	Benton Ave - Mpls via Vernon Ave & 50th St Ltd
156	58th St - Mpls via Diamond Lake Ltd
250	St Josephs PR - Mpls via 95th Ave PR Exp
260	Rosedale - Mpls via Co Rd B2
261	Shoreview - Mpls via Roseville
270	Mahtomedi - Mpls via Maplewood
288	Forest Lake - Mpls Exp
355U	Mpls - Woodbury via U of M Exp
460	Burnsville - U of M via Mpls Exp
464	Burnsville - Mpls via Savage Exp
465	Burnsville - U of M via Apple Valley & Mpls
467	Lakeville - Mpls Exp
470	Eagan - Mpls via Blackhawk PR Exp
472	Eagan - Mpls via Blackhawk PR Exp
477	Apple Valley - Mpls Exp
478	Rosemount - Mpls Exp
479	Rosemount - Mpls Exp
490	Prior Lake/Shakopee - Mpls Exp
535	S Bloomington - Mpls via Richfield Ltd
552	12th Ave - Mpls via Bloomington Ave Exp
553	Bloomington - Mpls via Portland Ave Exp
554	Bloomington - Mpls via Nicollet Ave
558	Southtown - Mpls via Lyndale Ave & Penn Ave Exp
568	Nicollet Ave - Opportunity Partners via 50th St Rev Com
578	Edina - Mpls via Southdale Exp
587	Edina - Mpls via Valley View Rd Exp
589	W Bloomington - Mpls Exp
597	Masonic Home - Mpls via W Bloomington Exp
643	Cedar Lake Rd - Mpls Ltd

Table 4.2 (Continued): Downtown Minneapolis Express Bus - LRT Connections

Route	Description
649	Louisianna Ave - Mpls via Cedar Lake Rd Exp
663	Cedar Lake Rd - Mpls Exp
664	Co Rd 3 - Mpls via Excelsior Blvd Exp
665	Opportunity Partners - Mpls via 11th Ave Exp
667	Minnetonka - Mpls via St Louis Pk Exp
668	Hopkins - Mpls via St Louis Pk Exp
670	Co Rd 19 - Mpls via TH7 Exp
671	Excelsior - Mpls via Deephaven Exp
672	Wayzata - Mpls via Minnetonka Exp
673	Co Rd 73 PR - Mpls Exp
674	Orono - Mpls via Long Lake & Wayzata Exp
675	Mound - Mpls via Wayzata & Ridgedale Exp
677	Mound - Mpls via Orono & Plymouth Rd Exp
680	Eden Prairie - Mpls Exp
684	Eden Prairie - Mpls via Southdale Exp
685	Eden Prairie - Mpls Exp
690	Eden Prairie - Mpls, U of M Exp
691	Eden Prairie - Mpls Exp
692	Eden Prairie - Mpls Exp
694	Chaska - Mpls via Chanhassan Exp
695	Chaska - Mpls via Chanhassan Exp
696	Chaska - U of M via Victoria, Mpls Exp
697	Chaska - Mpls via Chanhassan Exp
698	Chaska - Mpls via Chanhassan Exp
699	East Creek - U of M via Mpls Exp
721	Mpls - Hennepin Tech Coll via Brkln Ctr Ltd
724	Mpls - Target Campus via Starlite & Brkln Ctr Ltd
742	Plymouth - Mpls via Bass Lake Rd Exp
755	Mpls - Winnetka Ave vie TH55 & Golden Valley Rd Ltd
756	Mpls - Boone Ave via Mendelssohn Rd & TH55 Exp
758	63rd Ave PR - Mpls via Douglas & Noble Exp
760	Zane Ave - Mpls via 63rd Ave 65th Ave PR Exp
761	Brkln Prk - Mpls via Xerxes & 49th Ave Exp
762	Brkln Ctr - Mpls via N Mpls Ltd
763	85th Ave - Mpls via Brookdale Dr & Humboldt Exp
764	Winnetka Ave - Mpls via 42 Ave Exp
765	Target - Mpls via TH252 & 73rd Ave PR Exp
766	Champlin - Mpls via Noble PR & W River Rd
767	Mpls - 63rd Ave PR via 65th Ave PR Exp
772	Plymouth - Mpls via Station 73 Exp
774	Plymouth - Mpls via Station 73 Exp
777	Plymouth - Mpls via Station 73 Exp
780	Maple Grove - Mpls via Shepherd of the Grove PR Exp
781	Maple Grove - Mpls via Maple Grove Station Exp
783	Maple Grove - Mpls via Crosswinds Ch PR Exp
824	Northtown - Mpls via Monroe & University Ltd
829	Blaine - Mpls via TH65 & Central Ave Ltd
852	Anoka - Mpls via Coon Rapids & Northtown Exp
854	Paul Pkwy - Mpls via Northdale & Northtown Exp

Note: All routes listed make stops >.25mi and <30min from LRT connection.

Accessibility gains along major transit corridors generally appear quite significant (and almost universally positive) beginning right with the 5:00-6:00am map. Of course, many, if not most routes are already operating at or near peak frequencies during this hour; the Hiawatha line runs a 5-10-minute headway. Accessibility gains become even more pronounced in the hour from 7:00-8:00am, and large unbroken areas of major gains are more common further from downtown Minneapolis. This appears to represent the height of the morning peak, as far as low-wage employment accessibility gains along major transit corridors are concerned.

In fact, the gains shown in the 8:00-9:00am hour are much less impressive. Given the tendency of low income workers to work long hours, often starting earlier than traditionally scheduled office workers, this apparent trend of especially large accessibility gains very early in the service day appears quite positive for poor workers depending on transit for job access, since some of the greatest accessibility gains of the day occur at times they are especially likely to be on their way to work.

Moving into the mid-day service period, (spanning generally from 9:00am to 3:00pm, with 12:00pm to 1:00pm here shown as an example), accessibility gains along major transit corridors actually seem somewhat more prevalent and significant than in the morning rush. In fact, though fewer areas of dark red (signifying extremely large accessibility gains) appear in the mid-day period, moderate to large gains in low-wage accessibility are quite consistent throughout the mid-day period. Of particular interest to this study, some of the largest mid-day gains occur along the Hiawatha corridor and its connecting local bus routes. By contrast, several key high-frequency bus corridors, which had produced some of the largest peak-period accessibility gains, show only barely positive changes in accessibility—and even some negative changes—as in the case of the 5. This trend reflects quite positively on the Hiawatha line's impacts on job access for low-wage and transit-dependent workers. Given the non-traditional commute times (sometimes even including an extra commute from one job to a second) common among the poor and transportation-disadvantaged, reduced mid-day transit service can be a significant detriment to their employment opportunities. In addition, a worker who is truly transit dependent depends upon transit for all trips outside of walking distance, not only those to and from work. Mid-day transit service can have a major impact on the ability of transit-dependent workers to run an errand during a lunch break, or to accomplish other daily business.

The afternoon peak period, stretching from 3:00pm to 6:30pm, shows interesting changes, which, oddly do not appear symmetrical with those observed in the morning peak period. While the accessibility gains observed in the Hiawatha corridor and along feeder bus routes remain more or less intact, many key bus corridors show lesser accessibility gains in the afternoon peak period than at mid-day. This pattern is difficult to understand, given the large accessibility gains observed during the morning.

It is true that the accessibility changes displayed only represent accessibility to jobs, and most transit trips in the evening peak period are actually from job to home. However, the transit routes likely to account for the vast majority of the accessibility changes shown run nearly identical headways in both directions at any given time. The coordination of scheduled transfers for trips to employment centers in the morning peak, and away from employment centers in the afternoon peak could possibly explain such a pattern. This pattern could be significant, since roughly half of all Hiawatha passengers transfer to or from a bus at some point in their trips. Though it is difficult to understand the pronounced, network-wide differences between morning and afternoon peaks, the consistently large accessibility gains observed along the Hiawatha line seem to particularly stand out from the backdrop of much smaller gains along major bus corridors.

The last hour shown, 8:00pm-9:00pm, shows by far the smallest accessibility gains of any hours considered. Overall, accessibility gains are much less widespread, and are concentrated much more closely around the downtowns. Likely due to lengthening headways and wait times for transfers, significant accessibility gains only prevail relatively close to downtown. Though the areas immediately surrounding most Hiawatha stations show at least moderate gains, these are much less than at other times of day for stations south of Franklin Avenue.

It has been suggested that this pattern may be caused by the fact that late-evening bus schedules are subject to significantly less traffic congestion than peak or even mid-day schedules, and are therefore accelerated. Such a pattern might lead to smaller relative accessibility gains, due to a faster pre-Hiawatha, bus-only transit system. Though a fully comprehensive analysis of Metro Transit's schedules with respect to traffic flows is beyond the scope of this study, a brief examination of key bus schedules suggests that many routes are, in fact, scheduled at different average speeds at different times of day. However, this practice is by no means universal, and the 8:00pm to 9:00pm service hour is often not the time of the fastest schedules. In fact, many routes are actually timed to make their fastest runs during the mid-day period; this pattern appears especially common among the high-frequency routes (possibly due to reduced dwell times at stops during boarding and alighting of passengers and skipped non-timepoint stops due to short headways and lower mid-day ridership). It seems that factors such as increased wait times and less-efficient transfers may play more of a role than traffic conditions in the reduced accessibility gains in the 8-9pm service hour, especially considering that the average wait time for a 30-minute frequency route (common after 8:00pm) is 15 minutes, which eats up half of the 30 minute accessibility cutoff before any actual transit travel takes place.

Most routes in the high-frequency bus network show significant gains in most or all hours considered, though the degrees of these gains vary significantly throughout the day. Though these gains appear more consistent along the corridors served by the high-frequency routes themselves (due to shorter stop spacings, as most high-frequency routes are locals), it is interesting to note that accessibility gains along these bus routes do not seem to spill over to non-high frequency routes which connect with them, a pattern markedly different from that observed along Hiawatha.

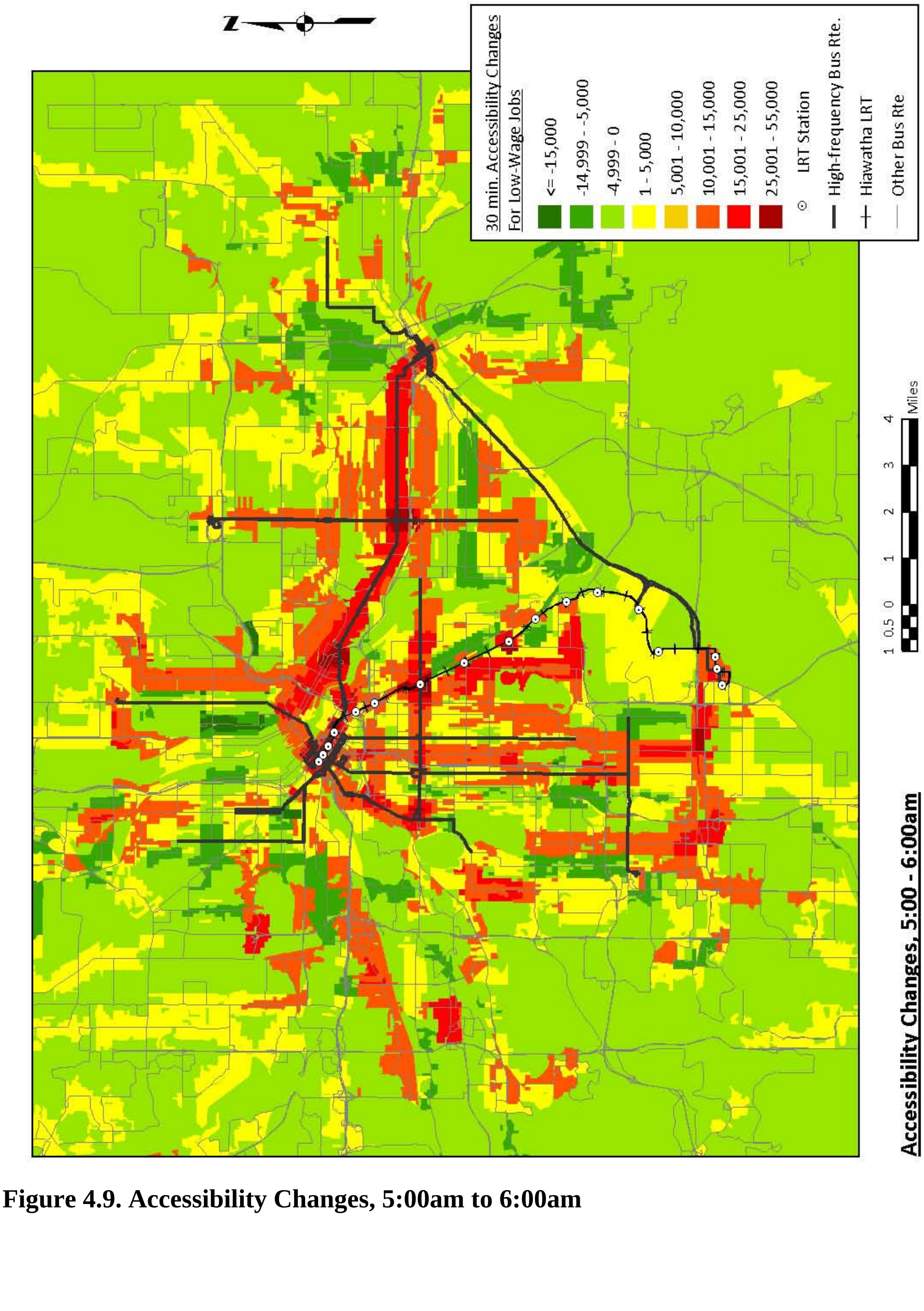

Figure 4.9. Accessibility Changes, 5:00am to 6:00am

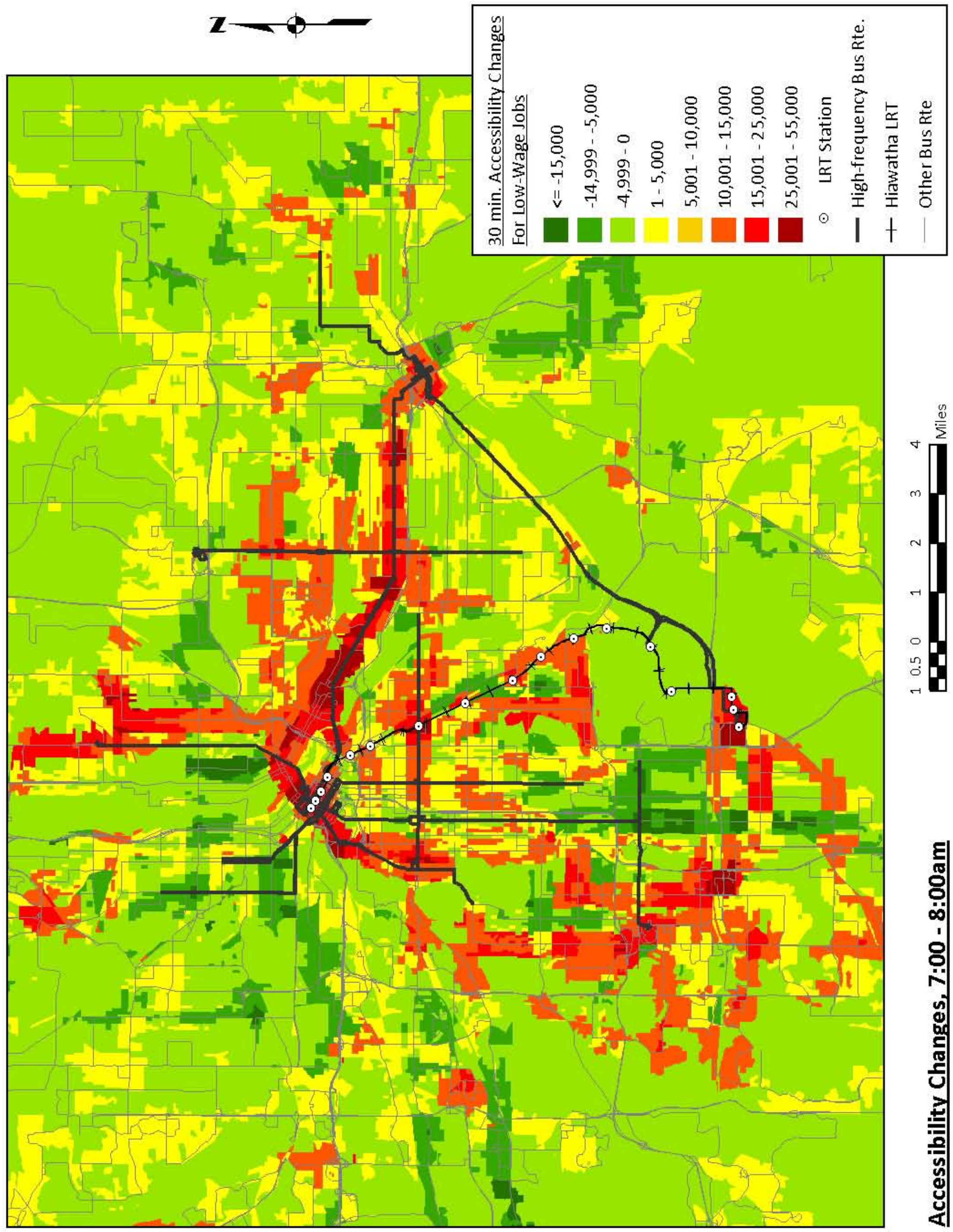

Figure 4.10. Accessibility Changes 7:00am to 8:00am

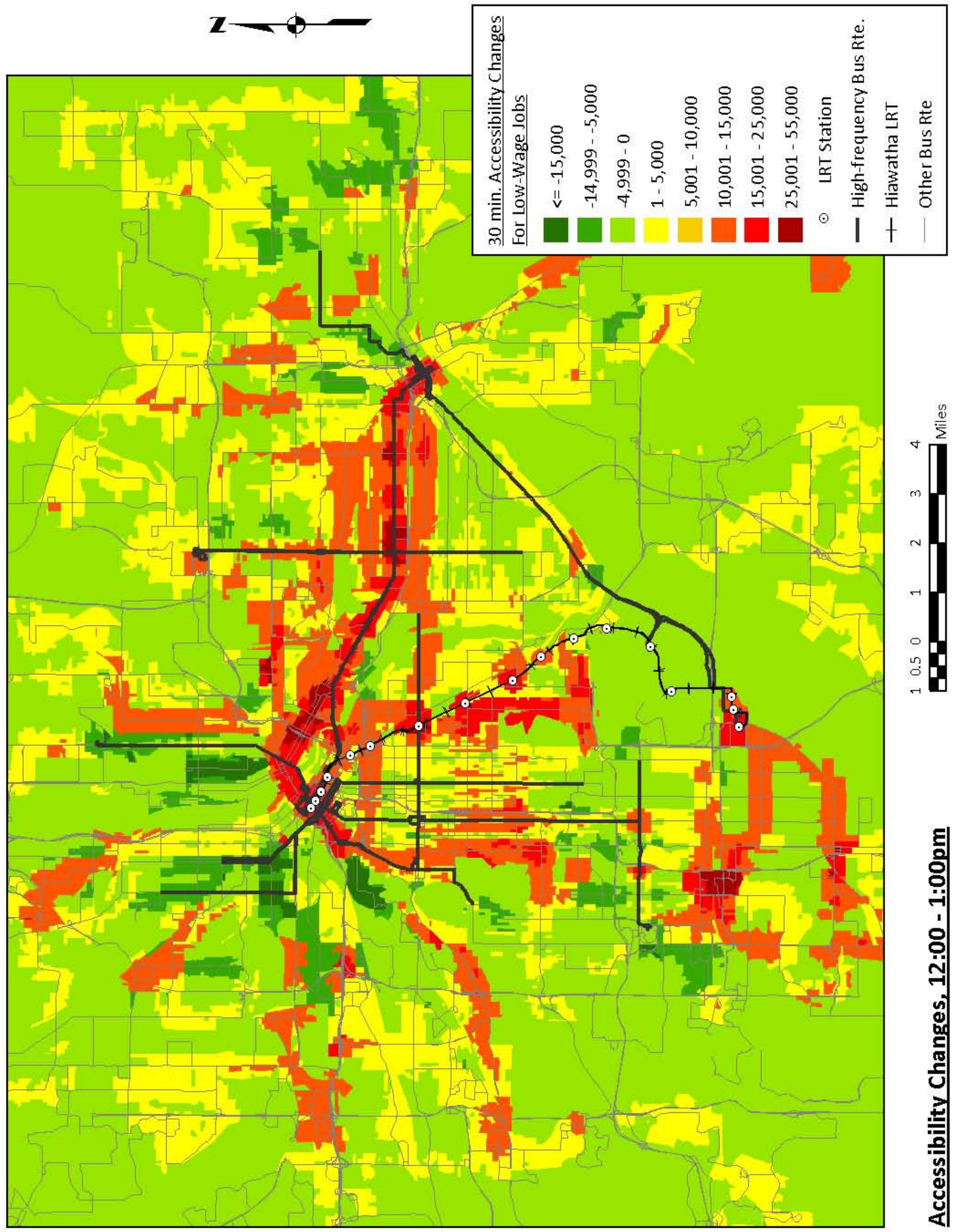

Figure 4.11. Accessibility Changes, 12:00pm to 1:00pm

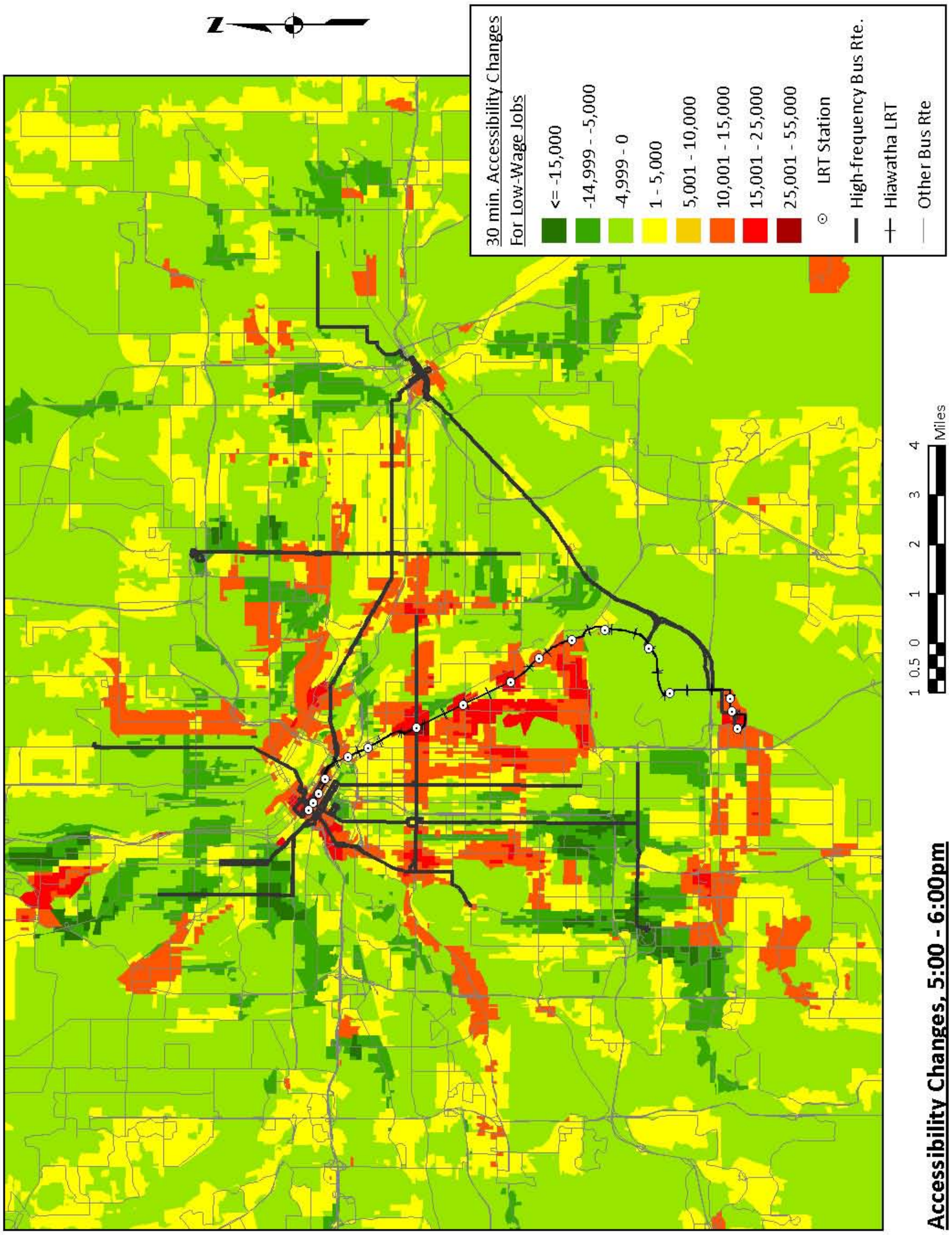

Figure 4.12. Accessibility Changes, 5:00pm to 6:00pm

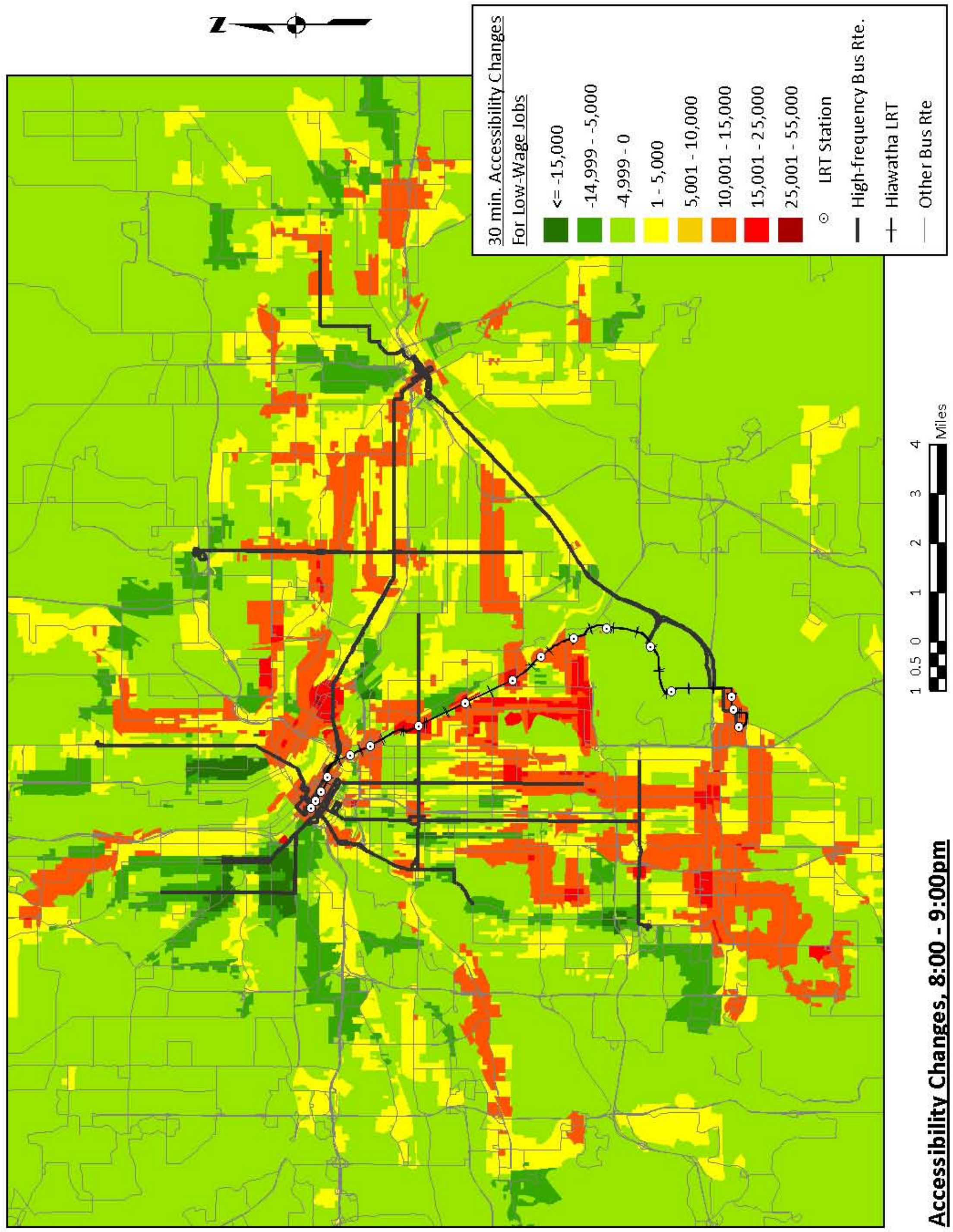

Figure 4.13. Accessibility Changes, 8:00pm to 9:00pm

4.2.3 Consistency of Accessibility Gains

In addition to examining specific before-and-after accessibility changes at different time points, we examined the consistency of those changes throughout the service day by mapping the number of hours in which census blocks experienced net accessibility gains of at least 5,000 low-wage jobs within the 30-minute cutoff. Consistency of transit-based employment accessibility improvements throughout the service day may be of particular importance to low-wage workers, as they are more likely than others to use transit services at off-peak times, particularly during the mid-day period. In addition, while only job accessibility is directly considered here, higher levels of transit service throughout the service day are likely to provide significant benefits both for transit-dependent users in performing their non-work daily business, and potentially for low-income households with one or more motor vehicles who may be able to realize large savings relative to their incomes by taking advantage of improved transit to reduce the number of vehicles they need.

Once again, though the blocks immediately adjacent to light rail stations almost invariably show very consistent low-wage job accessibility gains, these gains appear more as islands surrounded by seas of much less consistent gains. By comparison, accessibility gains along major bus corridors are more even, though less uniformly large. Though this pattern can partly be attributed to Hiawatha’s long stop spacing compared with that of most major bus routess, one must bear in mind that large, institutional land uses (such as Fort Snelling and MSP International Airport) at the southern end of the light rail line lead to a number of extremely large census blocks. Since these maps employ accessibility data based on the centroids of census blocks, a very large block can lead to the entire block being considered inaccessible to transit based on its centroid distance.

The threshold map also underscores the importance of considering the Twin Cities transit system as an integrated network. One cannot help but note the large clusters of consistently strong low-wage job accessibility gains which occur around connections between two or more major transit routes, or between a major route and a route which appears to serve a feeder/distributor function for it. Even well outside either of the two downtowns, the large areas of consistent gains found at important transfer points seem to suggest that the changes implemented in the transit system have strengthened the network effects between its individual routes. In addition, the highly consistent gains shown along bus routes which feed into Hiawatha underscore the importance of connections in many transit trips and the accessibility gains possible with transitways even for trips with origins or destinations on a regular bus route, in spite of the need to make a transfer. The gains shown along routes 7 and 22 (in terms of connections with Hiawatha at Lake Street – Midtown, and 38th Street and VA Medical Center Stations, respectively) suggest that the implementation of light rail benefited not only suburb to downtown trips, or neighborhood station area to downtown trips, but also neighborhood to downtown, neighborhood to neighborhood, neighborhood to suburb, etc. trips even in cases where origins and/or destinations lie along local bus routes outside of station areas, even in cases of trips which appear to require an additional transfer as compared with before the implementation of light rail.

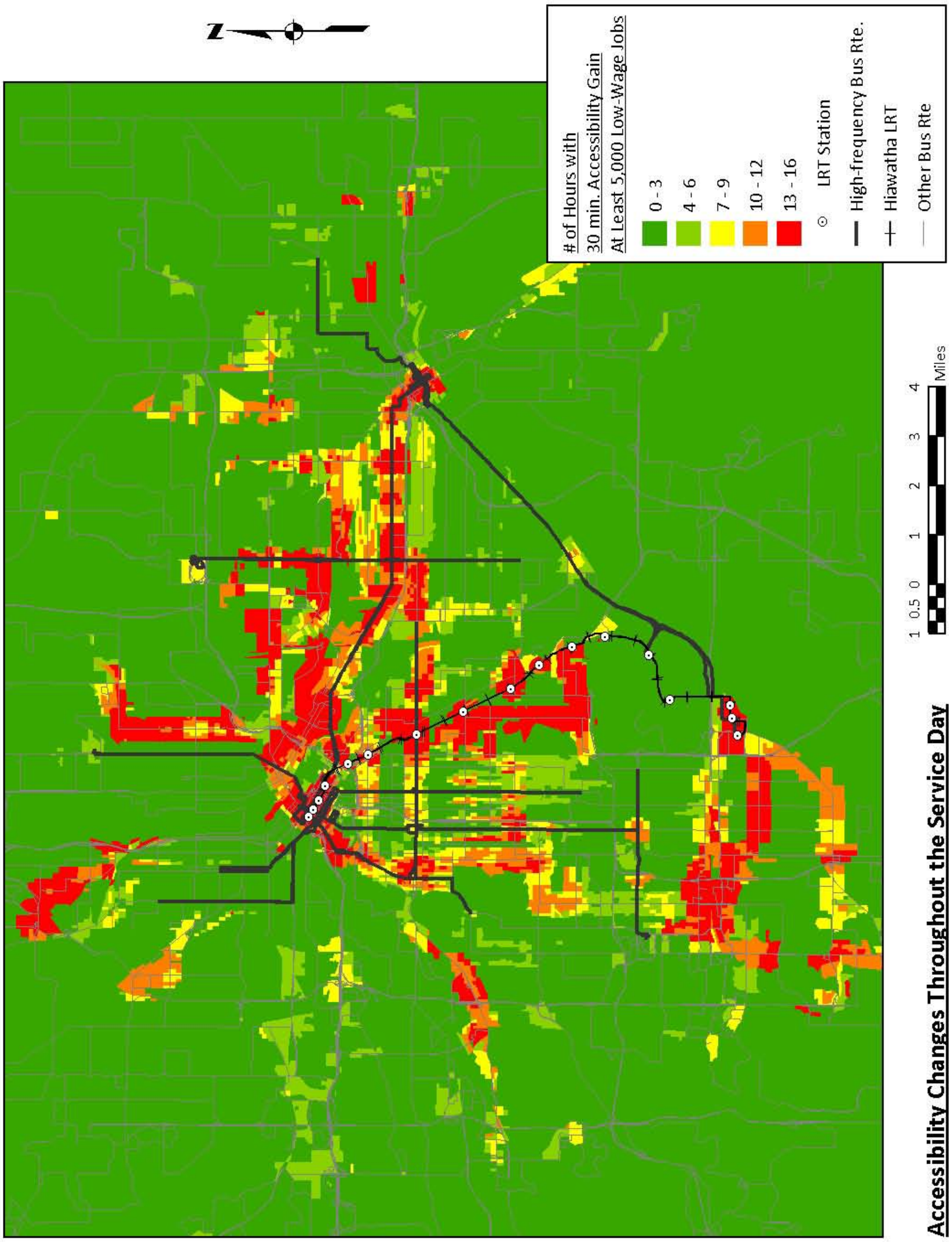

Figure 4.14. Consistency of Accessibility Gains

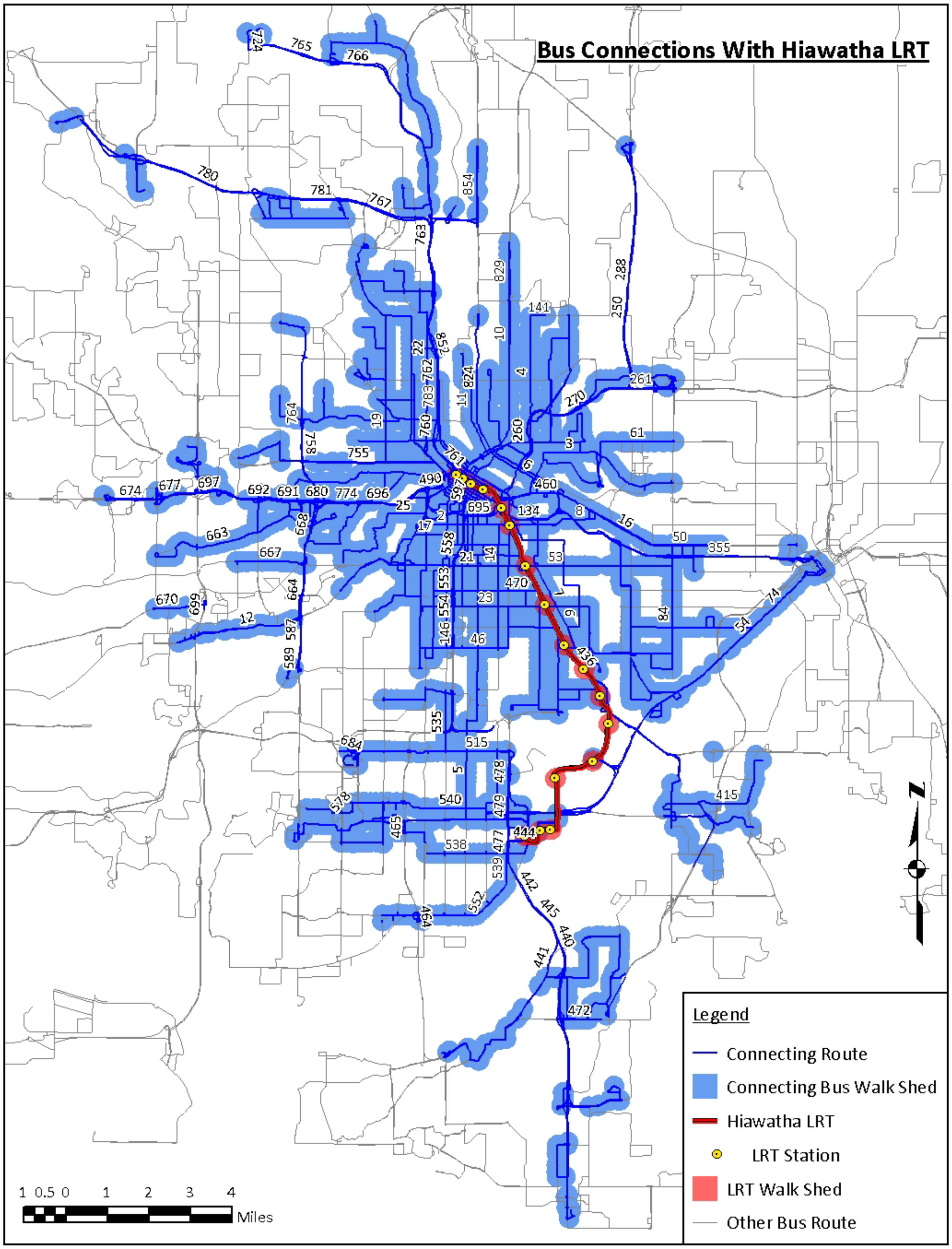

Figure 4.15. Bus Connections with Hiawatha

4.3 Statistical Analysis of the Before-and-After Accessibility Changes

4.3.1 Variables

In all of the accessibility regression models, the dependent variable describes census block level 30-minute cumulative accessibility by transit to low-wage, high-wage, or all jobs during each of the following five service hours: 5:00am – 6:00am, representing the early morning period, 7:00am – 8:00am, representing the morning peak period, 12:00pm – 1:00pm, representing the mid-day off-peak period, 5:00pm – 6:00pm, representing the evening peak period, and 8:00pm - 9:00pm, representing the late evening period. Changes in the low-wage job accessibility are the main focus of this regression analysis. The high-wage and the all jobs categories are included for comparison. Only census blocks served by the transit system (as defined by the 0.25-mile walking distance assumption of the accessibility model) were considered in this regression analysis.

The independent variables included in the regression models can be broken into two groups: those describing the spatial locations of census blocks, and those describing social conditions within census blocks. The first four variables are the former, describing the distance between each block and various access points to the transit network, or to downtown Minneapolis. All subsequent variables are social, denoting demographic data from either the LEHD data set, or the 2000 census.

In addition, the two groups of variables are intended to serve somewhat different functions. In the case of the distance variables, it is relatively easy to form reasonable hypotheses about their relationships to transit job accessibility—one would tend to expect transit accessibility to increase as distance to downtown Minneapolis decreases, for example. As such, these variables are primarily included to confirm relationships we already expect.

In terms of the demographic variables, however, it is much more difficult to make even educated guesses about what types of relationships with transit job accessibility to expect, as many such relationships are unlikely to be causative. While the transit system is largely designed using a demand index which calculates the level of transit service a given area can support based on factors such as population density, job density, automobile ownership, etc. service is less deliberately designed with respect to social factors which do not directly influence ridership but which do influence the impacts transit service quality has on vulnerable populations, such as concentrations of single-parent families. This second group of variables, in other words, is included to shed light on general trends about which relatively little is known, but which may have significant impacts on how well populations with the greatest needs for good transit service are served by transit.

The independent variables included in the regression models are as follows:

All_stops— Distance, in miles, from the centroid of the census block to the nearest transit stop, regardless of type. Includes light rail stations as well as all bus stops. In keeping with the accessibility models' walking distance assumption, only blocks within 0.25mi of a transit stop are considered.

DowntownDummy— Dummy variable identifying blocks to which the nearest transit stop is the Warehouse District—Hennepin Avenue, Nicollet Mall, Government Plaza or Downtown East—Metrodome LRT station. (The recently opened Target Field station is clearly part of the downtown zone, but was neither open nor under construction when any of the data included in the study were collected; it is not included in this analysis.) The maps show large localized accessibility gains around LRT stations—in which case we expect positive coefficients.

NorthDummy— Dummy variable identifying blocks to which the nearest transit stop is the Cedar—Riverside, Franklin Avenue or Lake Street—Midtown LRT station. The maps show large localized accessibility gains around LRT stations—in which case we expect positive coefficients.

SouthDummy— Dummy variable identifying blocks to which the nearest transit stop is the 38th Street, 46th Street, 50th Street—Minnehaha Park or VA Medical Center LRT station. The maps show large localized accessibility gains around LRT stations—in which case we expect positive coefficients.

SuburbDummy— Dummy variable identifying blocks to which the nearest transit stop is the Fort Snelling, Lindbergh Terminal, Humphrey Terminal, Bloomington Central, 28th Avenue or Mall of America LRT station. (Though the eventual construction of the American Boulevard station was planned even before the initial construction of the Hiawatha line, it was not yet certain when—or if—this would occur when the data included in the study were collected; this station is not included in the analysis.) The maps show large localized accessibility gains around LRT stations—in which case we expect positive coefficients.

While the definitions of “downtown” and “suburban” stations used here follow those used by the Metropolitan Council, as well as in several previous studies of the Hiawatha line, this study breaks the “neighborhood” stations into northern and southern groups, a practice the authors have not encountered before. While the three-zone, downtown-neighborhood-suburban breakdown of stations appears well suited to describing the urban forms, built environments and redevelopment potentials of Hiawatha station areas, this study is more concerned with the socioeconomic characteristics which predominate in each station area. From this perspective, there is significant divide between the Cedar—Riverside, Franklin Avenue and Lake Street—Midtown station areas on the one hand and the 38th Street, 46th Street, 50th Street—Minnehaha Park and VA Medical Center station areas on the other. In addition, the fact that the areas surrounding the northern neighborhood stations appear to be home to the greatest concentrations of low-income and traditionally marginalized residents, and are also adjacent to downtown Minneapolis would seem to place the population most vulnerable to displacement in the very area arguably the most ripe for gentrification. Given this study’s specific focus on low-wage and transit-dependent workers, a finer breakdown seems in order.

ConnectDummy— Dummy variable identifying blocks to which the nearest transit stop is a bus stop offering a direct connect to the Haiwatha line. The maps show large localized accessibility gains around connecting bus routes—in which case we expect positive coefficients.

HFDummy— Dummy variable identifying blocks to which the nearest transit stop is a bus stop served by one of Metro Transit’s high-frequency bus routes. These routes operate frequent “no pocket schedule required" service throughout the service day, and, based on GIS map analysis, seem associated with significant accessibility gains over the study period. Expected to return negative coefficients. [42, 43, 44, 45, 46].

PctAfrAm— The percentage of census block residents who self-identify as African American.

PctLatino— The percentage of census block residents who self-identify as Latino.

PctAsian— The percentage of census block residents who self-identify as Asian.[47].

PctSingPar— The percentage of families in a census block headed by a single parent with minor children present.

PctCollDeg— The percentage of block-group residents over the age of 25 who have been awarded a bachelor's or higher degree.

PctOwnOc— The percentage of occupied housing units in a census block-group which are owner-occupied.

PNoVehHH— The percentage of households in the block-group with no motor vehicle available.

MedInc1K— The median household income, in thousands of dollars, of the census block-group [47].

The six dummy variables included in the models describe every condition of a block's nearest transit stop except for that of a non-high-frequency bus stop which does not offer a direct connection to Hiawatha. As a result, the IRR for each of the dummy variables represents the percentage difference in predicted accessibility between the area that particular dummy variable describes and a block to which the nearest transit stop is served only by regular transit.

4.3.2 Descriptive Statistics

Tables 4.3 and 4.4 show descriptive statistics produced from the variables listed above. These statistics provide general background information about the variables and offer a reference point for evaluating the magnitudes of empirical relationships demonstrated by the regression models. In evaluating the descriptive statistics produced for individual service hours, the first three variables in each table (30_1, 30_3 and 30_A, describing low-wage, thirty-minute accessibility, high-wage, thirty-minute accessibility and all jobs thirty-minute accessibility, respectively) show the most interesting variations. These are the only variables which are dynamic both between years of observation and throughout the day.

Descriptive statistics for dependent variables during the 5:00 am to 6:00am service hour (see Table 4.3) show considerably higher average accessibility gains for high-wage jobs than low-wage jobs, though all three accessibility variables do experience gains after the introduction of light rail transit. (In all cases, one must bear in mind that the definitions of low- and high-wage jobs are based on the Census Bureau's Longitudinal Employment and Housing Dynamics [LEHD] data set. These data do not correspond directly to thirds of the study area's income scale.

Considering this, it seems more appropriate to focus on comparing the relative gains or losses in accessibility experienced by each income group, rather than on comparing absolute accessibility scores.) This pattern may partially reflect the largely radial, downtown-oriented nature of the transit system, an orientation which may be accentuated during this service hour by lower levels of service on most routes which are not major trunk lines. Standard deviations which are, in all cases, significantly larger than means show that considerable variability exists in transit employment accessibility across different areas of the metropolitan area.

In the 7:00am to 8:00am morning peak hour, accessibility figures are, as one would tend to expect for peak-period service levels, considerably higher across the board than those for the previous hour. During this hour of the service day, virtually all transit routes are on their shortest headways. Trip origin waiting times and transfer waiting times can be expected to be at or near their shortest, especially as any deliberately coordinated transfers will likely be optimized for moving people from residential areas to employment centers. This pattern is reflected in the large accessibility values. However, the trend of greater gains for high-wage than low-wage accessibility continues, and actually strengthens, with the gains in mean value for high-wage accessibility more than four times those found for low-wage accessibility. Once again, the radial orientation of the transit system seems likely to play some role in this pattern, possibility accentuated by heavily suburb-to-downtown-oriented peak-period only express busses. Also, standard deviations are still invariably larger than means, though generally by a lesser amount in relative terms, suggesting that transit accessibility differences between different parts of the metro area are somewhat smaller when the transit system is at its highest overall level of service.

The descriptive statistics produced for the 12:00pm to 1:00pm hour of the mid-day service period actually show a largely similar pattern to those from the 5:00am to 6:00am hour, with generally similar means. Standard deviations are once again uniformly larger than means.

The 5:00pm to 6:00pm, evening peak service hour is the only case in which mean accessibility to low-wage jobs actually declines, albeit by a very small amount. High-wage and all jobs maintain the same trend of gains in accessibility. It is also worth noting that while the absolute mean values for low-wage job accessibility are quite similar to the pre-LRT mean in the 7:00-8:00am hour, both absolute values and relative gains are somewhat smaller for the other two accessibility variables during this hour than during the 7:00am to 8:00am hour discussed above. Large standard deviations once again indicate significant variability in the transit employment accessibility of individual census blocks.

The final set of descriptive statistics, for the 8:00pm to 9:00pm hour show a largely similar pattern to both the 5:00am to 6:00am and 12:00pm to 1:00pm hours, with relatively similar starting and ending point means for each of the accessibility variables, though with a somewhat smaller gain in accessibility to low-wage jobs. Standard deviations, however, while still always considerably greater than corresponding means, are generally smaller than in other hours, both in absolute terms and relative to means. This pattern points to smaller differences in employment accessibility by transit at this hour, in spite of generally reduced service levels. This pattern may be partly explained by the fact that virtually all transit routes operate at reduced frequencies this late in the evening.

Table 4.3a: Descriptive Statistics of Dependent Variables

Variable	Mean	Std. Dev.	Min	Max
5-6am, 30_1	5,566	7,488	0	62,354
Pre-LRT 30_3	12,404	18,816	0	117,113
30_A	26,970	38,722	0	276,947
5-6am, 30_1	7,643	10,478	0	93,378
Post-LRT 30_3	18,759	26,728	0	160,366
30_A	36,940	51,595	0	370,188
7-8am, 30_1	8,715	9,505	0	68,949
Pre-LRT 30_3	19,020	23,117	0	137,302
30_A	41,509	48,083	0	313,732
7-8am, 30_1	10,308	12,290	0	100,291
Post-LRT 30_3	24,553	30,450	0	180,712
30_A	49,749	60,322	0	415,060
12-1pm, 30_1	6,180	7,887	0	56,093
Pre-LRT 30_3	12,676	19,247	0	110,275
30_A	28,358	39,976	0	257,731
12-1pm, 30_1	7,976	10,319	0	81,964
Post-LRT 30_3	18,517	26,996	0	158,047
30_A	37,863	52,588	0	354,515
5-6pm, 30_1	8,740	9,534	0	71,848
Pre-LRT 30_3	17,365	22,086	0	135,265
30_A	39,315	46,819	0	315,916
5-6pm, 30_1	8,718	10,398	0	88,887
Post-LRT 30_3	20,083	27,476	0	160,594
30_A	41,197	53,443	0	369,982
8-9pm, 30_1	5,970	8,194	0	58,591
Pre-LRT 30_3	12,265	19,462	0	120,706
30_A	27,478	40,951	0	276,802
8-9pm, 30_1	6,675	9,192	0	68,838
Post-LRT 30_3	16,499	25,479	0	155,738
30_A	32,966	48,871	0	329,777

(N=23193)

Figures 4.16 through 4.18 offer graphical comparisons of mean low-wage accessibility levels throughout the service day before and after Hiawatha. Once again, strong accessibility gains appear for all income levels and at almost all hours of the service day. The accessibility values shown in these three figures represent average accessibility for the entire transit-served metro area. As a result, even the significant gains they show do not take into account localized accessibility gains arising out of proximity to a light rail station or connecting bus route. It is interesting to note considerably higher accessibility figures for high-wage jobs than low-wage jobs both before and after light rail. In fact, based on these average values, high-wage jobs tend to account for roughly half of all jobs accessible by transit.

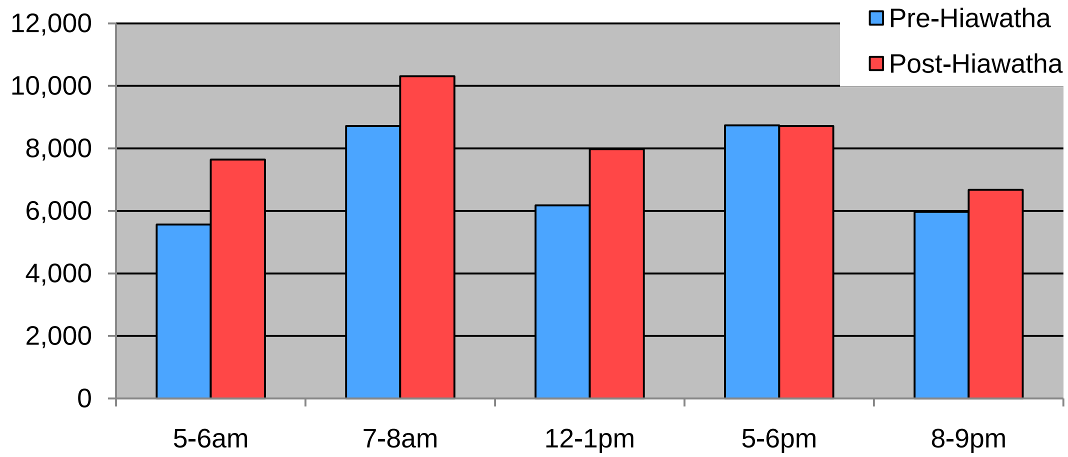

Figure 4.16. Average Low-Wage Jobs Accessible by Transit Before & After LRT

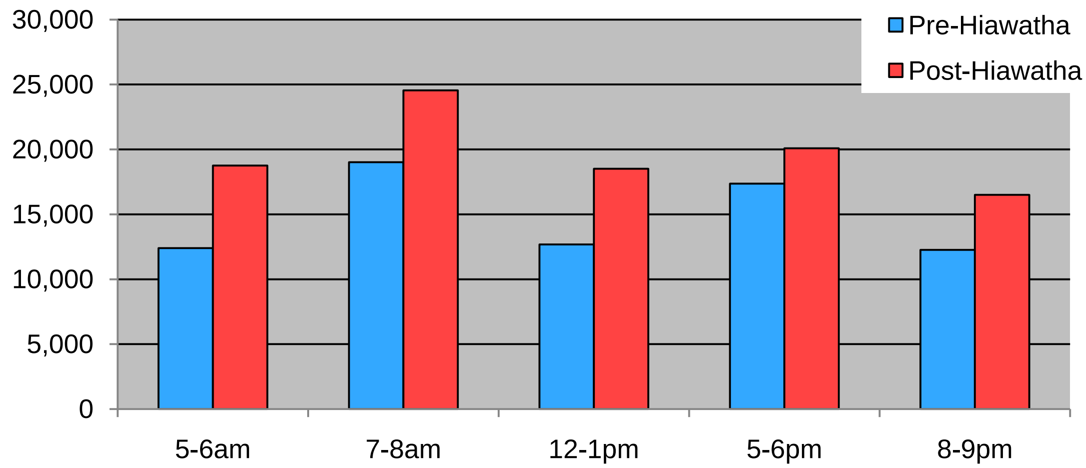

Figure 4.17. Average High-Wage Jobs Accessible by Transit Before & After LRT

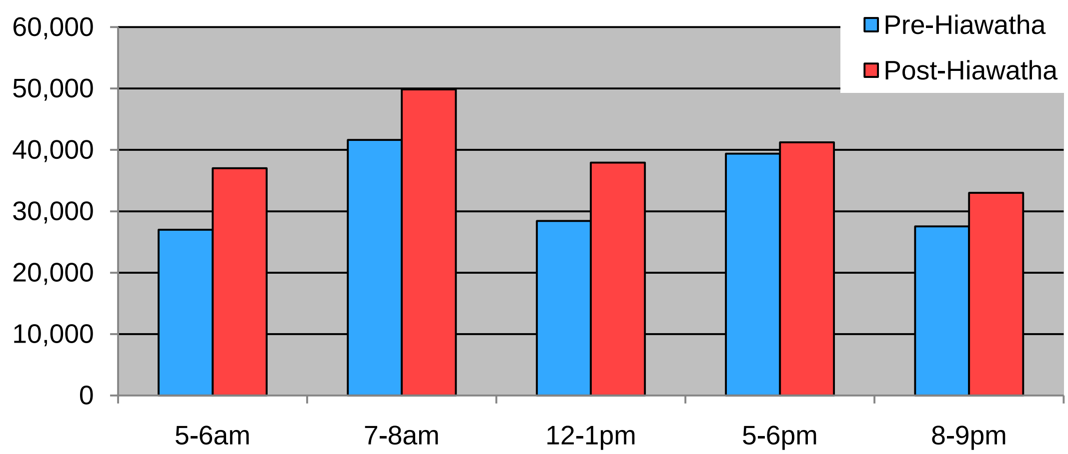

Figure 4.18. Average Jobs at All Wage Levels Accessible by Transit Before & After LRT

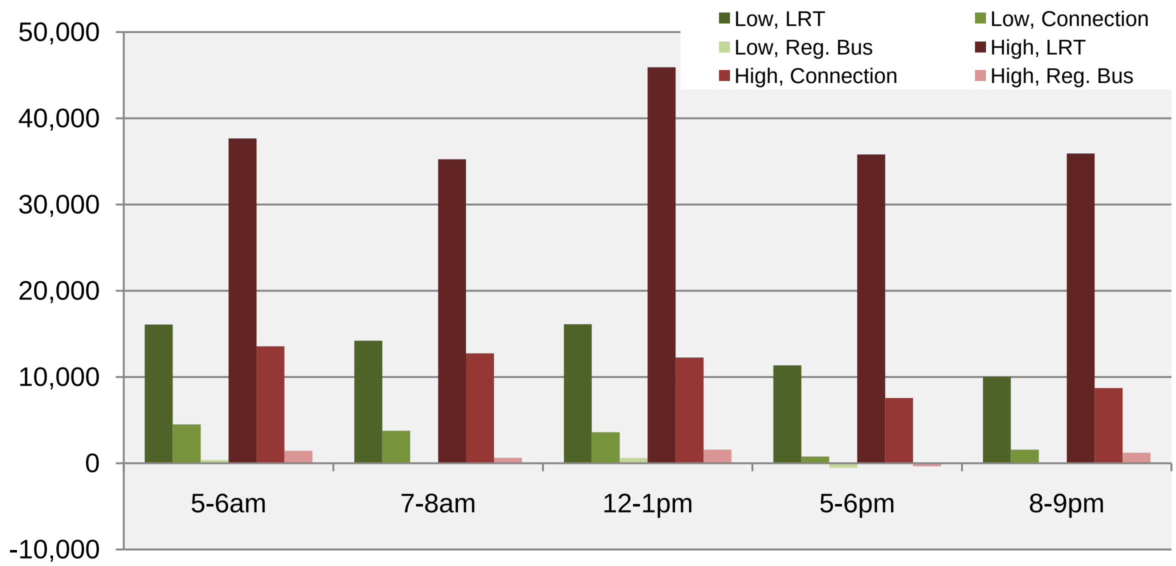

Figure 4.19. Localized Accessibility Changes, Low- and High-Wage Jobs

Figures 4.19 and 4.20 show average accessibility changes for blocks within a quarter mile of a light rail station, within a quarter mile of a bus stop offering a direct connection to light rail and within a quarter mile of only bus stops served by regular bus service. Large gains appear without exception for light-rail station areas. These *gains* over and above starting-point accessibility values are generally about as large as the *absolute*, post-LRT accessibility figures shown in Figures 4.16-18, a fact which underscores the accessibility benefits that come with location near a light rail station. Though not as large as those for blocks served by light rail, accessibility gains for blocks served by connecting bus routes appear consistently and are quite large in their own right, particularly considering the size of the area served by LRT-connected bus routes. Regular bus routes, on the other hand, show only small changes in accessibility, and some of these changes are even slightly negative.

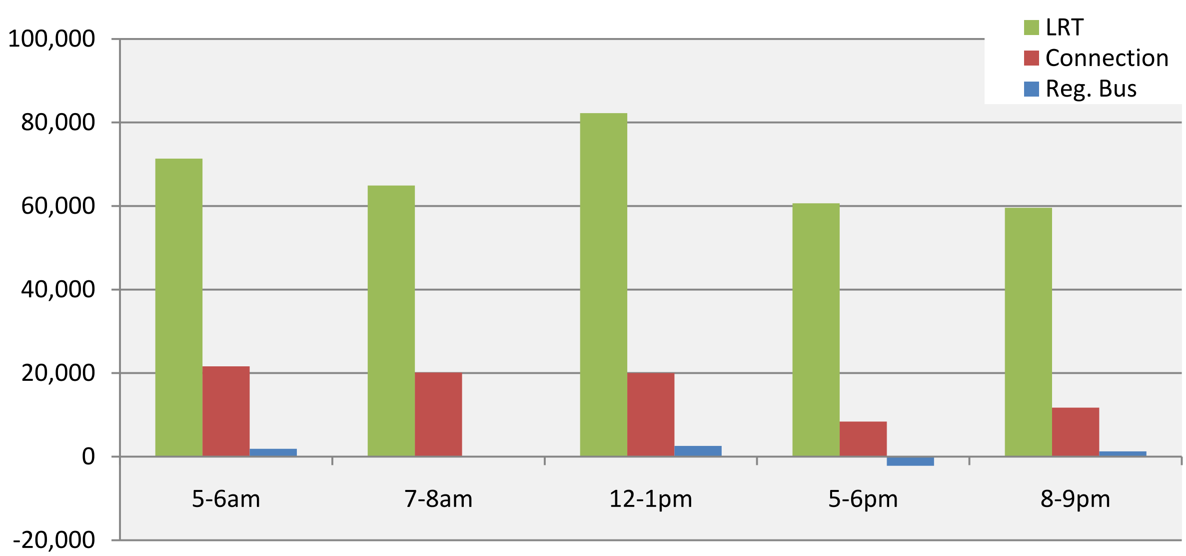

Figure 4.20. Localized Accessibility Changes, All Jobs

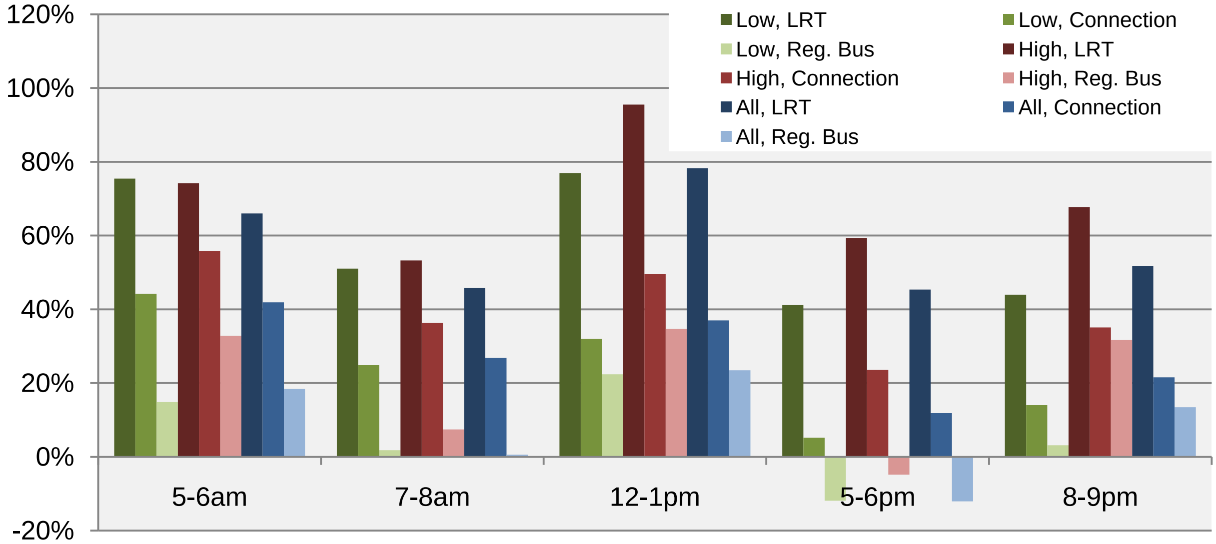

Figure 4.21. Percentage Changes in Jobs Accessible by Transit

Figure 4.21 shows percent changes in transit job accessibility broken down both by income groups and types of transit service. This graph allows direct comparisons between income groups as there is no difference in scale between the three. It also avoids any confusion which might arise out of the three LEHD income categories not corresponding to thirds of metro-area incomes. When percentages are considered, the differences in gains between low-, high-wage- and all-job accessibility are much less pronounced, particularly for LRT station areas. Areas served by connecting bus routes generally show large relative accessibility gains as well, though these gains are never as large as those found in Hiawatha station areas.

Tables 4.3b-4.3d show a more detailed breakdown of mean accessibility values, with separate means calculated for each income group in each of the station/stop area groups considered in the models. In all cases, accessibility increases after light rail. However, both the base, “before” values and the magnitudes of increases vary greatly between both station/stop area groups and income levels. For low-wage jobs (See Table 4.3b), the downtown station area group, not surprisingly, consistently produces the highest accessibility values both before and after light rail. Still, in spite of the enormous number of bus routes converging on the area both before and after LRT, the accessibility gains are quite large. Much of this gain is likely associated with high-frequency and other bus services, but still underscores the power of light rail to increase accessibility. Among the remaining groups, the north neighborhood station area group stands out

Table 4.3b: Mean Accessibility Comparisons, Low-Wage Jobs

Hour	Group	N	Before	After	Change
5-6 am	Downtown	82	38,903	62,322	23,419
	North Nbhd	62	15,440	28,014	12,574
	South Nbhd	70	8,755	21,098	12,343
	Suburb	13	5,909	12,504	6,595
	Connection	8,921	10,186	14,693	4,507
	Hi Frequency	3,267	15,181	22,858	7,677
7-8 am	Downtown	82	50,111	72,326	22,215
	North Nbhd	62	22,046	32,638	10,592
	South Nbhd	70	10,722	19,058	8,336
	Suburb	13	7,221	19,823	12,602
	Connection	8,921	15,174	18,944	3,770
	Hi Frequency	3,267	20,366	27,075	6,709
12-1 pm	Downtown	82	40,913	60,271	19,358
	North Nbhd	62	17,224	30,577	13,353
	South Nbhd	70	3,627	19,160	15,533
	Suburb	13	5,986	18,061	12,075
	Connection	8,921	11,236	14,831	3,595
	Hi Frequency	3,267	17,100	21,673	4,573
5-6 pm	Downtown	82	53,201	63,510	10,309
	North Nbhd	62	24,083	32,740	8,657
	South Nbhd	70	4,248	19,494	15,246
	Suburb	13	8,670	18,636	9,966
	Connection	8,921	15,112	15,896	784
	Hi Frequency	3,267	21,982	22,599	617
8-9 pm	Downtown	82	42,391	52,949	10,558
	North Nbhd	62	19,259	27,684	8,425
	South Nbhd	70	5,686	17,353	11,667
	Suburb	13	7,962	13,243	5,281
	Connection	8,921	11,271	12,850	1,579
	Hi Frequency	3,267	17,760	19,162	1,402

in terms of both starting and ending values, running a consistent second to downtown both before and after light rail. In fact, the difference between the northern neighborhoods and the remaining areas is most striking before LRT, showing a high level of transit service even before Hiawatha. Even so, post-LRT accessibility gains are consistent and large for the northern neighborhoods, though often not as large as those experienced by other station/stop area groups, due to exceptionally high starting point values. At the other end of the spectrum, the southern neighborhood station area group stands out for its consistent increases from very poor accessibility before light rail to relatively high accessibility after.

Table 4.3c: Mean Accessibility Comparisons, High-Wage Jobs

Hour	Group	N	Before	After	Change
5-6 am	Downtown	82	85,496	130,769	45,273
	North Nbhd	62	41,957	77,835	35,878
	South Nbhd	70	25,149	57,732	32,583
	Suburb	13	11,473	36,910	25,437
	Connection	8,921	24,285	37,846	13,561
	Hi Frequency	3,267	35,213	55,572	20,359
7-8 am	Downtown	82	112,315	148,482	36,167
	North Nbhd	62	58,069	93,419	35,350
	South Nbhd	70	28,960	60,803	31,843
	Suburb	13	14,304	61,706	47,402
	Connection	8,921	35,127	47,877	12,750
	Hi Frequency	3,267	44,641	64,807	20,166
12-1 pm	Downtown	82	92,062	134,540	42,478
	North Nbhd	62	45,921	86,216	40,295
	South Nbhd	70	5,993	60,027	54,034
	Suburb	13	7,784	58,633	50,849
	Connection	8,921	24,780	37,051	12,271
	Hi Frequency	3,267	36,892	52,450	15,558
5-6 pm	Downtown	82	111,217	135,181	23,964
	North Nbhd	62	61,100	91,977	30,877
	South Nbhd	70	8,630	60,803	52,173
	Suburb	13	13,535	59,455	45,920
	Connection	8,921	32,166	39,742	7,576
	Hi Frequency	3,267	46,033	53,641	7,608
8-9 pm	Downtown	82	96,110	127,928	31,818
	North Nbhd	62	50,146	82,119	31,973
	South Nbhd	70	12,537	57,522	44,985
	Suburb	13	13,233	45,047	31,814
	Connection	8,921	24,813	33,523	8,710
	Hi Frequency	3,267	38,595	47,978	9,383

General trends are quite similar both for accessibility to high-wage jobs and accessibility to all jobs (see Tables 4.3c & 4.3d). For high-wage jobs, echoing the trend seen in Table 4.3a, before and after accessibility values are significantly high than those found for low-wage jobs, though, once again, one must bear in mind the LEHD income group definitions.

Table 4.3d: Mean Accessibility Comparisons, All Jobs

Hour	Group	N	Before	After	Change
5-6 am	Downtown	82	189,817	279,864	90,047
	North Nbhd	62	84,477	148,423	63,946
	South Nbhd	70	48,565	109,870	61,305
	Suburb	13	26,534	69,598	43,064
	Connection	8,921	51,598	73,221	21,623
	Hi Frequency	3,267	75,531	110,082	34,551
7-8 am	Downtown	82	247,399	324,050	76,651
	North Nbhd	62	18,852	179,433	160,581
	South Nbhd	70	58,196	110,423	52,227
	Suburb	13	32,974	112,798	79,824
	Connection	8,921	75,121	95,263	20,142
	Hi Frequency	3,267	97,374	131,718	34,344
12-1 pm	Downtown	82	203,779	283,342	79,563
	North Nbhd	62	93,453	166,640	73,187
	South Nbhd	70	15,170	108,593	93,423
	Suburb	13	22,310	104,148	81,838
	Connection	8,921	54,089	74,094	20,005
	Hi Frequency	3,267	81,081	106,293	25,212
5-6 pm	Downtown	82	251,646	292,349	40,703
	North Nbhd	62	127,175	177,273	50,098
	South Nbhd	70	19,575	111,054	91,479
	Suburb	13	34,964	105,913	70,949
	Connection	8,921	71,107	79,525	8,418
	Hi Frequency	3,267	102,362	109,628	7,266
8-9 pm	Downtown	82	211,648	265,241	53,593
	North Nbhd	62	103,169	156,309	53,140
	South Nbhd	70	28,092	102,812	74,720
	Suburb	13	33,005	79,663	46,658
	Connection	8,921	54,305	66,022	11,717
	Hi Frequency	3,267	84,794	95,974	11,180

Table 4.4 shows descriptive statistics for the independent variables. Unlike the dependent variables described above, these variables are static; they do not change throughout the service day. The All_stops distance variable displays a mean less than half the maximum distance of 0.25mi imposed by the definition of the study area. The very small standard deviation indicates that the vast majority of blocks considered lie within a very convenient walk of at least one transit stop.

In interpreting the six dummy variables, the mean value for each variable represents the percentage of the blocks within the study area for which the type of transit stop described is the closest. One can see that the overwhelming majority are closer to at least one bus-stop than to a light rail station. (Though, of course, a significantly larger percentage of blocks lie within one quarter mile of a light rail station irrespective of their distances from a bus stop.) It is very interesting to note, however, that a bus stop offering a direct connection with light rail is the closest transit stop for roughly 38% of all blocks in the study area. This fact underscores the importance of bus connections in understanding the full impact of Hiawatha, and of considering the Twin Cities transit system as an integrated network. By contrast, a stop served by a high-frequency bus route is the closest transit stop to roughly 14% of all blocks. In comparing this mean value with those of the light rail station dummy variables, it is critical to bear in mind the much shorter stop spacings of most high-frequency bus routes.

Table 4.4: Descriptive Statistics, Independent Variables

N=23193

Variable	Mean	Std. Dev.	Min	Max
All_stops	0.1154	0.0595	0.0014	0.25
DowntownDummy	0.0035	0.0594	0	1
NorthDummy	0.0027	0.0516	0	1
SouthDummy	0.0030	0.0549	0	1
SuburbDummy	0.0006	0.0237	0	1
ConnectDummy	0.3846	0.4865	0	1
HFDummy	0.1408	0.3478	0	1
PctAfrAm	0.0548	0.1282	0	1
PctLatino	0.0330	0.0801	0	1
PctAsian	0.0409	0.0953	0	1
PctSingPar	0.1769	0.1349	0	1
PctCollDeg	0.3339	0.1898	0	0.9297
PctOwnOc	0.6838	0.2694	0	1
PNoVehHH	0.1058	0.1226	0	0.8767
MedInc1K	51.8447	22.0014	0	200.001

Note: These variables remain constant in all models.

The remaining demographic variables show that the study area has almost exactly the same percentage of minority residents as the Twin Cities MSA. Standard deviations invariably more than twice as great as means, however, suggest significant variations in the racial makeups of individual blocks. Mean values for the remaining demographic variables show socioeconomic characteristics for the study area generally quite similar to those of the Twin Cities MSA as well, albeit with slightly higher numbers of single-parent families and households with no motor vehicle available and slightly lower median incomes and rates of home ownership. Most standard deviations are smaller than means, suggesting some degree of homogeneity in terms of socioeconomic characteristics within the study area. The median household income standard deviation, however, does represent the difference between poverty and a fairly comfortable, middle class existence in spite of being less than half as great as the mean. It is interesting to note that, counter to this trend, the standard deviation for carless households is actually greater than the mean, demonstrating that there is a great deal of variability in automobile ownership rates even in the areas of the Twin Cities which are directly served by transit. In fact, relative to means, there is greater variability in automobile ownership than in home ownership.

4.3.3 Regression Models and Results

The regression results stem from a negative binomial regression model. Negative binomial regression is somewhat better suited to count (rather than continuous) dependent variables than simple, ordinary least squares regression, particularly when significant numbers of zero values are involved. In addition, the negative binomial model is better able to capture the non-linearity of, for example, transit-stop-distance relationships with accessibility, than a linear model would be. However, as negative binomial regression is a non-linear function, the interpretation of its regression coefficients is considerably more complex than the interpretation of OLS regression coefficients. As a result, an Incidence Rate Ratio (IRR) was produced for each variable, as well as a coefficient. The IRR represents the percentage change in the dependent variable associated with one unit of change in the independent variable as follows: (IRR*100%)-100%=% change in dependent variable. Put simply, an IRR of 1.1 predicts a 10% increase in the dependent variable for each unit increase in the independent variable, while an IRR of 0.9 predicts a 10% decrease in the dependent variable for each unit increase in the independent variable. In addition to IRR's, the marginal effects of the models were estimated at various values of transit stop distance, and graphs of the predicted behavior of the accessibility variables with respect to distance from transit stops were produced.

In interpreting the regression results, our primary interest is not in the raw coefficients or IRR's themselves, but in the difference between the pre-Hiawatha and post-Hiawatha models-including the effects of the constant terms. The model cannot hope to include all factors influencing transit-based employment accessibility. While interpretation of the difference between results over time cannot fully claim to hold all else equal, it comes as close to this ideal as was possible with the data employed.

The all stops variable (which shows the distance to the nearest transit stop of any kind) shows a very strong relationship between proximity to transit stops and accessibility, even within the restrictive quarter-mile radius of the study area. IRR values are very low, ranging from 0.006 to 0.05. These values signify a decline in the number of jobs available of from 99.1% to 95% with an increase in the distance to the nearest transit stop of one mile. This equates to a decline of between 24.775% and 23.75% over the space of the quarter mile buffer used in the models. This pattern underscores the amount of time increased walking distances can add to a transit trip, and seems to suggest that the quarter mile maximum walking distance assumption built into the accessibility calculations is likely reasonable for the majority of the transit system. However, the Hiawatha line may be something of a special case in this regard: it offers shorter headways and much higher in-vehicle travel speeds than the transit system as a whole. It is actually almost unique in the degree to which it combines the two. Most high-frequency bus routes are low-speed locals, and the only bus routes which approximate the schedule speeds of light rail are express routes which spend most of their runs on the freeway, and, as a rule, operate on longer headways than light rail. Given these observations and research showing that over 75% of Hiawatha riders do, in fact, walk more than one quarter-mile at at least one end of their trip, this stop distance linked accessibility decline may not be entirely representative of walking trips to light rail stations.

The regression results show patterns of higher-than-average absolute accessibility in light rail station areas and in areas surrounding bus stops offering connections to light rail, as well as relative accessibility gains between the 2000 transit/2002 employment model and the 2005 transit/2006 employment model. This pattern, with few exceptions, is consistent across all three income categories and all five service hours.

Beginning in the 5:00-6:00am (early morning off-peak) hour, considering low-wage job accessibility, the southern neighborhoods dummy, connection dummy and high-frequency dummy achieve statistical significance before light rail. After light rail, these three as well as the downtown dummy achieve statistical significance. All of the statistically significant dummies show a positive relationship between having the stops they describe as the nearest transit stop and low-wage job accessibility. In addition, all three of the variables that achieve statistical significance both before and after the implementation of the Hiawatha line show an increase in the strength of that positive relationship after light rail.

This increase is especially noticeable for the southern neighborhood dummy variable. Though high before light rail—at roughly 1.9—this variable's IRR increases to 3.1 after light rail. In other words, after the opening of Hiawatha, a worker living in a block to which the nearest transit stop is one of the southern neighborhood LRT stations is predicted to be able to reach more than three times as many low-wage jobs in thirty minutes or less than one living in a block to which the nearest transit stop offers only basic bus service. The connection dummy variable shows an increase of roughly forty-six percentage points after light rail, but is actually quite high before light rail as well, with a starting value of 2.2. At first glance, this may seem strange, given the lack of any light rail line for these routes to connect to prior to opening of Hiawatha, but may partly be explained by the large number of routes connecting to Hiawatha which make their connection in the large employment center of downtown Minneapolis. In fact, most light rail stops that are major bus transfer points appear to be located in regional or sub-regional employment centers, likely meaning that much of the high IRR for the connection dummy variable can be explained by jobs accessible via one-seat rides on the connecting bus routes themselves. Even so, the observed forty-six percentage point increase appears to show significant accessibility benefits associated with light rail.

The same set of dummy variables achieves statistical significance when considering either high-wage jobs or all jobs, and demonstrates largely the same overall pattern. The southern neighborhood dummy variable shows a similar, though actually slightly smaller, increase when considering high-wage jobs (roughly one-hundred percentage points as opposed to roughly one-hundred and twenty percentage points). However, it begins from a larger base, reaching a value of 3.8 after light rail. A very similar pattern can be observed with the high-wage connection dummy variable: an increase of somewhat fewer percentage points beginning from a larger base. Interestingly, in spite of the large number of high-wage jobs located in downtown Minneapolis, the downtown dummy actually produces a lower IRR value for high-wage jobs than for low-wage jobs. This could indicate a greater concentration of low-wage jobs in the downtown area than expected, a general dearth of low-wage jobs in the transit served area of the Twin Cities metropolitan area, or some combination of both. (See the home-to-work commute flow analysis in Chapter 5 for more detail.) With accessibility to all jobs as the dependent variable, largely the same pattern persists, with both relative changes and starting points tending to fall in between the values observed with low-wage employment accessibility and high-wage employment accessibility.

In the 7:00-8:00am (morning peak) hour, only the connection dummy and high-frequency dummy achieve statistical significance before light rail with low-wage job accessibility as the dependent variable. Both produce similar IRR's to their respective starting-point values in the 5:00-6:00am hour. After the introduction of light rail, the downtown and southern neighborhood dummies are also statistically significant. Interestingly, though all are still quite high (the lowest—high-frequency—is 1.62), post LRT IRR's are invariably lower in the 7:00-8:00am hour than in the 5:00-6:00am hour, in spite of the fact that the Hiawatha line, the bus routes which connect with it, and the high-frequency bus system have all shifted from early-morning to peak-period headways. On the other hand, the remainder of the bus system is operating on shorter headways as well; many lower-frequency routes, in fact, make their first runs of the day at or near 6:00am. As a result, though Hiawatha, its connections and the high-frequency routes are likely providing higher absolute accessibility during the morning peak, they do not stand out from the remainder of the transit network as much when the entire system is running at maximum frequency.

With accessibility to either high-wage jobs or all jobs as the dependent variable, similarly lower IRR's are produced for significant dummy variables as during 5:00-6:00am hour. However, a different set of dummy variables achieves statistical significance after light rail from those which do with low-wage employment accessibility as the dependent variable. For high-wage accessibility, the southern neighborhood, suburb, connection and high-frequency dummies are significant. For all jobs, all dummies except the northern neighborhood dummy are significant. All IRR's show strong, positive relationships with employment accessibility. In addition, the connection dummy shows a very similar pattern of starting IRR's and gains as it did in the 5:00-6:00am hour across all three dependent variables, with high values before LRT, but significant increases after, though these IRR gains are not quite as large as those observed in the earlier hour.

In the 12:00-1:00pm (mid-day off-peak) hour, only the connection dummy and high-frequency dummy are significant before light rail with low-wage accessibility as the dependent variable. After light rail, however, the downtown and southern neighborhood dummies become significant as well, and both show strongly positive relationships between proximity to the LRT stations they describe and low-wage job accessibility. In addition, the connection dummy variable's IRR increases by roughly fifteen percentage points, once again seeming to underscore the importance of bus connections in evaluating the impacts of Hiawatha. The high-frequency dummy, however, actually shows an IRR decline of roughly eleven percentage points after the opening of the light rail line, showing less of a difference in accessibility between areas adjacent to high-frequency bus routes and areas which are not after light rail.

When only high-wage jobs are considered in the dependent variable, the southern neighborhood, connection and high-frequency dummies are significant before and after light rail, and the suburb dummy is also significant after light rail. Interestingly, while the southern neighborhood variable does not move from insignificant to significant as it did for low-income accessibility, it actually shifts from a strongly negative coefficient to a strongly positive coefficient. In addition, the ending point IRR value for the southern neighborhood dummy is considerably higher with high-wage accessibility as the dependent variable than with low-wage accessibility (4 as opposed to 2.5). The connection dummy variable's IRR increases somewhat less for high-wage accessibility than for low-wage accessibility, but begins from a considerably larger starting point.

With accessibility to all jobs as the dependent variable, the same set of dummy variables achieves statistical significance as with high-wage accessibility, with the addition of the downtown dummy variable after the introduction of light rail. Though the base IRR values are somewhat smaller than when only high-wage jobs are considered, trends of change after the introduction of light rail are quite similar.

In the 5:00-6:00pm (evening peak) hour, all dummy variables achieve statistical significance after light rail, and all but the northern neighborhood and suburb dummies do before. This pattern persists regardless of which dependent variable is used. With low-wage employment accessibility as the dependent variable, all of the dummy variables that are significant both before and after light rail except the high frequency dummy show significant IRR gains after the implementation of LRT. In addition, all dummies produce strong, positive relationships with accessibility after light rail.

Of particular interest is the strong, statistically significant positive relationship found between proximity to the northern neighborhood stations and low-wage job accessibility, given both the concentrations of low-income residents and throughout-the-day accessibility gains observed in the areas surrounding the northern neighborhood stations in the preceding map analysis, as well as the lack of statistically significant results produced by this variable in the earlier service hours. The model predicts that a worker living in a block to which the nearest transit stop is one of the northern neighborhood stations can access roughly 48% more low-wage jobs within a 30-minute transit trip than a worker living in a block to which the nearest transit stop is a bus stop served by regular bus routes. In addition, while the post-LRT IRR values this variable returns for accessibility to high-wage jobs and all jobs are higher than for accessibility to low-wage jobs, the difference is relatively small, with IRR's of 1.59 and 1.55 for the remaining two income categories, respectively.

The gains in IRR values shown by the southern neighborhood dummy variable (across all three income categories)are particularly striking as well. In all three cases, this variable has a strong negative relationship with accessibility before light rail—ranging from 0.4 (for high-wage accessibility) to 0.44 (for low-wage accessibility), showing an lower accessibility by up to sixty percentage points. While the range of IRR's is considerably wider after light rail—from 2.3 for low-wage jobs to 3.5 for high-wage jobs—it shows uniformly, strongly positive relationships between proximity to southern neighborhood stations and transit employment accessibility.

In general, the models for the 8:00-9:00pm (late-evening off-peak) hour produce highly similar results for the dummy variables as the models for the 12:00-1:00pm (mid-day off-peak) hour. In fact, all three off-peak hours (5:00-6:00am, 12:00-1:00pm and 8:00-9:00pm) return similar results for the dependent variables.

Overall, though it achieves statistical significance in many cases, and invariably produces positive coefficients when it does, the downtown dummy variable seems to produce surprisingly low IRR values considering the high density of employment in downtown Minneapolis, as well as considering the higher values found for variables describing proximity to stations in areas with much lower employment densities. Two potential explanations suggest themselves: First, as the dummy variables only describe the one closest transit stop to each block, the high density of bus stops throughout the entire downtown area may somewhat skew the results for this variable, since most blocks within a quarter mile of a downtown light rail station unavoidably have at least one bus stop between themselves and the station. Second, 30-minute cumulative opportunity accessibility may actually miss most employment accessibility benefits conferred on downtown station areas by the introduction of light rail, since the Hiawatha line's schedule puts the suburban employment centers it serves just outside of the cutoff time from much if not most of the downtown area, especially with walking time and waiting time factored in.

It also seems somewhat surprising that the northern neighborhood dummy variable only achieves statistical significance during the 5:00-6:00pm hour, given the strong accessibility gains observed surrounding the northern neighborhood stations during the analysis of accessibility maps. Once again, it seems likely that a relatively high density of bus stops in the areas surrounding these stations may effectively screen them from most of the blocks which surround them. This trend may also be exacerbated by the line's alignment in a somewhat isolated, greyfield corridor to which few blocks are centered near.

Given the patterns observed with the first two dummy variables, the high IRR values consistently produced by the southern neighborhood dummy variable may seem somewhat surprising as well. However, since the southern neighborhood stations lie roughly in the middle of the Hiawatha line in terms of running time, they are all well within half an hour of the employment centers at both extreme ends of the line. In addition, a lower density of bus routes and stops than in the zones to the north likely reduces the degree to which light rail stations are rendered effectively invisible by surrounding bus stops.

The overall trend for the dummy variables dealing with light rail is one of improved accessibility after the introduction of light rail. It is particular important to note the consistency and strength of this trend for the connection dummy variable. The behavior of this variable does not only underscore the importance of bus connections to light rail; it also appears to broaden the reach of light rail by extending to a much larger area of the metropolitan area. It is especially interesting to note that these trends persist at off-peak times. This consistency may be of particular importance to low-wage workers, as many such workers must arrive at work early, leave work late and/or even work multiple jobs, a fact which often reduces the usefulness of traditional, peak-period-oriented transit systems to them. In addition, though our data only directly address employment accessibility, they do at least seem to suggest a general broadening of accessibility into off-peak hours of the service day. Since transit-dependent people are dependent on transit for all motorized travel, not only travel to and from work, the above trend appears positive even for low-wage workers on traditional work schedules, as such workers must often extend their transit system use well beyond their commutes to access childcare, run errands and conduct their daily business. Though the map analysis conducted in Chapter 1 suggests that significant localized low-income employment accessibility gains are associated with Hiawatha, these results are significant in that they suggest that—at least in connection with some parts of the line—those impacts are consistently measurable over a considerably broader region.

The three demographic variables describing racial/ethnic minorities invariably show positive relationships between minority percentages of block populations and employment accessibility by transit. However, strikingly different patterns appear for the three individual minority groups considered: African Americans, Latinos and Asians. While the IRR's for the percentage of African Americans are always the lowest of the three both before and after light rail—falling between 1.2 and 2, and meaning that a 100% African American block is predicted to have between 120% and 200% the transit accessibility of a 0% African American block—IRR's nearly always increase after light rail, especially when only accessibility to low-wage jobs is considered. Percentage of Latinos always produces the highest IRR in each individual model (generally by a wide margin)—ranging from 2.56 to 14.04—but nearly always produces a lower IRR after light rail than before. IRR's for percentages of Asian residents fall in between those for African Americans and Latinos and generally increase after the introduction of light rail. These patterns may partly be explained by African Americans mostly belonging to a well established, native-born minority community, and therefore being less concentrated into majority minority enclave neighborhoods. Such a pattern would lead one to expect African American transit accessibility trends to more closely track accessibility trends for the study area as a whole.

All of the demographic variables describing socioeconomic status show uniformly positive relationships with transit employment accessibility, with the exception of median household income. Percent single parent produces IRR's ranging from 1.4 to 2.7 when considering low-wage jobs; IRR's increase after light rail in the two peak hours and decrease after light rail in the two off-peak hours. The pattern of changes is more erratic when either high-wage or all jobs are considered.

Percentage of residents with college degrees produces extremely high IRR's, ranging from 4.6 to 14.9. These values invariably increase after the opening of Hiawatha. This trend seems somewhat at odds with the trends shown by two of the remaining variables. While owner-occupancy rates for housing always produce positive coefficients, IRR values are much lower, and consistently decline after light rail. In addition, median household income invariably produces negative coefficients—in spite of the normally positive relationship between educational attainment and income. This negative relationship between median income and transit accessibility actually strengthens after light rail.

Finally the variable for percentage of households without a motor vehicle always, as one might expect, shows a strongly positive relationship with transit accessibility. However, IRR values for this variable consistently decline after light rail, though they do remain quite high. This trend, as well as the trend of a strengthening positive relationship between educational attainment and transit accessibility suggests an increasing focus on the attraction of choice riders to transit, with the effect of either improving service to less disadvantaged populations, curtailing service to more disadvantaged populations, or some combination of both.

Table 4.5: Accessibility Models, 5:00-6:00am

Regression Results, 5:00-6:00am

N=23193	Low-Wage				High-Wage				All-Jobs			
	Pre-LRT		Post-LRT		Pre-LRT		Post-LRT		Pre-LRT		Post-LRT	
LR chi2	2975.87		3598.01		3757.12		3777.97		3188.52		3467.48	
Prob>chi2	0		0		0		0		0		0	
Pseudo R2	0.0083		0.0097		0.0101		0.0096		0.0079		0.0082	
	Coeff.	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***
All_stops	-4.219***	0.015	-2.991***	0.05	-4.758***	0.009	-3.206***	0.041	-4.495***	0.011	-3.101***	0.045
DowntownDum.	0.316	1.372	0.631**	1.879	0.329	1.39	0.539*	1.714	0.336	1.399	0.598**	1.818
NorthDummy	-0.03	0.97	0.298	1.347	-0.004	0.996	0.37	1.448	-0.015	0.985	0.352	1.422
SouthDummy	0.664**	1.943	1.126***	3.083	1.038***	2.824	1.343***	3.831	0.860***	2.363	1.259***	3.522
SuburbDummy	0.32	1.377	0.117	1.124	0.272	1.313	0.42	1.522	0.292	1.339	0.321	1.379
ConnectDum.	0.790***	2.203	0.978***	2.659	1.091***	2.977	1.220***	3.387	0.970***	2.638	1.124***	3.077
HFDummy	0.522***	1.685	0.662***	1.939	0.512***	1.669	0.599***	1.82	0.508***	1.662	0.621***	1.861
PctAfrAm	0.388***	1.474	0.713***	2.04	0.613***	1.846	0.982***	2.67	0.534***	1.706	0.891***	2.438
PctLatino	1.747***	5.737	1.410***	4.096	2.436***	11.43	1.661***	5.265	2.149***	8.576	1.602***	4.963
PctAsian	1.177***	3.245	1.291***	3.636	1.722***	5.596	1.555***	4.735	1.485***	4.415	1.458***	4.297
PctSingPar	1.009***	2.743	0.645***	1.906	1.453***	4.276	0.809***	2.246	1.268***	3.554	0.742***	2.1
PctCollDeg	2.168***	8.741	2.634***	13.93	2.195***	8.98	2.699***	14.87	2.145***	8.542	2.646***	14.1
PctOwnOc	0.540***	1.716	0.172***	1.188	0.567***	1.763	0.165***	1.179	0.555***	1.742	0.166***	1.181
PNoVehHH	2.399***	11.01	1.697***	5.458	2.445***	11.53	1.736***	5.675	2.447***	11.55	1.726***	5.618
MedInc1K	-0.017***	0.983	-0.019***	0.981	-0.022***	0.978	-0.020***	0.98	-0.020***	0.98	-0.020***	0.98
Constant	7.528***		7.852***		8.216***		8.576***		9.035***		9.333***	
lnAlpha Const.	1.825***		1.799***		1.938***		1.923***		1.976***		1.952***	

Legend: * p<.1; ** p<.05; *** p<.01

Table 4.6: Accessibility Models, 7:00-8:00am

Regression Results, 7:00-8:00am

N=23193	Low-Wage				High-Wage				All-Jobs			
	Pre-LRT		Post-LRT		Pre-LRT		Post-LRT		Pre-LRT		Post-LRT	
LR chi2	4035.97		6691.52		4489.55		6877.68		4133.76		6701.71	
Prob>chi2	0		0		0		0		0		0	
Pseudo R2	0.0093		0.0148		0.0099		0.0144		0.0084		0.013	
	Coeff.	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***
All_stops	-3.821***	0.022	-3.330***	0.036	-4.487***	0.011	-4.093***	0.017	-4.206***	0.015	-3.787***	0.023
DowntownDum.	0.387*	1.473	0.466***	1.594	0.420*	1.522	0.3	1.35	0.431**	1.539	0.385**	1.47
NorthDummy	0.082	1.085	0.255	1.29	0.178	1.195	0.34	1.405	0.143	1.154	0.318	1.374
SouthDummy	-0.06	0.942	0.665***	1.944	0.011	1.011	1.049***	2.855	-0.011	0.989	0.905***	2.472
SuburbDummy	-0.274	0.76	0.58	1.786	-0.229	0.795	0.979**	2.662	-0.225	0.799	0.833*	2.3
ConnectDum.	0.752***	2.121	0.857***	2.356	0.974***	2.649	1.093***	2.983	0.891***	2.438	1.006***	2.735
HFDummy	0.348***	1.416	0.448***	1.565	0.247***	1.28	0.381***	1.464	0.280***	1.323	0.406***	1.501
PctAfrAm	0.403***	1.496	0.393***	1.481	0.630***	1.878	0.684***	1.982	0.545***	1.725	0.582***	1.79
PctLatino	1.271***	3.564	0.939***	2.557	1.692***	5.43	1.261***	3.529	1.542***	4.674	1.135***	3.111
PctAsian	0.751***	2.119	1.052***	2.863	1.089***	2.971	1.174***	3.235	0.953***	2.593	1.101***	3.007
PctSingPar	0.345***	1.412	0.458***	1.581	0.639***	1.895	0.687***	1.988	0.533***	1.704	0.609***	1.839
PctCollDeg	1.529***	4.614	2.483***	11.977	1.579***	4.85	2.548***	12.78	1.545***	4.688	2.545***	12.74
PctOwnOc	0.445***	1.56	0.416***	1.516	0.570***	1.768	0.532***	1.702	0.508***	1.662	0.483***	1.621
PNoVehHH	1.737***	5.68	2.050***	7.768	1.986***	7.286	2.233***	9.328	1.879***	6.547	2.172***	8.776
MedInc1K	-0.013***	0.987	-0.015***	0.985	-0.015***	0.985	-0.018***	0.982	-0.014***	0.986	-0.017***	0.983
Constant	8.409***		8.127***		8.973***		8.855***		9.843***		9.598***	
lnAlpha Const.	1.105***		0.838***		1.283***		1.050***		1.267***		0.999***	

Legend: * p<.1; ** p<.05; *** p<.01

Table 4.7: Accessibility Models, 12:00-1:00pm

Regression Results, 12:00-1:00pm

N=23193	Low-Wage				High-Wage				All-Jobs			
	Pre-LRT		Post-LRT		Pre-LRT		Post-LRT		Pre-LRT		Post-LRT	
LR chi2	2909.14		4045.36		3746.86		5010.2		3153.12		4381.73	
Prob>chi2	0		0		0		0		0		0	
Pseudo R2	0.008		0.0102		0.01		0.0121		0.0077		0.0098	
	Coeff.	*IRR*	*Coeff.*	*IRR*	*Coeff.*	*IRR*	*Coeff.*	*IRR*	*Coeff.*	*IRR*	*Coeff.*	*IRR*
All_stops	-3.984***	0.019	-3.206***	0.041	-5.041***	0.006	-3.822***	0.022	-4.555***	0.011	-3.568***	0.028
DowntownDum.	0.281	1.324	0.516**	1.675	0.398	1.489	0.424	1.528	0.374	1.454	0.485*	1.624
NorthDummy	0.007	1.007	0.313	1.368	0.155	1.168	0.383	1.467	0.094	1.099	0.365	1.441
SouthDummy	-0.465	0.628	0.915***	2.497	-0.832***	0.435	1.385***	3.995	-0.596*	0.551	1.195***	3.304
SuburbDummy	0.093	1.097	0.777	2.175	0.123	1.131	1.459**	4.302	0.132	1.141	1.181*	3.258
ConnectDum.	0.788***	2.199	0.854***	2.349	1.122***	3.071	1.146***	3.146	0.982***	2.67	1.035***	2.815
HFDummy	0.550***	1.733	0.481***	1.618	0.478***	1.613	0.495***	1.64	0.504***	1.655	0.482***	1.619
PctAfrAm	0.219	1.245	0.272**	1.313	0.478***	1.613	0.613***	1.846	0.387**	1.473	0.486***	1.626
PctLatino	1.861***	6.43	1.709***	5.523	2.642***	14.04	2.284***	9.816	2.320***	10.176	2.046***	7.737
PctAsian	1.096***	2.992	1.080***	2.945	1.512***	4.536	1.254***	3.504	1.317***	3.732	1.154***	3.171
PctSingPar	0.632***	1.881	0.572***	1.772	0.895***	2.447	1.075***	2.93	0.791***	2.206	0.876***	2.401
PctCollDeg	2.076***	7.973	2.272***	9.699	1.681***	5.371	2.467***	11.787	1.847***	6.341	2.388***	10.892
PctOwnOc	0.405***	1.499	0.274***	1.315	0.234**	1.264	0.532***	1.702	0.313***	1.368	0.404***	1.498
PNoVehHH	2.338***	10.36	2.055***	7.807	2.572***	13.09	2.500***	12.182	2.511***	12.317	2.331***	10.288
MedInc1K	-0.018***	0.982	-0.019***	0.981	-0.017***	0.983	-0.025***	0.975	-0.018***	0.982	-0.022***	0.978
Constant	7.858***		8.135***		8.502***		8.613***		9.323***		9.468***	
lnAlpha Const.	1.843***		1.544***		1.940***		1.673***		1.987***		1.695***	

Legend: * p<.1; ** p<.05; *** p<.01

Table 4.8: Accessibility Models, 5:00-6:00pm

Regression Results, 5:00-6:00pm

N=23193	Low-Wage				High-Wage				All-Jobs			
	Pre-LRT		Post-LRT		Pre-LRT		Post-LRT		Pre-LRT		Post-LRT	
LR chi2	6285.5		8067.9		6903.77		8816.07		6678.68		8661.04	
Prob>chi2	0		0		0		0		0		0	
Pseudo R2	0.014		0.0179		0.0148		0.0186		0.0131		0.0169	
	Coeff.	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***
All_stops	-3.484***	0.031	-3.246***	0.039	-3.881***	0.021	-3.734***	0.024	-3.703***	0.025	-3.518***	0.03
DowntownDum.	0.376**	1.456	0.631***	1.879	0.446**	1.562	0.567***	1.763	0.435**	1.545	0.611***	1.842
NorthDummy	0.121	1.129	0.394**	1.483	0.26	1.297	0.462**	1.587	0.206	1.229	0.439**	1.551
SouthDummy	-0.811***	0.444	0.803***	2.232	-0.909***	0.403	1.252***	3.497	-0.832***	0.435	1.076***	2.933
SuburbDummy	-0.106	0.899	0.720*	2.054	-0.097	0.908	1.345***	3.838	-0.069	0.933	1.085***	2.959
ConnectDum.	0.641***	1.898	0.814***	2.257	0.836***	2.307	1.123***	3.074	0.760***	2.138	1.006***	2.735
HFDummy	0.446***	1.562	0.400***	1.492	0.413***	1.511	0.328***	1.388	0.421***	1.523	0.356***	1.428
PctAfrAm	0.340***	1.405	0.264***	1.302	0.723***	2.061	0.572***	1.772	0.590***	1.804	0.459***	1.582
PctLatino	1.212***	3.36	1.415***	4.116	1.805***	6.08	1.901***	6.693	1.570***	4.807	1.699***	5.468
PctAsian	0.749***	2.115	0.894***	2.445	1.139***	3.124	1.130***	3.096	0.978***	2.659	1.014***	2.757
PctSingPar	0.408***	1.504	0.666***	1.946	0.666***	1.946	1.062***	2.892	0.579***	1.784	0.906***	2.474
PctCollDeg	1.692***	5.43	2.075***	7.965	1.767***	5.853	2.199***	9.016	1.746***	5.732	2.179***	8.837
PctOwnOc	0.178***	1.195	0.165***	1.179	0.159**	1.172	0.231***	1.26	0.170***	1.185	0.192***	1.212
PNoVehHH	1.922***	6.835	1.760***	5.812	2.350***	10.486	2.093***	8.109	2.172***	8.776	1.961***	7.106
MedInc1K	-0.013***	0.987	-0.015***	0.985	-0.014***	0.986	-0.018***	0.982	-0.014***	0.986	-0.017***	0.983
Constant	8.479***		8.251***		8.926***		8.788***		9.838***		9.619***	
lnAlpha Const.	0.714***		0.626***		0.969***		0.895***		0.878***		0.793***	

Legend: * p<.1; ** p<.05; *** p<.01

Table 4.9: Accessibility Models, 8:00-9:00pm

Regression Results, 8:00-9:00pm

N=23193	Low-Wage				High-Wage				All-Jobs			
	Pre-LRT		**Post-LRT**		**Pre-LRT**		**Post-LRT**		**Pre-LRT**		**Post-LRT**	
LR chi2	2860.52		2983.84		3868.65		3157.85		3176.89		2918.52	
Prob>chi2	0		0		0		0		0		0	
Pseudo R2	0.0084		0.0085		0.011		0.0086		0.0083		0.0074	
	Coeff.	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***	***Coeff.***	***IRR***
All_stops	-3.987***	0.019	-3.304***	0.037	-4.673***	0.009	-3.877***	0.021	-4.335***	0.013	-3.645***	0.026
DowntownDum.	0.343	1.409	0.497	1.644	0.468	1.597	0.434	1.543	0.44	1.553	0.493	1.637
NorthDummy	0.123	1.131	0.426	1.531	0.255	1.29	0.607	1.835	0.201	1.223	0.547	1.728
SouthDummy	0.105	1.111	1.073***	2.924	0.07	1.073	1.460***	4.306	0.141	1.151	1.320***	3.743
SuburbDummy	0.361	1.435	0.614	1.848	0.211	1.235	0.892	2.44	0.321	1.379	0.787	2.197
ConnectDum.	0.725***	2.065	0.965***	2.625	1.030***	2.801	1.195***	3.304	0.904***	2.469	1.116***	3.053
HFDummy	0.591***	1.806	0.584***	1.793	0.603***	1.828	0.602***	1.826	0.590***	1.804	0.591***	1.806
PctAfrAm	0.869***	2.385	0.557***	1.745	1.158***	3.184	0.723***	2.061	1.055***	2.872	0.656***	1.927
PctLatino	1.524***	4.591	1.687***	5.403	2.388***	10.892	1.942***	6.973	2.030***	7.614	1.855***	6.392
PctAsian	0.799***	2.223	1.255***	3.508	1.285***	3.615	1.152***	3.165	1.079***	2.942	1.163***	3.2
PctSingPar	0.551***	1.735	0.496***	1.642	0.928***	2.529	0.522***	1.685	0.785***	2.192	0.523***	1.687
PctCollDeg	2.280***	9.777	2.470***	11.822	2.088***	8.069	1.898***	6.673	2.173***	8.785	2.142***	8.516
PctOwnOc	0.220**	1.246	0.423***	1.527	0.256**	1.292	0.477***	1.611	0.254**	1.289	0.437***	1.548
PNoVehHH	2.863***	17.514	2.124***	8.365	3.160***	23.571	1.909***	6.746	3.047***	21.052	1.996***	7.36
MedInc1K	-0.016***	0.984	-0.020***	0.98	-0.022***	0.978	-0.021***	0.979	-0.019***	0.981	-0.021***	0.979
Constant	7.681***		7.694***		8.293***		8.688***		9.125***		9.336***	
lnAlpha Const.	2.032***		1.984***		2.111***		2.115***		2.169***		2.143***	

Legend: * p<.1; ** p<.05; *** p<.01

4.3.4 Marginal Effects

The following graphs (Figures 4.16 through 4.21) show the results of marginal effects computations of the regression models described above at various values of the all stops distance variable, with the value of the connection dummy variable set to 1, the values of all other dummy variables set to 0, and all other independent variables held at their mean values. The connection dummy was chosen for a "yes" value due to its consistently strong positive relationships with accessibility and pattern of strengthening positive relationships after light rail, the much broader, more regional context it allows us to consider the impacts of light rail in, and because of survey research indicating more than half of all Hiawatha light rail riders transfer to or from a bus at at least one end of their trip. As the dummy variables are mutually exclusive, this choice necessitated assigning a "no" value to each of the other dummies. These computations show the predicted numbers of accessible jobs based on distances from transit stops, holding all else equal. Though they do not directly show the significant areas of extremely high accessibility in the areas immediately surrounding light rail stations (see Figures 4.9 through 4.13), the trends they show do offer insight into the regional effects of light rail. They also show the extent to which transit accessibility (here representing the most efficient path through the transit system) has become oriented towards the Hiawatha line on a regional scale.

Figure 4.16 shows predicted accessibility to low-wage jobs in the two peak-period hours considered in the study, 7:00-8:00am and 5:00-6:00pm. These predictions underscore the surprising difference in accessibility between the morning and evening peak periods. Though both hours show an increase in predicted accessibility after the implementation of light rail, this increase is fairly significant during the morning peak and barely even noticeable during the evening peak. In addition, even the line showing predictions of pre-LRT accessibility during the 7:00-8:00am hour is considerably higher on the graph than the line showing predicted post-LRT accessibility during the 5:00-6:00pm hour.

Turning to the graphs of predicted accessibility to low-wage jobs during the three off-peak hours—5:00-6:00am, 12:00-1:00pm and 8:00-9:00pm, a much different pattern presents itself. First, though the lines of predicted values are allowed to fill the graph, its scale is markedly different, with a maximum *y* value of 12,000 as opposed to 19,000. This change of scale drives home the accessibility consequences of the reduced level of transit service provided during the lower-demand, off-peak hours. However, it must be noted that the difference between pre-LRT and post-LRT lines is actually much greater in the off-peak periods of the service day than during the peak periods. In particular, the highest pre-LRT line is lower on the graph than even the lowest post-LRT line during the off-peak hours. The post-light rail gains shown for the off-peak hours (roughly 2,000 jobs for each) are also much larger than the gains for the peak hours (roughly 1,000 jobs for the morning peak; less than 100 for the evening peak.)

Figures 4.18 and 4.19—the graphs for peak and off-peak, high-wage accessibility, respectively—show the same general pattern as described above, yet with several critically important differences: First, both graphs must use an entirely different scale to show the much higher accessibility values predicted for high-wage employment. Of course, one must bear in mind that the wage scale used in these models does not reflect thirds of the study area's actual wage scale, and that, in fact, the descriptive statistics strongly suggest many more high-wage than low-wage workers and jobs. Even so, it is impossible to ignore the maximum *y* values of 50,000 jobs and 30,000 jobs for the peak and off-peak periods, respectively.

In terms of the peak period graphs for high-wage accessibility, both hours actually show significant gains after light rail. However, the pre-LRT line for the morning peak is still higher than the post-LRT line for the evening peak for nearly all its length. In addition, the off-peak hours show even larger accessibility gains than they did for low-wage job accessibility—approaching 10,000 jobs. The much closer grouping of the post-LRT off-peak lines also shows accessibility to high-income employment becoming more uniform between the three off-peak hours considered.

The trends observed for both low- and high-wage job accessibility are preserved when accessibility to all jobs is considered. Though, of course, the scale of the graphs is not at all comparable, proportionally speaking, the patterns of absolute before and after accessibility values and relative accessibility gains appear quite similar to those described above.

4.4 Summary of Findings

We find significant changes in accessibility after the introduction of light rail transit. Though a majority of these changes are consistently positive, they vary greatly in terms of degree between areas of the metropolitan region, hours of the service day and income groups. Different methods of analysis corroborate each other, but also show subtle differences in accessibility changes.

Map analysis finds large accessibility gains for low-wage jobs around light rail stations, bus routes which connect with light rail, and bus routes that are part of Metro Transit's high-frequency network. Most other areas show either no change or a slight decline in accessibility.

Descriptive statistics once again find consistent accessibility gains, and once again also find significant variations in those gains. Both starting point values and gains are larger for accessibility to high-wage jobs than to low-wage jobs (though definitions of "high" and "low" wage are based on a different area than the study area of this research.) In addition, accessibility gains are considerably larger in the 5:00-6:00am, 7:00-8:00am and 12:00-1:00pm service hours than for the 5:00-6:00pm and 8:00-9:00pm service hours. Accessibility values and changes also vary significantly based on location within a quarter mile of a light rail station, bus stop offering a light rail connection or bus stop served by a high-frequency route. While areas within a quarter mile of a downtown station, northern neighborhood station or connecting bus stop consistently have the highest ending-point accessibility values, areas within a quarter mile of a southern neighborhood or suburban light rail station show the largest accessibility gains, as they have much lower starting point values than the others.

Negative-binomial regression models show a strong, consistent and significant negative relationship between accessibility and distance from the nearest transit stop. Dummy variables indicating location within a quarter mile of a light rail station, connecting bus stop or high-frequency bus stop do not always achieve statistical significance. However, they are much more frequently significant after light rail than before. Before light rail, these variables produce a mixture of positive and negative coefficients; after light rail, coefficients are positive and coefficients which were positive before tend to strengthen.

Marginal effects calculations of predicted accessibility values based on the regression models follow a similar pattern to the other analysis methods, particularly the descriptive statistics. All service hours see accessibility gains for all wage level, and most of these gains are large. Peak hours have the highest absolute accessibility values. While the morning peak sees large gains in accessibility, gains in the evening peak are much smaller. Early morning, mid day and late evening off-peak hours have lower absolute accessibility values, but see large relative gains. Once again, predicted values are considerably higher for accessibility to high-wage jobs than for accessibility to low-wage jobs.

The significant disparity between predicted accessibility to low- and high-wage jobs is cause for some concern, bearing in mind, of course, the imperfections in the income category definitions outlined above. It certainly seems to warrant continued study and monitoring going forward. However, it is clear that accessibility by transit to low-wage jobs did improve significantly between the two observations of the study. In addition, the large improvements observed for low-wage accessibility during the off-peak hours seem especially important for low-income and transit-dependent people, as the commute time analysis detailed in Chapter 2 shows lower-income workers are considerably more likely to use the transit system outside of traditional peak times. This is particularly true during the mid-day peak, the hour for which the greatest low-wage job accessibility benefit was observed. In addition, though they do not directly address accessibility to non-employment destinations, the off-peak accessibility gains observed speak to improved levels of transit service at off-peak times of day, and strongly suggest a post-LRT transit system both better able to meet the non-work travel needs of the transit-dependent, and better able to allow an even larger number of low-income households to realize the great economies of doing without a car, or of simply reducing the number of cars in a multi-car household. Such economies can be large enough to easily make the difference between living paycheck-to-paycheck and being able to gradually build wealth, or even between stable poverty and desperation. Overall, the marginal effects paint a picture of benefits for all, including low-wage workers, with some benefit likely to have special significance for the transit-dependent and transportation-disadvantaged. Still, apparent disparities between absolute accessibility predictions to high- and low-income jobs demand some further scrutiny.

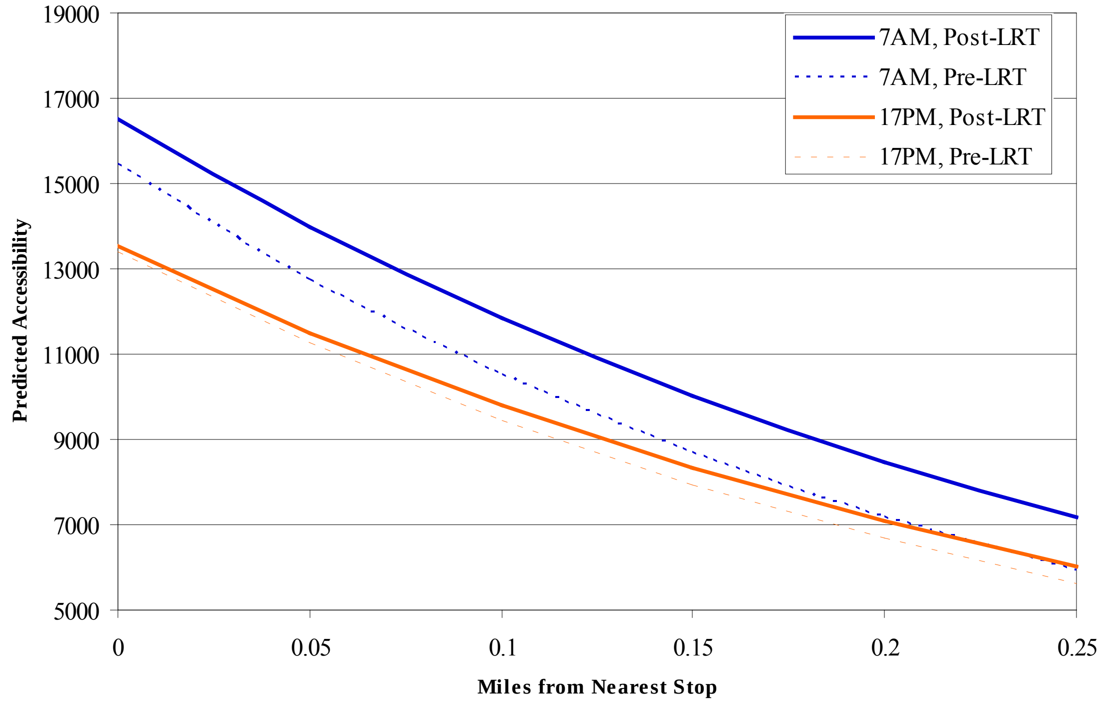

Figure 4.22. Marginal Effects for Low-Wage Peak-Hour Accessibility

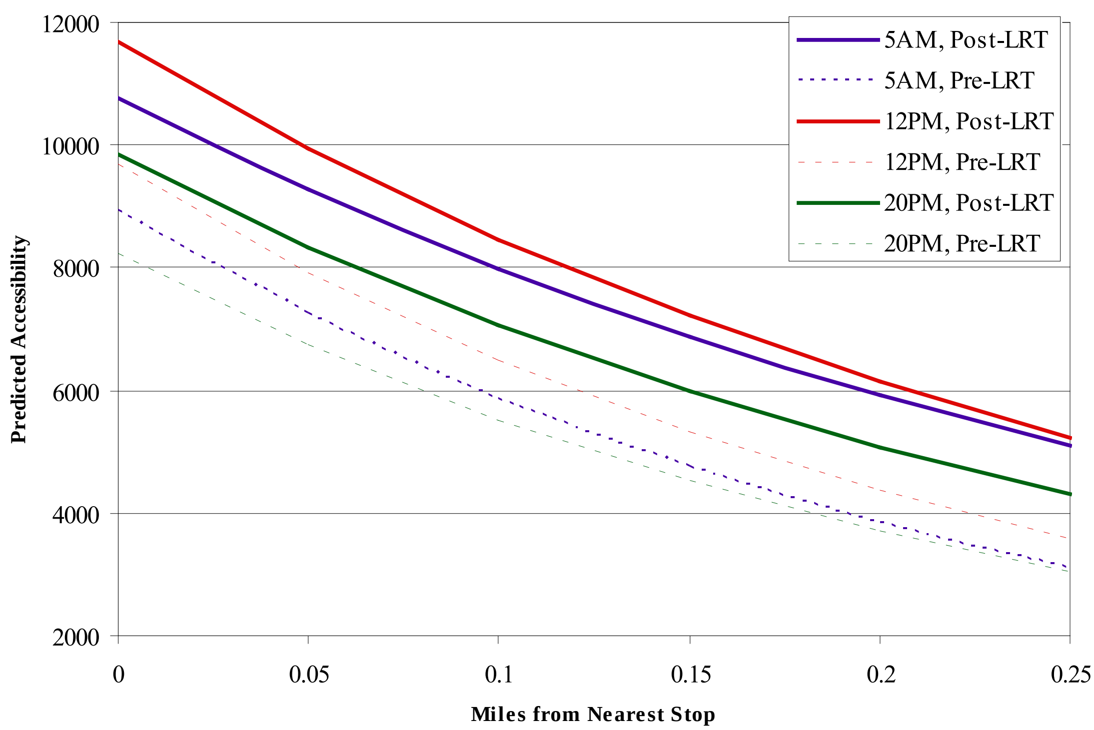

Figure 4.23. Marginal Effects for Low-Wage Off-Peak Accessibility

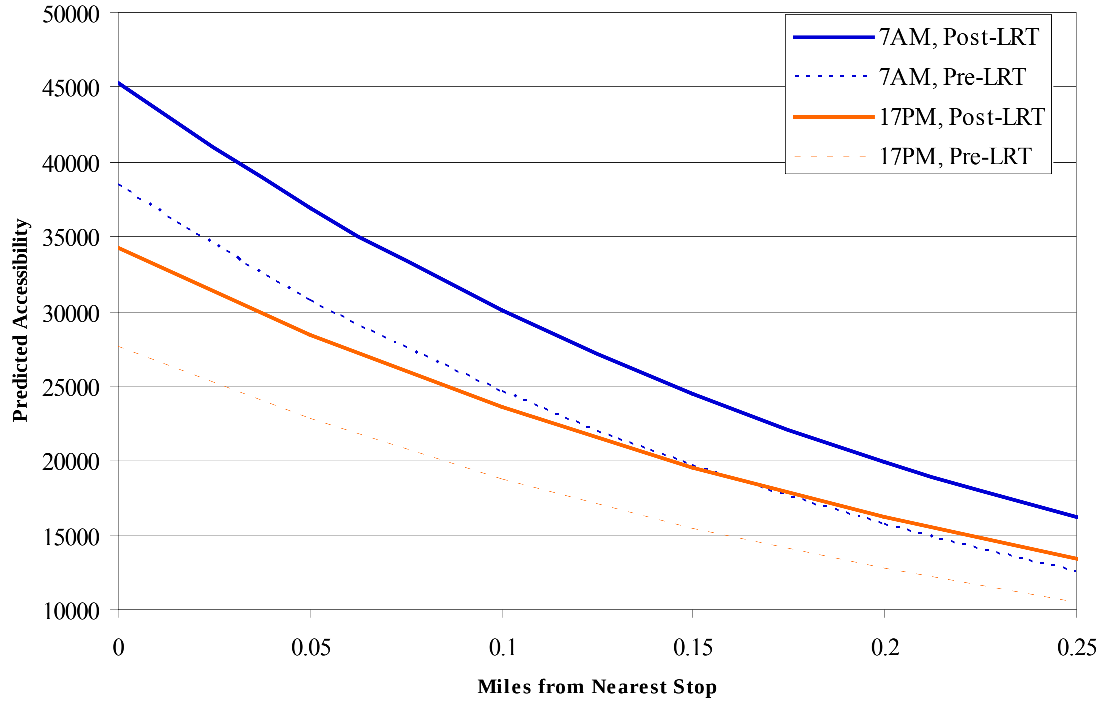

Figure 4.24. Marginal Effects for High-Wage Peak Accessibility

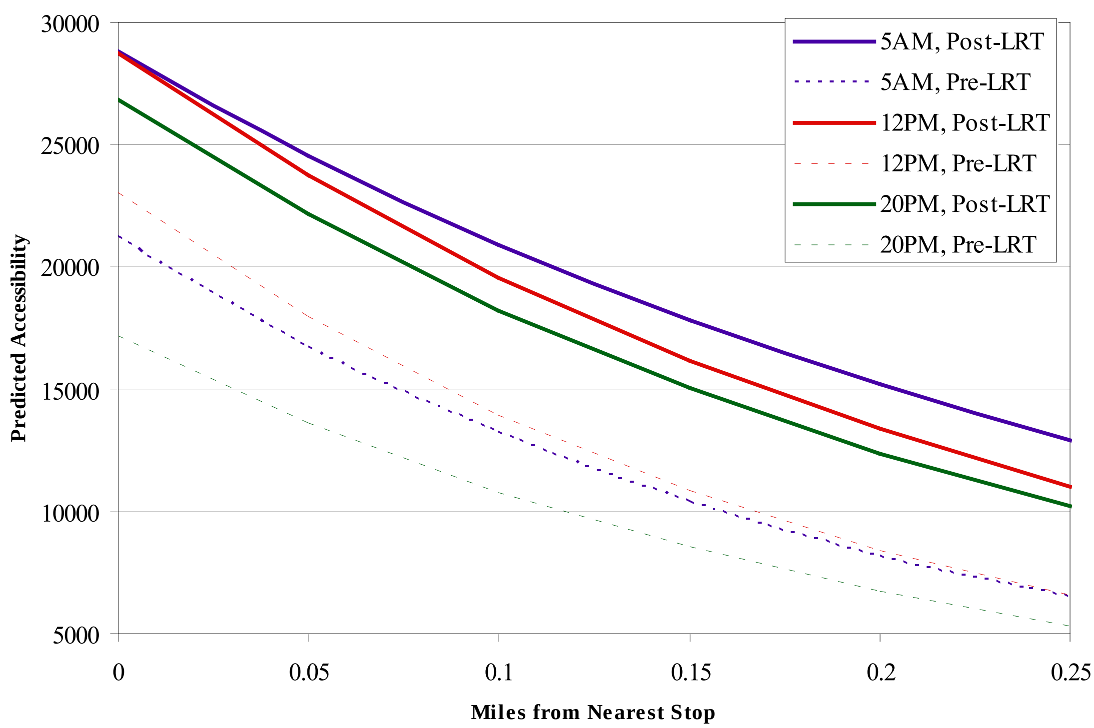

Figure 4.25. Marginal Effects for High-Wage Off-Peak Accessibility

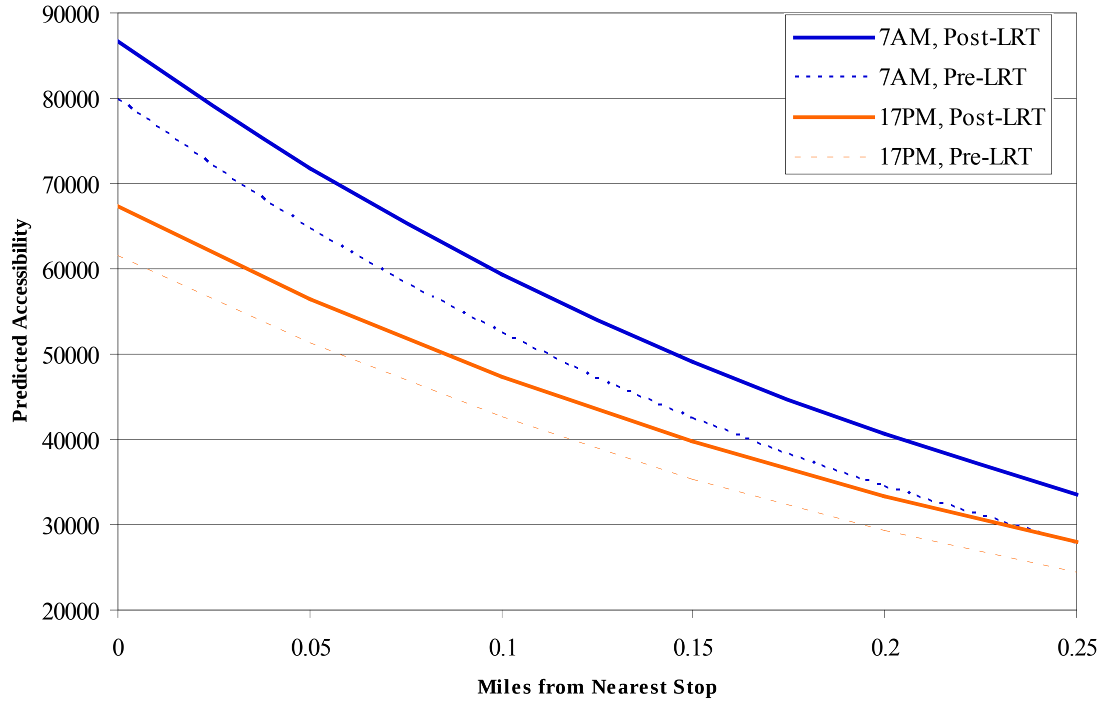

Figure 4.26. Marginal Effects for Peak Accessibility to All Jobs

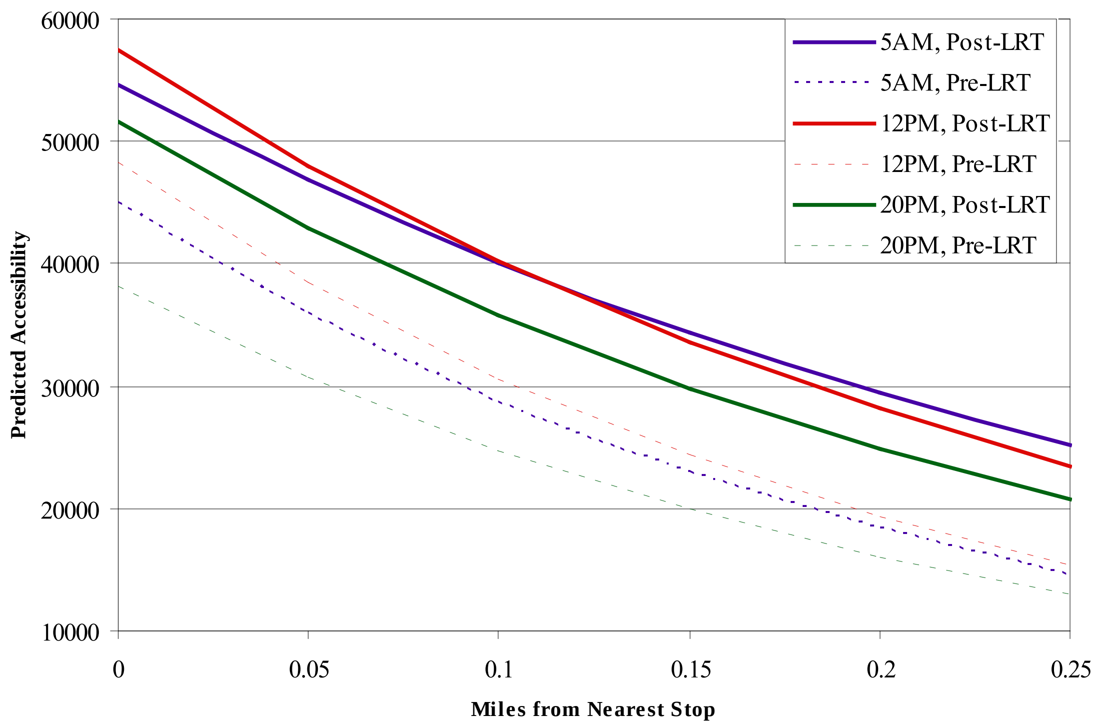

Figure 4.27. Marginal Effects for Off-Peak Accessibility to All Jobs

Chapter 5: Commuter Flow Analysis

The accessibility models described in the preceding chapter help to quantify the number of jobs that could be reached by low-wage workers, high-income workers and all workers both before and after the implementation of the Hiawatha light rail transit line. They describe what was possible at the starting point of the analysis, and what became possible after the opening of the Twin Cities' first modern transitway. Possibilities—or impossibilities, however, do not necessarily equal realized gains or losses. To put it simply, the ability to commute to a given job by transit is not the same as being hired for that job and starting to make the commute. This chapter attempts to quantify the extent to which low-wage, high-wage and all workers have changed their places of residence, and to what extent low-paying, high-paying and all employers have changed their places of business to take advantage of accessibility gains conferred by light rail. In addition, this chapter examines any displacement of low-wage workers or jobs which may have taken place following the implementation of light rail due to the ability of rail transit to attract higher-income choice riders, and the strong push for the redevelopment of significant areas of the Hiawatha corridor.

5.1 Methodology

At their hearts, the models examining relocation behavior and displacement effects hinge on the counting of individual, commutes. The home and work locations of these commutes are geocoded at the census block-group level. These counts are based on the LEHD home to work commute flow data (also referred as the O/D matrix data) collected by the census bureau during the years 2002 and 2006. These data are provided for each year in the form of a matrix of *block* to *block* commutes, with the census Summary Tape File IDentification number (STFID) of the origin (home) and destination (work) census blocks, as well as a listing of worker counts in different earning, age and industrial categories. To confine our analysis within the transit-served areas, we excluded the commute records that either have an origin block centroid or destination block centroid more than a quarter mile away from the nearest transit stops. The counts of low-wage commuters, high-wage commuters and all commuters form the bases of the dependent variables in the O/D models [41]. The commute data were collected at the block level, rather than the block-group level, but the Census deliberately reduces the accuracy of block-level demographic data to protect confidentiality for repondents. To allow us to use accurate, block-group level data, we aggregated counts of origin and destination blocks into the block groups containing them—resulting in about 500,000 block group-to-block group commute records.

Ordinary least squares regression was used to estimate the 2002-2006 changes in the number of low-income commuters, high-income commuters and all commuters. In interpreting the models' results, it is important to keep in mind that the dependent variables represent changes in numbers of commuters between the two observations rather than the actual commute flow counts. Independent variables included in the commute flow change analysis include a set of distance variables describing the proximity of each home and work block group to the Minneapolis central business district and to the transit system, as well as the airline distance between the home block group and the work block group. In addition, the regression analysis also includes dummy variables identifying origin and destination blocks within one quarter mile of a downtown, northern neighborhood, southern neighborhood and suburban light rail station (as defined in Chapter 4), connecting bus stop or high frequency bus stop. In each case, a block group with at least one block within a quarter mile of the type of transit stop in question received a value of 1, even if its centroid lay outside the quarter mile distance.

In addition to the distance variables and the station area dummies, six demographic variables based on data from the 2000 census were included in the final models:

earn_2002_sum— The total number of low-income, high-income or all workers (depending on the model in question) making each individual commute in 2002. Included to allow consideration of the base for each change measured by the dependent variable.

PctBlack— The percentage of residents of each block group who self-identified as African American in the 2000 census. Included on the theory that minorities are generally more likely than whites to both use transit and to make location decisions based on transit access.

PctAsian— The percentage of residents of each block group who self-identified as Asian in the 2000 census. Included on the theory that minorities are generally more likely than whites to both use transit and to make location decisions based on transit access.

PctLatino— The percentage of residents of each block group who self-identified as Hispanic or Latino in the 2000 census. Included on the theory that minorities are generally more likely than whites to both use transit and to make location decisions based on transit access.

PctSingPar— The percentage of households in the block group containing each block group made up of families with minor children headed by a single parent. Included on the theory that transit-dependent and transit-using single parents may experience compounded (and particularly attractive) benefits from improved transit service due to their complex trip patterns, and, on the other hand, that they may be particularly vulnerable to displacement from suddenly more desirable areas due to low household incomes relative to expenses and housing needs.

PctCollDeg— The percentage of residents over age twenty-five in the block group containing each block group who had achieved a bachelor’s degree or higher at the time of the 2000 census. Included as an additional measure of the employment qualifications of residents at the starting point of the study.

PctOwnOc— The percentage of occupied housings units in each block occupied by owners. Included on the theory that renters may be more easily and quickly able to relocate than owner-occupants. (10)

PctNoCar— The percentage of households in the block group with no motor vehicle. Included as a measure of numbers of residents for whom improved transit service is likely to be particularly beneficial and attractive.

In all cases, the demographic variables describe the characteristics of the block group at the *origin* end of the commute—the block groups where commuters live. Since census data are collected at people's homes, this method allows the demographic variables to at least indirectly offer some information about the actual commuters themselves, not just the places where they work.

Descriptive statistics were produced for all variables. The main analysis estimated an ordinary least squares regression model for each of the three dependent variables, and calculated predicted changes in numbers of commutes beginning and ending near each type of transit stop considered.

5.2 Descriptive Statistics

Table 5.1 contains descriptive statistics produced from the variables included in the Origin/Destination regression models. Of primary interest, to start with, are the mean values of the three dependent variables—which represent changes in the counts of commuters making a given commute. While the mean values Change_Low and Change_Total, representing low-wage commuters and all commuters, respectively, both show declines, Change_High's mean shows an increase. This trend could indicate displacement of low-wage residents by high-wage residents, displacement of entry-level jobs by higher-skilled jobs, shifts in the pay scales of jobs remaining in place, or some combination of the three. It is important to note again that the income categories listed here do not represent thirds of our study area's income scale. It is also interesting to note that, based on their respective standard deviations, the popularity of individual commutes is significantly less variable for low-wage workers over the study period than for high-wage workers.

Looking at Table 5.1, one major, interesting difference between the home and work dummy variables is immediately apparent: each home dummy variable has a much lower mean and standard deviation than its corresponding work dummy variable. In other words, more people work close to the Hiawatha line, its connecting bus routes, and the high-frequency bus network than live close to them. Of particular interest are the extremely high mean values observed for the dummy variables describing home and work block groups within a quarter mile of a bus stop offering a direct connection with Hiawatha, but not within a quarter mile of a Hiawatha station. These dummies show that roughly 47% of all commute pairs within the transit service area have origins within one quarter mile of a connecting bus stop, and that roughly 59% of all commute pairs have destinations within the same buffer distance. By comparison, less than 3% of all commute pairs have origin points within a quarter mile of a light rail station, and about 6% of commute pairs have destination points within a quarter mile of light rail. (It should be noted that these percentages reflect only the number of block-group-to-block-group pairs, not the numbers of commuters who actually make each trip.)

Both the home and work stop distance variables have very low mean values, even taking into account the maximum of 0.25 imposed by the definition of the study area. Both means are less than 0.05, suggesting that most home and work locations within the transit service area have at least one transit stop quite close by.

The cbd_Home and cbd_Work variables show relatively little difference between the distances to downtown Minneapolis at which people tend to live and work, though the latter does tend to be closer. Interestingly, the mean value of OD_Miles—the distance between each origin-destination pair's ends—is larger than the mean of either of the aforementioned two variables. This pattern suggests a more complex commuting pattern than a traditional, radial flow focused on the central business district. However, the relatively small differences do not point to an overwhelming dominance of cross-town or suburb-to-suburb commutes.

Table 5.1: Descriptive Statistics, Commute Flows

N=395920

	Mean	Std. Dev.	Min	Max
Change_Low	-0.0360	1.1157	-29	61
Change_High	0.0745	1.3266	-51	102
Change_Total	-0.0280	2.2687	-65	94
earn1_2002~m	0.4482	1.1486	0	60
earn3_2002~m	0.5315	1.6995	0	121
total_2002~m	1.6067	3.4907	0	247
All_stops_Work	0.0408	0.0247	0.0014	0.2472
DowntownDu~W	0.0208	0.1429	0	1
NorthDummy_W	0.0174	0.1306	0	1
SouthDummy_W	0.0090	0.0943	0	1
SuburbDumm~W	0.0117	0.1075	0	1
ConnectDum~W	0.5867	0.4924	0	1
HFDummy_W	0.2977	0.4573	0	1
cbd_Work	7.0418	4.1956	0.0528	23.4440
All_stops_Home	0.0483	0.0263	0.0014	0.2472
DowntownDu~H	0.0029	0.0534	0	1
NorthDummy_H	0.0094	0.0963	0	1
SouthDummy_H	0.0086	0.0924	0	1
SuburbDumm~H	0.0008	0.0277	0	1
ConnectDum~H	0.4670	0.4989	0	1
HFDummy_H	0.2052	0.4038	0	1
cbd_Home	7.9923	4.4236	0.0528	23.4440
PctBlack	0.0785	0.1210	0	0.7870
PctAsian	0.0526	0.0735	0	0.7412
PctLatino	0.0454	0.0666	0	0.5928
PctSingPar	0.1770	0.1284	0	1
PctCollDeg	0.3375	0.1839	0	0.9297
PctOwnOc	0.6796	0.2754	0	1
PctNoCar	0.1020	0.1163	0	0.8767
MedInc1K	51.9959	20.8231	0	200.0010
UnitsAcre	3.9611	3.6971	0	31.7658
OD_Miles	9.0847	5.7715	0	44.1003

5.3 Regression Models

Table 5.2 shows the results of the regression models. The adjusted R-squared values show high goodness of fit for all three models, particularly with low-income commuters as the dependent variable. This model has an adjusted R-squared of 0.338; in other words, it explains 33.8% of the observed variability in commute flow changes. Especially considering that the dependent variable considers all commutes, regardless of mode choice, while the independent variables only

Table 5.2: Regression Results, Commute Flows

	Low-Wage	High-Wage	All
N=395920			
Adj. R2	0.338	0.114	0.171
F	7491.55	1895.07	3020.81
earn_2002_sum	-0.5814***	-0.2653***	-0.2802***
All_stops_Work	-0.8207***	-0.6226***	-1.4773***
DowntownDu~W	0.5241***	1.5058***	1.8914***
NorthDummy_W	-0.0891***	-0.3336***	-0.3640***
SouthDummy_W	-0.0794***	-0.6951***	-0.5287***
SuburbDumm~W	0.1354***	-0.2684***	-0.5036***
ConnectDum~W	0.0839***	0.0240***	0.0874***
HFDummy_W	0.0718***	-0.0280***	0.0637***
cbd_Work	0.0180***	0.0020***	0.0152***
All_stops_Home	-0.7940***	-0.8985***	-1.7809***
DowntownDu~H	0.0265	0.3019***	0.2713***
NorthDummy_H	0.1156***	-0.0459**	0.1283***
SouthDummy_H	-0.0380**	-0.0025	-0.0614*
SuburbDumm~H	-0.0707	-0.0873	-0.1823
ConnectDum~H	0.0177***	0.006	0.0170*
HFDummy_H	-0.0076*	-0.0082	-0.0287***
cbd_Home	0.0136***	0.0068***	0.0174***
PctBlack	0.0906***	-0.0661***	-0.0026
PctAsian	-0.032	-0.2702***	-0.4554***
PctLatino	-0.0915***	-0.1424***	-0.2852***
PctSingPar	-0.0778***	0.0383	-0.1061***
PctCollDeg	-0.0509***	0.1073***	0.0813***
PctOwnOc	-0.1139***	-0.0476***	-0.1883***
PctNoCar	0.0062	-0.0750**	-0.0561
MedInc1K	0.0002*	0.0008***	0.0007**
UnitsAcre	0.0048***	0.0031***	0.0066***
OD_Miles	-0.0188***	-0.0077***	-0.0215***
Constant	0.2190***	0.2325***	0.5200***

Legend: * p<.1; ** p<.05; *** p<.01

consider transit service characteristics and (at least somewhat) transit-related demographics, this is impressive model performance. These good model fits suggest that transit service is important in determining commuting patterns within the transit service area. In addition, the better still model fit with low-income commuters considered in the dependent variable speaks to the special importance transit has in determining low-income commuting patterns.

As expected, both All_stops_Work and All_stops_Home produce negative coefficients in all three models. For low-income commuters, transit stop distance produces a slightly stronger negative coefficient for the work end of the trip than for the home end. The other two models show the opposite pattern, with the home ends of commutes actually demonstrating more strongly negative coefficients than the work ends.

In interpreting the locational dummy variables, positive coefficients indicate increases in commute origins or destinations associated with location within the areas described by the dummies, and negative coefficients indicate decreases, both holding all else equal. As regression coefficients on these variables are estimated by referencing areas served by regular bus routes as the base category, these coefficients indicate the pulling effect of the LRT stations and the bus stops with direct LRT connections as opposed to the pulling effect of the regular bus stops. All of the work dummy variables achieve a high level of statistical significance, with *p* values of less than 0.01 in all cases. For low-wage commuters, the downtown and suburban work dummies both produce strongly positive coefficients. The connection and high-frequency dummies also produce positive coefficients, but these are much weaker. High-wage and all commuters produce even stronger coefficients for the downtown work dummy, but produce negative coefficients for the suburban dummy. The connection dummy still produces (weaker) positive coefficients for the latter two models. The high frequency dummy produces a negative coefficient when only high-income commuters are considered.

The home dummy variables produce a very different pattern, and show much greater differences between the three models. When low-income commuters are considered, the north neighborhood, south neighborhood, connection and high-frequency home dummies achieve statistical significance. The north neighborhood and connection home dummies both produce positive coefficients, while the other two significant dummies produce negative coefficients. The positive coefficient for the north neighborhood home dummy is by far the strongest—either positive or negative—coefficient produced by any of the significant home dummy variables.

For high-income commuters, only the downtown and north neighborhood home dummies produce statistically significant results, with the former producing a strong positive coefficient, and the latter a weaker negative coefficient. With all commuters considered, all but the suburb home dummy are statistically significant. The downtown and northern neighborhood dummies produce strongly positive coefficients, while the connection home dummy produces a relatively weak positive coefficients. The southern neighborhood and high-frequency home dummies produce weak to moderate negative coefficients.

The CBD distance variables both return positive coefficients in all three models. This pattern runs counter to expectations, given increasing densities of jobs, residences and transit service as one moves closer to downtown Minneapolis.

The demographic variables behave largely as expected with the notable exception of PctNoCar. This variable only achieves statistical significance for high-income commuters. As one would expect in this case, its coefficient is negative, but its lack of significant results for either low-income or all commuters is surprising, as it suggests that transit-dependency rates of block-group populations have little influence on commuting patterns for either low-income or all workers.

5.4 Model Predictions

Table 5.3 shows the predicted marginal changes in numbers of low-income commuters relative to the changes predicted for an origin-destination pair of block groups with only regular transit service—non-high frequency bus routes with no light rail connection. Predicted values are reported in this manner so as to allow specific, local trends to be seen without the interference of general, metropolitan trends. Between the starting and ending points of the study, shifts in commute flows took place throughout the study area; many of these changes took place in locations not directly effected by light rail. To take these baseline regional changes into account, the predicted change in number of commuters for block-group pairs served only by regular transit is subtracted from the change in number of commuters predicted for each area pair in Table 5.3. In effect, the general trend in commute flows for the study area is set equal to zero; Table 5.3 shows how commute flows between specific areas deviate from that general trend. In fact, many positive marginal changes actually correspond to negative absolute changes, and simply represent a counter-trend of slow decline to a general trend of rapid decline. (For reference purposes, detailed predicted absolute changes are shown at the end of this section.)

The values in Table 5.3 are calculated as follows: The regression coefficients shown in Table 5.2 are used to produce a regression equation in the form: $y=ax_1+bx_2\ldots+c$, where y equals the dependent variable (here, change in low-wage commuters), a and b equal regression coefficients, x_1 and x_2 equal independent variables, and c equals the constant term. For each area pair (northern neighborhood to suburb, southern neighborhood to downtown, etc.) a predicted average change in commuters per block-group pair is computed with this equation by setting the appropriate home and work dummy variables equal to one, setting the remaining location dummy variables equal to zero and holding all other variables at their mean values. This average is multiplied by the total number of block-group pairs in each area pair to yield the absolute predicted change. Next, the predicted average change in commuters per regular transit-to-regular transit block group pair is multiplied by the total number of block group pairs in each area pair to yield predicted changes for areas the same size without light rail. These hypothetical, no light rail predictions are then subtracted from their corresponding area pairs to yield the commute flow changes between the specific areas shown in Table 5.3 separate from the overall trend for the study area.

Table 5.3: Predicted Low-Income Commute Flow Marginal Changes
Relative to O-D Pair with Only Regular Transit

		Work						
		Downtown	**N Nbhd**	**S Nbhd**	**Suburb**	**Connect**	**Hi Freq**	**Reg Trans**
	Downtown	19	-2	0	3	83	42	9
	N. Nbhd.	56	4	2	12	519	267	118
	S. Nbhd.	36	-13	-10	4	107	40	-38
Home	**Suburb**	3	-1	-1	1	3	0	-7
	Connection	2,143	-288	-125	328	12,075	5,471	1,088
	Hi Freq.	878	-177	-75	120	4,006	1,897	-199
	Reg. Transit	2,170	-244	-116	323	9,141	3,865	0

Commutes originating in the downtown station areas show relatively minor changes, regardless of destination areas. This pattern is consistent with the relatively small number of low-wage workers who live near the downtown light rail stations. In particular, light rail seems to have relatively little significance for low-income commuters living in downtown Minneapolis, as predicted marginal changes for the other three station area dummy variables range from -2 to 3. The marginal change predicted for LRT-connecting bus stop areas is larger, but still relatively small given the area covered by connecting bus routes. In addition, since many routes which connect with light rail make their connections in downtown Minneapolis, many of these downtown-to-connection trips (even those made by transit) are likely made only on the bus routes themselves.

Commutes originating in the northern neighborhood station areas show a very different pattern. While the 56 additional northern-neighborhood-to-downtown commutes predicted by the model are few in absolute terms, they may actually indicate a significant trend. Many of the commutes they include are likely, in fact, made by light rail, given the high proximity to stations at both ends inherent in the definitions of the dummy variables, and given the high costs of automobile parking in downtown Minneapolis. In addition, the highly restrictive station area definition used in the model (set at a quarter-mile buffer for consistency with the accessibility analysis discussed in Chapter 4) means that most of the origin station area is generally taken up by transportation rights-of-way, the light rail maintenance facility and non-residential land uses. As a result, the marginal changes listed here must be taken in the context of a very limited pool of commuters. In the case of the northern neighborhoods in particular, the baseline walking distance assumption is likely to lead to significantly understated results. As well as all of this, the predicted marginal increase of 519 commutes destined for connecting bus stop areas is more likely influenced by light rail than corresponding (smaller) increase predicted for commutes originating in the downtown station areas. Though Franklin Avenue and Lake Street—Midtown both offer several bus connections, these connections are not nearly as numerous as the bus connections on offer in downtown Minneapolis, and are greatly outnumbered by bus connections from other station zones. In addition, most residential units within a quarter-mile of these three stations are contained within the Riverside Towers apartment complex, adjacent to the Cedar—Riverside station, and the three northern neighborhood stations are well outside walking distance of each other (based on our assumption, at least), so even many trips from northern neighborhood station areas to connecting bus stop areas on routes which connect with light rail at one of the northern neighborhood stations may actually use light rail for part of their distances.

The extremely large values for commutes originating near bus stops offering a light rail connection are impossible to ignore. In spite of weaker coefficients, the much larger area this home dummy variable covers clearly allows it to produce large marginal changes in aggregate. It must, of course, be noted that, as with the downtown zone, many transit commutes originating near connecting bus stops with destinations in light rail station areas are likely made just on the bus routes themselves. There is also no guarantee that connection-to-connection transit commutes involve light rail either, as they may represent commutes on a single connecting bus route or on multiple connecting routes, because many connecting routes connect with each other as well as with the Hiawatha line.

Table 5.4: Total and Average Impact on Low-Wage Commute Flows

Area Categories	**WORKER Move-In's**		**JOB Move-In's**	
	Total workers	Average (Per BG Pair)	Total jobs	Average (Per BG Pair)
Downtown Hiawatha	103	0.123	**2,258**	**0.543**
North Hiawatha	**593**	**0.202**	-300	-0.070
South Hiawatha	124	0.047	-134	-0.061
Suburban Hiawatha	4	0.019	**347**	**0.154**
Connected Areas (blue areas)	14,134	0.108	12,788	0.103

Changes in commutes with both home and work locations within either Hiawatha station areas or bus connection areas are the most likely to have been impacted by the implementation of light rail. Table 5.4 shows Hiawatha's predicted impacts on low-wage commute flows. Each area category for worker or job move-in's represents commutes from/to block-groups in that area to/from block-groups in any part of the Hiawatha impact area. As in Table 5.3, these numbers do not represent absolute predicted changes, but marginal changes with changes in regular transit-to-regular transit commutes set at zero.

The total values in Table 5.4 are calculated for each area category by summing the values in Table 5.3 which have home locations in that category and work locations anywhere in the Hiawatha impact area for worker move-in's, and vice-versa for job move-in's. These total impacts are then divided by the numbers of block-group pairs in their area categories to produce category-wide average impacts per block-group pair.

After the calculation, the numbers in the Total Workers column in Table 5.4 represent the estimated additional workers who live in each of the five impact area category and commute to the Hiawatha impact area (i.e., the collective area that includes both the LRT station areas and the direct bus-LRT connection areas) after the opening of the Hiawatha light rail line. It is important to note that these are not the actual observed changes, but the estimated changes based upon the regression models presented in Table 5.2. As regression coefficients on the locational variables in Table 5.2 are estimated using areas served only by regular buses as the base category, these coefficients indicate the pulling effect of the LRT stations and the bus stops with direct LRT connections as opposed to the pulling effect of the regular bus stops. Therefore, once again, Table 5.4 does not show absolute predicted changes in numbers of commuters. It actually shows the ***difference*** in predicted changes between ***the block-group pairs with origin or destination in each area category*** and ***the block-group pairs served only by regular transit***. As a result, the numbers presented in Table 5.4 are mostly *greater* than the predicted absolute change, as the predicted change for a block-group pair served only by regular transit is *negative* for all three income groups considered.

Considering low-wage commutes, the northern neighborhood station areas stand out again in terms of low-wage workers moving into and commuting to destinations within the Hiawatha impact area. In addition, the number of additional low-wage workers moving in per block-group pair is significantly higher for northern neighborhood stations than for other areas.

Downtown station areas show a very large gain in low-wage jobs held by workers commuting from origins within the Hiawatha impact area, both in terms of absolute numbers and average per block-group pair. As mentioned before, the number of bus routes offering Hiawatha connections which converge on downtown Minneapolis likely clouds the picture somewhat. However, this is much less likely to cause problems for suburban station areas, which also show significant—though less than predicted for downtown—gains in both numbers of low-wage workers commuting from the impact area and average numbers per block-group pair.

Table 5.5: Predicted High-Income Commute Flow Marginal Changes
Relative to O-D Pair with Only Regular Transit

		Work						
		Downtown	**N Nbhd**	**S Nbhd**	**Suburb**	**Connect**	**Hi Freq**	**Reg Trans**
Home	**Downtown**	237	123	36	80	3,990	2,258	1,834
	N Nbhd	564	613	278	218	12,839	6,947	5,009
	S Nbhd	484	480	362	197	11,589	5,862	4,895
	Suburb	45	23	33	37	968	440	501
	Connection	25,565	18,614	8,603	10,050	592,165	301,495	305,106
	Hi Freq	10,965	8,446	3,641	4,390	260,848	145,358	129,277
	Reg Transit	26,736	12,637	6,220	11,162	542,018	265,097	0

Table 5.5 shows marginal commute flow changes for high-wage commutes; it is calculated in the same manner as Table 5.3, and shows the same information, but for high-wage commuters. In almost all cases, the predicted changes are much larger than those for low-income commuters. This may be some cause for concern about disproportionate benefits going to high-income workers. However, most of the largest values are the results of extremely negative predicted

values for commute pairs served only by regular transit. In fact, absolute gains (where present) are much closer to those found for low-income commuters.

Table 5.6: Total and Average Impact, High-Wage Workers

Area Categories	WORKER Move-In's		JOB Move-In's	
	Total workers	Average (Per BG Pair)	Total jobs	Average (Per BG Pair)
Downtown Hiawatha	4,466	5.317	**26,895**	**6.465**
North Hiawatha	**14,512**	**4.938**	19,853	4.624
South Hiawatha	**13,111**	**5.054**	9,312	4.262
Suburban Hiawatha	1,105	4.891	10,582	4.690
Connected Areas (blue areas)	654,998	5.000	621,551	4.983

Table 5.6 shows marginal changes in high-wage workers and jobs with commutes to/workers from the impact area; it is calculated in the same manner as Table 5.4, and shows the same information, but for high-wage commuters.. Gains are large throughout. However, as mentioned above, a significant part of these predicted relative gains is due to large *losses* predicted in areas served only by regular transit. As a result, these figures represent the avoidance of a decline as well as any true gain. Even so, they do represent real differences in Hiawatha-impacted areas and non-impacted areas. Both neighborhood zones show large increases in numbers of high-wage worker-residents, while downtown station areas show a large relative increase in both the absolute number of high-wage jobs held by workers commuting from the Hiawatha impact area and in the average number per block-group pair.

Table 5.7: Predicted All-Income Commute Flow Marginal Changes
Relative to O-D Pair with Only Regular Transit

		Work						
		Downtown	**N Nbhd**	**S Nbhd**	**Suburb**	**Connect**	**Hi Freq**	**Reg Trans**
Home	**Downtown**	76	-2	-2	-4	271	145	95
	N Nbhd	178	-32	-26	-18	562	273	131
	S Nbhd	137	-44	-50	-24	60	3	-61
	Suburb	12	-3	-6	-5	-19	-11	-19
	Connection	7,548	-1,397	-1,033	-1,043	12,399	4,933	1,044
	Hi Freq	3,167	-720	-478	-500	3,078	1,033	-751
	Reg Transit	7,830	-996	-772	-1,200	9,514	3,429	0

Table 5.7 shows marginal commute flow changes for all commuters; it is calculated in the same manner as Table 5.3, and shows the some information for all commuters. In spite of the larger numbers of workers involved, the marginal changes for all commuters are much smaller than those observed for high-income commuters, and many are in the same range as observed for low-income commuters. Again, many of the positive marginal changes found represent negative absolute changes which are not as strongly negative as the regular transit area changes to which they are compared.

Table 5.8 shows marginal changes in all workers and jobs with commutes to/workers from the impact area; it is calculated in the same manner as Table 5.4, and shows the same information for all commuters. The downtown and northern neighborhood station areas stand out from the rest in terms of numbers of workers moving in relative to areas served only by regular transit, as well as in terms of average numbers of new commuters per block-group pair. Though the average block-group pair served by only regular transit did not see nearly as large a decline in all commuters as it did for high-wage commuters, that decline was larger for all commuters than for low-wage commuters. The downtown station areas show a large increase in both number of workers commuting from the impact area and in the average number of workers per block-group pair.

This recurring pattern is consistent with both the overall metropolitan trend towards decentralization, and with the oft-cited emerging counter trend of "back to the city." While this latter is often viewed as a middle class phenomenon, low-wage commuters appear to participate in it as well. Indeed, it is impossible to ignore the fact that the only home dummy variable which consistently produces positive absolute changes in addition to marginal changes is the northern neighborhood dummy, the variable also showing some of the strongest gains for low-wage commuters.

Table 5.8: Total and Average Impact, All Workers

Area Categories	**WORKER Move-In's**		**JOB Move-In's**	
	Total workers	Average (Per BG Pair)	Total jobs	Average (Per BG Pair)
Downtown Hiawatha	**339**	**0.403**	**7,950**	**1.911**
North Hiawatha	**664**	**0.226**	-1,478	-0.344
South Hiawatha	79	0.031	-1,117	-0.511
Suburban Hiawatha	-21	-0.092	-1,093	-0.485
Connected Areas (blue areas)	16,475	0.126	13,274	0.106

Table 5.9: Detailed Predicted Changes, Low-Income Commutes

Home Location	Workplace	Change/ pair	Pairs	Commute	Reg Tran	Diff
Downtown Stations	Downtown Stations	0.2073	35	7	-12	19
	North Neighborhood Stations	-0.4060	25	-10	-9	-2
	South Neighborhood Stations	-0.3962	8	-3	-3	0
	Suburban Stations	-0.1814	16	-3	-5	3
	Connection Areas	-0.2329	756	-176	-260	83
	HF Bus Stop Areas	-0.2450	432	-106	-148	42
	Non-HF, Non-Connection Areas	-0.3168	349	-111	-120	9
North Neighborhood Stations	Downtown Stations	0.2963	88	26	-30	56
	North Neighborhood Stations	-0.3169	134	-42	-46	4
	South Neighborhood Stations	-0.3071	66	-20	-23	2
	Suburban Stations	-0.0923	47	-4	-16	12
	Connection Areas	-0.1438	2604	-374	-894	519
	HF Bus Stop Areas	-0.1559	1424	-222	-489	267
	Non-HF, Non-Connection Areas	-0.2277	1021	-233	-350	118
South Neighborhood Stations	Downtown Stations	0.1427	75	11	-26	36
	North Neighborhood Stations	-0.4705	104	-49	-36	-13
	South Neighborhood Stations	-0.4607	85	-39	-29	-10
	Suburban Stations	-0.2459	42	-10	-14	4
	Connection Areas	-0.2974	2330	-693	-800	107
	HF Bus Stop Areas	-0.3096	1191	-369	-409	40
	Non-HF, Non-Connection Areas	-0.3813	989	-377	-340	-38
Suburban Stations	Downtown Stations	0.1101	7	1	-2	3
	North Neighborhood Stations	-0.5031	5	-3	-2	-1
	South Neighborhood Stations	-0.4934	8	-4	-3	-1
	Suburban Stations	-0.2786	8	-2	-3	1
	Connection Areas	-0.3301	198	-65	-68	3
	HF Bus Stop Areas	-0.3422	91	-31	-31	0
	Non-HF, Non-Connection Areas	-0.4140	103	-43	-35	-7
Connection Areas	Downtown Stations	0.1985	3955	785	-1,358	2,143
	North Neighborhood Stations	-0.4148	4025	-1,669	-1,382	-288
	South Neighborhood Stations	-0.4050	2018	-817	-693	-125
	Suburban Stations	-0.1902	2143	-408	-736	328
	Connection Areas	-0.2417	118855	-28,726	-40,802	12,075
	HF Bus Stop Areas	-0.2538	61152	-15,522	-20,993	5,471
	Non-HF, Non-Connection Areas	-0.3256	61535	-20,037	-21,124	1,088
HF Bus Stop Areas	Downtown Stations	0.1732	1700	294	-584	878
	North Neighborhood Stations	-0.4400	1832	-806	-629	-177
	South Neighborhood Stations	-0.4303	857	-369	-294	-75
	Suburban Stations	-0.2155	939	-202	-322	120
	Connection Areas	-0.2670	52505	-14,018	-18,024	4,006
	HF Bus Stop Areas	-0.2791	29568	-8,253	-10,150	1,897
	Non-HF, Non-Connection Areas	-0.3509	26148	-9,176	-8,976	-199
Non-HF, Non-Conn Areas	Downtown Stations	0.1808	4140	748	-1,421	2,170
	North Neighborhood Stations	-0.4324	2736	-1,183	-939	-244
	South Neighborhood Stations	-0.4227	1461	-618	-502	-116
	Suburban Stations	-0.2079	2383	-495	-818	323
	Connection Areas	-0.2594	108921	-28,250	-37,392	9,141
	HF Bus Stop Areas	-0.2715	53835	-14,616	-18,481	3,865
	Non-HF, Non-Connection Areas	-0.3433	87381	-29,997	-29,997	0

Table 5.10: Detailed Predicted Changes, High-Income Commutes

Home Location	Workplace	Change/ pair	Pairs	Commuters	Reg Trans	Diff
Downtown Stations	Downtown Stations	1.6262	35	57	-180	237
	North Neighborhood Stations	-0.2132	25	-5	-128	123
	South Neighborhood Stations	-0.5748	8	-5	-41	36
	Suburban Stations	-0.1480	16	-2	-82	80
	Connection Areas	0.1444	756	109	-3,881	3,990
	HF Bus Stop Areas	0.0924	432	40	-2,218	2,258
	Non-HF, Non-Conn Areas	0.1204	349	42	-1,792	1,834
North Neighborhood Stations	Downtown Stations	1.2784	88	112	-452	564
	North Neighborhood Stations	-0.5610	134	-75	-688	613
	South Neighborhood Stations	-0.9226	66	-61	-339	278
	Suburban Stations	-0.4958	47	-23	-241	218
	Connection Areas	-0.2034	2604	-530	-13,368	12,839
	HF Bus Stop Areas	-0.2554	1424	-364	-7,310	6,947
	Non-HF, Non-Conn Areas	-0.2274	1021	-232	-5,242	5,009
South Neighborhood Stations	Downtown Stations	1.3218	75	99	-385	484
	North Neighborhood Stations	-0.5177	104	-54	-534	480
	South Neighborhood Stations	-0.8792	85	-75	-436	362
	Suburban Stations	-0.4524	42	-19	-216	197
	Connection Areas	-0.1600	2330	-373	-11,962	11,589
	HF Bus Stop Areas	-0.2120	1191	-253	-6,114	5,862
	Non-HF, Non-Conn Areas	-0.1840	989	-182	-5,077	4,895
Suburban Stations	Downtown Stations	1.2370	7	9	-36	45
	North Neighborhood Stations	-0.6024	5	-3	-26	23
	South Neighborhood Stations	-0.9640	8	-8	-41	33
	Suburban Stations	-0.5372	8	-4	-41	37
	Connection Areas	-0.2448	198	-48	-1,016	968
	HF Bus Stop Areas	-0.2968	91	-27	-467	440
	Non-HF, Non-Conn Areas	-0.2688	103	-28	-529	501
Connection Areas	Downtown Stations	1.3303	3955	5,261	-20,304	25,565
	North Neighborhood Stations	-0.5091	4025	-2,049	-20,663	18,614
	South Neighborhood Stations	-0.8707	2018	-1,757	-10,360	8,603
	Suburban Stations	-0.4439	2143	-951	-11,002	10,050
	Connection Areas	-0.1515	118855	-18,009	-610,174	592,165
	HF Bus Stop Areas	-0.2035	61152	-12,446	-313,940	301,495
	Non-HF, Non-Conn Areas	-0.1755	61535	-10,801	-315,907	305,106
HF Bus Stop Areas	Downtown Stations	1.3161	1700	2,237	-8,727	10,965
	North Neighborhood Stations	-0.5233	1832	-959	-9,405	8,446
	South Neighborhood Stations	-0.8848	857	-758	-4,400	3,641
	Suburban Stations	-0.4581	939	-430	-4,821	4,390
	Connection Areas	-0.1657	52505	-8,700	-269,549	260,848
	HF Bus Stop Areas	-0.2177	29568	-6,437	-151,795	145,358
	Non-HF, Non-Conn Areas	-0.1897	26148	-4,960	-134,238	129,277
Non-HF, Non-Conn Areas	Downtown Stations	1.3243	4140	5,483	-21,254	26,736
	North Neighborhood Stations	-0.5151	2736	-1,409	-14,046	12,637
	South Neighborhood Stations	-0.8766	1461	-1,281	-7,500	6,220
	Suburban Stations	-0.4499	2383	-1,072	-12,234	11,162
	Connection Areas	-0.1575	108921	-17,157	-559,176	542,018
	HF Bus Stop Areas	-0.2095	53835	-11,279	-276,377	265,097
	Non-HF, Non-Conn Areas	-5.1338	87381	-448,594	-448,594	0

Table 5.11: Detailed Predicted Changes, All Commuters

Home Location	Workplace	Change/ pair	Pairs	Commuters	Reg Trans	Diff
Downtown Stations	Downtown Stations	1.5186	35	53	-23	76
	North Neighborhood Stations	-0.7368	25	-18	-16	-2
	South Neighborhood Stations	-0.9014	8	-7	-5	-2
	Suburban Stations	-0.8763	16	-14	-10	-4
	Connection Areas	-0.2854	756	-216	-487	271
	HF Bus Stop Areas	-0.3091	432	-134	-278	145
	Non-HF, Non-Conn Areas	-0.3728	349	-130	-225	95
North Neighborhood Stations	Downtown Stations	1.3757	88	121	-57	178
	North Neighborhood Stations	-0.8798	134	-118	-86	-32
	South Neighborhood Stations	-1.0444	66	-69	-43	-26
	Suburban Stations	-1.0193	47	-48	-30	-18
	Connection Areas	-0.4284	2604	-1,115	-1,677	562
	HF Bus Stop Areas	-0.4520	1424	-644	-917	273
	Non-HF, Non-Conn Areas	-0.5157	1021	-527	-658	131
South Neighborhood Stations	Downtown Stations	1.1859	75	89	-48	137
	North Neighborhood Stations	-1.0695	104	-111	-67	-44
	South Neighborhood Stations	-1.2342	85	-105	-55	-50
	Suburban Stations	-1.2091	42	-51	-27	-24
	Connection Areas	-0.6182	2330	-1,440	-1,501	60
	HF Bus Stop Areas	-0.6418	1191	-764	-767	3
	Non-HF, Non-Conn Areas	-0.7055	989	-698	-637	-61
Suburban Stations	Downtown Stations	1.0650	7	7	-5	12
	North Neighborhood Stations	-1.1904	5	-6	-3	-3
	South Neighborhood Stations	-1.3550	8	-11	-5	-6
	Suburban Stations	-1.3300	8	-11	-5	-5
	Connection Areas	-0.7390	198	-146	-128	-19
	HF Bus Stop Areas	-0.7627	91	-69	-59	-11
	Non-HF, Non-Conn Areas	-0.8264	103	-85	-66	-19
Connection Areas	Downtown Stations	1.2643	3955	5,000	-2,547	7,548
	North Neighborhood Stations	-0.9911	4025	-3,989	-2,592	-1,397
	South Neighborhood Stations	-1.1558	2018	-2,332	-1,300	-1,033
	Suburban Stations	-1.1307	2143	-2,423	-1,380	-1,043
	Connection Areas	-0.5397	118855	-64,151	-76,551	12,399
	HF Bus Stop Areas	-0.5634	61152	-34,453	-39,386	4,933
	Non-HF, Non-Conn Areas	-0.6271	61535	-38,588	-39,633	1,044
HF Bus Stop Areas	Downtown Stations	1.2186	1700	2,072	-1,095	3,167
	North Neighborhood Stations	-1.0368	1832	-1,899	-1,180	-720
	South Neighborhood Stations	-1.2015	857	-1,030	-552	-478
	Suburban Stations	-1.1764	939	-1,105	-605	-500
	Connection Areas	-0.5855	52505	-30,739	-33,817	3,078
	HF Bus Stop Areas	-0.6091	29568	-18,010	-19,044	1,033
	Non-HF, Non-Conn Areas	-0.6728	26148	-17,593	-16,841	-751
Non-HF, Non-Conn Areas	Downtown Stations	1.2473	4140	5,164	-2,666	7,830
	North Neighborhood Stations	-1.0081	2736	-2,758	-1,762	-996
	South Neighborhood Stations	-1.1727	1461	-1,713	-941	-772
	Suburban Stations	-1.1476	2383	-2,735	-1,535	-1,200
	Connection Areas	-0.5567	108921	-60,638	-70,153	9,514
	HF Bus Stop Areas	-0.5804	53835	-31,245	-34,673	3,429
	Non-HF, Non-Conn Areas	-0.6441	87381	-56,279	-56,279	0

5.5 Summary of Findings

Descriptive statistics produced for the analysis of home-to-work commute flows show declines in the average numbers of low-income and all commuters, and an increase in the average number of high-income commuters in the transit served area of the metropolitan region. Only small percentages of commuters either live or work within a quarter mile of a light rail station, however, large percentages of commuters live and work within a quarter mile of a bus stop offering a direct connection to light rail—47% and 59%, respectively.

Ordinary least squares regression models find statistically significant increases in the popularity of commutes to areas within a quarter mile of downtown light rail stations and within a quarter mile of bus stops offering a light rail connection for all income groups, though the coefficients of the former are much stronger. In addition, commutes to areas within one quarter mile of suburban light rail stations produce a positive relationship with commute popularity for low-income commuters. Strong, positive relationships exist between commute origins and commute popularity in the northern neighborhood station areas for low-income and all commuters and in the downtown station areas for high-income and all commuters. Location in the areas of connecting bus stops produces weaker positive relationships for all income levels.

The estimated regression equations predict particularly significant increases in commute popularity (over and above changes predicted for areas served by only regular bus service) for low-income commutes from northern neighborhood station areas to downtown station areas, suburban station areas and connecting bus stop areas, and from connecting bus stop areas to downtown station areas, suburban station areas and connecting bus stop areas. The high-wage commute equation predicts that commute popularities increase more (or decrease less) in premium-transit to premium transit area pairs than between areas served only by regular bus service. The all commuters equation predicts many pairs lose commuters relative to regular transit served areas, however, the strong northern neighborhood to downtown and connection, and connection to downtown and connection commuter gains observed for low-income commuters persist. Though many observed marginal gains for low-wage commutes actually correspond to absolute predicted losses, they represent a strong counter-trend to the observed metro-wide trend of rapid decline. These particular relative changes equate to significantly more existing low-wage workers and jobs staying in Hiawatha-influenced areas than in areas served only by regular transit, more new low-wage workers and jobs moving into Hiawatha influenced areas than into areas served only by regular transit (even as existing workers and jobs move out), or some combination of the two. In either case, they represent a stark contrast to the baseline metropolitan trend.

Chapter 6: Generalization of the Approach to Other Transitways

Considering the interesting and important results found by this study, it may be highly beneficial to perform a similar analysis on future transitways. In addition, it should be possible to adapt some of the research methods from this study to plan future transitways and connecting bus services so as to maximize the social equity benefits of those transitways. The following chapter contains a concise summary of our research process, a list of the data required, a restatement of methodological limitations and some suggestions for improvement.

Our basic approach has two main parts: an analysis of changes in job accessibility by transit across income groups, and an analysis of changes in home-to-work commute flows across income groups. The former represents the maximum changes possible, while the latter indicates what real changes had occurred at the time of data collection. Each of these is divided into two subparts: a qualitative analysis of GIS-produced maps to allow for intuitive recognition of both regional and local trends, and quantitative, statistical analysis to test the significance and magnitude of these trends.

The accessibility part of the study employed a cumulative opportunity approach with a 30-minute cutoff time. Using LEHD employment data at the census block level, as well as map files describing the Twin Cities street network and transit network *including scheduled running time between timepoints,* we produced a table of the total number of jobs in low-, middle- and high-wage groups that could be reached from each block by transit before and after the introduction of light rail. These "before" and "after" accessibility tables formed the basis of the accessibility change maps use for the trend and pattern identification stage of the analysis. They also provided dependent variables for the subsequent regression analysis, and helped suggest definitions for types of transit stops and light rail station groups to be included in the models. (For both these and the origin-destination regression models, the study area is the transit-served area of the Twin Cities metro, defined as all units of analysis with a quarter mile of at least one transit stop.) The regression models estimated equations for accessibility as a function of distance from the nearest transit stop, location within a quarter mile buffer of each of the light rail station areas, location within a quarter mile buffer of a bus stop offering a direct connection with light rail, location within a quarter mile buffer of a bus stop served by a high frequency bus stop, as well as of several demographic control variables. Specifically, the following data would be required to repeat the analysis for another transitway:

- US Census LEHD data from before and after light rail
- Street network data from before and after light rail
- Transit route and service data, including frequency and scheduled running time from before and after light rail
- GIS shapefiles of census blocks
- GIS shapefiles of transit stops including types of service provided
- Census data describing the median household income and percentages of African Americans, Latinos, Asians, single-parent families, people over 25 with college degrees, owner occupied housing units and households without a motor vehicle in each block.

The home-to-work commute flow analysis compares the popularity of individual, block-group-to-block-group commutes with the locations of the origin and destination ends of commutes relative to light rail station zones and other types of transit stops. The analysis begins with the 2002 and 2006 Longitudinal Employment and Housing Dynamics (LEHD) origin-destination matrices. These datasets break commute flows down to the level of an origin census block and a destination census block, and list the numbers of high-, middle- and low-wage workers making each individual commute. We next produce maps showing concentrations of low-wage workers' places of residence and employment, which are used to confirm the presence of spatial mismatch in the Twin Cities and validity of our station group definitions. The block level data are aggregated to the block group level at both origin and destination end. (In defining both the study area and the light rail station and bus stop areas, we include any block group with at least one block within a quarter mile of a transit stop. Analyzing commute flows at the block group level allows some compensation for a restrictive walking distance assumption and for significant areas of transportation infrastructure, depressed industrial land uses and vacant land along the Hiawatha corridor.) Next we calculate the change in numbers of commuters between years for each commute. This change provides the dependent variable for the regression analysis, which estimates a model for change in commute popularity as a function of distance to a transit stop, location within a specific light rail station area group or bus stop area type and distance to downtown Minneapolis for origin and destination, as well as of commute distance and demographic controls. The resulting regression coefficients allow us to calculate marginal changes in numbers of low- and high-income commuters commuting to and/or from light rail station areas and specific types of bus stop areas as compared with the baseline change in commuters traveling between bus stop areas served only by regular bus routes. The follow data are required:

- LEHD commute matrices from before and after light rail
- GIS shapefiles of census blocks
- GIS shapefiles of transit stops including types of service provided
- A GIS shapefile with a point at Nicollet Mall & 7th St S (to locate CBD)
- Census data describing the percentages of African Americans, Latinos, Asians, single-parent families, people over 25 with college degrees, owner occupied housing units and households without a motor vehicle in each block.

This approach offers a good picture of accessibility and commute flow changes around the Hiawatha line, but it has some inherent limitations. First, the accessibility calculations assume a maximum walking distance of a quarter mile and no more than one connection. Both anecdotal and empirical evidence suggest the former is too conservative for Hiawatha, with the consequence that accessibility benefits to light rail station areas are likely understated. The quarter mile distance carries over into our definition of the study area, and of station and stop areas for the sake of consistency. This may further understate light rail benefits, as well as bus service benefits. In addition, while an assumption of no more than one transfer is fairly standard practice, and likely reasonable enough when considering choice riders, there is evidence both from Metro Transit's rider survey and other metro areas that low-wage workers are more likely than usual to make multiple transfers. In any case, Hiawatha's high line-haul speeds likely often make a bus-rail-bus trip come out faster than even a one-seat ride on a local bus route, again leading to an understatement of light rail benefits. Finally, though park-and-ride transit access was deliberately excluded from the study as less likely to serve low-wage workers and unavailable to the transit dependent, bike-and-ride transit access—a mode available to many low-wage and/or transit dependent workers—was excluded as well, due to the additional complexity it would have added. Though bike-and-riders currently make up a small portion or transit ridership, their numbers are on the rise, and both central cities, as well as the Metropolitan Council, have an increased bicycle mode share as a planning goal. Due to much higher access travel speeds and increased distance tolerances of cyclists, including bike-and-ride would significantly expand station areas (as well as the study area itself) and increase accessibility scores.

In the home-to-work commuting analysis, the station area definitions (based on a quarter mile distance) may also lead to an undercounting of actual commutes starting and ending in areas influenced by light rail as well. Finally, the LEHD O-D matrix does not include the mode-split of the commutes it counts. As a result, it is impossible to tell how many of the commutes which begin and end near light rail are actually made by light rail.

While some of these limitations would be difficult to overcome in any future use of this analysis approach, some could be easily alleviated. The accessibility calculations could be greatly improved by simply using a longer walking distance assumption; larger station area buffers would be more likely to capture all of the commute flow shifts influenced by the addition of a transitway as well. The Met Council uses a half mile buffer for much of its station area planning, and much of the literature suggests that half a mile is a reasonable—and possibly still even conservative—walking distance assumption when rail transit is concerned. In addition, as Hiawatha represents the beginning of a shift from a non-hierarchical transit network focused on direct bus services to a more hierarchical network with more dichotomy between line-haul and feeder-distributor services, allowing for at least two transfers seems reasonable in future. In addition, given the importance of connecting services in the results, it might be useful to separate bus connections by which station group(s) they connect to.

Our approach should be easily adaptable to other transitways. A similar process as the one described above could be used to define groups of stations along Central Corridor or any other transitway. Once Central Corridor is added, some consideration should be given to distance from downtown Saint Paul as well as Minneapolis. The network effects of having a system of transitways could be addressed by a variable for how many lines a station is served by, or how many lines a bus route connects with. As the transitway network expands, some consideration might be given to a longer accessibility cutoff if more transfers are allowed in the calculations. Other than minor tweaks such as these, the regional scope of this analysis should make it adapt well to new lines, especially with the improvements suggested above in place.

Chapter 7: Conclusions and Discussion

On balance, the Hiawatha light rail line has been greatly beneficial to the transit dependent and low-wage workers. In spite of these undeniable benefits, equity concerns about who benefits from LRT, and to what degree, remain. Careful consideration of both what the Hiawatha line does well for low-wage workers and what it could possibly do better should inform both the planning of future transitways and ongoing planning for areas and connecting transit services surrounding Hiawatha stations. The following chapter summarizes key findings of this study, and discusses their policy implications.

Spatial mismatch exists in the Twin Cities.

As can be seen in Figures 4.5-4.8, major concentrations of low-wage workers and low-wage jobs often do not match up. In addition, both are scattered throughout many different areas of the metropolitan area. Both of these observations—combined with both relatively high rates of transit dependency among low-wage workers and the large cost of living savings which can be realized by low-wage workers by depending on transit—underscore the importance of transit service as a provider of economic opportunity for low-wage workers.

The Hiawatha light rail line has significantly improved accessibility to low-wage jobs.

Both the map analysis and regression analysis conducted in this study show significant, positive changes in low-wage transit employment accessibility after the introduction of light rail transit. These accessibility gains are both spatial and temporal: they improve accessibility for both previously underserved areas of the metropolis and previously underserved times of day. The frequent, all-day service which is a standard feature of transitways holds special significance for low-wage workers and transit dependent, as they are much more likely than others to use the transit system at off-peak times and for non-commute trips. In planning future transit development in the Twin Cities region, it will be important to keep in mind that transitways can be a powerful tool not only for improving the lives of middle-class commuters choked by traffic, but also for improving the lives of the poor.

Hiawatha's impacts extend well beyond station areas.

Two of the most interesting findings of the study are the large areas of accessibility gains found along bus routes which connect with light rail, and the apparent importance of access to bus connections in shaping commute flows. These findings show that the impact of light rail—even with only one line up and running—is regional in scope. They also drive home the enormous importance of a fully-integrated transit network in realizing the maximum benefits from the investments made in transitways. Especially considering the difficulties of obtaining increased funding for basic local bus service, the effective and efficient planning of feeder/distributor services will be critical to ensuring low-wage workers reap the greatest benefits possible from future transitways.

Significant numbers of low-wage workers and low-wage employers stayed near or relocated towards light rail following its introduction.

In addition to the gains in the possibilities offered by low-income transit accessibility, the study finds significant shifts towards light rail in the actual commute flows of low-wage workers, relative to changes observed in areas served only by regular transit. These shifts occur at both the home and work ends of commutes. Specifically, they show low-income residents locating into the areas surrounding Cedar—Riverside, Franklin Avenue and Lake Street—Midtown Stations, as well as into the areas surrounding LRT-connecting bus routes, and low-wage employers relocating into the areas surrounding the downtown Minneapolis and suburban Bloomington stations, as well as the areas surrounding connecting bus routes. In the case of the northern neighborhoods, where low-income residential relocation is particularly apparent, the picture is made somewhat more complex by the high starting point accessibility in the area. This fact suggests that some characteristics of light rail other than improved accessibility—or some other neighborhood characteristics entirely unconnected with light rail—are at work in driving relocation behavior. However, though accessibility was good in this area before light rail, it most certainly did get better after. In addition, absolute post-LRT accessibility is higher in the northern neighborhood station area group than in any other with the exception of the much less affordable downtown area. Regardless of relative gains, high absolute transit accessibility is likely a strong draw for low-wage workers and the transportation disadvantaged. Overall, these findings confirm that the accessibility gains observed earlier in the study have led to realized gains for actual low-wage workers. The overall trend of decline in numbers of both low-wage jobs and low-wage workers within the transit service area causes some concern. On the other hand, it also underscores the importance of light rail's apparent ability to act as a bulwark for preserving employment access in a metropolitan situation that (by some measures) seems to be getting more difficult for low-wage workers. The findings also show needs to provide adequate quantities of affordable housing along transitways and to address jobs-housing balance along transitways, but most likely more at the corridor level than at the station area or neighborhood level.

In sum, the Hiawatha line provides positive evidence of the role of transit in promoting social equity.

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Appendix A:

Full Literature Review on Planners’ War against Spatial Mismatch

NOTE: This literature review paper is written by Yingling Fan, the project PI. The paper was presented on January 13, 2010 in Washington, DC at the Transportation Research Board 89th Annual Meeting.

Abstract

At least twelve review papers exist summarizing the spatial mismatch literature. However, almost all the existing reviews focus on the question of why spatial mismatch exists rather than the question of why current and past policy responses have succeeded or failed. In this paper, empirical studies that examine the effectiveness of existing policy interventions for helping low-income inner-city residents secure jobs are reviewed and few policy responses are found to fare well. A further exploration of potential factors underlying current policy failures suggests that divided, and often conflicting, attentions are paid to inner-city job creation, poverty deconcentration and transportation improvements without acknowledging their interconnected roles. Planners and policymakers are recommended to develop integrated, cross-sector solutions to address spatial mismatch. Promising practices are discussed, including incorporating the housing + transportation affordability assessment tool in rental assistance programs, consolidating FTA, HUD and NGA's welfare-to-work activities, bundling enterprise zone programs with transit-oriented development strategies and affordable housing policies, etc. It is also suggested that the spatial mismatch effects depend on a host of non-spatial factors such as child care, education and social support. To effectively reduce spatial mismatch, planners are recommended to focus at least equally on traditional place-based solutions (e.g., poverty deconcentration, enterprise zones and reverse commute services) and non-spatial, social approaches (e.g., social marketing campaign, asset-based community development and workforce development).

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Introduction

Planners, policymakers and the public have long struggled to increase access to employment for the socio-economically disadvantaged, especially since John Kain formulated the spatial mismatch hypothesis in his 1968 Quarterly Journal of Economics paper (Kain, 1968). In its simplest form, the mismatch hypothesis states that racial discrimination in the suburban housing market, exacerbated by the decentralization of jobs to suburbs and limited transportation options, contributes to poor employment outcomes for African American urban residents. Kain's hypothesis reflects the interrelated facets between race, space and labor market processes in a novel way and has stimulated research and debate in a wide range of social science disciplines (Glaeser, Hanushek & Quigley, 2004). Over time, the spatial mismatch literature has evolved in relation to economic restructuring, immigration, continuing suburbanization, and the devolution of welfare policy in urban America. The field has seen a shift of the study population from African Americans to other specific population groups such as Latinos, low-income single mothers, welfare recipients and immigrants. There is also an increasing recognition that spatial mismatch is deeply embedded in social structures and labor market processes. Emerging concepts from the recent literature include "modal mismatch" – employment inaccessible to carless residents in cities with auto-oriented land use patterns (e.g., sunbelt cities developed after the age of automobile) (Blumenberg & Manville, 2004; Grengs; Ong & Miller, 2005), "skill mismatch" – employment functionally inaccessible to geographically proximate but poorly educated residents (Holzer, 1996; Houston, 2005a; Stoll, 2005a), and "social mismatch" – mainstream labor market disconnected with the socio-economically disadvantaged due to their sparse social networks (Chapple, 2001; Pastor & Adams, 1996).

Multiple reviews already exist summarizing the spatial mismatch literature: seven different reviews were published in the 1990s (Holzer, 1991; Ihlanfeldt & Sjoquist, 1998; Jencks & Mayer, 1990; Kain, 1992; Moss & Tilly, 1991; Preston & McLafferty, 1999; L. A. Wheeler, 1990) and five more were published in this decade (Blumenberg, 2004; Blumenberg & Manville, 2004; Chapple, 2006; Gobillon, Selod, & Zenou, 2007; Houston, 2005b). The majority of these reviews focus on discussing the intellectual impact of the spatial mismatch literature such as empirical findings, methodological challenges, and theoretical models. The rest of the reviews emphasize the derivation of policy implications regarding welfare reform (Ihlanfeldt and Sjoquist, Blumenberg and Manville), gender equity (Preston and McLafferty, Blumenberg), transportation (Blumenberg and Manville, Chapple), and urban planning (Chapple). While these two sets of reviews have substantially enhanced the contribution of spatial mismatch research to current theoretical and policy debates about urban poverty and social equity, hardly any of the reviews have systematically reviewed or evaluated the prevailing policy strategies for reducing spatial mismatch. In other words, studies included in these reviews are typically those that test the spatial mismatch hypothesis and those that explore causes of spatial mismatch, but not those that empirically examine whether current and past policy responses to spatial mismatch have succeeded or not. The only exception is Chapple (2006), that briefly reviews recent evaluations of poverty deconcentration and employment accessibility programs.

I argue that the question of *why existing policy responses to spatial mismatch have succeeded or failed* is as important as, if not more important than, the question of *why spatial mismatch exists*. Answers to the first question as well as answers to the second questions are both crucial to the effective design and implementation of policies that would increase economic opportunities for poor inner-city workers. This review seeks answers to the first question as it grows out of the concern that poverty and joblessness persist in some inner-city neighborhoods despite decades of planning efforts and policy experiments. Building on relevant empirical studies in urban planning, this review evaluates the effectiveness of various planning and policy efforts for reducing spatial mismatch. The review demonstrates that the prevailing planning and policy strategies have not achieved much success in improving employment outcomes for disadvantaged urban jobseekers. After discussing possible explanations for the failed efforts, new directions and alternative tactics are suggested for urban planners to create winning opportunities in the war against spatial mismatch.

Failures of planning in combating spatial mismatch

Spatial mismatch has inspired policies around three main strategies: helping African-Americans move to suburban locations, attracting adequate jobs to the city centre, and improving connections between inner-city, black workers and suburban jobs (Gobillon, et al., 2007). Concerning the three strategies, straightforward policies that come to mind from an urban planning perspective are, respectively, suburban housing policy, land use management or place-based economic development, and transportation policy (as illustrated in Table 1). In the following text, we review spatial mismatch-related arguments and confront relevant empirical evidence in the broader literature on land use, economic development, transportation, and housing.

Table A-1. Traditional urban planning solutions for addressing spatial mismatch

Problem Element	Countermeasure	Traditional Urban planning solutions
Job suburbanization	Bringing jobs back to cities	<u>*Land use*</u> ▪ Urban containment, e.g., urban growth boundary ▪ Mixed use developments, e.g., smart codes, overlay zoning practices. <u>*Economic development*</u> ▪ Place-based economic development strategies, e.g., urban renewal programs, enterprise zones. ▪ Public financing tools, e.g., new markets tax, tax increment financing.
Lack of affordable suburban housing	Helping urban poor move to suburbs	<u>*Housing*</u> ▪ Demand-side rental assistance programs, e.g., Section 8 certificates, Moving to Opportunity voucher program, and Gautreaux. ▪ Supply-side affordable housing programs, e.g., fair-share housing, Hope VI, scattered-site public housing program, inclusionary zoning practices.
Limited transportation options	Improving job accessibility of working poor	<u>*Transportation*</u> ▪ Public transit improvements, e.g., reverse commute services. ▪ Private mobility improvements, e.g., car-purchase-assistance programs.

Economic development

Economic development is a way for municipalities to direct residential and commercial developments and thereby a promising strategy to remedy spatial mismatch. Throughout history there have been many instances in which the federal government attempted to spur economic development in distressed urban areas. Congress launched the federal urban renewal program in Title I of the Housing Act of 1949. According to Teaford (2000), "the provisions of Title I were ambiguous enough to accommodate the dreams of its varied supporters." The specific focus of Title I on "slum clearance and urban redevelopment" permitted federal subsidies for projects that destroyed residential slums and replaced them with commercial development and upscale housing projects, which was a loophole that private developers could exploit for their own profit. By the 1960s, social welfare reformers and public housing advocates had turned against it, claiming it burdened the poor rather than helped them and had become a means of enriching private development and downtown property owners (Teaford, 2000).

Congress, faced with growing discontent with the federal urban renewal program, produced the Community Development Block Grant (CDBG) program in 1974 and the Urban Development Action Grant (UDAG) program in 1977. Both programs sought to emphasize flexibility and ensure that low-and moderate-income residents would be the chief beneficiaries of the programs. Critics questioned again whether either the CDBG or UDAG programs primarily served the poor. Eager for economic growth, city development agencies allocated federal funds for upscale downtown projects, claiming that low-income residents could secure jobs in these new enterprises. According to Frieden and Sagalyn (1989), half of all downtown malls constructed between 1978 and 1985 received UDAG financing, which may have helped destroy the vital fabric in poor urban residential neighborhoods (Frieden & Sagalyn, 1989). With the negative image of urban renewal, the proportion of city revenues contributed by the federal government declined dramatically in the late 1970s from more than 20 percent to less than 15 percent (Teaford, 2000). The age of large-scale, federally funded urban renewal projects was over.

Throughout 1980s and early 1990s, U.S. policy makers showed interest in enterprise zone projects,[1] which aim to encourage economic growth and investment in distressed urban areas by offering tax advantages and incentives to businesses locating within zone boundaries. At the federal level, enterprise communities and empowerment zones were created by the Clinton administration as part of the Omnibus Budget Reconciliation Act of 1993. The authorizing legislation allows for nine empowerment zones (six located in urban areas and three located in rural areas), and 95 enterprise communities (65 urban and 30 rural). Most enterprise zone programs combine place and labor targeting: providing tax incentives for firms that hire disadvantaged workers and are located in disadvantage areas. The associated tax incentives often include employment credits (e.g., for employing residents from the designated areas), a 0% tax on capital gains, increased tax reductions on equipment, accelerated real property depreciation and other incentives such as reduced licensing requirements, zoning restrictions, permit requirements and franchises restrictions.

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[1] The idea for enterprise zones first came to America from the United Kingdom. British House of Commons member Geoffrey Howe (future Lord Geoffrey Howe) and Professor Peter Hall coined the phrase and promoted the concept of enterprise zones in 1978. The belief of Howe and Hall--that 1) reducing governmental involvement in commerce on a geographically designated basis would increase local economic development and that 2) targeting underdeveloped communities for this strategy would decrease economic disparity between areas--still forms the rationale and design of today's U.S. state enterprise zone programs.

The enterprise—or, in the language of the Federal legislation, empowerment—zone experiments have stimulated a series of post-program evaluation efforts. Analysis of existing empirical evidence has consistently painted a pessimistic picture of the impacts of enterprise zones across the U.S. (Boarnet, 2001; Boarnet & Bogart, 1996; Elvery, 2009; Fisher & Peters, 1997; Ladd, 1994; Papke, 1994; Peters & Fisher, 2002, 2004; Wilder & Rubin, 1996). Most evaluations show little or no evidence on job growth, and for those showing positive impact on job growth, effects are not found to benefit local residents within the zones. The pessimistic evaluations have raised considerable doubts regarding the potential of spatially targeted economic development strategies in improving employment outcomes. Built upon the broader literature on economic development, researchers have widely used the following statements to explain the failure of most enterprise zone programs.

- The locational negatives associated with enterprise zones (e.g., high crime rates, high tensions, inadequate housing, and lack of social capital) are seldom mitigated by the incentive offered (Dabney, 1991).
- Some programs impose highly demanding eligibility criteria for the firm to receive any credits. As a result, few firms, even those eligible ones, take advantage of the incentives (Peters & Fisher, 2004).
- Politically, there are demands of other areas (e.g., greenfield sites and brownfield sites) to be granted similar economic development incentives. The older, more distressed areas are likely to be the losers in a contest against other areas with similar incentives (Peters & Fisher, 2004).
- The process of capitalization could transfer some of the local residents' benefits to people outside the zone (e.g., land and property owners or real estate investors) (Chapple, 2006; Ladd, 1994).
- Many zone subsidies are tied to the number of new hires or the amount of new investment, which means that new establishments typically receive a much larger total subsidy than existing establishments. As existing establishments are placed at a competitive disadvantage, the positive effect of enterprise zones on the fortunes of new establishments is likely to be offset by their negative effects on the fortunes of existing establishments (Bondonio & Greenbaum, 2007; Greenbaum & Engberg, 2004) .

Given the consistent evidence that spatially targeted economic development programs do not fare well in creating jobs or benefiting disadvantaged zone residents, researchers have begun to lower planners' and policymakers' expectations about their ability to micro-manage economic growth. For example, Peters and Fisher (2004) called for "a more sensible view of the role of government—providing the foundations for growth through sound fiscal practices, quality public infrastructure and good education systems—and then letting the economy take care of itself." The field of economic development seems to achieve consensus on the ineffectiveness of traditional incentive-based economic development policy. When it comes to policy recommendations, researchers in the field have highlighted the importance of additional workforce and community development efforts in attracting employers to disadvantaged communities (Holzer, 1994; Ladd, 1994). It is also suggested that greater attention be paid to existing businesses within the zone areas. Bondonio and Greenbaum (2007) find that the requirement of a strategic local economic development plan in Enterprise Zone (EZ) programs facilitates open communication between local businesses leaders and various administrative and community officials, and has greater positive impacts on existing businesses than on new establishments. Such open communication and participatory management structure are recommended for implementation in all EZ programs because they help achieve mutual understanding of business needs, and increase awareness of the opportunities offered in the EZ incentive package.

Land use

Land use determines which activities occur at what intensities on a piece of land. Thus, land use-related policies and planning tools play central roles in influencing the spatial distribution of jobs and housing in cities and metropolitan areas. As spatial mismatch can be defined as spatially uncoordinated low-wage jobs and affordable housing, a city's land use patterns directly impact the extent of spatial mismatch. Sprawl—the spreading of jobs and population from cities to suburbs—has widely been attributed to exacerbate spatial mismatch.

However, when looking at the empirical literature, the findings on the connection between sprawl and spatial mismatch are conflicting and unclear. Stoll (2005b) explicitly examined the association between job sprawl (measured by the percentage of employment located outside a 5-mile ring around the CBD) and spatial mismatch (measured by jobs-people dissimilarity index) across roughly 300 Metropolitan Statistical Areas in the U.S. in 2000. He found that greater metropolitan job sprawl is strongly associated with higher spatial mismatch for African Americans, moderately for Latinos, but not for whites (Stoll, 2005b). Similar findings are also seen in Martin (2001) and Webber and Sultana (2008), which respectively suggest that suburbanization and decentralization disproportionately affect black populations in terms of economic opportunities and commuting time (Martin, 2001; Webber & Sultana, 2008). However, other studies exist suggesting a weak, if any, relationship between sprawl and spatial mismatch (Foster-Bey, 2002; Jaret, Adelman, & Reid, 2006; C. H. Wheeler, 2008). Foster-Bey (2002) specifically mentioned that while Portland, OR and Minneapolis-St. Paul, MN are leaders in promoting growth management strategies, both metropolitan areas performed poorly in terms of social equity improvement from 1980-1990. Several explanations have been used to rationalize the weak association:

- Sprawl may offer affordable housing and hence reduce the black/white housing ownership gap (Kahn, 2001);
- Black suburbanization has increased substantially since the 1960s (Frey, 2001);
- Sprawl itself is a derivative of rapid economic growth and areas with fast employment growth tend to have higher social equity (Foster-Bey, 2002).
- If black and white residents are highly segregated from each other (especially, if the former are largely contained in the central cities), the vast majority of jobs are likely to be located in places with the lowest concentrations of black residents no matter whether density is high, moderate, or low or whether land uses are mixed or homogenous (Jaret, et al., 2006).

Inconsistent empirical findings consequently result in conflicting policy implications for land use planning. On one hand, researchers who found evidence on the sprawl-spatial mismatch connection have not hesitated to make recommendations such as the establishment of urban growth boundaries and the promotion of compact cities with mixed use developments. On the other hand, researchers who failed to find any evidence have suggested that the connection between sprawl and spatial mismatch might be spurious. The latter researchers have also raised concerns over the use of land use policies to address spatial mismatch problems. First, growth controls such as development quotas and urban growth boundaries may result in a smaller supply of affordable homeownership units which may disproportionately affect minorities and low-income populations, possibly limiting their residential access to job-rich locations either in central cities or fringe suburbs. Second, the vast diversity of jobs and people in modern metropolitan regions to some degree limit the potential effectiveness of land use policy interventions for achieving a better jobs-housing balance. An example of such policy interventions is one proposed by the Southern California Association of Governments (SCAG) in 1989 that redirects new jobs from job-rich to job-poor areas and redirects new housing to job-rich areas. Finally, relying on land use policies and planning tools alone may alleviate the appearance of spatial mismatch without actually mitigating the spatial mismatch problem (e.g., the locations of job-rich and job-poor areas may shift in the region but black residential areas may also change, leaving African Americans with limited residential access to job-rich areas). Even worse is the fact that suburban locations often have fewer transit options than urban centers. The relocation of the urban poor to these areas may actually exacerbate the spatial mismatch problem. Increasing consensus exists that land use issues are of less importance than issues of residential segregation and regional economic growth in the war against spatial mismatch.

Transportation

Transportation determines how people move from place to place. People who have access to reliable and rapid transportation such as private vehicles can easily commute between home and work even if home is physically far away from work. Therefore, spatial mismatch on many levels is a problem of access, and the availability of reliable and rapid transportation (either private or public) directly impacts the degree of spatial mismatch in cities and metropolitan regions.

Across the nation, surveys of low-income individuals or welfare recipients suggest lack of reliable transportation to be a significant barrier to employment success (Blumenberg, Ong, & Mondschein, 2002; Sanchez, 2008). Additional studies confirmed relatively low levels of auto ownership and that existing transit systems in the U.S. typically fail to accommodate low-income job seekers' complicated travel needs as many entry-level jobs require working late at night or on weekends when conventional transit services in many communities are either reduced or non-existent (Guiliano, 2005; Sanchez, Shen, & Peng, 2004; Sen, Metaxatos, Soot, & Thakuriah, 1999).

The well-documented evidence on "uneven access to job opportunities" had led to a series of planning and policy efforts in addressing the transportation problems of low-income residents and welfare recipients. At the federal level, the Job Access and Reverse Commute (JARC) program was established under the Transportation Equity Act for the 21st Century (TEA-21) in 1998 to specifically address the unique transportation challenges faced by welfare recipients and low-income persons seeking to get and keep jobs. Under TEA-21, funding for JARC grants was authorized at $150 million annually beginning in Fiscal Years 1999 till 2005. In 2005, another landmark bill, Safe, Affordable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), authorized a total of $727 million for JARC grants from FY2006 through 2009. At the regional level, many state agencies and metropolitan planning organizations (MPOs) have sponsored studies examining whether improvements to existing transportations systems (with a primary focus on transit systems) could contribute to urban poor and welfare recipients' employment success. Examples include the New Jersey WorkFirst Study, New York Tri-State Region Access-To-Jobs Plan, etc. These studies typically conclude with recommendations such as expanding transit/para-transit services, increasing distribution of public transportation information and initiating programs to assist car purchases and maintenance.

Despite high expectations that transit improvements would positively affect employment status for low-income persons, empirical evidence has been inconsistent. First, there is strong evidence that reverse commute transit services are ineffective in meeting the transportation needs of unemployed single mothers, a population group deeply affected by spatial mismatch (Blumenberg, 2004). According to the US Department of Health and Human Services (2002), women constitute 85 percent of the adults on welfare and the majority of female welfare recipients are single mothers. Chapple (2001) conducted in-depth interviews with 92 women on welfare in San Francisco and found that low-income women with children tend to seek jobs close to home. As transit riders, such women face time-consuming commutes, which are not compatible with their parental responsibilities and employment constraints. Their time poverty makes reverse commutes too costly to sustain (Chapple, 2001). Second, employment benefits associated with transit improvements are often predicted but not empirically demonstrated (Rosenbloom, 1998). Only a handful of rigorous studies exist examining the impact of transit improvements on employment outcomes of disadvantaged population groups. As summarized in Table 2, these studies reach conflicting conclusions. While studies in Los Angeles, CA found a positive effect of transit accessibility on employment outcomes (Kawabata, 2002, 2003; Ong & Houston, 2002), studies in other regions show little or no association between transit availability/quality and employment participation (Bania, Leete, & Coulton, 2008; Cervero, Sandoval, & Landis, 2002; Sanchez, 1999; Sanchez, et al., 2004; Thakuriah & Metaxatos, 2000).

At least three explanations have been used to explain the inconsistency in the empirical literature on the effectiveness of transit for increasing employment participation among low income population. *First,* some researchers have attributed the inconsistency to the inherent difficulties in determining the effectiveness of transit mobility programs for socially disadvantaged groups, which include having no accepted performance measures and an inability to control for intervening factors that affect such population groups' employability. *Second,* it has also been noted that, as low-wage workers benefit from increased job access, they have the opportunity to purchase an automobile, which would end their reliance and use of public transit and thereby increase the difficulty in assessing the impact of transit services on job seeking and retention. *Third,* many researchers also concede that the inconsistency in the empirical literature to some extent reflects the ineffectiveness of U.S. transit services in meeting the transportation needs of disadvantaged groups, especially the needs of unemployed single mothers. The lack of high-quality transit service in the U.S. has greatly diminished the attractiveness of distant suburban jobs for low income populations. While the JARC program is a landmark improvement in US transit history, the improvement it makes is insufficient to bring U.S. transit systems to the tipping point past which transit can serve as a viable substitute for the automobile. Given the US context, it is difficult to empirically detect the role of transit availability and quality in influencing employment participation.

Table A-2. Review of the empirical literature on transit and employment

Author, Year	Study Area /Population	Methodology	Key Findings	Transit impact
Kawabata 2003	1,518 welfare recipients in Los Angeles, CA in 1999-2000	Multinomial logit regression of employment outcomes	Transit-based job accessibility increases employment probability for autoless welfare recipients.	Yes
Ong, and Houston 2002	565 carless, single women welfare recipients in Los Angeles, CA in 1999-2000	Logistic regression of employment outcomes	Transit service level at residences moderately increases employment probability.	Yes
Yi 2006	2,008 individuals age 16-64 in Houston, TX in 1995	Multinomial logit regression of employment status	Transit accessibility increases employment probability and the positive effect is higher for captive transit riders than choice riders.	Yes
Sanchez 1999	449 census block groups in Portland and 409 in Atlanta in 1990	Two-stage least squares regression of average employment levels	Transit-based job accessibility positively influences employment levels for Atlanta block groups but not for Portland block groups.	Partially
Thakuriah and Metaxatos 2000	40,000 female welfare clients in northeastern Illinois area in 1998	Multinomial logit regression of job tenure	Auto and transit-based job accessibility positively influence employment retention for female clients with high school or higher educational degrees but not for non-high-school-graduates.	Partially
Cervero, Sandoval, and Landis 2002	466 welfare recipients in Alameda County, CA in 1992-1993	Multinomial logit regression of employment status changes.	Car ownership is much more important than transit service quality in getting people off welfare and into gainful employment.	No
Sanchez, Shen, and Peng 2004	190,405 welfare recipients in Atlanta, Baltimore, Dallas, Denver, Milwaukee, and Portland MAs in 1999	Multinomial logit regression of recipients' case status.	Of transit and employment access variables, none performed consistently and in no cases were there statistically significant coefficients with the expected signs.	No
Bania, Leete et al. 2008	Welfare leavers in Cuyahoga County, OH in 1998-2000	Logistic and OLS regression of employment status, earnings, wage, and working hours	Auto and transit-based job accessibility shows no significant association with any of the job outcomes.	No

A significant body of research also exists on linking private auto transportation to job seeking and retention (Garasky, Fletcher, & Jensen, 2006; Grengs; Gurley & Bruce, 2005). The consensus is that car ownership is a far more powerful predictor of whether people will find a job than the availability and quality of transit services. In addition, private mobility improvements may be more cost-effective than transit improvements to bridge welfare recipients and suitable job opportunities, given the dispersed distribution of entry level jobs in many U.S. metropolitan areas (Thakuriah, et al., 1999). However, there is increasing recognition that excessive auto use has negative societal consequences such as sprawling development patterns, declining social capital, and deteriorated environmental quality. Thus, promoting car ownership among low-income population may not receive much public support. There has also been the concept of welfare queen perpetuated by President Regan during his campaign for president in 1976. The story portrays a woman who drove a Cadillac and received mass amounts of benefits from the government by using aliases, false husbands, and excessive children. This story was widely reported to be exaggerated or all together false but it has shaped some of the perceptions of people on welfare. Currently, many states limit vehicle ownership for welfare recipients, forcing them to drive only older, more unreliable cars and thus contributing to the problem of getting to work. In California, for example, state regulations limit welfare participants to vehicles with values no greater than $4,650.

Housing

Kain's initial hypothesis highlighted racial discrimination in the suburban housing market as one of the central factors causing spatial mismatch. In today's housing market, the overt racism that moved white people out of central cities and kept minorities in them has become less obvious (Kain, 2004). The housing arguments in the spatial mismatch literature have shifted from the role of race to the role of poverty concentration. Accordingly, housing programs targeted to deconcentrate poverty (often referred as dispersal programs) have been widely applied to increase employment outcomes of inner-city poor residents.

Existing dispersal programs can be categorized into two groups: demand-side rental assistance programs and supply-side affordable housing programs. Rental assistance programs often provide relocation assistance and housing vouchers to encourage or require poor families to move to areas with lower concentrations of poverty or minority groups. Rental assistance subsidies were initially offered in the format of certificates. The Section 8 certificate program, started in 1974, provides assistance to eligible low- and moderate-income households who can rent any house or apartment as long as two conditions are met: 1) the unit must pass an inspection to determine that it meets housing codes, and 2) the rent must be reasonable, generally meaning at or below the fair market rent (FMR). The certificate program has a major limitation. Many households had, and continue to have, difficulty finding suburban housing of acceptable quality for rent below the published FMR standards. In response, a less-restrictive voucher program was created to give participants greater freedom in finding acceptable units. The Gautreaux Assisted Housing Program is the first experimental voucher program, which was started in 1976 and was a result of a series of class-action law suits filed against the Chicago Housing Authority (CHA) and the U.S. Department of Housing and Urban Development (HUD). Modeled on Gautreaux, the Moving to Opportunity (MTO) program was enacted in 1992 and designed to offer rent subsidy to very-low income families to relocate from high-poverty neighborhoods to neighborhoods with less poverty, often in suburbs. When compared to the Section 8 program, the MTO program not only provides less-restrictive rent assistance but also provides additional housing counseling to participants to help them find housing and stay in low-poverty areas. The more recent Hope VI relocation program is different from most voucher programs because it specially focuses on public housing residents, redevelops large, distressed public housing sites into lower-density, mixed-income housing, and provides vouchers to families of demolished units to relocate to low-poverty areas. Hope VI programs are not voluntary voucher programs because families are forcibly moved out of their previous homes.

Unlike rental assistance programs that typically focus on families on welfare, supply-side affordable housing programs are often city-wide or region-wide in application and seek to promote and distribute the development of affordable housing all across the city or metropolitan area. Typical affordable housing policies include regulatory approaches (e.g., mandatory inclusionary zoning policy to mandate the percentage of affordable housing in the development) or incentive programs (e.g., streamlining administrative processes, creating Overlay Zones, and using density and height bonuses to encourage affordable housing production). There are also state programs (such as those in California, New Hampshire, and Oregon) that require local communities to provide reasonable opportunities for the development of affordable housing. In practice, developers can take legal actions (often referred to Builder's Remedy Lawsuit[2]) to force a municipality to permit construction of affordable housing projects. For example, Massachusetts has a law known as 40B that allows developers to appeal decisions made by municipalities if they allocate 20 percent of their new housing development to be affordable.

In the policy debate, demand-side voucher programs have been preferred to supply-side production programs because of the widely-accepted agreement that more people can be subsidized in older housing than in newer housing (Weicher, 1990). New multifamily housing for low-income families typically incur additional costs that other new housing may not because political resistance to such developments may lead to legal battles, and public financing may also come with special legal restrictions. McClure (1998) challenged this widely-accepted view using a longitudinal comparison of the subsidy costs of Section 8 new construction projects and Section 8 certificates in St. Louis and Kansas City, MO. He find that the cost premium associated with project-based assistance may be lower than conventionally believed, around 40 percent, and may get even lower if the cost comparison could extend to longer time periods and could control for the quality of the housing units (McClure, 1998). However, Shroder and Reiger (2000) reexamined the St. Louis and Kansas City cases and found that analytic errors rather than new information are responsible for McClure's conclusions. They find that, 15 to 20 years after construction, Section 8 New Construction projects remained to be considerable more expensive than Section 8 Certificates, solidly supporting the widely-accepted wisdom (Shroder & Reiger, 2000).

Literally hundreds of scholarly studies exist examining the impacts of housing assistance on the economically disadvantaged and their employment outcomes (Kling, Liebman, & Katz, 2007;

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[2] Typically, the developer's court brief will make specific mention of the Mt. Laurel decision, a landmark case that holds municipalities responsible for providing affordable housing to low and moderate income households. However, many local officials believe that "Builder's Remedy Lawsuits" are used by developers to force the construction of unneeded housing under the guise of providing affordable housing for those that need it most, when in reality they are only interested in building large quantities of market rate homes for profit.

Leventhal & Brooks-Gunn, 2003; Ludwig, Duncan, & Pinkston, 2004; Popkin, Rosenbaum, & Meaden, 1993; Rosenbaum & Harris, 2001; Shroder, 2002). Most studies did not find participating families in dispersal programs to be associated with better employment outcomes. Only a hand of studies found positive effects. With quasi-random experimental data on city and suburban mover groups, Popkin, Rosenbaum, and Meaden (1993) and Rosenbaum (1991) found moderate impacts of the Gautreaux program on suburban movers' employment rates but no impact on their hourly wages or numbers of hours worked (Popkin, et al., 1993; Rosenbaum, 1991). A recent study using administrative data on wages and welfare receipts finds that Gautreaux women who move to predominantly white neighborhoods with moderate to high resources spent significantly more time employed and less time on welfare (Keels, Duncan, Deluca, Mendenhall, & Rosenbaum, 2005). Also, non-experimental analysis finds that MTO adults who moved to low-poverty neighborhoods in the suburbs earned $75 a week more than those in control neighborhoods (Cove, Turner, Briggs, & Duarte, 2008).

Although housing assistance is not persuasively associated with any effect on employment, existing empirical evidence suggests that housing assistance contributes to other improvements in the well-being of participating families. Adults and female youth who moved to lower-poverty neighborhoods are found to experience substantial improvements in mental and physical health and decreases in delinquency and risky behavior (Kling, et al., 2007; Orr, et al., 2003). However, there is no evidence that boys have enjoyed comparable benefits from poverty dispersal. Housing assistance is also found to influence the job search tactics and social networks of subsidized families. Dispersed residents tend to have neighborhood social networks that contain greater diversity but receive assistance from their neighbors less frequently when looking for a job than clustered residents (Kleit, 2001, 2002). While these neighborhood effects may not influence residents' employment outcomes in the short term, they may impose indirect, long-term impacts.

Why does poverty dispersal have little, if any, impact on employment prospects of the urban poor? First, although it is part of the government's intention for poverty dispersal programs to reduce spatial mismatch, very few participating families cite "getting a job" or "being near my job" as their most important reason for wanting to move (Turner & Briggs, 2008). Escaping unsafe areas is the primary motive for these families to participate in the programs (Turner & Briggs, 2008). Second, although neighborhood job proximity is found to be associated with better employment outcomes (Allard & Danziger, 2002; Dawkins, Shen, & Sanchez, 2005; Weinberg, Reagan, & Yankow, 2004), relocation in poverty dispersal programs does not necessarily mean better proximity to jobs. In fact, geographic analysis of MTO families in Chicago and Los Angeles suggests that these families are no closer to entry-level jobs than those they left behind (Cove, et al., 2008). Finally, many researchers suggest that housing subsidies alone are not enough to crack the glass ceiling of high unemployment rates of inner-city poor residents (Corcoran & Heflin, 2003; Tegeler, 2007; Turner & Briggs, 2008). Recipients of housing assistance face multiple barriers to work, and additional assistance programs such as post-move counseling, child care subsidies and transportation mobility improvements are in great needs to overcome the barriers.

Lessons, alternative tactics and promising practices

The review above demonstrates that existing policy responses to spatial mismatch have failed to improve employment outcomes of disadvantaged urban jobseekers: regions with compact and mixed land use patterns do not show lower levels of spatial mismatch between urban minorities and their economic opportunities; inconsistent empirical evidence is found on the effectiveness of existing transit programs for increasing employment participation; car ownership is found to play a significant role in improving employment outcomes, but few private mobility programs exist in the U.S. and even fewer programs are empirically examined; for housing and economic development policy programs, a vast majority of studies on these programs suggest few, if any, employment effects for disadvantaged inner-city workers. Thus, rather than advocating that planners expand their efforts in these areas, I now turn to discuss lessons that planners can draw from past failures and alternative tactics for planners to use in the ongoing war against spatial mismatch. In discussing the texts to follow, two tactics emerge from the losing experience.

Unifying strength at low-conflict zones

Planners have reached consensus that the spatial mismatch issue is attributable to land use, housing, transportation and economic development factors, and as such the issue has been addressed by diverse and sometimes conflicting policy strategies. Divided attentions were paid to inner-city job creation, poverty deconcentration, and transportation improvements without acknowledging the interconnected roles of economic opportunities, residential development, and transportation investments. As illustrated in Figure 1, efforts to spur inner-city economic opportunities may counteract the poverty deconcentration efforts as the former allocate capital subsidies to cities while the latter allocate resources to their suburban counterparts. In another example, promotion of private mobility using car voucher programs may decrease demand for public transit and conflict with the mission of reverse commute programs.

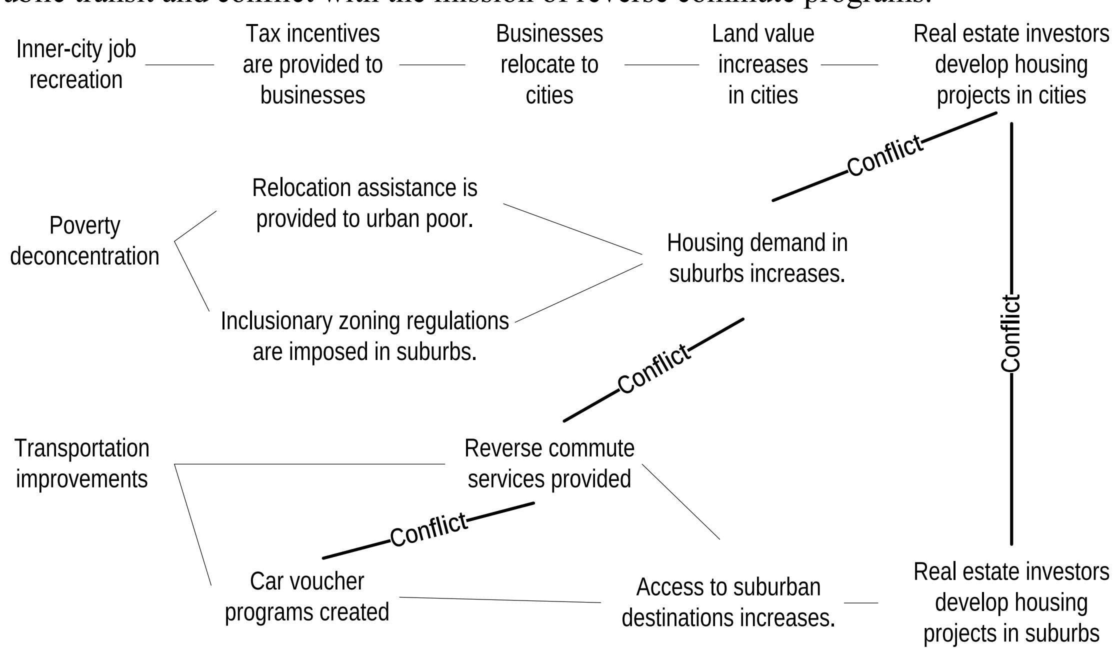

Fig. A-1: Simplified illustration of conflicts among traditional spatial mismatch policy solutions.

There are far more policy strategies available for addressing spatial mismatch than those illustrated in Figure 1, and as planners in different fields deal with diverging priorities, disagreements and tensions occur regarding where the limited governmental resources should be allocated. Experience has shown that the conflicts are not superficial ones arising from uncoordinated approaches. Rather, they are grounded in differences in various players' deeply held values and alternative visions of human settlements. For example, while transit providers regard the expansion of the current transit system as the best way to serve welfare recipients, private industry representatives may envision market-oriented solutions such as car purchase, maintenance, and insurance assistance programs. In an effort to illustrate the distinctive values held by different players, Blumberg, Ong and Mondschem (2002) quoted a statement made by the former chairman of the Los Angeles Metropolitan Transit Agency: "Transit dependent people are always going to take the bus, are always going to need buses. We need to help them". In other words, to many people, transit is taken for granted as the default solution to help the economically disadvantaged achieve better employment outcomes. When confronted by questions regarding the lack of empirical support of public transit solutions, many of them complain about the limited scale of improvements or insufficient coordination from other agencies for catalyzing the change (Blumenberg, et al., 2002).

Their complaint is not without substance. In retrospect, most policy interventions addressing spatial mismatch appear neither a despoiler nor a benefactor of the urban poor, but appear to have little effect either way. All the discussion about spatial mismatch and all the remedy plans (e.g., Section 8, reverse commute, enterprise zone, smart growth, and MTO) did not actually change the fate of America's urban poor radically. As Teaford (2000) sarcastically suggested, many relevant legislations generated more paper works than houses, jobs, or travel time savings; they promised much more than they produced. Much of the employment development in central cities was not due to enterprise zones (EZs). In the case of Hagerstown EZ program in Maryland, employment increases were detected in August and October 1984, 8 and 10 months after the program was implemented. A closer look into the case suggests that two new employers accounted for the two employment jumps and both employers indicated that the program was not the catalyst for the change. Comparable results were found in other EZ programs such as the Cumberland and Salisbury EZ in Maryland. Likewise, the suburbs have become increasingly diverse, but little of the change is due to the poverty deconcentration programs. For instance, ongoing black suburbanization has largely been regarded as more of a resegregation of African Americans in particular sectors of suburbia than dispersal in an open housing market (Clay, 1979). Additionally, the difference that reverse commute services made was also marginal in that only a small proportion of low-wage workers find them useful in fulfilling their complicated mobility needs (Thakuriah, et al., 1999). As it is unlikely that every existing program addressing spatial mismatch is ill-managed or administered, it is safe to say that limited resources and insufficient coordination from other agencies play a significant, if not critical, role in contributing to the failure of existing policy interventions. Chapple (2006) summarizes the problems succinctly: "authority is fragmented, program funding low, and prospects for change poor." So, what went wrong?

Urban planning operates in a complex and turbulent decision-making arena reflecting a high-stakes game in which various stakeholders attempt to gain planning and policy decisions that most benefit their own interests (Berke & Kaiser, 2006). With the democratic decentralization in the U.S. political system, it is difficult to maintain a truly focused program without acceding to the demands of other places or people for policy benefits.   As discussed earlier, spatial mismatch is associated with various social, economic, political, and cultural causes and consequences, and as such it is difficult to place the problem in or not in any of the specific planning areas. Stakeholders involved in spatial mismatch issues are as diverse as those involved in any comprehensive urban planning process. For planners to create wining opportunities in the war against spatial mismatch, the tactic of unifying strength at low-conflict zones is worth exploring.

In practice, this tactic may translate to the development of integrated policies or planning tools that generate fewer conflicts, more teamwork and momentum. A promising practice is the recent innovation of the Housing + Transportation (H+T) Affordability Index tool, popularized by the Center for Neighborhood Technology in 2006. This new tool promotes a new and more comprehensive way of thinking about the cost of housing and true affordability by exploring the impact that transportation costs associated with the location of the housing have on a household's economic burden[3] (Haas, Makarewicz, Benedict, & Bernstein, 2008). This tool can and should be applied to integrate housing subsidy programs and transportation assistance programs. For example, if public housing agencies are equipped with the H+T affordability assessment tool, their staff can rely on the tool to generate tangible neighborhood-based indicators of housing and economic opportunities through which relocation areas for Section 8 or Move-to-Opportunity program participants may be identified. This would be a significant improvement on existing housing dispersal practices that mainly identify relocation areas based on poverty rate or racial makeup. Additionally, public housing agencies may partner with social services or transportation agencies to provide "car + housing voucher" programs to promote access by low-income families that move to car-reliant communities. In fact, cross-sector partnerships among government agencies are increasingly deemed important in addressing the spatial mismatch problem. A recent U.S. Government Accountability Office (GAO) report pointed out that the Federal Transit Agency (FTA), Department of Housing and Urban Department (HUD), and National Governors' Association (NGA) have separate activities to help low-income people secure jobs and few interactions exist among these activities (i.e., FTA's JOBLINKS, HUD's Bridges to Work, and NGA's Transportation Coordination Demonstration project). The report concludes with strong recommendations for cross-sector partnerships, e.g., require that transportation grant recipients coordinate strategies with local job placement and other social service agencies, and require FTA work with the departments of Health and Human Services, Labor, and Housing and Urban Development to coordinate welfare-to-work activities to ensure that program funds complement and do not duplicate other welfare-to-work funds available for transportation services.

At the local level, municipal governments may integrate enterprise zone programs with transit-oriented development (TOD) strategies and affordable housing policies. Transit investments such as light rail systems have the potential of shaping urban fabric and shifting population and

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[3] The current assessment framework proposed by CNT only integrates out-of-pocket transportation costs into the calculation of affordability index and does not include true location efficiency measures such as job accessibility. Therefore, while the CNT's H+T affordability index is innovate in its integrated concept, it still needs further improvement to incorporate accessibility-related benefits associated with residential location.

employment distribution across the region (Cervero, 1998), which, at least theoretically, could serve as a catalyst or facilitating agent in maximizing the positive impact of tax credits/incentives on economic development in distressed urban areas. However, without proper housing policies, targeting transportation investments or economic development strategies in economically disadvantaged neighborhoods may cause gentrification and displace existing neighborhood residents from their established tight-knit communities, contradicting TOD's and EZs' intentions of benefiting local residents. Incorporating affordable housing policies into the TOD-integrated EZ programs may ensure that poor people living in targeted areas benefit from the programs. In addition, concerted, coordinated attempts to bundle regional smart growth[4] strategies or neighborhood revitalization efforts with EZ programs may also help to maximize the positive economic impact of EZ programs.

Seeking social solutions to spatial problems

The recent advances in geographic information systems, coupled with detailed urban spatial databases, have greatly improved our ability to measure and analyze spatial mismatch. Taken together, recent findings do not provide definitive support that spatial mismatch affects employment outcomes or that place-based planning solutions (e.g., poverty deconcentration, enterprise zones, and reverse commute services) mitigate the negative impacts of spatial mismatch on employment outcomes. The lack of definitive conclusions somewhat indicates that the magnitude and significance of spatial mismatch effects depend on a host of non-spatial factors that remain to be specified. Planners and public policy makers have only begun to understand that spatial mismatch is a contingent phenomenon influenced by a diverse array of social dimensions such as the attitudes and practices of employers, individual characteristics of job seekers, neighborhood characteristics, etc. These social dimensions may not only have an independent influence on employment outcomes separated from the effects of spatial access, but also interact with the spatial mismatch effects (Hodge, 1996; Preston & McLafferty, 1999).

The idea of using social solutions to ameliorate spatial problems such as spatial mismatch has theoretical foundations because underlying the spatial mismatch phenomenon are decisions, choices, and behaviors undertaken by individuals, families, and businesses: employers' business location decisions and hiring decisions, real estate developers' site choices, rental property owners' selection of tenants and low-income families' residential location choices and job search behavior. Efforts targeting distressed urban areas for economic development could be useless if employers are reluctant to locate businesses in these areas or hire local residents from these areas. Voluntary voucher programs that attempt to deconcentrate urban poor will not succeed if these families are reluctant to move. Thus, in the war against spatial mismatch, planners should focus at

[4] Smart growth" is anti-sprawl development that values long-range, holistic considerations of environmental protection, economic growth, and social equity over short-term fiscal considerations. The term of "smart growth" is often used interchangeably with "growth management." Examples of growth management/smart growth strategies include (a) urban containment boundaries that direct urban development into areas intended or needed for urban uses and protect rural land from urban spillovers, (b) capital improvements programming and adequate facilities standards that discourage developments farther away from existing civil infrastructure systems and encourage infill and redevelopments, (c) land preservation techniques (e.g., transfer of development rights and agriculture/forest buffers) that protect resource land from urban development pressures, etc.

least equally on the type of form that spatial mismatch takes and its underlying behavioral mechanisms.

Employers anywhere in the world have never hesitated to generalize about race or ethnic differences in the quality of the labor force. In the U.S., inner-city and lower-class workers, especially black men, are seen as unstable, uncooperative, dishonest, and uneducated (Kirschenman & Neckerman, 1991; Moss & Tilly, 1991). Empirical evidence shows that employers differentiate job applicants on the basis of their addresses, refusing to hire residents of public housing or from very poor neighborhoods (Pastor & Adams, 1996). In addition, employers are also discouraged from investing in distressed urban areas by the areas' high crime rates, inadequate housing, and lack of social capital. Public policies must invest more (and more effectively) to restore the safety and vitality of inner-city neighborhoods, to increase the job readiness of inner-city residents, and to reduce employers' negative prejudice and stereotyping of inner-city workers. Chapple (2006) pointed out that low income workers have particularly weak performance on soft skills such as resolving conflicts, showing up on time, and dressing appropriately for the job. In term of promising practices for addressing the problem, she highlighted the success of the Job-Plus program, which provided employment services, financial incentives, and community support networks to residents of public housing, as well as job readiness programs that focus on changing participants' attitudes and offer explicit discussion of race and class issues in corporate America.

Real estate developers are less likely to invest in affordable housing projects because these projects usually do not generate enough profit to warrant the investment. Even with generous tax credits and streamlined application process provided by local governments, affordable housing projects could bring additional burdens to the developers as they may encounter organized resistance from groups such as NIMBYs (Not in My Backyard) and LULUs (Locally Unwanted Land Uses) who consider affordable housing projects in their neighborhoods as a social and financial blight: social stigmatization brought about by the projects may diminish the value of their homes. Other causes of concern include fear for safety and for diminishing quality of local environments (Pendall, 1999). These concerns are not supported by empirical evidence: while some studies have shown slight negative effect of subsidized housing projects on nearby property values (Goetz, Lam, & Heitlinger, 1996; Lee, Culhane, & Wachter, 1999), others have found no effect or slight positive impacts (Galster, Tatian, & Smith, 1999). To reduce suburban wealthier residents' opposition to affordable housing projects, planners may apply a social marketing approach to campaign for integrated neighborhoods and/or create public gathering places/events for attracting people with diverse socio-economic backgrounds, help them to engage in conversations and foster connections.

Rental property owners may not accept voucher holders as tenants for at least two reasons: 1) unwillingness to deal with the paperwork and inspection requirements of Section 8 or MTO programs; and 2) deep and persistent stigmas tied to minorities, the poor, and welfare recipients. Regarding the former obstacle, recent years have seen increasing efforts by voucher programs to change the standard lease and make it more landlord-friendly (Orr, et al., 2003). For the latter, while housing discrimination has shown a downward trend in the U.S., it still exists and rental agents' prejudices toward their customers are shown to be significant in explaining discrimination (The Urban Institute, 2002). On this front, planners and policymakers can work or assist effective nonprofits to work, through outreach, education and enforcement of fair housing laws, to eradicate discrimination. A promising tool is audit programs of rental housing business practices, which have been implemented in many states and metropolitan regions such as Vermont and the Philadelphia metropolitan area. In addition, it has been found that the participating families in voucher programs tend to move to neighborhoods experiencing declines in prosperity. This pattern is closely related to landlords' behavior. Landlords are more willing to rent to families on Section 8 or families from public housing when they see reduced demand for their rental stock, with softening rents. This is a worrying trend because moves to low-poverty neighborhoods in decline may not provide the opportunity-rich environments hypothesized to improve the lives and well-being of the movers. To reverse the trend, public policy must invest more in relocation assistance programs and provide movers access to longitudinal neighborhood profiles.

Inner-city residents may not be willing to relocate to suburban locations. US housing policy has attempted to facilitate the deconcentration of poverty through both involuntary relocation and voluntary mobility programs. Relocation is guaranteed for families involved in involuntary programs (e.g., the federal HOPE VI project) as such programs force families move out of their previous homes. However, voluntary mobility programs allow participating families not only to move to more integrated neighborhoods, but also to stay where they are—subject to HUD's housing quality guidelines—and increase non-housing consumption. Rosenbaum and Harris' Chicago study (2001) reported that just under one-third (31.3%) of MTO families relocated to homes in the suburbs. The Experimental Housing Allowance Program (EHAP) of the 1970s and early 1980s revealed that many tenants used housing allowances not to improve their housing conditions, but rather to reduce overpayment, that is, to increase non-housing expenditures (Allen, Fitts, & Glatt, 1981). In addition, although African-Americans appear to prefer an integrated neighborhood to an all-black one, they also prefer an all-black neighborhood to a mostly white one (Farley, Fielding, & Krysan, 1997). Consequently, even African-American households that do move with their housing allowance may opt for urban neighborhoods with a relatively high proportion of African Americans because there are so few integrated suburban neighborhoods (Pendall, 2000). Finally, for low-income families without reliable access to a car, they may experience isolation from friends, families, church, or other support networks after relocation, which may make them move back to higher poverty neighborhoods to be closer to their networks (Briggs, 1997; Orr, et al., 2003; Varady & Walker, 2000). As Briggs (1997) reminds us, "geographic proximity does not a neighbor make" (p.197).

Existing socio-political structure also limits the ability of low-income inner-city residents to extend their social connections, especially the weak-tie connections (e.g., work contacts, casual acquaintances, or other non-intimate associates). Yet, these ties provide access to more varied sources of information about job vacancies and sources of referrals to local employers, from a greater variety of people, than provided through family and friends (Chapple, 2001). Inner-city residents may not have the luxury of taking suburban jobs, either. This is especially true for low-income single parents. People look for jobs in areas to which they are able to commute. Blumenberg (2004) examined the travel patterns of working-age adults and low-income single parents in the Los Angeles and Fresno Counties in California and found that low-income single parents' average commute distance is less than 8 miles, compared to 12.5 miles for all working-age adults. This indicates the unattractiveness of long-distance commuting to low-income single parents who typically have sole responsibility for the functioning of their households and must balance the costs of traveling to and from jobs with the needs to make trips that serve their children and other household needs. Consequently, they have a much smaller pool of suitable jobs and are more likely to earn lower wages.

The challenges above suggest that poverty deconcentration efforts will not fully succeed unless urban planners and public policymakers pay more attention to non-housing burdens faced by low-income families, including transportation, child care, education, etc. The challenges also highlight the importance of access to social supports. Improvement on these fronts demands more than simply increasing neighborhood density, diversity and mobility, but requires significant community development, engagement and integration efforts. Federal administrations appear to have understood these lessons from past experience and, consequently, have included more community-building components in recent housing and economic development programs. For instance, one the three major revitalization areas emphasized by the HOPE VI program is local social and community services. The Federal empowerment zone program has also stressed a community-based approach for economic revitalization. Among recent community development practices, the asset-based community development (ABCD) approach appears to hold promise in strengthening community social ties and increasing social capital (Morris, 2000; Walthall, 2008).The ABCD approach focuses on discovering, mapping and mobilizing all local community assets, mainly including the skills of local residents, the power of local associations, and the supportive functions of local institutions. The basic tenet is that a capacities-focused approach is more likely to empower the community and therefore mobilize citizens to create positive and meaningful change from within. Planners must assist the ongoing movement for community integration and should apply the ABCD framework to both suburban and inner-city neighborhoods so the low-income families that choose to live in either neighborhood can thrive.

Conclusions

Taken separately, land use strategies and existing housing, transportation, economic development strategies such as MTO, reverse commute, and enterprise zones are not as effective as we expected in reducing spatial mismatch or improving employment outcomes for the socio-economically disadvantaged in distressed urban areas. Although federal government moneys and guidelines underlie all of these approaches, they do not constitute a concerted, coordinated attempt. It seems that, if planners are to create wining opportunities in the war against spatial mismatch, they must not only invest more but also invest smartly. Divided attentions and diverging priorities are likely to generate conflicting solutions that counteract each other’s effects and starve government of its already limited resources. It is time to put traditional sector-specific interventions to rest and promote cross-sector partnerships and solutions.

It also seems that the various social, economic, political, and cultural causes and consequences associated with spatial mismatch are so intrinsically complex and politically explosive as to defy simple solutions that fix the spatial dimension only. There is little question that disadvantaged inner-city families are in desperate need of job proximity, but whether job proximity can benefit them hinges on a chain of cooperative actions by employers, developers, landlords, tenants and sometimes others. Planners and policymakers must use a more appropriate set of approaches to address spatial mismatch; these approaches must pay more attention to non-spatially-related barriers to employment (e.g., skill mismatch, child care burdens and lack of social support), extend beyond simple matters of neighborhood diversity and mobility, emphasize community integration, and appreciate various stakeholders’ behavioral mechanisms

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