TRAM

Non-stop equity:

Assessing daily intersections between transit accessibility and social disparity across the Greater Toronto and Hamilton Area (GTHA)

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Prepared for Metrolinx

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Executive summary

To: Metrolinx

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Subject: An assessement of transit accessibility and social disparities over the day in the GTHA

Accessibility can be conceptualized as the potential for people to reach places through the transportation system. Accessibility is a key performance measure to better understand the interactions between transportation and land-use. The transport system can alter the accessibility of places, producing interest in development. Development alters land-use, producing changes in the demands on the transport system. Residents of areas with good transit accessibility to employment may enjoy shorter travel times to work and potentially have a larger range of job opportunities available to them through transit. In contrast, a lack of transit accessibility for vulnerable populations may be one factor contributing to systemic social and economic exclusion. By comparing transit accessibility to low- and higher-wage jobs, and from more or less socially disadvantaged areas, we investigate if those with potentially greater transit need experience equitable transit access. In this way, we are using a transit accessibility measure to assess the equitable distribution of public transportation resources in the GTHA; a policy issue raised by Metrolinx in The Big Move: “Access to frequent, fast and affordable transit is…crucial for equity and social cohesion...there are several pockets of concentrated social need in the GTHA. The transportation system needs to improve the mobility options for people in these areas, connecting at-risk, vulnerable and disadvantaged communities to the jobs, social services, and health care facilities which can improve people’s lives” (Metrolinx, 2008, p.8).

To assess equity and to highlight areas in need of more public transportation resources, two general questions are asked:

1. What is the level of accessibility to jobs provided to the most socially disadvantaged areas in the GTHA region? Is the level of accessibility to jobs in these disadvantaged areas better or worse compared to the rest of the GTHA region? Does this level of accessibility affect the usage of public transit in these areas?
2. Are there any imbalances in accessibility to jobs using transit and actual settlement patterns in the region? Is transit accessibility available at the time of day when it is actually needed?

To answer these questions we looked at how easy it is to reach job opportunities using transit at different periods of the day from socially disadvantaged and other areas. We also divided GTHA employment opportunities into low and higher-wage categories to examine accessibility for two different wage groups. Lastly, we looked at the impact of daily accessibility variation on transit usage. The main findings of this work are highlighted in the next section, followed by a list of recommendations.

Social Disadvantage and Accessibility

- The most socially disadvantaged areas (areas with a low median wage, high unemployment, concentrations of recent immigrants, and unaffordable housing costs) have better accessibility to jobs by public transit than the rest of the region. The number of high or low-wage jobs actually accessible using transit from these areas is, on average, 12 times greater than from other areas.

- These higher levels of accessibility are linked to travel time savings for these areas. Residents have shorter travel times to their jobs than the rest of the region. They may spend, on average, 64% less time traveling to work compared to people from all other areas.

- These disadvantaged areas are overwhelmingly located in the City of Toronto (74%) This helps explain why these disadvantaged areas have such good transit accessibility.

- High levels of accessibility to jobs by transit may lead to higher transit ridership. Ridership is more likely amongst residents of the City of Toronto. Ridership is also more likely amongst residents of socially disadvantaged areas.

- Although transit may be a viable and useful mode of travel for residents of the *most* socially disadvantaged areas, lower-middle income areas actually have less transit based accessibility to jobs. On average, people from the most socially disadvantaged areas have twice the number of jobs, both low- and high-wage, accessible to them using transit than lower-middle income areas. Also, lower-middle income areas have almost half the number of jobs accessible to them than higher-income areas.

- Lower-middle income areas are less likely to be in the City of Toronto (66%) and much less likely to be in the downtown core (13%). The regional dispersion of these places helps explain their low levels of accessibility to jobs using transit.

Transit Ridership and Employment Wages

- Transit use among low-wage workers is lower than high-wage workers. On average, 23% of higher-wage workers use transit, compared to only 11% of low-wage workers. This may indicate that low-wage workers are travelling to and from areas that are not well served by transit, and travelling during off-peak hours.

- Low-wage workers use transit more often between 5:00 to 6:00am. Also, transit ridership for higher-wage workers increases as the distance between their home and work increases. For low-wage workers, distance appears to have the opposite effect.
- There is a large imbalance between the high number of jobs reachable by transit along the western lakeshore corridor (between Toronto and Hamilton) and the number of workers who are within close and easy transit proximity to these jobs.

Recommendations

1. Off- or early peak commuting is important, especially for low-wage earners. Service increases during the early morning, afternoon, and evening need to be considered, especially to the airport and North York region. Increased bus services can be considered in newer lower income neighbourhoods with street layouts that are difficult to serve via rail transit.
2. Lower middle-income areas are more scattered throughout the region. New service should try to connect these areas to employment centers and regional transit hubs.
3. Metrolinx should use accessibility to jobs on a regular basis to evaluate land-use and transportation performance, and to see how this performance changes over time.
4. A better understanding of the existing transit market is recommended to develop policies that are tailored towards different groups of transit users in the region.
5. Future research should focus on fare structure in the region, especially from the most socially disadvantaged and lower-income areas. With presto card’s implementation, fares should help, not hinder, transit use for those less fortunate.
6. Regional standardization, organization, and coordination of online General Transit Feeds Specifications (GTFS) data for all transit operators across the region is essential to the future of transit research in the region.
7. While equity is mentioned as a goal in the Big Move, the concept receives little to no explicit attention throughout the remainder of the document. Equity is a complex concept. Some further thought should be given to what Metrolinx’ concept of equity is, how transit users conceptualize equity, and how – if it is indeed a concept that holds value—it will be inculcated into the planning and operation of transit across the GTHA.
8. Lower middle-income areas requires much more attention with detailed analysis to better understand the transportation needs of residents in these areas and how to fulfill these needs.

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Acronyms and terms

CT	Census Tract
GIS	Geographic Information System
GTHA	Greater Toronto and Hamilton Area
GTFS	Google Transit Feed Specification
Urban core	City of Toronto before it was amalgamated with the surrounding cities in 1993
Inner suburbs	Former independent municipalities (except for the City of Toronto) that are now part of the present City of Toronto.

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1. Introduction

The achievement of equity in the allocation of public resources is a long-term goal for many urban planning departments and transportation agencies. Public transportation systems generate benefits that can reduce economic disparities when transit supply is distributed fairly among different population groups within a region (Grengs, 2010; Jones & Lucas, 2012). Public transportation benefits include high access to desired destinations, shorter travel times, extended operating hours, and shorter waiting and transfer times (Foth, Manaugh, & El-Geneidy, 2013). In other words, the location, quality, and level of service of transit affect people's economic and social opportunities. A fair distribution of transportation resources is expected to provide a variety of options to commuters who do not have many travel choices, while also providing them with shorter commuting times (Krumholz & Forester, 1990). On the other hand, an inequitable distribution of these resources may harm socially and economically disadvantaged groups (Sanchez, Stolz, & Ma, 2003). As a publically provided good, it is necessary to determine if the spatial and temporal distribution of transit services is equitable. Poor or socially disadvantaged communities not only benefit from transit service, but also are more likely to be dependent on transit for their daily travel, making the fair distribution of services even more important.

Purpose of Report

Transportation systems are designed to help people participate in activities distributed over space and time. This report attempts to measure if daily fluctuations in service and accessibility are equitably distributed in the GTHA. In it's most basic form, accessibility measures count how many "potential opportunities" are reachable using a certain travel mode (Hansen, 1959). These measures are often used as an indicator of the collective performance of land use and transportation systems, determining how well the system serves its residents. For this report, we generate transit accessibility measures at different times for the GTHA metropolitan region. Using these measures, we first see if transit use for low-wage workers has different characteristics compared to the transit use of higher-wage counterparts. Secondly, we analyze whether people residing in socially disadvantaged areas in the GTHA experience the same levels of transit accessibility to jobs compared to those living in other, less socially disadvantaged, areas over the course of the day. We also seek to discover whether high levels of accessibility are related to shorter commuting travel times for socially disadvantaged groups. These objectives are relevant as they reflect some of the main goals of *The Big Move*, the regional transportation plan for the GTHA. In particular, it states that "access to frequent, fast and affordable transit is…crucial for equity and social cohesion…There are several pockets of concentrated social need in the GTHA. The transportation system needs to improve the mobility options for people in these areas, connecting at-risk, vulnerable and disadvantaged communities to the jobs, social services, and health care facilities which can improve people's lives" (Metrolinx, 2008, p.8).

In particular, the measures developed in this report go one step further than many previous measures. Previous accessibility measures usually use one time period to represent daily transit service. In contrast, we develop six separate measures that indicate accessibility at different times throughout the day. Using these measures we can discover times and areas where service is lacking and demand is forthcoming. In this way our measure is dynamic: it takes into account daily fluctuations in transit service and job availability. Using these measures we can better assess the region's most vulnerable population's access to employment.

This report is organized into eleven sections. The first section introduces the reader to the literature of accessibility and equity issues in transportation. Second, the data and methodology are described, followed by a description of the study context. The following four sections describe our findings. First, we explore differences in transit mode share between low-wage and higher-wage jobs, seeing if low-wage workers have a harder time using transit to reach employment than their higher-wage counterparts. Next, we present three different ways to define socially disadvantaged groups, and the accessibility these different groups enjoy in the region. We focus on the most socially deprived CTs first, comparing these areas' accessibility to accessibility at other areas. We then expand the focus to include the lowest 20% and then 30% of socially deprived CTs to see if any changes in comparison occur. In this way we can see if the GTHA is equitably providing transit to not just the most deprived, but to other areas that are still at risk. The report points out that an inequitable distribution of accessibility may be hidden by lumping CTs together based on their relative social disadvantage. This is noticeable by comparing the accessibility available to the 2nd and 3rd most socially deprived areas to the accessibility of worse and better-off areas. A final section also looks at the transit use of low-wage workers, and how this compares to higher-wage workers, irrespective of their spatial home or work locations. Two additional sections describe the effect

Go-Train stations have on transit accessibility and what factors are related to high transit accessibility.

2. Literature review

Why Accessibility?

Most people travel daily because they need to reach a destination (work, school, or a store, for instance). Because of this, travel is often seen as a cost of participating in activities (Wachs & Kumagai, 1973). It follows that the relationship between origins and desired destinations should be considered when assessing how well a region's transportation system serves its population. Measures of accessibility take into account how 'reachable' potential destinations are from an area using a certain mode. Areas of high accessibility are beneficial to residents because it takes less time to reach more opportunities from these areas. These residents enjoy 'less costly' travel because they do not have to travel for lengthy periods of time to reach the destinations they desire.

Many recent transportation plans have used accessibility measures, making it the standard for assessing an area's public transportation system. Cities such as San Francisco, Boston, and San Diego all incorporate a form of this measure into their plans, and researchers continue to expand and evaluate this approach (Baradaran & Ramjerdi, 2001; El-Geneidy, Cerda, Fischler, & Luka, 2011; El-Geneidy & Levinson, 2006; Geurs, 2006; Geurs & Ritsema van Eck, 2001; Handy & Niemeier, 1997). Through the years, various measures of accessibility have been developed, from a simple count of potential opportunities accessible in a certain amount of travel time, to more comprehensive measures that take into account the relative attraction opportunities have based on how far away they are.

Accessibility is best at assessing how a transportation network interacts with the distribution of opportunities in a region (the area's land-use situation). In contrast, simple measures of mobility assess how easy travelling on the network is, ignoring what the traveller could potentially reach (Handy, 1994; Hansen, 1959). However, mobility measures are often used in transportation plans because they are easy to calculate and interpret (Geurs & Ritsema van Eck, 2001). Nevertheless, they can be misleading because they do not take into account what people can reach. For example, congestion is often viewed as a negative situation, something that cities should actively try to limit. Yet, using accessibility measures, congestion can be an indicator of the attractiveness or economic health of a city center (Cervero, 1998; Downs, 1992). To better represent this attractiveness, measures of accessibility approximate the ease with which residents reach desired locations. In this way, planners can incorporate how land-use impacts a region's transportation situation, and vice versa (Levinson, Krizek, & Gillen, 2005). By taking these two facets of a region's growth into consideration, more appropriate and accurate transportation projects can be planned. In particular these measures can help reveal populations that are being underserved. The following review will discuss how equity is viewed in transportation planning, and how different accessibility measures can help with assessing the equitable distribution of transit services.

Equity and Transportation Planning

Equity issues are a concern in multiple disciplines, including economics (Atkinson, 1983; Duclos & Araar, 2007), law (Louka, 2006), and medicine (Williams & Cookson, 2000). However, the way in which the concept of equity is understood varies. In economics, equity is about "how the economic 'pie' is divided up" (Field & Olewiler, 2011, p. 4), whereas the Oxford English Dictionary defines equity as the "quality of being fair and impartial"(Soanes & Stevenson, 2003). Equity relates to how certain goods or services are distributed, and if this distribution affects individuals fairly. However, the notion of what can be considered a equitable distribution is complex and differs among individuals and institutions. Moral judgment and socio-cultural norms are often involved (van Wee & Geurs, 2011).

Two notions of equity have been used when assessing transportation services, horizontal equity, vertical equity, and intergenerational equity. The use of these notions can help practitioners compare and contrast different planning intentions with consistency. Horizontal equity refers to the equal distribution of effects (benefits and costs) among individuals. This type of equity, which comes from egalitarian theories, avoids favoring one individual or group over another (Litman, 2002). In contrast, vertical equity requires special considerations for socially and economically disadvantaged groups. Using this notion, benefits should be intentionally provided to those with the greatest need for them (Murray & Davis, 2001). In this case, rather than attempting to provide the same benefit to each individual, vertical equity stipulates that their should be a reparation of benefits to those suffering without them (Litman, 2002). Within the field of transportation planning, Marten et al. (2012) – who are inspired by the concept of vertical equity - suggest that the evaluation of transportation equity should be based on Rawls' Theory of Justice (1971). There are three central points to their method: (a) the average access to transportation and opportunities should be maximized while (b) maintaining a certain minimum for all and (c) containing the range of access (maximum gap) in order to prevent excessive disparities. Researchers use different statistical dispersion tools such as the Gini coefficient (Delbosc & Currie, 2011; Kaplan, Popoks, Prato, & Ceder, 2014), the Theil index (Delafontaine, Neutens, Schwanen, & Van de Weghe, 2011; Geurs & Ritsema van Eck, 2001; Santos, Antunes, & Miller, 2008), the range (Foth et al., 2013), and the coefficient of variation (Ramjerdi, 2006; Talen, 1998) to conceptualize and estimate inequalities (understood as range of accessibility or gaps in accessibility). See Ramjerdi (2006) for an extensive analysis of equity measures. For this report we use the range of accessibility as a measure of equity (van Wee & Geurs, 2011).

In the literature, equity is related directly to spatial, temporal and socio-demographic inequalities or gaps in the distribution of transportation supply and corresponding benefits (Jones & Lucas, 2012). One example is a study by Delbosc and Currie (2011), which assessed horizontal and vertical equity in Melbourne, Australia. They found that low-income households in inner-city areas experience relatively high access to transit. Scott and Honner (2008) researched whether or not opportunities in Louisville, Kentucky were more or less available to groups at risk of social exclusion and to less at-risk groups. A Canadian study focusing on Toronto, by Foth et al. (2013), used an accessibility measure to see if transit equity changed between 1996 and 2006. Both the Scott and Honner and Foth et al. studies suggest that there is a fair distribution of transportation supply among socio-economic groups in their study area. The former study found that groups considered to be at risk of social exclusion are not disadvantaged in term of accessibility to goods and services, whereas the latter found that socially deprived areas experienced better transit accessibility and lower travel times compared to better-off areas.

Accessibility Measures and Equity Issues

The literature reveals that one substantive way to study the equitable distribution of transportation resources is to evaluate the effectiveness of a transit service for different stratified socio-economic groups. Accessibility measures, as previously mentioned, are a comprehensive measure of both the ease of reaching a destination and the availability of desirable destinations. Essentially, these measures can be easily adapted to measuring if a transit service is providing effective service, allowing for a comparison between different groups or areas.

Much of the literature disregards the fact that not all opportunities in a region will be equally attractive, i.e., in a cultural or economic sense, to all populations. In the case of employment opportunities, job-matching considerations and the competition for those jobs should be taken into account (Shen, 1998). Not all job types will be equally attractive to all residents, and unskilled workers or workers with few qualifications cannot access the same job as someone with a specific expertise. In addition, many individuals often compete for the same job, which lessens that job's overall availability (Shen, 1998). By using a competitive measure of accessibility, this study reports how accessible jobs are for GTHA residents, and where these jobs are more or less available because of the competition for them. Moreover, this report assesses this situation not just at one time period, but at multiple periods throughout the day, providing a fine-grained picture of daily accessibility experienced in the GTHA.

In transportation research, it is common practice to calculate accessibility for a certain area of a region at a specific time, and ignore possible variations of this accessibility during the day. Convenient and easy to calculate, this current practice can overestimate the accessibility experienced by individuals, especially for transit users (Anderson, Owen, & Levinson, 2012; Kim & Kwan, 2003). In fact, the assumption that transit accessibility stays constant throughout the day is not acceptable since transit frequency and travel times fluctuate. Furthermore, the availability of jobs also has daily fluctuations. Given this variability in service level and opportunities, it is possible that certain socially and economically disadvantaged groups have unacceptable transit access to jobs at specific periods during the day. Few accessibility studies (Anderson et al., 2012) have tried to include these daily fluctuations, and, to our knowledge, transit equity has never been evaluated *over the day* for socially disadvantaged and non-socially disadvantaged groups. In addition the impact of these fluctuations on commuting travel time among different groups has not, to our knowledge, been explored in the literature.

3. Data and methodology

In order to analyze the fairness of transit availability for low-wage workers and job accessibility from socially disadvantaged areas we measure accessibility using both spatial and temporal measurements. Three main data sources are utilized. The first source is the 2011 National Household Survey provided by Statistics Canada. The data consists of a matrix of CT level data showing the total total number of commuters travelling from each CT to every other CT, as well as the number of travelers by mode, for six time periods: from 5:00am-6:00am, 6:00am-7:00am, 7:00am-8:00am, 8:00am-9:00am, 9:00am-12:00pm, and 12:00pm-5:00am. The 9am-12:00pm and 12:00-5:00am collapses occur because data is suppressed in the National Household Survey when cells contain less than five observations, a frequent occurrence if data were to be presented on an hour-by-hour base during these two time periods. The data was further split according to job category, which will be discussed in detail below. The second dataset used is also sourced from the 2011 National Household Survey, and helped calculate our measure of social deprivation (discussed below). Finally, a travel time matrix is also used.

Social Deprivation Indicator

With the assumption that socially disadvantaged groups are spatially concentrated (Apparicio & Séguin, 2012) , a composite indicator of social deprivation at the CT level is calculated using 2011 National Household Survey data. Essentially, this indicator helps us identify the most deprived areas in the GTHA. This indicator, which was developed in previous research (Foth et al., 2013), is composed of four equally weighted variables: median income, unemployment rate, share of residents who are newly arrived immigrants (landed less than five years ago), and share of tenants spending more than 30% of their income on rent (Maps presenting the spatial distribution of each of these variables in the GTHA are provided in appendix I). Each variable is normalized using a z score. A composite score is then generated by summing these normalized variables (see Foth et al (2013) for details of this measure). For this report, this indicator is grouped by deciles, which shows allows for a comparison of accessibility based on relative social disadvantage. Figure 1 shows the spatial distribution of these deciles across the GTHA. Some CTs are excluded from this report and appear blank on the figure because land use is not residential, or the data are not reported in the National Household Survey.

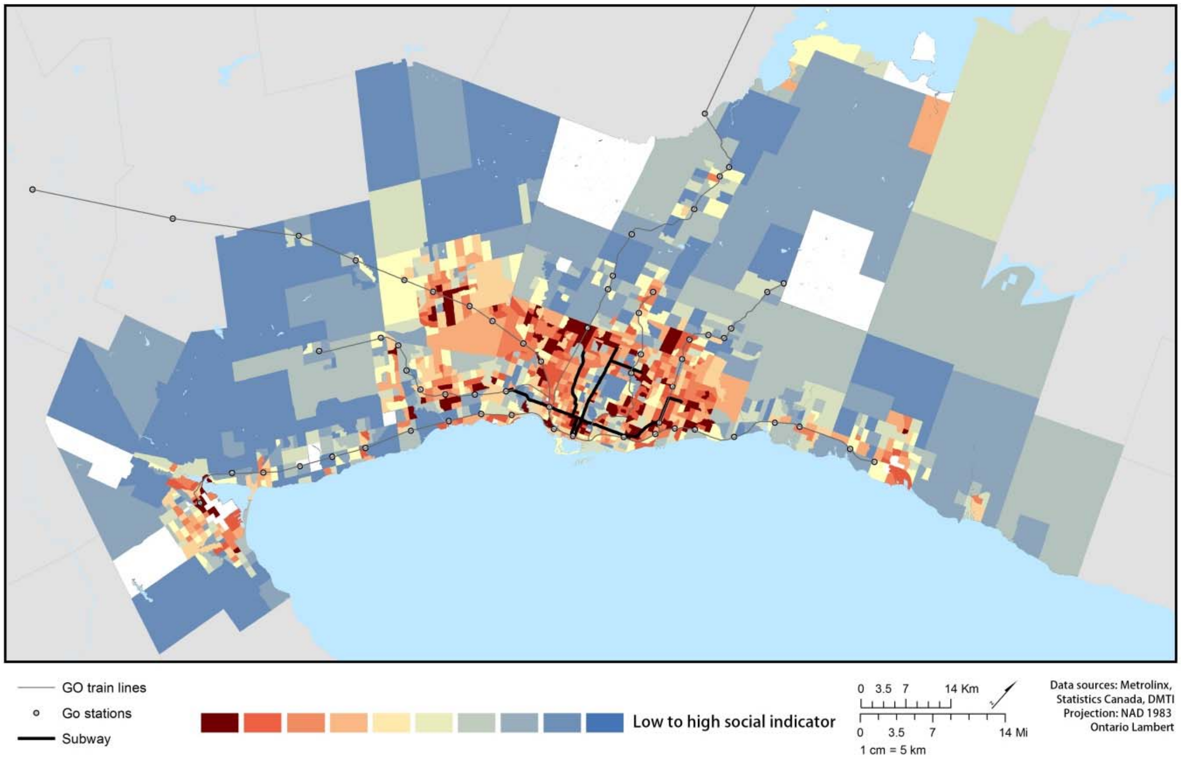


Figure 1: Social indicator deciles, 2011

By rank, the first decile represents the most socially disadvantaged CTs, while the tenth decile accounts for the least socially disadvantaged CTs. To come to a better understanding of the region's equitable allocation of public transportation resources, we look at different decile categories of social disadvantage. We first assess the standing of the most socially deprived CTs (decile 1). We expand this group to include deciles 2 and 3 to assess the standing of the lowest 20% and 30% of deprived CTs, respectively. Finally, we also investigate whether grouping these areas together hides an important difference between decile 1, deciles 2 and 3, and other, less disadvantaged areas.**Figure 1**

Gravity and Competitive Accessibility Measure

To better understand how the GTHA's transport agencies are serving the region over the course of the day we look at two working population groups: the working population who earns $16.00 an hour or less, and those who earn more than $16.00 an hour. These income cut-offs are used because $16.00 is considered to be the living-wage for Toronto (Mackenzie & Stanford, 2008). Throughout the analysis, jobs that pay $16.00 an hour or less are referred to as ‘low-wage jobs’, and those that pay more as ‘all other jobs’ or ‘better paid jobs.’ The list of National Occupation Classification (NOC) subcategories that make on average less than or equal to $16.00 an hour in the Toronto Census Metropolitan Area is generated using the most recent Canada Job Bank wages for Toronto (Government of Canada, 2014). This list is available in appendix IX.

For each group of jobs, two measures of transit accessibility are calculated at the census tract level for the entire region: gravity-based and competitive accessibility.

a. Accessibility to jobs is calculated using the gravity-based (Hansen, 1959):

$$A_i^{\mathrm{PT}} = \sum_{j=1}^{n} D_{e^{-\beta Cij}}$$

Where A_i^{PT} is the accessibility at the centroid of zone *i* to all jobs at zone *j* using public transit. C_{ij} is the travel cost (measured in time) between the centroid of zone *i* and the centroid of zone *j*, and β is a negative exponential cost function. All zones represent census tracts. This cost function is based on a negative exponential decay curve, which is derived from reported work trips in the 2011 National Household Survey linked to transit time estimated using GTFS data (this will be discussed in detail later in the study). This gravity-based approach discounts jobs *(D)* based on how far they are from the origin, considering that jobs farther away are less attractive than those that are closer (Foth et al., 2013). To know how many jobs each CT has we sum the number of people who travel to the CT in question. Similarly, to know the number of workers who reside at each CT, we sum the number of people who depart the CT in question. Competitive accessibility to jobs is considered in order to reveal the places where the accessibility to jobs is high, but the demand for workers is not being met. Inspired by Kawabata and Shen’s measure (2006), we develop a measure to determine competitive accessibility by public transit only:

$$A_i^{\mathrm{PT}} = \sum_j \frac{E_j \mathrm{f}\left(C_{ij}^{\mathrm{PT}}\right)}{\sum_k W_k \mathrm{f}\left(C_{kj}^{\mathrm{PT}}\right)}$$

Where:

A_i^{PT} = Accessibility to jobs at zone i, using public transit

E_j = Number of jobs in zone j

W_k = Number of workers living in zone k

$f(C_{ij}^{\mathrm{PT}})$ and $f(C_{kj}^{\mathrm{PT}})$ are the impedance functions for the travel between i and j, or k and j

In this case, the impedance function is the same β function used in the previously mentioned gravity measure. This measure first discounts the jobs at zone j by the distance they are from i (similar to equation 1). It then divides this discounted number jobs at zone j by the accessibility to workers j has. This measure represents a more refined form of a gravity-based measure because it accounts for the spatial distribution of opportunities on the supply side (e.g. job opportunities) and the competition for those opportunities from the demand side (e.g. workers). This competition can affect the attractiveness of a destination, and accordingly, the travel cost. The approach requires special consideration of job-matching issues (Shen,1998). Throughout the paper, we use standardized values (z-score) of accessibility to compare results. This is necessary because each measure is calculated for not just one time period, bot for our six time periods in question. Accurate comparison across the day required these measures to be standardized so that the magnitude in difference does not distract from the relative change that occurs.

Transit Travel Time & Mean Travel time Per CT

In addition to accessibility measures, this report also uses the estimated transit travel time from home location to work locations at the CT level to me

The travel time from each CT centroid to every other CT centroid at each departure time period in question is calculated using current GTFS data for all eight public transit agencies serving the GTHA. These calculations provide us with a travel time matrix for each departure time period showing travel times for each CT to every other CT. These transit times are estimated using the OpenTripPlanner Analyst, provided by Conveyal (OpenTripPlanner, 2014), which uses GTFS data to determine which route is the fastest option between two points at a certain departure time, and records the time it would take. Travel times from each CT to all other CTs are measured for departures at the top of the hour for each hour under question. For the collapsed time periods (9:00am to noon and noon to 5:00am) an average travel time is calculated. However, for the noon to 5:00am period, travel time at noon is used because of misleadingly long transit times measured during the early morning hours (when most transit systems are closed). The modeled commute times include access and egress time, waiting time, time in vehicle, and transfer time.

Average travel time is the weighted mean travel time for each CT. For a CT, we multiply each trip's travel time by the corresponding number of commuters who took that trip. This number is then divided by the total number of commuters departing from that CT. This was calculated for every departure period in question. However, several CTs did not have any departures during certain time periods, making it impossible to calculate mean travel times at these times. These areas were excluded from the analysis during the period in question. The average number of CTs included in the analysis for each time period is 500 (out of approximately 1300), with a standard deviation of 438. This accurately captures the real travel times taken by residents to reach their desired destinations.

4. Context

The GTHA is the largest urban area in Canada, and is composed of multiple cities and regions: the Cities of Toronto and Hamilton, and the regions of Halton, Peel, Durham, and York (Figure 2). For the purpose of the study, the City of Toronto is divided into two distinct areas: We use the borders of the City of Toronto before it was politically amalgamated with surrounding inner suburban municipalities in 1998 as a base area representing the urban core of the region, including its downtown. Secondly, we take those areas that are part of the present (post-amalgamated) City of Toronto, excluding the urban core, as the City of Toronto's inner suburbs. The GTHA is a dynamic area where the population is growing constantly, particularly within the outer suburbs. Employment areas are also increasingly found in the suburbs as well (Shearmur, Coffey, Dube, & Barbonne, 2007). In 2011, the population of the area was 6 million, with 2.7 million workers and 2.8 million jobs (Limtanakool, Dijst, & Schwanen, 2006).

The region is served by eight public transit agencies collectively providing a commuter rail system (the GO Train), a centrally located subway system and streetcar network, and bus services. Metrolinx itself is primarily charged with the planning of regional transportation services, as well as the operation of the GO Train. The pre-1998 city (referred as Toronto's urban core in this report) is served by streetcars, subways, and bus services – with the inner suburban neighbourhoods primarily served by local buses and some subway stations. To better visualize daily transit service frequency in the region, a video has been made by the Transportation research group at McGill (TRAM) using 2011 data and funded by Metrolinx (Stewart, El-Geneidy, & Buliung, 2014).

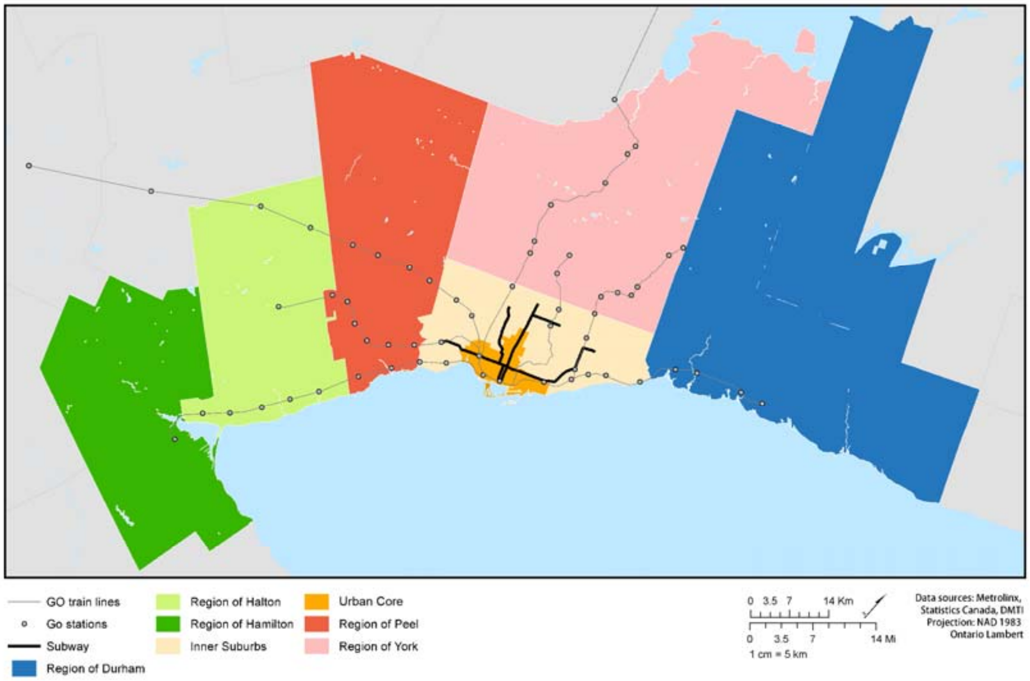


Figure 2: Context map

5. Accessibility for the most disadvantaged areas

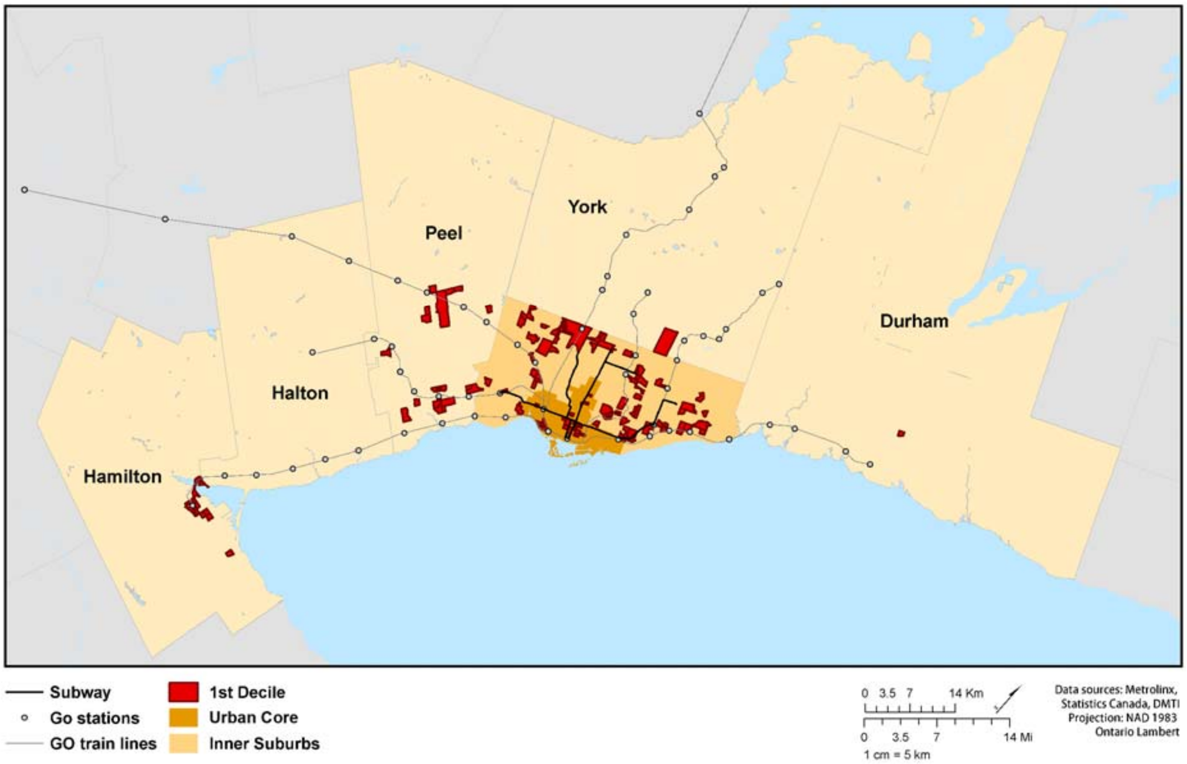


Figure 3: Spatial distribution of the most socially disadvantaged CTs (Decile 1)

The dark red areas in Figure 3 represent the ten percent most socially disadvantaged CTs. Residents of these CTs are more likely to be transit-dependent than residents of other CTs (Foth et al., 2013). While there is a certain concentration of socially disadvantaged CTs in downtown Toronto (18%), most of the socially disadvantaged CTs are located in the inner suburbs of Toronto (56%). They are also found further from downtown Toronto in the outer suburban regional municipalities of Peel (16%), Durham (1%) and York (1%) and in the City of Hamilton (8%). The distribution of these socially deprived areas may be related to a suburbanization of these groups, which is a growing trend in Canadian metropolitan areas (Ades, Apparicio, & Séguin, 2012). This new spatial pattern of socially disadvantaged groups being dispersed throughout the area may be due to a variety of reasons, including increases in housing prices in the Toronto urban core

(Bunting, Walks, & Filion, 2004), the suburbanization of jobs (Shearmur & Coffey, 2002), as well as improvements to the transit network (Foth et al., 2013).

Figure 4 displays the spatial distribution of standardized gravity-based accessibility to both low-wage and higher-earning jobs by CT, while Figure 5 displays the accessibility to workers (low-wage workers and all other workers). Both figures show these measures for two time periods; from 5:00 am to 6:00 am and from 7:00 am to 8:00 am. The standardized values show each CT's relative standing (in terms of values) for the same time period. These two time periods are provided as examples of the fluctuation in accessibility over time. Appendix II (low-wage jobs), appendix III (better-paid jobs), appendix IV (low-wage workers), and appendix V (all other workers) present gravity-based measures of accessibility for each of the six times period analyzed. Figure 6 displays the spatial distribution of the standardized competitive measure of accessibility to jobs (low-wage jobs and better-paid jobs), which simultaneously takes into account the number of jobs accessible and the number of workers accessible, from 5:00 am to 6:00 am and from 7:00 am to 8:00 am. Appendix VI (low-wage jobs) and appendix VII (better-paid jobs) present the full evolution of the competitive measure over a 24-hour time period.

We observe great disparities between regional accessibility to jobs by public transit depending on the accessibility measure used. Generally, the gravity-accessibility maps (Figure 4 and Figure 5) show that the urban core has the highest access to jobs and to workers throughout the day. This is particularly true for accessibility to jobs paying more than $16 an hour. Also, areas near the airport, which is located to the northwest of the City of Toronto, have higher accessibility to low-wage jobs during the 12:00 am to 5:00 am period than the urban core.

In contrast, the competitive measure of accessibility paints a different picture. Accessibility to low-wage jobs and all other jobs shifts toward the west side of the study area, into the Halton and Peel regions (Figure 6, appendix VI & VII). There are more job opportunities available in these regions than people competing nearby to fulfill them. The only time where the urban core area shows better competitive accessibility is during the 5:00 am to 6:00 am period.

It is interesting to compare mean travel time to employment to these accessibility findings. Figure 7 displays the spatial distribution of mean travel time to low-wage jobs available between 8:00 am to 9:00 am. Figure 8 presents the same information but for better-paid jobs. We observe that the closer a CT is to downtown Toronto, the shorter its mean travel time to better-paid jobs. This reveals that there is most likely a high concentration of better-paid jobs in downtown Toronto, and that transit services are most efficient when serving this area. Inversely, we observe that CTs with shorter travel times to low-wage jobs are more spread out across the region (Figure 7). Indeed, many CTs at the extremities of the region have very short mean travel times to low-wage jobs, including CTs on the lakeshore in the Peel and Halton regions, and in the city of Hamilton. In addition, the inner-suburbs of Toronto, where the greatest proportion of decile 1 CTs are located (56%), have very short mean travel times by transit to low-wage jobs. These results tend to indicate that the most socially disadvantaged CTs, especially those located in downtown Toronto and its inner-suburbs, have short travel times to both low-wage and better-paid jobs.

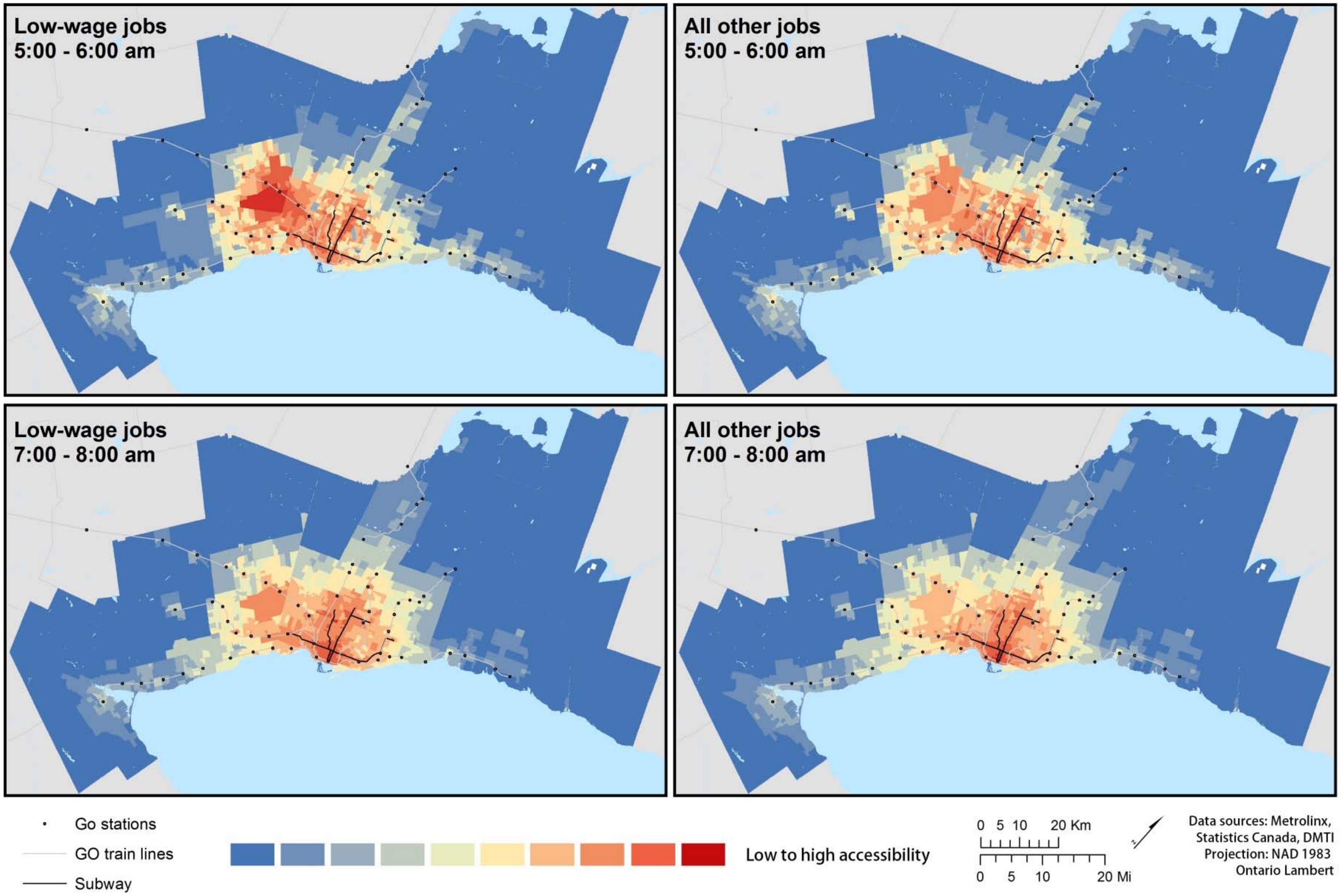


Figure 4: Accessibility to jobs (low-wage jobs and other jobs) using the gravity-based measure, 2011

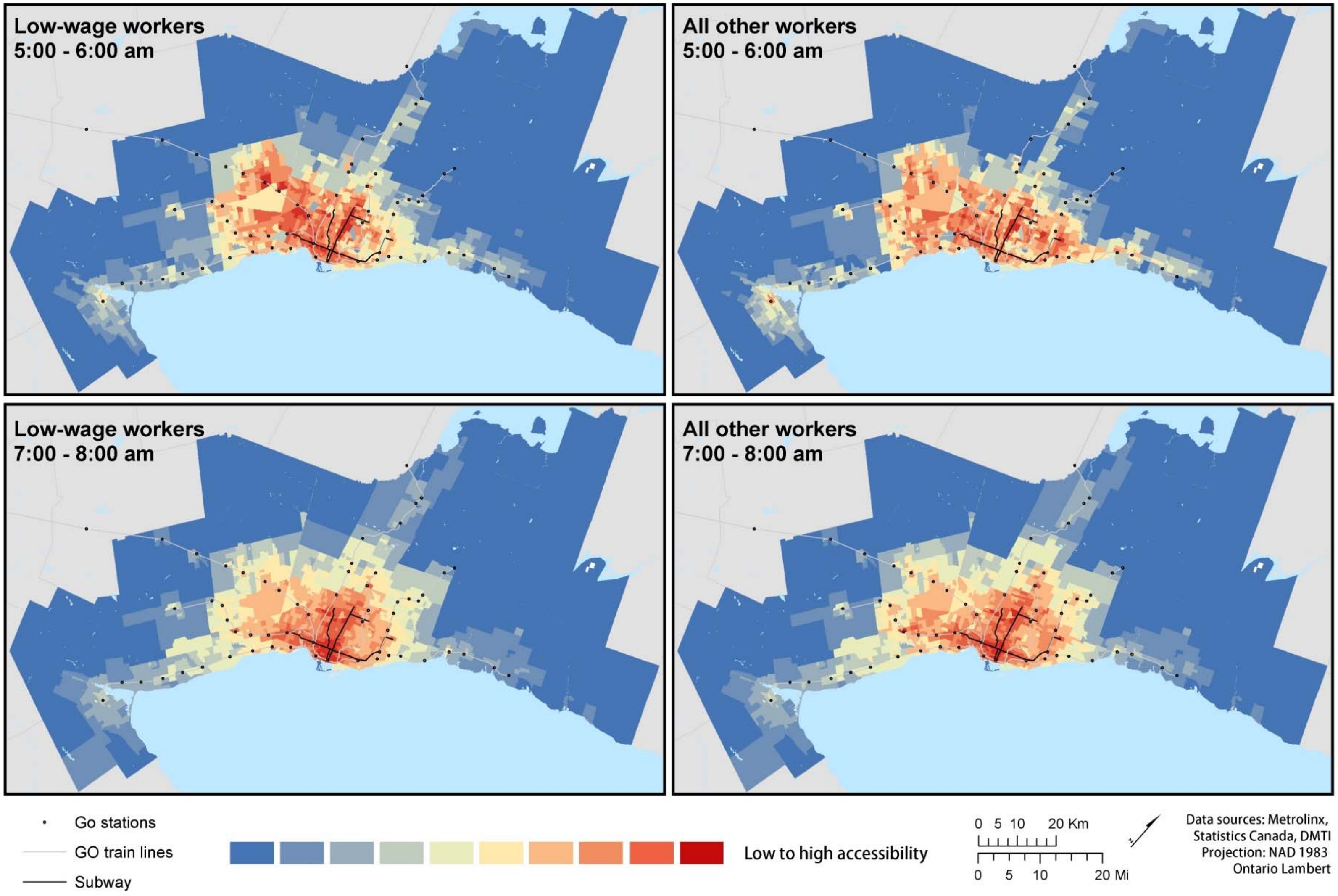
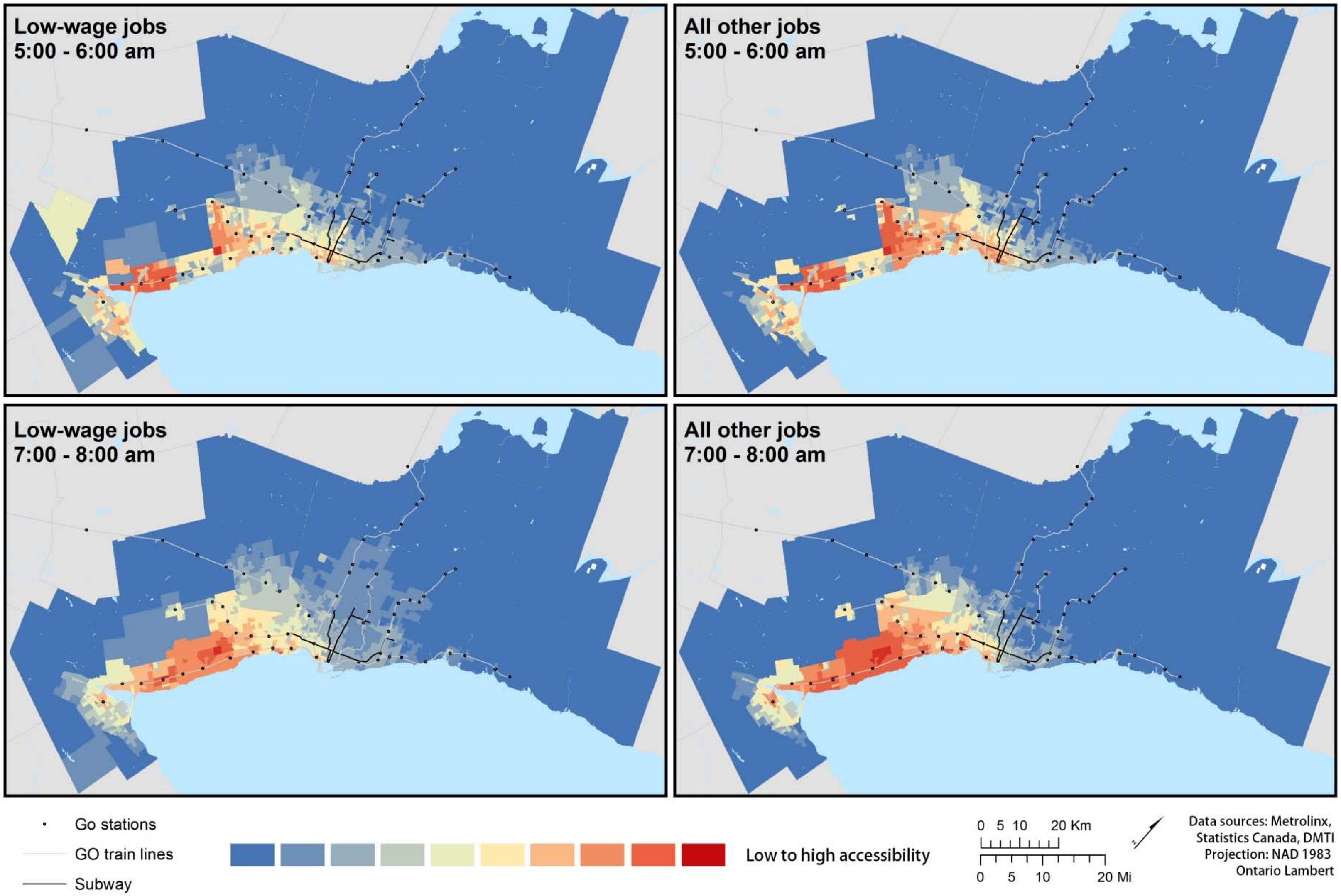


Figure 5: Accessibility to workers (low-wage workers and all other workers) using the gravity-based measure, 2011.



Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

Figure 6: Measurement of employment opportunities using the competitive measure of accessibility, 2011.

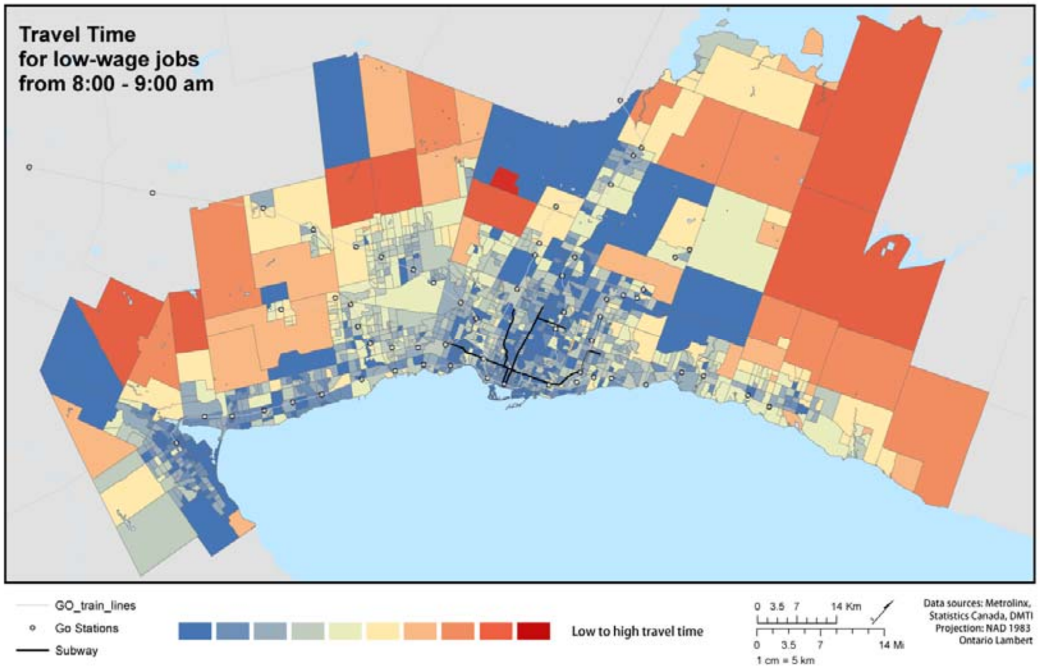


Figure 7: Spatial distribution of mean travel time to low-wage jobs between 8:00 am and 9:00 am.

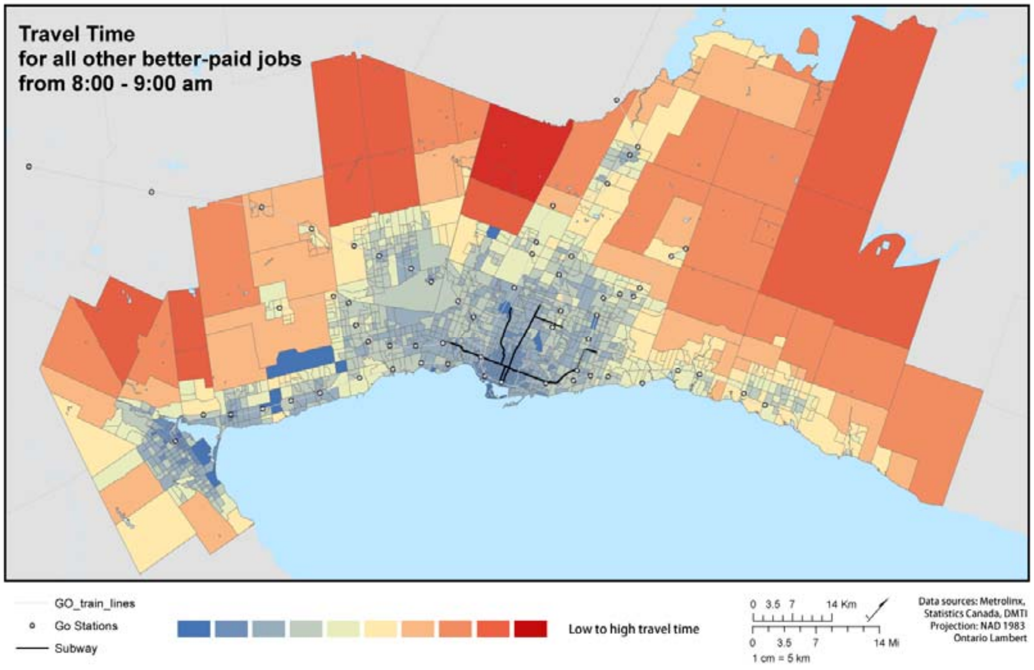


Figure 8: Spatial distribution of mean travel time to higher-wage jobs between 8:00 am and 9:00 am.

Table 1 presents standardized descriptive statistics for our measures of accessibility. The table shows accessibility to low-wage jobs and to all other jobs for the most socially disadvantaged

CTs (decile 1) and compares these findings to those for all other CTs (deciles 2-10). This table also compares travel time statistics. The table makes clear that accessibility to both low and higher-wage jobs from the most socially disadvantaged areas is always greater than accessibility from other, less disadvantaged, areas. These socially disadvantaged areas also enjoy shorter mean travel times. These findings indicate that the most socially disadvantaged CTs generally have better levels of accessibility than all other CTs, and this benefit may result in shorter commuting times for residents. Several correlation matrixes are used to understand the relationship between standardized travel time and accessibility measures. Findings indicate a statistically significant and negative correlation between accessibility to jobs and actual travel time. In other words, when accessibility increases, travel time decreases for trips to both low-income and higher-income jobs.

Furthermore, we are able to observe that the ranges and standard deviations of accessibility measures and mean travel time is narrower for the most socially disadvantaged CTs compared to all other CTs, at all time periods. Consequently, as well as having greater accessibility and shorter mean travel times, the most socially disadvantaged CTs experience less variability in their access to job opportunities.

To summarize, residents of the most socially disadvantaged CTs live in areas with a high level of accessibility to both jobs categories. A bold cell in Table 1 indicates that there is a statistically significant change in accessibility between this time period and the period immediately succeeding it. As can be seen, only a few statistically significant differences in accessibility are found. Due to this finding, the following sections further discuss the results by focusing on both spatial location and time period. For simplification, the discussion will only use the competitive accessibility measure.

Table 1: Standardized descriptive statistics of accessibility and travel times over time (10% most socially disadvantaged CTs)

Accessibility measure	Time	Low-wage jobs					All other jobs				
		Range	Min.	Max.	Mean	Std. Dev.	Range	Min.	Max.	Mean	Std. Dev.
Gra vity acce	5 - 6 AM	3.64	-1.61	2.03	0.69	0.65	3.87	-1.65	2.23	0.74	0.63

	Accessibility for 10% most socially disadvantaged CTs	6 - 7 AM	3.70	-1.50	2.20	0.70	0.69	3.98	-1.47	2.52	0.70	0.73
		7 - 8 AM	3.65	-1.42	2.23	0.68	0.72	3.87	-1.39	2.47	0.68	0.76
		8 - 9 AM	3.56	-1.39	2.18	0.69	0.73	**3.81**	**-1.33**	**2.48**	**0.69**	**0.78**
		9 - 12 PM	**3.82**	**-1.54**	**2.28**	**0.71**	**0.71**	3.83	-1.50	2.33	0.71	0.73
		12 - 5 AM	5.19	-1.52	3.67	0.53	0.73	3.79	-1.58	2.20	0.71	0.68
	Accessibility for all other CTs	5 - 6 AM	4.16	-2.04	2.11	-0.06	1.00	4.24	-2.11	2.13	-0.07	1.00
		6 - 7 AM	4.19	-2.04	2.16	-0.06	0.99	4.40	-1.99	2.41	-0.06	0.99
		7 - 8 AM	4.08	-1.88	2.20	-0.06	0.99	4.21	-1.83	2.38	-0.06	0.99
		8 - 9 AM	4.13	-1.92	2.21	-0.06	0.99	4.21	-1.81	2.40	-0.06	0.99
		9 - 12 PM	4.20	-1.92	2.28	-0.06	0.99	4.15	-1.85	2.31	-0.06	0.99
		12 - 5 AM	13.62	-2.12	11.50	-0.05	1.00	4.14	-1.99	2.16	-0.06	0.99
Competitive accessibility	Accessibility for 10% most socially disadvantaged CTs	5 - 6 AM	2.50	-0.91	1.59	0.12	0.51	**4.31**	**-1.29**	**3.02**	**0.27**	**0.80**
		6 - 7 AM	**3.23**	**-0.98**	**2.24**	**0.07**	**0.63**	3.99	-1.21	2.78	0.14	0.77
		7 - 8 AM	2.72	-0.71	2.01	0.01	0.49	4.28	-1.15	3.12	0.11	0.78
		8 - 9 AM	2.02	-0.58	1.44	0.02	0.37	4.02	-1.02	3.00	0.11	0.70
		9 - 12 PM	**3.67**	**-0.92**	**2.74**	**0.04**	**0.66**	**3.88**	**-1.11**	**2.77**	**0.12**	**0.71**
		12 - 5 AM	3.38	-1.00	2.38	0.07	0.68	3.35	-1.19	2.16	0.19	0.73
	Accessibility for all other CTs	5 - 6 AM	4.12	-1.01	3.12	-0.06	0.72	4.75	-1.41	3.34	-0.05	0.97
		6 - 7 AM	5.29	-1.11	4.17	-0.04	0.85	5.48	-1.38	4.10	-0.03	0.99
		7 - 8 AM	3.60	-0.76	2.83	-0.04	0.63	5.57	-1.25	4.32	-0.02	1.00
		8 - 9 AM	2.98	-0.65	2.34	-0.05	0.54	5.71	-1.16	4.55	-0.02	1.01
		9 - 12 PM	5.13	-0.99	4.14	-0.03	0.91	5.42	-1.19	4.23	-0.02	1.00
		12 - 5 AM	5.49	-1.06	4.43	-0.02	0.98	5.59	-1.27	4.32	-0.03	0.99
Travel time (in minutes)	Accessibility for 10% most socially disadvantaged CTs	5 - 6 AM	27.87	26.43	54.30	39.56	14.00	93.95	17.30	111.25	54.48	25.18
		6 - 7 AM	71.63	12.55	84.18	47.39	19.26	67.27	10.35	77.62	44.17	14.98
		7 - 8 AM	40.32	20.30	60.62	36.75	12.59	**94.86**	**9.48**	**104.33**	**41.84**	**16.82**
		8 - 9 AM	24.02	16.75	40.77	29.37	10.66	**59.19**	**7.93**	**67.13**	**35.38**	**13.05**
		9 - 12 PM	17.58	7.07	24.65	15.70	7.36	**63.42**	**7.60**	**71.02**	**29.97**	**14.31**
		12 - 5 AM	93.75	9.22	102.97	40.35	21.45	114.28	7.72	122.00	38.89	19.44
	Accessibility for all other CTs	5 - 6 AM	**68.10**	**30.83**	**98.93**	**55.94**	**20.99**	**473.90**	**14.27**	**488.17**	**81.58**	**48.56**
		6 - 7 AM	102.25	21.10	123.35	59.23	22.81	**627.58**	**7.32**	**634.90**	**70.39**	**43.81**
		7 - 8 AM	**395.57**	**15.45**	**411.02**	**63.89**	**51.97**	**493.09**	**9.85**	**502.94**	**61.97**	**39.12**
		8 - 9 AM	448.62	9.03	457.65	51.38	56.31	**627.86**	**11.48**	**639.35**	**53.70**	**44.50**
		9 - 12 PM	328.48	9.17	337.65	47.30	41.94	**453.50**	**8.18**	**461.68**	**46.41**	**33.72**
		12 - 5 AM	691.53	7.48	699.02	50.70	53.42	688.83	10.18	699.02	54.87	52.25

Bold indicate indicates statistical significance in means t-test between consecutive time periods, e.g. 9-12 PM period and 12-5 AM period records.

Trends by Social Decile

Figure 9 displays competitive accessibility to each job type over the day, divided by decile. It gives a holistic view of the relationship between accessibility and social deprivation. Figure 9 shows that there are disparities in the distribution of accessibility depending on the level of social deprivation a CT has. A quick visual comparison shows that those CTs in the fifth decile come out on top. They experience better access by transit to low-wage and other-wage jobs throughout the day than any other areas. Also, first decile CTs (our most socially disadvantaged decile) enjoy relatively high accessibility to jobs; they have the second highest level of accessibility to better-paid jobs, and third highest to low-wage jobs. Interestingly, the second and third deciles, which are still CTs with overall higher levels social deprivation, experience a lower level of accessibility to both low-wage jobs and other-wage jobs. This situation is alarming and will be further analyzed in section 7. In addition, the seventh to ninth deciles experience the lowest level of accessibility by transit to job opportunities. These three deciles are more likely to be located in suburban areas, which helps explain their low levels of transit accessibility (Figure 1). Even if these areas are among the least socially deprived in the region, their relative transit accessibility to jobs is worrisomely low.

Figure 9 displays standardized mean commute times, also divided by decile (negative scores indicate shorter travel time positive scores indicate longer travel time). One major trend is clearly illustrated in this figure: mean travel time decreases as deprivation level increases. This indicates that residents of socially disadvantaged areas have shorter travel times to their jobs by transit compared to those who reside in less deprived areas.

Figure 10 displays average commute time for people travelling to lower-paid jobs compared to better-paid jobs by decile. Commutes to low-wage jobs are shorter than commutes to better-paid jobs. These shorter commute times are significant different at the 99% confidence level. Figure 10 clearly displays that this trend occurs in every decile.

Regarding the most socially disadvantaged CTs (those in decile one), the average travel time to low-wage jobs is 31.2 minutes. For other areas, it is 39.8 minutes. This indicates that residents of decile 1 CTs save, on average, nine minutes to reach low-wage jobs compared to people residing in all other CTs. (A finding which is is statistically significant at the 95% confidence level). Moreover, savings are even greater for travel to better-paid jobs. In this case, decile 1 average transit travel time is 40.4 minutes, while it is 60.2 minutes for all other areas (a difference which is also statistically significant). These findings reveal that residents of the most socially disadvantaged CTs experience the shortest travel time to both low-wage jobs and higher-wage jobs compared to all other CTs taken together. The increase in transit travel time as CT groups become less deprived may indicate that less disadvantaged CTs are more often located further from employment opportunities by transit compared to the most disadvantaged CTs. This results also demonstrates that less skilled workers and socially deprived people tend to be located in CTs closer to convenient transit services and to their places of employment, findings which are consistent with the literature (Glaeser, Kahn, & Rappaport, 2008).

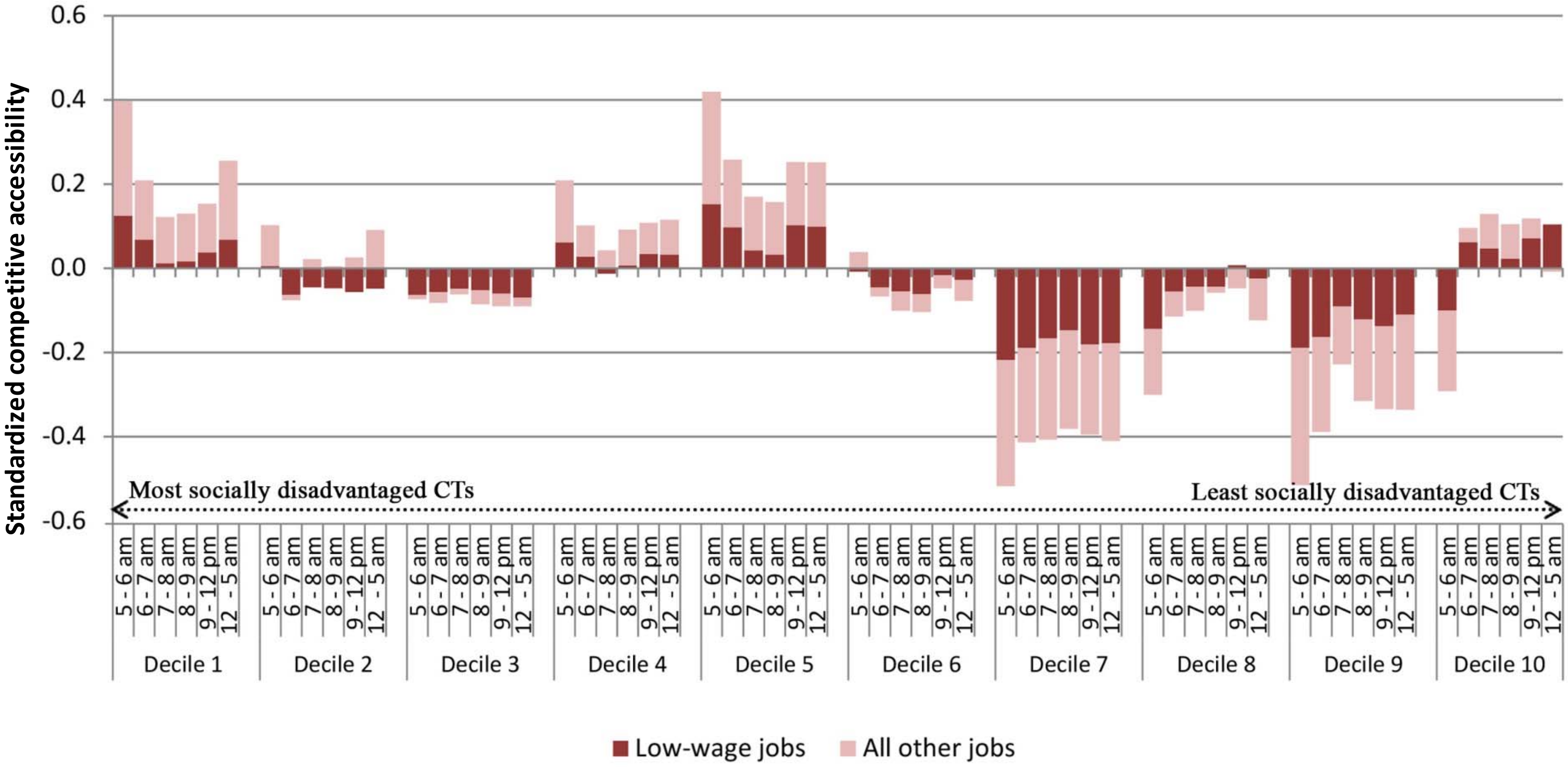


Figure 9: Standardized competitive accessibility to job type by CT decile on the social deprivation scale

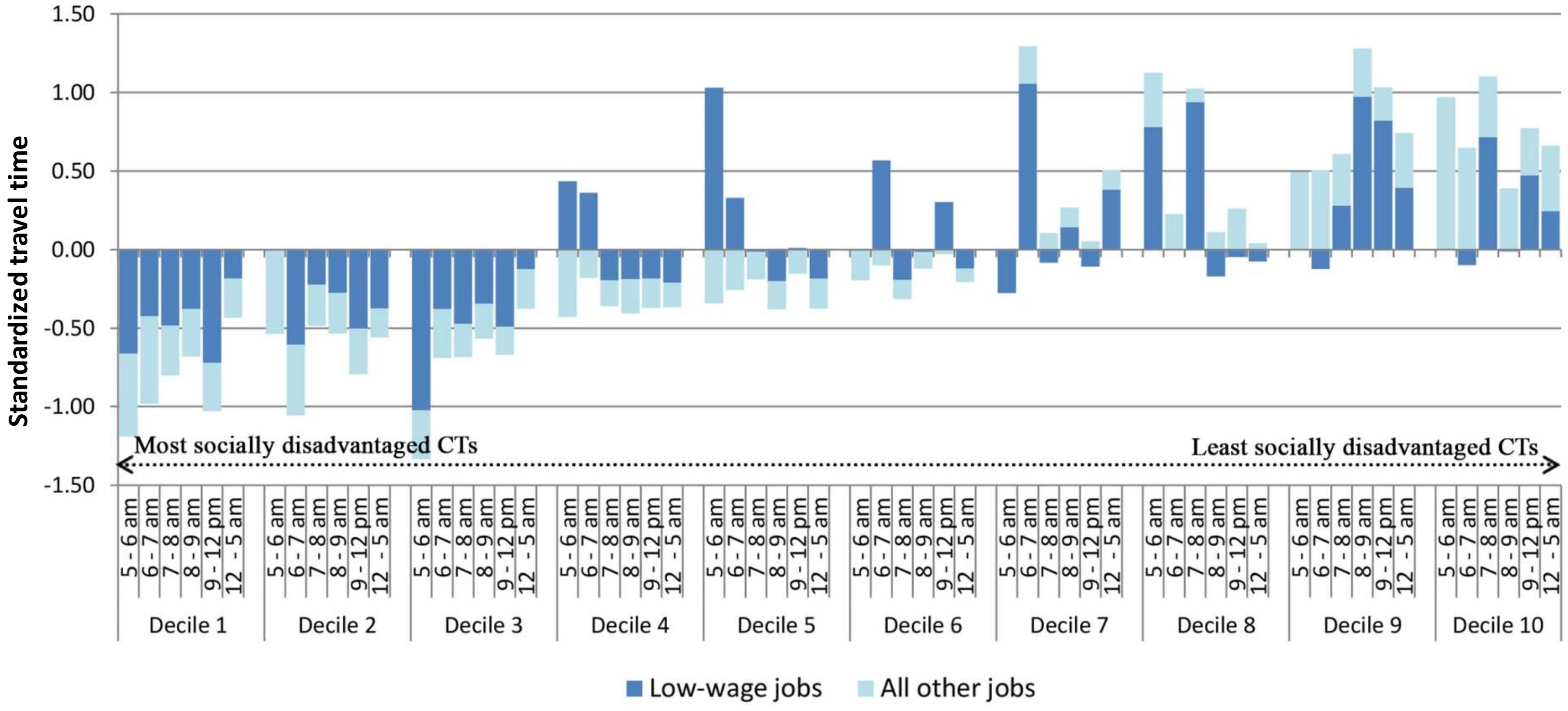


Figure 10: Standardized travel time to job type by CT decile on the scale of social deprivation

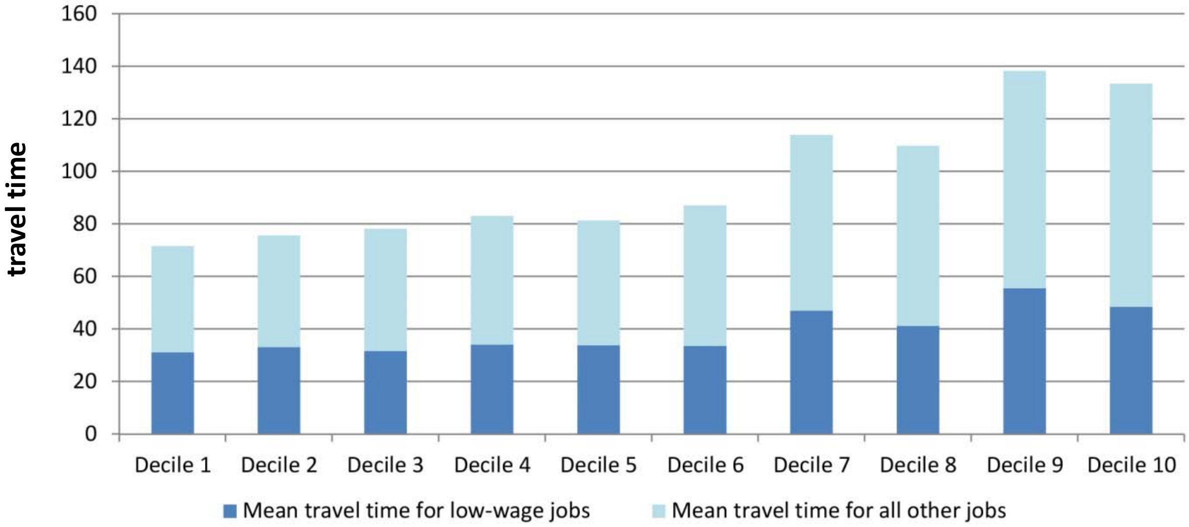
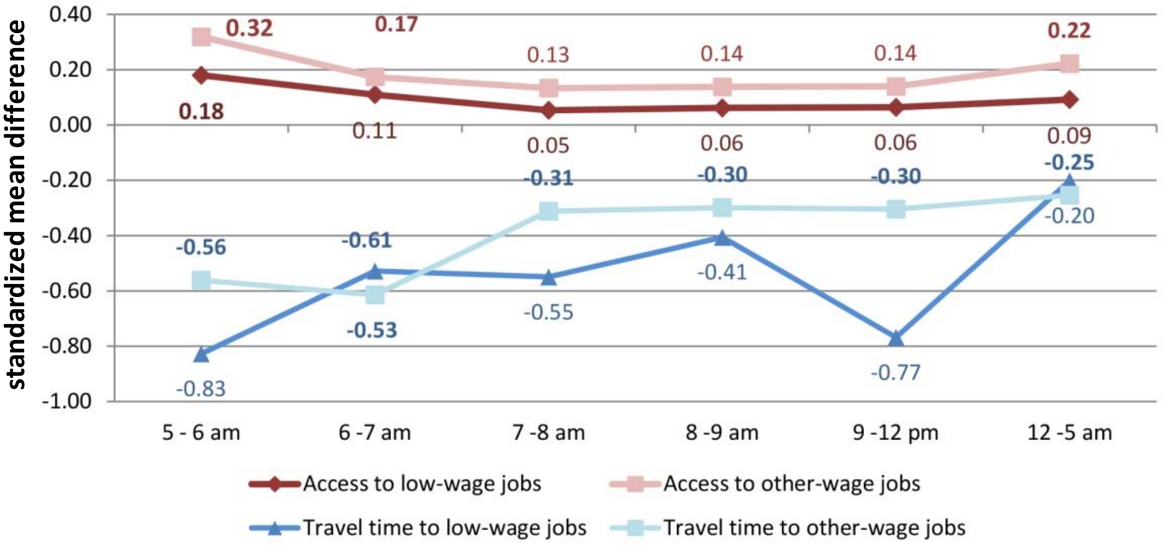


Figure 11: Average travel time to job categories by CT decile (not standardized)

Figure 11 illustrates the mean difference in accessibility and travel time between decile 1 CTs and all other areas over the course of the day. The figure confirms that the most disadvantaged areas in the region enjoy better access to low-wage jobs by transit than all other CTs (red line). Nevertheless, this benefit is only significant from 5:00 am to 6:00 am. Regarding better-paid jobs (the pink line), the most socially-disadvantaged CTs only have statistically better access compared to other CTs between 5:00 am and 6:00 am and from noon to 5:00 am. It is interesting to note that better access to better-paid jobs from the most socially disadvantaged CTs compa occurs early in the morning (between 5:00 am to 7:00 am) and from noon to 5:00 am. Transportation agencies wishing to increase access to employment opportunities for socially disadvantaged people should consider these results when planning transit services.

Regarding transit travel time to jobs, Figure 11 also shows that the most disadvantaged CTs experience consistently shorter transit commute times to low-wage jobs and to better-paid jobs. This finding is consistent with those demonstrated in Figure 8 and Figure 9, found above. While the mean differences in commuting time to better-paid jobs are statistically significant at every time period, they are only significant from 6:00 am to 7:00 am for travel to low-wage jobs. Savings in travel time to low-wage jobs are greater from 5:00 am to 6:00 am and from 9:00 am to noon. In contrast, savings in travel time to better-paid jobs is greatest in the early morning, from 5:00 am to 7:00 am. Again, these temporal differences should be considered when planning new transportation service or schedules.



Bold numbers indicate statistically significant difference (p < 0.05)

Figure 12: Standardized mean difference in access between the most disadvantaged CTs and all other CTs by job type and travel time

Spatial Accessibility of The First Decile Over Time

We have shown that the most socially disadvantaged CTs in the GTHA experience equal or better access to job opportunities than all other CTs taken together. This section aims to understand the spatial variation in accessibility and travel time among socially disadvantaged CTs (decile 1) in different parts of the GTHA region.

Table 2 compares each region's accessibility and travel time to accessibility and travel time in the urban core. Throughout the day, the urban core (which contains 18% of the most socially disadvantaged CTs) has more access to low-wage jobs than the inner suburbs, the Durham and York regions and the city of Hamilton. In contrast, residents of the Halton region, a region that contains no decile 1 CTs, experience better competitive accessibility to low-wage jobs than the urban core between 5:00am and 6:00 am. The Peel region also experiences better accessibility to low-wage jobs compared to the urban core from 9:00 am to noon. Similar results are observed for access to better-paid jobs.

When considering the spatial distribution of the 10% most socially disadvantaged CTs in the GTHA, these results allow us to identify which of these areas experience the best accessibility to jobs in comparison to others. People residing in Peel's most disadvantaged CTs experience the best accessibility to job opportunities compared to other disadvantaged CTs in the GTHA. Coming in second are disadvantaged areas in the urban core. In contrast, the inner suburbs of Toronto, which contain more than 50% of the most socially disadvantaged CTs, have low accessibility to job opportunities when compared to other disadvantaged CTs in the region. Transit agencies that wish to limit public transportation disparities in the region should try to improve transit accessibility in the inner suburbs.

All regions have longer mean transit commute times compared to the urban core. Better transit frequency and better service options in the downtown core (e.g. subways, streetcars and buses) help explain these results. Another possible influencing factor is that workers who work in this area may tend to live much closer to their place of work, and therefore travel shorter distance than others. Overall, these results show that the most socially disadvantaged CTs located in downtown Toronto benefit most in terms of transit travel time.

Table 2: A comparison of accessibility and travel time between the urban core and other regions.

A. Standardized competitive accessibility*						
	Time period					
	5 - 6 am	6 -7 am	7 -8 am	8 -9 am	9 -12 pm	12 -5 am
Low-wage jobs						
Toronto suburbs	**-0.66**	**-0.34**	**-0.21**	**-0.24**	**-0.23**	**-0.30**
Region of Durham	**-1.27**	**-1.06**	**-0.67**	**-0.65**	**-0.85**	**-0.97**
City of Hamilton	**-0.20**	0.18	0.07	-0.04	**-0.16**	-0.14
Region of Halton	0.59	**1.54**	**1.33**	**1.14**	**1.57**	**1.68**
Region of Peel	**-0.28**	0.18	0.29	0.12	**0.67**	0.47
Region of York	**-1.15**	**-0.81**	**-0.49**	**-0.56**	**-0.66**	**-0.86**
Other-wage jobs						
Toronto suburbs	**-0.96**	**-0.49**	**-0.40**	**-0.42**	**-0.43**	**-0.55**
Region of Durham	**-1.91**	**-1.42**	**-1.23**	**-1.23**	**-1.26**	**-1.50**
City of Hamilton	**-0.61**	0.06	-0.08	**-0.29**	**-0.43**	**-0.66**
Region of Halton	0.04	**1.33**	**1.42**	**1.34**	**1.33**	**1.01**
Region of Peel	**-0.27**	0.16	**0.33**	**0.32**	**0.34**	0.05
Region of York	**-1.71**	**1.10**	**-0.92**	**-1.04**	**-1.03**	**-1.32**
B. Standardized travel time*						
Low-wage jobs						
Toronto suburbs	na	**0.98**	0.33	0.07	0.36	**0.19**
Region of Durham	na	2.33	3.07	1.09	0.67	**1.20**
City of Hamilton	na	1.78	0.23	0.09	0.00	**0.39**
Region of Halton	na	1.62	1.11	0.20	0.72	**0.40**
Region of Peel	na	**1.76**	**0.64**	0.43	0.41	**0.44**
Region of York	na	**1.21**	**0.73**	0.90	0.76	**0.48**
Other-wage jobs						
Toronto suburbs	0.59	**0.42**	**0.34**	**0.27**	**0.21**	**0.27**
Region of Durham	**1.74**	**1.67**	**1.07**	**0.87**	**0.81**	0.98
City of Hamilton	0.57	**0.69**	**0.45**	**0.29**	**0.31**	0.35
Region of Halton	**1.87**	1.12	**0.70**	**0.48**	**0.39**	0.48
Region of Peel	**0.76**	**0.69**	**0.54**	**0.51**	**0.49**	0.58
Region of York	**1.15**	**1.02**	0.86	**0.75**	**0.72**	0.59

***Bold** indicates statistically significant mean difference ($p < 0.05$) between the urban core and the case in question
na= not available because of data suppression

Conclusion

A competitive measure of accessibility has been used to compare the most socially disadvantaged CTs with all other CTs. The results of this analysis suggest that the most socially disadvantaged areas in the GTHA experience equitable levels of transit benefits over the course of the day. Access to low-wage jobs and all other jobs from the most socially disadvantaged decile is never significantly lower than average access from all other areas. In other words, the most socially disadvantaged areas (areas with a low median wage, high unemployment, concentrations of recent immigrants, and unaffordable housing costs) have better accessibility to jobs by public transit than the rest of the region. The number of high or low-wage jobs actually accessible using transit from these areas is, on average, 12 times greater than from other areas. These higher levels of accessibility may be linked to travel times: Residents have shorter travel times to their jobs than the rest of the region, spending, on average, 64% less time traveling to work than residents of other areas.

6. Who has the greatest need?

Determining what a fair distribution of transportation resources is, is difficult. Part of the problem is defining what subset of the population needs greater transit service, and why. The previous section focused on transit accessibility to jobs for the 10% most socially disadvantaged CTs in the GTHA region. This threshold was chosen on the supposition that these CTs are areas with the greatest potential transit need. Nevertheless, it would be short-sighted to neglect the presence of socially and economically deprived people in other areas, particularly in CTs in the second and third deciles. Even though these deciles are not as worse off their populations are still experiencing relative social deprivation. In what follows, we looks at accessibility to job opportunities of the three most socially disadvantaged deciles. The objective is to identify which deciles should be included in a study that assesses the fairness of transit service in a region.

Spatial Distribution of the Lowest Three Deciles

Figure 13 and Figure 14 show the spatial distribution of second and third decile CTs. These CTs are often located further from downtown Toronto and are more widely dispersed throughout the region than the first decile.

Table 3 presents the share of CTs in the first, second and third decile by region. 15.9% of the second decile are located in the urban core of Toronto, while just 11.4% of the third decile are. Similar to the first decile, the majority of the second decile is located in the inner suburbs of Toronto (60.6%), whereas only 44.7% of the third decile is located in these suburbs. Furthermore, about 44% of third decile CTs are located outside of the City of Toronto: in Peel (19%), Hamilton (11%), York (7%), Durham (6.1%), and Halton (1.5%). In contrast, only about 24% of the first or second decile CTs are located outside the City of Toronto.

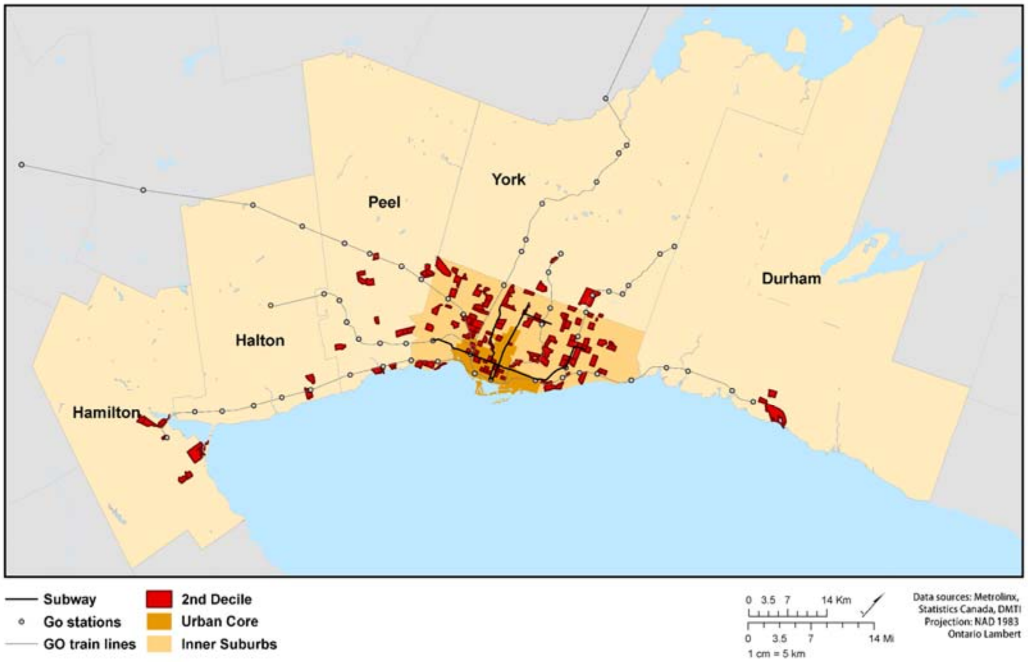


Figure 13: Spatial distribution of the most socially disadvantaged CTs (Decile 2)

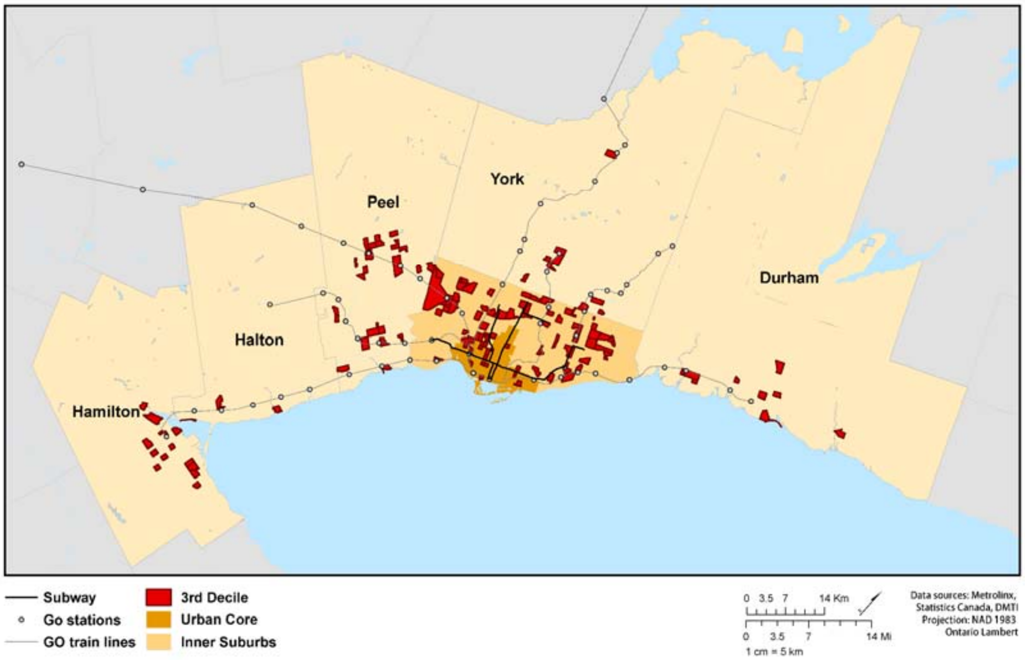


Figure 14: Spatial distribution of the most socially disadvantaged CTs (Decile 3)

Table 3: Percentage of decile in areas of the GTHA

Decile	City of Toronto		
	Urban core (pre-1993)	Inner Suburbs	Total
1st decile	18.2	56.1	**74.2**
2nd decile	15.9	60.6	**76.5**
3rd decile	11.4	44.7	**56.1**
All other deciles	10.6	18.3	**28.9**

Decile	Outside of City					
	Durham	Hamilton	Halton	Peel	York	Total
1st decile	0.8	8.3	0.0	15.9	0.8	**25.8**
2nd decile	2.3	5.3	1.5	11.4	3.0	**23.5**
3rd decile	6.1	10.6	1.5	18.9	6.8	**43.9**
All other deciles	11.4	11.6	11.3	18.2	18.6	**71.1**

Accessibility by Transit to Job Opportunities from the 1st and 2nd Deciles

Table 4 presents descriptive statistics of accessibility to job opportunities and mean travel times experienced by residents of CTs in the first and second deciles combined. In this way, the 20% most socially deprived areas are compared to all other, less deprived, areas. Grouping our deprivation category in this manner does not greatly change our previous findings, which relate to the 10% most socially deprived areas.

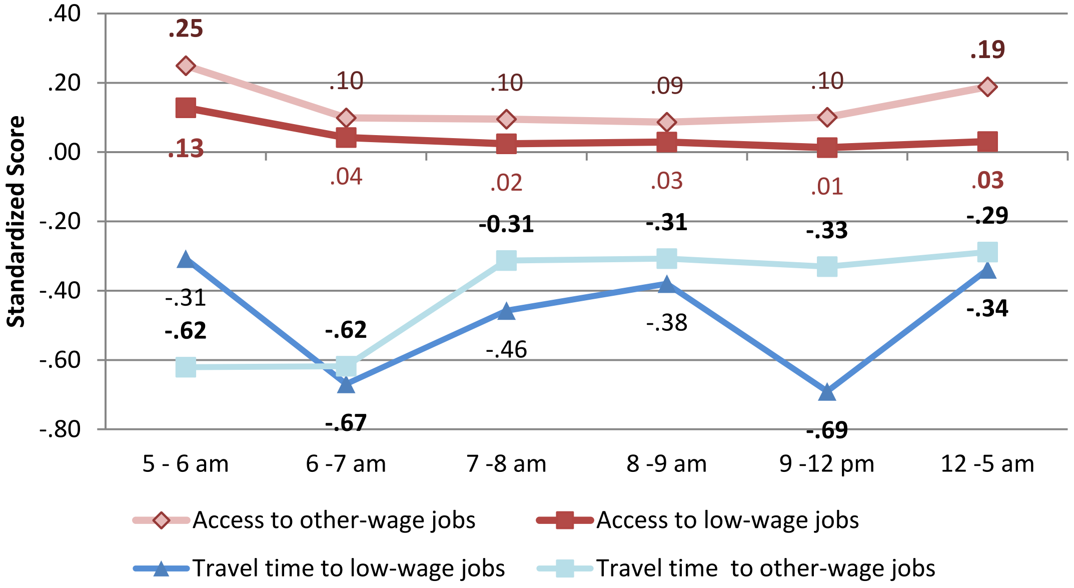
Mean competitive accessibility to both low-wage jobs and better-paid jobs for the 20% most socially disadvantaged CTs is better at all six time periods than all other CTs. However, mean differences are not always statistically significant (Figure 15). Regarding access to low-wage jobs, this difference is only significant between 5:00 am and 6:00 am, which is consistent with the previous analysis, (compare to Figure 12). Regarding access to better-paid jobs, mean differences are only significant early in the morning (from 5:00 am to 6:00 am) and later during the day (from noon to 5:00 am), which is also similar to previous findings. Furthermore, according to Table 4, the range and standard deviation over time for accessibility is narrower for the 20% most socially disadvantaged CTs. These results indicate that with the addition of the second decile in the target group, the accessibility to both job categories is still greater than all other deciles.

Table 4 Standardized descriptive statistics of accessibility and mean travel time (20% most socially disadvantaged CTs)

Accessibility measure		Time	Low-wage jobs					All other jobs				
			Range	Min.	Max.	Mean	Std. Dev.	Range	Min.	Max.	Mean	Std. Dev.
Competitive accessibility	Accessibility for 20% most socially disadvantaged CTs	5 - 6 AM	**2.50**	**-0.91**	**1.59**	**0.06**	**0.50**	**4.33**	**-1.30**	**3.02**	**0.18**	**0.77**
		6 - 7 AM	3.63	-1.00	2.64	0.00	0.61	4.22	-1.24	2.98	0.06	0.75
		7 - 8 AM	3.55	-0.72	2.83	-0.02	0.50	5.50	-1.18	4.32	0.07	0.79
		8 - 9 AM	2.94	-0.60	2.34	-0.02	0.38	5.63	-1.08	4.55	0.06	0.73
		9 - 12 PM	4.20	-0.92	3.28	-0.01	0.65	**4.56**	**-1.11**	**3.45**	**0.07**	**0.71**
		12 - 5 AM	3.99	-1.00	3.00	0.01	0.66	4.08	-1.19	2.89	0.14	0.72
	Accessibility for all other CTs	5 - 6 AM	4.12	-1.01	3.12	-0.06	0.75	4.75	-1.41	3.34	-0.07	1.00
		6 - 7 AM	5.29	-1.11	4.17	-0.04	0.87	5.48	-1.38	4.10	-0.03	1.02
		7 - 8 AM	3.57	-0.76	2.81	-0.04	0.65	5.50	-1.25	4.25	-0.03	1.02
		8 - 9 AM	2.89	-0.65	2.25	-0.05	0.55	5.34	-1.16	4.18	-0.03	1.04
		9 - 12 PM	5.13	-0.99	4.14	-0.02	0.94	**5.42**	**-1.19**	**4.23**	**-0.03**	**1.03**
		12 - 5 AM	5.49	-1.06	4.43	-0.02	1.02	5.59	-1.27	4.32	-0.05	1.02
Travel time (In minutes)	Accessibility for 20% most socially disadvantaged CTs	5 - 6 AM	47.67	26.43	74.10	48.19	20.71	96.48	14.77	111.25	54.35	21.79
		6 - 7 AM	71.63	12.55	84.18	46.88	18.39	94.87	7.32	102.18	46.42	17.59
		7 - 8 AM	64.32	16.62	80.93	43.67	20.46	**94.86**	**9.48**	**104.33**	**43.86**	**16.69**
		8 - 9 AM	42.18	16.75	58.93	32.43	13.62	**76.98**	**7.93**	**84.91**	**36.77**	**14.25**
		9 - 12 PM	37.99	7.07	45.06	21.01	11.47	**63.42**	**7.60**	**71.02**	**30.36**	**13.67**
		12 - 5 AM	93.75	9.22	102.97	35.46	18.76	114.28	7.72	122.00	38.79	19.53
	Accessibility for all other CTs	5 - 6 AM	**68.10**	**30.83**	**98.93**	**54.28**	**21.18**	**473.90**	**14.27**	**488.17**	**84.32**	**49.78**
		6 - 7 AM	102.25	21.10	123.35	60.99	22.94	**625.15**	**9.75**	**634.90**	**72.80**	**45.08**
		7 - 8 AM	**395.57**	**15.45**	**411.02**	**66.67**	**55.47**	**493.09**	**9.85**	**502.94**	**64.06**	**40.67**
		8 - 9 AM	448.62	9.03	457.65	53.02	58.65	**627.86**	**11.48**	**639.35**	**55.60**	**46.47**
		9 - 12 PM	328.48	9.17	337.65	49.43	43.14	**452.70**	**8.98**	**461.68**	**48.19**	**34.87**
		12 - 5 AM	691.53	7.48	699.02	52.86	55.60	688.72	10.29	699.02	56.92	54.67

Bold indicate indicates statistical significance in means t-test between consecutive time periods, e.g. 9-12 PM period and 12-5 AM period records

The 20% most disadvantaged CTs also enjoy shorter travel times. The fluctuation throughout the day of the mean differences in travel time between the 20% most socially disadvantaged CTs and all other CTs are presented in Figure 15. Once again, mean travel times to low-wage jobs are shorter than mean travel times to better-paid jobs between 5:00 am to 6:00 am. Figure 15 also confirms that travel time to better-paid employment opportunities is shorter for the 20% most socially deprived areas.



Bold means it is significant at the 95% confidence interval

Figure 15: Standardized mean differences in competitive access and travel time between 20% most disadvantaged CTs and all other CTs

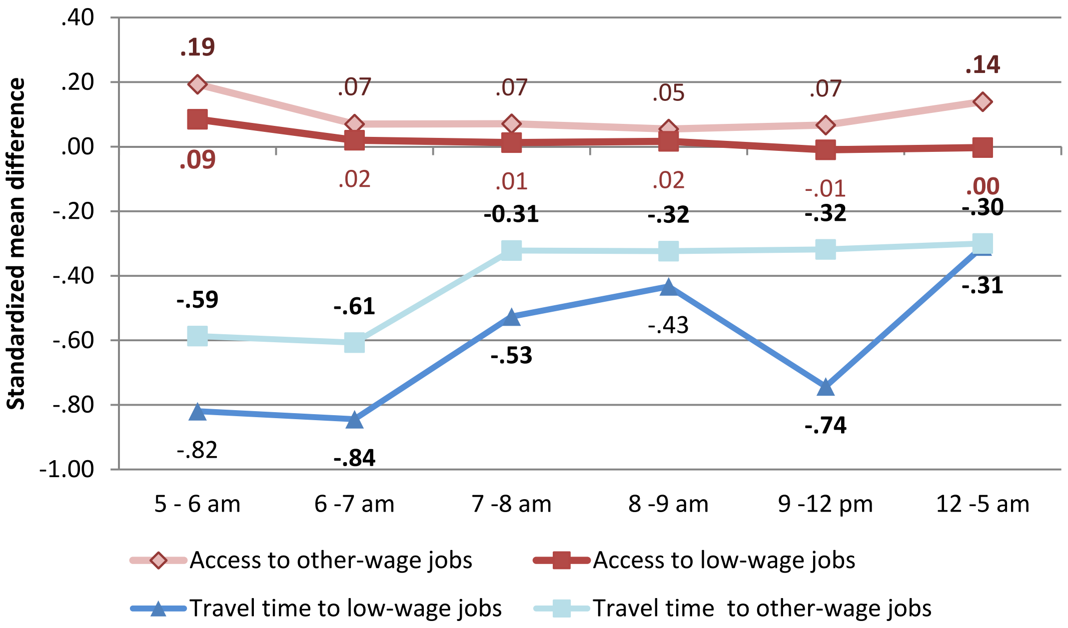
Accessibility to Job Opportunities of the Three Most Socially Disadvantaged Deciles

Table 5 presents descriptive statistics of accessibility and travel time to job opportunities experienced by the three most socially disadvantaged deciles (Decile 1, 2 & 3) relative to all other social deciles in the GTHA. This group represents the 30% most socially deprived areas in the region. Again the addition of another decile into the study group does not change our findings. Similar to our findings for the 10% and 20% most socially disadvantaged CTs, the 30% most socially disadvantaged CTs have better accessibility and shorter mean travel times when compared to all other, less deprived, deciles.

Table 5: Standardized descriptive statistics of accessibility and mean travel time (30% most socially disadvantaged CTs)

	Accessibility measure	Time	Low-wage jobs					All other jobs				
			Range	Min.	Max.	Mean	Std. Dev.	Range	Min.	Max.	Mean	Std. Dev.
Competitive accessibility	Accessibility for 30% most socially disadvantaged CTs	5 - 6 AM	2.65	-0.91	1.73	0.02	0.50	**4.33**	**-1.30**	**3.02**	**0.12**	**0.77**
		6 - 7 AM	3.63	-1.00	2.64	-0.02	0.61	4.24	-1.24	3.00	0.03	0.75
		7 - 8 AM	3.56	-0.73	2.83	-0.03	0.49	5.50	-1.18	4.32	0.04	0.78
		8 - 9 AM	2.94	-0.60	2.34	-0.03	0.38	5.63	-1.08	4.55	0.03	0.73
		9 - 12 PM	4.20	-0.92	3.28	-0.03	0.66	**4.57**	**-1.11**	**3.45**	**0.04**	**0.72**
		12 - 5 AM	4.26	-1.00	3.26	-0.02	0.68	4.51	-1.19	3.32	0.09	0.74
	Accessibility for all other CTs	5 - 6 AM	4.12	-1.01	3.12	-0.06	0.78	4.75	-1.41	3.34	-0.07	1.03
		6 - 7 AM	5.29	-1.11	4.17	-0.04	0.91	5.48	-1.38	4.10	-0.04	1.06
		7 - 8 AM	3.57	-0.76	2.81	-0.04	0.67	5.50	-1.25	4.25	-0.03	1.05
		8 - 9 AM	2.89	-0.65	2.25	-0.04	0.57	5.34	-1.16	4.18	-0.03	1.07
		9 - 12 PM	5.13	-0.99	4.14	-0.02	0.98	**5.42**	**-1.19**	**4.23**	**-0.03**	**1.06**
		12 - 5 AM	5.49	-1.06	4.43	-0.01	1.05	5.59	-1.27	4.32	-0.05	1.06
Travel time (in minutes)	Accessibility for 30% most socially disadvantaged CTs	5 - 6 AM	47.67	26.43	74.10	42.92	18.03	**178.75**	**14.77**	**193.52**	**58.23**	**27.27**
		6 - 7 AM	71.63	12.55	84.18	47.49	17.13	**126.20**	**7.32**	**133.52**	**49.27**	**18.71**
		7 - 8 AM	65.48	15.45	80.93	42.56	20.55	**98.37**	**9.48**	**107.84**	**45.55**	**17.21**
		8 - 9 AM	46.60	12.33	58.93	31.98	13.64	**76.98**	**7.93**	**84.91**	**38.05**	**14.01**
		9 - 12 PM	38.46	7.07	45.52	23.06	10.76	**70.89**	**7.60**	**78.49**	**32.69**	**14.20**
		12 - 5 AM	93.75	9.22	102.97	38.15	18.27	114.28	7.72	122.00	40.19	18.90
	Accessibility for all other CTs	5 - 6 AM	**67.80**	**31.13**	**98.93**	**59.15**	**20.34**	**473.90**	**14.27**	**488.17**	**86.57**	**50.86**
		6 - 7 AM	102.25	21.10	123.35	65.86	23.59	**625.15**	**9.75**	**634.90**	**75.17**	**46.93**
		7 - 8 AM	**394.12**	**16.90**	**411.02**	**69.05**	**56.74**	**493.09**	**9.85**	**502.94**	**66.29**	**42.56**
		8 - 9 AM	448.62	9.03	457.65	55.45	61.23	**627.76**	**11.59**	**639.35**	**57.86**	**49.14**
		9 - 12 PM	328.48	9.17	337.65	53.64	45.32	**452.70**	**8.98**	**461.68**	**49.85**	**36.66**
		12 - 5 AM	691.53	7.48	699.02	54.04	58.58	688.72	10.29	699.02	59.04	58.01

Bold indicate indicates statistical significance in means t-test between consecutive time periods, e.g. 9-12 PM period and 12-5 AM period records



Bold means it is significant at the 95% confidence interval

Figure 16: Standardized mean difference in access and travel time between the 30% most disadvantaged CTs and all other CTs

Conclusion

Overall, in terms of providing for groups that have the greatest potential need for public transit, GTHA's transit providers offer the most socially disadvantaged areas in their region with high levels of accessibility. This is true regardless of the composition of the group studied (decile 1, decile 1 & 2, or decile 1, 2 & 3). There is only one main difference observed by the successive addition of the second and the third decile into the study group; the enlargement of the group reduces its overall advantage in accessibility. These groupings still have better transit accessibility to low-wage jobs and better paid-jobs, but the accessibility is lower than what it is for the first decile alone. This may indicate that deciles 2 and 3 may be in a precarious situation when compared to decile 1. To better understand this possibility, the next section looks at deciles 2 and 3 together, comparing their level of transit service to the most socially disadvantaged CTs (decile 1) and to all other CTs (decile 4 and above).

7. In focus: 2nd and 3rd deciles

Transit service to socially deprived areas, whether those areas are defined as the bottom 10%, 20%, or 30% of the social deprivation index, is in good shape. Those CTs with the greatest transit need have higher accessibility and shorter travel times to employment opportunities. Although mean values decrease slightly when we look at 20% compared to 10%, or 30% compared to 20%, CTs that are socially deprived are in a favorable transit position when compared to less socially deprived CTs in the GTHA. In particular, the lowest 30%, although not as spatially concentrated in the core as the lowest 10%, are generally located closer to the center of the region than less socially deprived deciles (see Figure 1 and Table 3). This spatial configuration indicates that although the cost of living in the region may be rising—the index price for a home rose almost 8% in 2014, to just over 0.5 million dollars (Toronto Real Estate Board, 2014)—those with less means are still able to live in areas where jobs are accessible by transit.

However, Figure 2 reveals that there is a difference in transit service between the most socially deprived decile (decile 1), and the deciles immediately succeeding it, deciles 2 and 3. In other words, while deciles 2 and 3 are in the bottom half of the scale of social deprivation, these deciles experience lower accessibility to low-wage jobs and better-paid jobs than deciles 1, 4 and 5. These deciles' relative transit disadvantage is hidden when they are combined into 20% or 30% divisions of social deprivation. This difference between the 1st decile and the 2nd and 3rd deciles indicates that although the transit system in the GTHA is doing a good job serving the most socially deprived CTs, there are CTs on the lower half of the social deprivation index in need of better transit service. These areas and their populations, although not in as dire a social situation as CTs in the 1st decile, are areas where more transit service is needed, and where an increase in transit ridership is perhaps more likely to occur with such increases.

To better investigate the disadvantage these CTs have, we combine CTs in deciles 2 and 3 and compare their situation to CTs in decile 1 (our most socially deprived decile) and to CTs in deciles 4 and greater. It should first be noted that CTs in decile 1 are more heavily located in the urban core of Toronto (18%) than either the 2nd or 3rd decile (16% and 11%, respectively). The population located in deciles 2 and 3, although still socially deprived, may be have less equitable access to jobs using transit because of their dispersal throughout the region. They may, with the income they earn, be deciding to live in areas that are affordable and offer better living standards (better schools, housing, and safety) from those experienced in the most socially deprived CTs. This combination of affordability and amenity is perhaps most likely found outside of the urban core (Glaeser et al., 2008), which may help explain the high percentage of CTs in deciles 2 and 3 located outside of this area.

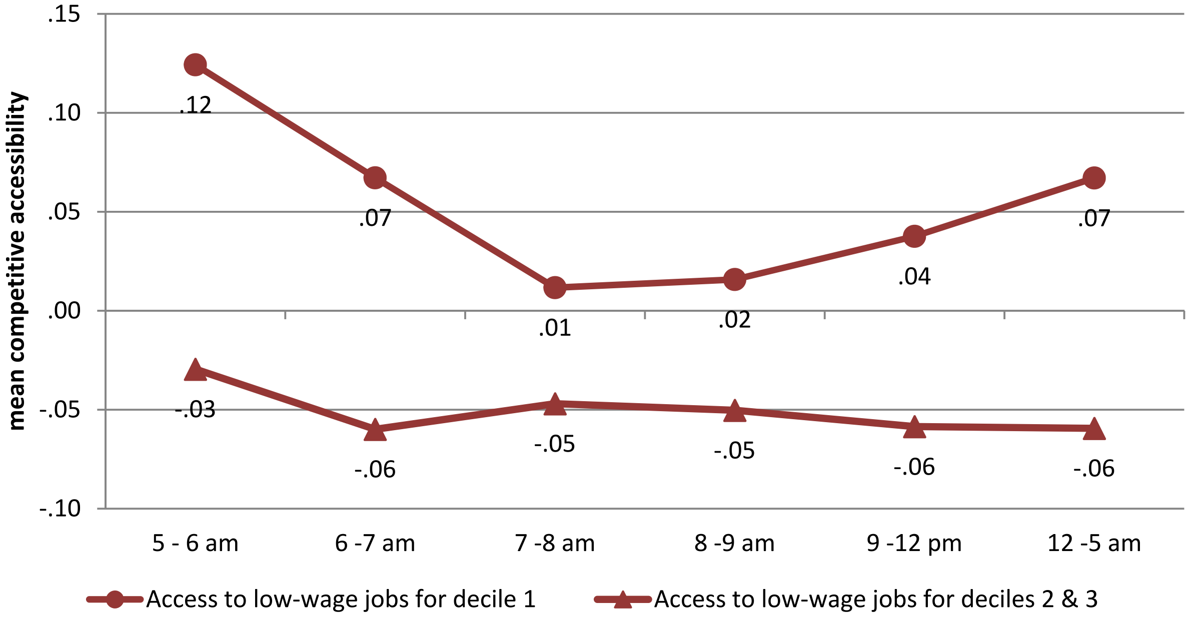
Table 6 shows descriptive statistics for accessibility to jobs for three categories (decile 1, deciles 2 and 3, and deciles 4 and greater). When compared to decile 1, deciles 2 and 3 have lower accessibility to both low-wage and all other jobs. This difference is statistically significant in the early morning (5:00 am-6:00 am for low-wage jobs, 5:00 am-7:00 am for all other jobs).

Table 6. Comparing deciles 1, 2 & 3, and 4

	Time	Low-wage jobs					All other jobs				
		Range	**Min.**	**Max.**	**Mean**	**Std. Dev.**	**Range**	**Min.**	**Max.**	**Mean**	**Std. Dev.**
Accessibility for Decile 1	5 - 6 AM	2.50	-0.91	1.59	0.12	0.51	**4.31**	**-1.29**	**3.02**	**0.27**	**0.80**
	6 - 7 AM	**3.23**	**-0.98**	**2.24**	**0.07**	**0.63**	3.99	-1.21	2.78	0.14	0.77
	7 - 8 AM	2.72	-0.71	2.01	0.01	0.49	4.28	-1.15	3.12	0.11	0.78
	8 - 9 AM	2.02	-0.58	1.44	0.02	0.37	4.02	-1.02	3.00	0.11	0.70
	9 - 12 PM	3.67	-0.92	2.74	0.04	0.66	**3.88**	**-1.11**	**2.77**	**0.12**	**0.71**
	12 - 5 AM	3.38	-1.00	2.38	0.07	0.68	3.35	-1.19	2.16	0.19	0.73
Accessibility for Deciles 2 & 3	5 - 6 AM	2.65	-0.91	1.73	-0.03	0.48	3.54	-1.30	2.24	0.04	0.75
	6 - 7 AM	3.63	-1.00	2.64	-0.06	0.60	4.24	-1.24	3.00	-0.02	0.74
	7 - 8 AM	3.56	-0.73	2.83	-0.05	0.49	5.50	-1.18	4.32	0.00	0.79
	8 - 9 AM	2.94	-0.60	2.34	-0.05	0.39	5.63	-1.08	4.55	-0.01	0.74
	9 - 12 PM	4.20	-0.92	3.28	-0.06	0.66	**4.57**	**-1.11**	**3.45**	**0.00**	**0.73**
	12 - 5 AM	4.26	-1.00	3.26	-0.06	0.68	4.51	-1.19	3.32	0.03	0.74
Accessibility for Deciles > 3	5 - 6 AM	4.12	-1.01	3.12	-0.06	0.78	4.75	-1.41	3.34	-0.07	1.03
	6 - 7 AM	5.29	-1.11	4.17	-0.04	0.91	5.48	-1.38	4.10	-0.04	1.06
	7 - 8 AM	3.57	-0.76	2.81	-0.04	0.67	5.50	-1.25	4.25	-0.03	1.05
	8 - 9 AM	2.89	-0.65	2.25	-0.04	0.57	5.34	-1.16	4.18	-0.03	1.07
	9 - 12 PM	5.13	-0.99	4.14	-0.02	0.98	**5.42**	**-1.19**	**4.23**	**-0.03**	**1.06**
	12 - 5 AM	5.49	-1.06	4.43	-0.01	1.05	5.59	-1.27	4.32	-0.05	1.06

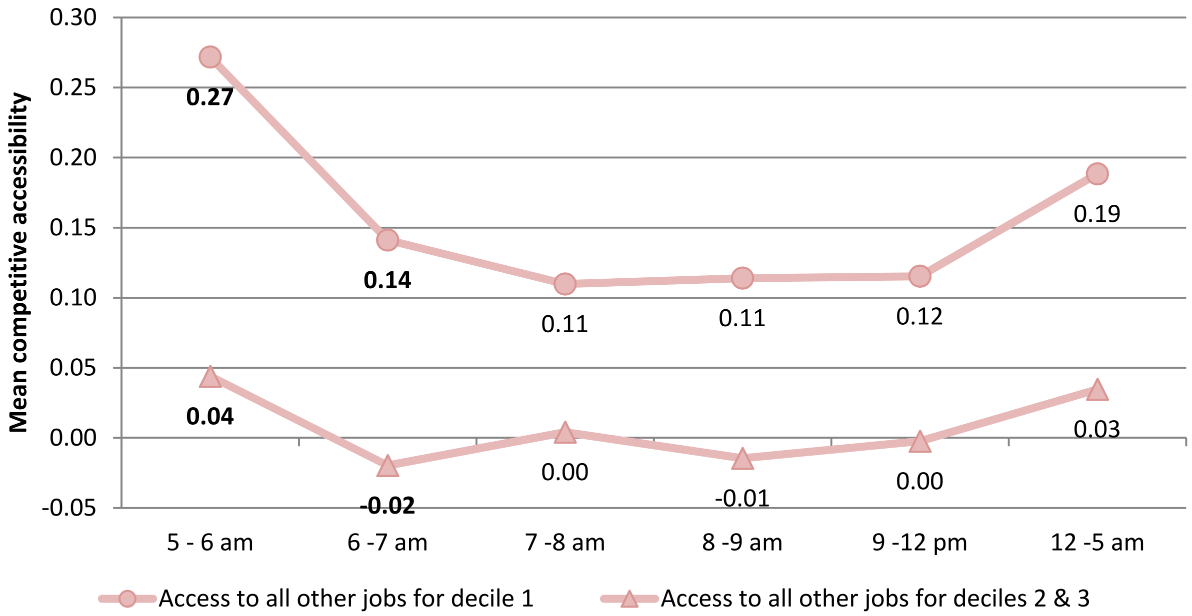
Bold indicate indicates statistical significance in means t-test between consecutive time periods, e.g. 9-12 PM period and 12-5 AM period records

Figure 17 and Figure 18 show that the difference in accessibility between the 1st decile and the 2nd and 3rd deciles is greatest in the morning and evening. In contrast, there is the least amount of difference during the morning peak travel period (between 7:00 am and 9:00 am, see Appendix IX). However, this effect is not due to an increase in accessibility for deciles 2 and 3. Rather, it is due to a decrease in accessibility for decile 1 during the peak (accessibility to both job categories for decile 1 is at its lowest point between 7:00 am to 9:00 am). This demonstrates that residents from CTs in deciles 2 and 3 suffer from a relative lack of transit service when compared to residents from CTs in decile 1. Although the gap may narrow during peak travel times, it does not indicate an increase in transit service for populations in the second and third deciles.



Bold means it is significant at the 95% confidence interval

Figure 17: Mean accessibility of deciles 1 and 2 & 3 to low-wage jobs.



Bold means it is significant at the 95% confidence interval

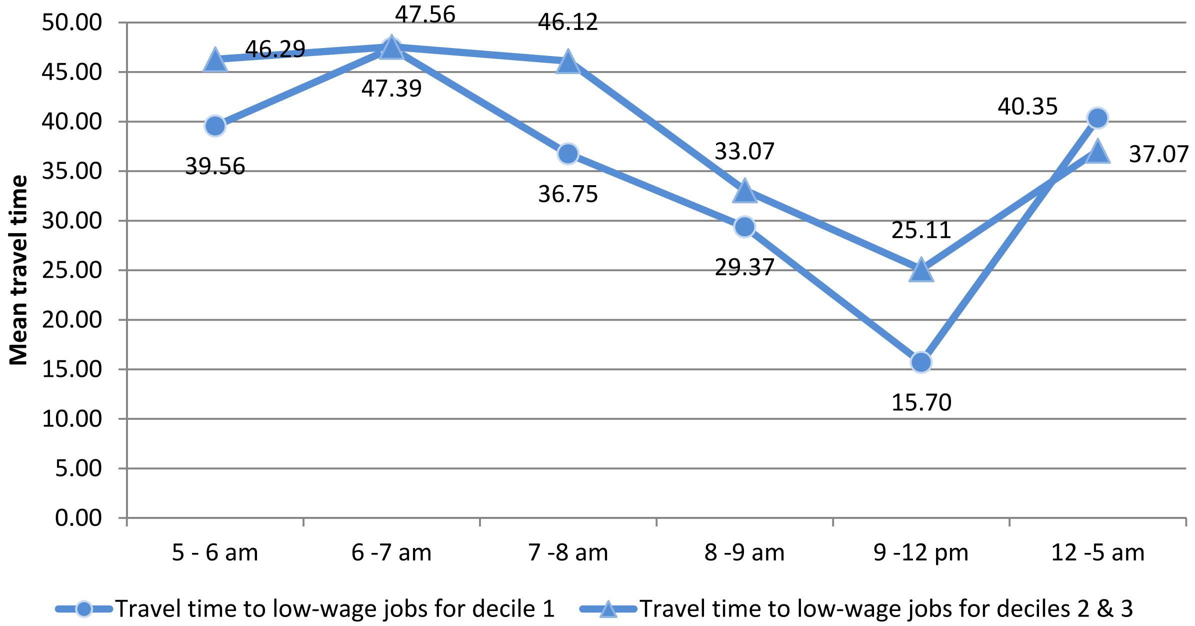
Figure 18: Mean accessibility of deciles 1 and 2 & 3 to all other jobs.

This relative disadvantage is also present when looking at mean travel times (see Table 7). Mean travel to work from decile 1 is almost always shorter than travel from deciles 2 and 3 using transit (see Figure 19 and Figure 20). For instance, between 9:00 am and noon the mean difference in travel time is almost a full 10 minutes for commuting to low-wage jobs between these two decile groups. These differences, however, are only statistically significant for travel to all other jobs at departures between 6:00 am and noon, where the average difference is around 5 minutes.

Table 7: Transit time descriptive statistics for decile 1, 2 & 3, and all other deciles.

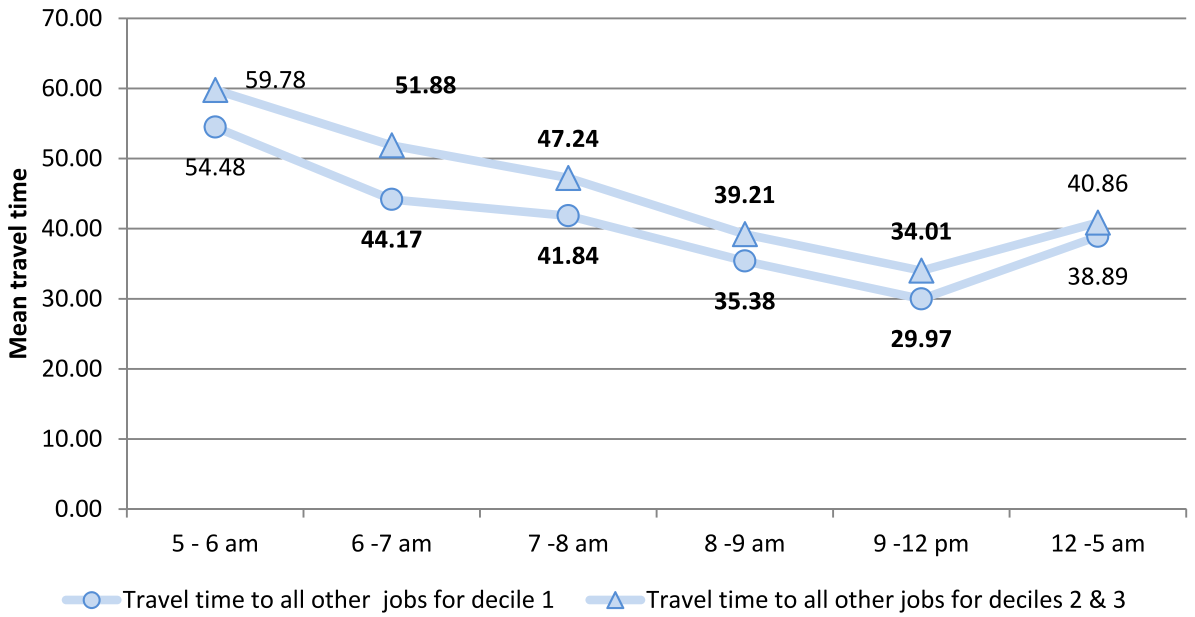
	Time	Low-wage jobs					All other jobs				
		Range	Min.	Max.	Mean	Std. Dev.	Range	Min.	Max.	Mean	Std. Dev.
Travel time for Decile 1	5 - 6 AM	27.87	26.43	54.30	39.56	14.00	93.95	17.30	111.25	54.48	25.18
	6 - 7 AM	71.63	12.55	84.18	47.39	19.26	67.27	10.35	77.62	44.17	14.98
	7 - 8 AM	40.32	20.30	60.62	36.75	12.59	**94.86**	**9.48**	**104.33**	**41.84**	**16.82**
	8 - 9 AM	24.02	16.75	40.77	29.37	10.66	**59.19**	**7.93**	**67.13**	**35.38**	**13.05**
	9 - 12 PM	17.58	7.07	24.65	15.70	7.36	**63.42**	**7.60**	**71.02**	**29.97**	**14.31**
	12 - 5 AM	93.75	9.22	102.97	40.35	21.45	114.28	7.72	122.00	38.89	19.44
Travel time for Deciles 2 & 3	5 - 6 AM	43.27	30.83	74.10	46.29	24.13	**178.75**	**14.77**	**193.52**	**59.78**	**28.18**
	6 - 7 AM	53.35	22.75	76.10	47.56	15.93	**126.20**	**7.32**	**133.52**	**51.88**	**19.90**
	7 - 8 AM	65.48	15.45	80.93	46.12	23.82	**97.98**	**9.87**	**107.84**	**47.24**	**17.16**
	8 - 9 AM	46.60	12.33	58.93	33.07	15.00	**73.43**	**11.48**	**84.91**	**39.21**	**14.27**
	9 - 12 PM	35.34	10.18	45.52	25.11	10.80	**70.31**	**8.18**	**78.49**	**34.01**	**14.00**
	12 - 5 AM	78.13	10.53	88.67	37.07	16.55	101.49	10.18	111.68	40.86	18.64
Travel time for Deciles > 3	5 - 6 AM	**67.80**	**31.13**	**98.93**	**59.15**	**20.34**	**473.90**	**14.27**	**488.17**	**86.57**	**50.86**
	6 - 7 AM	102.25	21.10	123.35	65.86	23.59	**625.15**	**9.75**	**634.90**	**75.17**	**46.93**
	7 - 8 AM	**394.12**	**16.90**	**411.02**	**69.05**	**56.74**	**493.09**	**9.85**	**502.94**	**66.29**	**42.56**
	8 - 9 AM	448.62	9.03	457.65	55.45	61.23	**627.76**	**11.59**	**639.35**	**57.86**	**49.14**
	9 - 12 PM	328.48	9.17	337.65	53.64	45.32	**452.70**	**8.98**	**461.68**	**49.85**	**36.66**
	12 - 5 AM	691.53	7.48	699.02	54.04	58.58	688.72	10.29	699.02	59.04	58.01

Bold indicate indicates statistical significance in means t-test between consecutive time periods, e.g. 9-12 PM period and 12-5 AM period records



Bold means it is significant at the 95% confidence interval

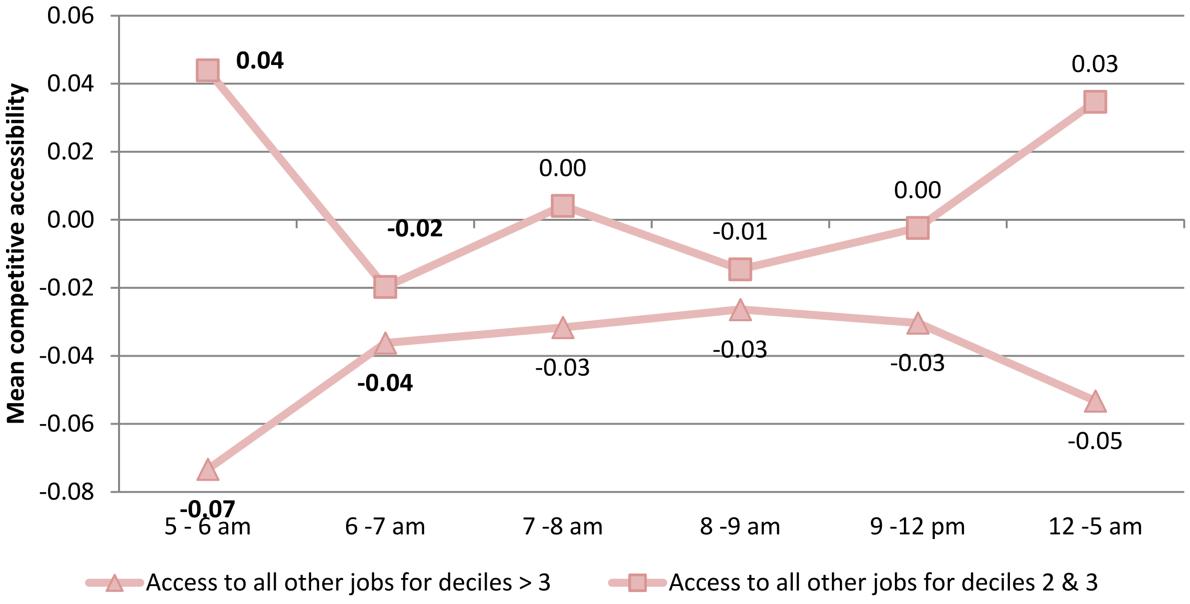
Figure 19: Mean travel time from deciles 1 and 2 & 3 to low-wage jobs.



Bold means it is significant at the 95% confidence interval

Figure 20: Mean travel time from deciles 1 and 2 & 3 to all other jobs.

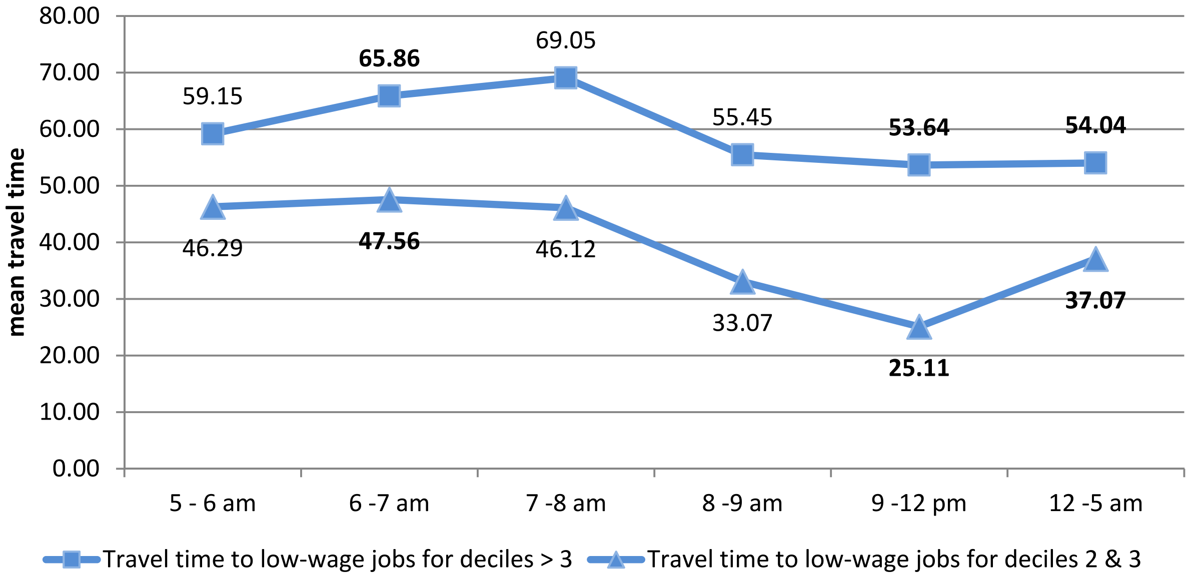
The relative disadvantage deciles 2 and 3 have in transit service when compared to decile 1 is only part of the picture. A comparison between deciles 2 and 3 and all other, higher, deciles also reveals this group’s unique and precarious transit situation in the GTHA. There is a worrisome difference between accessibility to low-wage jobs and accessibility to all other jobs when we compare accessibility between these two groups: To all other jobs, deciles 2 and 3 enjoy better access than CTs in deciles 4 and greater. This is especially true between 5:00 am and 7:00 am (where this difference is significant) and between noon and 5:00 am (see Figure 21).



Bold means it is significant at the 95% confidence interval

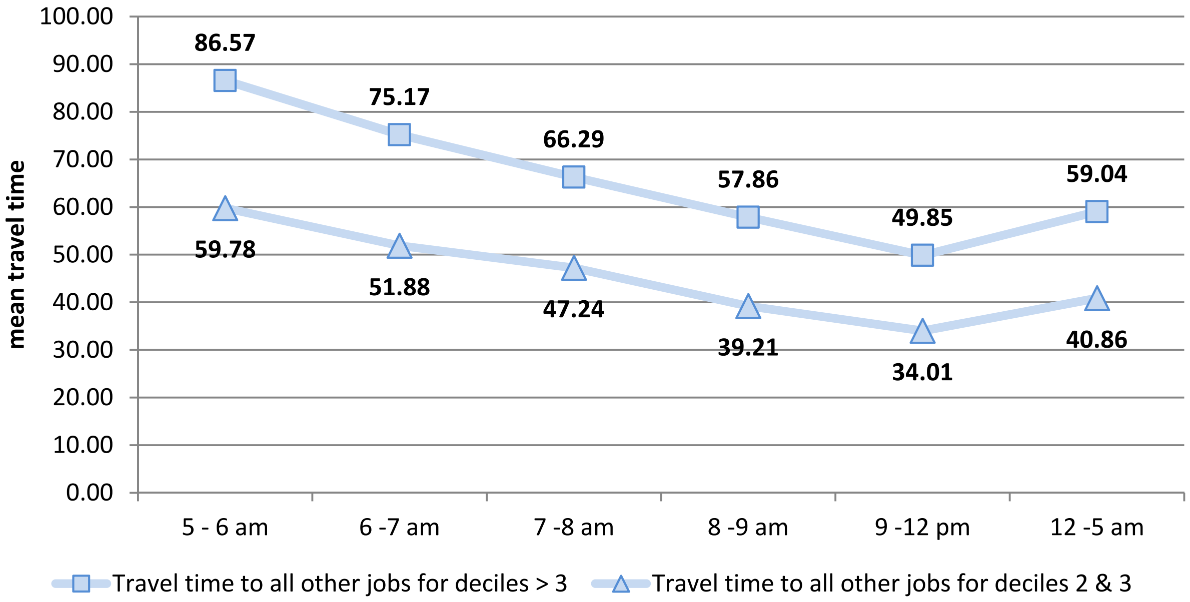
Figure 21: Mean accessibility of deciles > 3 and 2 & 3 to all other jobs.

Similarly, deciles 2 and 3 enjoy shorter mean travel times throughout the day to both low-wage jobs and all other jobs (see Figure 22 and Figure 23). These differences are statistically significant for every hour for travel to all other jobs, and for travel after 9:00 am to low-wage jobs. These findings indicate that although deciles 2 and 3 do not enjoy the same level of service as decile 1, they still have relatively good transit service when compared to other, less socially deprived, areas.



Bold means it is significant at the 95% confidence interval

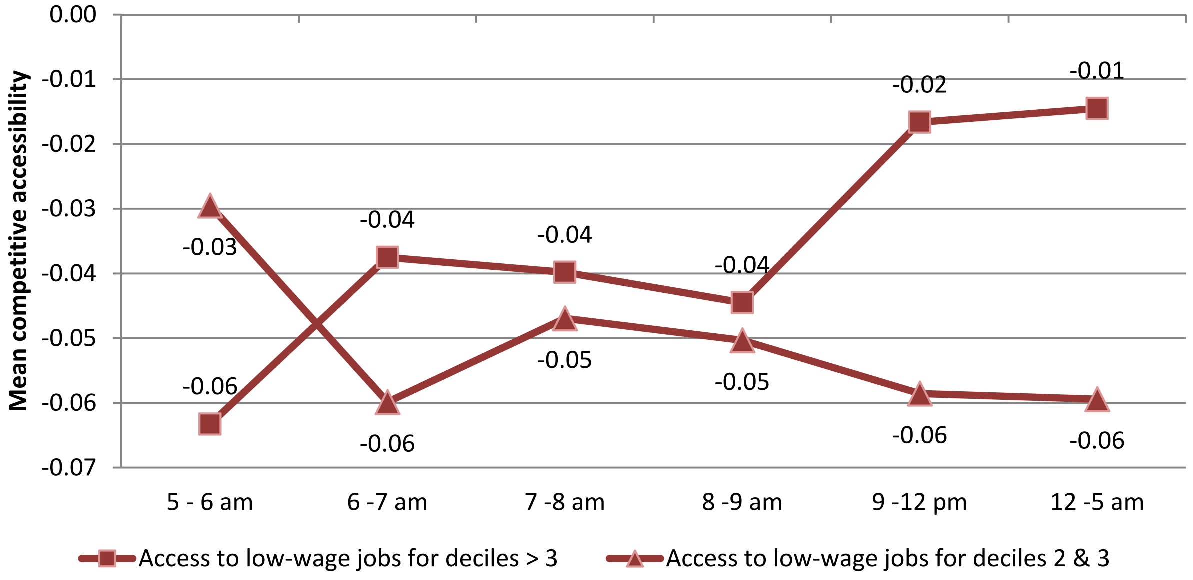
Figure 22: Mean travel time of deciles > 3 and 2 & 3 to low-wage jobs.



Bold means it is significant at the 95% confidence interval

Figure 23: Mean travel time of deciles > 3 and 2 & 3 to all other jobs.

However, deciles 2 & 3 have less accessibility to low-wage jobs than more socially advantaged areas after 6:00 am (see Figure 24). This difference is at its greatest between noon and 5:00 am (refer to Appendix IX). Although these differences are not statistically significant at any time period, they still indicate that these socially deprived areas have less comparable access to low-wage jobs; jobs that may be in demand by their residents. This finding may be indicating a mismatch between the 2nd and 3rd deciles locations and the location of low-wage jobs.



Bold means it is significant at the 95% confidence interval

Figure 24: Mean access of deciles > 3 and 2 & 3 to low-wage jobs.

Conclusion

The findings in this section nuance the findings in previous sections. The transit situation of socially deprived populations in Toronto, whether you define those populations to be the 10%, 20%, or 30% most socially deprived CTs, is good. However, this section shows that those populations near to the bottom of our social indicator are in a precarious situation. They do not enjoy the same level of transit service (higher accessibility or shorter travel times) than populations in the first decile, and they have less access to low-wage jobs than more advantaged areas during some time periods.

8. Comparing low-wage and higher-wage worker transit use

Why do people use public transit over other options? Most answers mention socio-economic reasons, ease of use (proximity and frequency of transit), and perhaps culture or education (for instance, those with a college education are more likely to take trains over other forms of transit (Limtanakool et al., 2006)). However, these influences are secondary to a more fundamental question commuters may ask themselves before travelling; “Does transit work for me?”

There has been much research on determining what makes transit work and what does not. Many of the studies on commuting look at transit mode share to all jobs, ignoring the potential effect job category may have on transit mode share and accessibility (for example, Moniruzzaman & Paez, 2004). Foth et al. (Foth, Manaugh, & El-Geneidy, 2014), found that job category does have an effect on transit mode share. However, they used broad categories that include a wide range of wage groups, potentially ignoring the effect wage has on transit ridership. This effect may be present because social deprivation and low income have long been linked to transit ridership (Giuliano, 2005). In addition, income has been linked to captive transit ridership, which is caused when income limits access to other modes (*4*). Yet, there has been little effort to determine *when* transit works and *when* it does not. Although one’s economic situation stays fairly constant throughout the day, the ease of using public transit can fluctuate, sometimes with great volatility.

This study asks if there is a relationship between the transit mode shares of two wage groups and the daily fluctuations in transit service and job availability that they experience. We incorporate transit service and job availability during different times of the day into statistical models that include typical spatial and temporal variables known to associate with, if not influence, transit mode share. We hypothesize that the availability of jobs and transit change throughout the day, and these changes affect the share of travellers who find public transit convenient enough to use for their commuting needs. We also expect that the independent variables’ coefficients will also vary daily because the needs of users change as the day progresses.

Transit mode share for each job group at the CT level is the dependent variable for each model. For all model groups (all jobs, low-wage earners, and the comparison group), one regression is run for each time period, resulting in 18 models (six time periods for three job categories). All models include the same variables, described below. These models help demonstrate that variable coefficients related to transit mode share fluctuate over the course of the day. A correlation matrix between all continuous variables was produced to consider multicollinearity problems, and no relationship between variables significantly greater than $p>0.6$ was found. Also, some continuous variables demonstrate potentially non-normal distributions, namely "transit frequency", "network distance to highway on-ramp", and "Euclidian mean distance travelled to low-wage jobs." For each of these variables, a natural log transformation was applied, and they were tested. However, sensitivity analysis using transformed variables produced little effect on regression results when compared to the results from models with untransformed variables. The rest of this section explains the models we use and how variables were calculated. If variables required a specific point origin and destination in order to be calculated, CT centroids are used.

Socio-Economic Indicator

To test for the effect of socio-economic status, the same social deprivation indicator used throughout this report is incorporated.

Built Environment and Transit Proximity

Mean straight-line distance travelled to work from each census tract is included. This variable is calculated by determining the straight-line distances of all trips originating at a census tract during a day, and weighting these trips by the number of commuters who take each trip. This number, divided by the total number of commuters at the CT in question, gives us the mean distance travelled at each census tract during a day. It is generally acceptable to use straight line distances when studying relations at the regional level since the ratio between this distance and network distance is generally stable across a region (Levinson & El-Geneidy, 2009).

Two dummy variables, indicating whether or not a CT's centroid is within one kilometer of a subway and whether or not it is within one kilometer of a GO (commuter) train station, are included to test for transit proximity. Distances are gathered using a pedestrian network. One kilometer is used as a buffer because previous research indicates that most people are willing to walk 900 meters but never more than 1750 meters to a rapid transit station (S. O'Sullivan & J.

Morrall, 1996). Distance to the nearest controlled-access highway on-ramp is also measured, using automobile network distances.

A variable indicating transit frequency is included as well. Using the General Transit Feed Specification (GTFS) data for the entire GTHA region, a frequency analysis is run using the 'Better Bus Buffers' toolset developed by M. Morang and ESRI (for more information see, Farber, Morang, & Widener, 2014). We measure how many transit trips stop within one kilometer of each CT centroid between 5am and noon, on a typical Monday. The mean (by hour) is used to give a rough approximation of frequency. Table 8 shows summary statistics for all the independent variables included in our models. Three of the continuous variables display potentially skewed distributions ("transit frequency", "network distance to highway on-ramp", and "Euclidian mean distance travelled to low-wage jobs"), where their standard deviations are greater than their means. Potential transformations were tested (discussed above). Finally, whether or not a CT is within the urban core or inner suburbs of the region are included as variables.

Table 8: Descriptive statistics of the influences on transit ridership

(N=1290)	Mean	Median	SD	Min	Max
Transit frequency (trips per hour)	36.09	20.40	44.36	0.00	339.20
Located in city center	0.12	0.00	0.03	0.00	1.00
Located in inner suburbs	0.30	0.00	0.05	0.00	1.00
Network distance to nearest subway station (km)	24.19	18.74	22.73	0.00	83.97
Network distance to nearest GO station (km)	5.29	4.09	5.00	0.36	53.37
Network distance to nearest highway on-ramp (km)	4.02	3.00	4.72	0.02	53.00
Euclidian mean distance travelled to all jobs (km)	10.21	9.53	4.58	1.32	38.62
Euclidian mean distance travelled to low-wage jobs (km)	11.78	6.63	12.15	0.46	35.42
Euclidian mean distance travelled to higher-wage jobs (km)	9.57	8.79	4.45	0.83	35.35

Findings

A simple chart shows that transit mode share fluctuates over the day depending on which job category is under inspection (see Figure 25), an indication that daily fluctuations of some set of factors are influencing transit ridership. In Figure 25, one can see that low-wage worker transit mode share has different peaks when compared to our comparison group. Figure 26 show transit mode share fluctuations for these two groups spatially. Transit mode share for those working in low-wage jobs grows throughout the day, and has its peak between noon and 5am. In contrast, higher-wage workers see their peak in the early morning (6am). Their share declines at 8am, only to rise again in the afternoon. It is surprising to find that transit mode share is highest outside of usual commuting to work peak hours (7am-9am) for the low-wage group. This may indicate that low-wage workers use transit service later than better-paid workers. It should also be noted that those working in low-wage jobs always have a lower transit mode share than higher-wage earners. This runs counter to findings that hold that those with lower incomes are more likely to use transit than others (Garrett & Taylor, 1999; Polzin, Chu, & Rey, 2000). This lower transit ridership rate may indicate that commuting transit service is not adequately meeting low-wage worker needs.

The regression findings indicate that the relationship variables have with transit mode share fluctuates throughout the day, possibly explaining why the fluctuations in transit mode share, seen in Figure 25 and Figure 26, occur. The changing effect of these variables highlights where fluctuating levels of service and travel need positively or negatively impact transit ridership for our wage groups. Table 9 shows our regression results.

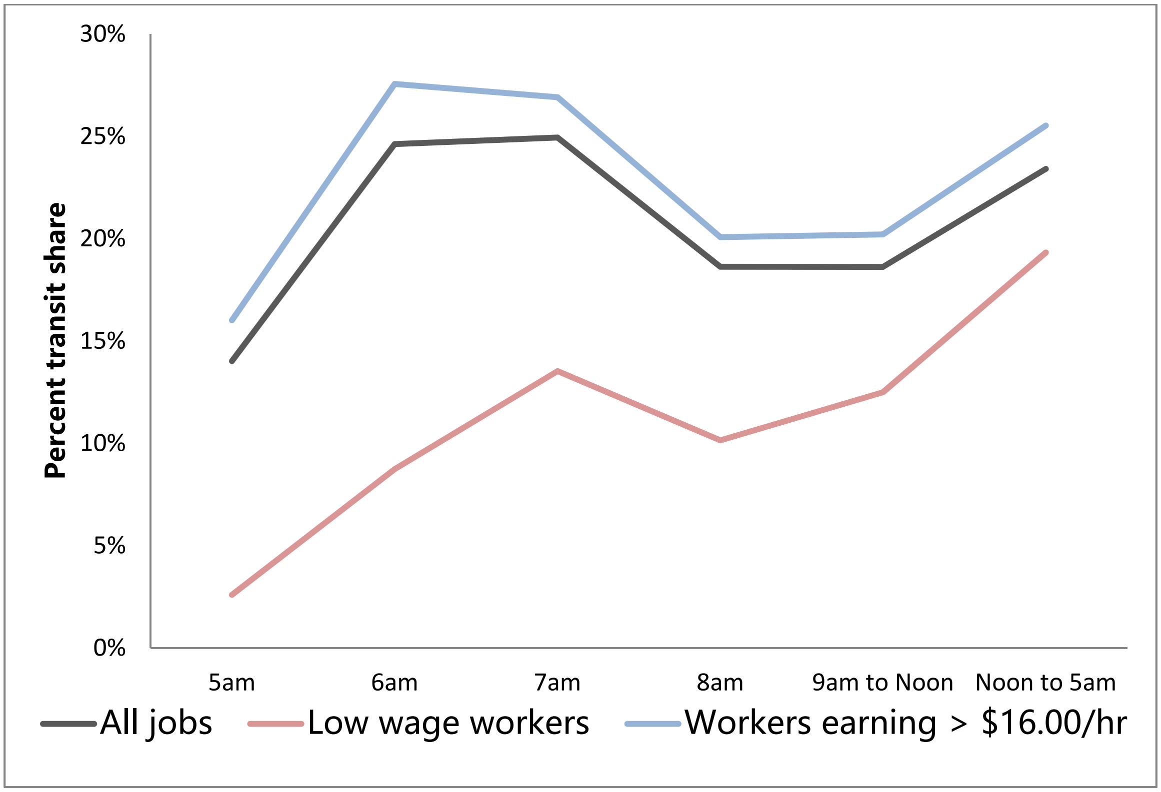
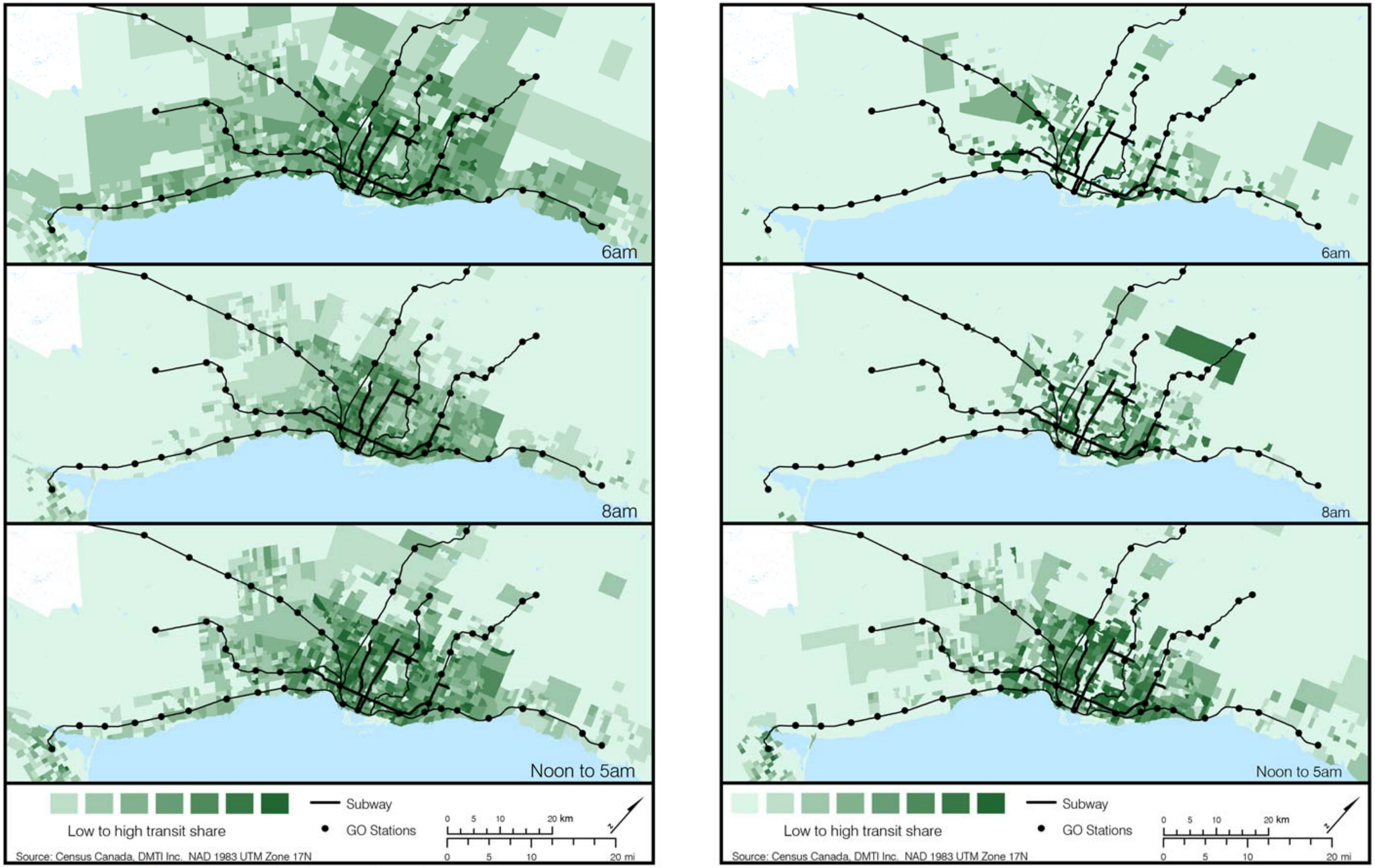


Figure 25: Transit mode share over the day



Source: Census Canada, DMTI Inc. NAD 1983 UTM Zone 17N

Source: Census Canada, DMTI Inc. NAD 1983 UTM Zone 17N

Figure 26: Visualizing daily fluctuations in transit mode share

Table 9: Regression results for the changing influences of mode share

	6am			7am			8am		
	Total jobs	Low-wage	Higher-wage	Total jobs	Low-wage	Higher-wage	Total jobs	Low-wage	Higher-wage
Transit frequency[b]	0.003	0.035*	-0.005	0.012	0.048**	0.006	0.017*	-0.021	0.023**
In urban core	0.171***	0.078***	0.167***	0.134***	0.175***	0.111***	0.200***	0.217***	0.190***
In inner suburbs	0.120***	0.140***	0.119***	0.123***	0.190***	0.117***	0.154***	0.164***	0.149***
1km to subway station	0.385**	0.25	0.089	0.254*	-0.002	0.218	0.633***	0.692**	0.498***
1km to GO station	-0.027	0.447	-0.193	-0.144	0.371	-0.226	-0.04	0.292	-0.054
Distance to highway on-ramp†	-0.022**	-0.005	-0.022**	-0.015**	-0.018	-0.013*	-0.003	-0.009	-0.003
Social indicator decile	0.008***	0.014***	0.010***	0.014***	0.010***	0.015***	0.011***	0.008***	0.013***
Mean distance†	0.069***	-0.017***	0.049***	0.068***	-0.023***	0.045***	0.020**	-0.007	0.019**
Accessibility to jobs by transit[a]	0.019***	-0.014	0.024***	0.013***	0.013	0.015***	0.011***	0.018	0.013***
Constant	-0.027	-0.019	0.017	-0.077***	-0.001	-0.028*	-0.071***	-0.03	-0.067***
R^2	0.529	0.234	0.463	0.731	0.338	0.674	0.78	0.319	0.753
AIC	-2008.354	-821.513	-1577.426	-2736.932	-696.775	-2379.064	-2771.349	-897.782	-2516.496

	9am to Noon			Noon to 5am		
	Total jobs	Low-wage	Higher-wage	Total jobs	Low-wage	Higher-wage
Transit frequency[b]	0.019	-0.007	0.029*	0.029**	0.018	0.041**
In urban core	0.198***	0.191***	0.179***	0.206***	0.273***	0.183***
In inner suburbs	0.165***	0.165***	0.156***	0.192***	0.243***	0.170***
1km to subway station	0.299*	0.035	0.181	-0.017	-0.603**	0.231
1km to GO station	0.11	-0.787*	0.387	0.185	0.196	0.235
Distance to highway on-ramp†	0.003	0.008	0.002	0.001	-0.005	-0.006
Social indicator decile	0.018***	0.019***	0.018***	0.014***	0.020***	0.013***
Mean distance†	0.011	-0.018***	0	0.008	-0.018***	0.018
Accessibility to jobs by transit[a]	0.011***	0.015	0.015***	0.017***	-0.002	0.033***
Constant	-0.053**	-0.046**	-0.028	-0.018	0.001	-0.008
R^2	0.639	0.304	0.556	0.684	0.457	0.57
AIC	-2037.444	-601.848	-1571.55	-2108.392	-865.694	-1489.261

* p<0.05
**p<0.01
***p<0.001
† Variable/10
[a]: Accessibility /10,000
[b]: Frequency/1,000

A comparison of Akaike's Information Criterion (AIC) for each model shows that modeling transit mode share by wage offers a better analysis than without such a division. AIC is a way of comparing nested models to a general model. If the nested models, when combined, have a greater absolute AIC than the general model, it indicates that the nested models improve data fit. In each time period, the two wage-category models are nested models of the all worker model (both wage populations entirely make up the all job population). In every case the combined AIC of these two nested models is greater than (in absolute terms) the AIC of the all job model, indicating an improved data fit.

Three variables are significantly and positively related to transit mode share across all job categories and time periods. If a CT is located in either the urban core or inner suburbs, transit mode share increases compared to other parts of the region. Furthermore, having a higher social indicator decile (meaning a CT is more socially deprived) is linked to higher rates of transit ridership. This confirms previous findings linking social deprivation with transit ridership (Bento, Cropper, Mobarak, & Vinha, 2005; Foth et al., 2014; Giuliano, 2005; Liu & Painter, 2011; Mercado, Paez, Farber, Roorda, & Morency, 2012; Moniruzzaman & Paez, 2004; Taylor, Miller, Iseki, & Fink, 2009). What follows is a discussion of each variable's relationship to transit mode share. Highway proximity is not discussed because its effect is inconclusive.

Transit frequency is statistically significant and has a positive relationship with transit mode share for low-wage workers in the early morning (6am and 7am). For higher-wage workers, transit frequency is statistically significant and positive from 8am onwards. This may indicate a number of things: low-wage workers who have an early morning departure time are influenced to take transit if transit service is frequent at this time, perhaps because those low-wage workers with early start-times work in areas served by transit. For higher-wage workers, departing early while using transit seems not to be a concern, thus transit frequency is only significant after 8am.

We see a similar change when considering transit proximity. Being close to a subway station is significant for total jobs up until noon. This confirms previous findings regarding rapid transit proximity (Crowley, Shalaby, & Zarei, 2009; Foth et al., 2014; Mercado et al., 2012). However, by wage category, subway influence is much more complicated. It is positively related to transit mode share for both low-wage workers and higher-wage workers at 8am. Yet, it is negatively related to transit mode share for low-wage workers between noon and 5am. In other words, at 8am, proximity to the subway is an important factor potentially influencing transit mode share. However, for low-wage workers with afternoon or evening jobs, other factors, such as little transit service to their destinations at these times or for their return journey (which is most likely in the early morning) may dissuade these workers from using transit, even if they live close to a subway.

Proximity to a Go-Train station has little demonstrated relation to transit mode share, and where it does this relationship is negative (between 9am and noon for low-wage workers). This may indicate a mismatch between where Go-Trains serve and where low-wage workers need to travel to at this time. The majority of GO stations are located outside of the urban core of the City of Toronto. Also, this regional service is geared towards ferrying commuters between these suburban locations and downtown. For low-wage workers, being close to a GO station at this time may simply be indicating that they live outside of the urban core, and that this housing location has a negative relationship with their transit use.

Furthermore, the effect of mean commuting distance switches depending on which job category is under scrutiny. Cervero and Kockleman found that mean distance between home and work locations has a negative effect on non-personal vehicle ridership, meaning it has a potential negative effect on transit mode share (Cervero & Kockelman, 1997). This finding is partially supported in our results. In our case, mean distance has a negative effect on transit ridership for low-wage workers at all time periods except at 8am. However, for higher-wage workers, an increase in mean distance is linked to greater transit ridership up until 8am. Afterwards this variable is insignificant. These findings further substantiate the claim that it may be difficult for low-wage workers to commute using transit at certain times. For low-wage workers, an increase in distance between their home and job may make a commuting trip by transit more inconvenient compared to other modes. For higher-wage workers, an increase in distance may make a commuting trip by transit more convenient in the morning compared to other modes, especially if it ends downtown.

The most unexpected finding from this study is that transit accessibility at any time period has no statistically significant relationship with ridership for low-wage workers, which is somewhat contrary to common conceptions of the relationship between income, transit use, and accessibility (Blumenberg & Hess, 2003; Fan, Guthrie, & Levinson, 2012; Glaeser et al., 2008; Hess, 2005). Foth et al. (Foth et al., 2013, 2014) do show that accessibility has the smallest transit mode share effect for those working in manufacturing, construction, and transport. However, income variation in this NOC category is quite broad, which means conclusions made between income and accessibility are limited in their case (Government of Canada, 2014). One possibility explanation for our results is that low-wage workers are captive riders. They will take transit whether they have high accessibility or not. This possibility seems less likely considering that other factors (proximity and frequency of transit, mean distance travelled) have an influence on their transit mode share, indicating that they may have some choice when it comes to transit use.

In contrast, accessibility is positively associated with transit ridership for higher-wage workers at every time period. By looking at the change in influence over time we see a pattern emerge. An additional 10,000 jobs accessible at 6am increases their ridership by 2.4%. This influence then declines, reaching its nadir at 8am. Afterwards it starts to increase, reaching its peak between noon and 5am, where an additional 10,000 accessible jobs results in a 3.3% increase in transit mode share. This finding may be of particular interest to local transportation and planning agencies. Increasing accessibility in the afternoon and evening may have the most effect on increasing ridership for higher-wage workers.

Conclusion

This section investigates how variables have a fluctuating relationship with transit mode share during the day. Many transit mode share studies use data that represent one time period, usually the morning travel peak, combined with job data that represent the entire day. This section looks at transit mode share at six time periods throughout the entire day, and the accessibility at those periods, to demonstrate that different departure times have different transit mode share rates, and that variable coefficients at these times also vary. Understanding these daily fluctuations in travel behavior will allow researchers and transit agencies to more adeptly predict demand and need in transit service.

The GTHA is a vast region, containing a large share of Canada’s entire population. If transit mode share is to grow there then adequate transit availability during non-peak hours may be the key. It is also important to realize that low-wage workers may be having a difficult time using transit to reach their jobs at certain times. Noticing that low-wage workers demonstrate a number of key differences from their higher-wage counterparts substantiates this finding: Accessibility to jobs using transit has no relationship with their ridership. Being close to a subway station has a negative effect during non-peak hours, potentially indicating that although transit service may be close to their homes, the ultimate destinations they can reach using transit at these times is not satisfactory. Finally, low-wage workers are less likely to take transit because of lengthy distances between their home and work, indicating that as distance increases the ease of covering that distance using transit may decrease. In contrast, for higher-wage workers, an increase in distance is positively related to transit ridership in the morning (from 6am to 8am), demonstrating that an increase in distance may, in some instances, mean an increase in the ease of using transit for that trip. This may also indicate that higher-wage workers are much more likely to travel to the downtown area, which is easily accessible by transit, versus low-wage earners, whose employment locations are perhaps more evenly dispersed throughout the region. Future research into the spatial locations of different wage groups’ homes and employment could help elucidate this point, the lack of which is a limitation of this study. Also, the division into two wage groups could be expanded to include other groups, an area of potentially fruitful investigation.

9. The benefits of the GO-Train

Metrolinx directly influences the GTHA's transit system by providing commuter rail and bus services through the GO Transit network. We briefly assess the benefit these services bring to the region by focusing on the CTs that are located close to GO train stations. For this analysis we compare mean accessibility scores and travel times of CTs close to GO stations to other CTs. Those CTs that are at least partially within 1000m of a GO station serve as our 'GO Station CTs'. An appropriate distance to study according to O'Sullivan and Morral (1996). They found that most people are willing to walk between 900m-1750m to a rapid transit stop. We consider CTs that are totally or partially within this 1000m buffer to be close enough to a GO station to be affected by the transit service this station provides.

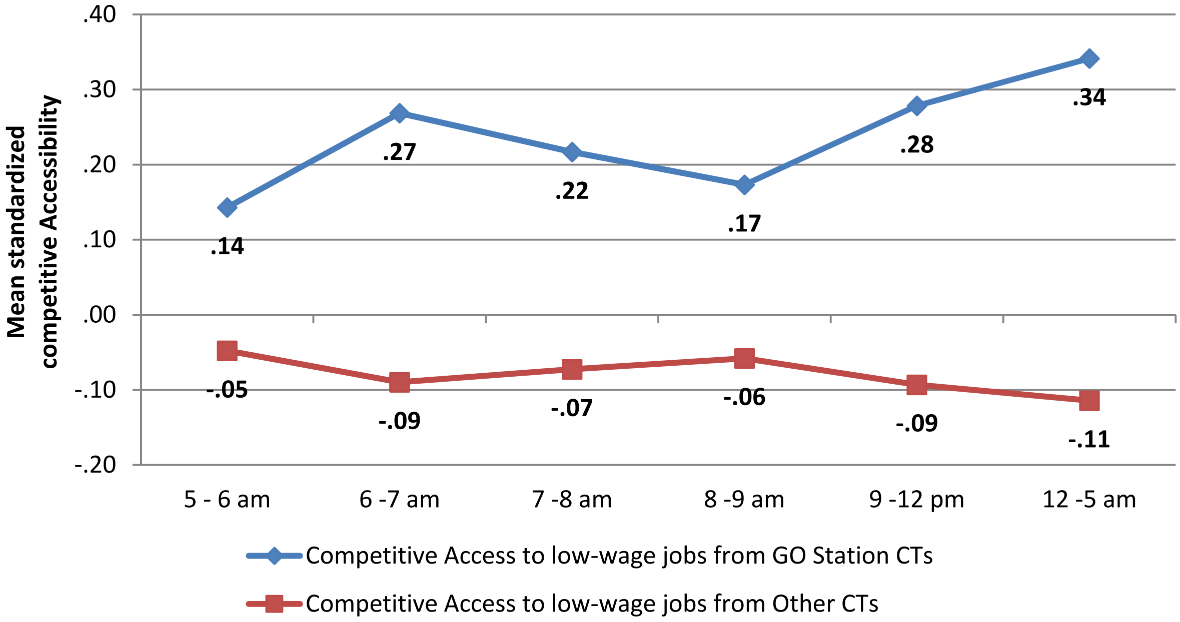
Of the 1328 CTs analyzed in this project, 333 (25%) are within 1000m of a GO station. **Table 10** presents descriptive statistics comparing GO station CTs to all other CTs using three measures, gravity accessibility to jobs, competitive accessibility to jobs, and transit travel times. Travel times are provided unstandardized, which allows the reader to discern the mean savings in minutes residents gain if they reside in CTs close to GO stations. Again, findings in bold indicate a statistically significant difference between consecutive time periods.

Table 10: Descriptive statistics comparing CTs close to GO stations to other CTs

			Low-wage jobs					**All other jobs**				
		Time	**Range**	**Min.**	**Max.**	**Mean**	**Std. Dev.**	**Range**	**Min.**	**Max.**	**Mean**	**Std. Dev.**
Accessibility to Jobs	**For GO Station CTs**	5 - 6 AM	4.11	-2.00	2.11	0.10	0.88	3.79	-2.08	1.71	0.11	0.86
		6 - 7 AM	4.29	-1.97	2.32	0.12	0.87	4.65	-1.94	2.71	0.13	0.88
		7 - 8 AM	4.19	-1.81	2.38	0.12	0.87	**4.51**	**-1.77**	**2.74**	**0.12**	**0.88**
		8 - 9 AM	3.98	-1.80	2.18	0.10	0.88	4.24	-1.70	2.54	0.09	0.89
		9 - 12 PM	**4.29**	**-1.87**	**2.42**	**0.11**	**0.86**	**4.29**	**-1.80**	**2.48**	**0.10**	**0.86**
		12 - 5 AM	13.45	-1.96	11.50	0.24	1.15	4.29	-1.88	2.41	0.12	0.87
	For all other CTs	5 - 6 AM	4.09	-2.04	2.04	-0.04	1.04	4.34	-2.11	2.23	-0.04	1.04
		6 - 7 AM	4.19	-2.04	2.16	-0.04	1.04	4.34	-1.99	2.34	-0.04	1.04
		7 - 8 AM	4.08	-1.88	2.20	-0.04	1.04	**4.21**	**-1.83**	**2.38**	**-0.04**	**1.03**
		8 - 9 AM	4.13	-1.92	2.21	-0.04	1.04	4.21	-1.81	2.40	-0.03	1.03
		9 - 12 PM	**4.20**	**-1.92**	**2.28**	**-0.04**	**1.04**	4.15	-1.85	2.31	-0.04	1.04
		12 - 5 AM	5.94	-2.12	3.82	-0.08	0.93	4.12	-1.99	2.14	-0.04	1.04
Competitive Accessibility	**For GO Station CTs**	5 - 6 AM	**17.79**	**-0.93**	**16.86**	**0.14**	**1.25**	**8.82**	**-1.40**	**7.42**	**0.21**	**1.14**
		6 - 7 AM	**13.37**	**-1.10**	**12.27**	**0.27**	**1.18**	6.70	-1.37	5.33	0.30	1.16
		7 - 8 AM	**15.24**	**-0.74**	**14.50**	**0.22**	**1.06**	5.77	-1.21	4.56	0.34	1.14
		8 - 9 AM	**15.18**	**-0.63**	**14.55**	**0.17**	**1.03**	5.76	-1.13	4.63	0.31	1.17
		9 - 12 PM	**10.73**	**-0.95**	**9.77**	**0.28**	**1.13**	**6.75**	**-1.16**	**5.59**	**0.32**	**1.15**
		12 - 5 AM	8.78	-1.03	7.74	0.34	1.21	7.26	-1.24	6.02	0.36	1.19
	For all other CTs	5 - 6 AM	**19.50**	**-1.01**	**18.49**	**-0.05**	**0.90**	8.18	-1.41	6.77	-0.07	0.94
		6 - 7 AM	16.38	-1.11	15.27	-0.09	0.91	7.12	-1.38	5.74	-0.10	0.92
		7 - 8 AM	**25.02**	**-0.76**	**24.26**	**-0.07**	**0.97**	7.39	-1.25	6.14	-0.11	0.92
		8 - 9 AM	27.56	-0.65	26.91	-0.06	0.99	7.40	-1.16	6.24	-0.10	0.92
		9 - 12 PM	**14.09**	**-0.99**	**13.10**	**-0.09**	**0.94**	**7.68**	**-1.19**	**6.49**	**-0.11**	**0.92**
		12 - 5 AM	8.11	-1.06	7.05	-0.11	0.89	6.77	-1.27	5.50	-0.12	0.90
Travel Time (Min)	**For GO Station CTs**	5 - 6 AM	0.00	54.30	54.30	54.30		**151.10**	**14.27**	**165.37**	**70.67**	**33.77**
		6 - 7 AM	80.28	21.10	101.38	53.88	24.16	176.47	9.75	186.22	60.43	26.76
		7 - 8 AM	107.32	19.33	126.65	49.85	27.79	**154.53**	**9.85**	**164.38**	**56.46**	**23.55**
		8 - 9 AM	107.90	9.03	116.93	44.31	28.04	**110.55**	**7.93**	**118.49**	**45.45**	**18.68**
		9 - 12 PM	111.86	9.17	121.03	44.18	30.22	**172.55**	**7.60**	**180.15**	**42.28**	**24.58**
		12 - 5 AM	351.42	7.48	358.90	42.25	39.75	199.10	7.72	206.81	45.04	23.93
	For all other CTs	5 - 6 AM	**72.50**	**26.43**	**98.93**	**52.54**	**21.27**	**470.69**	**17.48**	**488.17**	**82.51**	**51.23**
		6 - 7 AM	110.80	12.55	123.35	57.57	22.29	627.58	7.32	634.90	70.56	46.47
		7 - 8 AM	395.57	15.45	411.02	62.73	52.81	**1425.13**	**9.48**	**1434.61**	**64.51**	**73.31**
		8 - 9 AM	441.68	15.97	457.65	52.84	64.76	**1358.67**	**11.48**	**1370.16**	**56.86**	**70.01**
		9 - 12 PM	330.58	7.07	337.65	45.93	44.99	**1262.93**	**8.15**	**1271.08**	**48.16**	**61.39**
		12 - 5 AM	689.22	9.80	699.02	52.28	54.51	1200.43	8.50	1208.93	57.95	71.57

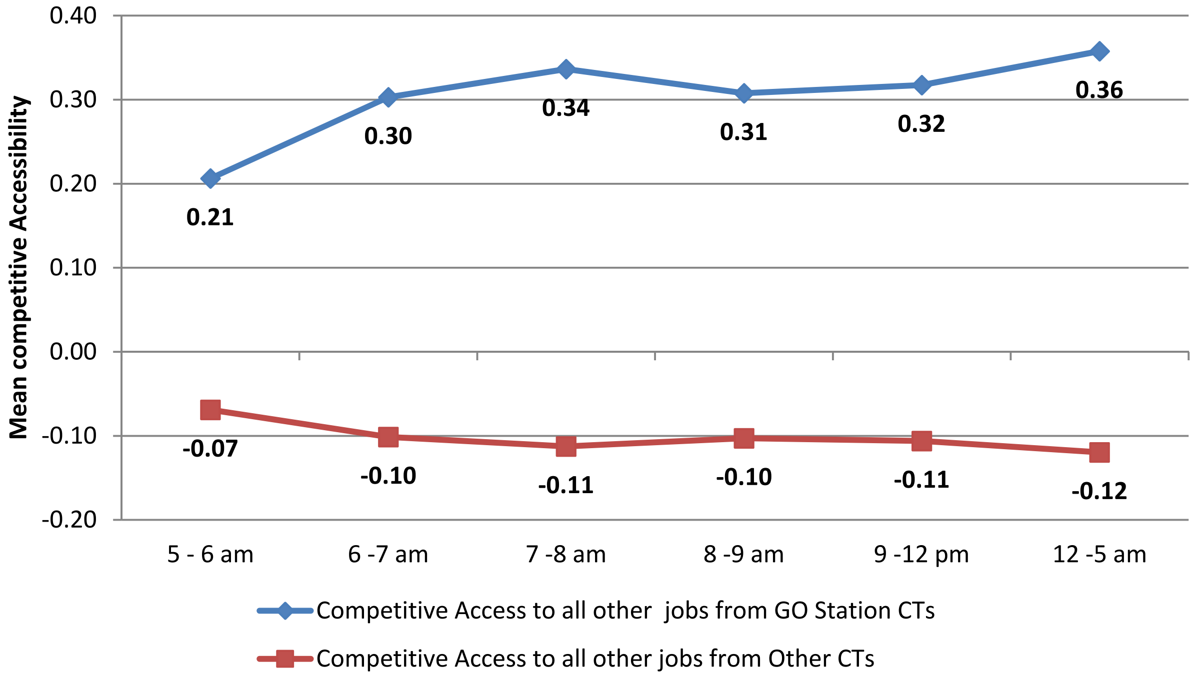
Findings

CTs closer to GO stations are consistently better served than those farther away according to all measures and at all time periods. **Figure 27** and **Figure 28** show daily fluctuations in mean competitive accessibility to low-wage and all other jobs for CTs close to GO stations and for CTs farther away.



Bold numbers indicate statistically significant difference (p<0.05)

Figure 27: Mean competitive accessibility to low-wage jobs from GO station CTs and other CTs.

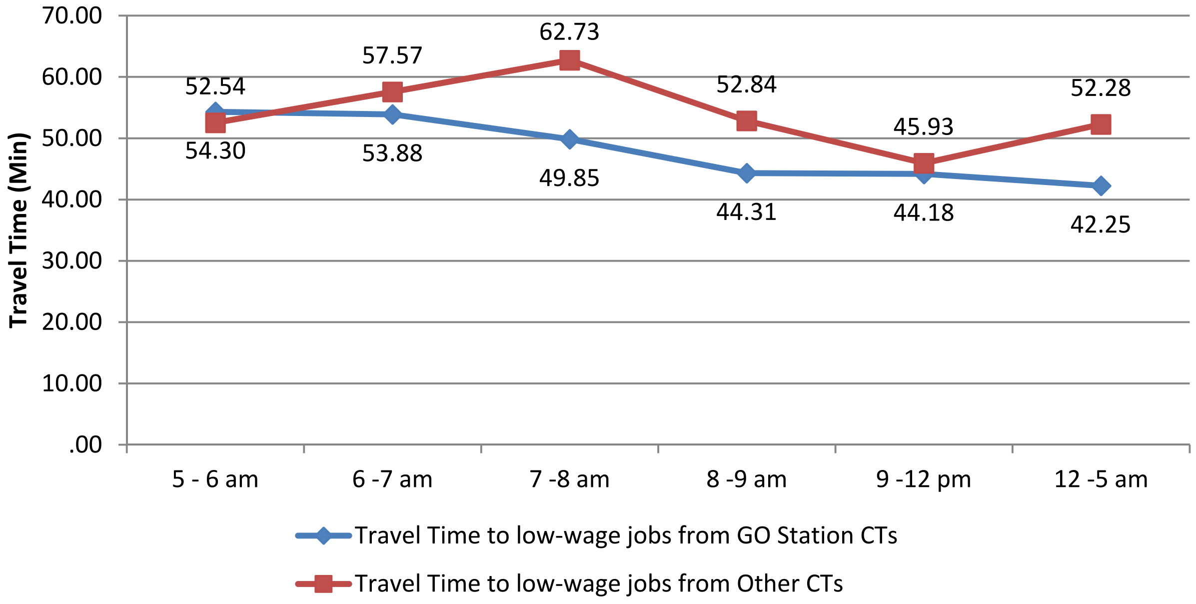


Bold numbers indicate statistically significant difference (p<0.05)

Figure 28: Mean competitive accessibility to all other jobs from GO station CTs and all other CTs

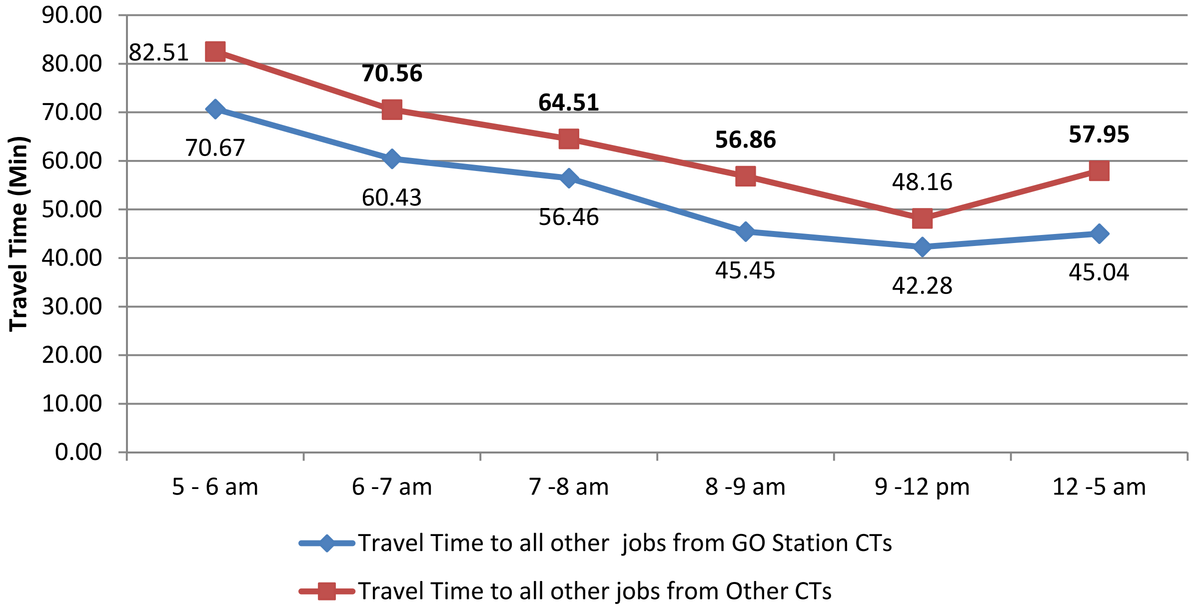
These findings show that GO station CTs have greater accessibility to both low-wage and better-paid jobs, and that accessibility increases throughout the day for these CTs, reaching its peak between noon and 5:00am. It should be noted, however, that GO trains do not run past 1:00am. Nevertheless, this peak indicates that service during the afternoon and evening is an important component of the region’s transit network.

Similarly, CTs that are in close proximity to a GO station benefit from smaller mean travel times to work by transit at almost all time periods. Figures 29 and 30 show mean travel times throughout the day for both job categories. For low-wage jobs, the difference is minimal between 5:00am and 6:00am. However, between 7:00am and 8:00am, mean travel to work is almost 13 minutes shorter from GO station CTs than from other CTs. For travel to all other jobs, the difference is greatest between 5:00am and 6:00am, where CTs closer to GO stations have 12 minute shorter mean travel times than other CTs.



Bold numbers indicate statistically significant difference (p<0.05)

Figure 29: Mean travel time to low-wage jobs from GO station CTs and all other CTs



Bold numbers indicate statistically significant difference (p<0.05)

Figure 30: Mean travel time to all other jobs for GO station CTs and other CTs

10. What causes high accessibility? Discovering underserved areas

High transit accessibility scores indicate areas where the proximity of jobs and the availability of transit are high. People residing in locations with high transit accessibility scores can more easily take transit to reach their place of employment. Since our accessibility scores are influenced by both transit service (incorporated through our travel time matrices) and the location of employment opportunities, understanding when transit is the cause of high accessibility is hard to determine. If a CT enjoys a high density of employment, then transit service may have little role in the accessibility score this area has. Although an in-depth investigation into the relationship between employment densities and transit service is beyond the scope of this report, the following section will briefly discuss how transit service and employment location influence accessibility in the GTHA. We also point out CTs where transit service offers the most benefit to residents, as well as CTs where more transit service could be beneficial. This section only uses data pertaining to the 8:00 am time period. Nevertheless, the method presented could be expanded to include other time periods. For simplicity, this section focuses on our gravity-based accessibility to jobs measure, not our competitive measure. The competitive measure takes into account both gravity-based accessibility to jobs and to workers, which in turn take into account transit service to and from places of residence and employment, respectively. By focusing on just job accessibility, some concrete findings can be had by looking at the components that influence this measure: job location and transit travel times.

To tease out what components influence a CT's accessibility score we calculated three decile rankings for each CT based on the following variables:

(1) Gravity accessibility to jobs. The 1st decile has the lowest scores (indicating those CTs with the lowest level of accessibility) and the 10th has the highest scores. Decile rankings for each accessibility score (to low-wage or higher-wage jobs) are calculated.

(2) Job density at the census tract. This variable is calculated by taking the number of jobs available at 8:00am at a CT and dividing it by the area of the CT. Similar to (1), the 1st decile indicates low job density, while the 10th decile indicates high job density. Decile rankings for low-wage and higher-wage job density are calculated.

(3) To account for transit service, we calculate the transit travel time from each CT to Union Station, in downtown Toronto. It is important to note that the 1st decile has the lowest travel times, whereas the 10th decile has the highest travel times. **Figure 31** shows these travel times for the GTHA. As expected, shorter travel times are centered in the region. The GO train lines also have a noticeable effect.

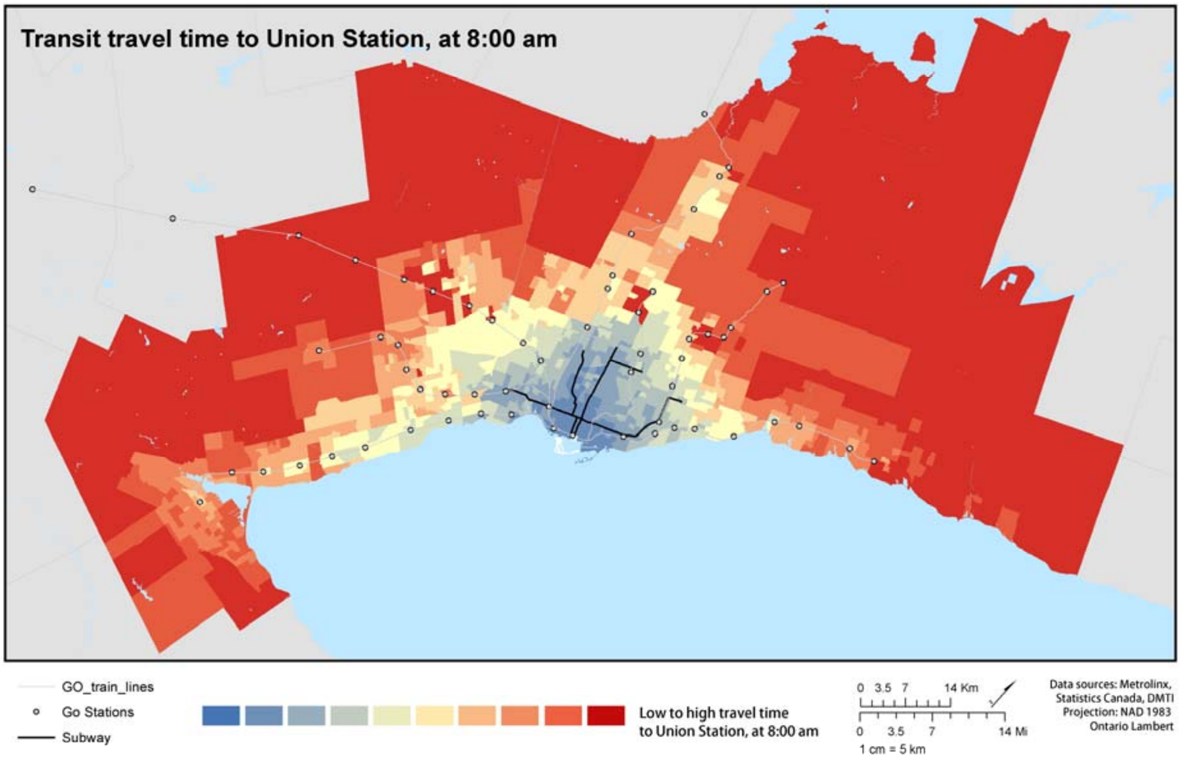


Figure 31: Travel time to Union Station at 8:00

Findings

First, a correlation matrix is run between these decile groups to see how transit service and job density relate to accessibility. Travel time to Union Station is negatively correlated to both accessibility to low-wage and all other jobs ($r \leq -0.90$). This indicates that as travel time increases, accessibility tends to decrease, and this correlation is very strong. Travel time to Union Station is also negatively correlated to job density, but not as strongly. Interestingly, this correlation is stronger for higher-wage jobs ($r = -0.51$) than for low-wage jobs ($r = -0.24$), which may show that low-wage jobs tend to be less strongly centered on Toronto’s downtown core. Although it is hard to determine the exact effect transit service has on accessibility, transit travel time's strong correlation with accessibility demonstrates that frequent and convenient service to downtown is an important component of increasing transit accessibility in the region.

By using deciles we can relate a CT's accessibility ranking to its travel time and job density ranking. It should be noted that this endeavor is just a brief attempt to understand the relationship between these variables. The idea underpinning this endeavor is shown below (see **Figure 32**):

		Accessibility	Job Density
Influence of Transit Service on Accessibility	Strong	High	Low
	Indiscernible	High	High
		Low	High
	Weak	Low	Low

Figure 32: possible relationship between accessibility and job density

If a CT is in the top accessibility decile but is not very job-dense, then transit service most likely has a strong effect on accessibility at this tract. However, if both accessibility and job density are high, it is impossible to discern what component—the density of jobs or transit service—is having the greatest influence on a CT's accessibility score. Most likely the CTs with the highest levels of accessibility in the region have both high levels of employment and good transit service. Conversely, CTs that do not have many jobs (i.e. are not very job-dense) and also have low accessibility could use more transit service. These are areas that, if they have many residents, may benefit from increased and more frequent service to employment centers.

We first focus on the most accessible decile (the 10th decile) in either accessibility score (accessibility to low-wage or higher-wage jobs). We look at these CT's standing in job density and travel time to Union Station. All these high access CTs have travel times that are in the lowest three deciles, with over 78% in either wage-category having travel times in the 1st (shortest) decile. On average, travel time for this 1st decile is just under 30 minutes. Conversely, if we look at CTs in the lowest decile (the 1st decile) of accessibility scores, we find that they all have travel times in the three highest travel time deciles (the deciles with the longest travel times). This finding indicates that shorter transit service to downtown Toronto has a very important relationship with accessibility scores (whether that score indicates accessibility to low-wage or higher-wage jobs).

Nevertheless, the effect of job density on accessibility should not be minimized. Following from Figure 32, we want to discover CTs that have high accessibility and low job density. These CTs are most likely benefiting from a robust transit service. For CTs in the highest decile of low-wage accessibility, 20 (15.2%) have job density in the lowest decile (see Figure 33). These CTs most likely have good transit service to low-wage jobs outside of their areas. It’s interesting to note that all of these CTs are located within the present City of Toronto. For accessibility to higher-wage jobs there is only one high scoring CT that also has low job density. Furthermore, 86.3% of these high-scoring CTs have densities in deciles greater that seven, which indicates that for higher-wage accessibility, job density may have a greater influence than for their low-wage job accessibility.

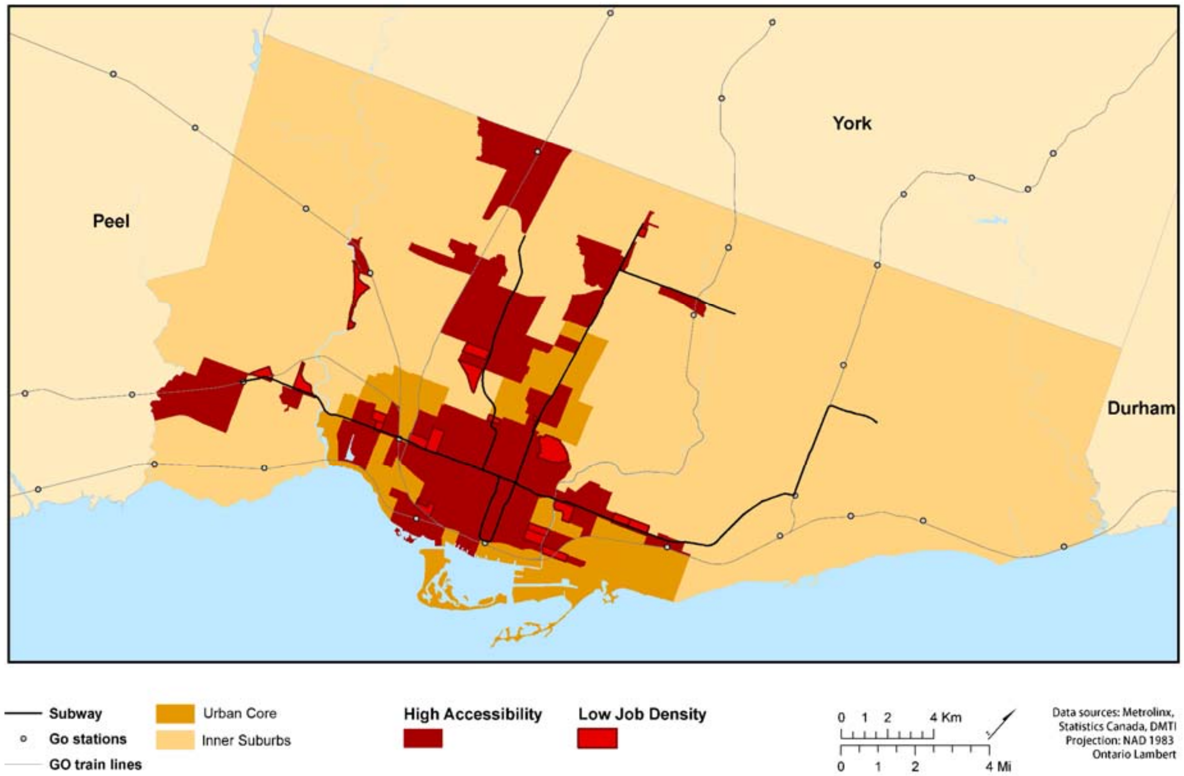


Figure 33: CTs in the highest low-wage accessibility decile, highlighting those with low job density.

We can also discover CTs that are being underserved by the transit system by finding CTs that have both low accessibility and low job density. For low-wage accessibility, 45 (33.8%) of CTs in the lowest accessibility decile are also in the lowest decile of job density (see Figure 34). These areas could respond well to increased transit service to employment areas. CTs in the lowest decile of accessibility are not found in the City of Toronto; instead, they are the periphery of the region. The findings for accessibility to higher-wage jobs are similar. 64 (48.9%) of CTs in the 1st decile of accessibility are also in the lowest job density decile. Again, the influence of job density on accessibility is stronger for higher-wage jobs than for low-wage jobs.

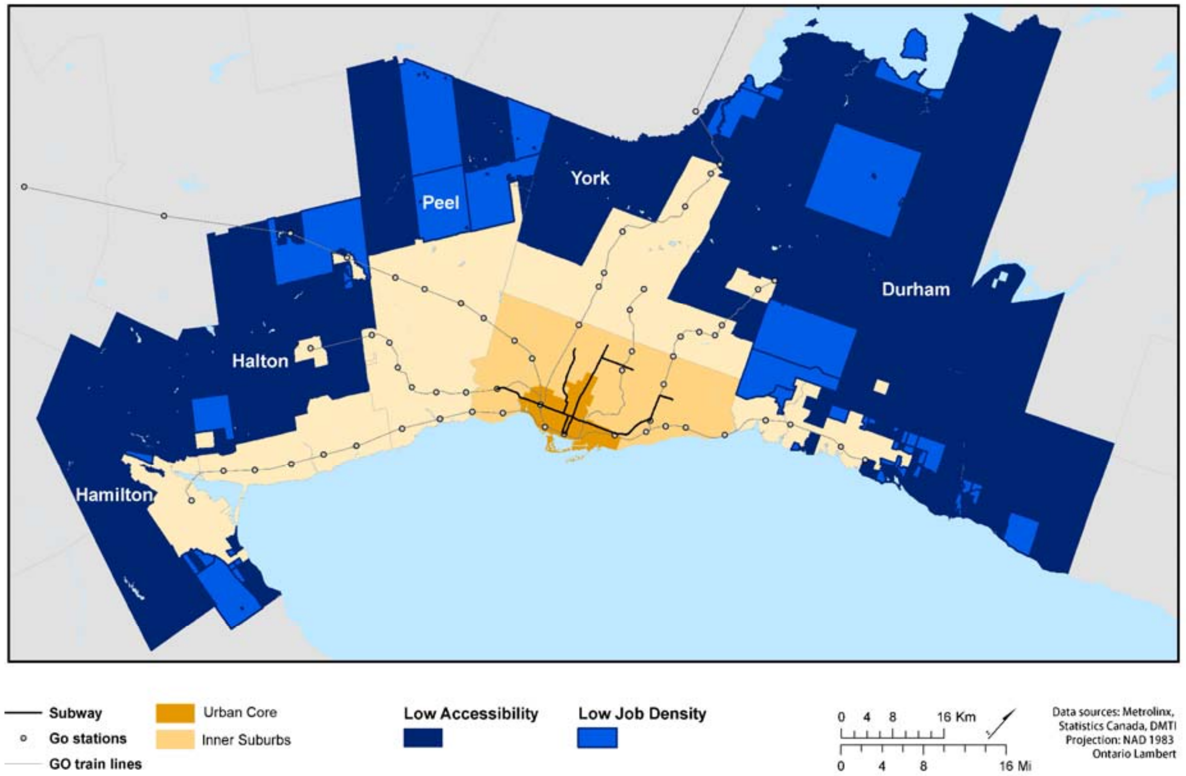


Figure 34: CTs in the lowest low-wage accessibility decile, highlighting those with low job density.

9. Discussion and Conclusion

Previous studies suggest that the location and quality of transit infrastructure as well as the level of service provided affect people's economic and social opportunities. A fair distribution of transportation resources may result in improved accessibility for socially disadvantaged groups, whereas an inequitable distribution may harm the socially and economically disadvantaged (Krumholz & Forester, 1990; Sanchez et al., 2003).

This report analyzes the region's accessibility to jobs both spatially and temporally, and links accessibility to levels of social deprivation in order to identify any imbalances in the region. Many of the findings correspond with those of Scott and Horner (2008) and Foth et al. (2013), which suggest that socially disadvantaged groups have equal or better accessibility and lower transit travel times relative to other groups in the region.

Using various measures we find that accessibility is generally better for socially disadvantaged deciles over the course of the day, whether one is looking at the bottom 10%, 20% or 30%. For instance, the 10% most socially disadvantaged areas (areas with a low median wage, high unemployment, concentrations of recent immigrants, and unaffordable housing costs) have better accessibility to jobs by public transit than the rest of the region. The number of high or low-wage jobs actually accessible using transit from these areas is, on average, 12 times greater than from other areas. The better accessibility by transit experienced by these areas is also reflected in shorter travel times to work. Residents spend, on average, 64% less time traveling to work than people from all other areas.

The spatial location of the 10% most disadvantaged areas helps explain why transit service from these areas provides such better levels of accessibility to jobs. They are overwhelmingly located in the City of Toronto (74%) where transit service is most available. However, while these promising results bode well—indicating that the GTHA's various transit agencies are doing a good job providing transit service equitably—this report also shows that there are some disparities within the bottom 30%. The second and third deciles (low-middle income areas), although often having higher transit service compared to less disadvantaged areas, do not enjoy the same level of service as the first decile. This finding indicates two things. First, planners of transit service should be cognizant of these differences. Although the most socially deprived areas of the region are being served well, those areas that are still relatively socially deprived, but are not the *most* socially deprived, are experiencing comparatively lower levels of service. Also, the second and third deciles are more likely to be outside of the urban core and less densely developed, meaning that increasing service to these populations will be difficult and costly.

Understanding how accessibility to employment changes over the course of the day is essential for assessing equity issues in the region. Comparing accessibility scores can highlight areas in need of more service at particular times. This analysis accurately assesses transit equity by taking into account not only when people need to travel, but also when jobs are available.

The Big Move calls for the development of key performance indicators that measure how public transit is serving those individuals who need it most (Metrolinx, 2008). Findings from this report address this goal. Metrolinx should continue to use accessibility to employment on a regular basis to evaluate land use and transportation performance for various socio-demographic groups and to compare existing levels of performance to historical ones. To facilitate future research, this will require standardization, organization and coordination of online General Transit Feeds Specifications (GTFS) data.

The Big Move aims to increase annual transit ridership from 546 million to 1.27 billion. Increases in ridership should be planned with social equity in mind. With the goal of increasing equity and ridership, special considerations should be given to residents of the second and the third deciles (low-median-income earners) when planning improvements to transit services.

Also, transit services are not sufficient outside the morning peak to meet low-wage earners travel needs, which may help explain why transit mode share among low-wage workers (11%) is lower than for high-wage workers (23%). Low-wage workers have demonstrably different transit needs when compared to higher-wage workers, and these needs fluctuate throughout the day. In particular, connections to employment zones outside of the urban core may help convince low-wage workers that transit is a viable commuting option for them.

Future Research

In many respects, this report leaves many questions regarding transit equity to be answered, some of which are discussed below:

This report assesses the benefits (accessibility to job categories) and costs (travel times) of the transit system in the GTHA. However, the report neglects to analyze the distribution of one important cost: transit fares. Future research could help discover how transit fares effect the equitable distribution of transit service in the region. A better understanding of the impact of transit fares is essential for developing policies that avoid, minimize, or mitigate any adverse effects of fare zones. The distribution of services to the lower-middle income groups requires much more detailed analysis that should be accompanied with interviews of residents in these areas to better understand reasons for home location choices as well as mode choice constraints.

Finally, to complete the results of the present report, an investigation into the home and work location choices of disadvantaged and lower-middle income groups in the GTHA region is needed. Presently, more riders choose to use transit (choice riders) than are forced to use transit (captive riders). This may be due to the current configuration of the transit system, which offers better service to areas with heavy concentrations of high-wage jobs. Future research focusing on understanding the transit market in the GTHA and where needy populations live and work will help reveal if the overall accessibility benefits described in this report actually translate to equity on the ground.

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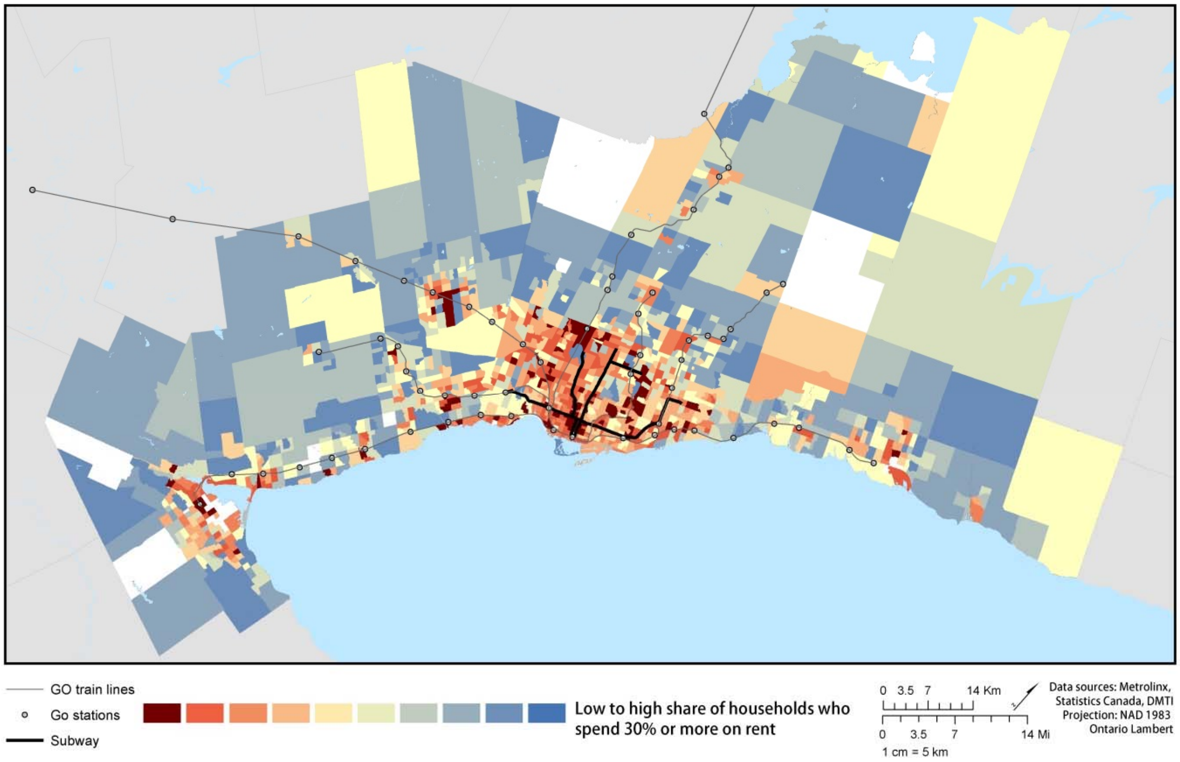
APPENDIX I: SOCIAL INDICATOR INDEX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Low to high share of households who spend 30% or more on rent
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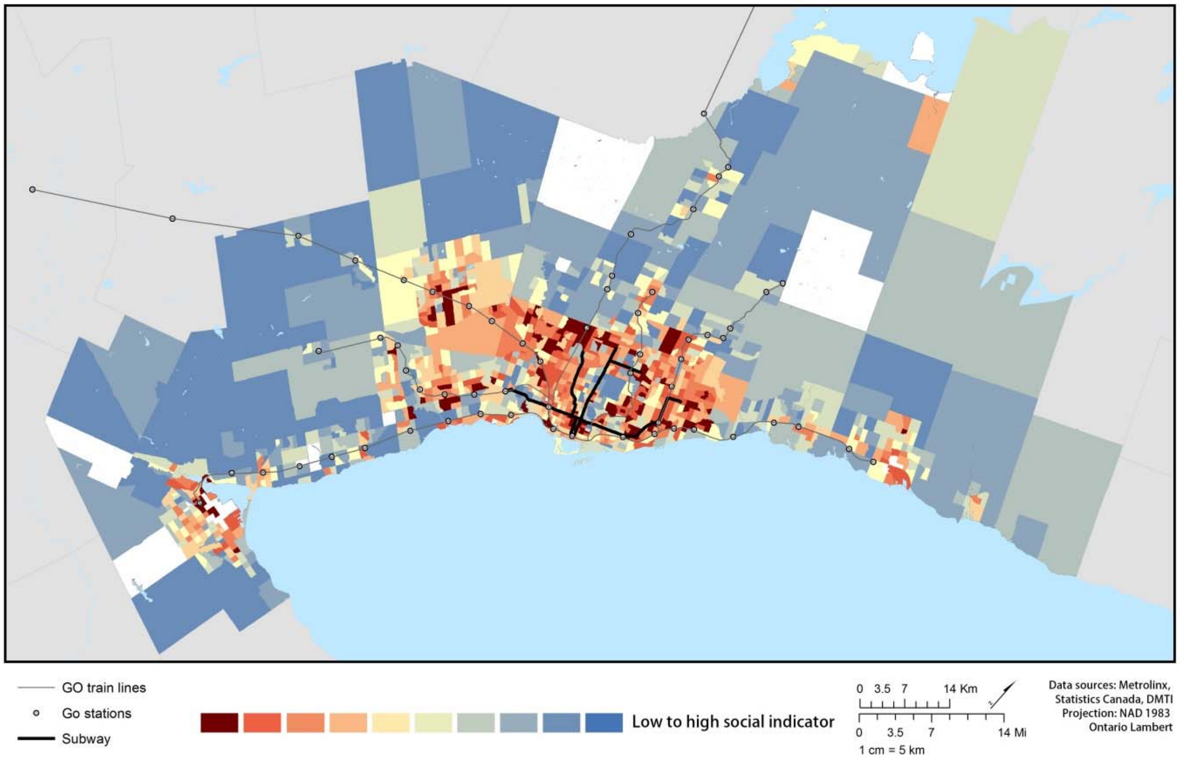
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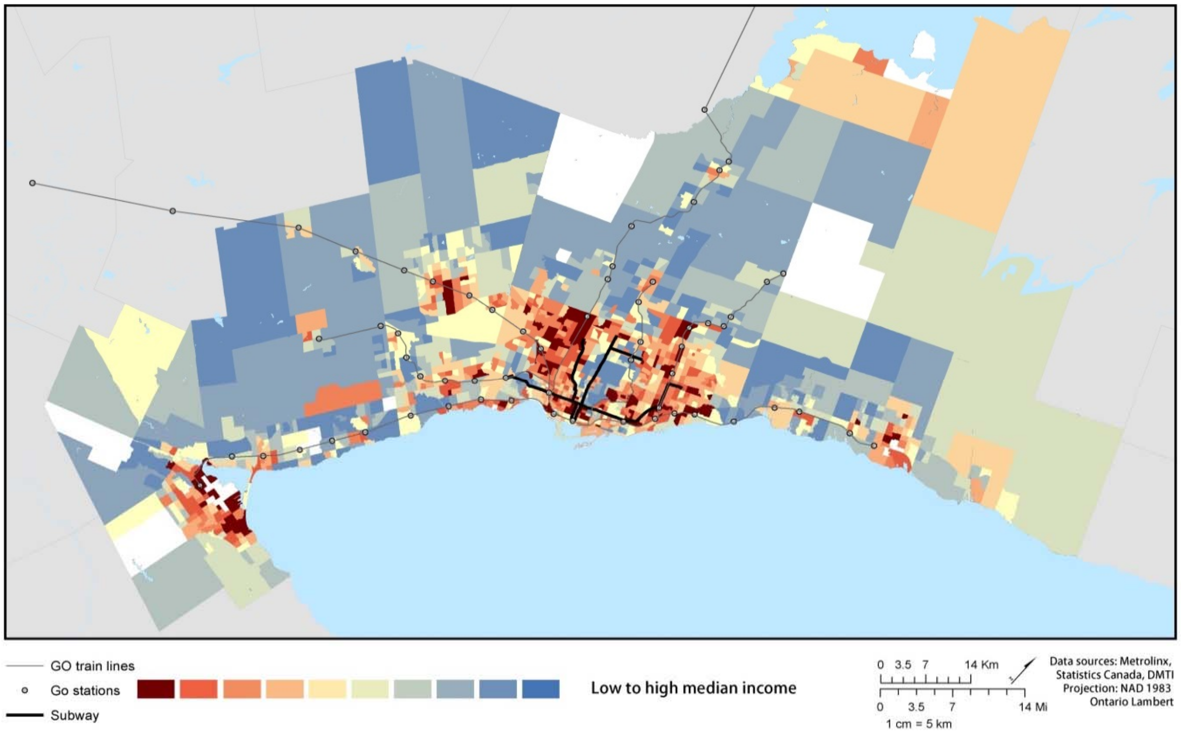
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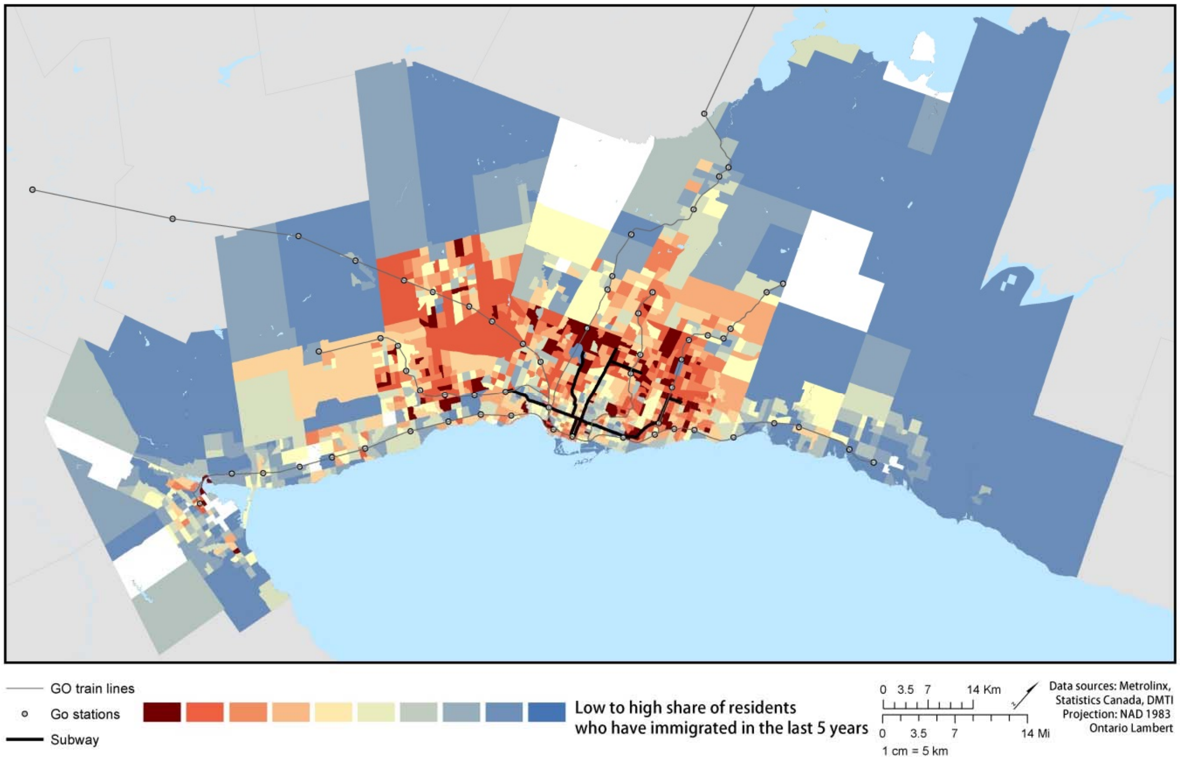
Projection: NAD 1983 Ontario Lambert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Subway
Low to high share of residents who have immigrated in the last 5 years
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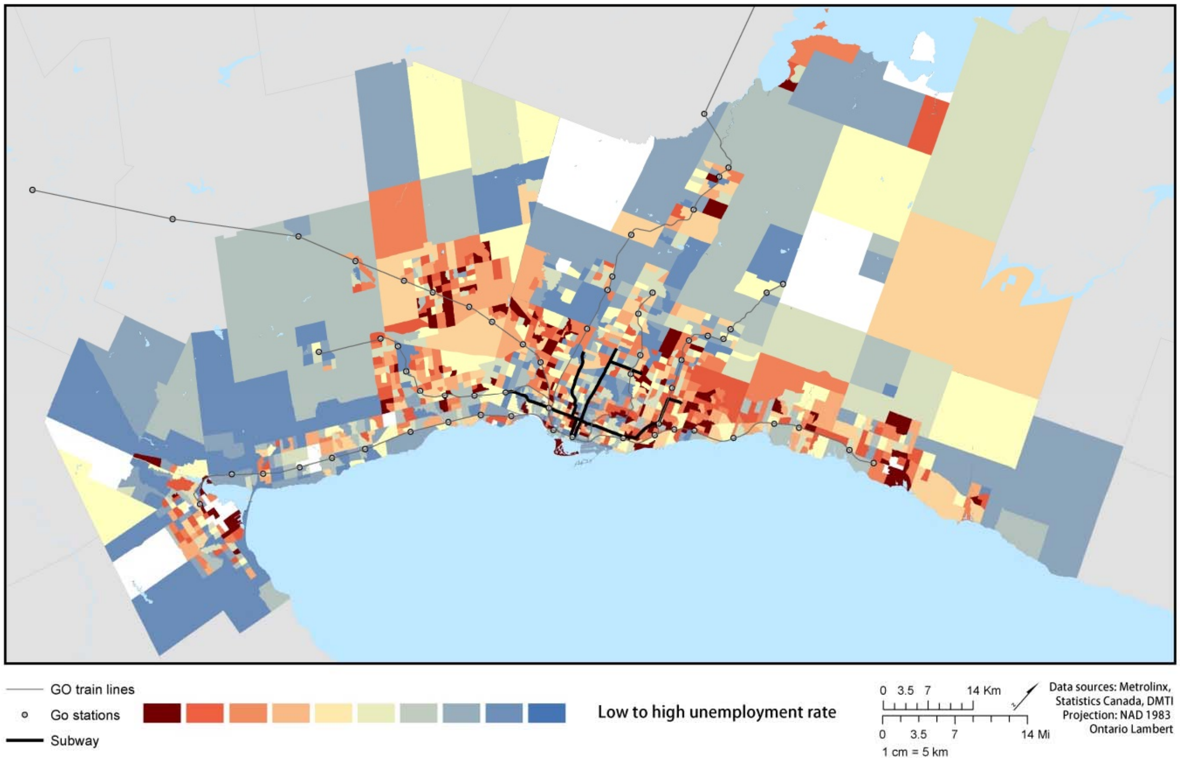
Projection: NAD 1983 Ontario Lambert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Subway
Low to high unemployment rate
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0 3.5 7 14 Mi
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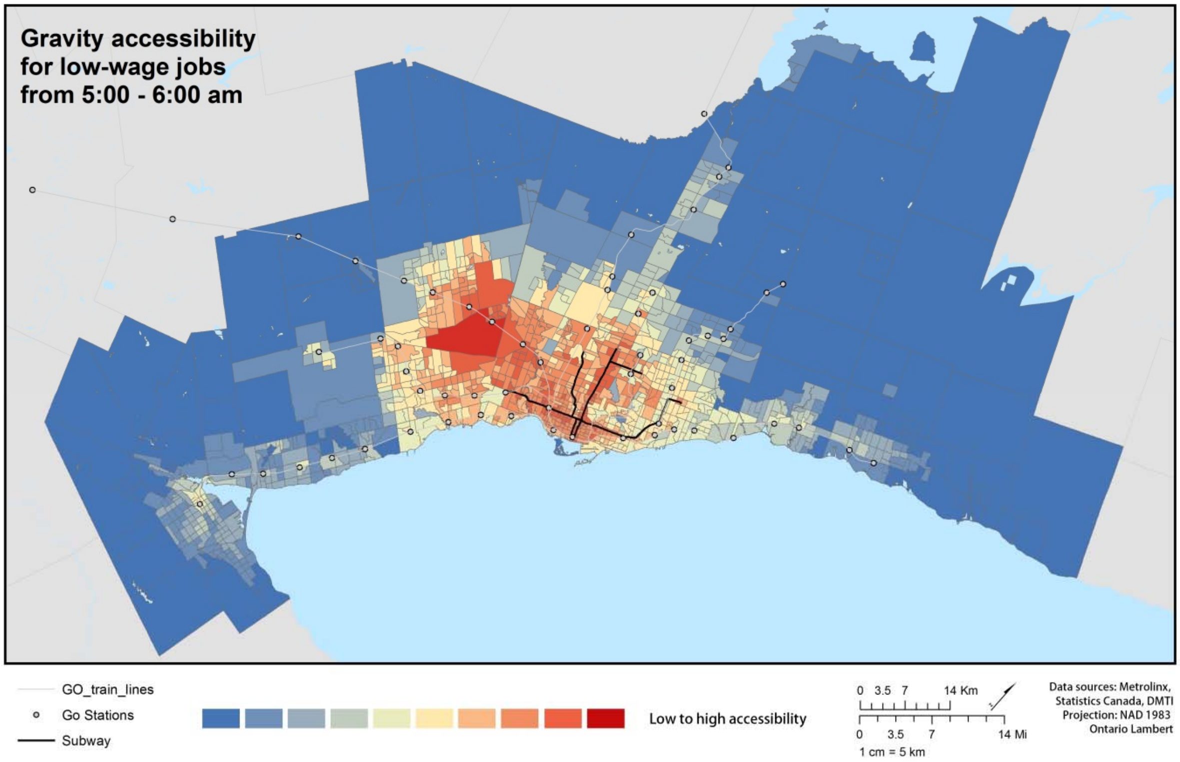
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

APPENDIX II: GRAVITY-BASED ACCESSIBILITY TO LOW-WAGE JOBS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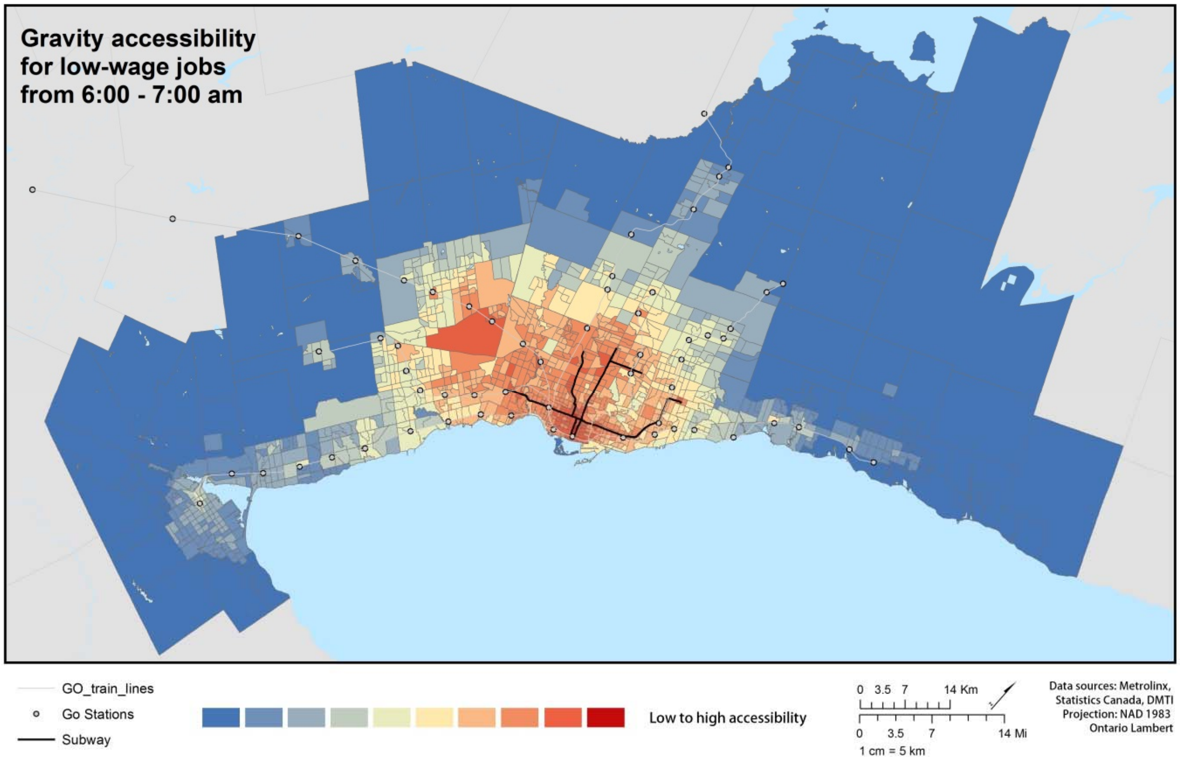
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert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Subway
Low to high accessibility
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Data sources: Metrolinx, Statistics Canada, DMTI
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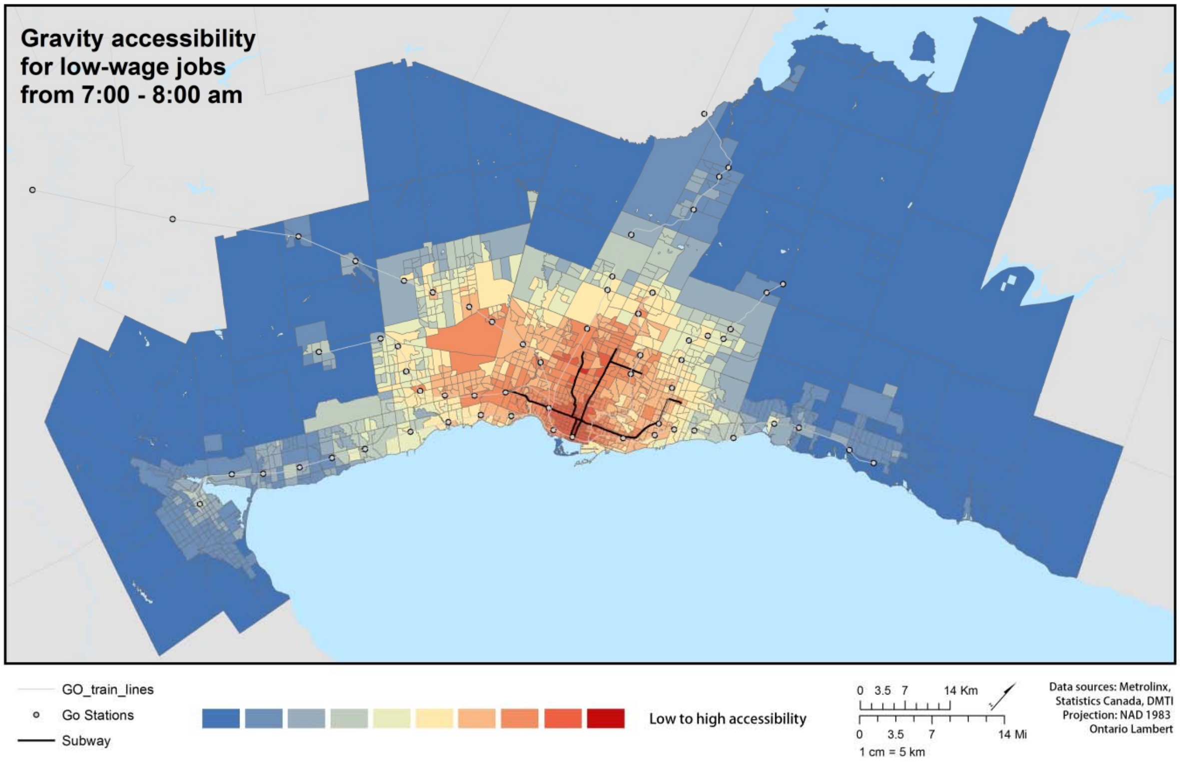
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Subway
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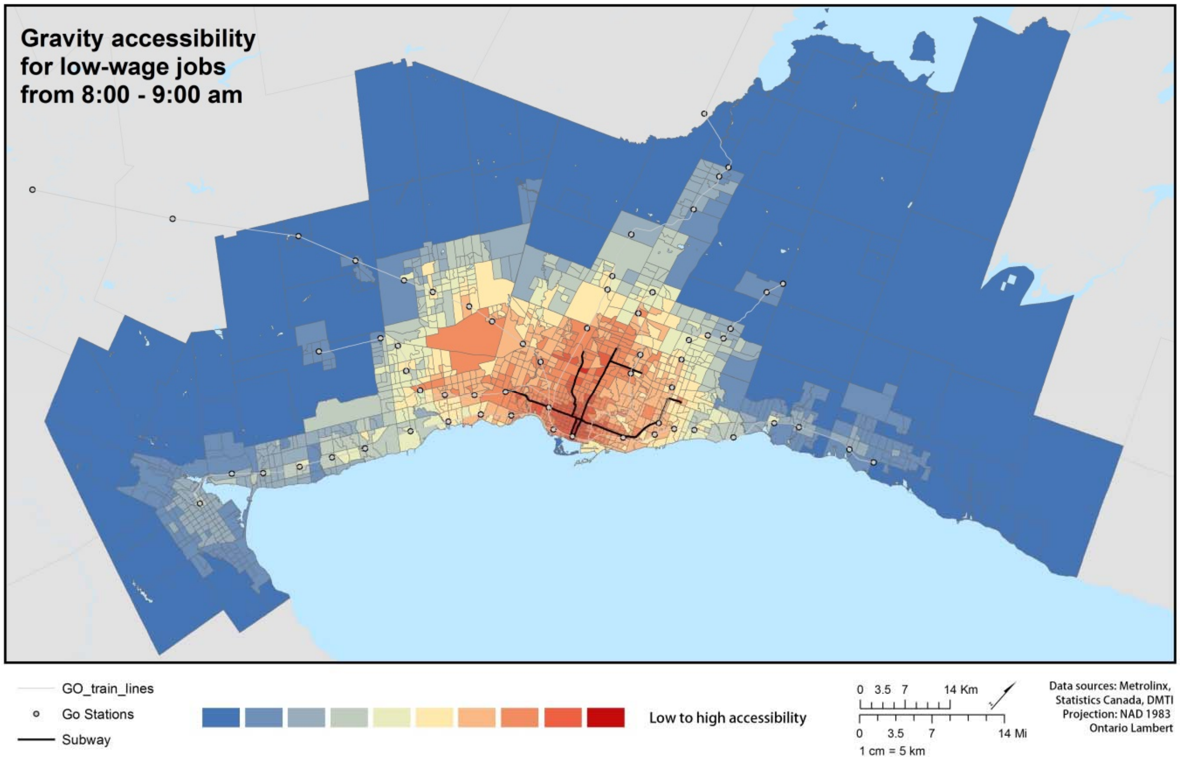
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Gravity accessibility for low-wage jobs from 8:00 - 9:00 am
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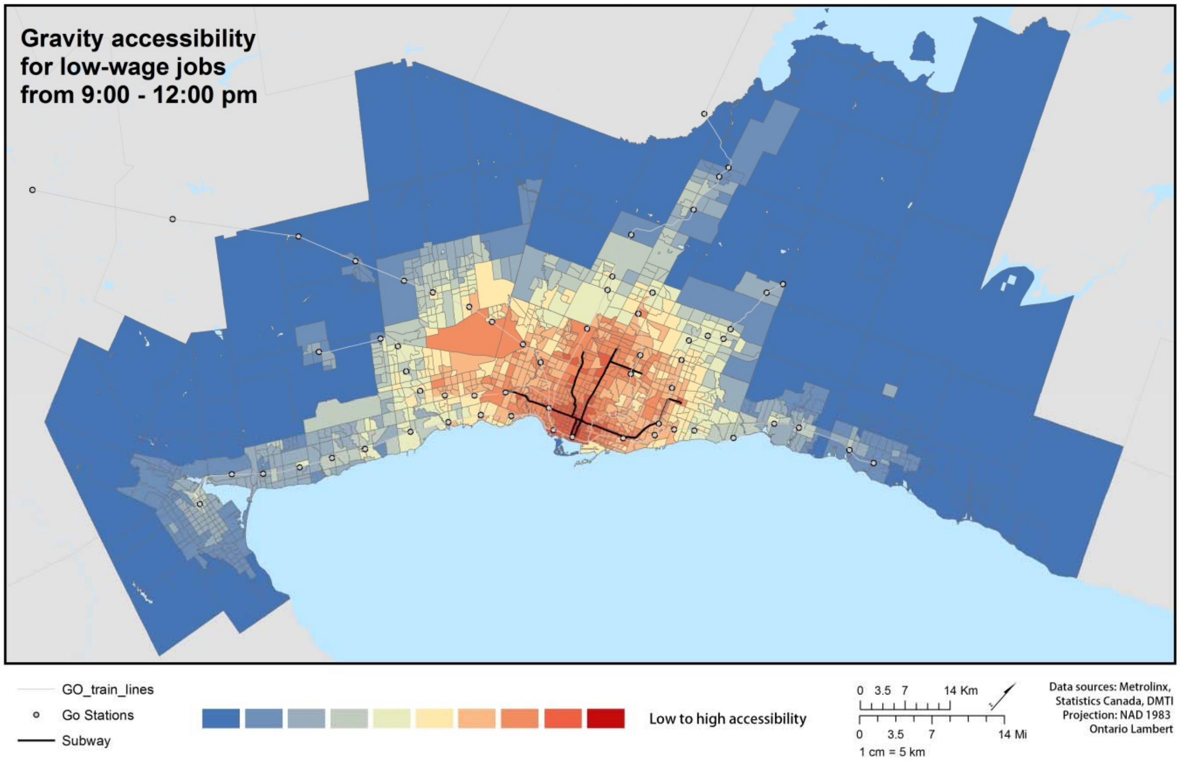
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert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Subway
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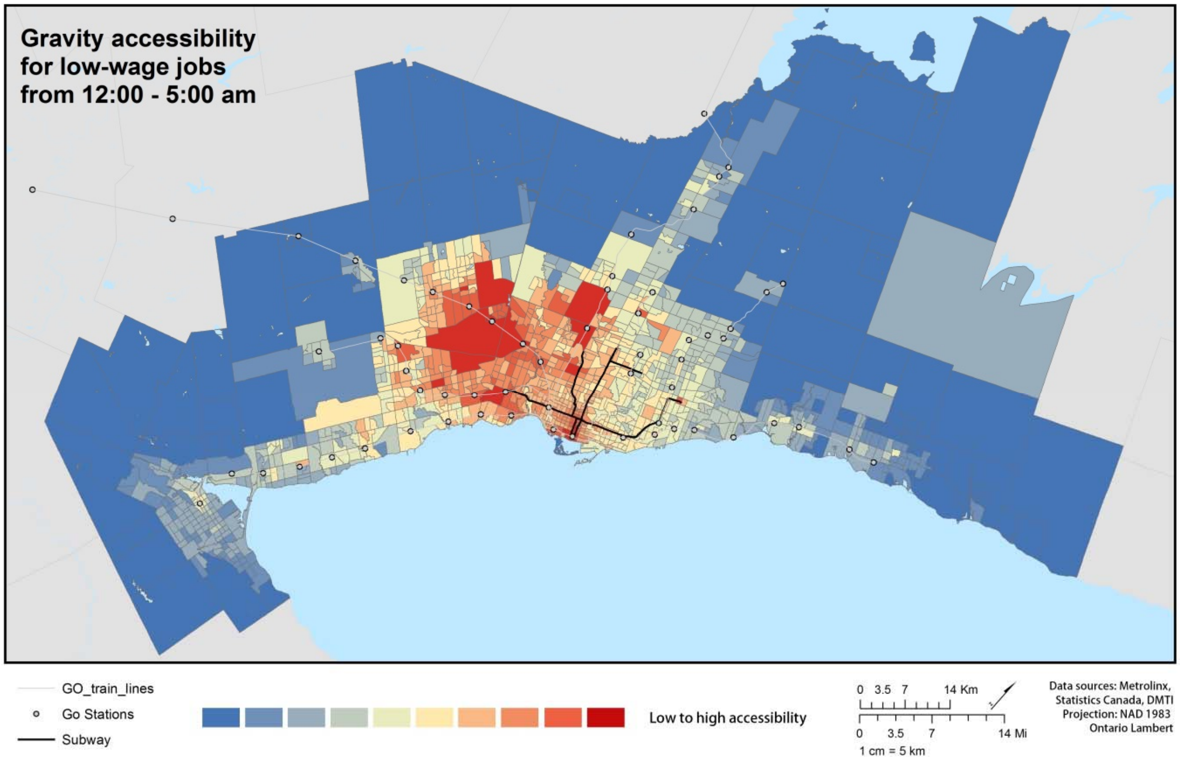
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert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Low to high accessibility
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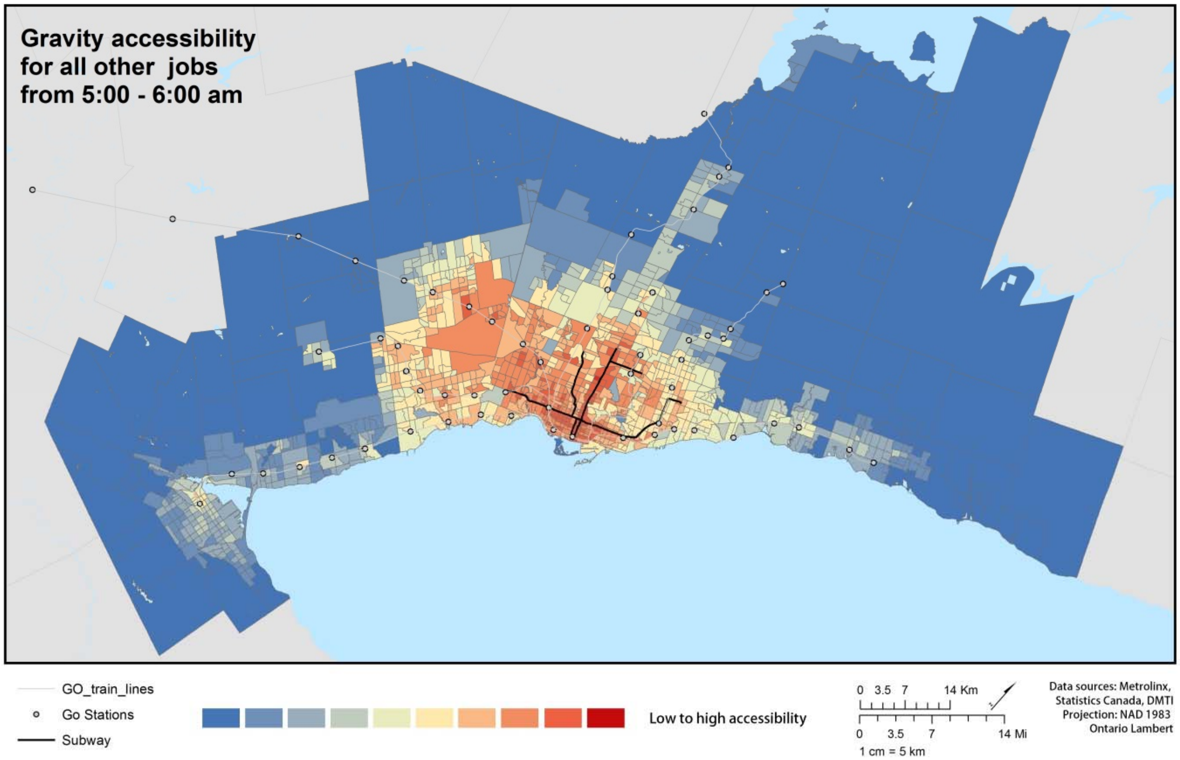
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

APPENDIX III: GRAVITY-BASED ACCESSIBILITY TO OTHER-WAGE JOBS


Gravity accessibility
for all other jobs
from 5:00 - 6:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
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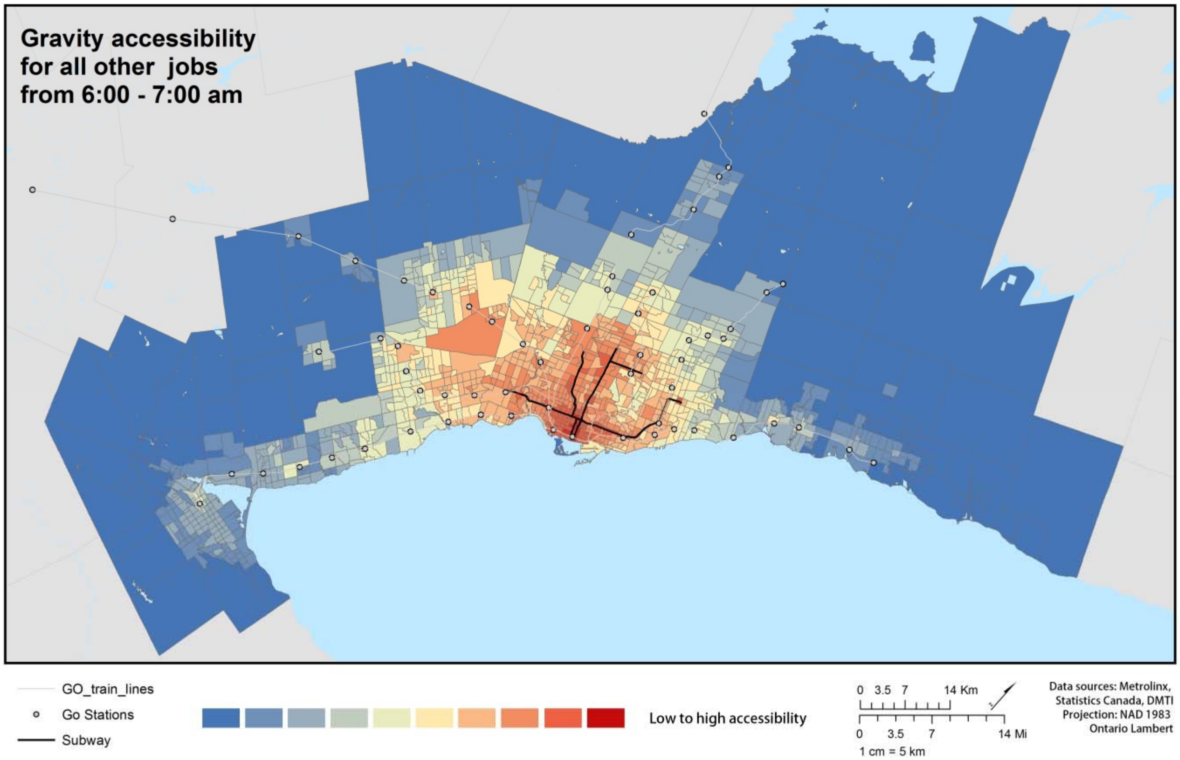
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Gravity accessibility
for all other jobs
from 6:00 - 7:00 am
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Go Stations
Subway
Low to high accessibility
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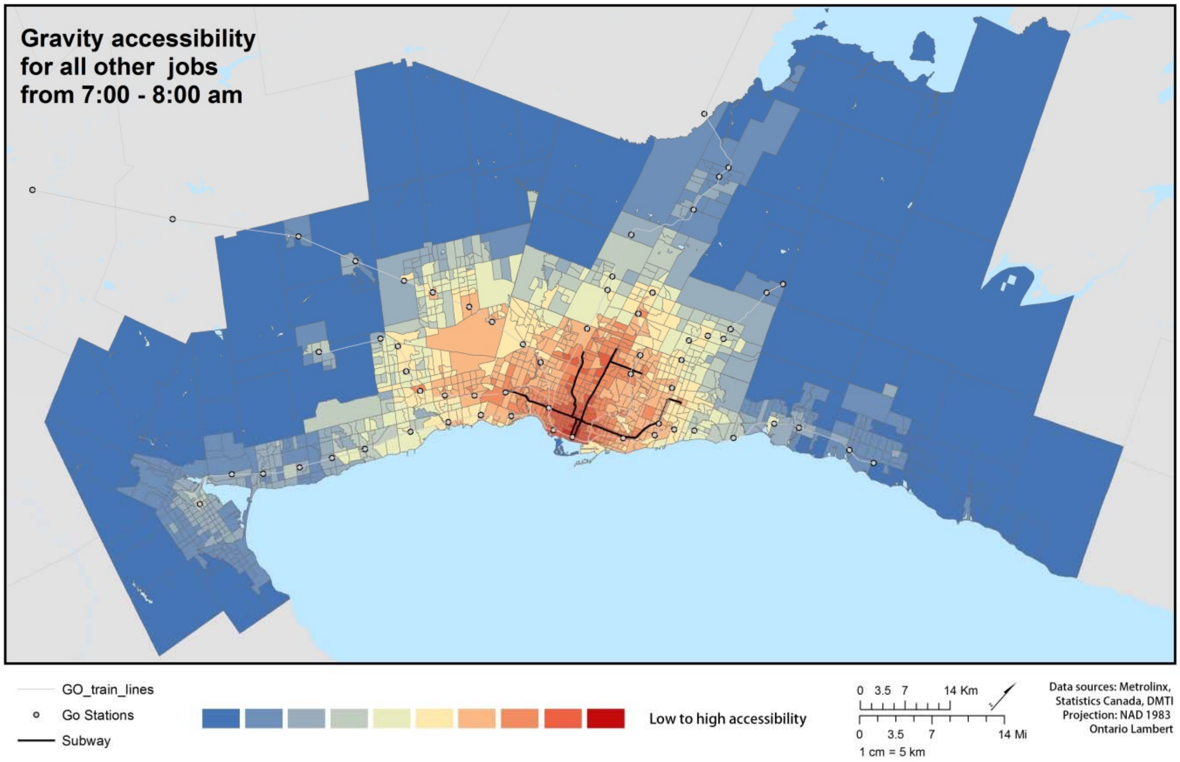
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Gravity accessibility
for all other jobs
from 7:00 - 8:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
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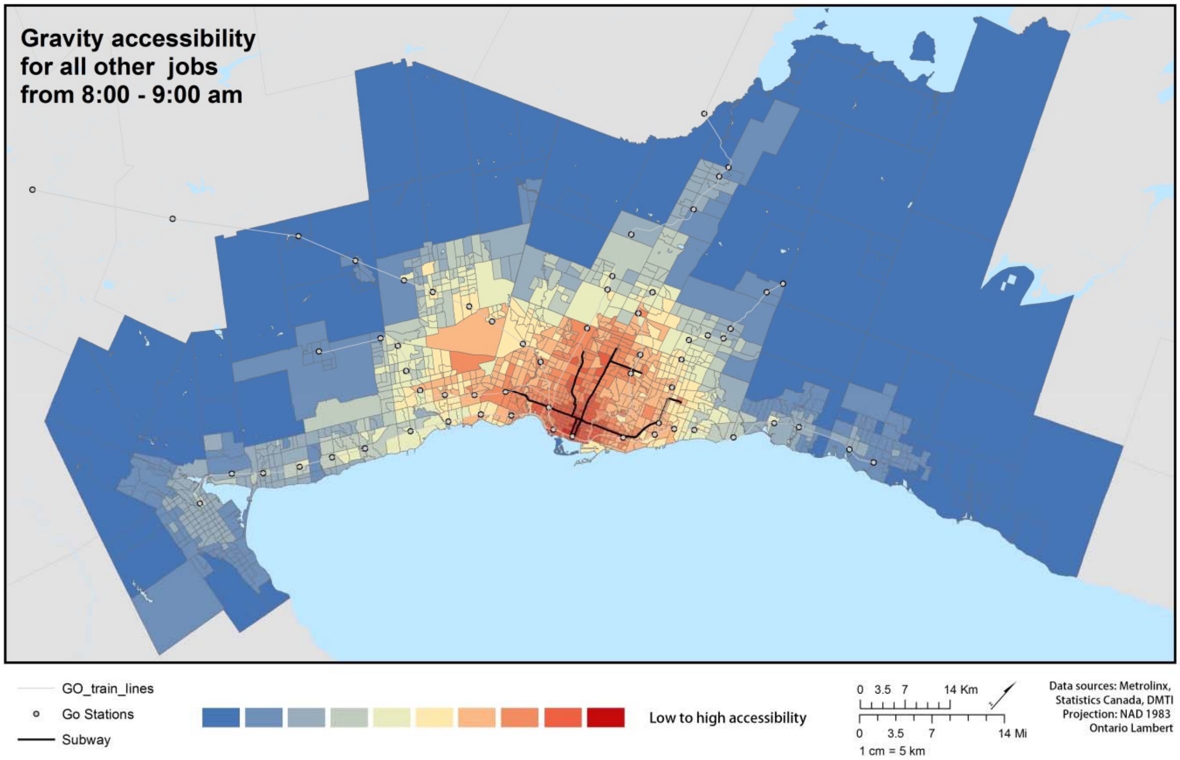
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Gravity accessibility
for all other jobs
from 8:00 - 9:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
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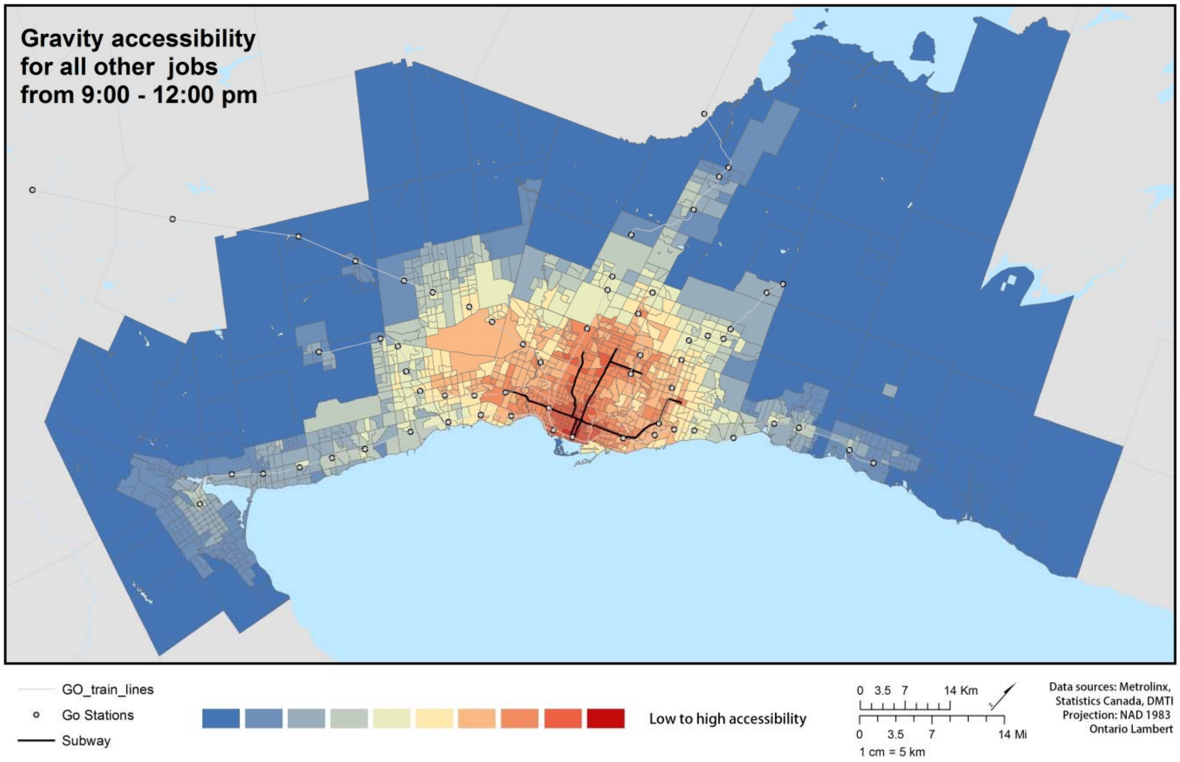
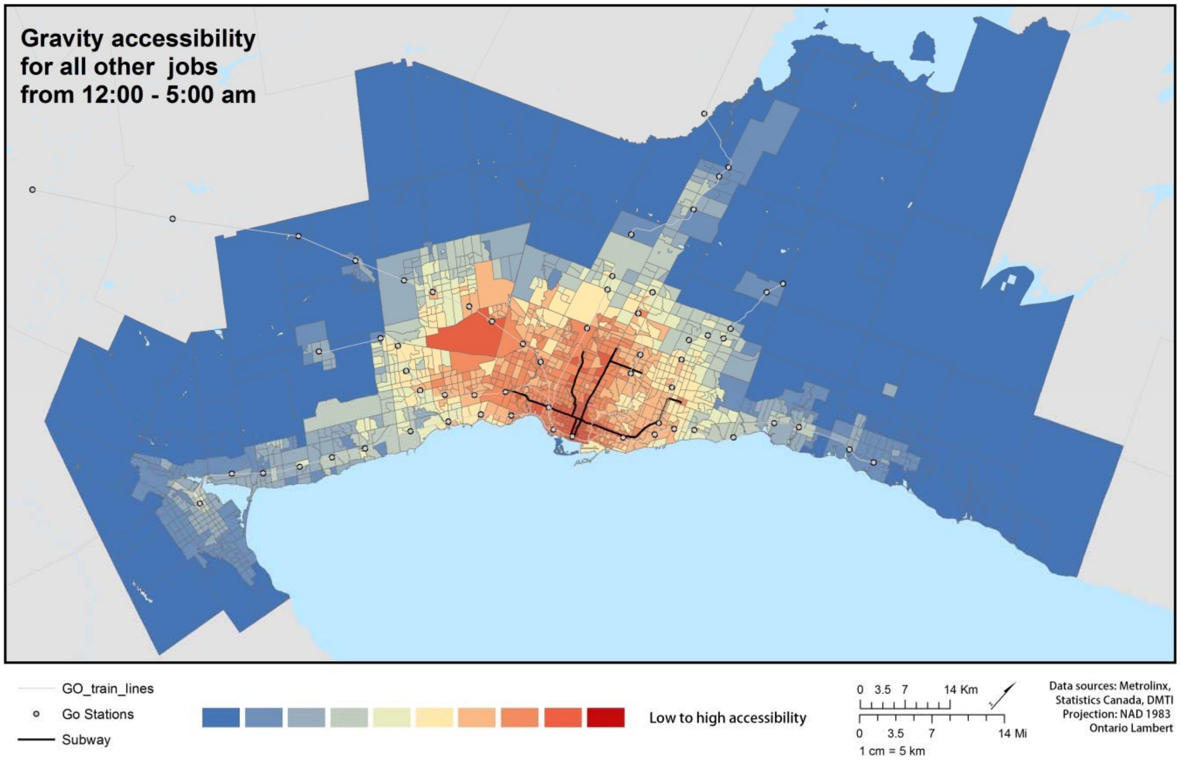
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert



Gravity accessibility for all other jobs from 9:00 - 12:00 pm

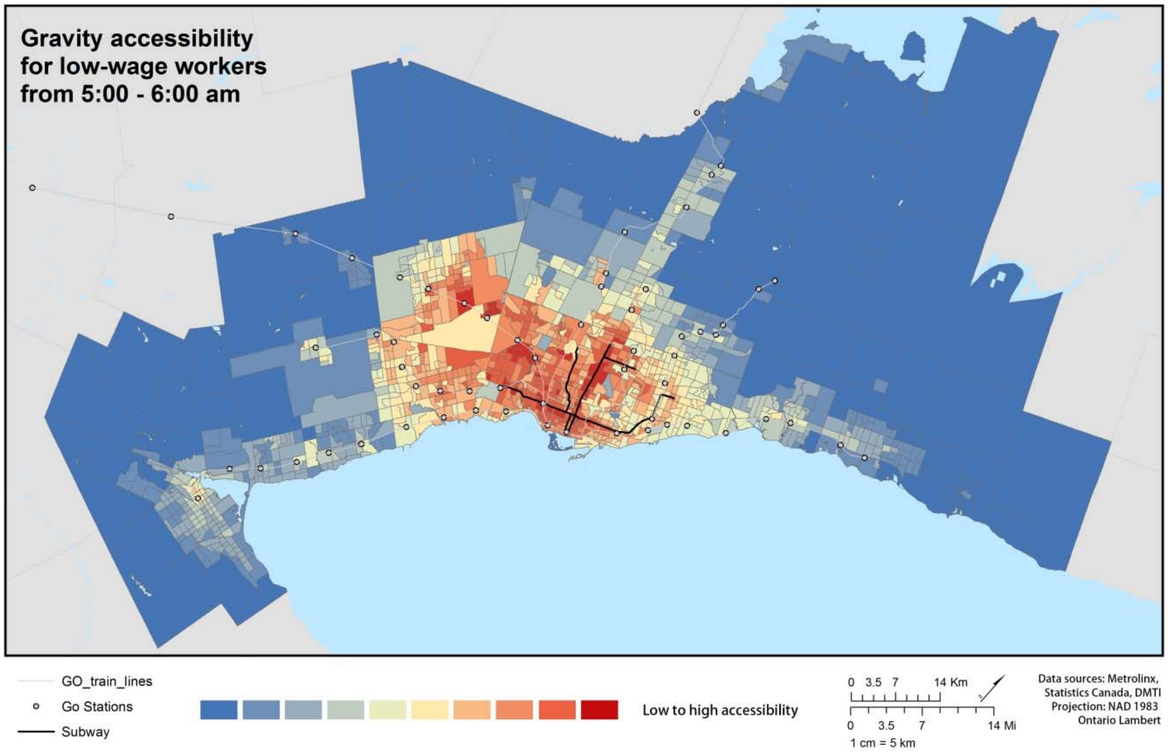
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert



Gravity accessibility for all other jobs from 12:00 - 5:00 am

Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

APPENDIX IV: GRAVITY BASED ACCESSIBILITY TO LOW-WAGE WORKERS


Gravity accessibility
for low-wage workers
from 5:00 - 6:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
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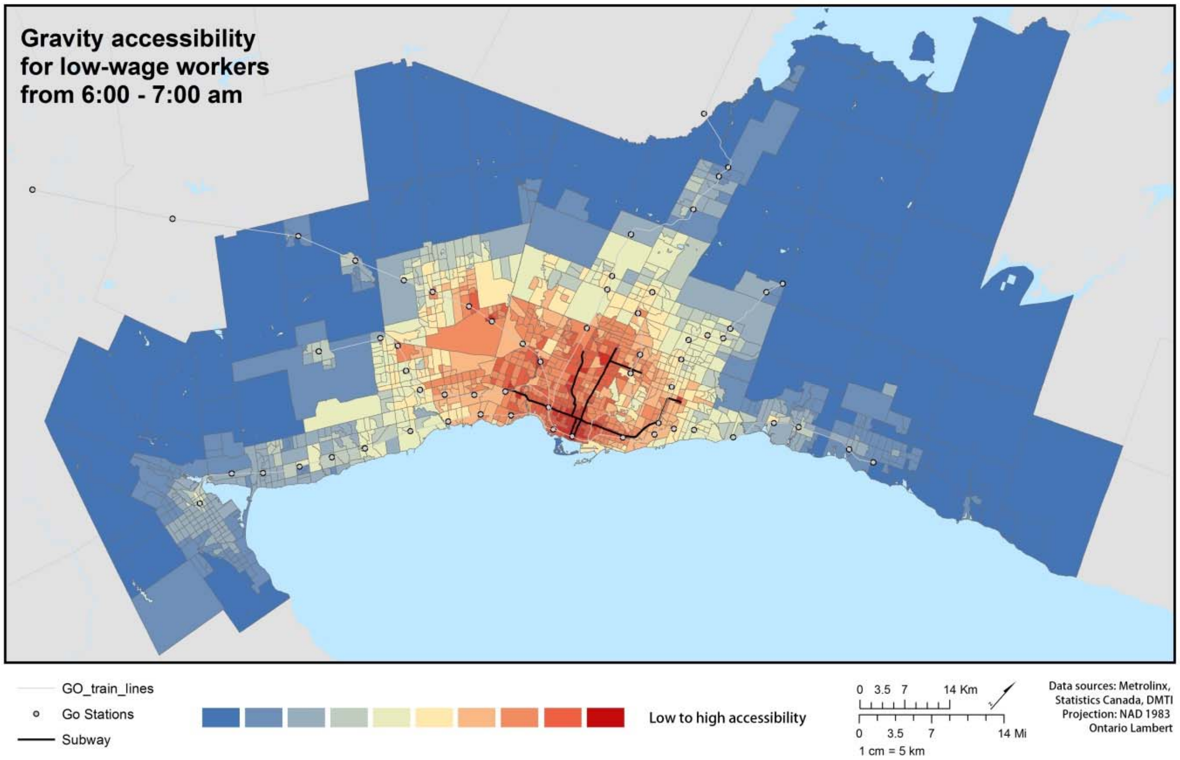
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Gravity accessibility
for low-wage workers
from 6:00 - 7:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
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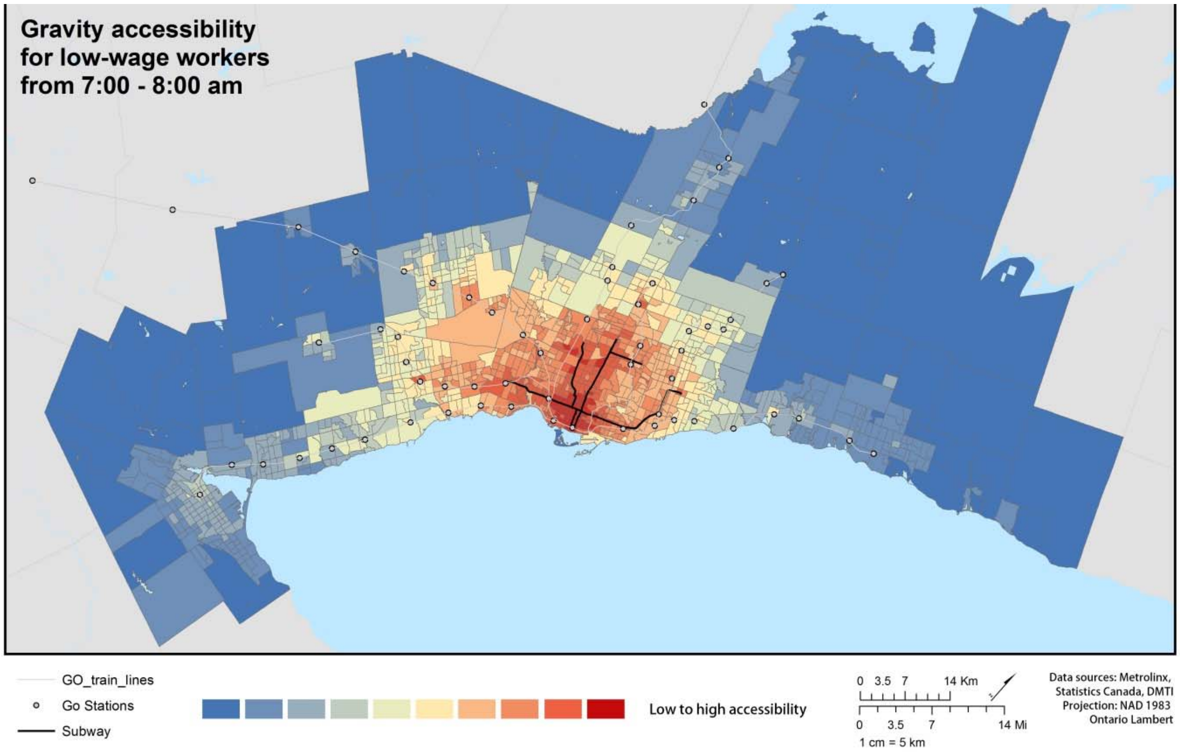
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert



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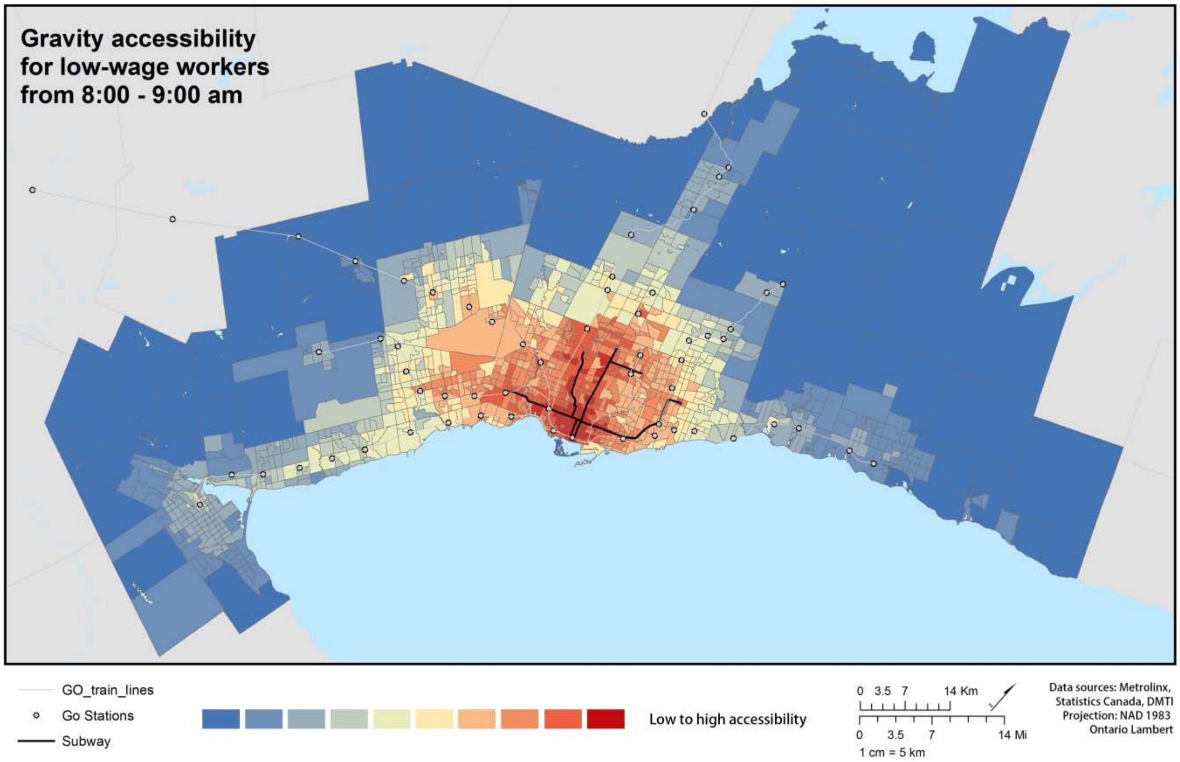

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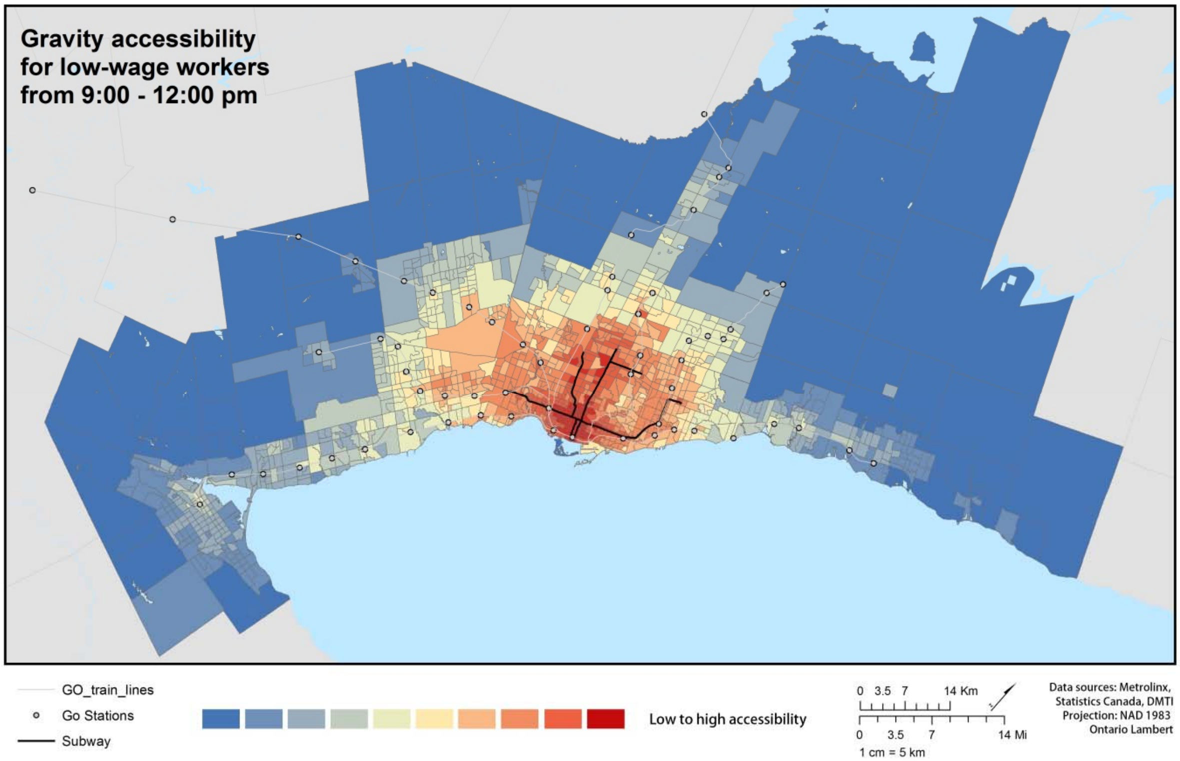
Gravity accessibility
for low-wage workers
from 9:00 - 12:00 pm
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Go Stations
Subway
Low to high accessibility
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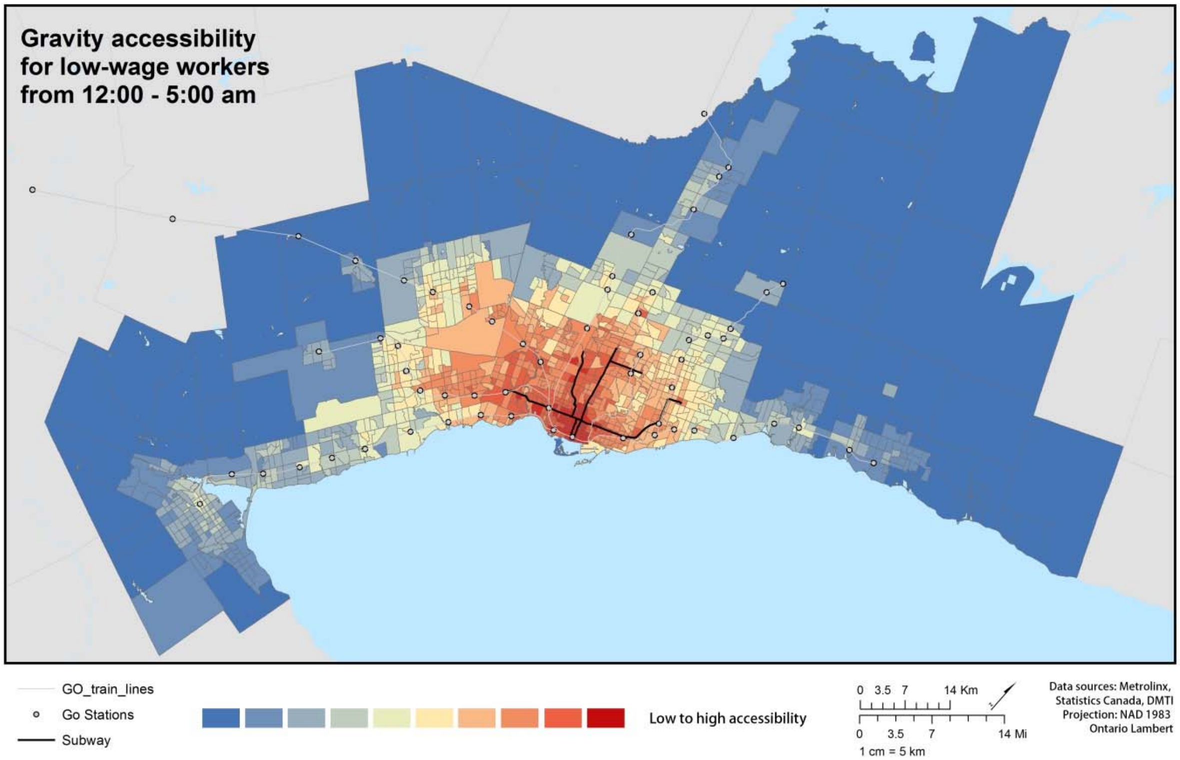
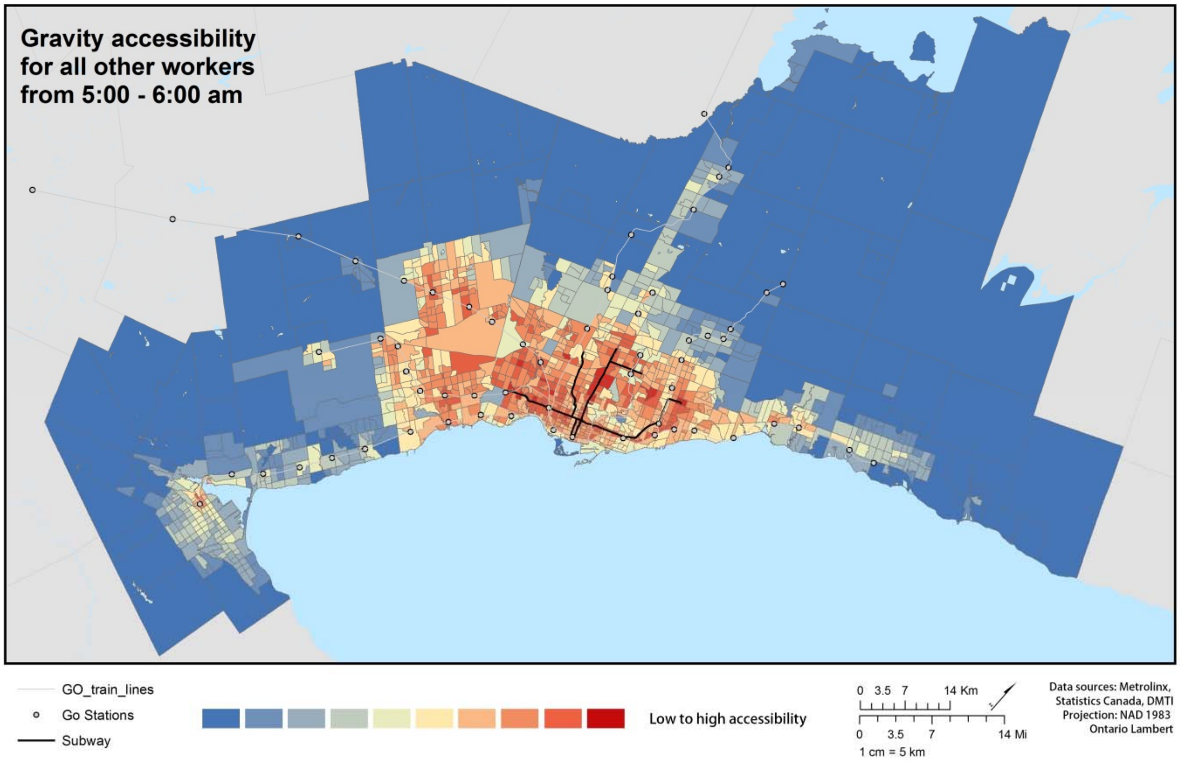
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Gravity accessibility
for low-wage workers
from 12:00 - 5:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert

APPENDIX V: GRAVITY-BASED ACCESSIBILITY TO OTHER WAGE WORKERS


Gravity accessibility for all other workers from 5:00 - 6:00 am
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Go Stations
Subway
Low to high accessibility
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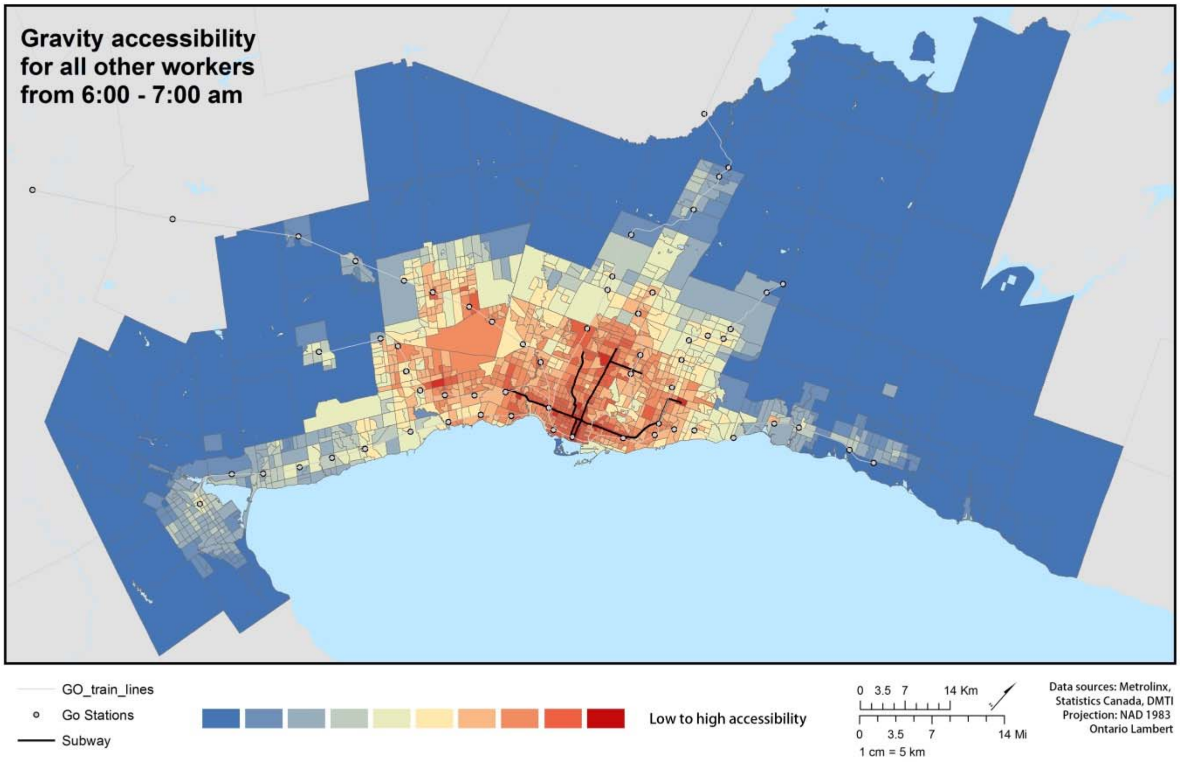
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Gravity accessibility for all other workers from 6:00 - 7:00 am
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Subway
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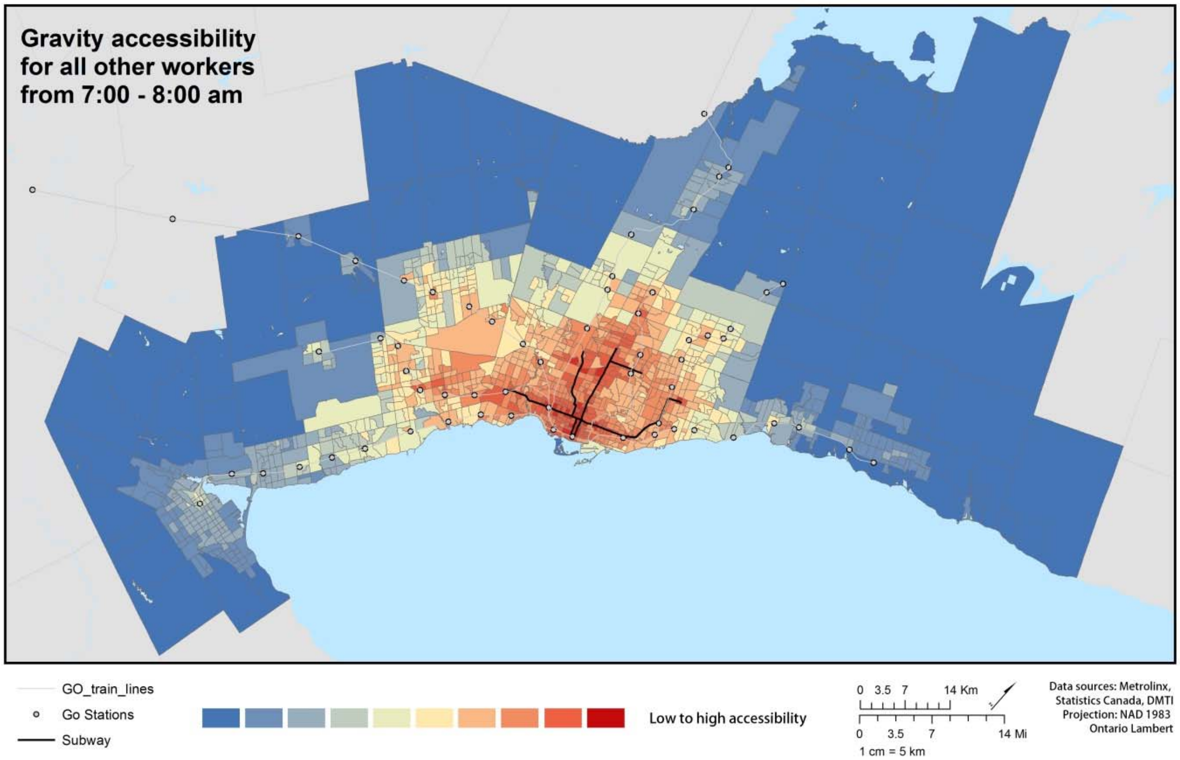
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Gravity accessibility for all other workers from 7:00 - 8:00 am
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Subway
Low to high accessibility
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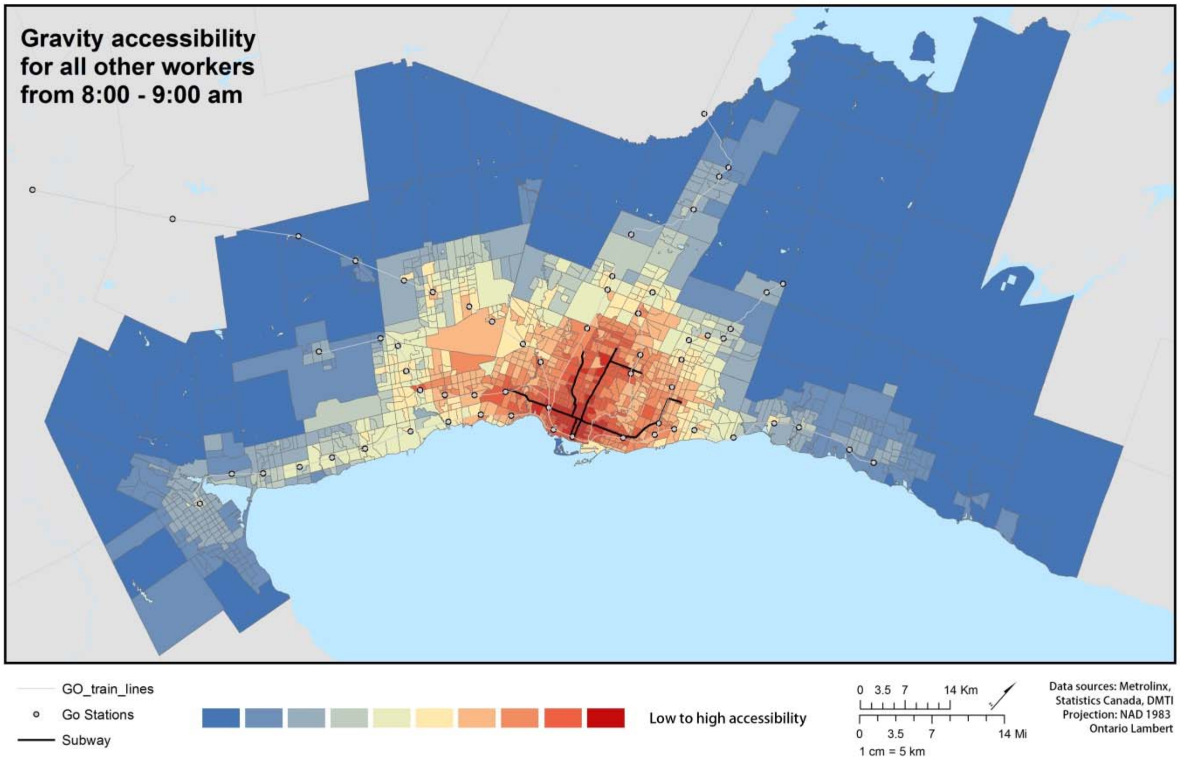
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Gravity accessibility for all other workers from 8:00 - 9:00 am
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Subway
Low to high accessibility
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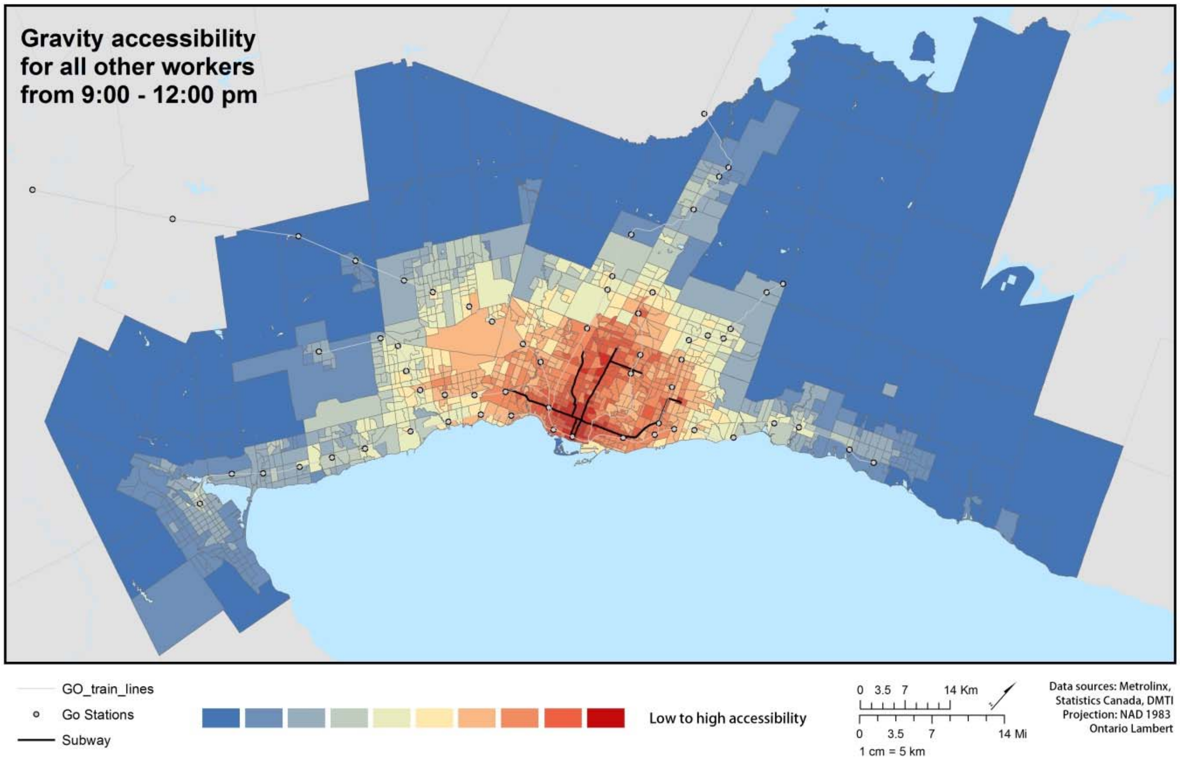
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert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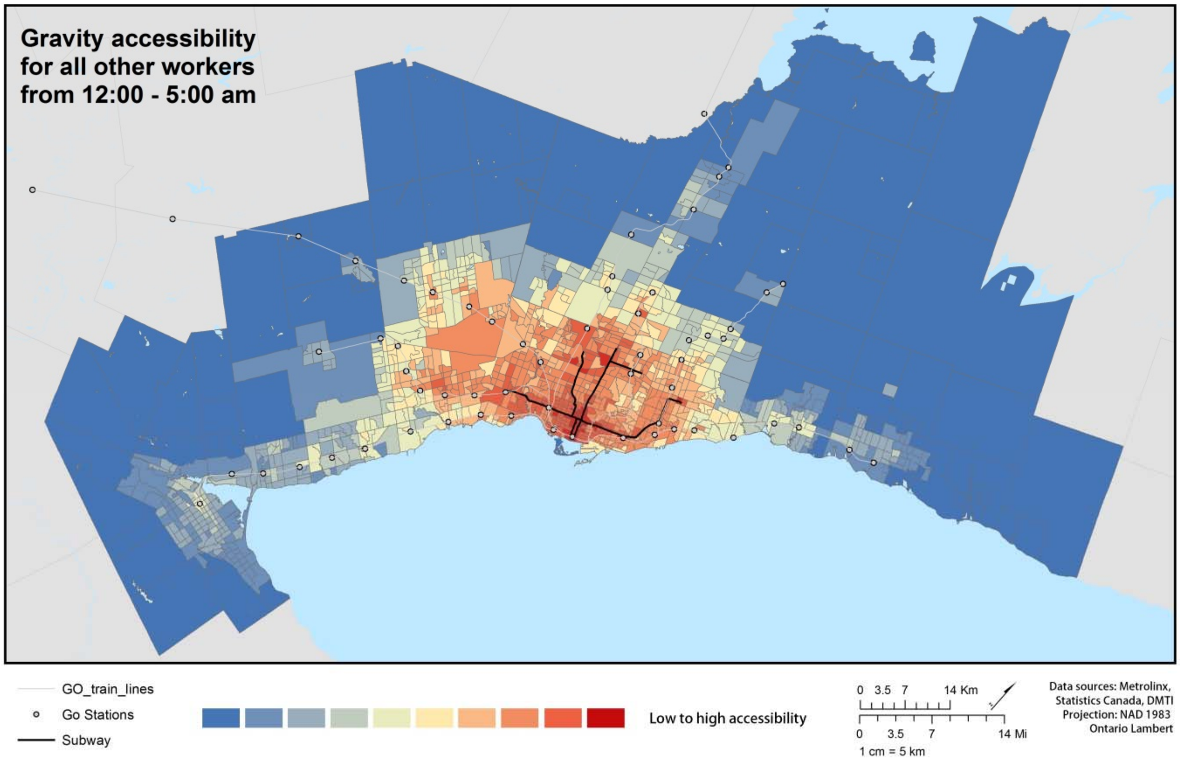
Gravity accessibility for all other workers from 12:00 - 5:00 am
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Subway
Low to high accessibility
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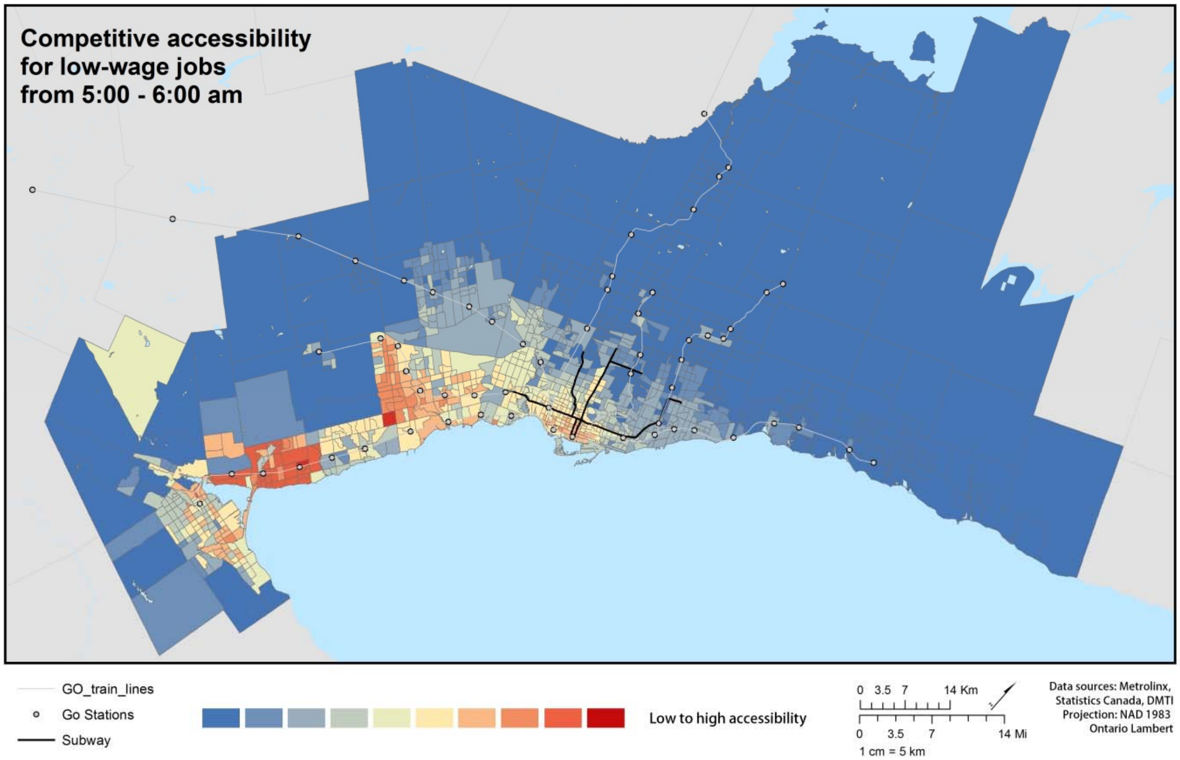
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

APPENDIX VI: COMPETITION BASED ACCESSIBILITY TO LOW-WAGE EMPLOYMENT


Competitive accessibility for low-wage jobs from 5:00 - 6:00 am
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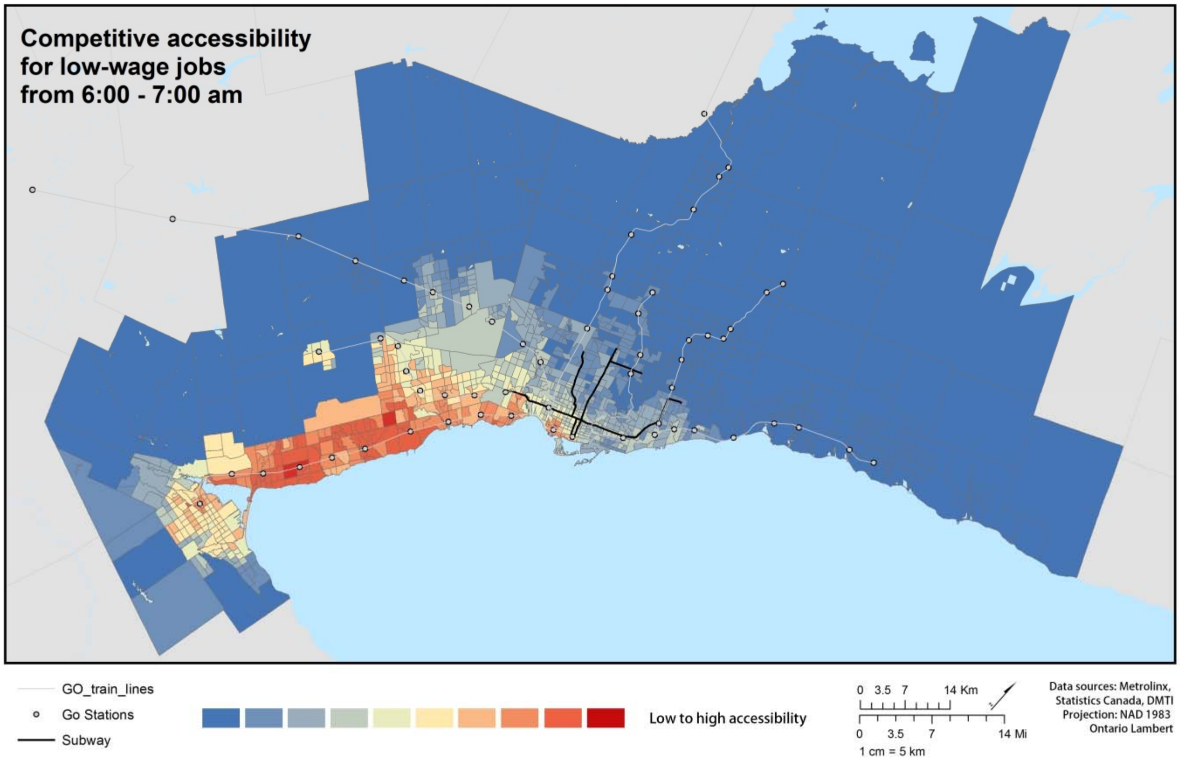
Competitive accessibility for low-wage jobs from 6:00 - 7:00 am
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Subway
Low to high accessibility
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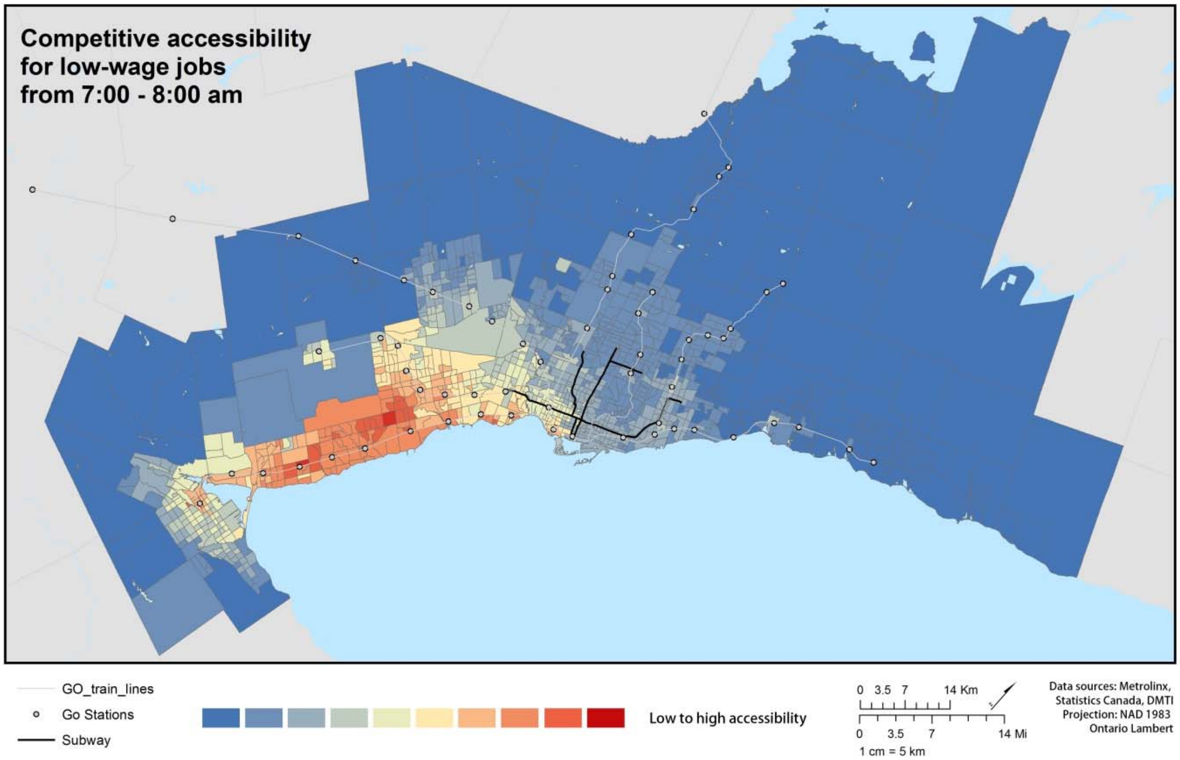
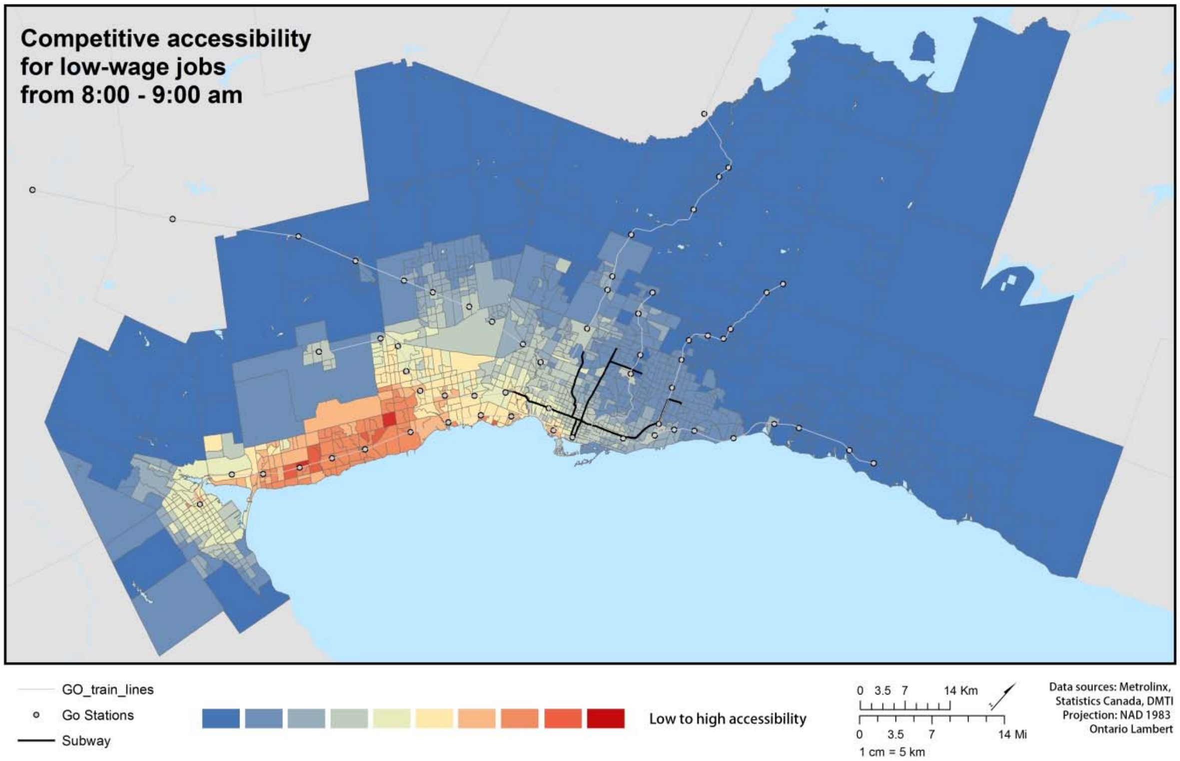


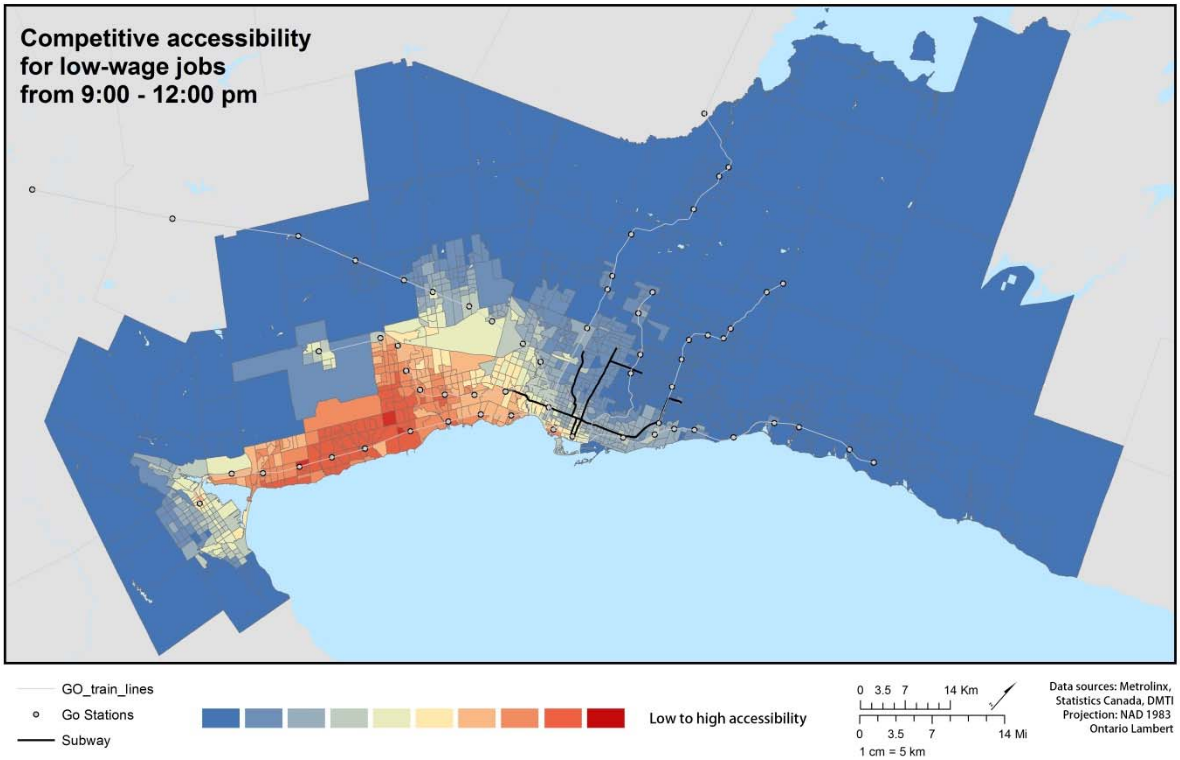
Competitive accessibility for low-wage jobs from 7:00 - 8:00 am

Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

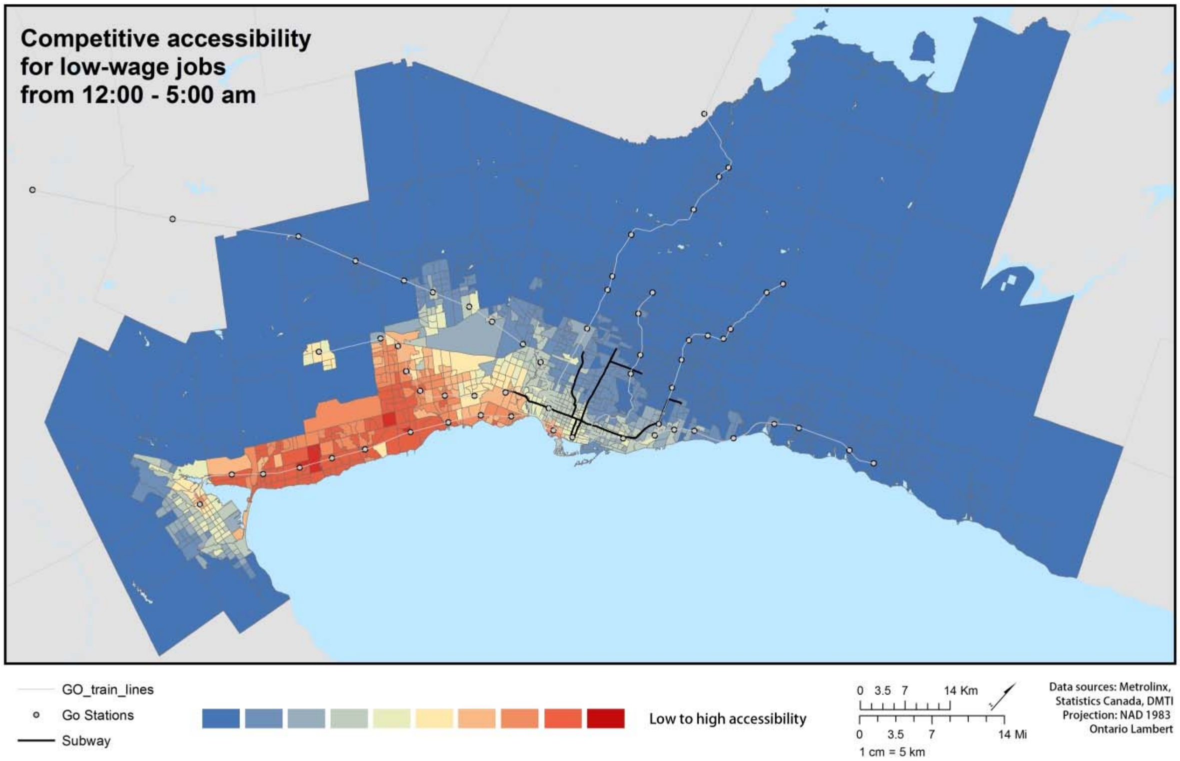


Competitive accessibility for low-wage jobs from 8:00 - 9:00 am

Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert

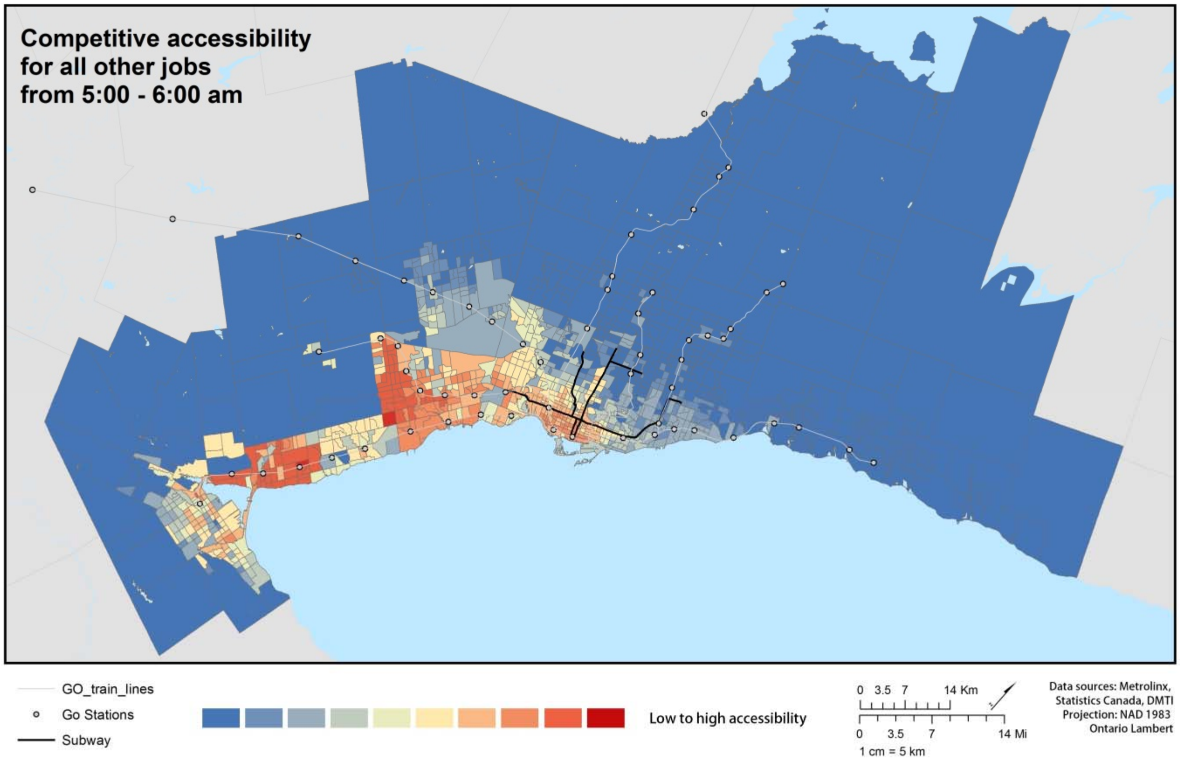


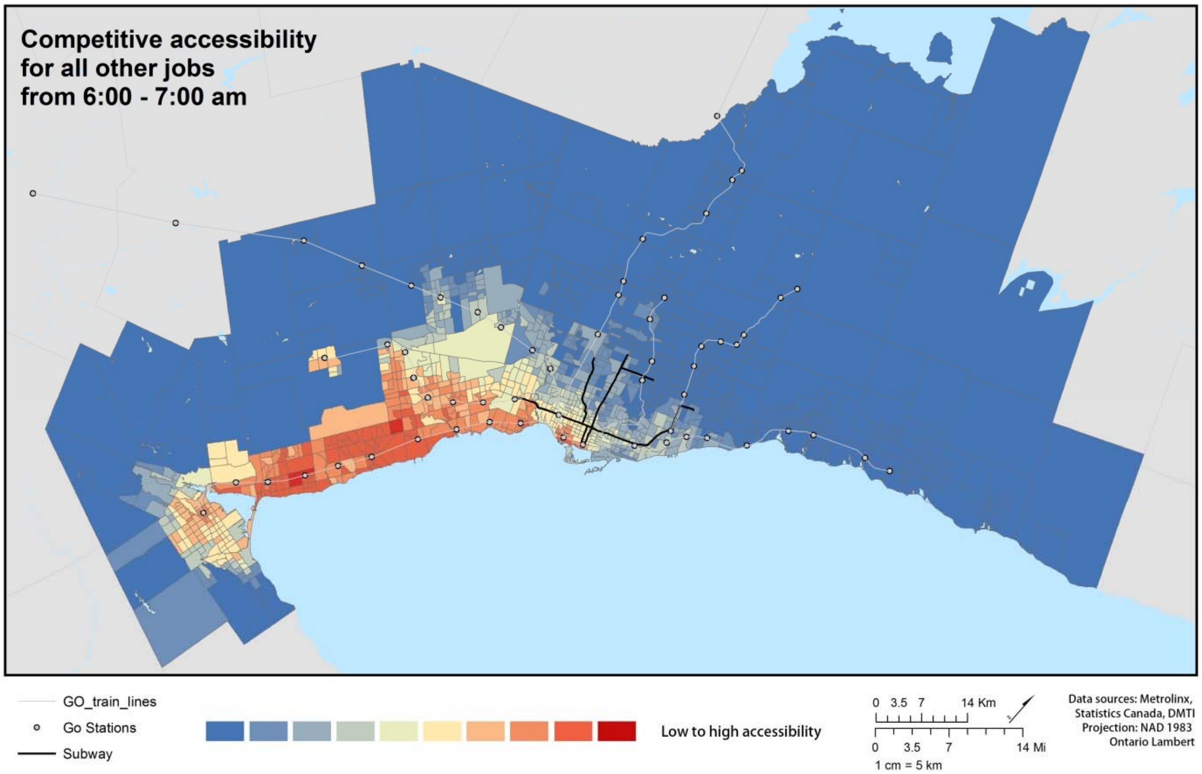
Competitive accessibility for low-wage jobs from 9:00 - 12:00 pm

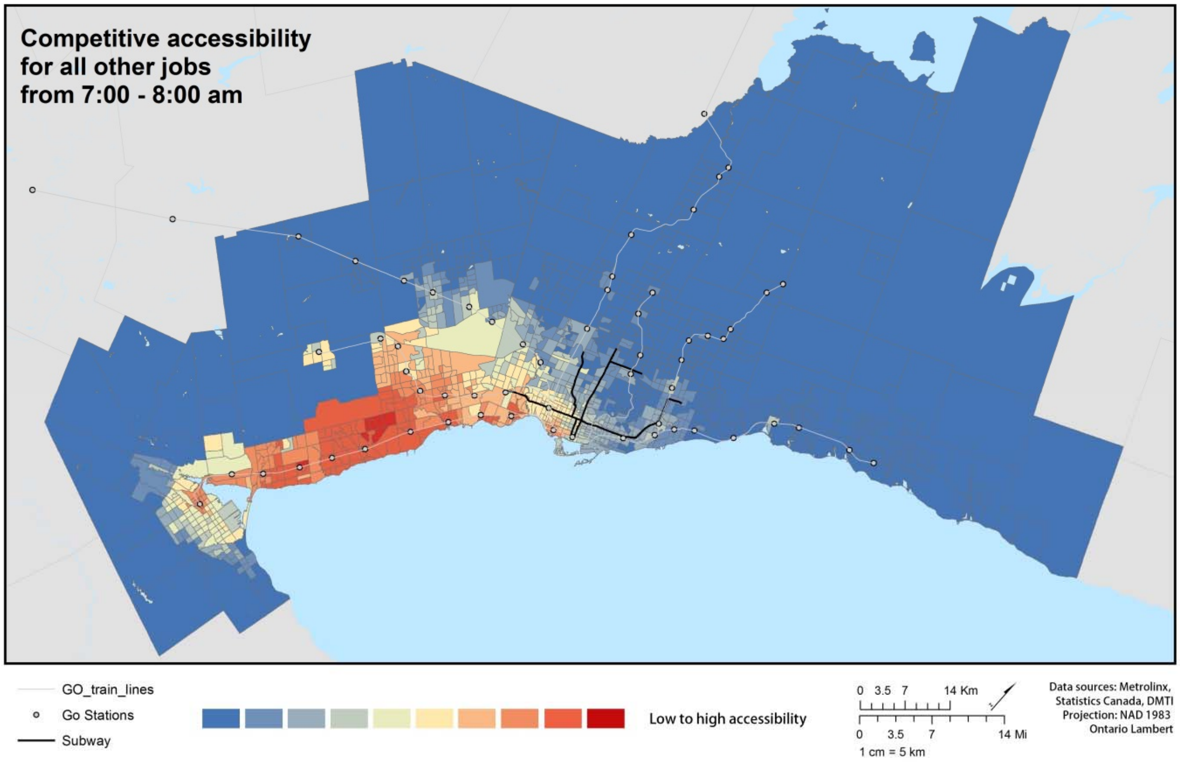


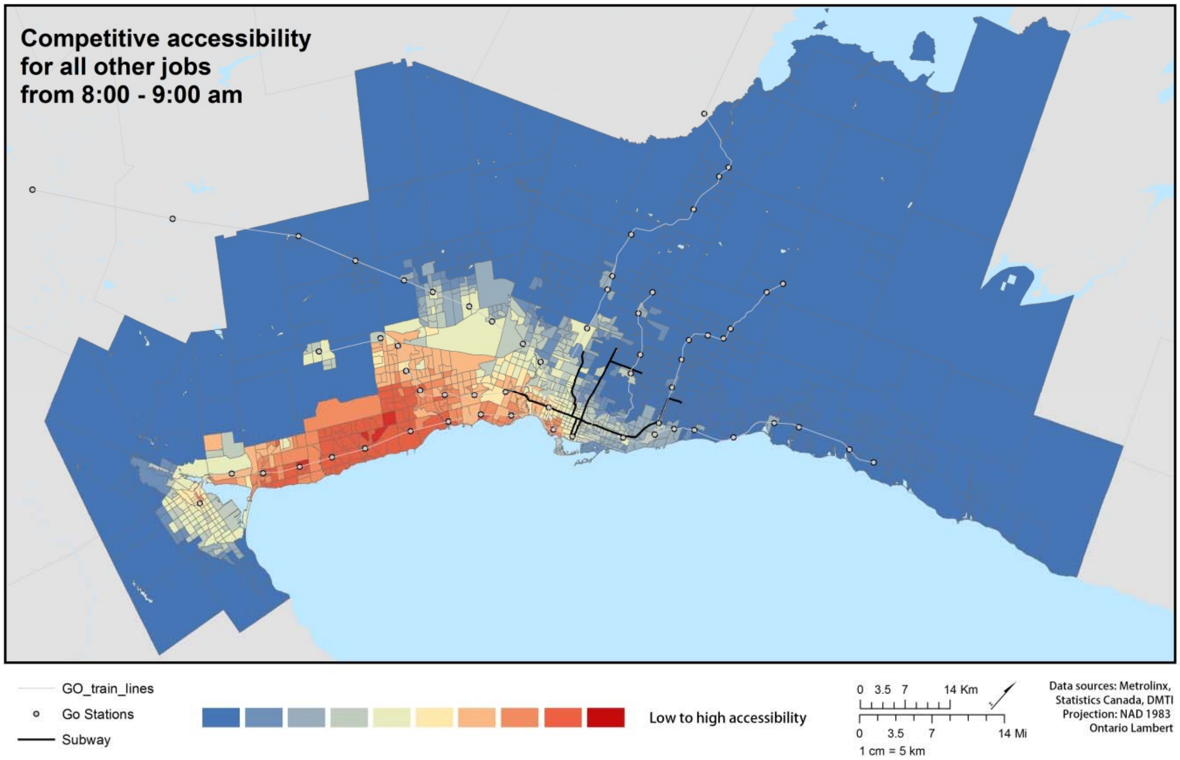
Competitive accessibility for low-wage jobs from 12:00 - 5:00 am

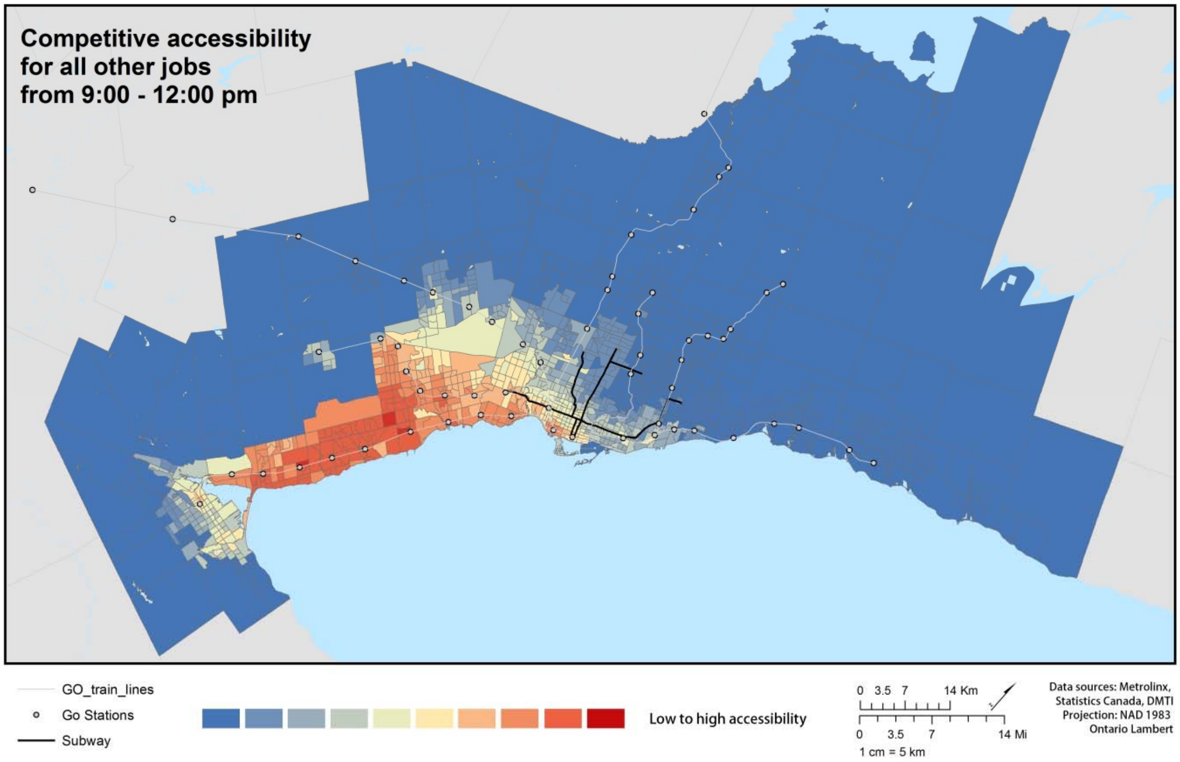
APPENDIX VII: COMPETITION - BETTER-PAID JOBS

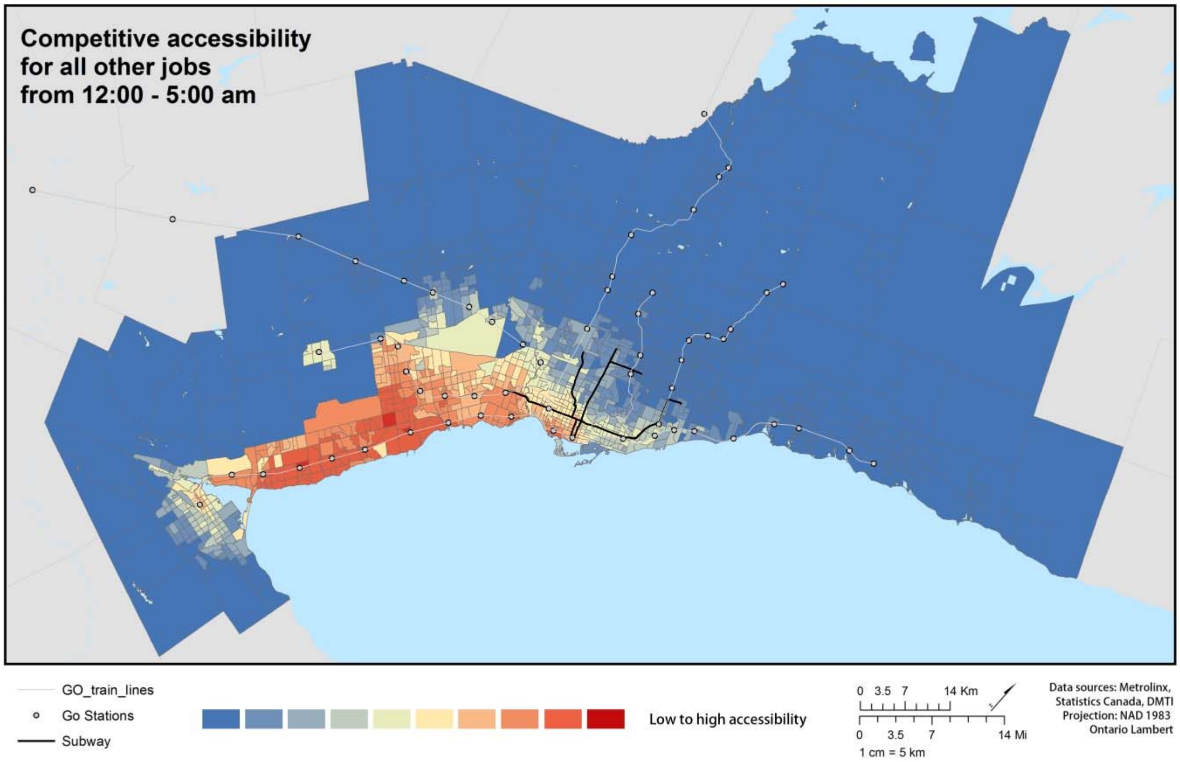

Competitive accessibility
for all other jobs
from 5:00 - 6:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Competitive accessibility
for all other jobs
from 6:00 - 7:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Competitive accessibility for all other jobs from 7:00 - 8:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Competitive accessibility for all other jobs from 8:00 - 9:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx, Statistics Canada, DMTI
Projection: NAD 1983 Ontario Lambert


Competitive accessibility
for all other jobs
from 9:00 - 12:00 pm
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert


Competitive accessibility
for all other jobs
from 12:00 - 5:00 am
GO_train_lines
Go Stations
Subway
Low to high accessibility
0 3.5 7 14 Km
0 3.5 7 14 Mi
1 cm = 5 km
Data sources: Metrolinx,
Statistics Canada, DMTI
Projection: NAD 1983
Ontario Lambert

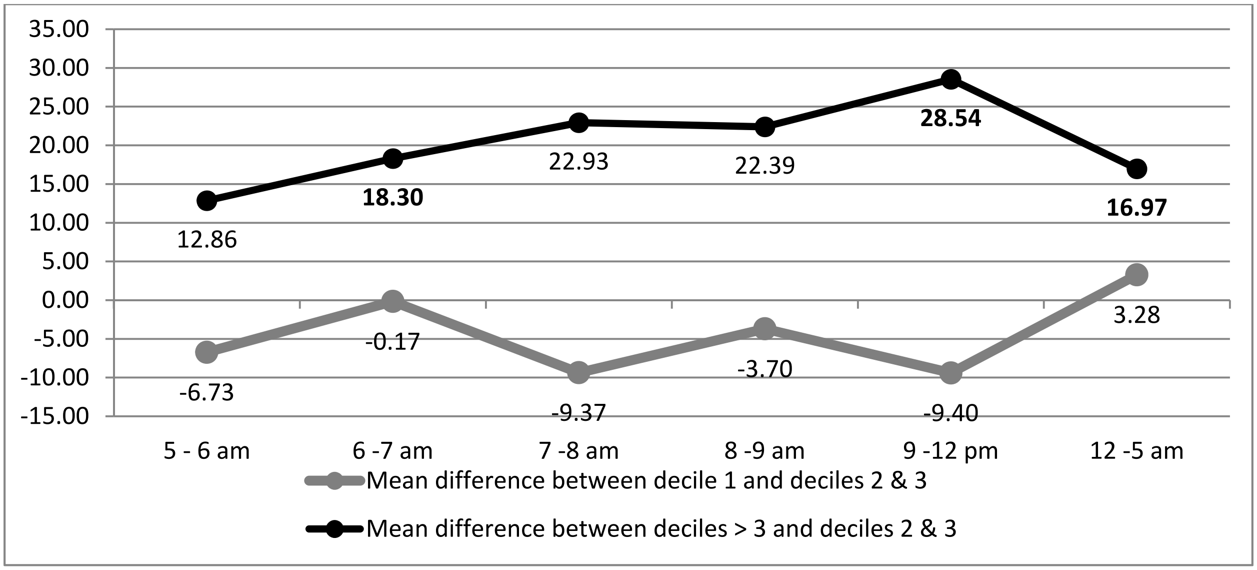
APPENDIX VIII: LOW-WAGE JOB CATEGORIES

Major Group	#	Group Name (2011)
00-09 (Management Occupations)	0621	Retail and wholesale trade managers
	0631	Restaurant and food service managers
	0822	Managers in horticulture
11-15 (Business, Finance, and Administration)	1241	Administrative assistants
	141	General office workers
	145	Library, correspondence, and other clerks
	1513	Couriers, messengers and door-to-door distributors
	1521	Shippers and receivers
	1524	Purchasing and inventory control workers
3 (Health Occupations)	3219	Other medical technologists and technicians (except dental health)
4 (Occupations in education, law and social, community and government services)	4214	Early childhood educators and assistants
	4411	Home child care providers
5 (Occupations in art, culture, recreation and sport)	5135	Actors and comedians
	5221	Photographers
	5232	Other performers, n.e.c.
	5242	Interior designers and interior decorators
	5244	Artisans and craftsperson’s
	5253	Sports officials and referees
	5254	Program leaders and instructors in recreation, sport and fitness
6 (Sales and service occupations)	6311	Food service supervisors
	6313	Accommodation, travel, tourism and related services supervisors
	6316	Other services supervisors
	6321	Chefs
	6322	Cooks
	6331	Butchers, meat cutters and fishmongers - retail and wholesale
	6332	Bakers
	6341	Hairstylists and barbers
	6342	Tailors, dressmakers, furriers and milliners
	6343	Shoe repairers and shoemakers
	651	Occupations in food and beverage service
	652	Occupations in travel and accommodation
	653	Tourism and amusement services occupations
	654	Security guards and related security service occupations
	656	Other occupations in personal service
	66	Sales support occupations

	67	Service support and other service occupations, n.e.c
7 (Trades, transport and equipment operators and related occupations)	7444	Pest controllers and fumigators
	7445	Other repairers and servicers
	7514	Delivery and courier service drivers
	7522	Public works maintenance equipment operators and related workers
	7535	Other automotive mechanical installers and servicers
	7622	Railway and motor transport labourers
8 (Natural resources, agriculture and related production occupations)	824	Logging machinery operators
	825	Contractors and supervisors, agriculture, horticulture and related operations and sevices
	843	Agriculture and horticulture workers
	8611	Harvesting labourers
	8612	Landscaping and grounds maintenance labourers
9 (Occupations in manufacturing and utilities)	9217	Supervisors, textile, fabric, fur and leather products processing and manufacturing
	9413	Glass forming and finishing machine operators and glass cutters
	9416	Metalworking and forging machine operators
	9418	Other metal products machine operators
	9422	Plastics processing machine operators
	9433	Papermaking and finishing machine operators
	9437	Woodworking machine operators
	9441	Textile fibre and yarn, hide and pelt processing machine operators and workers
	9442	Weavers, knitters and other fabric-making occupations
	9445	Fabric, fur and leather cutters
	9446	Industrial sewing machine operators
	9447	Inspectors and graders, textile, fabric, fur and leather products manufacturing
	9461	Process control and machine operators, food, beverage and associated products processing
	9463	Fish and seafood plant workers
	9471	Plateless printing equipment operators
	9472	Camera, platemaking and other prepress occupations
	9474	Photographic and film processors
	9523	Electronics assemblers, fabricators, inspectors and testers
	9524	Assemblers and inspectors, electrical appliance, apparatus and equipment manufacturing
	9527	Machine operators and inspectors, electrical apparatus manufacturing
	9532	Furniture and fixture assemblers and inspectors
	9533	Other wood products assemblers and inspectors
	9534	Furniture finishers and refinishers
	9535	Plastic products assemblers, finishers and inspectors
	9536	Industrial painters, coaters and metal finishing process operators
	9537	Other products assemblers, finishers and inspectors
	96	Labourers in processing, manufacturing and utilities

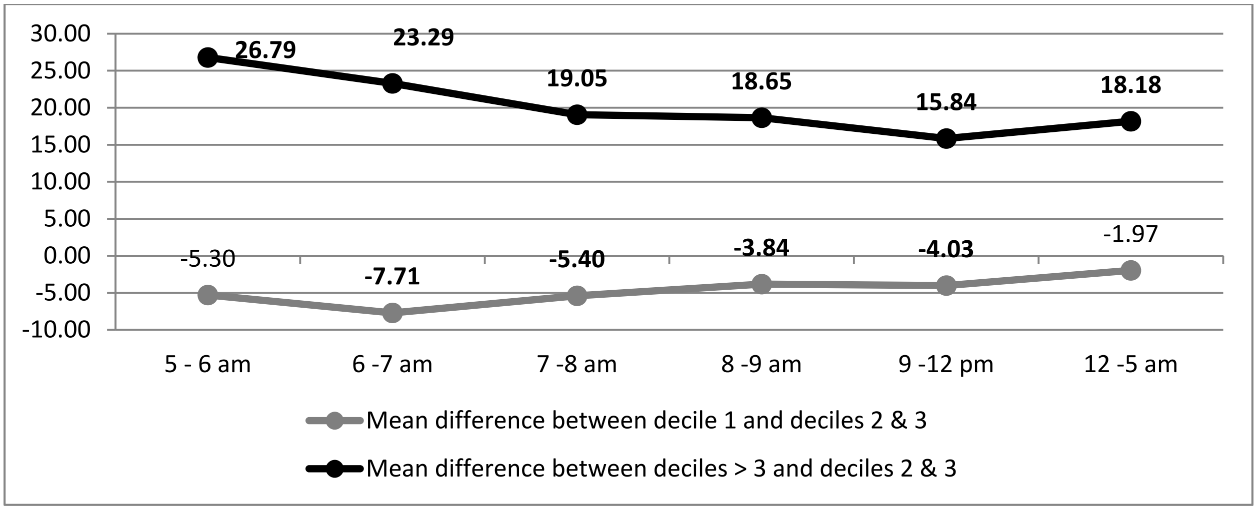
APPENDIX IX: SEC. 7: MEAN DIFFERENCES

A. Mean difference in travel time to low-wage jobs overtime



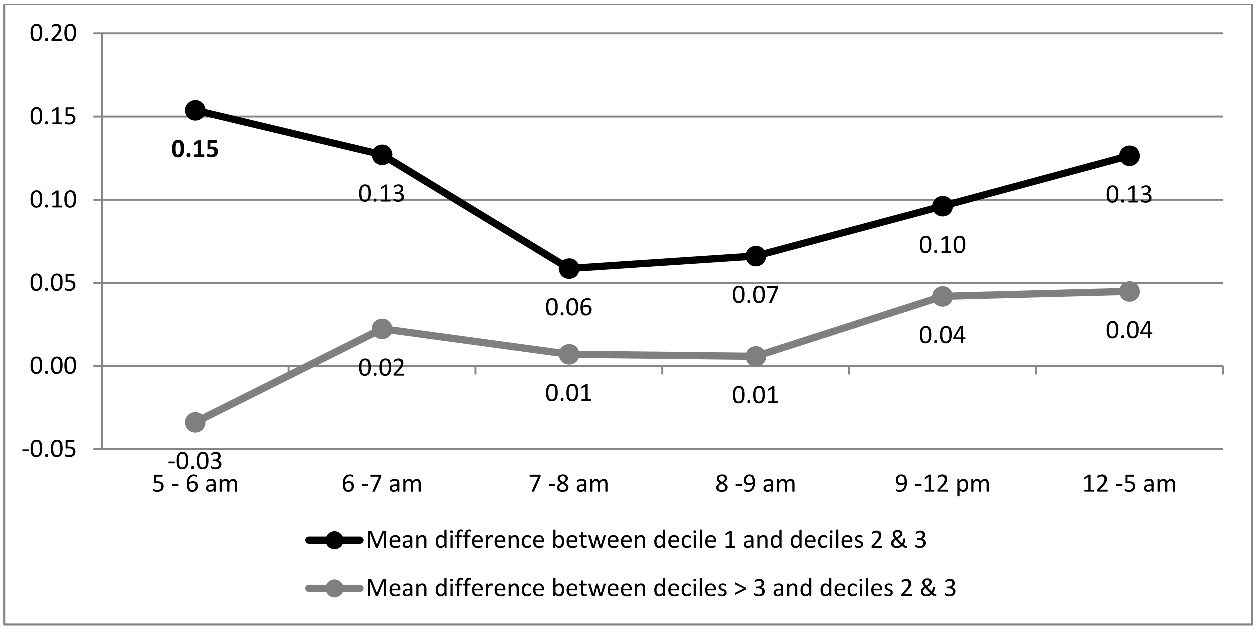
Bold means it is significant at the 95% confidence interval

B. Mean difference in travel time to all other jobs over time



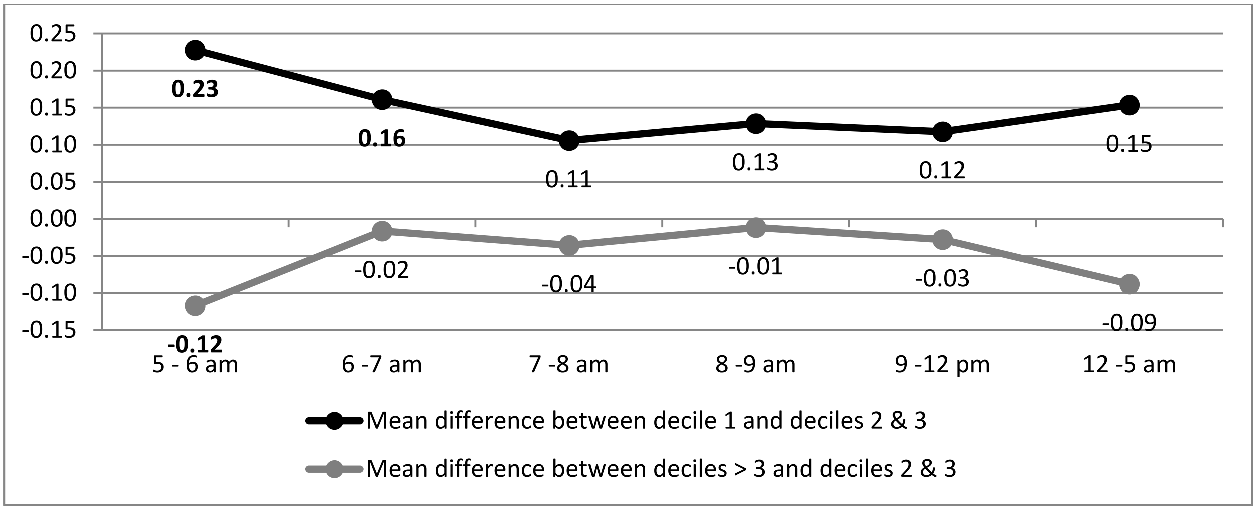
Bold means it is significant at the 95% confidence interval

C. Mean difference in accessibility to low-wage jobs overtime



Bold means it is significant at the 95% confidence interval

D. Mean difference in accessibility to all other jobs overtime



Bold means it is significant at the 95% confidence interval