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Mobility and Social Exclusion in Canadian Communities

An Empirical Investigation of Opportunity Access and Deprivation from the Perspective of Vulnerable Groups

FINAL REPORT

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Abstract

Human Resources and Social Development Canada, as part of its mandate to help Canadians build a stronger and more competitive nation, is concerned with the ability of Canadians, and in particular vulnerable individuals and families, to access all the places associated with their daily needs. An important question in this regard concerns the potential role of mobility and transportation in mediating differential accessibility outcomes in Canadian communities. Given the dearth of Canadian research on this topic, the objective of the present report is to investigate, within the context of three Canadian urban areas, the mobility and accessibility situation of three vulnerable population segments, namely seniors, low income people, and individuals within single parent households.

The research is informed by the concept of social exclusion, the notion that some members of society could be cut off from normal participation in important aspects of society. Various dimensions of exclusion are identified in the literature, in particular personal, living space, economic, mobility, and time use factors. These dimensions are used to develop a conceptual framework to guide the empirical investigation that comprises the majority of the report. Within the conceptual framework, personal, spatial, and economic factors are thought to influence, individually and in combination, the mobility and time use patterns of individuals. Accessibility is seen as a consequence of mobility. The empirical investigation on mobility and accessibility is based primarily on travel surveys for the Hamilton, Toronto, and Montreal areas, and complemented with Census information, and information about the distribution of economic and other opportunities in the regions under study. Study of time use patterns is primarily based on General Social Survey Cycle 19 information.

The report deals with two different but related aspects of mobility: trip generation and distance traveled. Trip generation is a necessary condition for accessibility. Distance traveled is, in combination with the spatial distribution of opportunities, a direct component of accessibility. Application of statistical and spatial analysis tools, coupled with the use of individual level data, leads to very detailed results that reveal important mobility and accessibility variations between population segments, and between cities as well as within cities. The results indicate that in general, members of the vulnerable groups tend to have lower levels of mobility, compared to the reference population, and that the differences tend in general to be greater further away from cities centers. Three accessibility case studies, to employment in Toronto, food services in Montreal, and health care in Hamilton, demonstrate that single parent households, low income individuals, and seniors, experience relatively lower levels of accessibility compared to the reference group, with the occasional exception near the central parts of these cities. Analysis of time use patterns provides a complementary perspective that demonstrates the importance of temporal constraints in determining the frequency of participation in shopping activities, as well as the duration of shopping episodes.

The report provides evidence concerning mobility, accessibility, and time use patterns of various population segments that suggest the existence of social exclusionary processes. The implications of the findings for policy are discussed, and knowledge gaps identified. In conclusion, the report represents an initial, but much needed step, towards a better understanding of transportation-related social exclusion issues in Canada.

Key Words

Social exclusion

Spatial mismatch

Single parent households

Seniors

Low Income

Mobility tools

Spatial behavior

Accessibility

Time use

Opportunity landscape

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Executive Summary

Introduction. Human Resources and Social Development Canada is concerned with the ability of vulnerable populations to access the places associated with their daily needs. This concern is closely linked to the question of the extent to which transportation infrastructure and services may facilitate or curtail this ability. This is a question on which very limited research exists, in particular in a Canadian context. There is a need to establish a broad knowledgebase to better understand the impact of mobility and transportation on the participation of Canadians in the activities of daily life. In order to approach this question, two theoretical perspectives are investigated, namely the spatial mismatch hypothesis, and the concept of social exclusion. Both frameworks are concerned with activity participation, and emphasize the importance of geographical propinquity and the spatial separation of activity locations in understanding participation. The concept of social exclusion provides a more general framework to guide the analysis, since it is inclusive of all activity types, and not only economic ones as in the spatial mismatch hypothesis. It also is concerned with disadvantaged groups in general, as opposed to a specific ethnic population (i.e. Black African-Americans) in the case of spatial mismatch. Based on an extensive review of the literature, the dimensions of exclusion are identified and used to develop an operational framework for the report. According to the framework, personal, living space, and economic conditions combine to influence mobility and time use. Accessibility in turn is a consequence of mobility. The report is concerned primarily with three vulnerable groups, seniors, low income people, and individuals within single parent households. Case studies are implemented for the urban areas of Hamilton, Toronto, and Montreal. Travel surveys conducted in 2001 in the Toronto region, including Hamilton, and in Montreal in 2003, provide information about the spatial behavior of individuals. This information is complemented using Census data and Business Point Data to derive opportunity landscapes. Time use information on the other hand is drawn from the General Social Survey Cycle 19.

Mobility analysis: Trip generation and distance traveled. Trip generation and distance traveled are two aspects of mobility that relate to the notion of inclusion. Trip generation is a measure of out-of-home activity engagement. Lack of this prevents the possibility of accessibility. Distance traveled is a measure that can be related to activity spaces, and therefore directly links to the range of opportunities that can be reached by individuals. These two aspects of mobility are useful to measure the level of involvement in everyday aspects of life. Two sections of the report are devoted to the analysis of mobility levels. The focus of the analysis is set on the urban areas of Hamilton, Toronto, and Montreal, and three vulnerable groups, namely single parent families, low income households, and seniors. The analysis is based on a statistical and spatial modeling approach that leads to person- and location-specific estimates of trip making frequency and distance traveled. The results of the analysis confirm the importance of car ownership in influencing both trip generation and distance traveled, with some exceptions including the case of people living in single parent households. The effect of proximity to transit stations is ambiguous in that this factor is found to increase mean distance traveled in Toronto and Hamilton, but decrease it in Montreal. Other highlights of the analysis include a finding that trip generation rates of the elderly and

single parents are found to be more sensitive to auto ownership and employment than the rest of the population, whereas trip generation rates of the low income individuals are more sensitive to transit access. Spatial analysis of mobility also reveals important differences within metropolitan areas, in particular with respect to behavioral variations between the suburbs and central cities. In general, three vulnerable groups display mobility patterns that could be indicative of social exclusionary processes, including a propensity towards fewer or no trips, and smaller activity spaces.

Accessibility Case Studies. The measures of mobility investigated are useful to understand the spatial competence of individuals. Accessibility, on the other hand, depends in addition to this, on the spatial distribution of opportunities within each city. Accessibility, defined as a cumulative measure of the opportunities potentially reachable by individuals, constitutes a powerful tool to investigate social exclusion issues. A key aspect of the research reported here is the use of model-based estimates of distance traveled for the calculation of accessibility measures. These estimates can be derived for specific socio-economic and demographic profiles, and open the door to comparative accessibility analysis. In addition to accessibility surfaces, relative accessibility indicators are used to answer the question of whether two population groups have equal access to various types of opportunities, or whether a population group with access to different mobility tools has better or worse access to a class of opportunities. Three cases studies are implemented. The first one investigates the accessibility situation of single parent households in Toronto with respect to jobs. The findings of this case study indicate that single parent households have relatively better accessibility to jobs near the central part of the city, but are in a situation of accessibility deprivation relative to the reference group throughout most of the region. An interesting finding indicates that a vehicle-owning single parent household still tends to have lower accessibility levels compared to non-vehicle-owning individuals of the reference groups. A second case study is concerned with access to food services in the city of Montreal, from the perspective of low income individuals. Two classes of food services are considered, retail food and fast food establishments. The accessibility patterns are reflective of the spatial distribution of opportunities in this city, displaying a more centralized pattern in the case of retail food, and more dispersed in the case of fast food. Access to retail food tends to be relatively better than access to fast food in the central part of the region and the outer suburbs, but the opposite is true of a broad ring covering the outer part of the central city and the inner suburbs. The last case study investigates access to health care services in the city of Hamilton from the perspective of seniors. Accessibility levels are seen to be higher in the central part of the city for both seniors and the reference group, but tend to decay very rapidly for seniors, resulting in extremely low accessibility in most parts of the city. Despite the potential of vehicle ownership to enhance mobility for the non-senior population, the effect is so small for the case of seniors as to make no difference in terms of accessibility outcomes. This case study provides the clearest evidence of accessibility disparities between a vulnerable group and the reference, and raises questions about the ability of seniors in the city to satisfy their need for primary health care.

Time use perspectives. Existing research on the topic of transportation-related social exclusion, including the components of the report described above, tends to be spatial in nature. Recent theoretical and technical advances however invite increased consideration of the temporal dimension of exclusion. In order to complement the spatial mobility and accessibility research reported here, a section is devoted to the analysis of time use patterns, with a particular focus on various factors that may impinge on social exclusion, including poverty, old age, or being a single parent. The analysis concentrates on shopping and using services, two classes of activities that are important from a social inclusion perspective, as they are essential for satisfying a host of daily needs, and other important if less frequent necessities such as using government services. A multiple equation approach is adopted to jointly estimate the daily duration of shopping activities and trips while simultaneously controlling for daily durations of four broad categories of activities as well as their associated travel times. The model results indicate: that being a senior citizen increases travel durations while decreasing shopping activity durations; that coming from a low income household decreases shopping activity durations; and single-parent status does not impact shopping activity durations when holding income and other activity durations constant. These results highlight the importance of time budgets in activity participation, and underline the importance of incorporating the temporal dimension in social exclusion research.

Conclusions and implications. This report represents a first step towards filling an important gap in the knowledge and understanding of social exclusion issues in a Canadian context. It also creates a previously unavailable knowledgebase to further delve into a series of issues that, if unattended, may prove detrimental to the objective of building a stronger, more competitive country. In general, the evidence uncovered in terms of mobility and accessibility patterns is suggestive of social exclusionary processes that may prevent various vulnerable groups from accessing the places required for their daily needs. The conceptual framework provides a useful reference to think about potential interventions if the objective is to improve accessibility. These include influencing the factors that affect mobility (economic conditions, mobility tools, etc.) or altering the spatial distribution of opportunities, in essence by bringing opportunities within closer reach of individuals. While a connection is not established in this report between the accessibility situation of individuals, and their economic and social outcomes, this is indicated as an important direction for future research.

CHAPTER 1 Framing the Report

Summary:

- The ability of vulnerable populations to **access** the places associated with their **daily needs** is an emerging concern that falls under the mandate of **Human Resources and Social Development Canada**.
- The role of **transportation** in enabling or curtailing accessibility of **vulnerable populations** is not well understood in a Canadian context.
- Two **theoretical perspectives** help to illuminate the effects of transportation on people's ability to partake in full in society: the **spatial mismatch hypothesis**, and the concept of **social exclusion**.
- Social exclusion provides a more **general conceptual framework** to guide analysis. In addition to poverty alleviation, a central idea in this literature is the importance of enhancing **access to resources** for the disadvantaged.
- The dimensions of social exclusion include **personal** and **spatial factors** that combine to create **mobility outcomes**. These outcomes in turn determine the **accessibility** situation of individuals.
- The report is concerned with three vulnerable groups: **low income** people, **seniors**, and individuals in **single parent households**, in three geographical regions: **Hamilton**, **Toronto**, and **Montreal**.
- Data used in the analysis include **travel surveys** from the Greater Toronto and Greater Montreal Areas, **Business Point Data**, 2001 **Census**, and **General Social Survey** Cycle 19 tables.

1.1 Background

Human Resources and Social Development Canada (HRSDC) is the department of the Government of Canada whose mandate is to contribute to build a stronger and more competitive Canada, to support Canadians in making choices that help them live productive and rewarding lives, and to improve their quality of life. As part of carrying out its mission, HRSDC is concerned with the ability of vulnerable individuals and families to access all the places associated with their daily needs, and the role that transportation may have in affecting this ability. This concern is coupled to the emergence of accessibility-disadvantaged groups in society, and the challenges that poor accessibility poses on people's well-being, not only in Canada, but in other countries as well (e.g. Social Exclusion Unit, 2003).

At a general level, accessibility challenges are thought to operate primarily by constraining the facility with which individuals can partake of quotidian activities, including reaching employment and training opportunities, as well as in accessing food stores, financial, recreational, health, and other social services. Despite the recognition of a host of emerging issues that may negatively affect the accessibility profiles of vulnerable individuals, families, and communities (including an aging population, aging infrastructure, sprawling development trends, and suburbanization of poverty), knowledge is still limited, in particular in a Canadian context, on their urban transportation use and needs. The links between different transportation tools, both public and private, and how effectively individuals perform their social and economic activities, have not been explored in detail. It is within this context that the current project is conceived and implemented. More specifically, the objective of the project is to contribute to create a knowledge base of the extent (if any) to which the ability of vulnerable individuals to access jobs and/or other essentials of daily living is being curtailed or made inefficient by current transportation and spatial factors in the case of Canadian urban areas. The findings of the investigations undertaken and summarized in this report hope to help to identify the effect of transportation and location (place of residence and spatial distribution of opportunities) on individual accessibility, and thus provide evidence to better appreciate the potential impacts of accessibility differentials on participation in essential activities. The special focus of the study is set on the following socio-economic deprived and vulnerable groups: single-parent families, low income households, as well as seniors residing in urban settings.

In terms of the approaches, the project is quantitative in character, and makes use of secondary data sources (i.e. Greater Toronto Area Transportation Tomorrow Survey, Montreal's travel survey, Census information, and General Social Survey [GSS] Cycle 19) which are analyzed using econometric and spatial analytical techniques. With respect to the policy relevance of this research, we place the current report under the rubric of identification of policy issues. In other words, we aim at empirically testing the proposition that potentially problematic conditions exist that may require policy intervention. This first step, with its required accumulation of knowledge, necessarily antecedes the establishment of evaluation criteria, identification and evaluation of policy alternatives, and eventually policy implementation {Patton, 1993 58 /id /ft ", figure 3.5"}. Theoretically, the project is primarily guided by the complementary themes of spatial mismatch and social exclusion, as they relate to vulnerable population. These themes provide useful reference frameworks to think about the different aspects of the questions under investigation. We argue that social exclusion subsumes the hypothesis of mismatch and provides a more general frame of reference to inform the empirical analysis. Empirically, the research provides the following complementary perspectives: 1) Investigation of spatial behavior in the context of dispersed activities, and differential access to transportation resources; 2) Analysis of the effect of mobility patterns on accessibility to various opportunities; and 3) Study of time use patterns by individuals with varying characteristics and locational profiles.

A general summary of the project findings and implications for policy and planning are gathered at the end of this report. Improvements in data collection to address current and future research needs concerning transportation and socio-economic outcomes interconnections are highlighted as well.

1.2 Theoretical Framework

Two related concepts that underpin the study of transportation issues as they relate to vulnerable individuals or groups in the society include the *spatial mismatch hypothesis* (Kain, 1968) and the concept of *social exclusion (inclusion)* (Klanfer, 1965; Lenoir, 1974). These conceptual frames come from different disciplinary streams (the former from economics and the latter mainly from sociology) but offer a complementary set of principles. From a transportation perspective, they help to inform a growing realization that transportation is not an independent and static infrastructure sector but is rather interwoven in and a key component of economic and social structures. As Pisarski (1999) argues, transportation's connections and impacts on these structures are inextricable from the understanding of a particular society or the society itself in general.

Both concepts of spatial mismatch and social exclusion deal with vulnerable groups in society and allude to the importance of transportation in addressing accessibility inadequacies. While the concept of spatial mismatch mainly focuses on the employment-mobility links, the idea of social exclusion offers a much more general perspective that goes beyond work-mobility nexus to encompass also social activities essential to attaining quality of life. The economic and social dimensions of these two ideas, and in particular social exclusion, provide the conceptual basis for the research undertaken under this project. In particular, they provide the rationale for the investigation of mobility and accessibility, as well as guide the empirical investigation that assesses various factors affecting the mobility and accessibility of vulnerable populations. Serving as the conceptual foundation for the present study, the two concepts deserve further elaboration.

1.2.1 Spatial Mismatch

The theory of spatial mismatch was first introduced by Kain (1968) to explain the poor labor market outcomes (high unemployment and low wages) of low-skilled, inner city resident Blacks in US metropolitan areas. Elements of this concept included two concomitant processes of development: the suburbanization of jobs, and discrimination in housing markets. Kain's controversial study eventually propelled studies that deal with the socio-economic effects of the significant divide between place of residence and job sites. Since its inception, as reflected in its name, the spatial mismatch hypothesis has clearly been concerned with key geographical processes that underlie the original question of poor economic outcomes. As a theoretical proposition, the spatial mismatch hypothesis has been validated by numerous empirical studies, in its original application to Blacks and also extended to other racial minorities in various urban settings (see extensive reviews by Holzer, 1991; Kain, 1992; Gobillon et al, 2007).

While the concept has been confirmed more than disputed, a number of studies have pointed to the differential extent of spatial mismatch occurring in various urban settings. This has been partly explained by the lack of a consistent set of variables to explain spatial mismatch stemming from a variety of social and economic mechanisms at work to explain why poor job access leads to poor labor outcomes. Important issues have been raised to explain spatial mismatch beyond physical distance between work-place and residence, including racial discrimination (e.g. Ellwood, 1986), social class (e.g. Wilson, 1987), racial preferences and institutional discrimination through housing credit, mortgage and insurance policies (Tootell, 1996; e.g. Ross and Tootell, 2004), land-use zoning (Squires, 1996) as well as access to job information affecting job search efficiency (Wasmer and Zenou, 2002). Indeed, the mechanisms of spatial mismatch are complex and could very well vary from city to city, not to mention between countries. The other half of the story of why spatial mismatch occurs differently between urban areas is the varying degrees of job suburbanization, poverty concentration and transportation problems. Ihlanfeldt and Sjoquist (1990) argued that spatial mismatch is prevalent mainly in big metropolitan cities, a finding that Gobillon et al. (2007) confirm using Raphael and Stoll's spatial mismatch index (Raphael and Stoll, 2002) as applied to 2000 US census data. These findings point to the fact that studies, and therefore policies to address spatial mismatch, a) should be placed within the context of specific urban areas where the condition could be most severe; and b) should be informed by comparative studies between metropolitan areas. Of note is the fact that the existence of spatial mismatch is not exclusive to the inner-city within a metropolis but can be found throughout the metropolitan area (Ong and Miller, 2005), including the suburbs. Relatedly, Wasmer and Zenou (2002) echoing Pugh (1998) argued that transportation policies should be tailored-fit to the particular urban area as the degree of mismatch may vary from one city to another (i.e. new cities vs. old cities) due to varying land and labor market. They surmise that the unemployed living in "new cities" (e.g. Atlanta) would be more likely to experience worse labor outcomes than those living in "old cities" (e.g. Chicago) who have better spatial connections to jobs. Khattak et al. (2000) also show similar findings of differences in commute times for residents of the lowest-income neighborhoods where it has been shown more problematic in some metropolitan regions than others, suggesting further research on problems within specific metropolitan or regional areas. Meanwhile, Blumenberg and Shiki (2003) question the applicability of the spatial mismatch hypothesis to welfare recipients living in areas (e.g. mid-size cities and rural settings) that not fit the simple model of poor, central-city neighborhoods, and distant, job-rich suburbs.

Studies on spatial mismatch have also suggested expanding the focus on job-housing balance to examine gender, race/migration status and accessibility to various travel modes. For instance, Blumenberg (2004) emphasizes the need to look into the special circumstances of low-income women not only in terms of job search but also their transportation needs to both employment and household-supporting destinations. Other studies have also looked beyond gender to consider its interrelations with race, class and commute mode when examining urban labor markets. Giuliano (2003) shows the importance of explicitly considering race/ethnicity in understanding residential location and travel. More specifically, Preston et al (1998) found that the effect of geographical barriers on women's employment access is greater for minority immigrants compared to white immigrants. Blumenberg and Ong (2001) glean a dramatic variation in access to employment depending upon the individual's residential location and transport mode. This has been strengthened by Garasky et al. (2006) where they find a strong relationship between employment and reliable transportation. In other words, people without access to vehicles are more likely to be unemployed while those employed are more likely to have access to vehicles. Residing in areas adjacent to metropolitan area also has a positive effect on being employed. Shen (2001), however, finds a bigger difference in accessibility differentials between transportation mode compared to residential locations and that the level of job access could vary depending on the travel mode used by job seekers. That is, those who travel by car could have higher than average level of access compared to those who depend on public transit. This echoes conclusion made by

Sanchez (1999) on the significant connection between access to public transit and labor participation rates, whereas Kawabata and Shen (2007) find a stronger effect for public transit than for driving. Macek et al. (2001) also finds a significant differential in employment probability among transit users than those who use automobiles. These findings have thus strongly called for transport policies that enhance mobility and accessibility for public transit relative to cars. On other hand, Hess (2005) recommends enhancements be made on public transit in places with large concentrations of low-wage jobs while providing greater access to car in places with small concentrations of low-wage jobs. These should also be complemented by programs that improve job readiness, placement and support services. While the improvement of public transit and the concentration of housing near public transit routes have been found to stimulate employment, the importance of improved car accessibility has also been underlined by Cervero et al.(2002) where improved automobility showed stronger effects on employment outcomes in the case of their study sample.

Gobillon et al (2007) provide a recent and most comprehensive review of the spatial mismatch hypothesis and the need to more fully understand the mechanisms that underlie the distance to jobs as being partly responsible for unemployment disparities. They argue that the current theoretical and empirical state of knowledge on spatial mismatch pointed for policies to look into ways to correct housing discrimination, employment availability in city centers as well as improving physical connections through more effective transport policies. The latter has been highlighted as one of the areas that need further research and evaluation. They surmise that transport policies could be an effective solution to spatial mismatch when the problem is linked to physical distance that will discourage workers to take on jobs due to cost and inconvenience or the reluctance of employers to hire workers when their punctuality or productivity may hinge on an inefficient transport system. If not, other solutions (e.g. anti-discrimination policy) should be formulated and enforced. In other words, an understanding of the mechanisms that influence spatial mismatch must be well understood so as to arrive at the best solution to the problem. Blumenberg and Manville (2004), meanwhile, stress that addressing spatial mismatch (i.e. through transport policy) must be matched with efforts to create employment opportunities and to promote education and training for low-income persons for them to be more competitive in the labor market or else transport policies will be meaningless.

As reflected in the above discussion, studies on spatial mismatch are abundant in the US. In contrast, there is a dearth of research to date on this subject in the case of Canadian urban areas. While a reason for this may be the fact that the standard spatial mismatch hypothesis deals with a specific situation (i.e. employment rates of low-skilled Blacks) that is not prevalent to the same extent in Canada. Nonetheless, the extension of the concept provides a valuable point of reference to investigate the ability of different population groups to participate in the economic and non-economic activities of daily life. Noteworthy in the Canadian case is the increasing population of low-income residents in urban and particularly suburban areas, whose job opportunities and life's activity destinations may be disconnected. A second emerging situation, the dramatic changes projected in the demographic outlook of the country, also provides a call for action. Of particular interest are the mobility needs of an increasing number of Canadian seniors, many of whom made of the suburbs their place of residence at a time of cheap transportation, and many of whom also tend to age in place. Access to different modes of transportation has been identified as a key factor in affecting the mobility of this population segment, and while auto ownership appears to be a powerful mobility enabler, the challenges of driving cessation have been clearly highlighted by recent research (Paez et al, 2007; Mercado and Páez, 2008). In the same fashion, the mobility profile of single parent households has not been investigated, despite the clear importance of mobility in ensuring that this population group is not being curtailed in their opportunities for education or work training and to fully participate in the labor market by poor accessibility patterns.

1.2.2 Social Exclusion

To fully appreciate the concept of social exclusion, it is valuable to consider its genesis and evolution. There is no universally agreed upon definition of social exclusion, neither is there consensus on the origin of the concept. Beland (2007) traced the idea of social exclusion to have first emerged in France from a book published by Jean Klanfer in 1965 entitled *L'Exclusion sociale: Étude de la marginalité dans les sociétés occidentales* [Social exclusion: The study of marginality in western societies] where Klanfer used the term to mean those "people who cannot enjoy the positive consequences of economic progress due to irresponsible behavior". Some sources, however, attribute the concept's beginnings to Max Weber who first defined it as constituting a form of "social closure," – the "…attempt of one group to secure for itself a privileged position [in society] at the expense of some other group through a process of subordination" (Todman, 2004; Burchardt et al, 2002; Parkin, 1979). Both Beland (2007) and Todman (2004), however, agree that the modern use of the term is due to Rene Lenoir, the former French Secretary of State for Social Action who published *Les exclus: Un français sur dix* [The excluded: One Frenchman out of ten], which has been considered the 'founding document' of the modern discourse about exclusion (Frétigné, 2008). Lenoir's definition is considered broader compared to Klanfer in that it focuses on social and economic conditions rather than personal responsibility only to explain social problems (Beland, 2007). For Lenoir, social exclusion refers to those citizens who are separated from mainstream society because of factors like disability, mental illness and poverty (Beland, 2007). These are individuals and groups of people who were administratively excluded from state social protection systems including the physically disabled, single parents, and the uninsured unemployed (Todman, 2004).

The concept of social exclusion has evolved in the 1980s and 1990s to embrace wider aspects of poverty, racism, and discrimination, which have been increasingly prevalent during this period not only in France but in other European countries as well. Social exclusion has then taken on a new meaning – social integration related to limited access to labor market opportunities (Beland, 2007). During this period, France and other European economies have been facing significant issues in unemployment and "new forms of poverty and marginalization" as a result of economic, technical and social changes (Atkinson and Davoudi, 2000). Todman (2004) explains that the severity of such social and economic problems strained and even exceeded the corrective capacity of the state welfare systems of these countries, that in time, the concept moved beyond France to other parts of Europe, most especially into continental and UK social policy discourses. While the concept of social exclusion has been debated since the 1970s in France, it was only during the 1990s that it became a blueprint for social reform in the country (Beland, 2007). In contrast, in the UK, the Blair government swiftly transformed it into a prominent policy blueprint and discourse before it emerged as a shared paradigm and the need for an ambitious social inclusion project has been emphasized time and again (Beland, 2007). In one of Blair's speeches:

> 'I have always said that turning the tide of social exclusion is a ten-year project. We have made a start but there are still far too many areas where people have no job, no shop, no bank account, no links to the mainstream economy. Bringing people into the economy and giving them access to the opportunities that others take for granted requires us to make a new connection between economic opportunity and social renewal' (Blair, 1999)

The adoption of social exclusion policy in the UK preceded most serious academic, journalistic and public intellectual discussions of it as a theoretical paradigm, which forced many British academics and intellectuals to embrace the concept or consider it as a critical theoretical and policy model (Beland, 2007). As a regional policy in Europe, the diffusion process began in the mid-1980s when Jacques Delors, then president of the European Commission advocated for a strong "social dimension" in the European project and eventually during the 1990s, in its poverty program, the fight against social exclusion became a key policy paradigm and discourse (Beland, 2007; Silver and Miller, 2003). At present, social exclusion is a central social policy focus of the European Union (EU) and its alleviation is reflected in many of the EU's strategic goals, policies, and programs (Todman, 2004) especially as regards to employment policy (van Berkel and Hornemann, 2002; Beland, 2007; Begg and Berghman, 2002). There have also been numerous excellent scholarships already available about the British case (Beland, 2007). In contrast, the diffusion of social exclusion as a paradigm in North America is just slowly starting to find its way in government and academic discourses. Todman (2004) argues that with the exception of the work of a few scholars (Silver, 1994; Kahn and Kamerman, 2003; Sandefur et al, 2004), social exclusion discourse is virtually nonexistent in the US. Although if it is accepted that the number of published articles in international journals is a measure, it seems to be gaining more attention from scholars in the US, with more recent articles – including Wagle (2008), Kelly (2006), Handler (2003), Lovell (2002), and Selwyn et al (2001) – than in Canada (which includes only two published articles: Silver et al, 2005; and Caragata, 2003). Social Development Canada (2005) has acknowledged the study of social exclusion as a key knowledge gap as there is dearth of research, and particularly empirical investigation in a Canadian context.

Interest in social exclusion is originally motivated by issues of poverty, and is still sustained by broad conceptualizations of material deprivation, including that by the United Nations, that suggest little difference between social exclusion and poverty. There are scholars however who argue that the two concepts are distinct. Todman (2004), for example, contends that the evolution of the social exclusion discourse transcended the focus away from economic poverty and material deprivation to one that considers the social, political, cultural and other development dimensions of being disadvantaged. Abrahamson (2003) gave a succinct differentiation between the two concepts: poverty is characterized by resource insufficiency; social exclusion is regarded as the inability to exercise rights. Poverty is caused by unmet needs; social exclusion is caused by discrimination or the denial of access to social institutions. Poverty is a static condition; social exclusion is a dynamic process. In poverty analysis, social stratification is vertical (i.e. poor at the bottom; non-poor at the top); in social exclusion analysis, social stratification is horizontal (i.e. excluded on the outside or peripheral to the insider mainstream). Policy prescription for poverty is income generation through job and social welfare transfers; for social exclusion it is enabling access to key service delivery and institutions. Todman (2004), however, clarifies that while increasing income is an important policy in social exclusion, increasing access of the disadvantaged to resources is central. From this perspective, social exclusion is multidimensional, and threads along the different situations in which individuals and groups may experience social exclusion: housing, education, employment, healthcare, legal and political systems, and social networks (Todman, 2004).

Evolution of the social exclusion discourse towards increasing access for the disadvantaged puts a spotlight into the role of transportation as a key to many, if not all, of the dimensions of social exclusion. Interestingly, while accessibility has long been a major area of research in transportation, it is only in recent years that transport researchers have looked at social exclusion as a paradigm for accessibility research. For instance, Lyons (2003) reports on the first time that the International Association of Travel Behaviour Research (IATBR) conference looked into the concept of social exclusion and the need to place it (and more specifically, social participation) at the heart of research into travel behavior. Reporting on the highlights of the meeting, he called for the need for transport researchers to examine its knowledge base, toolbox of data gathering methods and analytical techniques with the end goal of refining current research approaches in order to effectively address issues pertaining to mobility-related social exclusion. Miller (2006), in a paper originally given at the same conference, concludes that the use of aggregate and place-based measures and analysis, has contributed to a neglect of transportation in social exclusion research. In considering the way aggregate measures contribute to our understanding of social exclusion issues, it becomes clear that these approaches provide useful contextual information that nonetheless remains susceptible to the ecological fallacy of attributing general results to individuals. The static perspective of place-based measures, furthermore, is based on the increasingly heroic assumption that geographical propinquity is sufficient to explain social exclusion. Miller argues that a space-time activity approach, one that places mobility up and front in the research agenda, can make important contributions to social exclusion research, while deriving substantial benefits from the natural synergies between mobility research and geographic information technologies.

The realization that transportation is a key for the livability of modern cities (Solomon, 2000; cited in Miller, 2006) has, in the course of events, attracted substantial interest among transport researchers on mobility-related social exclusion. From a conceptual standpoint, efforts have been made to more deeply look into the relations between transport and social exclusion and how it is crucial to addressing such development problem. Church et al (2000), in relation to social exclusion initiatives in the UK, point out that transport has rarely been a central issue, in contrast to labor and housing markets and income inequality issues. They argue that most transport researchers studying exclusionary transport issues have dwelled on what they termed a “categorical” approach (i.e. focus on social groups, such as women, older people, employed) while paying little attention to the spatial characteristics that define how people move between their residential locations and the locations of their usual activities or where they want to participate. According to these researchers, more than the theoretical issues of the differences and connections between these two approaches, there is an important policy question relating to what extent resources should be allocated to particular social groups or to specific geographical areas. They propose the analysis of transport and social exclusion by examining three processes that can influence individual mobility: 1) the spatial and temporal organization of households, and their use the space and time resource; 2) nature of transport system; 3) time-space organization of the activities. These processes could affect mobility depending upon the individual’s material circumstances, their position within the household, and their personal and cultural characteristics. Policies must, therefore, not only address changes to the transport system but also to combat factors that limit an individual's journeys at either end.

Preston and Raje (2007) propose three criteria for measuring transport-related social exclusion that is not only based on mobility (ease of moving) but more importantly accessibility (ease of reaching). These criteria include 1) the level of travel in the area as a whole; 2) the level of travel made by particular individuals or groups (individual mobility); and 3) the overall accessibility of the area (area accessibility). They argue that this schema of analyzing these three related transport variables will provide an analysis of the excluded that is not isolated from the socially included mobile and thus produce a more comprehensive picture of accessibility situation and accordingly better policy responses. On the other hand, Cass et al. (2005) point to the importance of enlarging the scope of accessibility beyond formal or public services (i.e. visit to hospitals, stores, banks) but to include also social networking (i.e. “meetingness” vs. “missingness”) among people who are “living, working and visiting particular places”. The importance of location of activities and social integration and how people meet these destinations have also been echoed and thus taken the discussions with respect to the interaction between land use and transport policy being crucial to transport and social exclusion issues (Simpson, 2003). Another dimension put forward by Kenyon et al (2003) is that inadequate physical mobility is a contributory factor to social exclusion and that virtual mobility (i.e. access to Internet) could act as “a tool of transport” and a valuable tool in both social and transport policy. The concept of social exclusion and transport has also been tied to discourses on social and environmental justice. Schlossberg (2006), reviewing a book by Lucas (2004) which drew from the transport-related social exclusion experience in the US and the UK, highlight the range of issues in transportation and social exclusion and the historical, political and urban form context at play that help illuminate the complex issues of mobility and social justice. From a methodological standpoint, McCray and Brais (2007) suggest a data mapping technique using GIS to organize and analyze data to map individual space and activities that could be useful for transport planning with focus on social exclusion.

There have been a number of policy studies on transport and social exclusion, mostly coming from the UK. For instance, Hine and Mitchell (2003), demonstrating three research projects in the UK, give a compelling argument of the need for transport policy to take into account social considerations in the development of an integrated transport system (in addition to the current economic and environmental considerations in transport planning and provision). Meanwhile, based on case studies undertaken in Oxford City, UK, Raje (2004) argues that traffic engineering solutions could contribute to greater social inclusion by making planning and design of engineering schemes more socially aware by applying social equity audit in transport projects. This means infrastructure project implementation should not only be based on operational needs and financial constraints but also how the project would impact on accessibility and mobility in the event of no other alternatives to travel. Lucas (2004) underlined the need for greater synergy in policies so as to avoid policies that conflict with intentions to combat social exclusion. In the case of UK, she discussed how the Climate Change Agenda conflicts with efforts in the 2004 Transport White Paper with respect to policy guidelines to local transport authorities to address social exclusion through local transport provision and accessibility planning. Specific transport schemes should also be reviewed as to their impact on social exclusion. For instance, Parkhurst (2003) cautioned on the development of park and ride (P&R) schemes as these should be undertaken not at the expense of investment in conventional public transport. Hine and Mitchell (2003) provided a comprehensive discussion on the experience of various urban areas in Scotland with respect to transport and social exclusion. Reviewing Hine and Mitchell's work, MacPherson (2004), underlined the issue of generalizability of findings considering the particularities of the study areas. She pointed out that the range of factors that interact to create transport choice at the local level cannot be divorced from differences in local housing stock, local infrastructure and household composition in the urban area under consideration.

Though not many, a number of empirical studies have looked into the employment dimension of social exclusion and how difficulties in transportation access (or the lack of it) have constrained linkages between residences and jobs especially among low-income individuals or other disadvantaged groups. Casas (2007) investigated various factors that affect the number of opportunities available to an individual's activity space using data from Buffalo-Niagara region in the US. Using cumulative accessibility measures and comparing disabled and non-disabled groups, the study found the following factors to be significant: being young, coming from a small household, possessing a driver's license, having a steady job, living in urban setting, and being willing to travel a long distance. Social exclusion has also been related to the development of discourses on the sustainable development in transport. In this regard, Dobbs (2005), drawing from primary research in North East of England, concluded that access to private transport is a key factor in determining women's economic inclusion and stressed that gender implications should be considered in the development of sustainable transport systems. Finally, Scott and Horner (2008) tested the role of urban form in contributing to social exclusion using a trip survey conducted in Louisville, Kentucky in 2000. Using a comprehensive suite of accessibility measures (i.e. gravity, cumulative opportunity and proximity), they concluded that urban form does have a relation to social exclusion although found that the groups postulated to be at risk (i.e. low-income, single-parent and single-person households, women and seniors) showed high accessibility. The authors, however, cautioned on the limited subset of land use and transportation data used in the study that could affect results and also suggested that more complex accessibility measures be developed that takes into account land use, transportation and social exclusion factors.

1.3 Operational Framework

The literature reviewed in the preceding section is emphatic about the importance of incorporating transportation and mobility considerations in the study of activity participation. It also provides a conceptual framework to guide our investigations. In particular, social exclusion offers a more general and inclusive perspective, since it is concerned not only with employment outcomes, but with all normal (normatively defined) activities of daily life. Also, its focus is not exclusive of any ethnic groups, but rather includes any potentially disadvantaged population segments. Consider the dimensions of social exclusion identified by Kenyon (2003) and their respective potentially exclusionary factors. Table 1 gives an updated version of these dimensions, with the potential factors providing an illustrative, but by no means exhaustive, account of possible factors.

Table 1: Nine dimensions of exclusion

Dimension	Discussion	Potential exclusionary factors (not exhaustive)
Economic	Factors affecting and arising from access to money	Income poverty; unemployment; lack of access to credit facilities
Living space	Factors in the local environment, which may disadvantage the individual or group	Inadequate acces to private transport; inadequate public transport services; poor access to opportunities, services, social networks and other goods
Mobility	Factors affecting and arising from access to (motorised) transport	Inadequate access to private transport; inadequate public transport services; poor access to opportunities, services, social networks and other goods
Personal	Individual characteristics influencing position in society and attitudes towards the self	Class, culture, disability, ethnicity, gender, skills
Personal political	The ability to influence decision making at an oranised level	Powerlessness; disempowerment; restricted choices; lack of access to information
Organised political	The ability to influence decision making at an organised level	Denial of rights/freedoms; disenfranchisement; low participation in interest groups; lack of representaiton; lack of access to information
Social networks	Factors arising from access to and relations with other people	Isolation; loneliness
Societal	Social facotrs at a societal level	Crime; education levels; family dynamics; health and social care; inequality
Temporal	Factors causing and arising from time pressures	Insufficient time to participate in social, political, economic activities

Source: Kenyon (2003)

In the literature *mobility-related social exclusion* has been conceptualized as being the inverse of access (Lyons, 2003) or the consequence of reduced accessibility (Kenyon et al, 2003). The latter authors define it as follows:

"The process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities,

services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility."

The above definition stresses that the primary role of mobility is to provide access. In this regard, Kenyon et al. (2003) differentiates the lack of mobility as a factor (of social exclusion) while lack of access is the consequence. Thus, the denial of access could be the result of inadequate mobility. Two important questions arise. The first one looks at the root of the problem of mobility limitations: what are the factors that affect mobility (absence or lack of it)? And secondly, what are the accessibility implications of mobility outcomes given a surrounding opportunity landscape? In principle, a better understanding of these factors can help to decide whether policy intervention is warranted, and if so, what tools can be used to reduce exclusion to everyday economic and social opportunities and activities that have the capacity to improve well-being.

Our operational framework is displayed in Figure 1. In this framework, personal, living space, and economic factors combine to influence mobility and time use outcomes (the instrumental goals of this report), which in turn, and according to the perspective detailed above, result in better or worse accessibility situations (the prime goal of the research). The connections between time use and mobility, and time use and accessibility, are not investigated in this report for reasons that will be discussed in their moment.

We concentrate on two related but different manifestations of mobility, namely trip generation and distance traveled. Trip generation provides an indication of out-of-home activity engagement, and is therefore a precondition for accessibility. Individuals who do not travel will not, for obvious reasons, have access to any activities that must be conducted away from the place of residence and that cannot be completed remotely (i.e. activities that lack extensibility, as discussed by Miller, 2006). Distance traveled during the course of a day, on the other hand, determines the range of opportunities potentially available to individuals. In terms of our operational framework, the connection between trip generation and accessibility is null in the case of individuals who do not travel – a situation with self-evident social exclusion implications. For those who do travel, distance traveled provides the bridge between mobility and accessibility, thus leading to the primary goal of the report. A number of accessibility case studies are presented that cover economic (i.e. employment), and non-economic but nonetheless essential activities (i.e. food services and healthcare opportunities). Time use, although not explicitly linked to accessibility in the present report, provides a valuable perspective on the dedication and commitment to various activities by individuals with differing characteristics.

With regards to our indicators of mobility, it is important to note, of course, that some people may be able to satisfy all their needs and obligations without making a single trip, with just a very small number of trips, or with short trips alone. We feel, however, that while this may be the case for some individuals, for many others these two aspects of mobility provide a useful measure of potential for participation. The research then aims to identify significant differences in mobility patterns between groups recognized as being vulnerable to exclusion, and the mainstream of society. The results are not expected to be completely unambiguous. Low levels of mobility may be indicative that either vulnerable individuals: (1) are quite satisfied with staying home or local at most, in which case extra mobility may be a superfluous and even counterproductive objective; or (2) face mobility challenges that may require intervention if the objective is to facilitate their full participation in the activities of daily life. Selection of the variables employed in the empirical analyses is based on the dimensions identified in previous social exclusion research, in particular (and due mainly to data availability reasons) personal, living space, and economic factors. As well, this selection is informed by previous empirical travel behavior research with respect to trip making frequency (e.g.Schmöcker et al, 2005; Paez et al, 2007) and distance traveled (e.g. Stradling et al, 2005; Mercado and Páez, 2008).

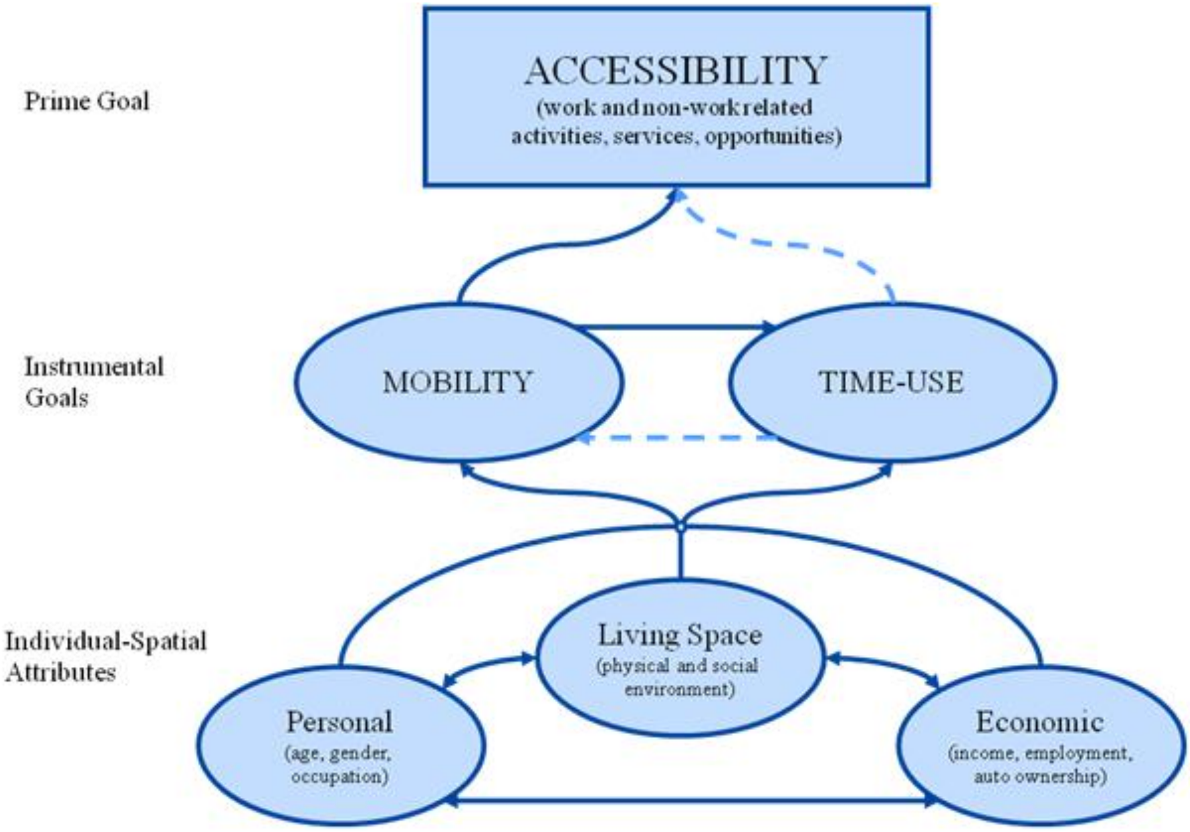


Figure 1: Conceptual diagram of study approach and implementation

1.4 Demographic Focus of Study

The focus of the study is on vulnerable groups perceived as being at risk of exclusion, specifically seniors, individuals in single parent households, and low income people.

Seniors. In addition to the traditional focus on low income individuals, seniors also represent an important group of interest considering their significant increase in number as Canada's population continues to age. In Central Ontario, it is reported that the proportion of population older than 65 years of age will escalate from 12% to 25% in 2021, because of the decline in fertility to offset the large aging baby boom population, born in the years 1946 to 1965 (Bourne, 2003). While higher levels of education, health, technology access and auto dependence have characterized the aging baby boom generation (Bush, 2005), there are continued concerns about their mobility needs in the future, since many made the suburbs their place of residence at a time of cheap transportation, and many are expected to "age in place". The accessibility effects of becoming a senior are ambiguous: on the one hand, it is conceivable that the reduction in mandatory activities (e.g. employment) at spatially fixed locations, will free time for more discretionary travel, thus increasing both the generation of trips, and their length. At the same time, seniors may suffer from deteriorating skills that affect their basic mobility, which may negatively impact their ability to participate in everyday activities. The net effect is not evident. In particular, the ability to use different modes of transportation has been identified as a key factor in affecting the mobility of this vulnerable population segment, and while auto ownership appears to be a powerful mobility enabler, the challenges of driving cessation have also been clearly highlighted by recent research (Paez et al, 2007).

Single parents. Single parents are another vulnerable group of interest. Single parent families are a significant population group in urban centers of Canada. According to the 2001 and 2006 Canadian censuses, the percentage of all families that are headed by a single parent has only increased slightly during this time period (from 15.7% to 15.9%). This relatively small percentage increase nonetheless represents a substantial absolute increase in the number of single parent households, which grew from 1.3 million in 2001 to 1.4 million in 2006. These rates tend to be higher in larger cities. In Toronto, for example, lone-parent families represent a slightly larger share of all families (16.89%) and the increase from the 2001 rate (16.39%) is more pronounced than the national level. Moreover, the vast majority of all single-parent families in Toronto (83%) are headed by women, and economically, these families achieve much lower incomes than couple-headed families and even male-headed single-parent families. In 2005, the percentage of family income resulting from government transfer payments was 16%, 10% and 7%, for female single-parent, male single-parent, and couple-headed families respectively. Thus the female single-parent families rely more than twice as much on government welfare programs for their income as compared to couple-headed families. This is not to say that male lone-parent families are much better off. Indeed, after-tax median income for couple-headed families in Toronto was $71,000, whereas the corresponding figure for male lone-parent families was $51,000, and a mere $39,000 for female lone parent families. Finally, if these median income numbers were not sufficiently indicative of income disparities, Statistics Canada reports that 26% of female-headed single-parent families have after-tax family incomes below the low-income cut-off, nearly 3 times the rate of couple-headed families. From an accessibility perspective, individuals in single-parent households face, in addition to economic hardship, non-trivial accessibility challenges arising from an increased tendency to carry the joint burden of generating employment income while maintaining household and child-care responsibilities. These extra responsibilities are particularly salient to job accessibility given the fixed daily time budget available to each person. Clearly, all time spent on household maintenance and child-care activities will reduce the amount of available time for the daily commute (Turner and Niemeier, 1997). Thus, given the double jeopardy of adverse economic prospects and dual household and employment demands, it becomes even more important to ensure equitable accessibility to employment for lone-parent family household heads.

Low income. While there is no official poverty line in Canada, a variety of measures are used to assess and track the rate and depth of poverty. The most widely used poverty measure is defined by Statistics Canada in terms of Low Income Cut-off (LICO) criteria which vary depending on household size and the population size of the area where people reside. As a rule of thumb, households that spend disproportionate amounts of their pre-tax income on food, clothing and shelter –20% above the average family – are considered low-income. Based on the LICO measure, Ontario has a lower proportion of low income persons than Quebec. In 2005 Ontario had 14.5% in the LICO category while Quebec showed higher with 17% (Centre for the Study of Living Standards 2007). Their respective metropolitan regions follow the same pattern. Toronto had 17% while Montreal posted even higher than the provincial estimate with 19.8%. Trend analysis, however, shows that over the period 2000-2005, poverty rate using the LICO measure in Quebec and Montreal had declined by about 11% and 17%, respectively. In contrast, during the same period, Ontario increased by 2.3% but a dimmer picture has been shown in the Toronto CMA where poverty rate has increased by about 13%. Low income individuals are considered a vulnerable group since they are the most likely to lack the material means to realize the mobility potential.

1.5 Geographic Focus of Study

The primary focus of the report is on the provinces of Ontario and Quebec, and concretely, the metropolitan areas of Hamilton, Toronto, and Montreal. Selection of these three urban areas is dictated by existing data. The Greater Toronto Area (including Hamilton) and the Greater Montreal Area conduct two of the largest urban travel behavior surveys in the world, and thus provide data-rich environments to investigate mobility issues. There are few surveys of comparable scale in Canada, and none that is readily available for this project at the level of spatial resolution needed. Similarly, to the best of our knowledge, there are no Canadian surveys that specifically attempt to track the travel behavior of rural residents.

1.5.1 Hamilton

The first study area is the Hamilton Census Metropolitan Area (CMA). Hamilton is located on the west shore of Lake Ontario, approximately 70 km southwest from the city of Toronto. The Metropolitan Area consists of three different administrative units, including the City of Hamilton (which was amalgamated in 2001 from previously separate administrative units), the City of Burlington, and the town of Grimsby. The population of the area is approximately 650,000 (Census of Canada, 2001), which makes of this metropolitan area the 4th largest urban centre in Ontario, after Toronto, Ottawa, and Mississauga (a satellite of Toronto), and the 9th largest in Canada. The Hamilton CMA is an important functional component of Greater Toronto, and is therefore part of one of the regions in Canada where the impacts of demographic aging are expected to be most strongly felt in the next few years (Hayward, 2001).

The population in the metropolitan area of Hamilton is by and large concentrated in the City of Hamilton, which enumerates around 500,000 persons. Rapid growth has been observed in parts of the city, in particular in association with suburban development in Ancaster and Waterdown (southeast part of Flamborough), two areas where population growth rates in the last few years have been rounding 30 and 20 percent respectively. Provincial projections estimate that in the next 30 years the population of Ontario will grow by about 4 million, and much of this growth is expected to be absorbed by cities in the Greater Toronto Area. The recent Places to Grow legislation (Bill 136 2005) of the Government of Ontario, for example, identifies Hamilton as a provincial growth center.

In parallel to these population projections, the 2001 Canadian Census reveals a substantial increase in the Hamilton metropolitan area of the senior population aged 75 years and over. A particular situation posed by this cohort is its characteristically dispersed residential pattern. This pattern, it has been suggested, has arisen over the years as a consequence of previous and still ongoing suburbanization trends, and current attitudes towards aging in place (Smith, 1998).

1.5.2 Toronto

The second study area is the Toronto area. The city of Toronto is located on the north shore of Lake Ontario, and is adjacent to other urbanized municipalities, with very little undeveloped land between metropolitan areas. The City of Toronto (2001 population of 2.48 million) is the historical centre of the GTA and has the large and concentrated employment base in the downtown core, surrounded by an inner urban area of largely high density residential areas and a second ring of medium-density post World War II suburbs. The Regions of Peel, York, Durham and Halton largely consist of lower density suburban residential and commercial development. The City of Mississauga is the largest population centre in the GTA outside of Toronto, with a 2001 population of 610,000. The area of land around Pearson International Airport in Mississauga is the second largest employment centre in the GTA after Toronto, consisting largely of manufacturing warehousing employment of which a significant proportion is related to the auto-sector.

Toronto, and the Greater Toronto Area, has been characterized by rapid population growth. The fastest growth has occurred in the Regions of York and Peel and more recently Halton Region, however, the City of Toronto has also experienced significant population growth despite its large population base and that the land within the City of Toronto is fully developed. Much of this growth has been due to large immigration from other parts of Canada and from other nations, and has been accommodated through infill and condominium construction. The population in the GTA has been aging significantly. Over just 5 years from 1996 to 2001 the average age in the Toronto CMA increased from 35.2 to 36.2 and the proportion of the population aged 75 and older increased from 4.3% to 4.8%. This increase is despite the influx of relatively young immigrants. Seniors are more heavily represented in the City of Toronto, in which 6.8% of the population was aged 75 and older in 2001.

1.5.3 Montreal

The Greater Montreal Area (GMA) provides a third case study at the metropolitan-level. Montreal has a population of approximately 3.6 million people, and is thus the second most populated urban area in Canada after Toronto. It is also the most populated metropolitan area in Quebec, and in fact concentrates about half of the total population in the province. The area is an agglomeration of a hundred municipalities of various sizes, with Montreal City (population 1.6 Million inhabitants) being the most important. The population is spread over a 5,500 square kilometres area. Higher population and job densities are observed near the

Central Business District and the Montreal Island and decrease concentrically towards the suburbs.

Between 2001 and 2006, the growth in population in the GMA was 5.3%, mainly due to immigration. During this period, growth was more important in the inner and outer suburbs relative to the central areas, in a sprawling development pattern. Spatial analysis has shown that areas where the proportion of children is higher tend to be located out of the Montreal Island and mainly in the outer suburbs; these areas also have lower proportion of senior residents (65 years and older).

In 2007, 14.4% of the Quebec population is aged 65 years and older (ISQ, 2007); this proportion is even over 60% is some census subdivisions located in the Montreal Island. Provincial projections estimate that the Quebec population will increase from 7.65 Millions in 2006 to 8.11 Millions in 2031 (+9.6%) and then decrease again (ISQ, 2007). At the same time, the proportion of seniors (65 years and older) will rise to 18% in 2016, 24% in 2026 and even 31% in 2051. In the GMA specifically, recent studies (Morency and Chapleau, 2008) have shown that the proportion of seniors (65 years and older) has risen from 10.6% to 13.6% in the GMA between 1987 and 2003. It also demonstrates that the senior population is dispersing at a higher rate than the general population but is still more concentrated near the CBD. Again for this population segment, it was observed that household size and automobile access within households are lower than for other population segments. Over time however, household size is rapidly decreasing among the seniors, while car ownership and accessibility are rapidly increasing.

1.6 Data sources

1.6.1 Travel Diary Data

Two sources of data are at the basis of this research: the Greater Toronto's Transportation Tomorrow Survey (TTS; see http://www.jpint.utoronto.ca/ttshome/index.html for details) and Montreal's travel survey (see http://www.cimtu.qc.ca/EnqOD/Index.asp). These are two of the largest cross-sectional origin-destination (OD) travel survey programs in the world, and have been conducted every 5 years since 1986 in the GTA, including the City of Hamilton, and since 1970, approximately every 5 years, in the GMA. Analysis and models presented in this report are based on the latest set of data available for each metropolitan area: the 2003 Montreal travel survey and the 2001 TTS.

These large-scale repeated cross-section travel surveys provide unique sets of data on travel behavior for these areas. Among their characteristics we count:

- *Scale*. The survey gathers information about a sample of approximately 5% of all households residing in the survey area: around 70,000 households in the 2003 GMA survey and more than 135,000 households in the 2001 GTA survey.
- *Depth*. Details regarding the travel behavior of every person (5 years and older in GMA, 11 years and older in GTA) belonging to the surveyed household are gathered as well as attributes of households and people, using Computer Aided Telephone Interview tools;

- *Spatial resolution*. Every location visited by an individual (home, trip-ends) is geocoded with x-y coordinates using structured databases on addresses, intersection, trip generators. This allows for great flexibility in spatial analyses that can be conducted, either at the microdata level or at any level of aggregation, using any type of mapping delimitation.
- *Itinerary*. Particular importance is given to the gathering of valid trip-related information; hence, transit trips are declared using routes and subway stations and, in the GMA, partial declaration of car routes is also added (highways and bridges).

An advantage of working with these data sets is that there are minimal differences between the survey instruments (a 24-hour trip survey), the survey procedure (telephone interview), the survey frequency (every 5 years) and the sampling rate (approximately 5% of all households) for these two data collection programs. This in turn allows for meaningful temporal and geographic comparisons. The content of both surveys includes socio-economic information about all household members. For a single fall weekday, individual trips by all modes of transportation, made by all household members greater than a specified minimum age are precisely documented in space and time. Contrary to often-used zoning systems for the coding of trip ends, origin and destination points for both surveys are geo-coded at the x-y coordinate level using various types of identifiers such as trip generator, address or nearest intersection. This in turn allows for meaningful geographic comparisons. Various spatial visualization tools using data from these surveys have been developed for data analysis or data dissemination (Chapleau et al, 2008; Chapleau and Morency, 2005; Buliung and Morency, 2008). Some differences need to be pointed out and addressed to insure compatibility between analysis and results. These include:

- *Travel behaviors*. Since the GTA+H surveys after 1986 gather travel information only for people aged 11 years or older, children under 11 years old are excluded from the analysis of trip characteristics for both regions. However, information for all household members is included in all socioeconomic analyses.
- *Main occupation*. In the GMA, main occupation data were only collected in 1998 and 2003. Five mutually exclusive answers are possible: full-time worker, part-time worker, student, retired, others. Information collected in GTA+H differs from that of the GMA. In the GTA+H, employment status and student status are collected separately, recognizing that a person can be both a student and maintain employment simultaneously. In the GTA+H, employment status is defined using the following categories: full-time worker, part-time worker, full-worker at home, part-time worker at home, and not employed. A common aggregated employment status variable was created to reflect a person's main occupation that included the categories: full-time worker (including full-time at-home workers and full-time workers that were also students), part-time worker (including part-time at-home workers and part-time workers that were also part-time students), student (including full-time students that were also part-time workers), other status (including not employed, and retired)
- *Income*. Income data were only collected in the 2003 GMA survey. This information is therefore only included in the analysis for Montreal, mainly for comparative purposes.

- *Non-motorized trips*. in the GMA, non-motorized trips are gathered for all purposes. In the GTA+H bike trips are collected for all work and school trip purposes in 1986 and for all trips in 1996 and 2001. Walk trips are only collected for work and school trip purposes in all survey years.

These surveys, despite their richness in terms of travel behavior information collected, are not activity surveys, and lack detailed information concerning the activities conducted throughout the day, such as detailed types, time spent, companions if any, which are available in many time use surveys. This limitation curtails our ability to establish a connection between time use and mobility in our operational framework.

1.6.2 Business Points

An additional source of data is a business point dataset based on infoCanada data. Business points provide a landscape of opportunities for the areas under study. This dataset is compiled from over 200,000 sources, including telephone directories, annual reports, press releases, city and industrial directories, news items, and new business listings. The database is telephonically verified annually by infoCanada to ensure the accuracy of the information, processed and packaged by Environics Analytics to produce a business profiles database. The final database for analysis includes a custom Standard Industrial Classification code which allows for the identification of business groups. Location coordinates are coded by Environics Analytics to enable mapping applications of the businesses recorded in the database. For the purpose of the empirical research conducted for this report, subsets of data points are extracted from the corresponding files to represent different opportunity classes.

1.6.3 Census of Canada

The 2001 Census of Canada is used to complement the business point dataset. In particular, we use Table 30 of the set of tables on the topic of place of work and commuting to work. These tables are a unique source of information regarding day time demographics, and can be used to obtain employment data by workplace location aggregated by Census Tracts.

1.6.4 Canadian General Social Survey

The final dataset used in this report is Cycle 19 of the Statistics Canada General Social Survey (GSS). This is an annual survey conducted with the primary objectives of: "gathering data on social trends in order to monitor changes in the living conditions and well being of Canadians over time; and to provide information on specific social policy issues of current or emerging interest" (Statistics Canada, 2006). Collected over a twelve-month period in 2005, Cycle 19 of the GSS contains a detailed one-day time-use survey, a socioeconomic questionnaire, data pertaining to transportation and vehicle ownership, and data on other topics not used in this research such as self-rated well-being, sport and physical activity participation, and questions pertaining to social values and social networks. The time-use questionnaire is composed of data entries pertaining to individual activity episodes greater than or equal to 1 minute in length. For the purposes of analysis, the duration and classification of activity episodes are used to construct daily duration variables for various activity classes and their associated trips. The entire GSS survey contains more than 19,000 respondents over the age of 15 from across the country, however, only half of the respondents were asked questions pertaining to transportation, accessibility and social networks. Of these, 2,108 resided in Toronto, Montreal or Hamilton. Unlike the travel behavior surveys for the Hamilton, Toronto, and Montreal areas, this survey includes detailed information about activities performed, including time spent traveling between activities, which allows us to investigate the impact of mobility on time use patterns. However, unlike the travel surveys, the GSS is spatially very sparse, and therefore not usable for the type of spatial analysis envisioned for our mobility and accessibility analysis. This prevents us from developing an explicit connection between time use and accessibility.

CHAPTER 2 Descriptive Statistics of Spatial and Time Use Behavior

Summary:

- **Descriptive analysis** of the datasets used in the report provides initial evidence of the **spatial** and **time use behavior** of the groups of interest.
- Descriptive statistics highlight the **differences** between the three case studies of **Hamilton**, **Toronto**, and **Montreal**, including variations in the **age structure** of the population, the composition of **households**, the average **population density**, and **vehicle ownership** rate.
- There is a high degree of **uniformity** in the **general mobility trends** across cities.
- The statistics indicate that **seniors** are more likely to undertake **fewer trips** and travel **shorter distances.**
- Members of **single parent** household make trips at about the **same rate** as **couples with children**; however, they are considerably more likely to travel **shorter distances**.
- **Low income** individuals in Montreal **travel less frequently** and for **shorter trips**.
- In terms of time use, **seniors** and young people tend to **travel longer** for **shopping** activities.
- Likewise, individuals in **low income** and high income households tend to **travel longer**. Low income people also tend to **spend less time** in their shopping activities.
- Individuals in **single parent** households tend to spend **less time shopping** and **more time** on **service activities**. They have **higher** grocery **shopping rates**, but no difference in participation in other activities.

2.1 Travel Diary Surveys: Spatial Behavior

The variables contained in the travel behavior datasets and used in the analysis are listed in Table 2, along with some basic descriptive statistics. The distributions of the variables (which, as an operating principle, are validated in all datasets for representativeness using the latest Census information), provide some basic information about the demographic composition of the three case studies. Montreal emerges as the city with the largest mature pre-retirement population, although Hamilton has a higher proportion of senior citizens. Toronto on the other hand has the lowest proportion of people younger than 20 in the population, but the highest in the 20 to 35 years class. While the household composition statistics are very similar for Hamilton and Toronto, Montreal in contrast has by far the highest proportion of childless couples and a correspondingly lower level of couples with children. Another difference in household composition is the lower proportion of households classified as "other", a catch-all class for multi-person households with no clear family relationship.

Table 2: Variables and summary statistics

	Hamilton	Toronto	Montreal
Age	Proportion in Sample	Proportion in Sample	Proportion in Sample
AGE < 20	14%	12%	14%
AGE 20-35	23%	28%	26%
AGE 36-50	28%	28%	30%
AGE 51-64	17%	16%	19%
AGE 65+	18%	16%	12%
Income			
INC. REFUSE/DON'T KNOW	-	-	23%
INCOME < 20K	-	-	10%
INCOME 20-40K	-	-	20%
INCOME 40-60K	-	-	18%
INCOME 60-80K	-	-	12%
INCOME 80-100K	-	-	7%
INCOME > 100K	-	-	9%
Household structure			
SINGLE	10%	11%	12%
COUPLE	26%	22%	39%
COUPLE W/CHILDREN	26%	23%	15%
SINGLE PARENT	3%	3%	3%
OTHER	36%	42%	31%
Mobility tools			
DRIVER LICENSE	76%	71%	74%
VEHICLE OWN	91%	84%	88%
*Age 65+	15%	12%	9%
*Low Income	-	-	6%
*Single Parent	2%	2%	2%
TRANSIT WITHIN 500m	2%	5%	3%
*Age 65+	0%	1%	0%
*Low Income	-	-	1%
*Single Parent	0%	0%	0%
Occupation			
FULL TIME EMPLOYMENT	44%	48%	49%
*Age 65+	1%	1%	0%
*Low Income	-	-	2%
*Single Parent	1%	1%	1%
PART TIME EMPLOYMENT	11%	10%	5%
*Age 65+	0%	1%	0%
*Low Income	-	-	1%
*Single Parent	0%	0%	0%
STUDENT	19%	19%	18%
FREE PARKING @ WORK	45%	37%	7%
Density	Mean	Mean	Mean
POPULATION DENSITY (1000s)	1.645	4.276	2.819

An area where there are some key differences concerns mobility tools, with Hamilton having both the highest proportions for private-oriented tools (licensed drivers and auto ownership) and the lowest for public transportation proximity, the precise opposite of Toronto. Incidentally, these statistics are mirrored by the average population density in these cities, which are highest for Toronto and lowest for Hamilton. Hamilton has the lowest rate of full time employment and the highest proportion of free parking at work. Free parking at work appears to be relatively infrequent in Montreal, although it is important to remark that this variable is only recorded for employment locations in the Island of Montreal. Montreal has the highest proportion of full time employment, but only marginally so compared with Toronto, and at the same time has the lowest proportion of part-time employment.

With respect to trip making frequency and average daily distance traveled, the summary statistics are fairly consistent between the three cities (Figure 2 to Figure 8). First, the statistics indicate that the old are by far the group most likely not to engage in trip making, with over 40% of seniors sampled in each of the three regions reporting zero trips for the day. Of those who do travel, the distance traveled tends to be fairly short for a majority of them (up to 5 km), and for every other distance class their proportions are below the proportions for every other group. Contrast this to the group aged less than 20, for whom the distance traveled also tends to be fairly short but seems to be compensated by more frequent trip making compared to the old.

Considering the variations in trip making according to household structure, it is interesting to note that there are only relatively small differences in terms of the number of trips reported. In fact, the rates are almost identical for individuals in single parent households, and those in households led by couples with children. There are more marked differences in distance traveled, with single parent households having a substantially higher frequency of short trips in the three cities. As well, the distance-decay effect is the steepest of any type of household. This suggests that while the ability of individuals in single parent households may not be too different compared to other households with children, the spatial extent of their trip making is more limited, which may affect the range of opportunities available to them.

Income statistics are available only for Montreal, but in this case show that the lower the income of the household the more limited the travel behavior becomes, both in terms of number of trips (individuals in households with income less that 20,000 are proportionally more likely to not travel) as well as average distance traveled, with a stronger decay effect (see Figure 8).

The differences between cities are relatively small. Still, seniors in Hamilton are slightly more likely to make more trips, whereas those in Toronto tend to report a higher proportion of zero trips. Individuals in single parent households in Montreal are slightly more likely to be mobile, but not to make many trips, whereas in Hamilton, individuals in households of this type are slightly more likely to have stayed home, but those who do engage in trip making, tend to make more trips.

It is important to note that these descriptions of the data, being univariate, do not control for confounding factors, and potential interactions between variables. Multivariate analysis in the following chapters achieves this objective.

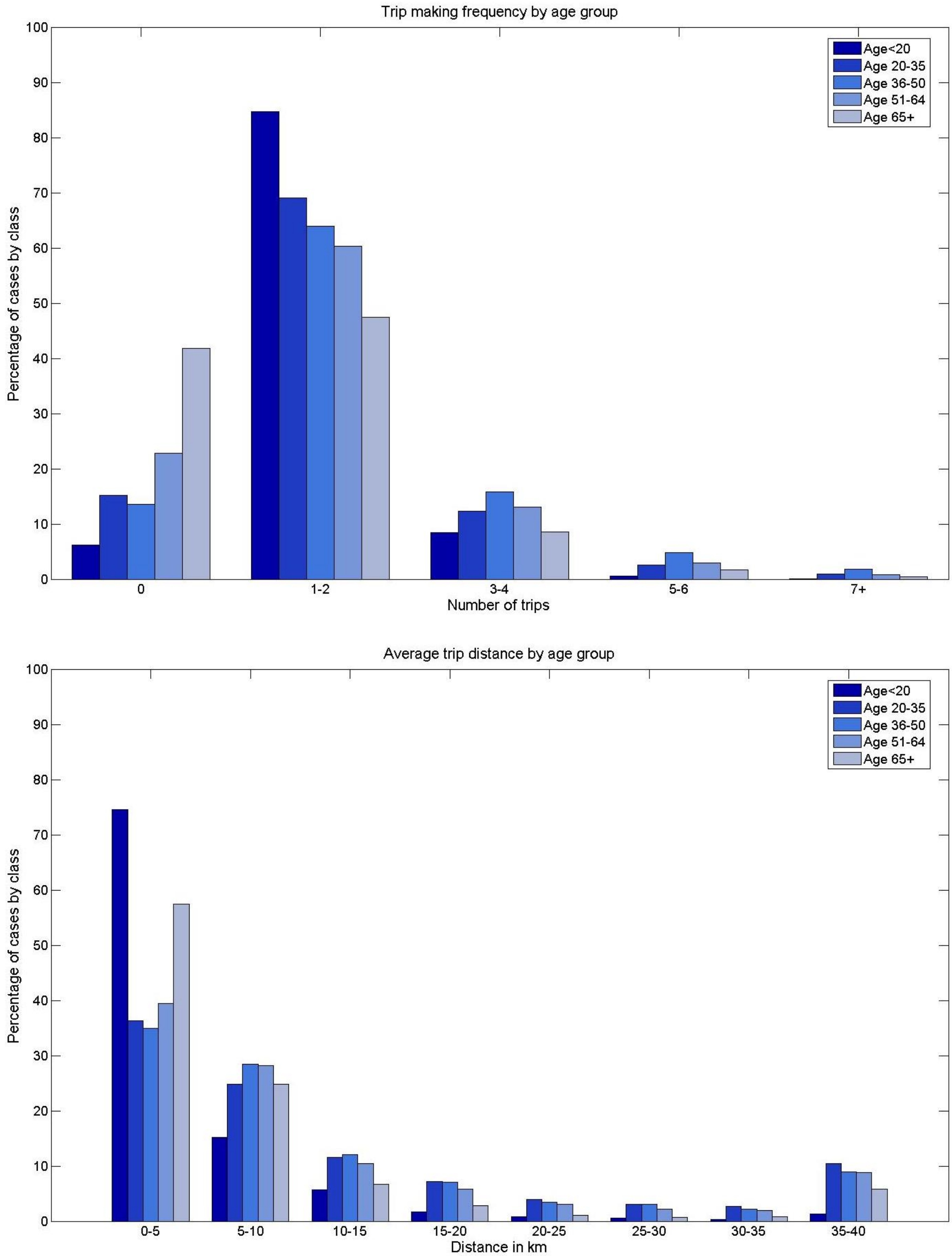


Figure 2: Trip making frequency and average distance by age, Hamilton

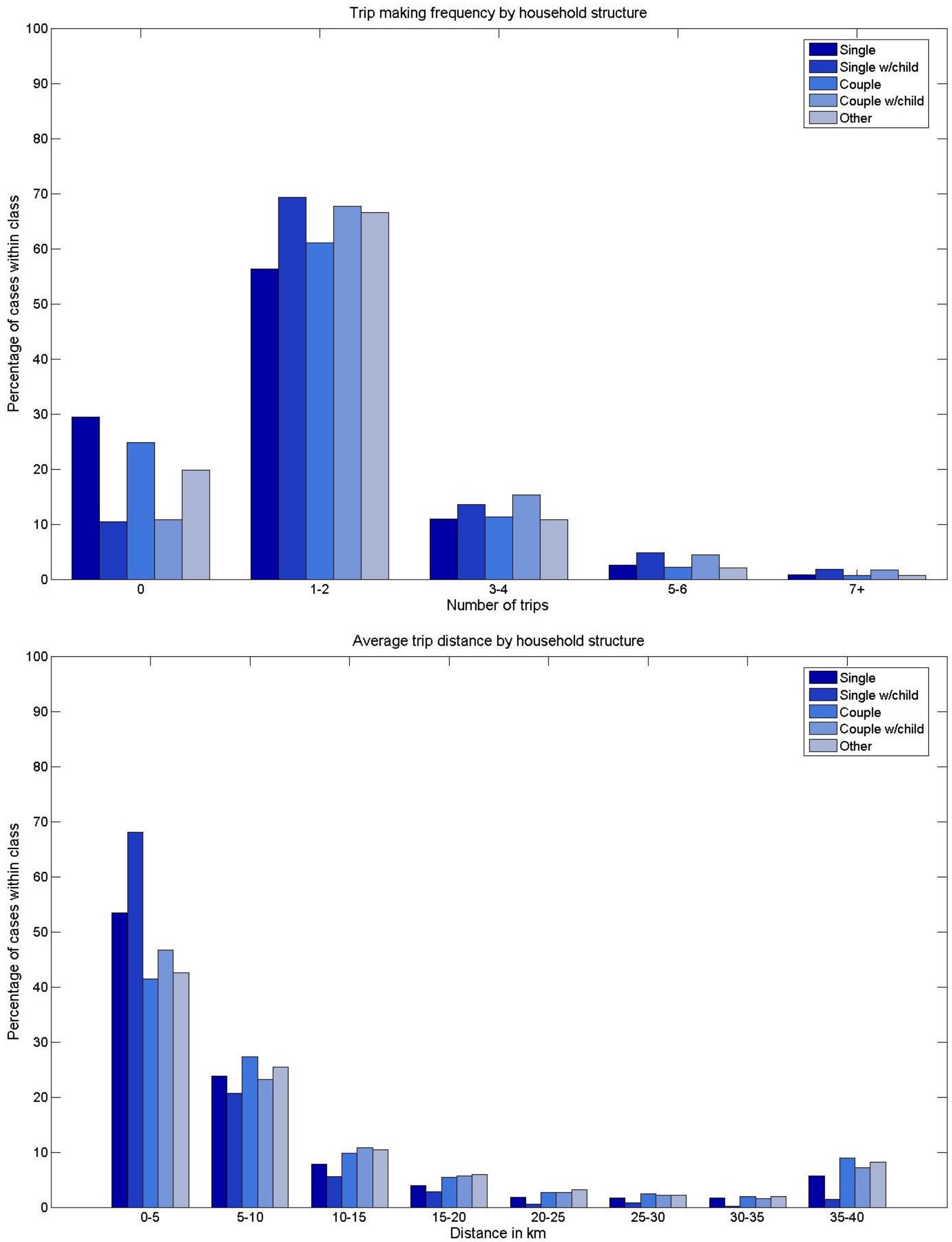


Figure 3: Trip making frequency and average distance by household structure, Hamilton

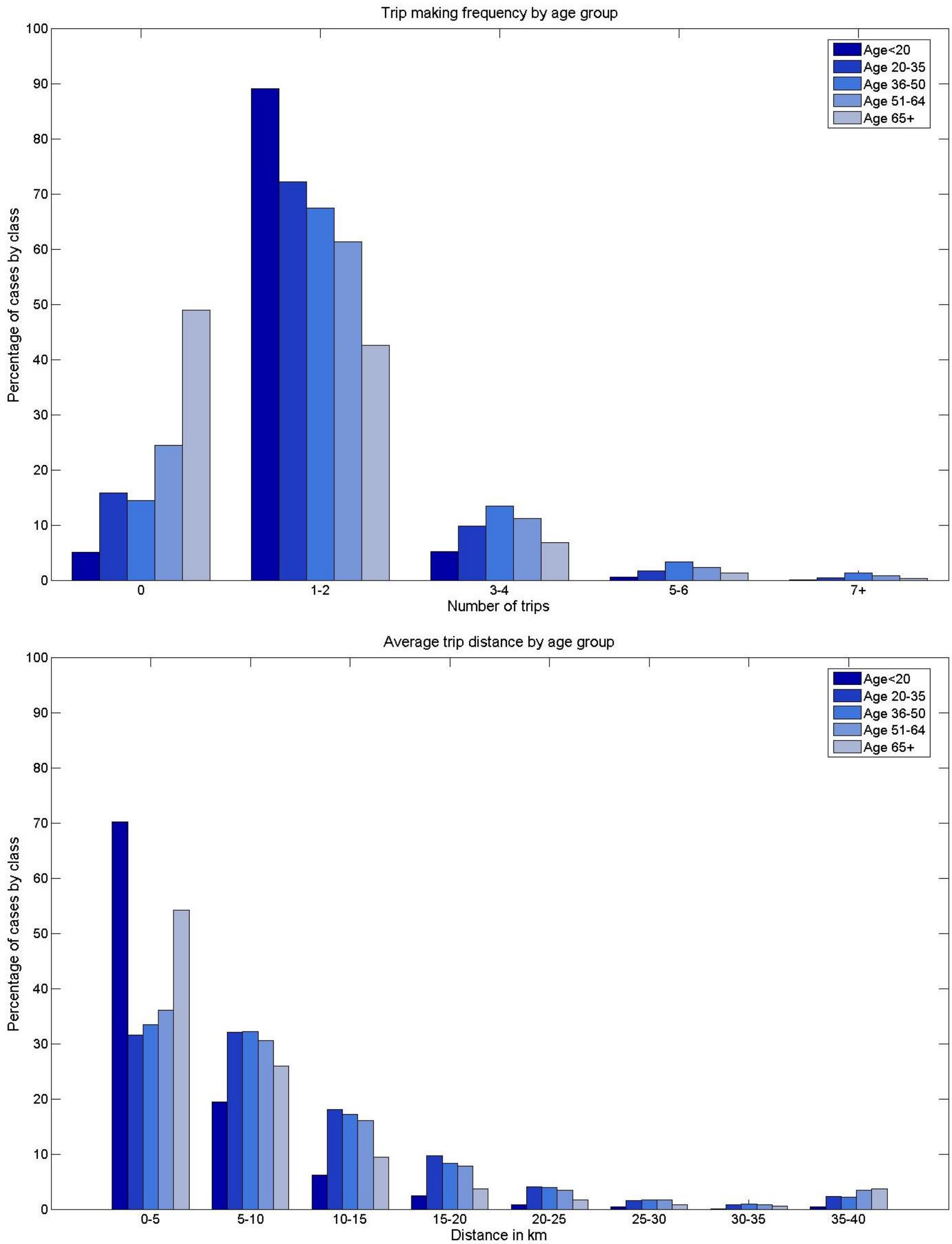


Figure 4: Trip making frequency and average distance by age, Toronto

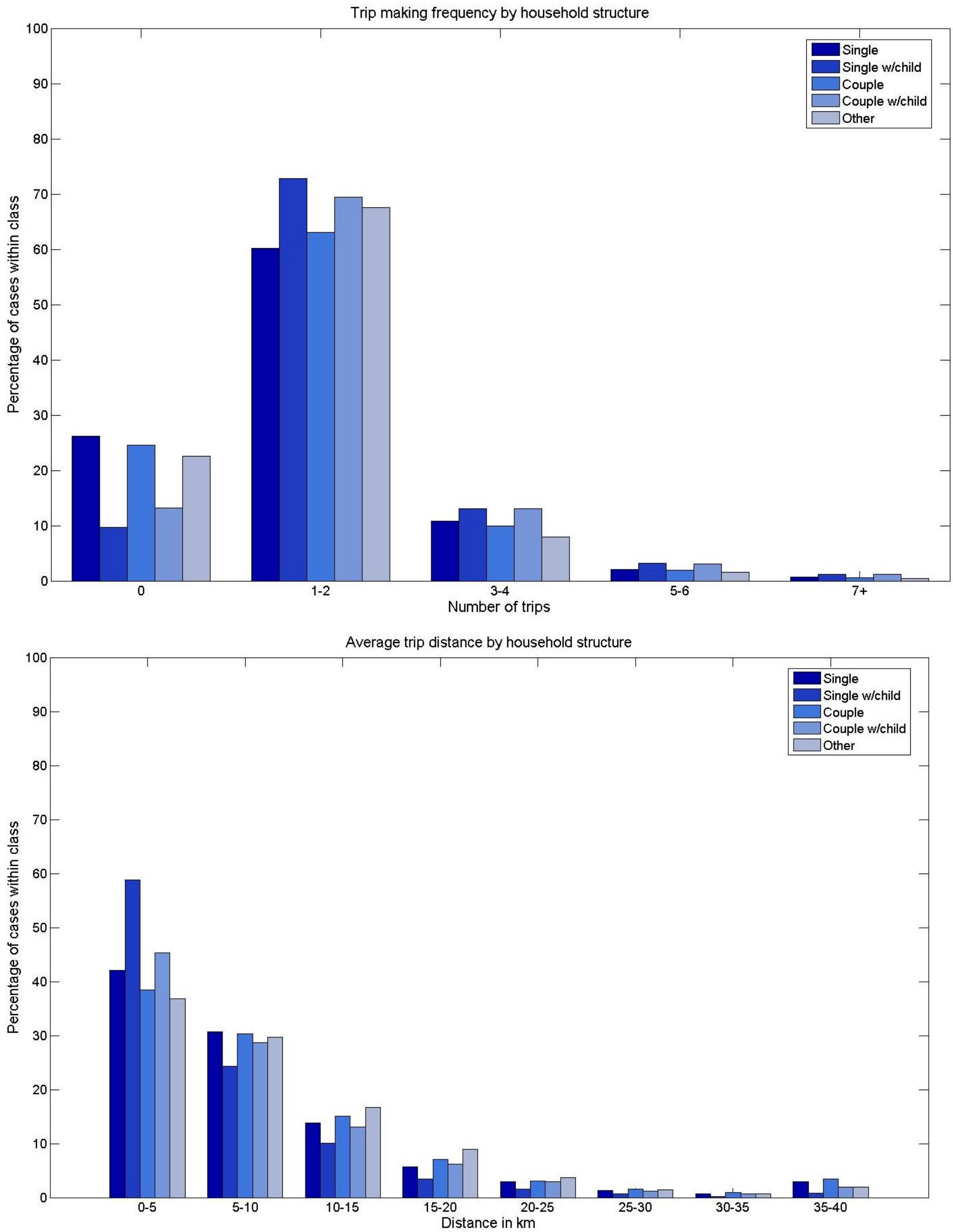


Figure 5: Trip making frequency and average distance by household structure, Toronto

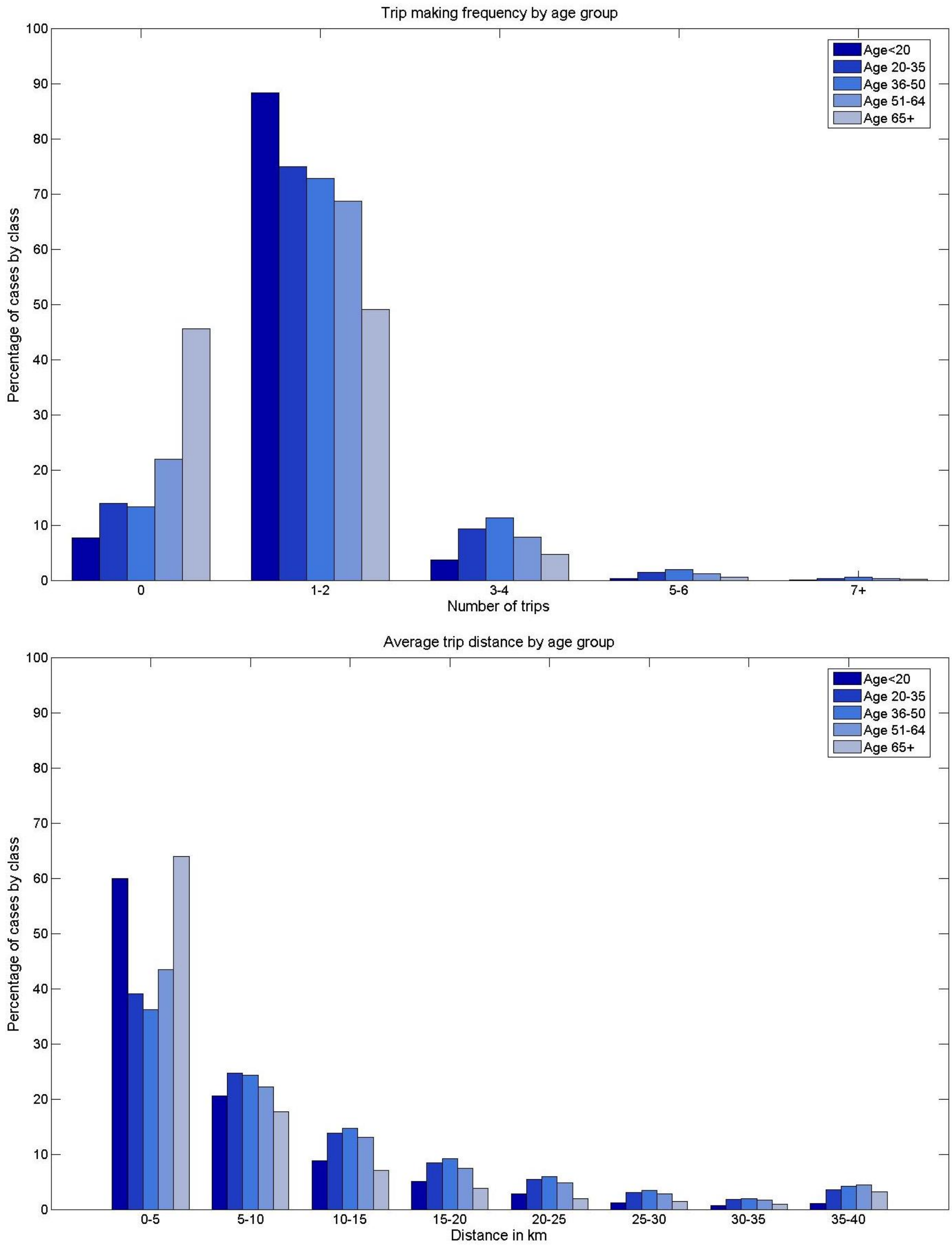


Figure 6: Trip making frequency and average distance by age, Montreal

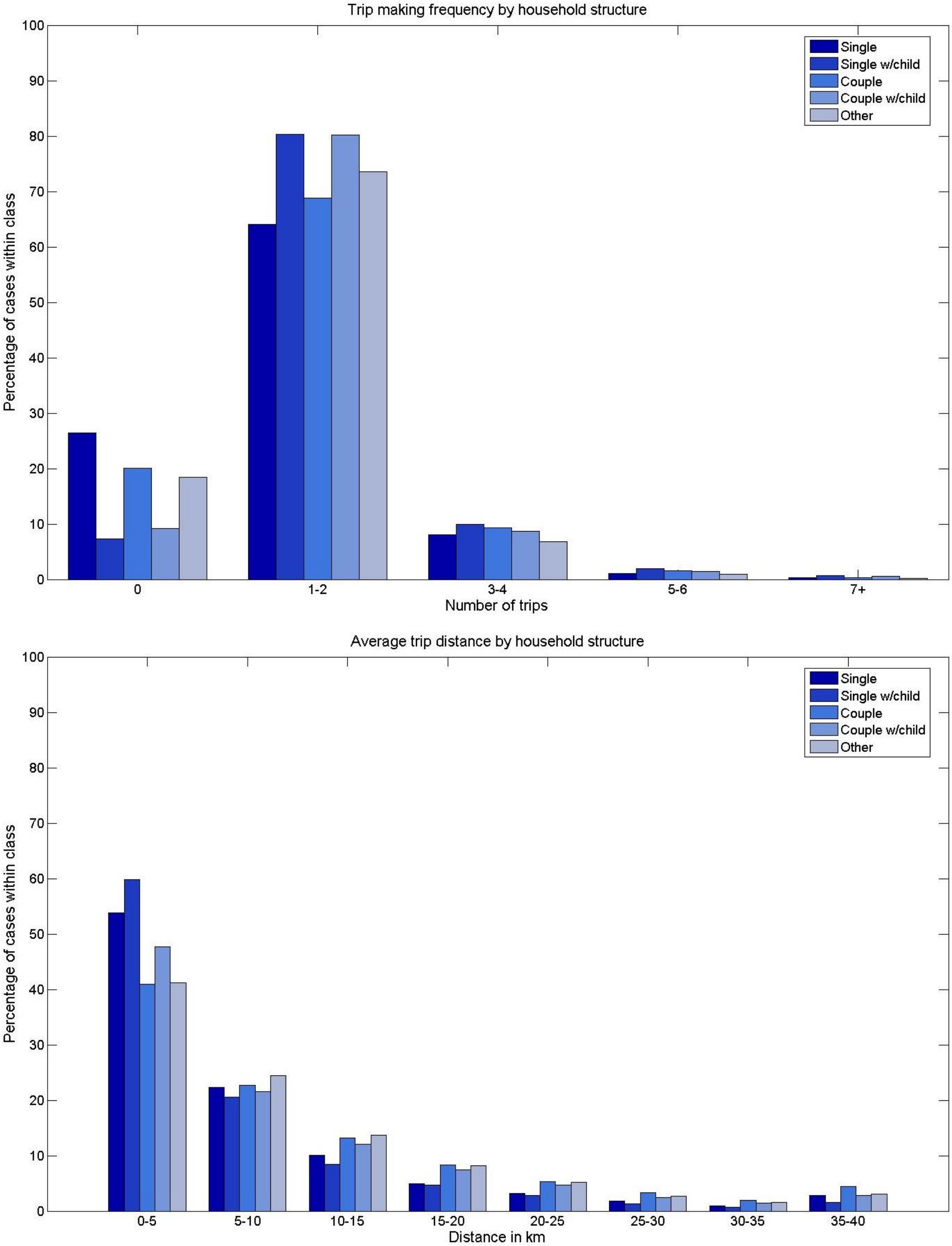


Figure 7: Trip making frequency and average distance by household structure, Montreal

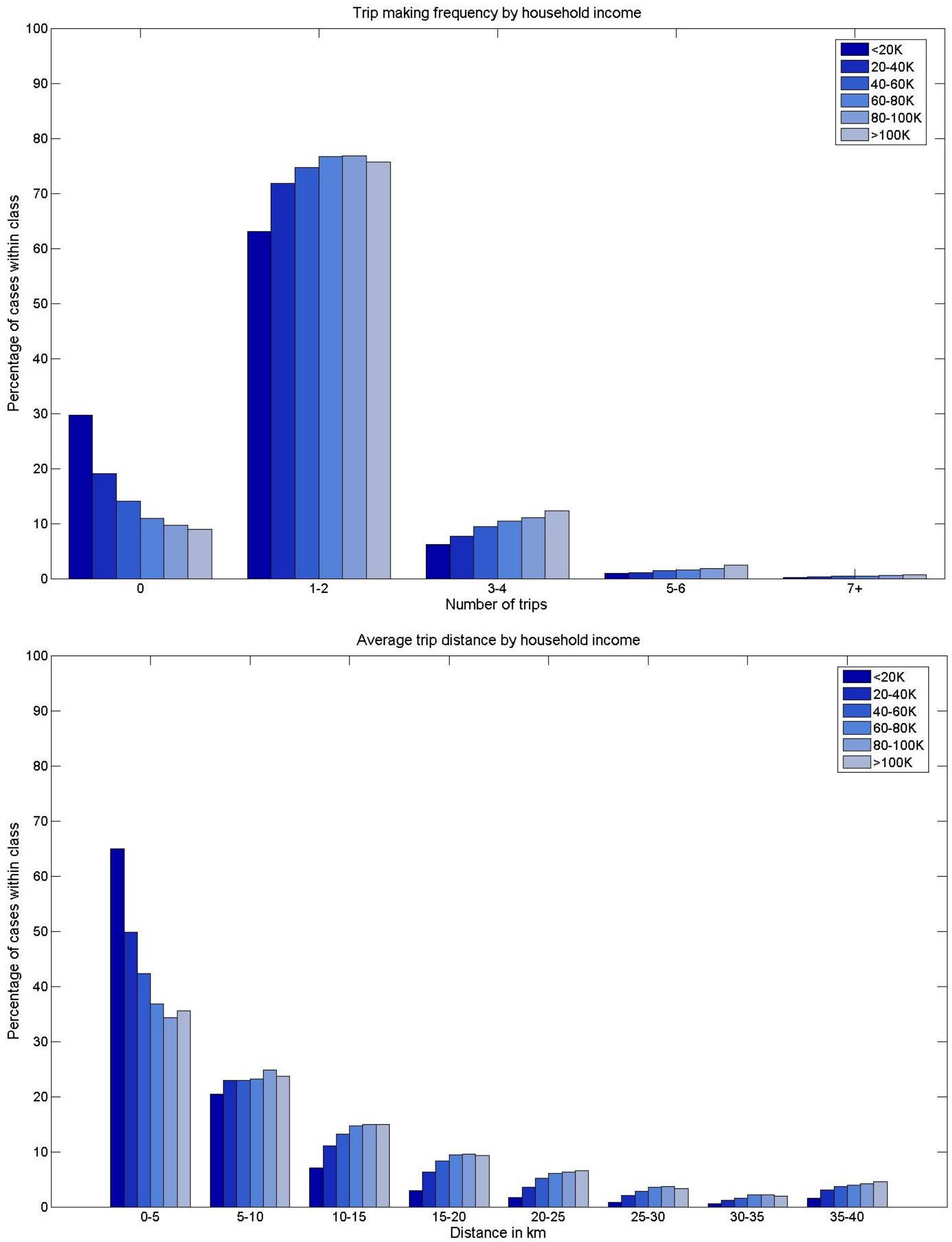


Figure 8: Trip making frequency and average distance by income, Montreal

2.2 GSS: Time Use Characteristics

In general, an item for exploration in terms of a time use perspective is whether those seen at risk of social exclusion due to mobility and accessibility have lower participation rates, shorter activity durations and longer trip durations in comparison to the rest of the population.

The items in the survey are classified in order to obtain broad groupings of activities, as seen in Table 3.

Table 3: Activity classification

Work and Education (WKEDU)	work for pay at main job, work for pay at other job(s), overtime work, looking for work, unpaid work in a family business/farm, travel during work, waiting/delays at work during work hours, meals/snacks at work, idle time before/after work hours, coffee/other breaks at work, other work activities, full-time classes, other classes (part-time), credit courses on television, special lectures (occasional outside regular work or school), homework, meals/snacks/coffee at school, breaks/waiting for class, leisure and special interest classes, other education related activities.
Household and Personal Maintenance and Care (DOMCARE)	meal preparation, baking, preserving food, food/meal cleanup, indoor cleaning, outdoor cleaning, laundry, ironing, folding and drying, mending clothes/shoe care, dressmaking and sewing, interior maintenance and repair, exterior maintenance and repair, vehicle maintenance, other home improvements, gardening/grounds maintenance, pet care, care of plants, household management, stacking and cutting firewood, other domestic/household work, unpacking groceries, packing and unpacking luggage and/or car, packing and unpacking for a move of the hou\sehold, child care (infant to 4 years old), child care - Putting children to bed, child care - Getting children ready for school, child care - Personal care for children of the household, helping, teaching, reprimanding, reading to/talking/conversation with children, playing with children, medical care - household children, unpaid babysitting - household children, personal care - household adults, medical care - household adults, help and other child care - household children, help and other care - household adults, washing, dressing, personal medical care at home, private prayer, mediation and other informal spiritual activities, meals/snacks/coffee at home, other meals/snacks/coffee: non-socializing, meals at restaurant, night sleep/essential sleep, naps/lying down, relaxing, thinking, resting, smoking, other personal care/private activities.
Social, Entertainment and Community (SOCIAL)	professional/union/general meetings, political, civic activities, child/youth/family organizations, religious meetings/organizations, religious services/prayer/Bible reading, meals/snacks/coffee at religious services, fraternal and social organizations, support groups, volunteer organizational work, meals/snacks/coffee at place of volunteer work, housework, cooking assistance, house maintenance/repair assistance, unpaid babysitting, transportation assistance to someone other than a household member, care for disabled or ill person, correspondence assistance, unpaid help for farm/business, other unpaid work/help, other civic, voluntary or religious activities, professional sports events, amateur sports events, pop music concerts, fairs, circuses, parades, amusement parks, ice follies, zoos, botanical gardens, planetarium, observatory, movies/films at a theatre/cinema, art films, drive-in movies, classical music concerts, opera, ballet, theatre, museums (excluding art museums), art galleries (art exhibition), heritage sites, socializing at a private residence (no meals), socializing at a private residence (with meals, excluding restaurant meals), other socializing with friends/relatives at a non-private and non-institutional residence, socializing with friends/relatives at an institutional residence, socializing at bars, clubs (no meals), attendance at casinos, bingo or arcades, other social gatherings.
Shopping for goods and services (SS)	grocery store, market, convenience store, shopping for every day goods and products, take-out food, rental of videos, shopping for durable household goods, personal care services, financial services, government services, adult medical and dental care, including having prescriptions filled, other professional services, car maintenance and repair, other repair and cleaning services, waiting for purchases or services, other shopping and services.

For Figure 9 and Figure 10, the focus is on the two age cohorts over the age of 65; for Figure 11 and Figure 12, on the lowest two income groups; and for Figure 13 and Figure 14, on single parents. Across the board, we see a great difference between seniors younger than 75 years and those aged over 75, but not necessarily a great difference between seniors in general and the remainder of the population. Quite importantly, with one exception, participation rates for seniors in all three categories of activities are on par with the rest of the population. However, those aged over 75 years have much higher participation rates in the services compared to all other age groups, perhaps partially as a function of increased demand for health services. There seems to be a greater variety in durations in comparison to participation rates. Interestingly, the figure for SS travel duration is convex, indicating that the oldest and youngest groups travel the longest for goods and services, while those middle aged have shorter travelling durations. This shape can be linked to Hägerstrand's (1970) theory of constraints which suggests that teens and seniors, both presumably with ample free time, are able to spend more time travelling to their destinations. In this light, longer travel durations are likely innocuous; besides the systems view of transportation efficiency, there is no normative directive stating that travel is per se a bad thing. However, if these longer travel times arise from a bias in the transportation system against those with mobility constraints, such as seniors, then these longer travel durations can be interpreted as a barrier to inclusion.

Similarly, space time constraints also help to explain Figure 11 and Figure 12, pertaining to activity durations and household income. First of all, the same convex pattern for travel durations observed in Figure 9 is also evident in Figure 11, indicating that both the poorest and the wealthiest households travel longer for goods and services. It is yet to be determined how income affects this process. However, whereas the wealthy may travel longer due to cheaper relative travel costs (for gas, parking, insurance etc.), the impoverished may be travelling longer because they do not have access to mobility tools, they live in underserviced parts of the city forcing them to travel further, or simply because they choose to travel further since their value of time is lower than for those with higher incomes.

In terms of shopping activities, the indication is that respondents from poorer households typically spend less time shopping for goods and services, and in particular spend far less time on financial, government, health and personal services. Interestingly, the poorest households have high participation rates for grocery shopping but lower grocery shopping durations. This may be indicative of a more precarious one-day-at-a-time situation, in which more frequent trips to the stores for shorter shopping episodes are associated with limitations to afford, carry, or store larger quantities of purchased items. At any rate, this provides preliminary evidence of distinct activity patterns associated with the poorest households, and the causes and outcomes on this must be further studied.

The third and final subgroup of interest for the analysis of time use patterns is single-parent households. Approximately 10% of respondents in the survey are single-parents living at home with one or more children in the household; nearly all are female and many have low incomes. Single parents face increased time constraints as the sole provider for income and child-care, and as can be seen in Figure 13 and Figure 14, they also differ greatly from the rest of the population in terms of durations and participation rates for shopping activities. The single parents on average spent approximately 20% less time shopping and 20% more time on services activities. Despite the reduced grocery shopping durations, single parents, like the low-income households, have higher grocery shopping rates, but no discernible participation difference in the other activities.

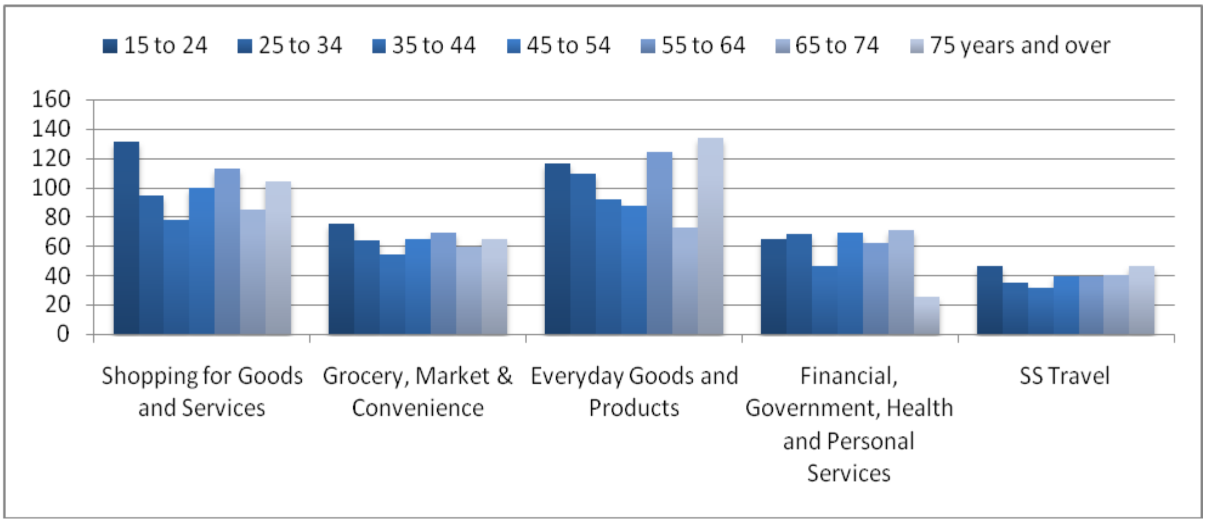


Figure 9: Duration of SS activities by age group

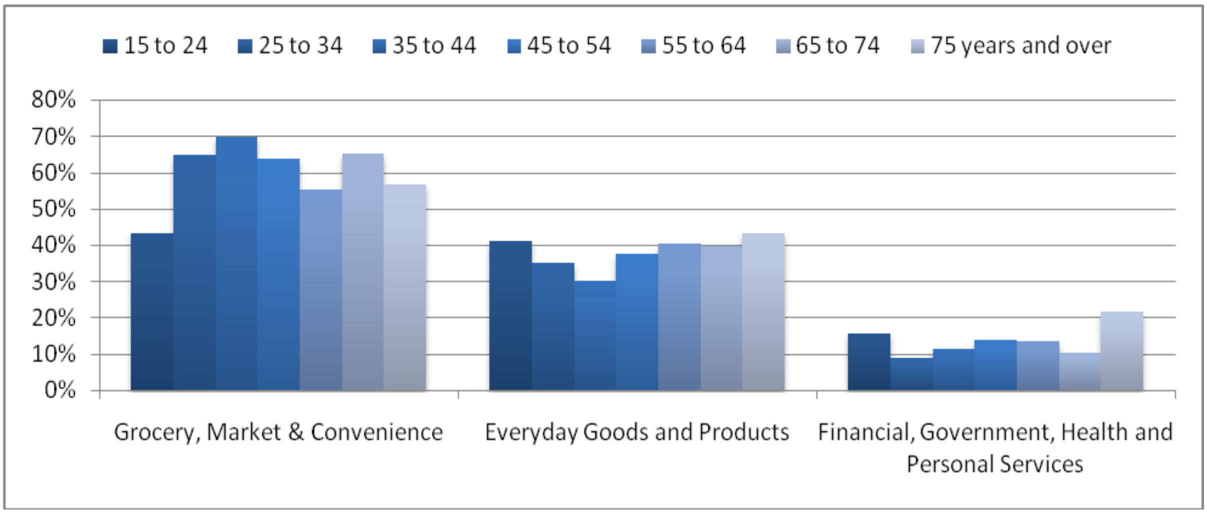


Figure 10: Participation in SS activities by age group

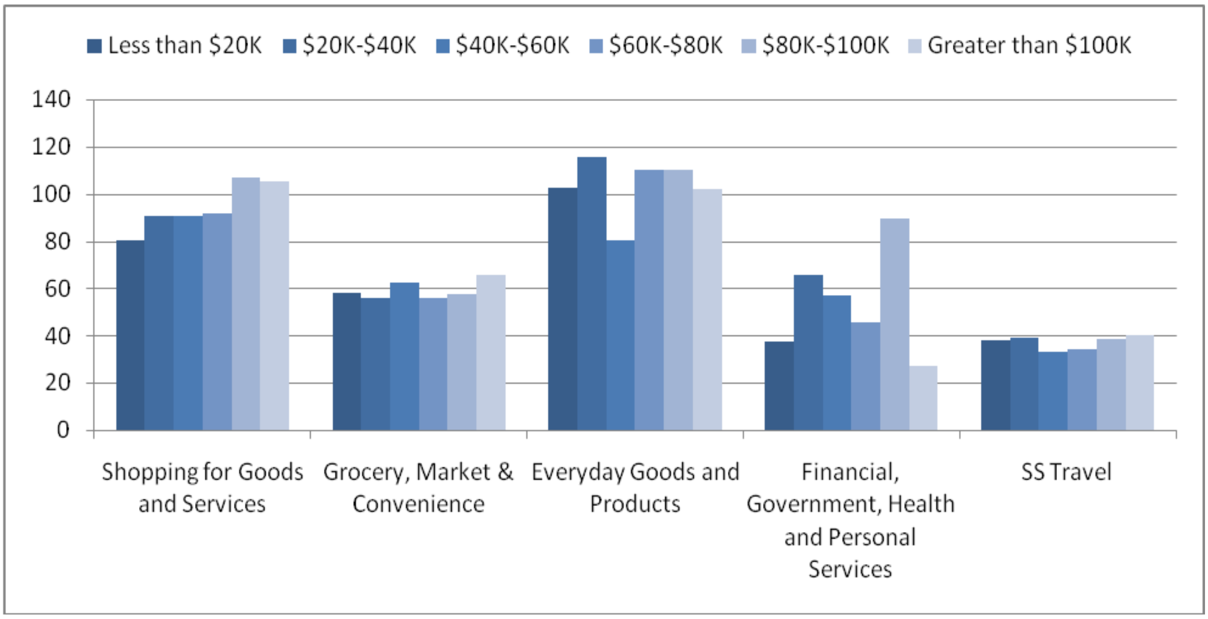


Figure 11: Duration of SS activities by household income group

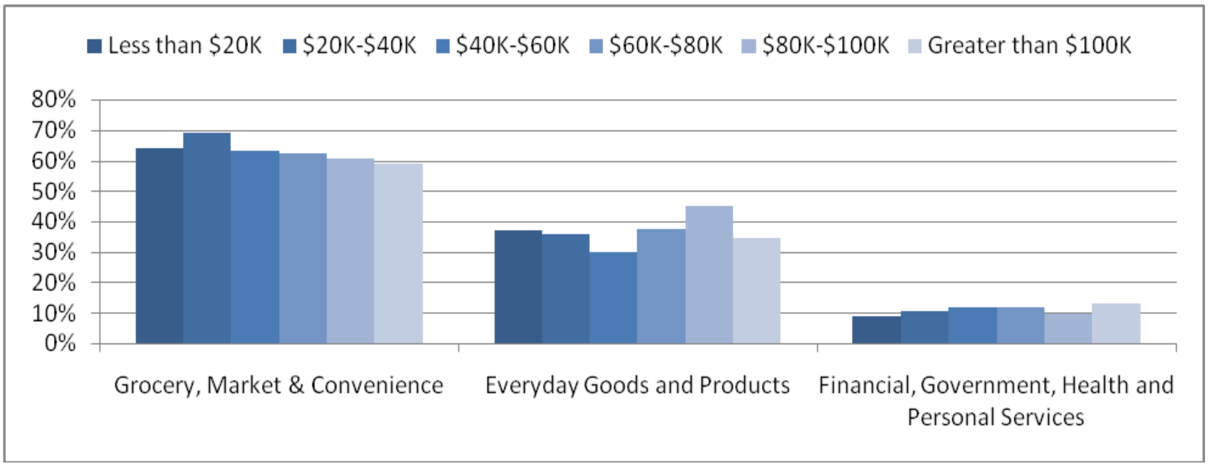


Figure 12: Participation in SS activities by household income group

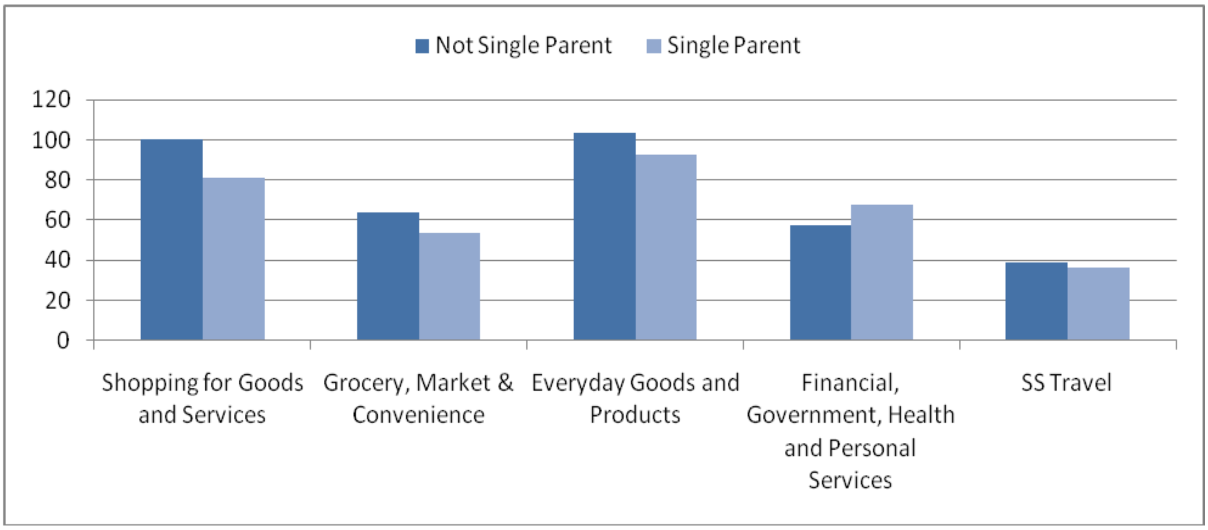


Figure 13: Duration of SS activities by single parent status

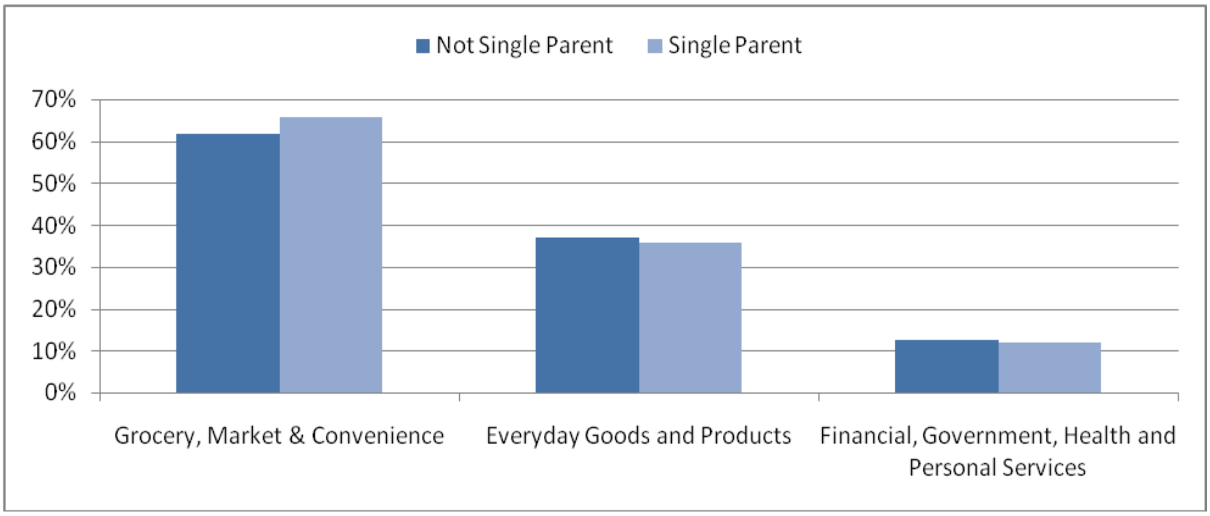


Figure 14: Participation in SS activities by single parent status

CHAPTER 3 Mobility Levels: Trip Generation in Hamilton, Toronto, and Montreal

Summary:

- **Trip generation** is a measure of **mobility** that provides indication of **out-of-home** activity engagement.
- Trip generation is a **necessary condition** for **accessibility**. Its absence negates the possibility of accessibility.
- Generation of trips is investigated using a combination of an **ordered probit** model, and a spatial analysis technique called the **expansion method**.
- The ordered probit model models the **probability** that an individual will be in a given **trip making class**. The expansion method provides **spatially-varying coefficients** useful to investigate **contextual variations** in trip making behavior.
- The results indicate **significant differences** in trip making frequency by **population segment**, as well as by **location** within each geographical region.
- **Trip rates** are **estimated** for various **population groups**.
- **Seniors** consistently have the **lowest** trip **rates** in the three case studies.
- **Low income** individuals are the **second least mobile** group in **Montreal**.
- Individuals in **single parent** households have **similar** trip rates as the **reference** group in **Toronto** and **Montreal**, but **lower rates** in **Hamilton**.
- **Vehicle ownership** significantly increases the tendency towards **more** frequent **trip making**. With respect to the reference group, the **effect** is even **greater** for **seniors** in the three cities, for **single parents** in Hamilton and Toronto, but not for **low income** people or **single parent** households in Montreal.
- The effect of **transit** is significant but **ambiguous** and **localized** by experimental design (proximity within 500 m of transit facility).
- There is evidence of significant **geographical variability** in trip making behavior within study areas, generally displaying **central city** and **suburban differences**. These trends are **specific** to each population group investigated.

3.1 Background and Objectives

The first aspect of mobility investigated in this report is the generation of trips, as a measure of out-of-home activity engagement. While the literature on spatial mismatch tends to concentrate on economic outcomes (i.e. employment participation) we adopt a more general perspective aligned with the social exclusion view, and focus instead at general levels of mobility, measured by the number of trips generated for all purposes by all modes. The number of daily trips is a simple but informative and robust measure of social exclusion, if one does not count the extensibility (i.e. ability to participate remotely) associated with the use of information and communication technologies (ICT; see Miller, 2006). Conceptually, people who make trips do so, in general, in order to reach work, school, shopping, social, entertainment, recreation, or personal business activity locations. Even leisure driving could be seen as a form of participation, in that it provides a different setting for recreational and social activities. More generally, participation in each of these activities is an indicator of inclusion in social and economic networks. Not making trips, on the other hand, indicates that significant time is being spent within the confines of one's home. As previously noted, we recognize the fact that it may be possible to effectively participate in society and the economy without making trips (e.g. through the use of information and communication technology, or by receiving visitors or home deliveries). However, we feel that the likelihood of doing so is much lower. The literature on ICT and travel behavior is inconclusive with regards to the degree that telecommunication substitutes travel (e.g. Mokhtarian, 2009), and relatively little is known in terms of the characteristics of travel for visiting and other forms of social contact (e.g. Habib et al, 2008; Farber and Páez, 2008) Thus, for the research reported here, we keep the analysis general, and aggregate each studied individual's trips over all modes, and all trip purposes, without distinction of the length of trip (which are the subject of in-depth investigation in a subsequent section in the report). More specifically, trip generation is the term used to indicate the number of trips made by a single unit of observation, (in this case, the individual person), for a specific purpose (in this case all purposes), over a specific time period (in this case 24 hours), by a specific mode (in this case all modes). Schematically, as an element of the operational framework of this report, trip generation is a precondition for accessibility, and the absence of trips negates the possibility of accessibility (see Figure 15 below).

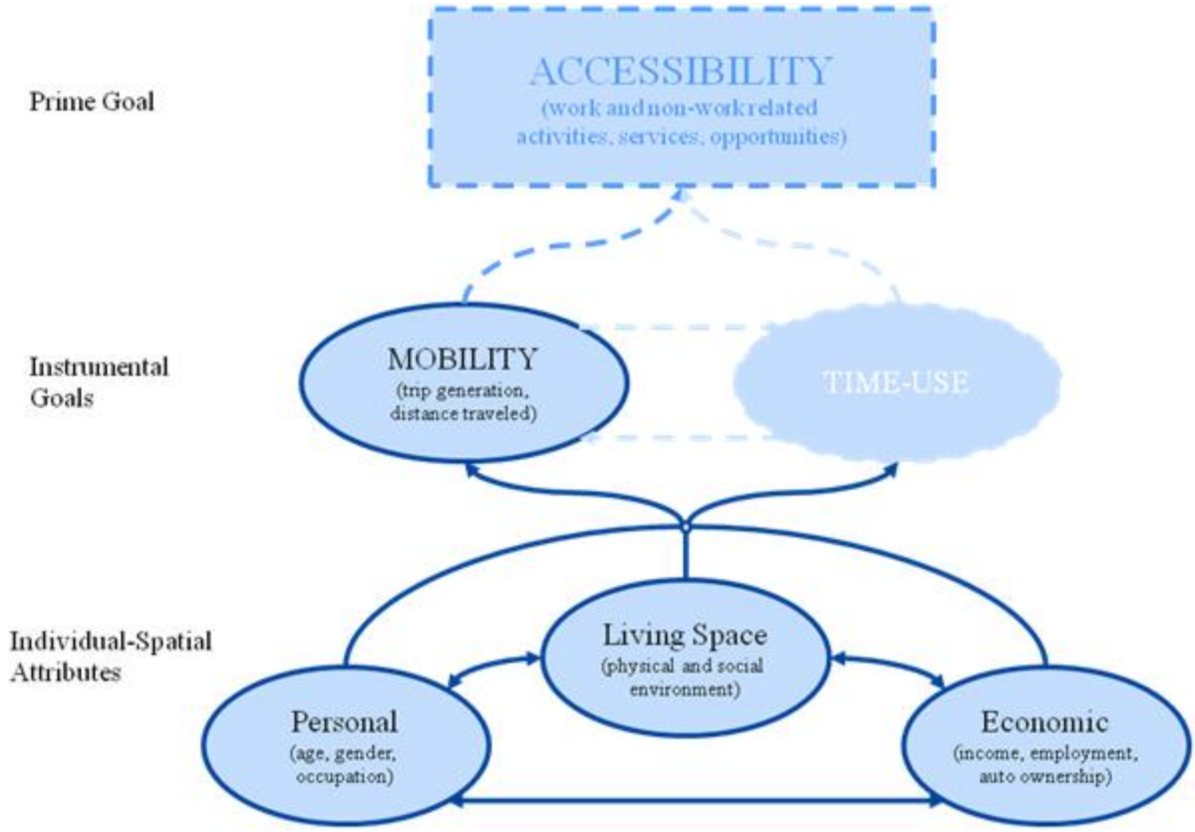


Figure 15: Conceptual framework: Trip generation

3.2 Methods

Trip generation modeling has traditionally followed one of three methods: cross classification models, trip rate models (Institute of Transportation Engineers, 2004), and multivariate regression models, usually at the zonal or household level of aggregation (Badoe and Chen, 2004). Multivariate regression models have been developed in Canada at the person level with large datasets in multiple cities over multiple years, to investigate why changes in trip rates have been observed (Roorda et al, 2008). In this research, we adopt a model structure that implements spatially expanded coefficients (Casetti, 1972) within an ordered probit modeling framework (Train, 2003). Further details regarding these modeling approaches can be found in Appendices A and C respectively.

The choice of modeling approach follows a number of considerations. The objective of the present analysis is to draw inferences on the factors that affect out-of-home activity participation. In other words, we aim at understanding travel behavior, and the probit model, with its well-established link to utility theory (see Train, 2003; pp. 163-167), is a better candidate for this objective than the Poisson and negative binomial models, which are probabilistic in nature. Although linear regression has been shown to predict trips better in some empirical applications (Badoe, 2007), this approach also suffers from some conceptual and practical limitation as discussed in Páez et al. (2007). In order to investigate potential variations in the relationships investigated, spatially expanded coefficients are introduced (Casetti, 1972). The spatial expansion approach belongs to the class of local spatial analysis techniques discussed by Fotheringham and Charlton (1999). The expansion method expands the coefficient of a variable in a model using the coordinates of the observation, thus providing a geographical anchor that helps to contextualize it. Use of expansion variables should not be confused with simple use of spatial variables. Spatially expanded coefficients represent in essence the interaction between an attribute and location. For instance, a spatially expanded coefficient for low income would give information of the effect of low income status at different locations. A key characteristic of local spatial techniques is that, as Fotheringham and Charlton (1999) note, they produce mappable results, such as could not be obtained by using aspatial and even so-called global forms of spatial analysis. The effect of income, without the expansion, would produce a unique coefficient which implicitly assumes that this condition (i.e. low income) has a constant impact on mobility regardless of location. Essentially, the result in this case would be a flat surface for the region under analysis. Spatially expanded, this variable would produce instead a parametric surface that could reveal potentially interesting geographical variations in responses. The significance of these variations can be tested using standard statistical measures, such as *t*-scores. As discussed by Miller (1999) and more recently by Páez and Scott (2004) within the context of transportation and urban systems analysis, spatial analysis approaches provide valuable tools for investigating processes in meaningful new ways.

3.3 Results

The results of the analysis are presented in Table 4 and Table 5 for the three case studies of Hamilton, Toronto, and Montreal. A standard goodness of fit statistic is the likelihood ratio test. This test compares two alternative (nested) models, in this case a full model with the complete set of explanatory variables, and a restricted model that includes the constant terms only and thus does not include explanatory factors. The test statistic is χ^2 distributed with degrees of freedom given by the number of variables in the full model that are not in the restricted model. As shown in Table 4, in every case the naïve model can be rejected at a very high level of confidence, which confirms the explanatory power of the variables used in the full model.

A few words about interpretation of the coefficients are in order. The probit model models the probability that an individual will be in a given trip making class as a function of the estimated utility that the individual obtains from making trips. A comparison of the individual's utility to the threshold coefficients determines that person's trip making class (i.e. how many trips they make). Class transitions are therefore defined by the values of the threshold coefficients. The transition between 0 and 1-2 trips happens at a threshold value of 0 in every case. As an illustration, for Hamilton, the transition between 1-2 trips and 3-4 trips is at 2.064, the transition between 3-4 trips and 5-6 trips happens at 2.8885, and the transition between 5-6 and 7+ trips is at 3.4746. Utility is estimated as the combined linear effect of all explanatory factors plus an unobservable random term, and compared to these thresholds. The random term is the reason why the model gives the probability, instead of the certainty that an individual will be in a given class. Suppose, however, as an example, that the combination of all factors, including the random term but excluding employment status, produces a value of 1.5 of the utility function, thus placing the individual in the 1-2 trips category. The effect of being employed (which is a 0-1 dummy variable) would be to add the value of the respective coefficient to the function. Since this coefficient is 0.6466, the result would be to push the individual to the next trip making class. Being part-time employed, with a coefficient of 0.5031, would not have this effect. The influence of variables with spatially expanded coefficients (Age > 65, Single Parent, and Low Income) are more easily interpreted graphically, since the net effect will be combination of all expansion terms.

The following general observations can be made about the results of the analysis. In terms of demographic attributes there is evidence that, all else being equal, the youngest cohort (age < 20) tends to make more frequent trips. After a bump for the 36 to 50 cohort (the reference group), trip generation tends to decrease with increasing age, but this effect only becomes evident for seniors (age > 65) when the net effect of the spatial expansion is calculated (see below). These results are fairly consistent across cities. The impact of income can only be evaluated for the Montreal. The results indicate that the effect of this variable is important. Compared to the reference, every other class has a negative coefficient associated with it, but the effect tends to decrease in magnitude with increasing income. Thus, while lower income individuals tend to be less mobile this difference tends to dissipate at higher incomes. The effect of income less than 20 thousand needs to take the spatial expansion coefficients into consideration for interpretation. Household structure also plays a significant role in number of trips made. Taking as a reference the class of households with a single adult, every other household type has coefficients that negatively impact the trips per person, the exception being couples with children in Hamilton and Montreal, which are not statistically different from singles. The coefficient for single parent households can only be fully interpreted once the net effect of the spatial expansion is calculated.

Table 4: Trip generation model with spatial expansion – Part 1

	HAMILTON		TORONTO		MONTREAL	
Log-Likelihood	-20974.861		-106047.403		-113952.306	
LR Test vs. Constants Only	3950.972		27095.64		478504.2	
N	22855		126645		150608	
VARIABLE	ESTIMATE	p-value	ESTIMATE	p-value	ESTIMATE	p-value
CONSTANT	0.2363	0.3131	-0.2179	0.0024	0.2618	0.0243
Thresholds (for identification: threshold 1=0)						
l_2	2.0649	0.0000	2.2252	0.0000	2.4122	0.0000
l_3	2.8885	0.0000	3.0415	0.0000	3.2863	0.0000
l_4	3.4746	0.0000	3.6007	0.0000	3.8708	0.0000
Age						
AGE < 20	0.1846	0.0000	0.3588	0.0000	0.0739	0.0000
AGE 20-35	-0.1190	0.0000	-0.1175	0.0000	-0.0335	0.0001
AGE 36-50	Reference		Reference		Reference	
AGE 51-64	-0.0400	0.0604	-0.0633	0.0000	-0.0797	0.0000
AGE 65+	-5.0795	0.0000	-1.4147	0.0000	0.7357	0.0088
Income						
INC. REFUSE/DON'T KNOW	-		-		-0.4008	0.0000
INCOME < 20K	-		-		0.1274	0.3653
INCOME 20-40K	-		-		-0.1866	0.0000
INCOME 40-60K	-		-		-0.1328	0.0000
INCOME 60-80K	-		-		-0.0824	0.0000
INCOME 80-100K	-		-		-0.0526	0.0004
INCOME > 100K	-		-		Reference	
Household structure						
SINGLE	Reference		Reference		Reference	
COUPLE	-0.1614	0.0000	-0.1539	0.0000	-0.0793	0.0000
COUPLE W/CHILDREN	0.0301	0.1842	-0.0548	0.0000	0.0168	0.1199
SINGLE PARENT	6.4708	0.0271	0.0114	0.4890	-0.2025	0.3889
OTHER	-0.2800	0.0000	-0.3270	0.0000	-0.2049	0.0000
Mobility tools	-		-			
DRIVER LICENSE	0.4795	0.0000	0.5355	0.0000	0.3881	0.0000
VEHICLE OWN	0.3364	0.0000	0.2212	0.0000	0.0920	0.0000
*Age 65+	0.3135	0.0000	0.3505	0.0000	0.3297	0.0000
*Low Income	-		-		-0.0956	0.0001
*Single Parent	0.3888	0.0006	0.1069	0.0091	0.0498	0.1690
TRANSIT WITHIN 500m	-0.1364	0.0441	-0.0971	0.0000	0.0462	0.0211
*Age 65+	-0.2707	0.0433	0.1222	0.0059	0.1140	0.0195
*Low Income	-		-		0.0810	0.0500
*Single Parent	0.0801	0.4299	0.1177	0.1158	-0.0761	0.2808
Occupation						
FULL TIME EMPLOYMENT	0.6466	0.0000	0.7909	0.0000	0.6444	0.0000
*Age 65+	-0.1053	0.1564	0.0420	0.1646	0.0298	0.2774
*Low Income	-		-		-0.0043	0.4354
*Single Parent	0.2396	0.0154	0.1311	0.0027	0.1225	0.0020
PART TIME EMPLOYMENT	0.5031	0.0000	0.5103	0.0000	0.6038	0.0000
*Age 65+	0.1404	0.1289	0.2735	0.0000	0.1613	0.0114
*Low Income	-		-		0.0695	0.0589
*Single Parent	-0.2434	0.0501	0.0583	0.1908	-0.0132	0.4480
STUDENT	0.4504	0.0000	0.5034	0.0000	0.6485	0.0000
FREE PARKING @ WORK	0.0229	0.1973	0.0353	0.0001	0.3327	0.0000
Urban form						
POPULATION DENSITY	-0.0371	0.0068	-0.0051	0.0679	0.0075	0.0000

Table 5: Trip generation model with spatial expansion – Part 2

VARIABLE	ESTIMATE	p-value	ESTIMATE	p-value	ESTIMATE	p-value
Spatial expansion						
DISTANCE TO CBD	-0.1026	0.3778	0.5107	0.0001	-0.0319	0.3915
*Age 65+	1.6046	0.0093	1.7262	0.0000	-1.0575	0.0000
*Low Income	-		-		-0.4447	0.0496
*Single Parent	-4.2506	0.0046	-0.0178	0.4899	0.8440	0.0537
X^2	-0.5976	0.2045	-1.1389	0.0000	-0.2662	0.1218
*Age 65+	-5.2035	0.0022	-2.0566	0.0001	1.8154	0.0008
*Low Income	-		-		1.2671	0.0251
*Single Parent	8.5024	0.0357	-0.0980	0.4671	-1.6429	0.0929
X	0.1717	0.4303	0.7643	0.0003	0.2819	0.1915
*Age 65+	7.9063	0.0009	2.5445	0.0000	-2.2993	0.0026
*Low Income	-		-		-1.5161	0.0466
*Single Parent	-11.2438	0.0454	0.2258	0.4315	2.6506	0.0607
X*Y	1.4549	0.0746	1.0554	0.0000	0.0889	0.2556
*Age 65+	-5.6841	0.0188	-0.3161	0.3029	-0.0427	0.4553
*Low Income	-		-		0.2175	0.3032
*Single Parent	4.0066	0.2886	-0.4563	0.3631	-1.0699	0.0775
Y	-1.0050	0.1784	0.3457	0.0026	0.3829	0.0334
*Age 65+	13.0076	0.0000	0.2345	0.2326	-1.6203	0.0015
*Low Income	-		-		-0.3457	0.3026
*Single Parent	-14.9886	0.0349	0.0427	0.4754	0.8549	0.2365
Y^2	0.1709	0.4236	-1.5851	0.0000	-0.5217	0.0092
*Age 65+	-13.0737	0.0000	-1.7419	0.0054	1.7204	0.0011
*Low Income	-		-		0.6997	0.1525
*Single Parent	15.0783	0.0182	0.0678	0.4819	-1.4243	0.1251

Note: Shading indicates a coefficient that is not significantly different from zero with a 95% level of confidence

Mobility tools are also important in determining the levels of trip generation. Vehicle ownership and the availability of a driver license both have a clear positive effect on the trip making rate in all three cities. Furthermore, vehicle ownership has a much greater positive effect on the trip rate of seniors, indicating the mobility benefits of vehicles for seniors. Single parents also have an additional positive effect associated with vehicle ownership in Hamilton and Toronto, but the effect is not significant in Montreal. Low income individuals in Montreal, on the other hand, do not derive the same utility from owning a car, since the net effect on trip generation is very close to zero. Compared with vehicle ownership, the effect of having transit within 500 m is small. Moreover, the results are mixed, since this factor exerts a significant negative effect in Hamilton and Toronto, but a positive and significant one in Montreal. The net effect for the case of seniors is even more negative in Hamilton, and positive but very small in Toronto. In Montreal the results give evidence of significant positive effects of proximity to transit for seniors, low income people, but not for single parents, for whom being close to transit facilities, does not appear to increase their mobility. It is important to note that in the travel survey for Hamilton and Toronto, short trips by walk and bicycle to non-work/ non-school activities are not collected, which may account for some of this difference (since high transit areas are generally more “walkable” as well).

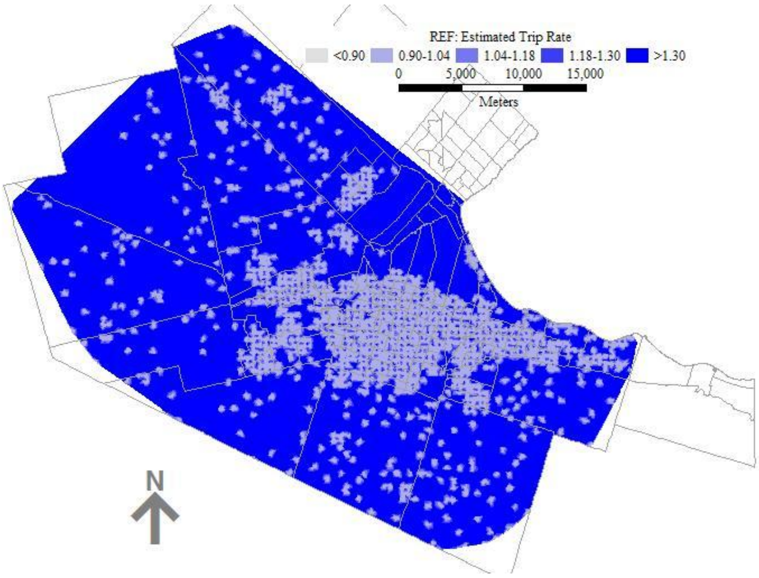
The effect of occupation (full time and part time employment, and student status) is to increase the propensity to make more trips (the reference class is not employed or unemployed individuals). Being employed full time does not increase the tendency towards more trips for seniors or low income people in Montreal, but it does for single parents in the three cities. Being employed part time tends to increase the number of trips only of seniors in Toronto and Montreal. Other coefficients associated with this variable are not significant.

Population density also has a significant impact, but interestingly, the impact is negative in Hamilton and Toronto, and positive in Montreal. In Toronto and Hamilton, this is likely due to two factors: a) there is in general a negative correlation between density and income in the Toronto Area, so the negative coefficient on population density may be a result of decreasing income in those areas, which is not captured in the model. Second, because short walk and bicycle trips to non-work non-school destinations are unreported in Hamilton and Toronto, the negative coefficient may reflect that higher density areas are more convenient for precisely these kinds of trips.

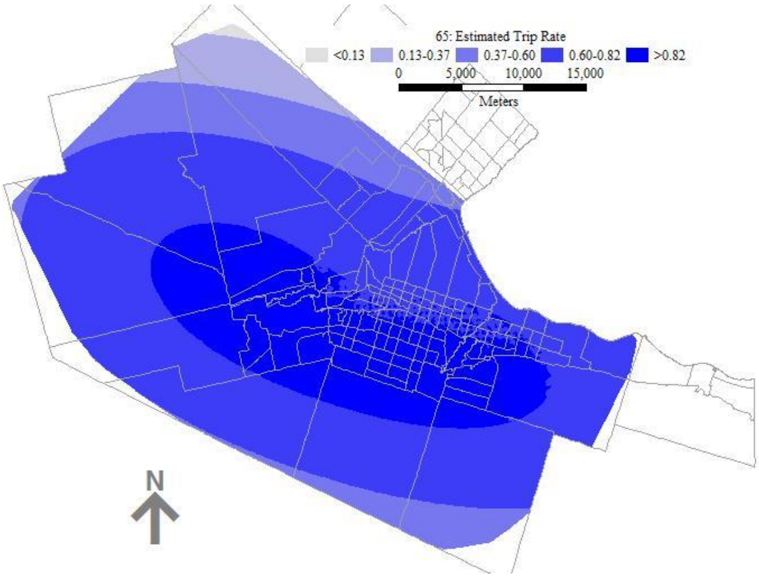
In order to better illustrate the effect of the expansion coefficients, trip rates are estimated as a composite of the number of trips in each trip making class, multiplied by the probability that an individual with a defined demographic and socio-economic profile at a given location will be in that class. The results provide some insights into the spatial variation of trip making behavior, which reveals that space indeed plays a role, but also that this role is specific to the city under examination, and to the population cohort of interest.

3.3.1 Hamilton

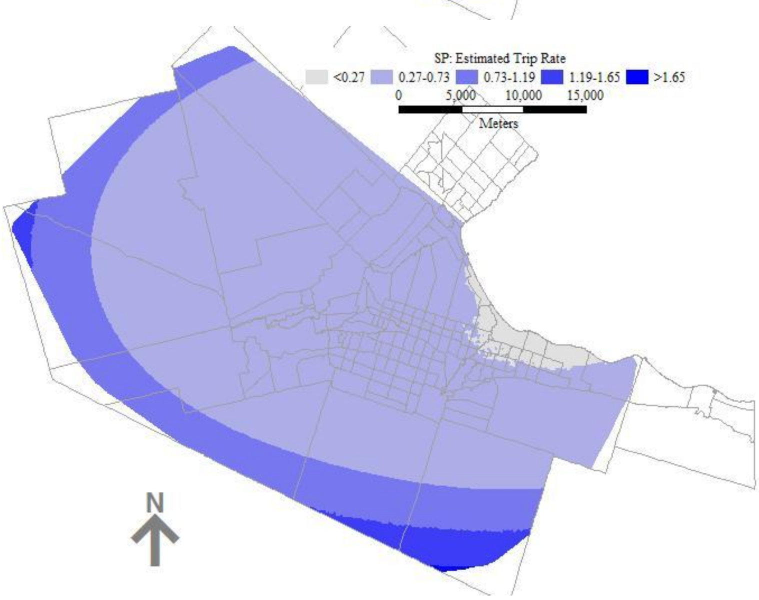
First, for the case of Hamilton, we note that none of the spatial variables for the reference group (Distance to CBD, X^2, X, XY, Y, and Y^2) are significant in the model. As a consequence, there is minimal spatial variability in the trip making behavior of this group, the only relevant spatial effect being that of density, which can be appreciated in reduced trip rates in downtown Hamilton (Figure 16). The spatial expansions for seniors and individuals in single parent households have significant components, indicating a degree of variability over space. In terms of the magnitude of the effect, there is less variability in the case of seniors. The trend surface indicates that the mobility of this group tends to be higher in the more central parts of the city, whereas the opposite is true of single parent households, who are less mobile in the central east end of the city. With regards to mobility tools, owning a vehicle has a positive and significant impact on trip making frequency. The effect is further enlarged for seniors, since this variable has an additional positive coefficient associated with it, just as single parent households do. As seen in Figure 17 the effect of auto ownership is to substantially increase the estimates of trip rates. In the case of single parent households, this also reveals more clearly a geographical pattern that to some extent coincides with a natural barrier formed by the Niagara escarpment. The effect of proximity to transit is negative, with an additional negative effect for seniors, but not significant for single parent households. These effects are barely noticeable in Figure 18, partly because the magnitude of the coefficients is very not large, but also because the effect of proximity to transit is geographically very localized by experimental design (within 500 m of a stop).



Reference

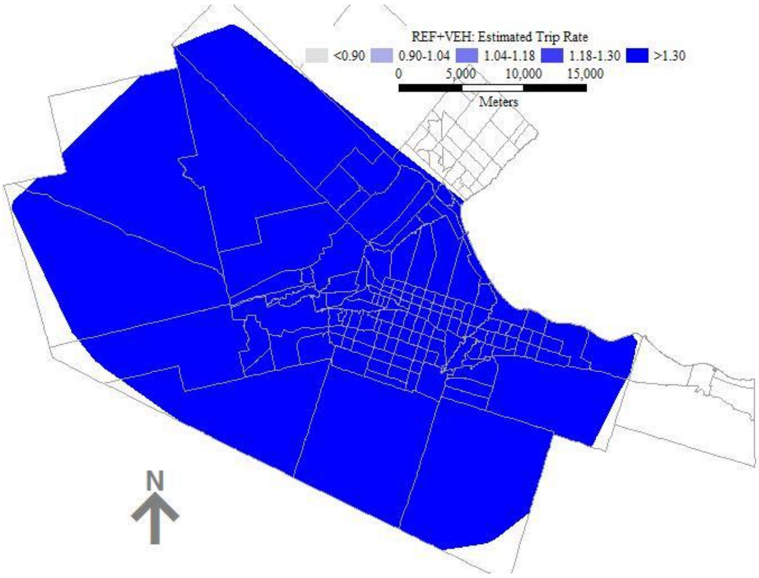


Age > 65



Single Parent

Figure 16: Estimated trip generation rates by population group in Hamilton



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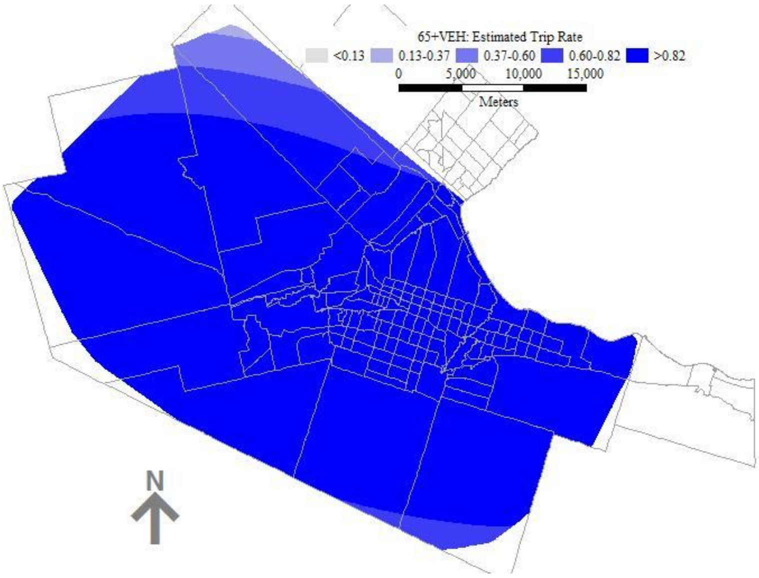
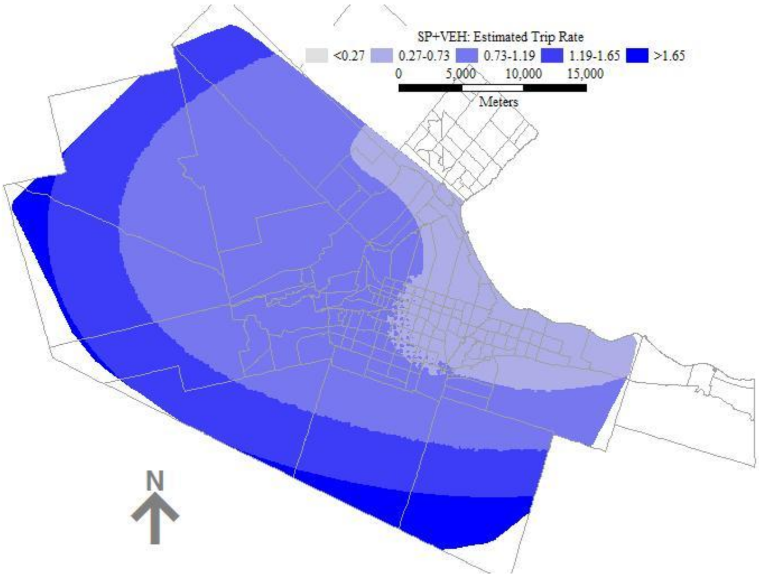
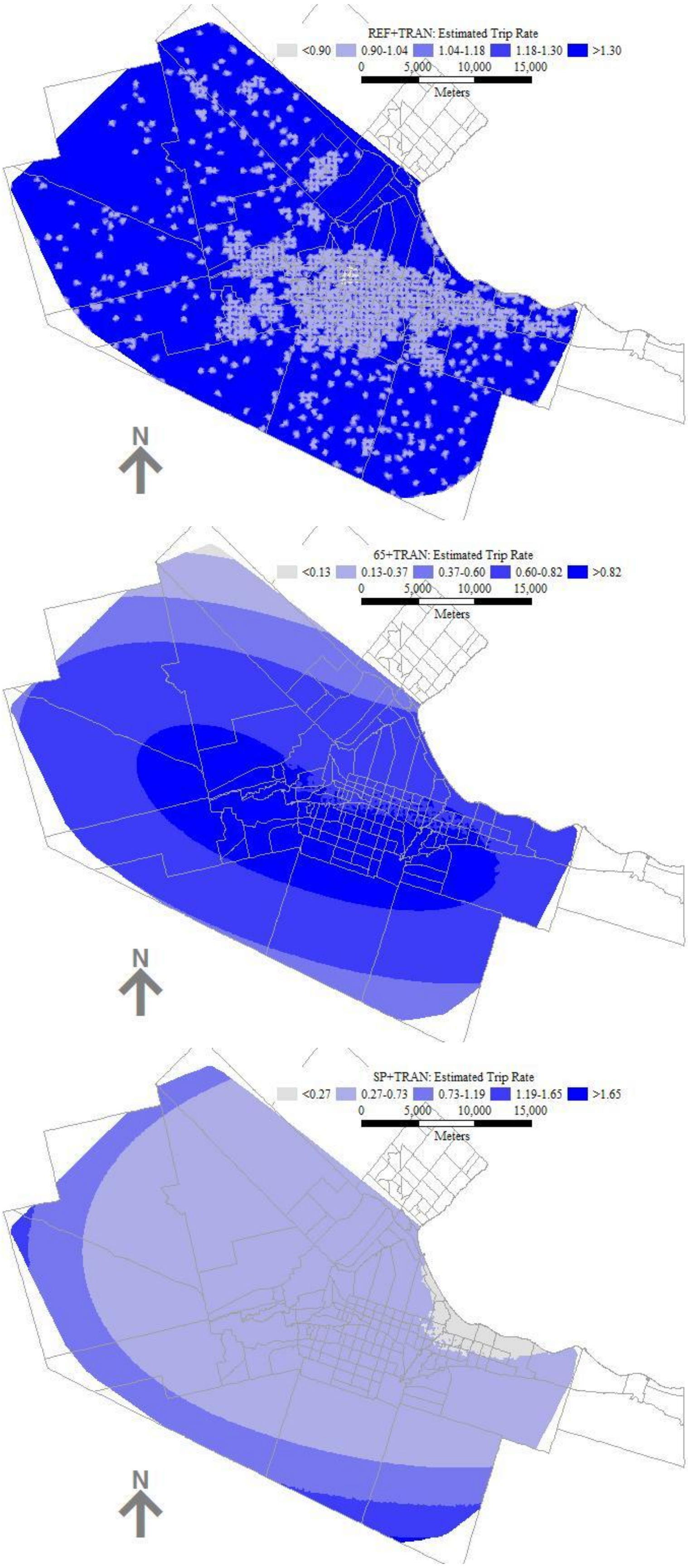


Age > 65



Single Parent

Figure 17: Estimated trip generation rates by population group in Hamilton, with auto-ownership effect



Reference

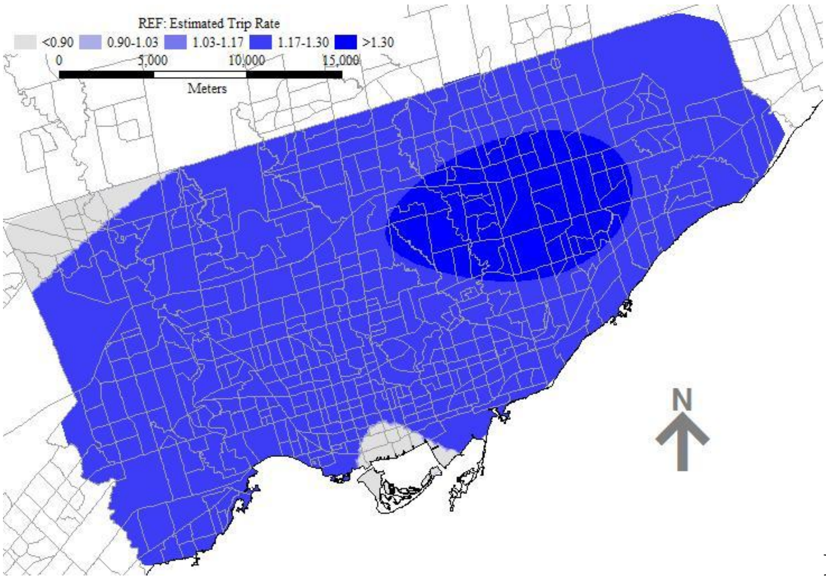
Age>65

Single Parent

Figure 18: Estimated trip generation rates by population group in Hamilton, with proximity to transit effect

3.3.2 Toronto

In Toronto, examination of the spatial coefficients also reveals important variations. First, in contrast to the City of Hamilton, the spatially expanded variables for the reference group are all statistically significant. As shown in Figure 19, it is possible to discern higher trip generation rates in the east part of the city, and lower levels downtown and in the northwest. While this may indicate, especially for the downtown area, a lower propensity towards trip making, it is important to keep in mind that as in the case of Hamilton, underreported non-work/school non-motorized trips may be to some extent responsible for this result. Lower rates in the northwest may also be related to the fact that some of the lowest income neighborhoods are located in that part of the city. Trip generation rates are substantially lower for seniors in Toronto compared the reference, and while the range of values is slightly more compact, there also appears to be more spatial variability. The overall trend is consistent with that observed for the reference group, with lower trip generation rates in the downtown area and the northwest part of the city. The expansion coefficients associated with single parent households, unlike those for the reference group and seniors, are all non-significant, and therefore there is no evidence of difference relative to the spatial pattern detected for the reference group. Furthermore, since both the direct effect for single parent in Toronto and the interaction with the transit variable, are also not significant, this suggests that the only difference in mobility patterns with respect to the reference is due to the extent to which individuals in single parent households benefit from vehicle ownership (significantly more than the reference group). Auto ownership in effect substantially increases the level of mobility of every demographic group (see Figure 20). The effect of transit is smaller compared to Hamilton, with a net decrease in the propensity to make more trips in the case of the reference, and a small positive contribution for seniors. As seen in Figure 21, this effect is geographically localized.



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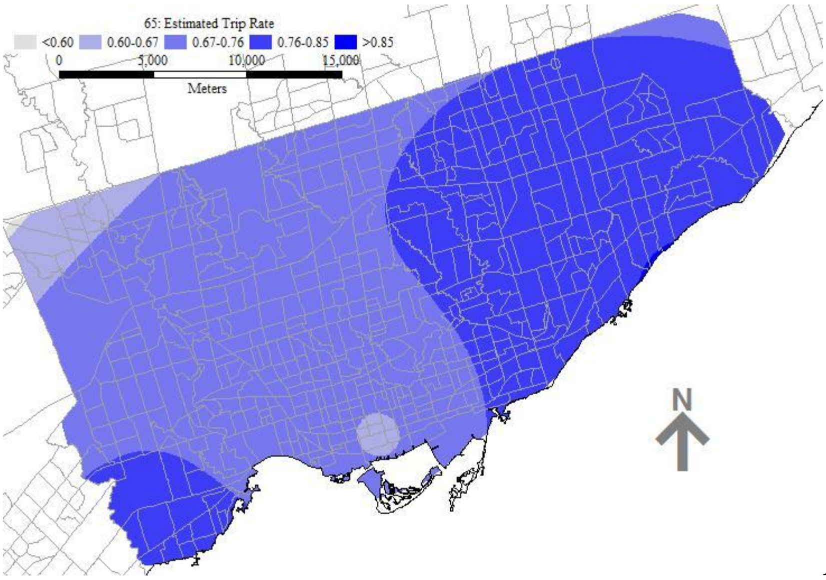
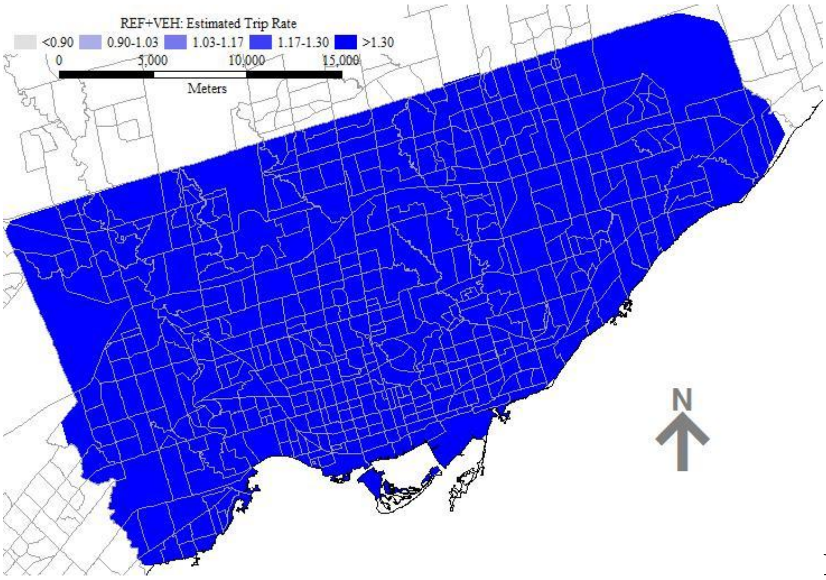
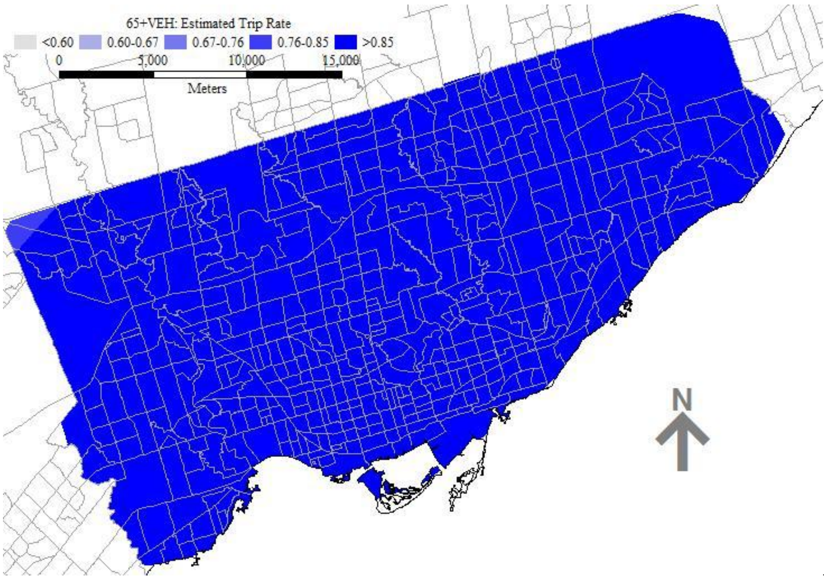


Age > 65

Figure 19: Estimated trip generation rates by population group in Toronto

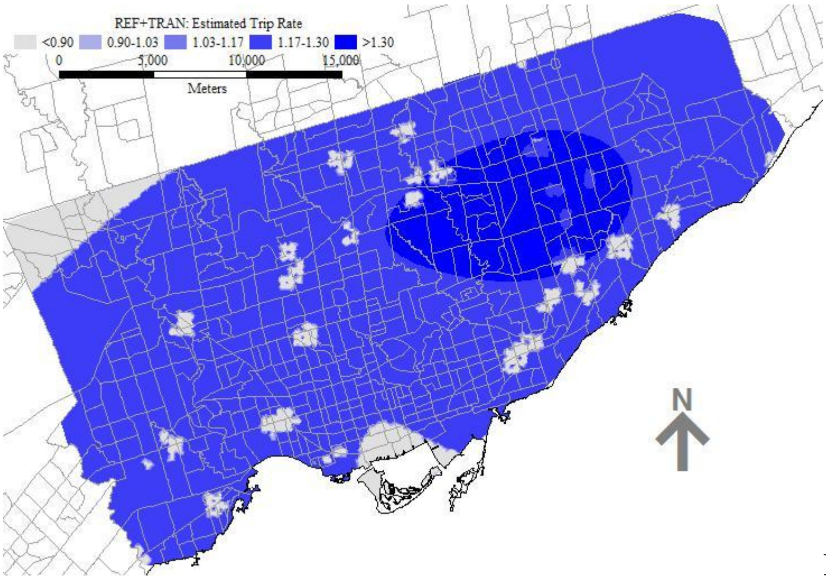


Reference

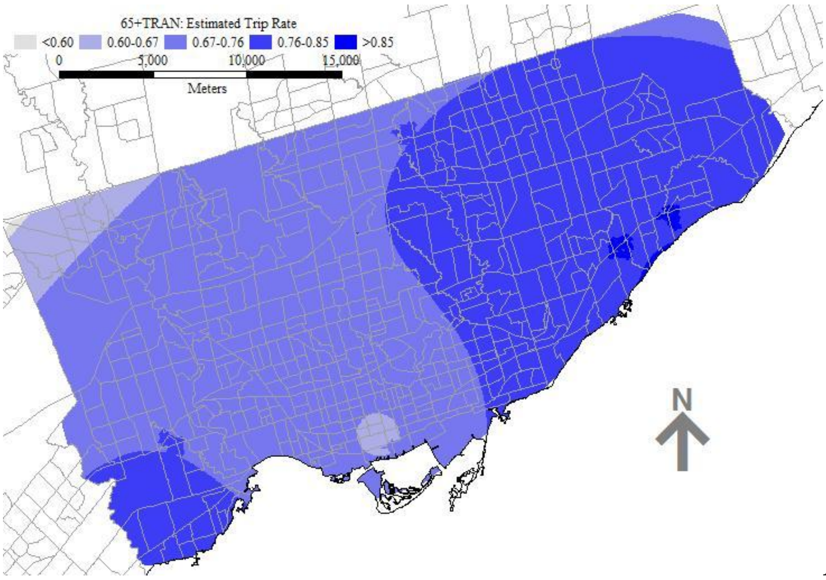


Age > 65

Figure 20: Estimated trip generation rates by population group in Toronto, with auto-ownership effect



Reference

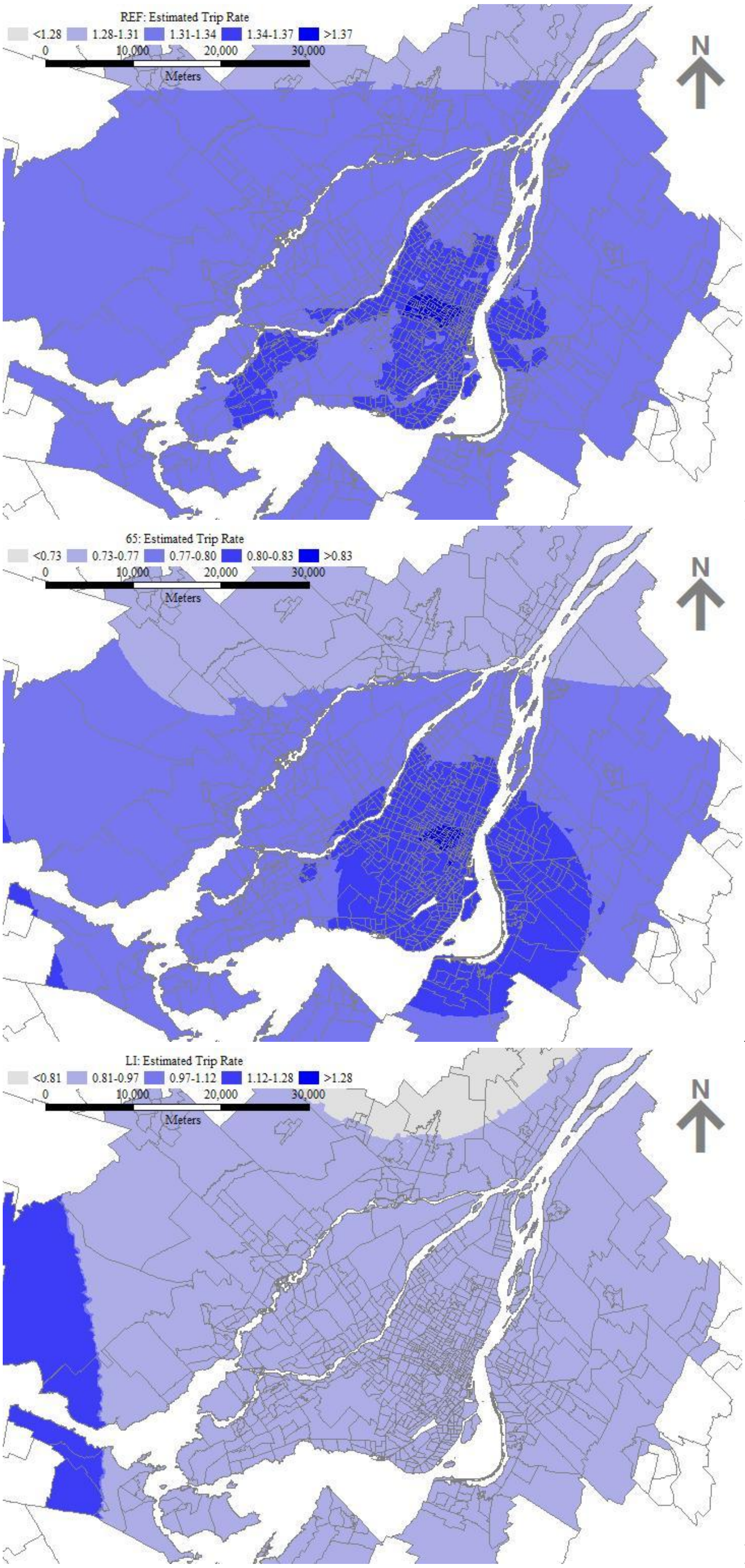


Age > 65

Figure 21: Estimated trip generation rates by population group in Toronto, with proximity to transit effect

3.3.3 Montreal

In Montreal, the spatial expansion coefficients for the reference group are only statistically significant in the north-south direction and show the levels of mobility for this group to decrease with distance from the centre of Montreal. A difference with the case of Toronto is that the density variable is significant, and exerts a positive effect on trip generation. The effect of density, combined with the significant components of the trend, produces the map shown in Figure 22. It can be seen there that there is definitely a trend, but the variation tends to be relatively small between the lowest trip generation rates and the largest. In general terms, the trend is very similar for seniors but for significantly lower levels of mobility. Also, within the corresponding range, there is a larger coverage of moderate to high trip generation rates. The most important deviations from the reference group in Montreal are for the low income population. The mobility of this population tends to decrease towards the north of the city, but to increase slightly towards the west. The range of values for low income individuals is the largest of the three population segments with significant spatial trends, but the spatial variation tends to be relatively small. As in the two previous cases, auto ownership (Figure 23) has a positive effect on mobility levels. This positive impact is smaller for the reference group compared to the effects observed for Toronto and Hamilton, but for seniors is of similar magnitude. Interestingly, the interaction effect for auto ownership and low income is negative, and the net effect of auto ownership for this group is negative but almost zero. Transit in Montreal has a positive effect that is nonetheless geographically circumscribed (Figure 24). In Montreal, no coefficients (direct or expansion) associated with single family households are found to be significant, so the mobility surface is virtually the same as for the reference group.

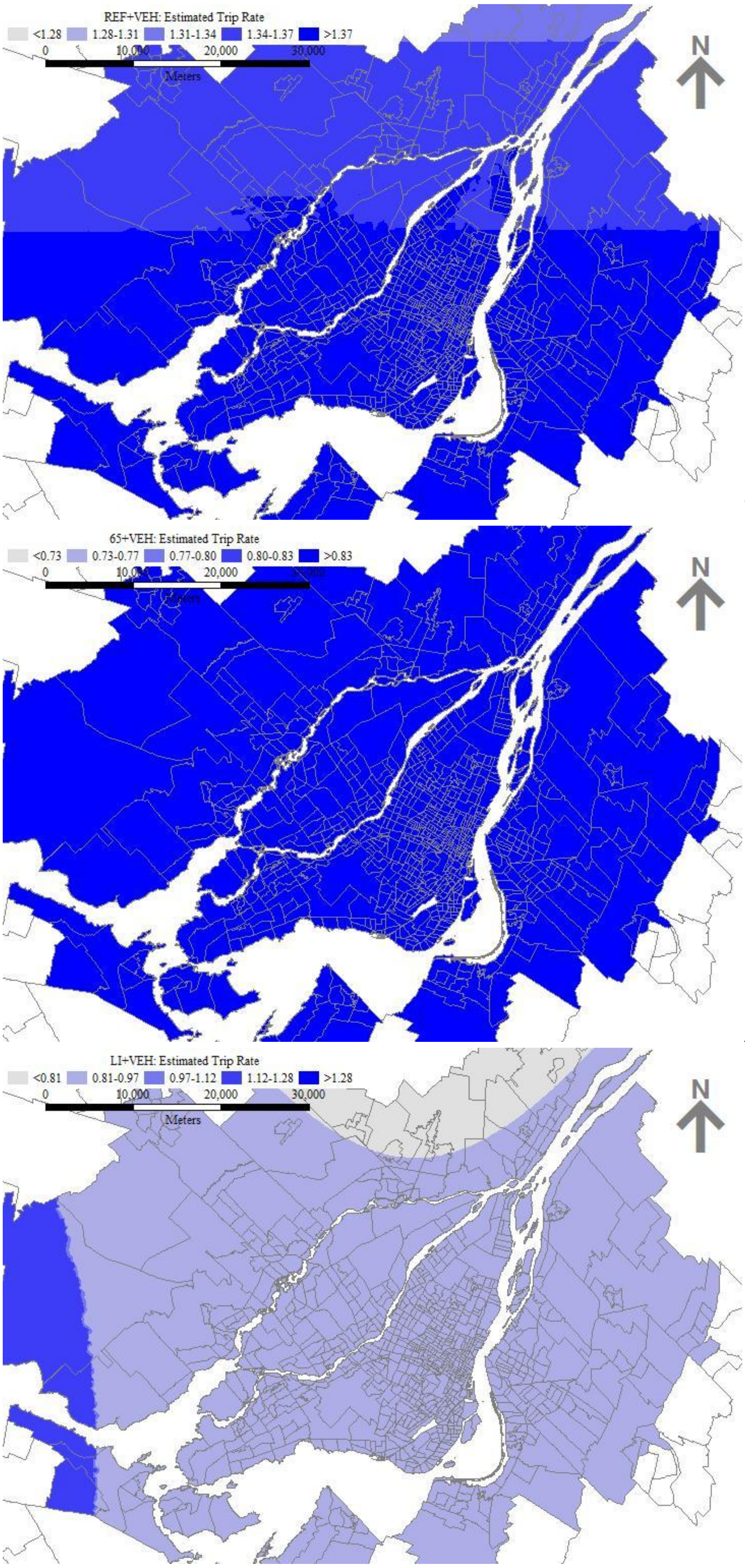


Reference

Age > 65

Low Income

Figure 22: Estimated trip generation rates by population group in Montreal

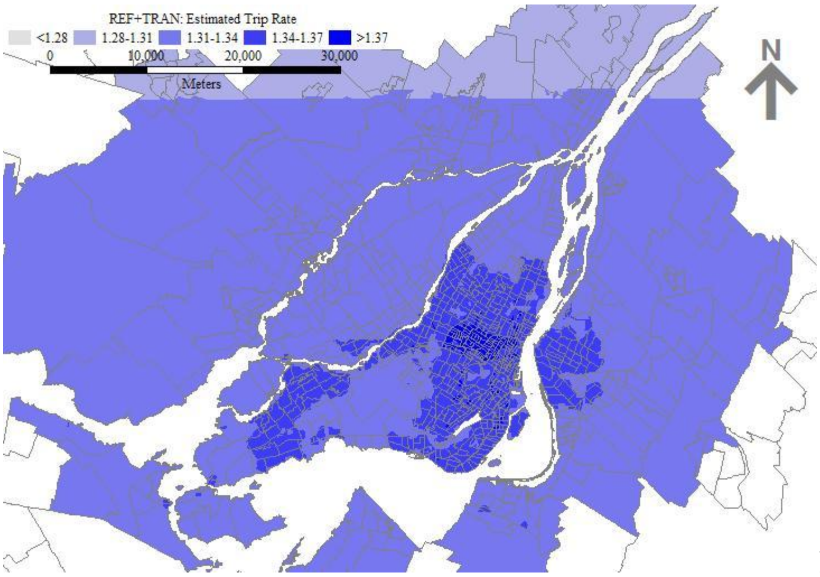


Reference

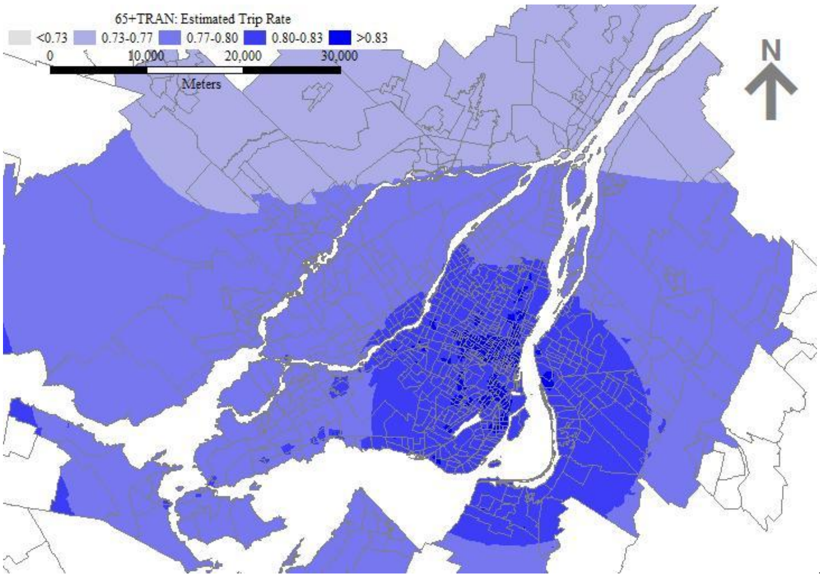
Age > 65

Low Income

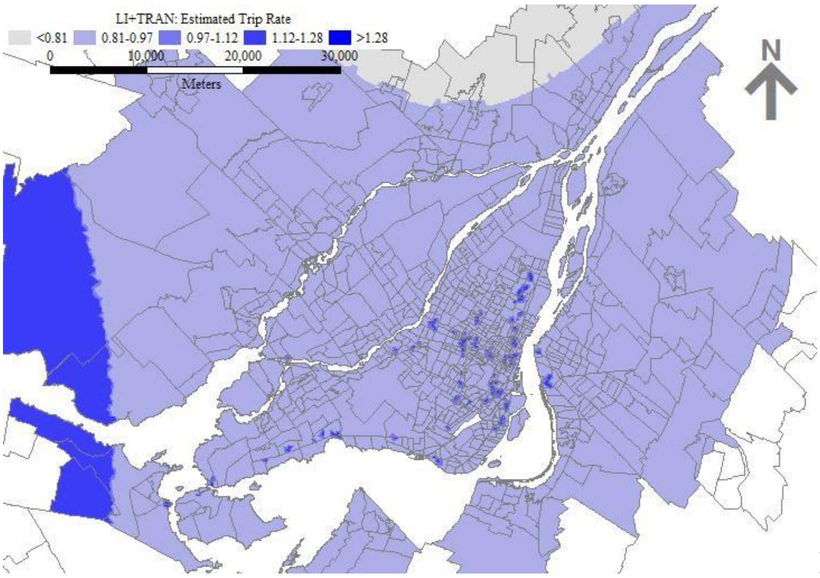
Figure 23: Estimated trip generation rates by population group in Montreal, with auto-ownership effect



Reference



Age > 65



Low Income

Figure 24: Estimated trip generation rates by population group in Montreal, with proximity to transit effect

3.4 Conclusions

The combination of an ordered probit approach with spatially expanded coefficients provides evidence of the inherent spatial nature of travel behavior. It allows for a convenient visualization of differences in mobility over space for different population groups, after other socio-economic characteristics have been taken into account. The analysis in this section has involved the assessment of mobility rates (as measured with trip generation) for seniors, single parents, and low income households as they compare to the reference population (non-senior, non single-parent, non-low-income). Trip generation is seen as an indicator of out-of-home activity participation. Conversely, lack of trips can be indicative of social exclusionary processes.

The key observations from the ordered probit model are summarized as follows:

- Trip generation tends to increase with increasing income (in Montreal), and also with vehicle ownership, ownership of a driver license, employment, being a student, having free parking at work, and living in a single-person household. Trip generation is negatively correlated with age and being part of a “couple” household. Population density shows mixed results for the different cities, as does proximity to transit.
- The trip generation of seniors (65+) is more influenced by vehicle ownership than the rest of the population. The effects of transit proximity and employment are also generally greater for the senior population, but these effects are less pronounced than for auto ownership.
- For single parents, vehicle ownership and full time employment have a more important effect than for the reference population, but not for transit access.
- Trip generation rates of low income individuals are less influenced by vehicle ownership and more influenced by transit proximity than are the rest of the population.

Use of the spatial expansion also facilitates drawing conclusions about the spatial trends in mobility after socioeconomic variables are accounted for. One important observation is that there are important variations in the geographical effects measured for each city, and therefore the conclusions are specific to each case study. Since the trends discussed are demonstrated to be statistically significant, this highlights the importance of locally contextualizing the analysis.

- For Hamilton, mobility for seniors decreases in the suburban areas, away from key transit corridors, while single parent families experience an opposite trend in mobility, with greater mobility levels away from the CBD.
- For Toronto, differences in mobility occur, especially for seniors, from east to west, with the lowest levels of mobility occurring in the northwest of the city, a low income area. Single parent families do not exhibit any geographic differences from the rest of the population.
- For Montreal, the most important differences in mobility for the reference population occur along the north-south axis of the city, the mobility of seniors decreases with distance from the central core, no geographic differences are found in the population

of single parent families, and low income families experience greater mobility than the reference population to the east and west but lower mobility in the north and south of the downtown.

These spatial variations in trip generation provide important clues about the parts of the analyzed cities where vulnerable populations may experience greater degrees of social exclusion. They also provide an opportunity to help prioritize transportation infrastructure projects or other social programs to take into account the needs of vulnerable populations with the lowest levels of mobility. The results indicate that all three vulnerable groups have lower mobility levels compared to the norm, that is, the travel behavior of the reference, although this is not the case in every city studied. In particular, there is a need to further investigate the mobility and social exclusion conditions of low income and senior individuals. In terms of mobility, investigations of the conditions of seniors need to be prioritized in the North West of the City of Toronto, and the suburbs of Hamilton and Montreal. In contrast, no strong evidence is found regarding single parent families in terms of low levels of mobility.

CHAPTER 4 Spaces of Daily Life: Average Distance Traveled in Hamilton, Toronto and Montreal

Summary:

- **Distance traveled** is an indicator of **mobility** that provides a **summary measure** of **how far** individuals are **willing** or **able** to go during the course of their day.
- Distance traveled can be related to the **activity spaces** of individuals, and thus provides an indication of potentially **reachable locations** as people move about their environment.
- Whereas trip generation is a **necessary condition** for **accessibility**, **distance traveled** directly **determines accessibility**.
- Distance traveled is modeled using a combination of multivariate **linear regression**, and **spatially expanded** coefficients.
- **Estimates** of distance traveled are retrieved that represent travel behavior trends for different **population groups** at various **locations**.
- In general, three **vulnerable groups** display a tendency towards traveling **shorter distances**. In turn, this is indicative of **reduced** activity **spaces**.
- In particular, seniors tend to travel shorter distances compared to other age groups in Hamilton and Montreal.
- In **Toronto** and **Montreal**, **single parent** household members have the **smallest** activity spaces. In **Hamilton**, **seniors** do.
- **Vehicle ownership** once again is associated with significant **mobility gains**, the **exception** being **seniors** in **Toronto** and **Hamilton**.
- The effect of **transit** is ambiguous, relatively small, and localized.
- Significant **geographical variations** in the estimates of distance traveled exist. In general, these estimates are consistently **lower** near **cities centers** and **increase** in the direction of the **suburbs**.

4.1 Background and Objectives

The second aspect of mobility investigated in this report is distance traveled. As previously noted, accessibility is not defined for individuals who do not engage in trip making. For those who do travel, accessibility is defined at the intersection between travel (realized or potential) and the distribution of opportunities across space. In particular, we think of distance traveled as a proxy for activity spaces, a concept that has previously been linked to social exclusion issues (e.g. Schönfelder and Axhausen, 2003). More mobile individuals who travel longer distances can reach farther destinations, and potentially a greater number of them. In contrast, individuals who travel only short distances will be more limited in the range of destinations they can reach, other things being equal. Distance traveled provides a powerful tool to enhance our understanding of activity-related travel behavior and space consumption. More concretely, it provides an indication of the price, in terms of travel activities, that people are willing or able to pay to reach various locations. Along the lines of the analysis reported in Chapter 3, in this section we strive to maintain the focus on general levels of mobility, therefore analyze distance traveled for all purposes and all travel modes during a day. In operational terms, mean distance traveled is defined as the ratio between total distance traveled daily by an individual person, divided by the total number of trips made on the same day (not counting for these calculations the return-home trip). This measure gives an indication of typical trip length centered on the place of residence, and an all-purpose indicator of the spaces of daily life. Analysis is based on data from the three Canadian urban areas previously described, which allows for in-depth comparative analysis of distance traveled by various population groups within and between areas. As before, particular attention is given to three population segments thought to be at risk of facing mobility challenges. Thus, in this application, low income households, single parents, and seniors are singled out for analysis. Schematically, within the context of our operational framework, distance traveled provides a direct link to accessibility, as illustrated in Figure 25 below.

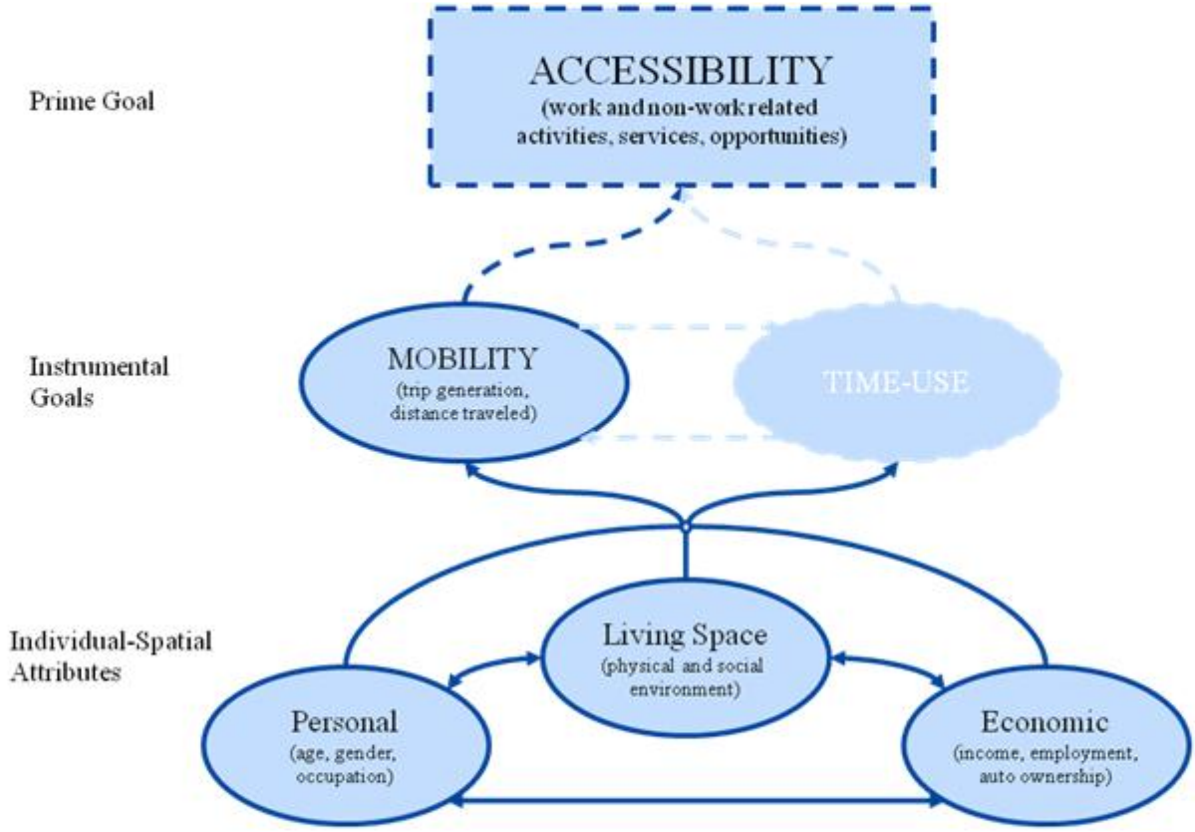


Figure 25: Conceptual framework: Mean distance traveled

The starting point for the investigation of distance traveled reported in this chapter is previous international research into the topic. A number of authors have considered distance traveled, and the effect of various demographic and socio-economic conditions of interest. Khattak et al. (2000), for instance, examine the commuting patterns of low-income individuals, and find that, among people who work, residents of low-income urban neighborhoods commute longer and farther than residents of low-income suburban neighborhoods. Casas (2007), on the other hand, showed that being young, coming from a small household, possessing a driver's license, having a steady job, living in an urban setting, increases the number of opportunities available. There has also been research reported for the Canadian context. Morency and Kestens (2007), for example, used travel survey data from the Montreal Area in recent research to observe how activity spaces of various population segments have evolved over a 5 years period (1998-2003). Using measures such as number of different places visited and scale of convex hull of activity locations, they observed that while the *size* of activity spaces has increased, the number of different locations visited during a typical day has tended to decline. This is consistent with time budget constraints: as people travel longer to reach various destinations, the time available to realize each becomes more limited. With respect to population segments, the study revealed that some population segments have wider activity spaces than others, namely people living further from the central parts of the city, males, people who own a car, and workers. Lack of access to a private vehicle in particular was noted to be the most important constraint to the size of activity spaces. Mercado and Páez (2008) report research for Hamilton that is concerned with the determinants of distance traveled with a particular focus on seniors, and the different modalities of travel. The results give evidence of a significant loss of mobility for seniors who use their private vehicles, and thus highlight the paradoxical situation of those who depend on a mode to maintain only very modest levels of mobility. The results regarding seniors are important since this population segment will become increasingly important in many societies including Canada. Access to different modes of transportation has in fact been identified as a key factor in affecting the mobility of seniors and, consequently, their quality of life (Banister and Bowling, 2004; Metz, 2004; Metz, 2003; Tacken, 1998). Finally, there has been research on gender and commuting distance (e.g. Turner and Niemeier, 1997), however, single parent households do not appear to have been the focus of previous research.

4.2 Methods

Trip distance is analyzed using a multivariate linear regression approach that is enhanced by means of spatially expanded coefficients (Casetti, 1972). Linear regression is a standard tool for modeling continuous variables such as distance. The outcome variable (mean trip distance) is transformed using a logarithmic function, to ensure that predicted values are positive for all values of the explanatory variables. As previously noted, the expansion method is characterized by its ability to produce spatially-varying coefficients, which help to contextualize, based on location, the relationship between different explanatory factors and distance traveled. Further details on the modeling methodology can be found in Appendices B and C. Selection of variables for the analysis is informed by the conceptual framework and previous literature on the topic. In particular, we include personal, living space, and economic factors to bear on the problem of trying to understand the determinants of distance traveled.

4.3 Results

The results of estimating regression models for distance traveled are presented in Table 6 and

Table 7 for the three case studies. The goodness of fit of the models is conventionally assessed using the coefficient of determination, or R^2 statistic. This statistic, which ranges between 0.16 and 0.22 in the set of models reported, is interpreted as the proportion of the variance that is explained by the model. In other words, around 20% of the variability contained in the data is being captured by the models. In order to account for the complexity of the model, the coefficient of determination can be adjusted by introducing a penalty that depends on number of variables used relative to size of the sample. The results are virtually identical in this case due to the large size of the samples used for the analysis. For comparison purposes, the selection of variables entering each of the models is preserved between cities, the only exception being income, a variable not available in the survey conducted for Toronto and Hamilton.

Regarding the interpretation of the models, in linear regression a coefficient is usually understood to represent the change in the dependent variable associated with a unit change of the corresponding explanatory variable. When the independent variable has been transformed using the natural logarithmic function, as in the present case, this interpretation no longer holds, and instead, the coefficients, when multiplied by 100, indicate the percentage change associated with a unit change in the explanatory variables. Consider for example the model for Montreal. In this city, being younger than 20 years old is associated with a 42% decrease in distance traveled, with respect to the reference age cohort. Couples with children tend to make trips that are 12% shorter compared to those of singles, and vehicle ownership confers almost a 17% increase in distance traveled. The results of the models can easily be converted back to the same metric of the dependent variable, to better understand the impact of various factors on distance traveled. This is done by selecting the coefficients that describe a desired individual profile, and introducing the corresponding variables in the calculation. Since most variables are dummies that take the value of 1 or 0, depending on whether an individual belongs to a given class or not, the effect for the most part is to switch on and off various combinations of coefficients. For instance, consider the profile of an individual in Montreal who is 36-50 years, with a household income of between 40 to 60 thousand dollars, and single. This person owns a vehicle, is in possession of a drivers license, and is employed full time. In addition, the individual lives exactly at the downtown location (in normalized coordinates X=0.64 and Y=0.43) where the density of population is about 3.8163 thousand people per square km. The estimate of distance traveled for a person fitting this profile would be calculated in the following way:

$$\begin{aligned}\log\left(\hat{d}\right) = {} & b_{CONST} \\ & + b_{INC_{40-60k}} INC_{40-60k} + b_{VEH} VEH + b_{DLIC} DLIC + b_{FTE} FTE \\ & + b_{PopDen} PopDen + b_{X^2} X^2 + b_X X + b_{XY} XY + b_Y Y + b_{Y^2} Y^2\end{aligned} \tag{1}$$

Accordingly:

$$\hat{d} = e^{-2.1166-0.1889+0.3061+0.1699+0.5701-0.28 PopDen-4.1085 X^2+5.6710 X-0.4131 XY+4.8965 Y-5.4665 Y^2} \tag{2}$$

which gives a value of the average trip length $\hat{d}$ for this profile equal to 1.8216 km. This profile can be evaluated at other locations in the region, or other socio-economic and demographic profiles could be explored. Note however, that without the spatially expanded coefficients, the estimates for distance traveled would be constant throughout the region.

Table 6: Average daily distance traveled models with spatial expansion – Part 1

	HAMILTON		TORONTO		MONTREAL	
R^2	0.226		0.163		0.199	
R^2_{adj}	0.225		0.163		0.198	
s^2	0.975		0.788		1.208	
S	0.988		0.888		1.099	
N	17956		97724		122420	
VARIABLE	ESTIMATE	p-value	ESTIMATE	p-value	ESTIMATE	p-value
CONSTANT	2.6499	0.0000	-0.1221	0.0292	-2.1166	0.0000
Age						
AGE < 20	-0.3900	0.0000	-0.5361	0.0000	-0.4165	0.0000
AGE 20-35	0.1126	0.0000	0.0623	0.0000	0.0520	0.0000
AGE 36-50	Reference		Reference		Reference	
AGE 51-64	-0.0215	0.1916	-0.0183	0.0255	-0.0217	0.0144
AGE 65+	0.3103	0.4095	0.7874	0.0000	0.6027	0.0529
Income						
INC. REFUSE/DON'T KNOW	-		-		-0.1730	0.0000
INCOME < 20K	-		-		-0.9787	0.0080
INCOME 20-40K	-		-		-0.2513	0.0000
INCOME 40-60K	-		-		-0.1889	0.0000
INCOME 60-80K	-		-		-0.1072	0.0000
INCOME 80-100K	-		-		-0.0571	0.0001
INCOME > 100K	-		-		Reference	
Household structure						
SINGLE	Reference		Reference		Reference	
COUPLE	0.1214	0.0000	0.0227	0.0209	0.0105	0.1809
COUPLE W/CHILDREN	-0.0253	0.2165	-0.1254	0.0000	-0.1236	0.0000
SINGLE PARENT	-1.3794	0.3380	1.4052	0.0000	0.3073	0.3242
OTHER	0.0823	0.0034	-0.0028	0.3973	0.0429	0.0002
Mobility tools						
DRIVER LICENSE	0.2454	0.0000	0.1530	0.0000	0.3061	0.0000
VEHICLE OWN	0.2192	0.0000	0.1124	0.0000	0.1699	0.0000
*Age 65+	-0.2089	0.0045	-0.1715	0.0000	-0.0036	0.4556
*Low Income	-		-		0.0159	0.2766
*Single Parent	-0.1264	0.1460	-0.0235	0.2642	-0.0410	0.2030
TRANSIT WITHIN 500m	0.1279	0.0473	0.0759	0.0000	-0.0826	0.0001
*Age 65+	-0.2033	0.1539	-0.0300	0.2688	-0.1679	0.0043
*Low Income	-		-		0.0925	0.0329
*Single Parent	-0.2727	0.2764	-0.2031	0.0055	-0.1284	0.1488
Occupation						
FULL TIME EMPLOYMENT	0.4811	0.0000	0.4171	0.0000	0.5701	0.0000
*Age 65+	-0.1086	0.1386	0.0005	0.4949	-0.0953	0.0262
*Low Income	-		-		-0.0602	0.0106
*Single Parent	-0.2521	0.0067	-0.1384	0.0001	0.0073	0.4278
PART TIME EMPLOYMENT	0.0493	0.0720	0.1382	0.0000	0.1674	0.0000
*Age 65+	0.1153	0.1633	0.2084	0.0000	0.0605	0.1878
*Low Income	-		-		0.1443	0.0006
*Single Parent	0.0933	0.2559	-0.0793	0.0737	0.0701	0.2369
STUDENT	0.0216	0.2487	0.1350	0.0000	0.5323	0.0000
FREE PARKING @ WORK	0.0756	0.0010	0.0415	0.0000	0.2271	0.0000
Urban form						
POPULATION DENSITY	-0.1221	0.0000	0.0194	0.0000	-0.0218	0.0000

Table 7: Average daily distance traveled models with spatial expansion – Part 2

VARIABLE	ESTIMATE	p-value	ESTIMATE	p-value	ESTIMATE	p-value
Spatial expansion						
DISTANCE TO CBD	1.4918	0.0000	3.4377	0.0000	4.3285	0.0000
*Age 65+	-1.0782	0.0754	-1.6443	0.0000	-0.5318	0.0334
*Low Income	-		-		-0.2927	0.1597
*Single Parent	0.3736	0.4129	-2.4148	0.0000	-1.3899	0.0024
X^2	1.2656	0.0314	-2.7723	0.0000	-4.1085	0.0000
*Age 65+	1.8929	0.1762	1.6982	0.0010	0.6009	0.1901
*Low Income	-		-		-2.7450	0.0000
*Single Parent	-2.2517	0.3378	3.1221	0.0007	2.1477	0.0336
X	-2.3984	0.0045	3.0780	0.0000	5.6710	0.0000
*Age 65+	-0.9046	0.3735	-1.9188	0.0008	-1.0814	0.1337
*Low Income	-		-		3.3953	0.0003
*Single Parent	5.8885	0.1979	-3.7150	0.0003	-3.7316	0.0105
X*Y	1.6096	0.0428	0.0705	0.3576	-0.4131	0.0009
*Age 65+	-5.8755	0.0239	-0.0150	0.4904	0.1262	0.3903
*Low Income	-		-		-0.4074	0.1887
*Single Parent	-6.0797	0.1983	0.8014	0.2246	1.5921	0.0119
Y	-4.3339	0.0000	0.1954	0.0276	4.8965	0.0000
*Age 65+	2.9260	0.1735	-0.2562	0.2181	-1.2045	0.0298
*Low Income	-		-		0.0420	0.4768
*Single Parent	-3.1464	0.3430	-1.4785	0.0043	-0.8996	0.2096
Y^2	4.3759	0.0000	-2.9179	0.0000	-5.4665	0.0000
*Age 65+	0.0473	0.4928	1.8066	0.0051	1.2649	0.0285
*Low Income	-		-		-0.3942	0.2974
*Single Parent	8.2742	0.1082	3.4292	0.0025	1.7897	0.0611

Note: Shading indicates a coefficient that is not significantly different from zero with a 95% level of confidence

The first class of variables in the model corresponds to the age of the respondent. These coefficients correspond for the most part to significant determinants of distance traveled, with the exception of the coefficients associated with the pre-retirement (51-64) and senior populations in Hamilton. Distance traveled peaks at age 20 to 35. Besides that, the estimates are lower for individuals who are younger than 20 years old, and also tend to decrease with increasing age after the peak, although this can only be appreciated for seniors once the expanded coefficients are considered. In Montreal, lower income is associated with lower estimates of distance. Individuals in the second highest income group (80 to 100 thousand) for example have an estimate value of distance traveled that is about 5% smaller compared to the top income class. The difference is -25% for the 20 to 40 thousand class. The lowest income class also tends to make shorter trips on average, as becomes clear when the coefficients are mapped. The composition of the household also has some impact on distance traveled, although the results are less clear cut. Not a single household type is associated with a significant coefficient for all three cities. In those cases where the coefficients are significant, the signs tend to agree. For instance, couples tend to travel longer compared to the reference in Hamilton and Toronto, but not in Montreal, where the difference between the two groups is not significant. Couples with children make shorter trips on average in Toronto and Montreal. Individuals in other types of multi-person (non-family) dwellings, who displayed a tendency towards less frequent trip making in the three cities, tend to travel longer distances in Hamilton and Montreal. The effect of living in a single parent household can only be assessed once the spatial trend has been calculated. It can be noted, though, that in Hamilton there are no differences between this group and the reference, neither in terms of geographical trends nor in the effect of mobility tools. For all purposes this group in Hamilton is indistinguishable from the reference.

Being in possession of a drivers license and vehicle ownership are two factors that associate positively with distance traveled. In the case of Montreal, the effect of auto ownership applies to the general population, and there are not differential effects from the perspective of the vulnerable population segments. In the case of Hamilton and Toronto, the net effect of vehicle ownership for seniors is either very small (a 1% net increment in distance traveled in Hamilton) or even negative (a 6% decrease in Toronto), a result that stands in contrast to the effect of owning a vehicle on the generation of trips (see Chapter 3, Section 3.3). Thus, while a vehicle may increase the frequency of trip making for seniors, it does not seem to help them to achieve larger activity spaces. The situation is similar for the case of single parent households, a population segment for which car ownership tends to increase the frequency of trip making in Hamilton and Toronto. In the case of distance traveled however, single parents do not appear to derive additional benefits from vehicle ownership in any of the three cities studied. Proximity to transit nodes associates positively with distance traveled in Hamilton and Toronto, but negatively in Montreal. The net effect for single parent households in Toronto, however, is a reduction of about 13% in distance traveled with respect to the reference group. Neither group is different from the reference in this respect in the case of Hamilton. In Montreal, in contrast, proximity to transit tends to further reduce the distance traveled of seniors, while the net effect is a small 1% increment in distance traveled in the case of low income individuals.

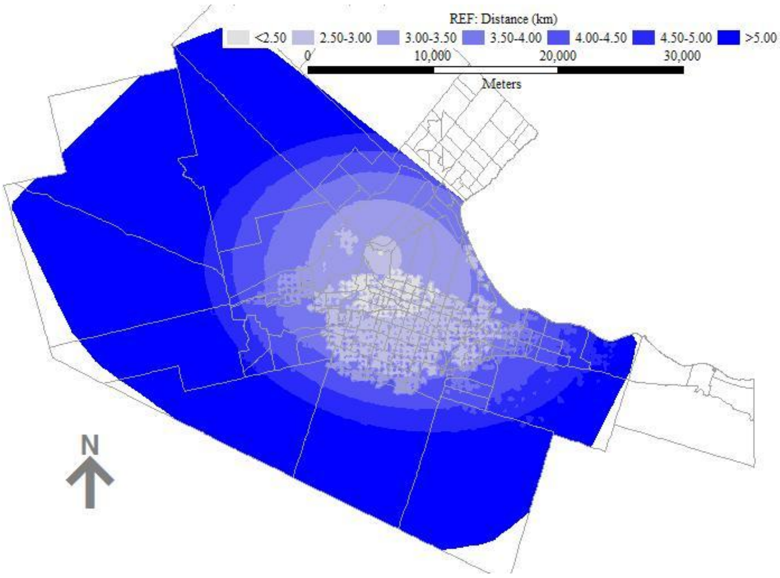
Being employed full-time associates with significant and substantial increases in distance traveled of between 41% (Toronto) and 57% (Montreal). Likewise, part-time employment tends to increase distance traveled, but not to the same extent, as the increments are only between 5% (Hamilton) and 17% (Montreal). Seniors and low income people who are full-time employed tend to travel shorter distances in Montreal. Single parents who are employed full time have smaller net increases in Hamilton and Toronto, but not in Montreal where the effect is not significant. In the case of part-time employment, the only segment that displays different behavior is seniors in Hamilton, who tend to travel even longer distances than individuals in the reference group who are also employed part-time.

The effect of population density is mixed across cities, as it tends to increase distance traveled in Toronto, but to decrease it in Hamilton and Montreal.

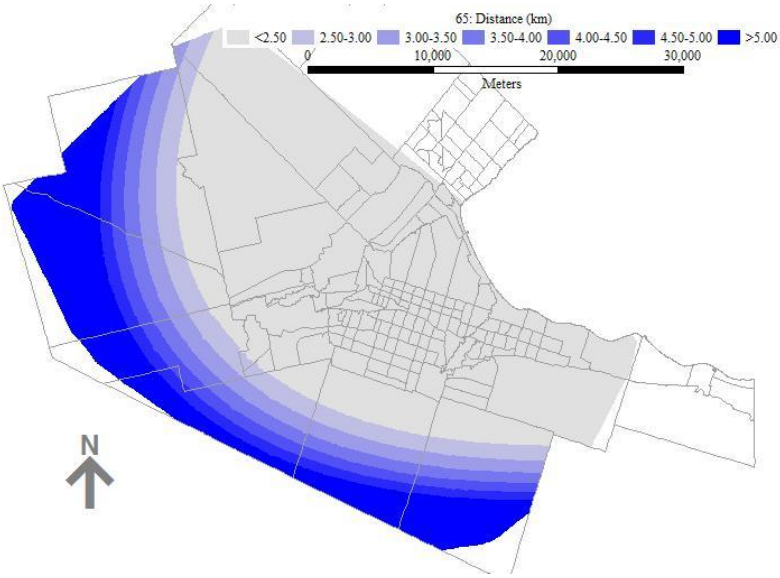
As previously described, spatially expanded coefficients can be used to obtain estimates of distance traveled that are specific to an individual with a selected socio-economic and demographic profile, and a specific location in space. Mapping these results provides valuable insights regarding the spatial variation of distance traveled behaviors, and graphically demonstrates the differences between locations and population cohorts of interest. Discussions of the results for each case study are provided. For each area, maps of estimated distance traveled are presented for the reference group, seniors and single parents, by access to mobility tools (vehicle ownership and proximity to transit nodes). When producing these maps only coefficients with a 5% level of statistical significance or better are employed.

3.3.1 Hamilton

For the case of Hamilton, the spatial trend variables have significant components for the reference group and seniors, but not for single parent households, which are not statistically different from the reference. Estimates of distance traveled are significantly and substantially lower for seniors all across the city, as the maps in Figure 26 show. In terms of the magnitude of the effect, there is somewhat less spatial variability in the travel behavior of seniors. The trend for this population group indicates that the average trip distance is less than 2.5 km within an approximate 10 kilometers radius from center of the city. Distance traveled tends to increase in the direction of the suburbs. The reference population shows a very similar pattern, with distance traveled generally increasing away from the central part of the region. This trend combines with more variability, in particular in the southern part of the region. With regards to mobility tools, owing a vehicle has a positive and significant impact on average trip distance for the reference population but the impact is lower for seniors and not significantly different for individuals in single parent households. These findings are visible in the two surfaces presented in Figure 27. While the effect of proximity to transit is positive, and thus tends to increase distance traveled, it is not significantly different between seniors, individuals living in single parent households and individuals from the reference group. The impact is geographically localized, and barely perceptible in the maps near the center of the city (Figure 28).

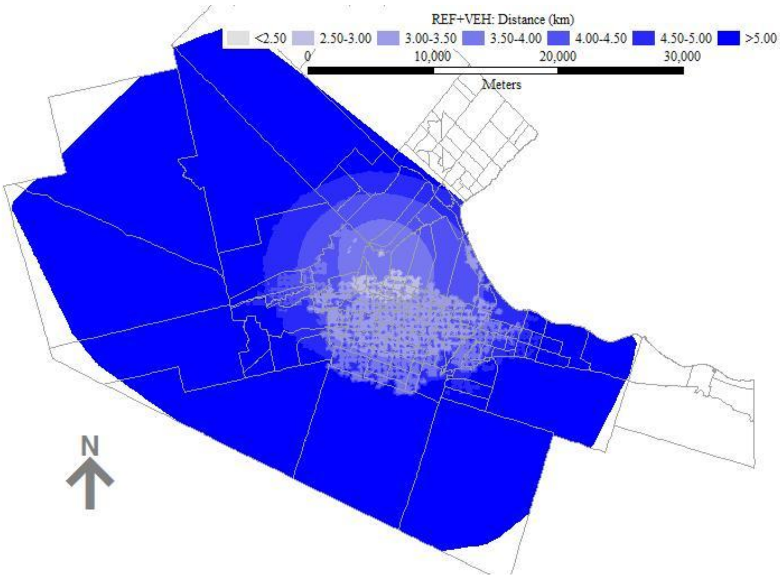


Reference

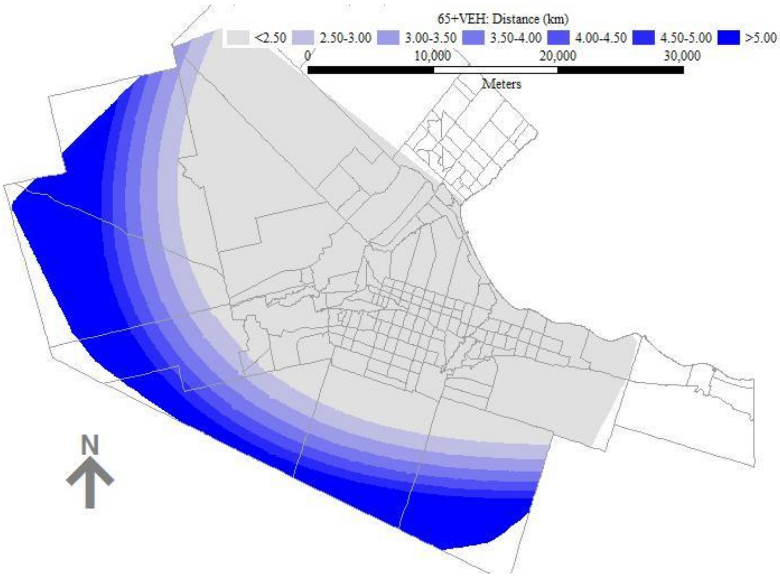


Age > 65

Figure 26: Estimated distance traveled by population group in Hamilton

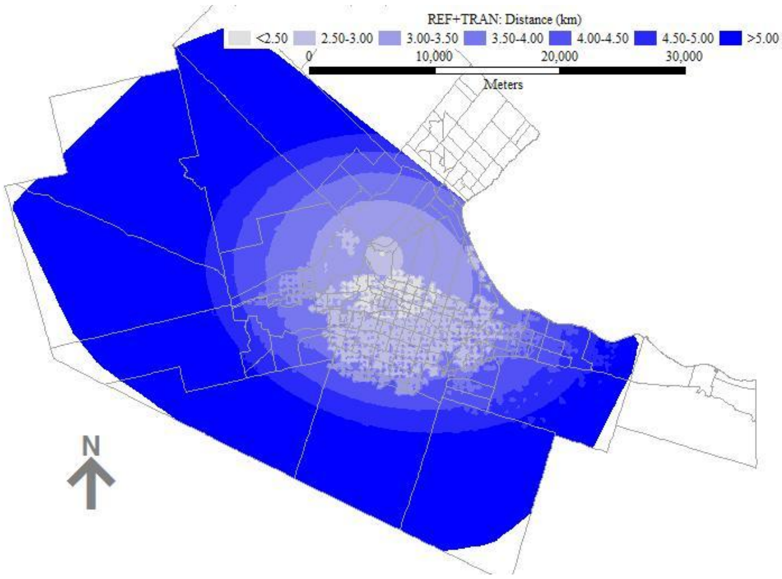


Reference

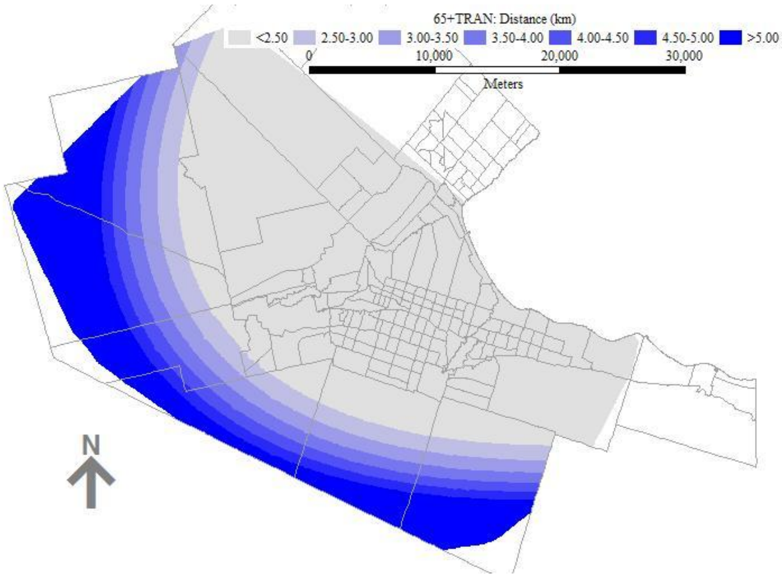


Age > 65

Figure 27: Estimated distance traveled by population group in Hamilton, with auto-ownership effect



Reference

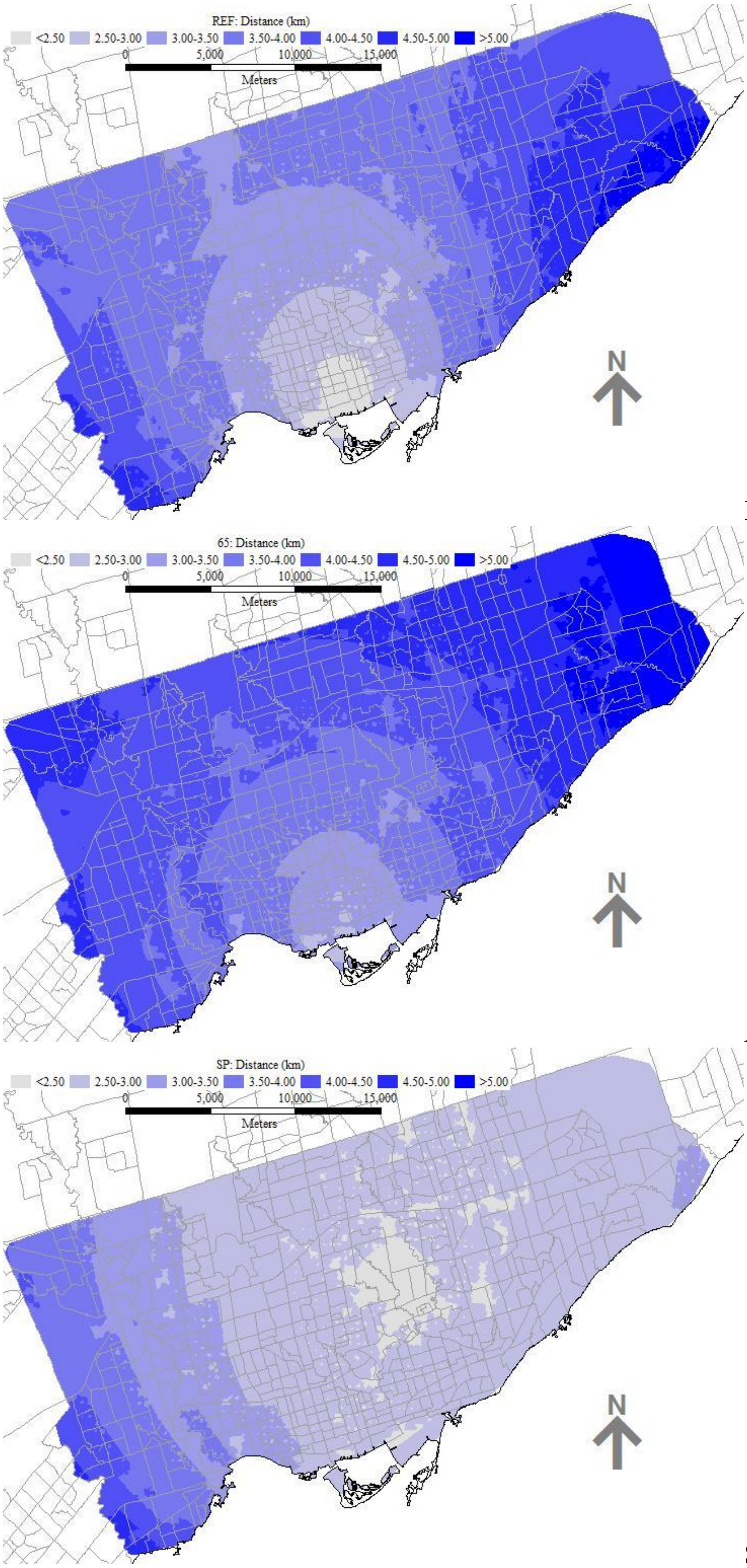


Age>65

Figure 28: Estimated distance traveled by population group in Hamilton, with proximity to transit effect

4.3.2 Toronto

Examination of the spatial coefficients for the case of Toronto also uncovers important geographical variations in distance traveled. The first thing that can be noted is that the spatially expanded coefficients are all statistically significant for the reference population. The general structure of the surface indicates that the estimates of distance traveled tend to be lower near the center of the city, and tend to increase and reach a maximum value in the north-eastern part of Toronto (Figure 29). This general pattern can likewise be discerned for the case of seniors, who also tend to travel slightly longer distances compared to the reference. The pattern, in contrast, is very different for individuals in single parent households. In addition to having the lowest estimates of distance traveled, the geographical pattern for this group places the lowest levels of mobility to the north and east of the center of the city, and increasing values from there, but particularly towards the west part of the region. With respect to mobility tools, owning a vehicle has a positive impact on distance traveled of people in the reference group and in single parent households (no significant differences are observed between these two groups with respect to car ownership), but tends to decrease distance traveled of seniors. As seen in Figure 30, an individual of the reference group with a vehicle tends to travel longer distances compared to a vehicle owning senior. Finally, access to a transit node associates positively with the distance traveled by seniors as well as by individuals in the reference group. The effect of transit is smaller compared to Hamilton, with a net increase in the average trip distance in the case of the reference group, and a negative contribution for individuals in single parent households. Specific locations where this effect is relevant can be identified in Figure 31.

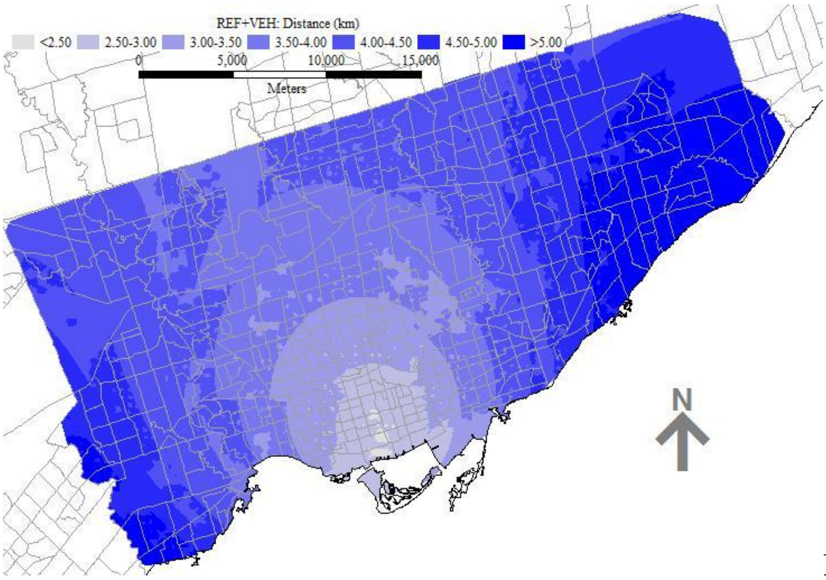


Reference

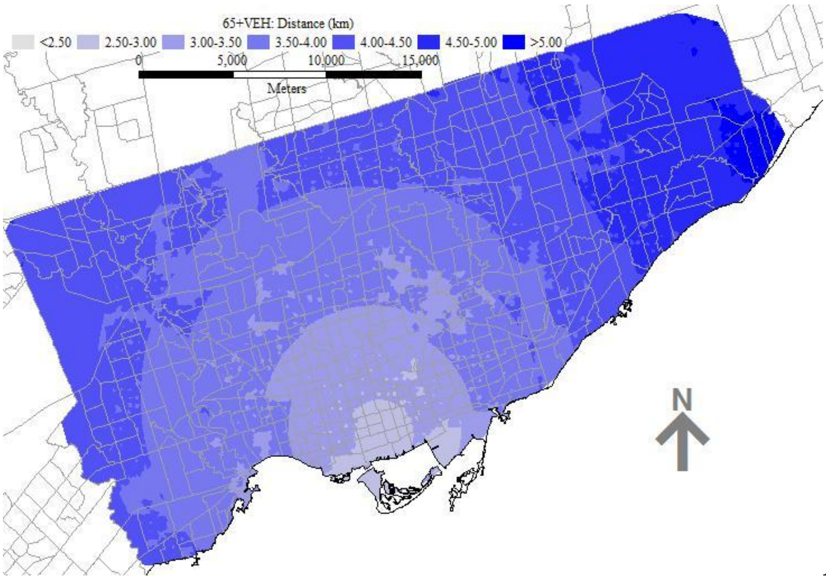
Age > 65

Single Parent

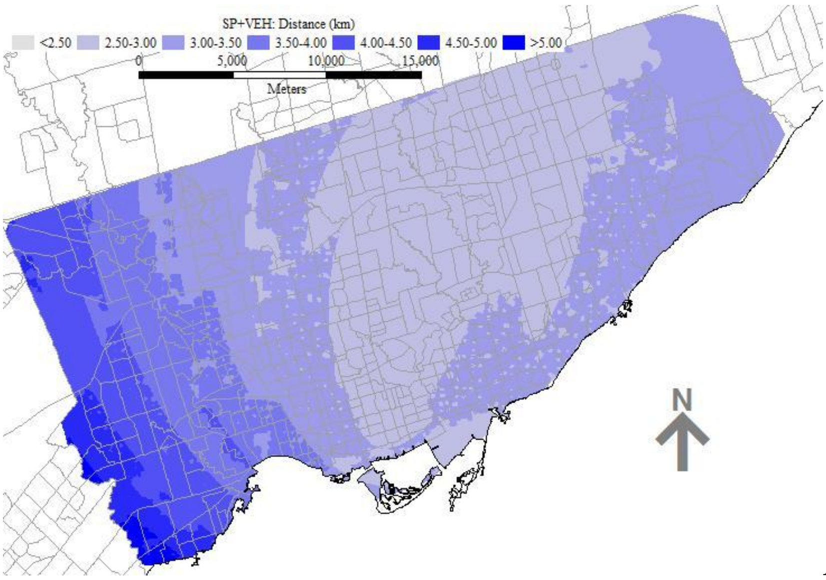
Figure 29: Estimated distance traveled by population group in Toronto



Reference

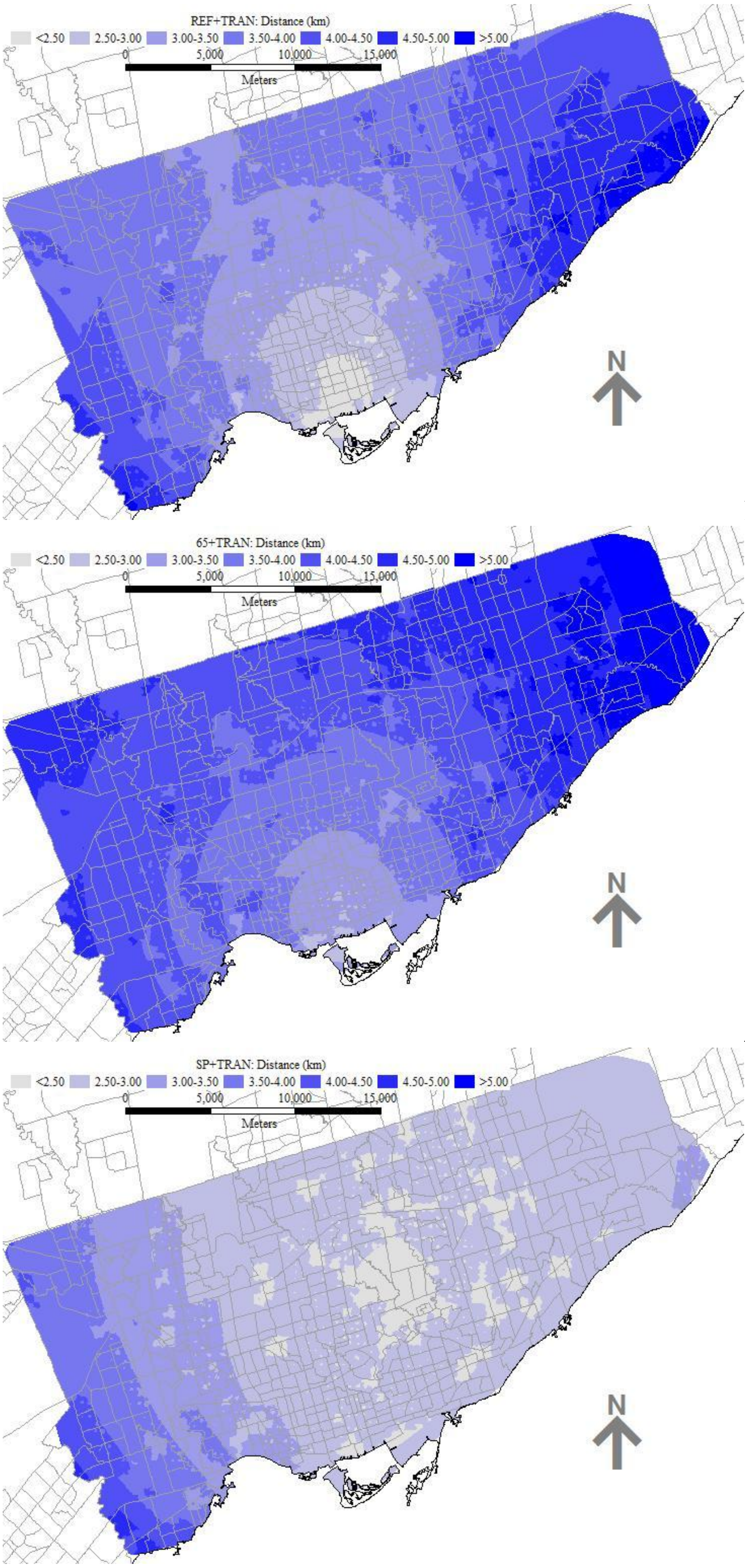


Age > 65



Age > 65

Figure 30: Estimated distance traveled by population group in Toronto, with auto-ownership effect



Reference

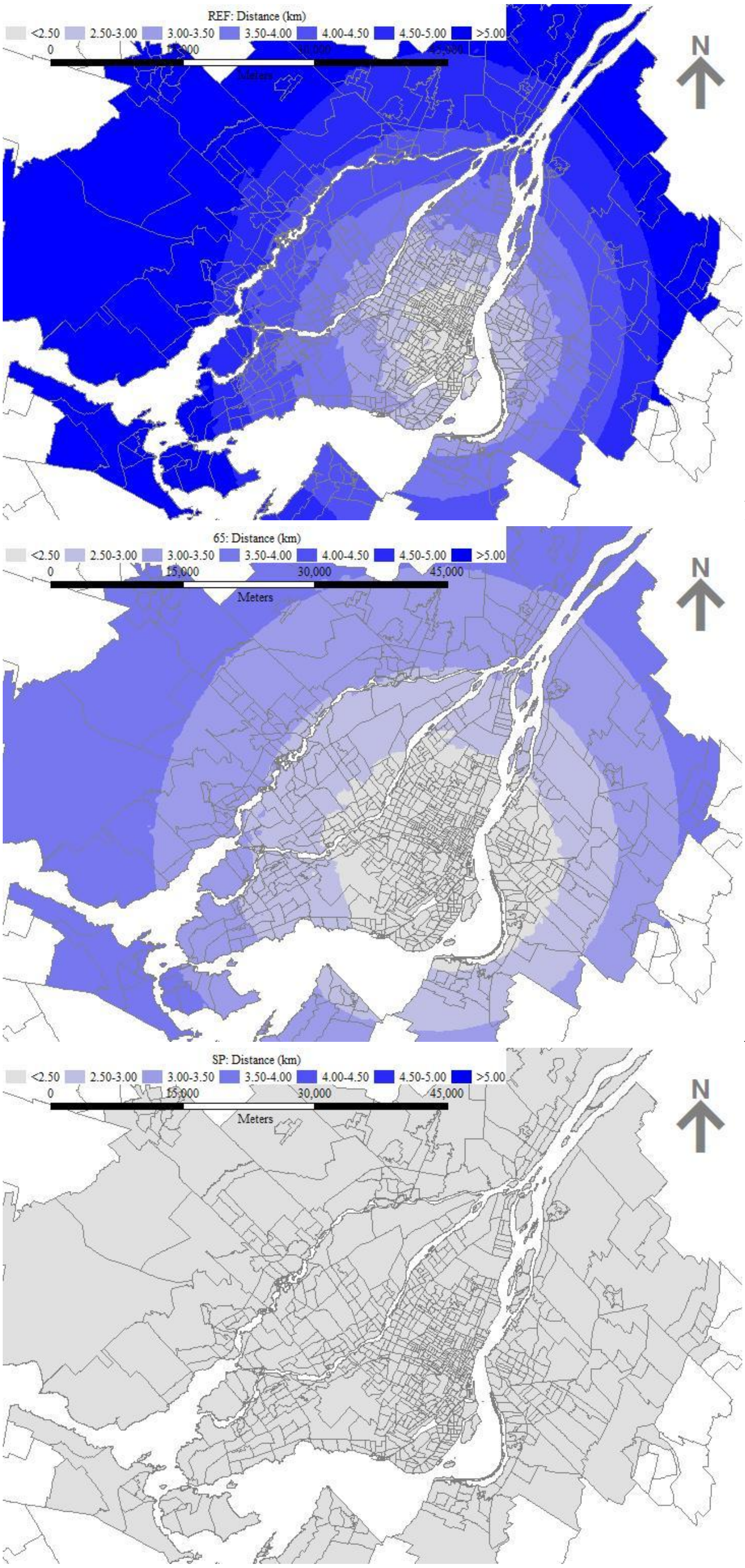
Age > 65

Single parent

Figure 31: Estimated distance traveled by population group in Toronto, with proximity to transit effect

4.3.3 Montreal

In Montreal, distance to the central city exerts a stronger effect than it does in the other two cities. This effect is somewhat weaker for seniors and single parent households, but does not differ significantly between low income individuals and the reference group. Mean distance traveled typically tends to increase with distance from the centre of Montreal, the part of the region where activities are more abundant, before reaching a plateau in the suburbs. Figure 32 and Figure 33 show that the estimates of distance traveled are similar (less than 2.5 km) for the three groups under examination in the central part of the city, within a radius of approximately 7 km of the Central Business District. As distance from that point increases, the differences between groups become more evident. Distance traveled estimates remain very low for individuals in single parent households. Combined with the findings in terms of trip generation behavior, this result suggests that while individuals in single parent households engage in trip making in levels comparable to the reference, they tend to remain geographically fairly circumscribed, even when controlling for age. A possible explanation for this could be linked that individuals in this class of household to local trips associated with children's activities. The surfaces indicate that mean distance traveled increases with access to a private vehicle for the reference group. This impact is not significantly different for seniors, individuals in low income or single parent households (Figure 34 and Figure 35). Proximity to a main transit station tends to reduce mean distance traveled by the reference group and to a greater extent by seniors (Figure 36 and Figure 37). However, it has the reverse impact for individuals in low income households, although the impact is relatively small. The impact of car ownership and proximity to transit is not significantly different for individuals in single parent households, compared to the reference population.

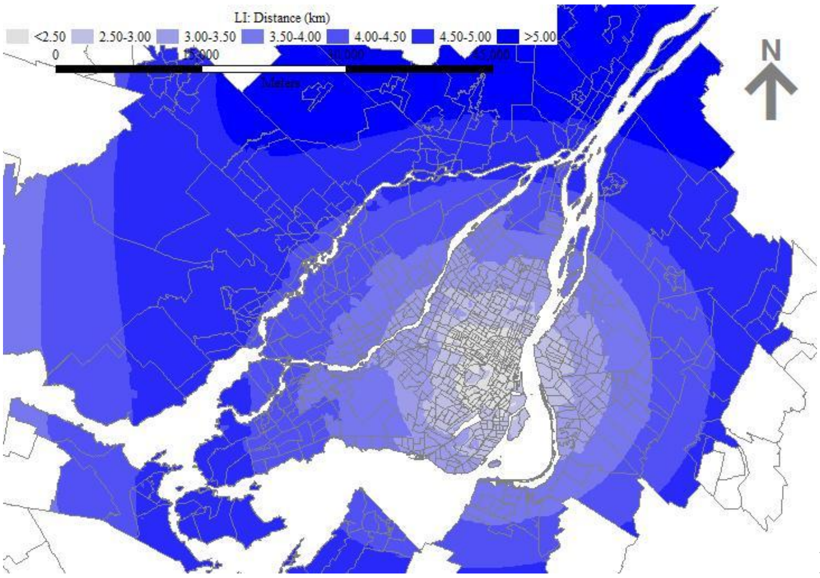


Reference

Age > 65

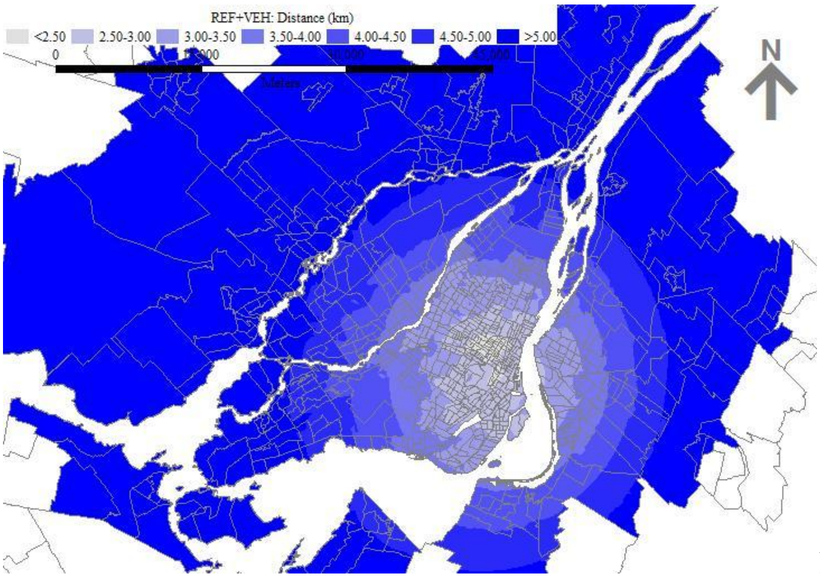
Single Parent

Figure 32: Estimated distance traveled by population group in Montreal

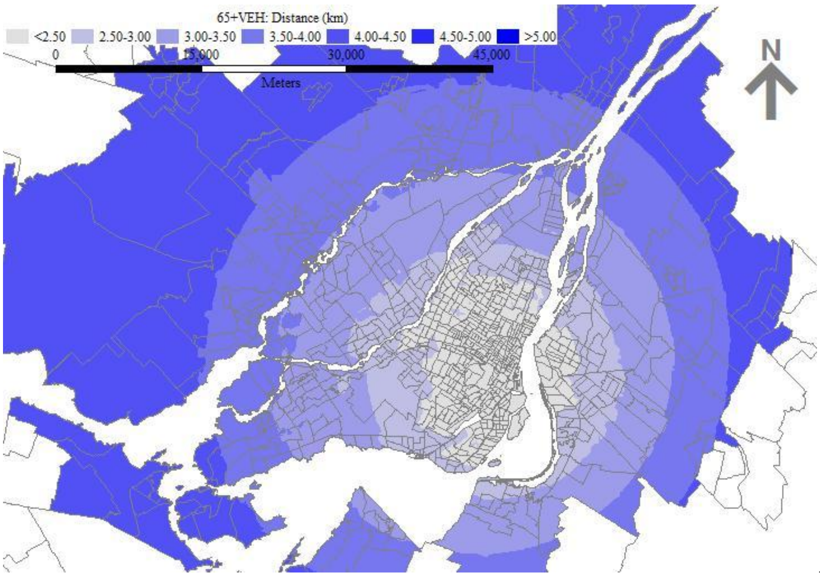


Low Income

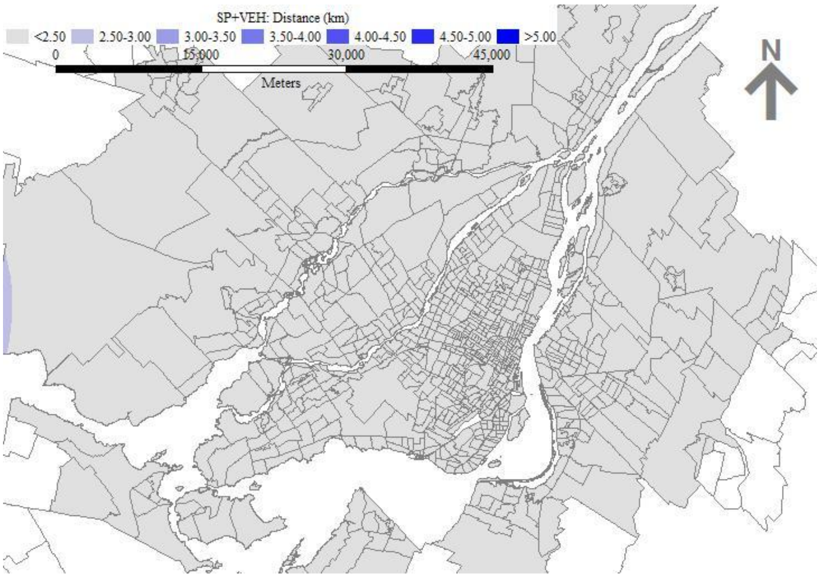
Figure 33: Estimated distance traveled by population group in Montreal (continued)



Reference

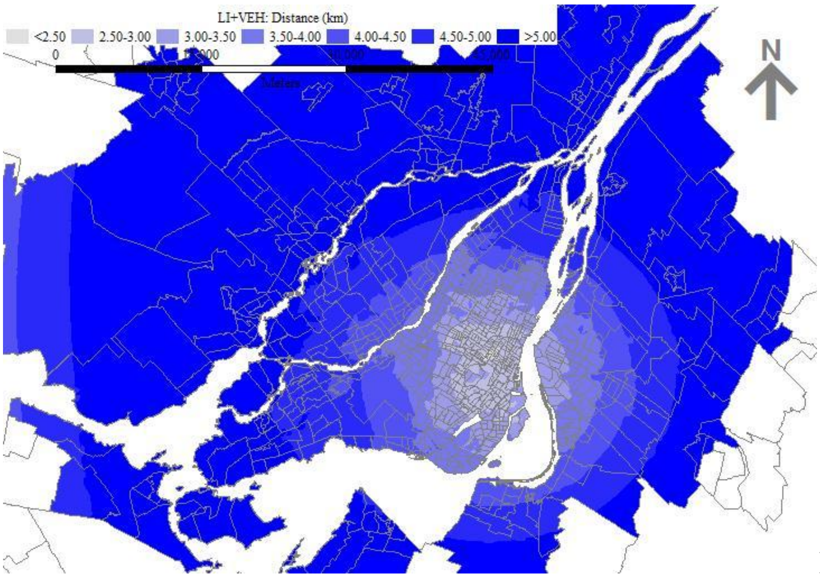


Age > 65



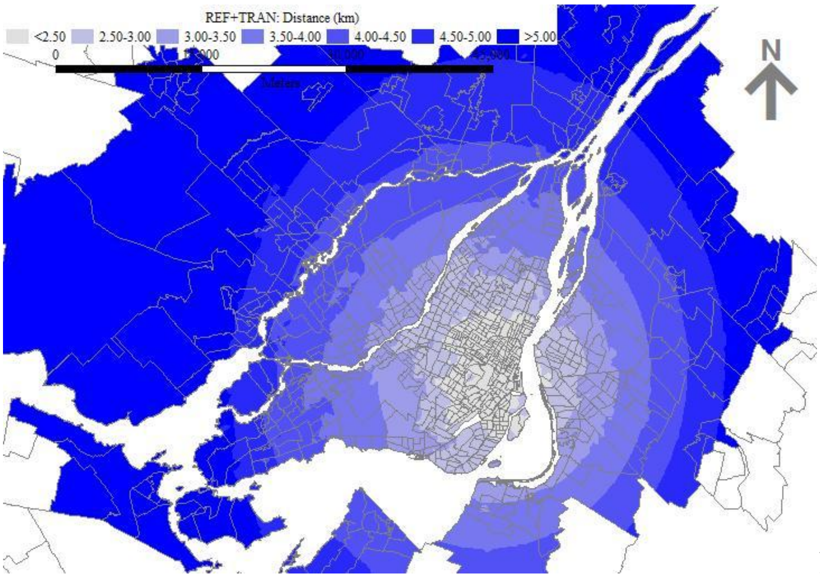
Single Parent

Figure 34: Estimated distance traveled by population group in Montreal, with auto-ownership effect



Low Income

Figure 35: Estimated distance traveled by population group in Montreal, with auto-ownership effect (continued)



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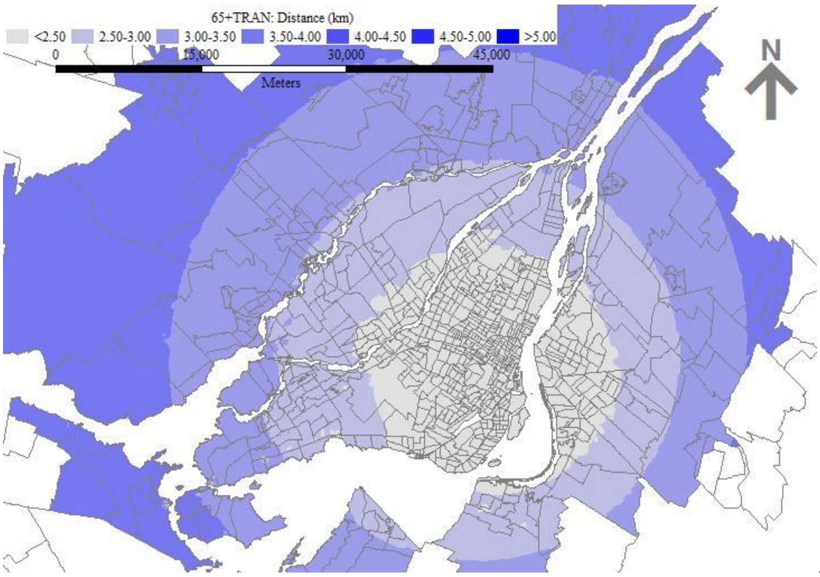
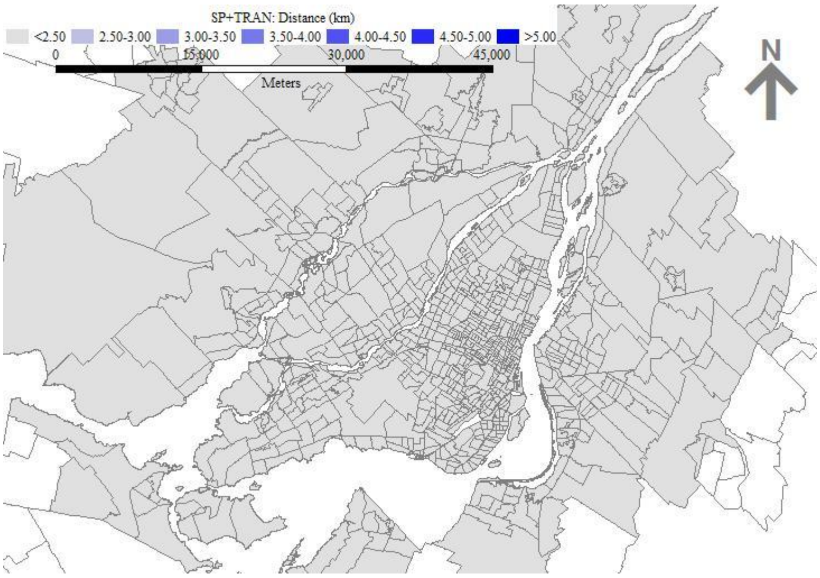
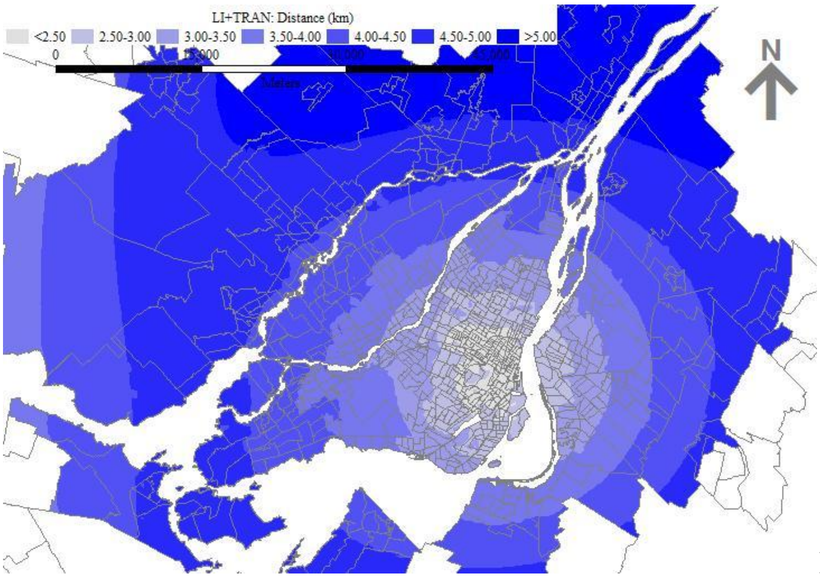


Age > 65



Single Parent

Figure 36: Estimated distance traveled by population group in Montreal, with proximity to transit effect



Low Income

Figure 37: Estimated distance traveled by population group in Montreal, with proximity to transit effect (continued)

4.4 Conclusions

In this chapter, mean distance traveled was investigated using multivariate linear regression with spatially expanded coefficients. The results confirm the fact that travel behavior has an important spatial component that when detected provides valuable insights regarding the effect of location. In particular, the results help to assess differences in distance traveled by various populations of interest, as well as the variability of this indicator of mobility as a function of residential location. The focus of the analysis is on seniors, individuals in single parent households, and low income households (for the Montreal case), in addition to the reference population. Distance traveled serves as a proxy for activity spaces. Revealed behavior provides information about the cost that people are willing or able to pay to access remote destination. Higher estimates of distance traveled are indicative, other things being equal, of a wider range of potential destinations that can be reached. Whether more opportunities are available needs to be further investigated within the context of the spatial distribution of opportunities.

Key observations from the analysis can be summarized as follows:

- Mean distance traveled tends to increase with income (only available for Montreal) and also with vehicle ownership, possession of a drivers license, employment (part or full time), being a student, having a free parking at work and living in a single parent household (except for Hamilton). It is higher for seniors and lower for people younger than 20 years old. Being part of a couple-led household with children decreases average trip distance. Population density is either related to increased travel distances (Toronto) or decreased ones (Hamilton, Montreal).
- The impact of vehicle ownership on average trip distance is lower for seniors and not significantly different than the reference group for low income and individuals in single parent households. The net impact is in effect negative for seniors in Toronto.

- Proximity to a transit node increases the distance traveled in the cases of Hamilton and Toronto, but decreases it in Montreal. The impact does not differ between the reference, and seniors and single parent households. In the case of Montreal, the impact on low income individuals is to slightly increase distance.
- The impact of full time employment on average trip distance is higher for the reference group than for individuals in single parent households.

Spatially expanded coefficients also help to observe geographical trends in average distance traveled after all personal, living space, and economic variables are accounted for. As could be observed in the analysis of trip generation, the variations detected imply that the conclusions are necessarily specific to each case study.

- For Hamilton, low estimates of distance traveled are obtained for seniors in the main part of the area (with values lower than 2.5 km). The estimates tend to rapidly increase near the edge of the city, away from the center of the city. Individuals in single parent household and the reference group have similar spatial patterns.
- For Toronto, the reference group and seniors show spatial patterns of increasing trip distance with distance from center of the city. In the case of individuals within single parent households, the lowest values of distance traveled are estimated to north and east of the central city. Distance traveled tends to increase from there especially in the east-west direction. Values remain low that for single parent households across most of the area under study.
- For Montreal, there is a clear concentric trend of increasing distance traveled estimates with increasing distance from the central part of the city. This is true for the reference group, seniors, and low income individuals. Average distance of individuals in single parent households remains low in the entire area with very little spatial variations.

The study of spatial trends in mean trip distance provides important information about the parts of the study areas where vulnerable populations may experience more restricted mobility conditions that may affect their access to opportunities. While in general the three at-risk groups tend to travel shorter distances and thus to have smaller activity spaces, maps showing distance traveled estimates allow to clearly visualize the differences between population segments and within population segments as a function of location and access to mobility tools. The results help to identify the groups and specific locations where interventions may be required to alleviate or compensate for poor mobility conditions.

CHAPTER 5 Accessibility Case Studies

Summary:

- **Accessibility**, a measure of the range of **opportunities potentially reachable** by individuals, constitutes a powerful **tool** to investigate **social exclusion** issues.
- Accessibility is defined as the **intersection** between travel, in particular **distance traveled**, and **opportunity landscapes**.
- **Model-based estimates** of **distance traveled**, obtained in Chapter 4, are used to implement a measure of accessibility based on **cumulative opportunities**.
- **Person-** and **location-specific** estimates of distance traveled, enabled by the use of the expansion method, also make it possible to conduct **comparative accessibility analysis**, by means of relative accessibility deprivation indicators.
- **Three** accessibility **case studies** are conducted: accessibility to **jobs** in **Toronto** from the perspective of **single parent** households; accessibility to **food services** in **Montreal** from the perspective of **low income** individuals; and accessibility to primary health care services from the perspective of **seniors** in **Hamilton**.
- The results for the case studies in general point towards a **disadvantageous accessibility** situation for the groups studied across most of the three geographical regions investigated, with some exceptions around city centers.

5.1 Background and Objectives

The two preceding sections in this report provide key insights regarding the trip generation (out-of-home activity engagement) and distance traveled (activity spaces) of various population segments. These two aspects of travel behavior provide measures of the general levels of mobility of seniors and people in single parent households in the cities of Hamilton, Toronto, and Montreal, as well as the mobility of low income people in the case of Montreal. The results of the analysis help to uncover trends that could be construed as relating to patterns of social exclusion, including a tendency towards fewer trips and evidence of relatively smaller activity spaces for each of these population segments. However, by themselves, these measures of mobility do not yet give a full picture of the potential of individuals to reach spatially disperse opportunities. Accordingly, a clearer understanding of potential exclusionary situations necessitates to be supported by information concerning the context that individuals face when trying to negotiate space in their daily lives. Given the variations in spatial competence for the different groups and also across space (see Chapters 3 and 4), an indication of the number of opportunities available to them is needed, conditional on their geographical situation and corresponding opportunity landscapes. In other words, additional analysis at the intersection between travel and opportunities is required.

A key to this analysis is the notion of accessibility – a concept that has proved its utility in previous research on the topic of transportation-related exclusion, and that has helped to produce a number of indicators useful for policy analysis (see Appendix D). Particularly, the value of accessibility research for the exploration of social exclusion issues has been enhanced by progress towards disaggregated indicators that better reflect individual mobility capabilities and constraints (Miller, 2006; 1991; Kwan, 1998). The individual-accessibility framework has in essence tried to respond to the question posed by Hägerstrand (1970), by placing people at the forefront of accessibility research. Related research has also furthered this goal by developing measures to investigate, from the perspective of longer term individual mobility patterns, the activity spaces of quotidian life (e.g. Rai et al, 2007; Newsome et al, 1998). Schematically, this chapter establishes a link between mobility, and concretely distance traveled, and accessibility (see Figure 38)

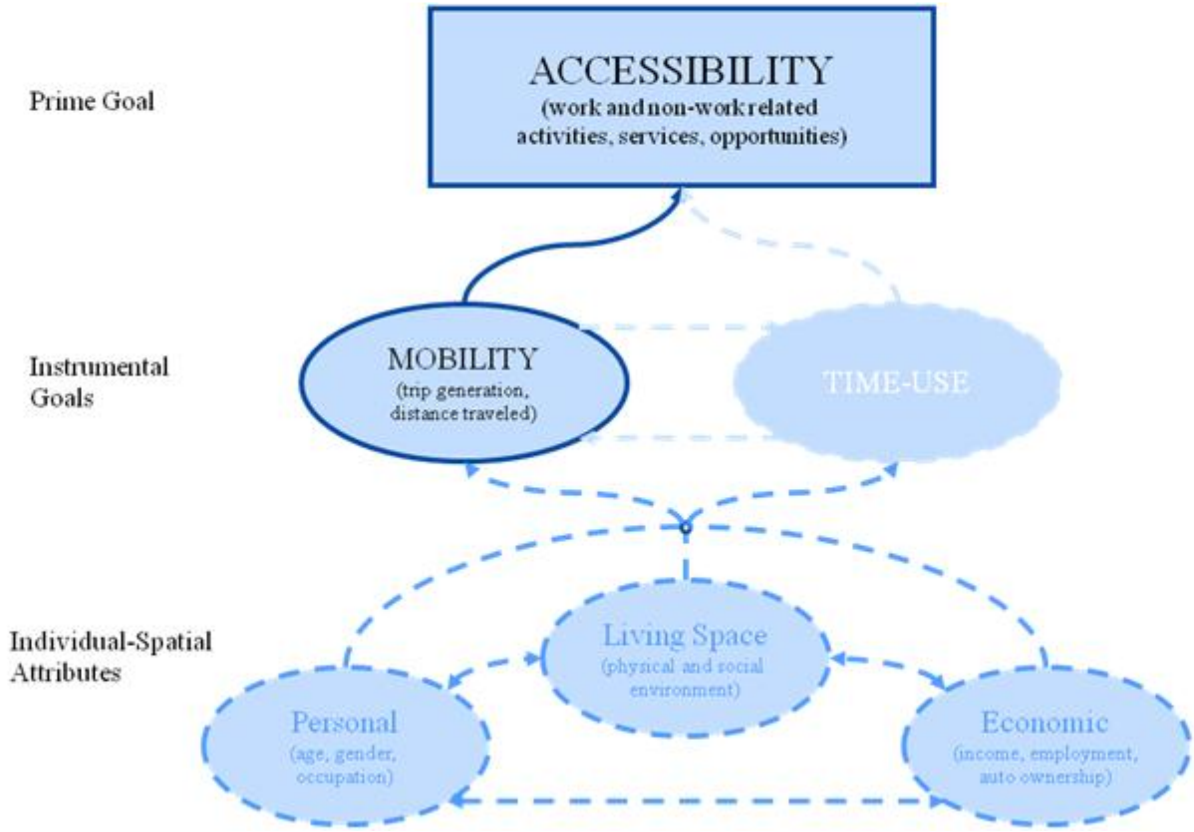


Figure 38: Conceptual framework: Accessibility

A key to the analysis is the use of model-based estimates of distance traveled (derived in Chapter 4) to implement measures of cumulative opportunities, a commonly used class of accessibility indicators. Distance estimates are specific to individual profiles, conditional on the set of explanatory variables. In addition, following the specification of spatially-varying coefficients, estimates are also location-specific. In combination with the opportunity landscape, an indicator of cumulative opportunities provides a summary measure of the number of opportunities available to individuals in places. This permits the investigation of accessibility trends as they relate to different population segments and locations in space. Comparative analysis is implemented by means of relative accessibility deprivation indicators (Páez et al, 2009). The analysis is useful to assess: 1) The proportion of opportunities available to an individual with defined characteristics at a selected location, relative to an individual from a reference group at the same location; or 2) The difference in levels of accessibility to opportunities of different types from the perspective of the same individual type at a given location. Three case studies are investigated, namely access to jobs in Toronto from the perspective of single parent households, access to food services in Montreal from the perspective of low income individuals, and access to health care from the viewpoint of seniors in Hamilton.

5.2 Accessibility to Jobs in Toronto from the Perspective of Single Parent Household Dwellers

5.2.1 Context for Application

At the heart of the spatial mismatch hypothesis is the notion that those with closer physical proximity to appropriate employment opportunities have superior economic outcomes compared to those for whom jobs are a geographically distant proposition (Kain, 1968). Over the decades, empirical analysis has primarily been in support of the core statement of spatial mismatch. In addition, the analysis has been expanded into new dimensions to characterize other marginalized populations, including other ethnic minorities (Farley, 1987), urban youth (Ihlanfeldt and Sjoquist, 1990), women (Kwan, 1999), or combinations thereof (McLafferty and Preston, 1992). In general, there is a growing recognition that the role of mobility, and access to transportation, is a vital consideration when analyzing job access at the individual level (Sanchez, 1999; Kawabata, 2003).

Drawing on evidence from the United States, it is clear that differential job accessibility amongst population subgroups is not restricted to questions of race, and thus there is a necessity to explore which subgroups of the Canadian population may face systematically reduced employment access. Of particular relevance to this line of inquiry are individuals in single parent households. In addition to economic hardship, these individuals also tend to carry the joint burden of generating employment income while maintaining household and child-care responsibilities. These extra responsibilities are particularly salient to job accessibility given the fixity of time budgets, which means that time spent on household maintenance and child-care activities reduces the amount of time available for the daily commute (Turner and Niemeier, 1997). This point is clearly and consistently reflected in the analysis of distance traveled in three Canadian cities where individuals in single parent households do not tend to make fewer trips compared to the reference group, but tend to have smaller activity spaces (Chapters 3 and 4). Thus, given the double jeopardy of adverse economic prospects and dual household and employment demands, it becomes even more important to ensure equitable accessibility to employment for single-parent family households.

In order to shed light on these questions, in this section we investigate accessibility to employment in the Toronto area, with a specific focus on the relative levels of accessibility of single parent households with respect to other household structures. Two classes of employment are considered: professional and managerial occupations, and service, trades, and blue collar occupations.

5.2.2 Employment Data by Workplace Location

In addition to results regarding distance traveled reported in Chapter 4, accessibility analysis requires information on the spatial distribution of opportunities. For the case of employment, this is obtained from the Canadian Census of Population, and specifically Table 30 of the set of tables on employment and commuting to work (catalogue number 97C0080). This allows us to obtain employment information by workplace location, as collected for Census Tracts. For the purpose of the analysis, a subset of data points is extracted from the file corresponding to the province of Ontario, for a total of 667 Census Tracts covering the city of Toronto and an additional 5 km buffer around the city to account for edge effects.

Table 30 includes information on the following broad employment categories: A) Management occupations; B) Business, finance and administrative occupations; C) Natural and applied sciences and related occupations; D) Health occupations; E) Occupations in social science, education, government service and religion; F) Occupations in art, culture, recreation and sport; G) Sales and service occupations; H) Trades, transport and equipment operators and related occupations; I) Occupations unique to primary industry; J) Occupations unique to processing, manufacturing and utilities. With the exclusion of occupations in art, culture, recreation and sport, we aggregate other classes to produce two broad classes of employment that we term “Professional and Managerial” (or P&M; categories A, B, C, D, and E) and “Service, Trades, and Blue Collar” (or S,T&BC; categories G, H, I, and J). Further, we break down the number of jobs according to their classification as “mostly full time, full year” (which we simply term full time) and “mostly part time and/or part year” (part time). The total number of jobs in Toronto and neighboring Census Tracts is 1,831,370, of which 1,161,380 are in the P&M class (including 822,410 full time), and 669,990 are S,T&BC (including 373,475 full time). Employment statistics are conventionally assigned to the centroid of their corresponding Census Tracts. This level of aggregation negates to some extent the benefits of working with individual-level travel behavior information, since employment in a Census Tract is assumed to concentrate at one point in space. In order to obtain a more comparable level of spatial resolution, we interpolate the employment data using the mass-preserving (pycnophylactic) method developed by Tobler (1979). This method works by redistributing employment in zones to a finely grained interpolation grid, all the while ensuring that the total number of jobs in the region remains constant. The results of this interpolation exercise provide a distribution of jobs in the city that more closely resembles the level of spatial detail available for distance traveled estimates (see Figure 39), and thus reduces the amount of aggregation bias in the calculation of accessibility measures.

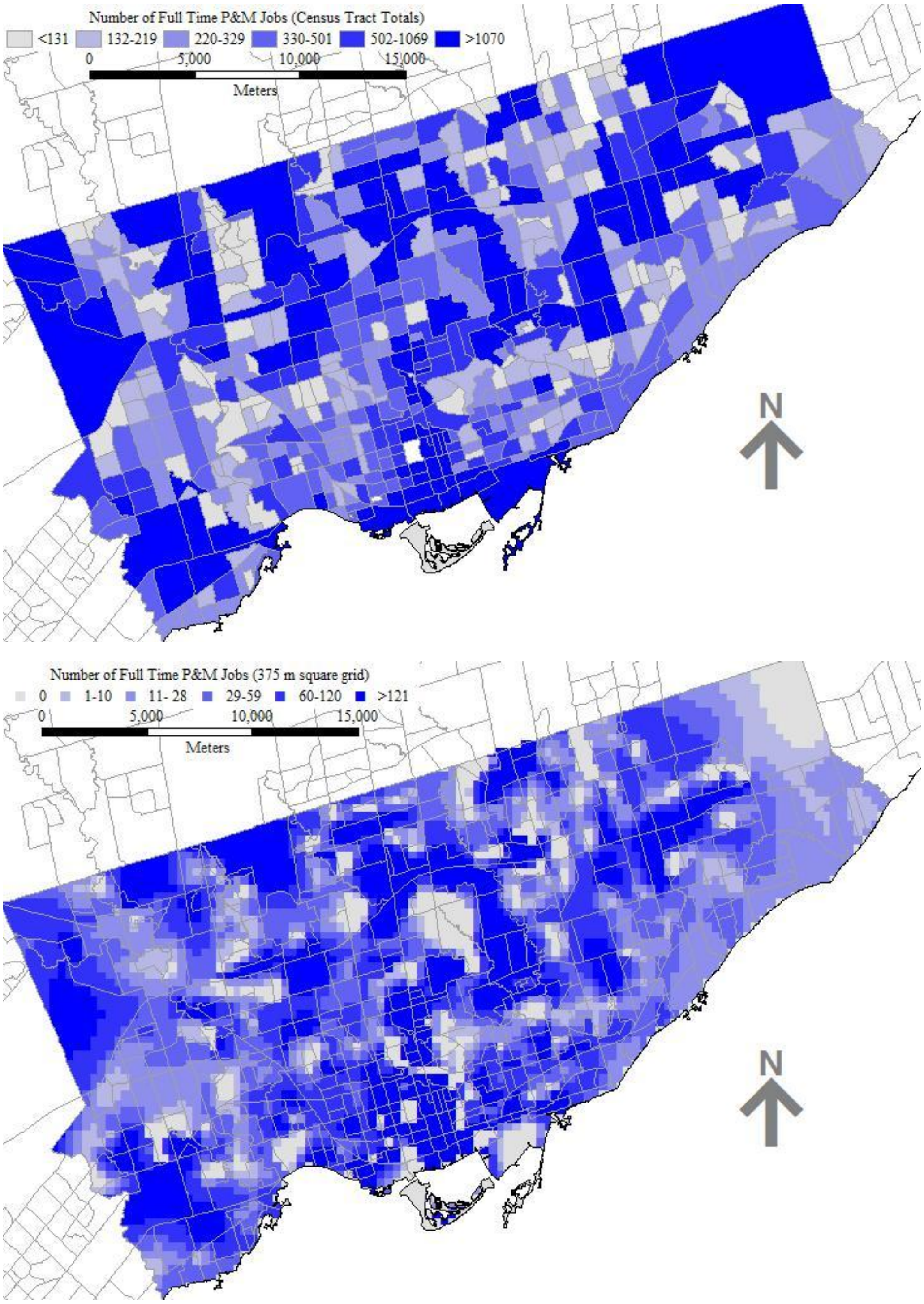


Figure 39: Professional and managerial jobs by Census Tract and interpolated on a fine grid

5.2.3 Accessibility to Full Time Jobs by Household Structure and Vehicle Ownership

The indicator of cumulative opportunities is calculated as follows:

$$A^k(i) = \frac{\sum_j W_j^k I\left(d_{ij} \le \hat{d}_{pi}\right)}{\sum_j W_j^k} \qquad (3)$$

In other words, access to opportunities of type *k* is simply the sum of all opportunities of that type that are at a distance d_{ij} smaller than or at most equal to the estimate of distance traveled for individual *p* at location *i* ($\hat{d}_{pi}$). The cumulative number of opportunities is divided by the total number of jobs in the region to give the proportion of all jobs in the region that are within reach of said the specified individual.

In this section, accessibility measures are calculated for Professional and Managerial jobs (P&M –Figure 40) and Service, Trades, and Blue Collar jobs (S,T&BC – Figure 41). As can be seen in the figures, the highest levels of accessibility are found in the area surrounding the central part of the city, where there is a higher concentration of employment, and a second spot on the western edge of the city, closer to the Toronto International Airport. Accessibility in these two areas, but especially in and around the center of the city tends to be relatively high. Being near the downtown confers access to between 10% and almost 30% of the total number of jobs in the city, depending on household structure and vehicle ownership status. Comparing the levels of accessibility between the reference and single parent households, it can be seen that the overall picture is similar, however with individuals in the single parent group enjoying slightly higher levels of accessibility in the downtown area but lower levels elsewhere in the city. Access to a private vehicle has the effect of increasing the levels of accessibility everywhere, although the gains tend to be rather limited in the areas beyond the central parts of the city due to the high degree of centralization of professional and managerial jobs in Toronto.

While the concentration of P&M jobs in central Toronto is reflected in the high levels of accessibility in that part of the city, analysis of S,T&BC employment reveals a different picture (see Figure 41). The level of centralization in this case is much less pronounced, and there are now broader parts of the city with higher accessibility levels, especially to the west and northeast of the city, two regions that were only hinted at in the case of professional and managerial employment. As before, accessibility to S,T&BC jobs is also enhanced for the case of individuals in vehicle-owning households.

Overall, analysis of access to employment in Toronto is indicative of different locational patterns for P&M and S,T&BC jobs, with clear evidence of centralization in the former and a more dispersed pattern in the latter. Two other regions besides the center of the city concentrate relatively high numbers of accessible jobs. The observation also emerges that although people in general tend to travel longer distances when they are located in the suburbs (see Figure 29 to Figure 31), the higher levels of mobility implied by the estimates of distance traveled do not translate into higher levels of accessibility in many parts of the city. As an additional point, we can note that accessibility to part-time jobs follows very similar spatial distributions as that for full-time jobs.

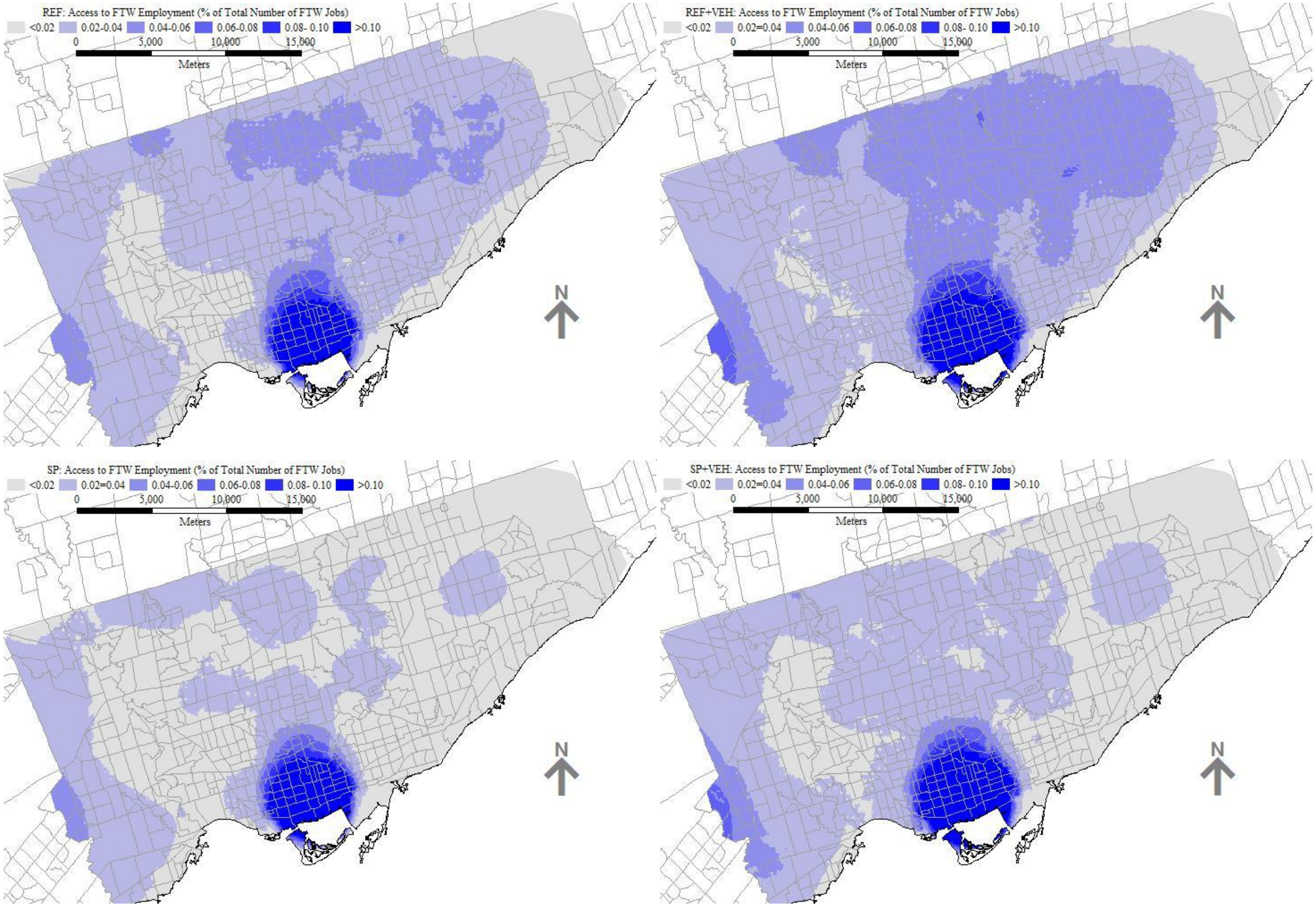


Figure 40: Accessibility to full time managerial and professional jobs by household structure and vehicle ownership

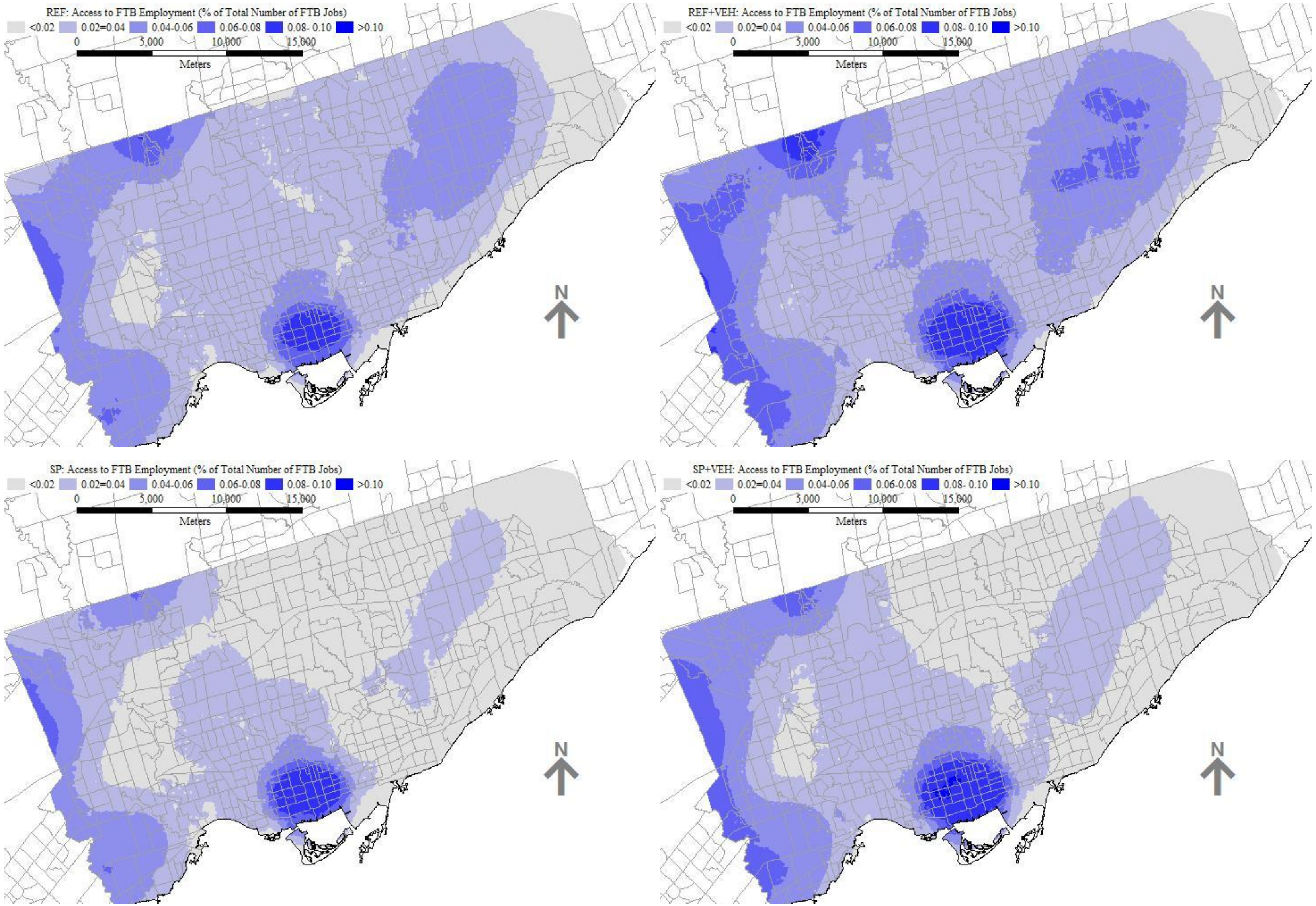


Figure 41: Accessibility to full time service, trades and blue collar jobs by household structure and vehicle ownership

5.2.4 Relative Access to P&M and S,T&BC by Household Structure

We now turn to the question of whether there is differential access to P&M and S,T&BC jobs in the city of Toronto. In other words, we are interested in whether individuals in the reference group and single parent households have better or worse access to Professional and Managerial jobs, compared to Service, Trades, and Blue Collar jobs. Two relative accessibility indicators are calculated to address this question. The first one (results shown in Figure 42) is as follows:

$$R_{REF}^{P\&M/S,T\&BC} = \frac{A_{REF}^{P\&M}}{A_{REF}^{S,T\&BC}} \qquad (4)$$

The indicator above measures the ease with which P&M jobs can be reached relative to S,T&BC jobs by individuals in the reference group. The indicator is interpreted as the ratio of proportions of opportunities of each type. A value of 1 means that at such location an individual in the reference group has access to equal proportions of P&M and S,T&BC jobs. A value of 2 for example would indicate that an individual at such location has access to twice the proportion of opportunities of the P&M type, whereas a value less than 1 would mean that from that location the individual has access to a larger proportion of jobs of the S,T&BC type compared to P&M jobs.

As seen in the figure, there are few parity locations in the region of Toronto, that is, places where the proportion of jobs accessible is equal for both types of employment. Typically, parity accompanies a transition where the relation of proportions of accessible jobs changes from one class to the other. A narrow band in the north south axis that extends from the CBD of the city depicts a region where jobs of the professional and managerial type are proportionally more accessible than other jobs, with the effect being slightly more pronounced in the area surrounding the CBD. Other areas where higher proportions of P&M jobs are relatively more accessible are the regions to the west and the east near the shore of the lake. Elsewhere, and covering an extensive part of the city, there tends to be a higher proportion of accessible S,T&BC jobs, again, reflecting the more decentralized pattern of these jobs in the city.

A second relative accessibility indicator is calculated from the perspective of single parent households (SP) as follows:

$$R_{SP}^{P\&M/S,T\&BC} = \frac{A_{SP}^{P\&M}}{A_{SP}^{S,T\&BC}} \qquad (5)$$

The results are shown in Figure 43, where it can be seen that there pattern of accessibility is very similar to that observed for the reference group. This indicates that proportionally, the levels of accessibility to different types of jobs are roughly the same for both population segments. The question remains whether these patterns are otherwise comparable. This is explored next.

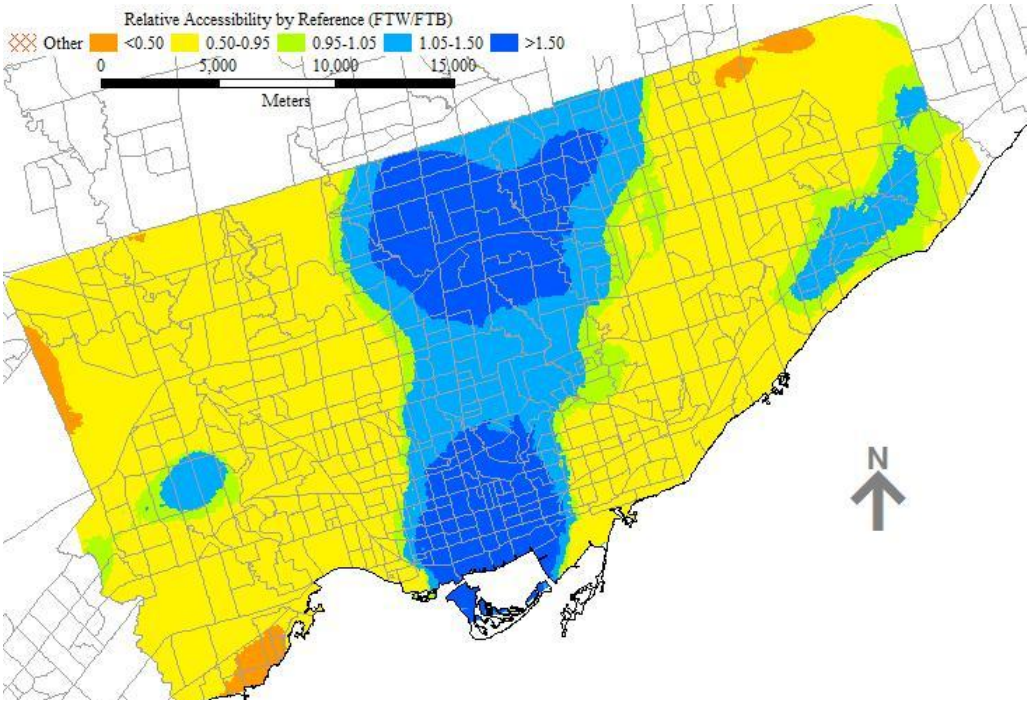


Figure 42: Relative accessibility of reference group individuals to full time P&M and S,T&BC jobs

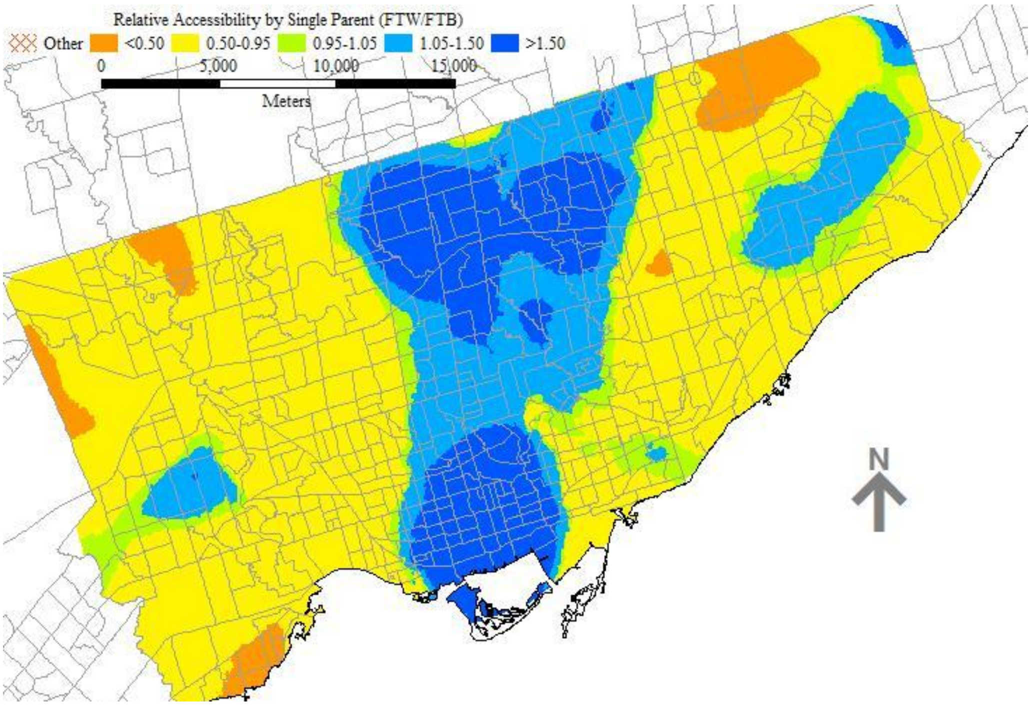


Figure 43: Relative accessibility of individuals in single parent households to full time P&M and S,T&BC jobs

5.2.5 Relative Access to Jobs by Household Structure

In order to assess whether there are differential accessibility levels between the two population groups under study, a comparison is made in terms of relative access to jobs from the perspective of individuals in the reference group relative to individuals in single parent households. In other words, the question becomes whether individuals in the reference group have better or worse access to Professional and Managerial jobs compared to single parent households. The relative accessibility deprivation indicator is defined as follows:

$$R_{REF/SP}^{P\&M} = \frac{A_{REF}^{P\&M}}{A_{SP}^{P\&M}} \quad (6)$$

The results of calculating and plotting this indicator appear in Figure 44. A value of 1 again indicates parity, in this case equal number of jobs of type P&M accessible to the two population types. A value greater than 1 indicates that an individual of the reference group at the location has access to more jobs than a person in a single parent household. For instance, an indicator of 2 is interpreted as a reference person having access to twice as many jobs as someone in a single parent household – in other words, if the level of accessibility for the individual in the reference group is considered the norm, single parent household dwellers would face a situation of relative deprivation in terms of access to jobs of the P&M type. A value of less than one indicates the opposite situation. 0.5 for instance is interpreted as someone from the reference group at the location who has access to half as many opportunities compared to an individual hailing from a single parent household.

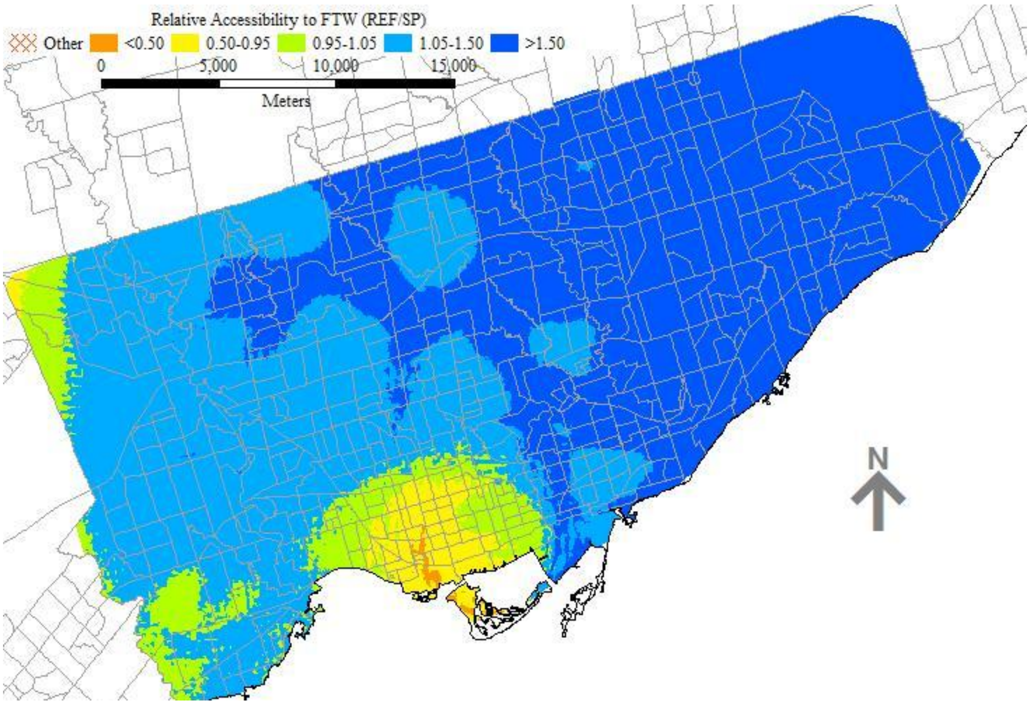


Figure 44: Relative accessibility to full time managerial/professional jobs by household structure type (single parent/reference)

As seen in the figure, single parent household dwellers enjoy relatively high levels of accessibility near the center of the city, and parity ensues in the areas surrounding the central parts of the city and to the west of the study region. In most other places, access to P&M jobs is less favorable for this demographic group, and thus they can be said to face relative accessibility deprivation.

Finally, an indicator is calculated to analyze relative access to S,T&BC jobs, as follows:

$$R_{REF/SP}^{S,T\&BC} = \frac{A_{REF}^{S,T\&BC}}{A_{SP}^{S,T\&BC}} \qquad (7)$$

The results appear in Figure 45. The pattern of accessibility is very similar for the case of P&M and S,T&BC jobs, with even a slight increase in the number of locations at parity, or better than parity from the perspective of single parent households. Thus, individuals in these households seem to have slightly better access to jobs in this category in and around the CBD of the city, and again along the western edge of the region.

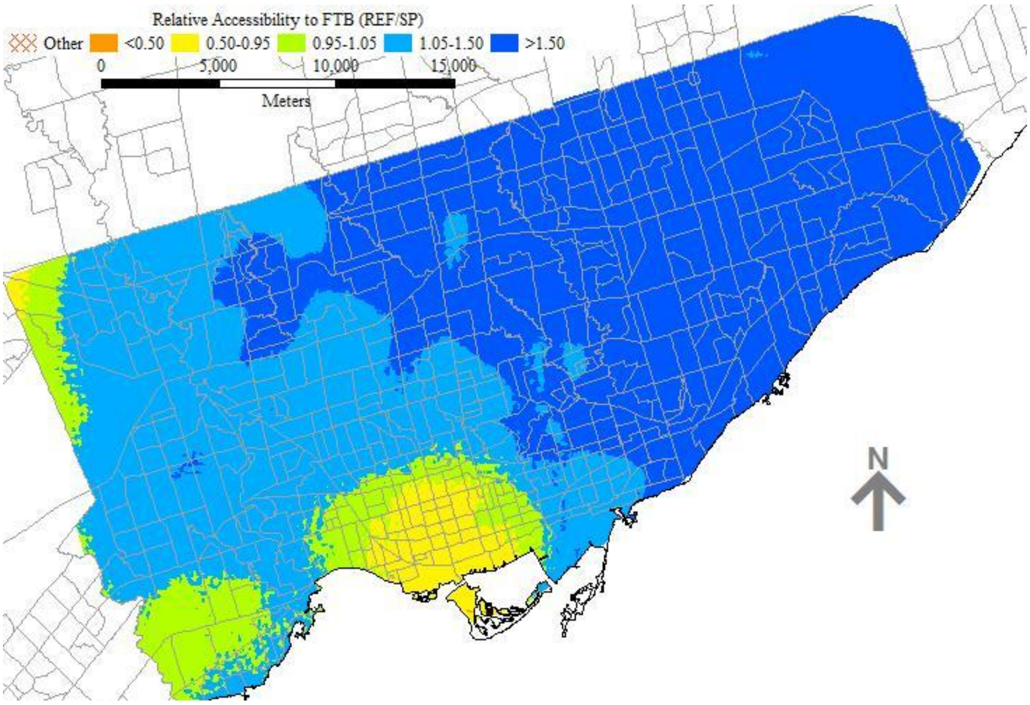


Figure 45: Relative accessibility to full time blue collar jobs by household structure type (single parent/reference)

5.2.6 Discussion

The spatial mismatch hypothesis – the notion that employment outcomes are influenced by proximity to jobs – has for more than 30 years animated a large body of research. While originally concerned with the case of African-American males in central cities in the US, the idea in fact is general enough to encompass others ethnic groups, or more generally, other population groups. This is the case of Hispanics, females, and immigrants, all population segments that have been investigated from the lens of spatial mismatch. A group that has received significantly less attention is single-parent households, despite the fact that members living in this type of households often face the double burden of household and employment responsibilities.

Investigation of the accessibility patterns to jobs in the city of Toronto reveals that there are important differences between the levels of accessibility for single parent households relative the reference population. Single parent households constitute a demographic group that, the statistics show, has increased in absolute and relative numbers in Toronto in recent years. Comparative accessibility analysis conducted by means of relative accessibility deprivation indicators, allows the investigation to proceed along several dimensions: differences between single parent and other types of households, between professional/managerial and other forms of employment, and between households with or without vehicles. The analysis illustrates the role of private mobility in increasing the access to jobs in the city. However, despite the mobility gains of vehicle ownership, it is interesting to note that across most of the city single parent households with vehicles still have lower levels of accessibility compared to reference households *without* vehicles. On the other hand, the results suggest that individuals in single-parent households enjoy, compared to other household structures, relatively high levels of accessibility to employment in the central areas of the city. This result comes about as positive, and also in line with previous findings by Shen (2001), who found that less-educated job seekers residing in central city still have relatively better access to job openings than those who live in the periphery of the metropolitan area. Our results, however, also provide sobering evidence that respective to other household types, single parent household dwellers face a situation of accessibility parity at best, or deprivation at worst in large parts of the city. This effect, in addition, is slightly more pronounced for the case of access to profession/managerial jobs compared to service, trades, and blue collar occupations.

5.3 Accessibility to food services in Montreal

5.3.1 Context for Application

The links between food consumption (quantity and quality) and health status have been made clear in a number of studies that investigate, among other outcomes, the relationship between dietary patterns and the risk for heart disease (e.g. Kerver et al, 2003), healthy food choices and a reduction in the risk for cancer (e.g. Kushi et al, 2006), and dietary patterns and Body-Mass Index, a commonly used marker for overweight and obesity conditions (e.g. Newby et al, 2003). Evidence of said linkages has prompted a fairly large body of literature that is concerned with the systematic effect of food availability on the nutrition and health status of disadvantaged (typically low income) individuals in society. This literature has been variously developed under the banners of “food insecurity”, and also “food deserts”, after the latter term was introduced in policy analysis papers in the United Kingdom (Beaumont et al, 1995). Of these two, the concept of food deserts provides a richer picture of the phenomenon because it operates jointly on the notions of socio-economic status (the main province of the food insecurity perspective) and geographical space, and is thus better able to capture the potentially complex interactions between status and location. Research on food deserts provides an important perspective on transportation-related social exclusion research, and has come to complement and extend existing evidence which suggests that dietary habits are to some extent influenced by availability of, and ease of access to, food services. For example, Cheadle et al. (1991) uncover positive and significant correlations between availability of healthy food and reported healthiness in a study of 12 communities in California and Hawaii. Morland et al. (2002) provide further evidence of these associations by linking the consumption of healthy food to proximity of supermarkets, while Shepherd et al. (2006) find that the ease of access to fast food can be counted amongst the barriers to healthy eating in young people. These and other investigations tilt the weight of evidence in favor of the hypothesis that access to food affects eating behavior, as opposed to a null relationship (Pearson et al, 2005).

Seminal research on food deserts in urban areas was conducted in the United Kingdom as part of the "Food Deserts in British Cities" project that aimed at identifying a research agenda for the topic, and at generating empirical evidence to inform discussions on access to food and health outcomes in various cities in Britain (Wrigley, 2002). As part of this study, a number of research priorities were identified, including the question of how to systematically identify food deserts in urban areas. This question was initially addressed in a companion paper by Clarke et al. (2002), who developed a number of indicators of access to food, and applied them to identify 6 problematic food deserts in the cities of Leeds/Bradford and Cardiff. In addition to this, there have been numerous efforts to measure and map access to food in other locations as well (e.g. Furey et al, 2001; Austin et al, 2005; Burns and Inglis, 2007). The concept of food deserts has since been more broadly adopted, as exemplified by the Canadian research of Smoyer-Tomic et al. (2006), who investigate the existence of food deserts in the city of Edmonton, and Bertrand et al. (2008), who are concerned with access to fruits and vegetables in Montreal. In this section, accessibility analysis is applied with the objective of measuring access to fast food locations, and retail food locations, that is, places where fresh food can be obtained. The specific focus of the analysis is low income individuals in the city of Montreal. An additional objective of the analysis is to identify food deserts, locations where accessibility to food in the city of Montreal is extremely low or zero.

5.3.2 Business Data Points

The setting for this case study is the city of Montreal, which is part of the Greater Montreal Area (GMA). In addition to estimates of distance traveled, Business Point Data are used to characterize the spatial distribution of opportunities in the city. For the purpose of this analysis, a subset of data points is extracted from the file corresponding to the Montreal CMA, to obtain an exhaustive listing of businesses with the following Standard Industrial Codes: 5411- Grocery store (count: 2907), 5421- Meat and fish markets (count: 94), 5431- Fruit and vegetable markets (count: 278), 5441- Candy, nut, and confectionery stores (count: 56), 5451- Dairy product stores (count: 64), 5461- Retail bakeries (count: 874), 5499- Miscellaneous food stores (count: 438). This gives a grand total of 4711 establishments that we classify as "Retail Food" locations. In addition, we also extract from the database a selection of businesses from the 5812 classification ("Eating Places") that can be identified as belonging to one of 11 well-known fast food chains (hamburger, pizza, sandwiches, etc.). From this selection we obtain a total of 543 points that we classify as "Fast Food" locations. The spatial distribution of Retail and Fast Food places is shown in Figure 46 below.

Figure 46: Distribution of retail and fast food locations in Montreal

5.3.3 Accessibility to Food Services by Income Status and Vehicle Ownership

Accessibility measures are calculated for access to retail food locations (HF – Figure 47) and fast food locations (FF – Figure 48). As can be seen in the figures, despite the spatial distribution of distance traveled (in general increasing with increasing distance from the center of the city), the highest levels of accessibility are found in the area surrounding the central parts of the city, where there is a higher density of food services. The levels of accessibility in that area tend to be relatively high, but the region with high accessibility is also fairly circumscribed. In the case of access to retail food, being near the centre of the city confers access to between 10% and upwards of 18% of the total of opportunities available in the city, depending on income and vehicle ownership status. Comparing the levels of accessibility between the reference and low income groups, it is evident that these display relatively small differences near the downtown area, with individuals in low income households enjoying slightly higher levels of accessibility to retail food outlets. An interesting effect can be observed in terms of vehicle ownership. Individuals with access to a private vehicle see their levels of accessibility increase near the centre of the city, especially for low income residents, since they tend to travel longer distances on average around this area. However, these gains in the centre of town are not accompanied by higher levels of accessibility in more peripheral locations of the city. These results overall indicate the relative concentration of retail food outlets in the central parts of Montreal city, and the importance of vehicle ownership for retail food access.

The situation is somewhat different for the case of accessibility to fast food outlets, since now it can be seen (Figure 48) that, while the higher levels of accessibility are not so pronounced in the area around the CBD, fast food remains more accessible in wider areas, including some accessibility patches in various sectors in the suburbs of the city. This effect is also enhanced for the case of individuals in vehicle-owning households, and is slightly more marked for low income people particularly around the central parts of Montreal. The general picture is indicative of different locational patterns for retail food and fast food outlets, with more centralization in the former and a pattern of centralized dispersion in the later, as well as different travel behavior patterns. The results suggest that patterns of longer distance traveled observed in the peripheral parts of the city are not necessarily followed by high accessibility levels due to the sparse pattern of food services in those regions. At the same time, the distribution of outlets tends to favor lower income households in the center of the city, due to the higher density, and the propensity of individuals in those households to travel slightly longer distances. A clearer picture of the accessibility relationships can be obtained by means of the relative accessibility indicators.

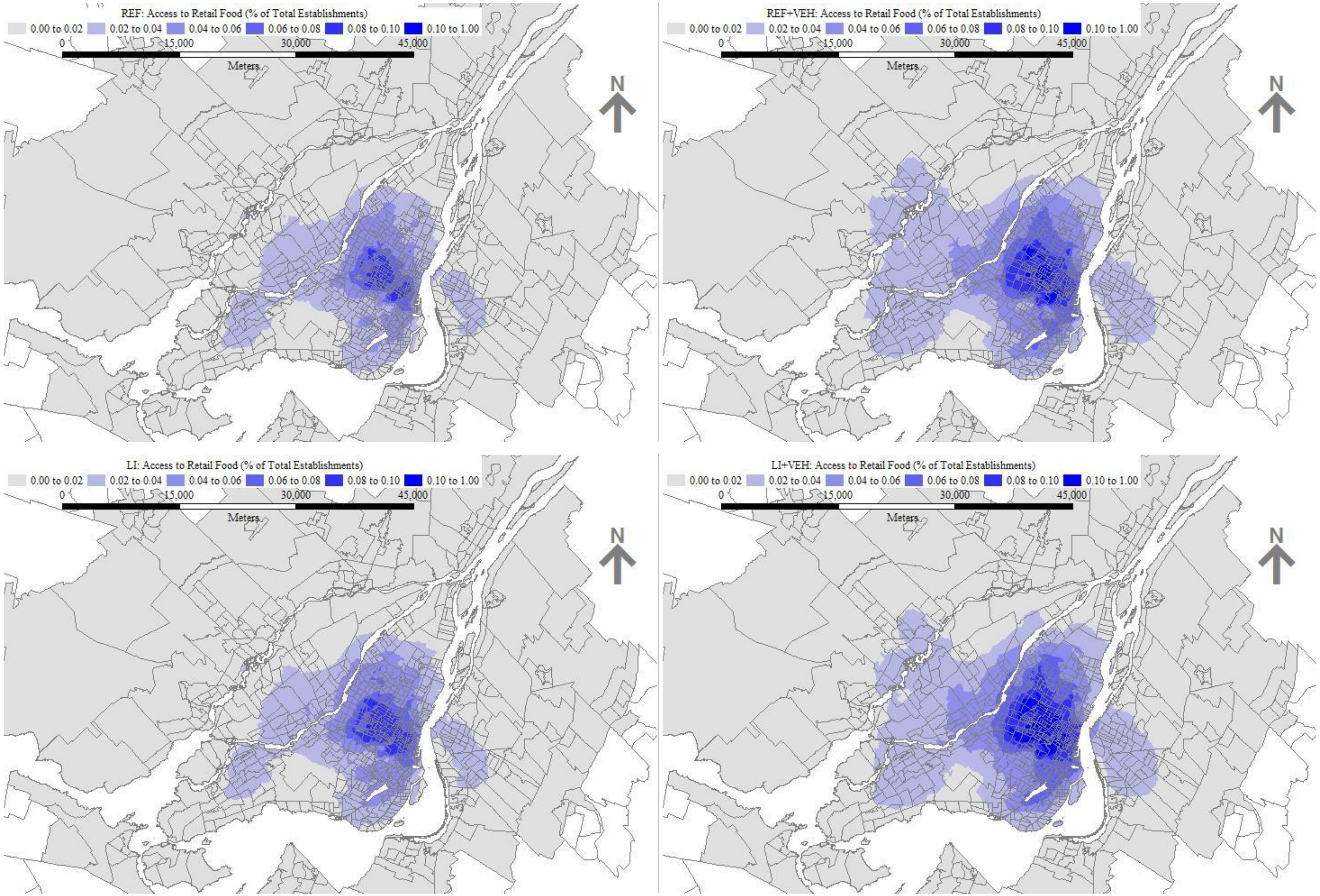


Figure 47: Accessibility to retail food by income and vehicle ownership

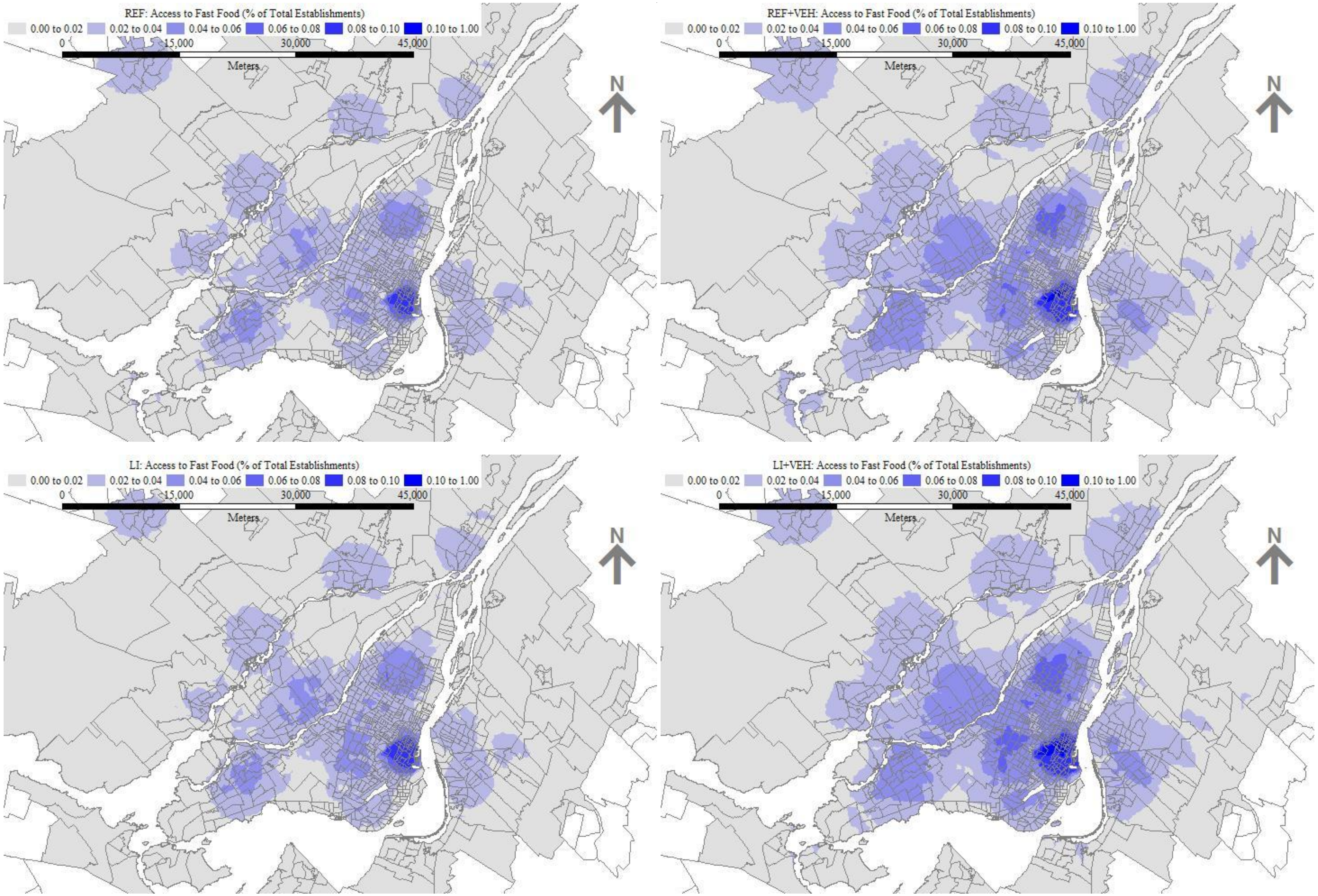


Figure 48: Accessibility to fast food by income and vehicle ownership

5.3.4 Relative Access to Retail and Fast Food by Income Status

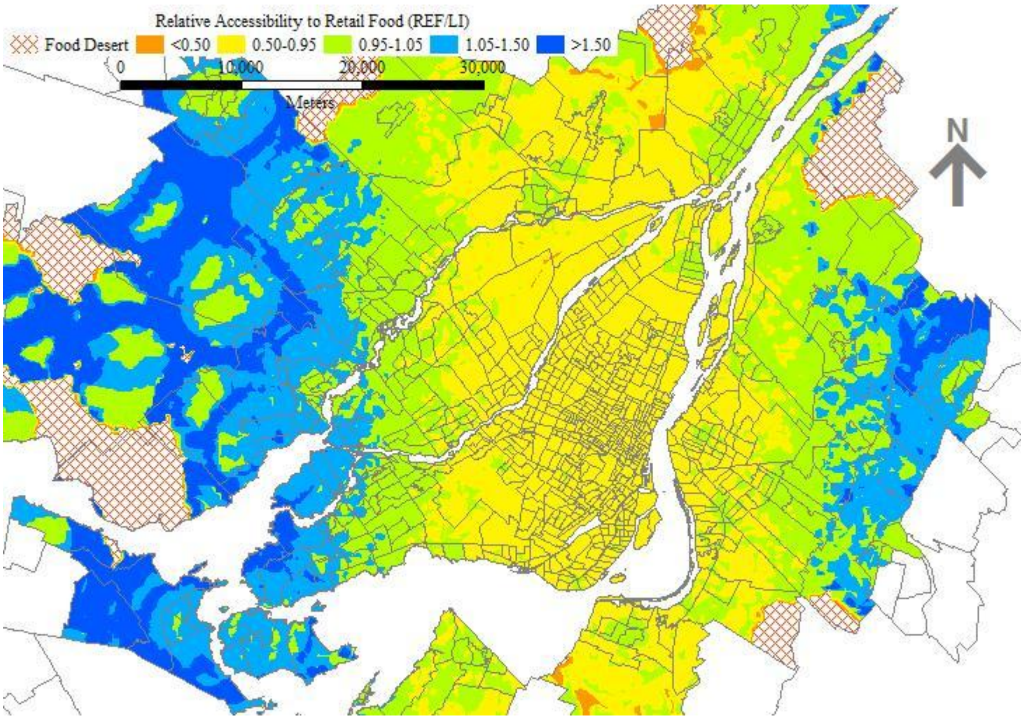
Figure 49 shows the results of calculating the following relative accessibility deprivation indicators. The map on the top of the figure, accessibility to retail food (*HF*) by the reference group (*REF*) with respect to the low income group (*LI*):

$$R^{HF}_{REF/LI} = \frac{A^{HF}_{REF}}{A^{HF}_{LI}} \tag{8}$$

The bottom map displays accessibility to fast food (*FF*) by the reference group (*REF*) with respect to the low income group (*LI*):

$$R^{FF}_{REF/LI} = \frac{A^{FF}_{REF}}{A^{FF}_{LI}} \tag{9}$$

The figures are useful to identify locations of accessibility deprivation. For instance, in the case of access to retail food, it can be seen that low income individuals enjoy relatively high levels of accessibility in the vertical band extending from the central city. Values of 1 indicate accessibility parity, that is, the reference group and the group for comparison have access to identical number of opportunities of the Retail Food type. Values less than 1 indicate locations where low income individuals enjoy access to a greater number of opportunities, whereas values greater than 1 indicate areas where the reference group enjoys access to more opportunities. In most places in this study, this means access to twice as many opportunities, but in some peripheral areas the differential could mean access to as many as 10 times the number of opportunities available to individuals in the low income group. The hatched areas indicate locations where the value of accessibility in the denominator is zero, and thus help to identify potential food deserts. Further analysis of the accessibility indicator for the case of fast food demonstrates that there is a limited number of locations where access to retail food by low income people is zero, and access to retail food by the reference group is different from zero. Thus, for the most part, these areas are indicative of locations with very limited accessibility to retail food outlets. The situation is similar in the case of access to fast food, as it can be seen that there are numerous locations that could be classified as food deserts (as before, there are very few locations with accessibility different from zero in the numerator). In addition to the extent of those areas with limited accessibility to food services, a second difference is that the advantage enjoyed by low income individuals in the case of access to retail food, especially in the central parts of Montreal, is less pronounced in the case of access to fast food. In other words, despite the greater extent of food deserts with respect to fast food, where it is available, accessibility to fast food is relatively more egalitarian.



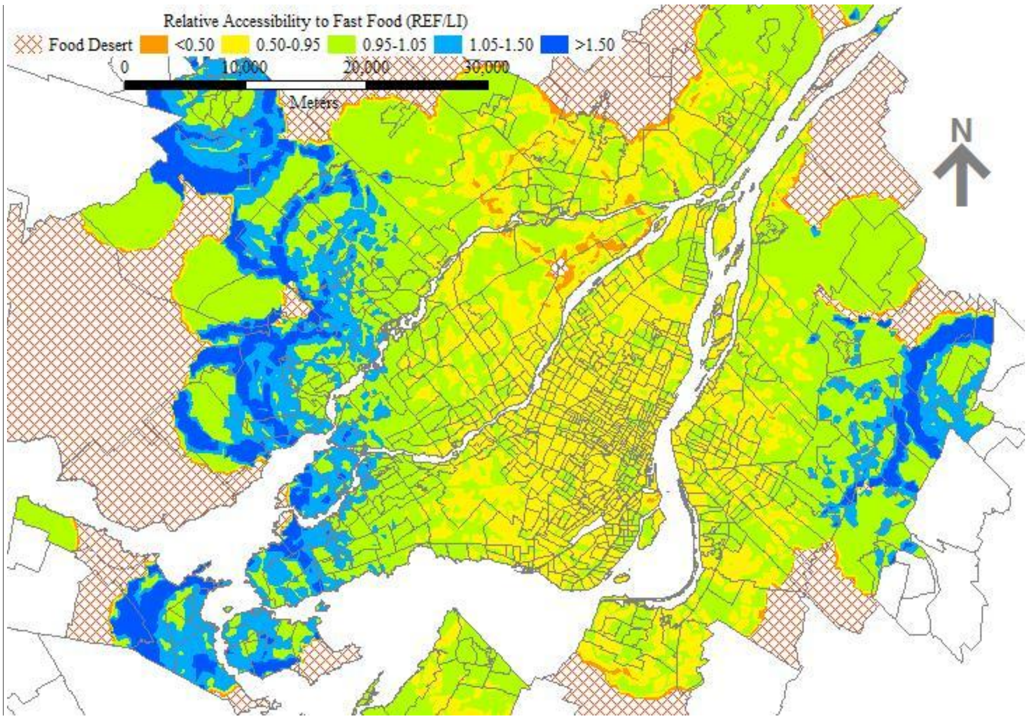


Figure 49: Relative accessibility to retail and fast food by income status

5.3.5 Relative Access to Retail and Fast Food by Low Income Individuals

A final comparison can be made in terms of relative access to fast food with respect to retail food by low income individuals, by plotting the following relative accessibility deprivation indicator:

$$R_{LI}^{FF/HF} = \frac{A_{LI}^{FF}}{A_{LI}^{HF}} \quad (10)$$

This indicator addresses the question of whether low income people have better or worse access to fast food, relative to retail food. The results appear in Figure 50. As before, a value of 1 indicates accessibility parity – that is, locations where low income individuals have access to equal *proportions* of retail and fast food outlets. Values greater than 1 indicate locations where there is relative accessibility deprivation of retail food outlets with respect to fast food. A typical value tends to be around 1.5, which indicates that in such a location, a low income individual has access to 50% more of the proportion of opportunities for fast food, compared to the proportion of opportunities for retail food. Again, the blank areas indicate potential food deserts, and their presence is confirmed by checking that there are no locations where A_{LI}^{HF}=0 and $A_{LI}^{FF}\neq 0$. Places where A_{LI}^{FF}=0 are indicative of areas where there is no access to fast food, but access to retail food is $A_{LI}^{HF}>0$. These locations tend to be in the outlying regions of the city, in places poorly served by fast food outlets, but that remain accessible to at least one food service location classified as retail. Overall, it can be seen that besides the center of the city, and a few isolated pockets of relative deprivation in terms of fast food (but low absolute accessibility to retail food, see Figure 47), access to fast food and food deserts tend to be fairly prevalent for low income individuals in the city of Montreal.

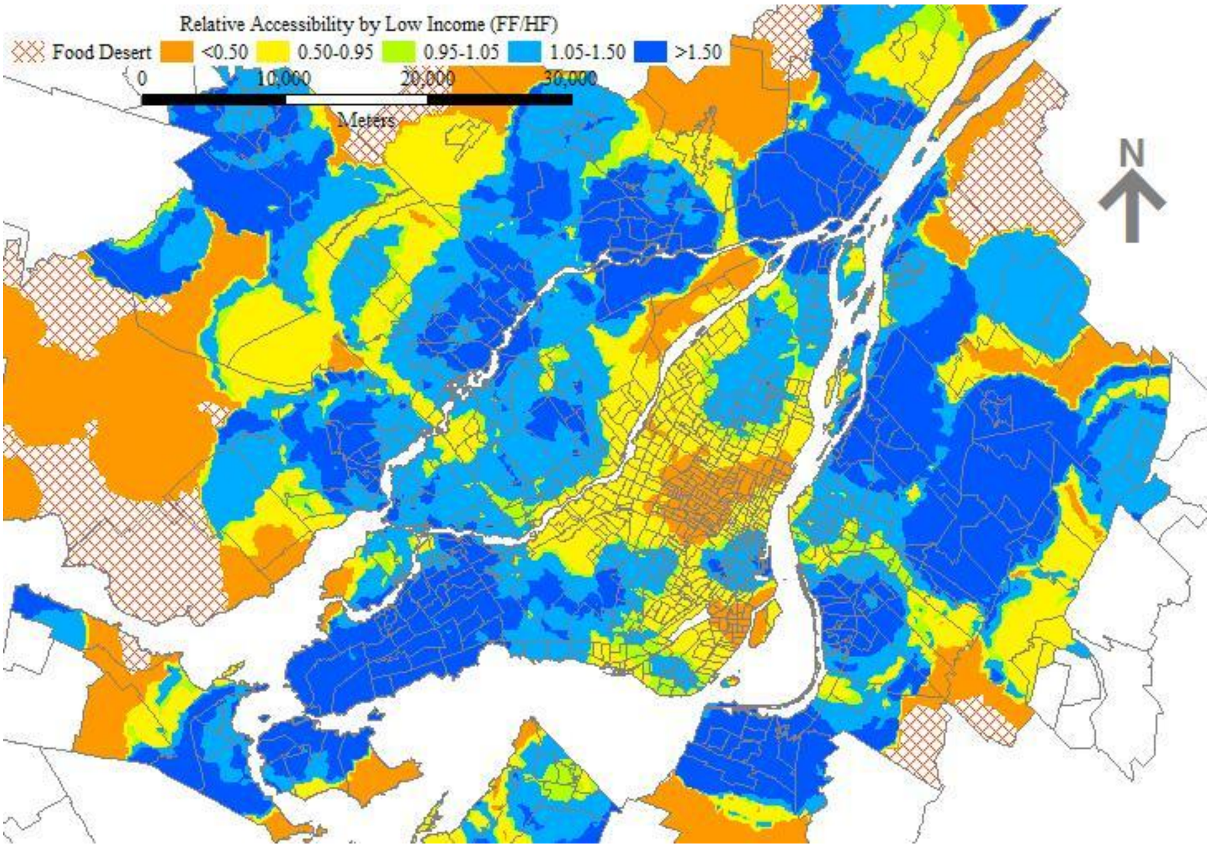


Figure 50: Relative accessibility of low income individuals by food location type

5.3.6 Discussion

The results of investigating accessibility to retail and fast food in the city of Montreal indicate that there are some important differences in accessibility to these services, depending on the income status of the individual, and also whether the person lives in a vehicle-owning household. In general, people in low income households tend to enjoy parity or better accessibility near the center of the city, but are at disadvantage from an accessibility perspective in the more peripheral parts of the city. While vehicle ownership tends to increase accessibility, the gains do not translate into much higher accessibility in the suburbs. The analysis also reveals that access to fast food is more egalitarian with respect to income status, and that fast food is generally more accessible, with the exception of locations near the centre of the city and some isolated points in the periphery. Finally, the results of the analysis are helpful to identify several areas in the city of Montreal that could be classified as food deserts.

5.3 Accessibility to Health Care in Hamilton from the Perspective of Seniors

5.4.1 Context for Application

There is at present a growing amount of evidence that besides the financial responsibilities that accompany health insurance coverage, barriers to health care are related to the socio-demographic characteristics of the individual and the environment within which the individual accesses health services. Included in the individual-based barriers are those that concern a person's age, race, income, gender, education and subjective satisfaction with service providers (Fitzpatrick et al, 2004; Janes et al, 1999; Hsia et al, 2009; Escarce et al, 1993; Schneider et al, 2002; Gormick, 1999). There have also been studies looking at the relational aspect of the individual and found some connections with the size and closeness of their social networks (e.g. Litwin and Landau, 2000; Phillips et al, 2000; Rittner and Kirk, 1995). Barriers to receiving health care also include cultural and linguistic factors (Janes et al, 1999). A recent study among older Chinese immigrants in Canada confirms most of these factors showing the following significant barriers to health service: being female, single, shorter length of residency, income, social network, health beliefs, and their self-identification as Canadian (Lai and Chau, 2007). As to oral health access, a review of evidence from studies in the US underlined the increasing diversity and unmet demand of the older adult population and the emerging dental workforce issues including training opportunities in gerontology and geriatrics for dental practitioners (Dolan et al, 2005).

Barriers with respect to place or spatial factors include the location and distribution of health care services location and the quality of the transportation infrastructure available to reach them. These barriers have been variously termed in the literature as "spatial factors" (Wang and Luo, 2005) or "structural or physical barriers" from the patient's standpoint (Janes et al, 1999). Studies on these aspects are few and have not focused on the elderly as a vulnerable population group. However, the results of these studies could reveal some aspects of the environment that act as barriers to health care access. A study in the UK which analyzed patient choice policy (i.e. people can choose the hospital where they would like to be treated) found that the use of services decreases with distance (Exworthy and Peckham, 2006). However, distance as a barrier alone does not fully explain accessibility as there are other important factors that interact with it such as the quality of these services, the socio-economic characteristics of the patient, the perception of the provider, and the past experience with the service or re-treatment (Exworthy and Peckham, 2006). Transportation factors come into play with respect to accessibility to the locations of services. Lack of access to a private vehicle has been found to restrict access to health and social care resources (Bostock, 2001). The elderly population becomes at risk when driving reduction or cessation eventually occur due to medical conditions that in turn limits their activities outside the home including visit to a doctor or a dentist. The role of conventional and specialized public transport becomes an important alternative to the automobile (Alsnih and Hensher, 2003). The present study contributes to the little work yet done in Canada on accessibility to health care services in general and among the elderly population, in particular.

5.4.2 Business Data Points

The setting for this case study is the city of Hamilton. Estimates of distance traveled derived in Chapter 4 are complemented with information extracted from the Business Point Data file. For the purpose of this analysis, the points extracted correspond to Hamilton and surrounding regions, to provides broad geographical coverage of health care opportunities. The points correspond to establishments with Standard Industrial Codes 8011 – Medical Doctors, and 8021 – Dentists. These are locations where primary health care can be obtained. The spatial distribution of health care opportunities is shown in Figure 51 below.

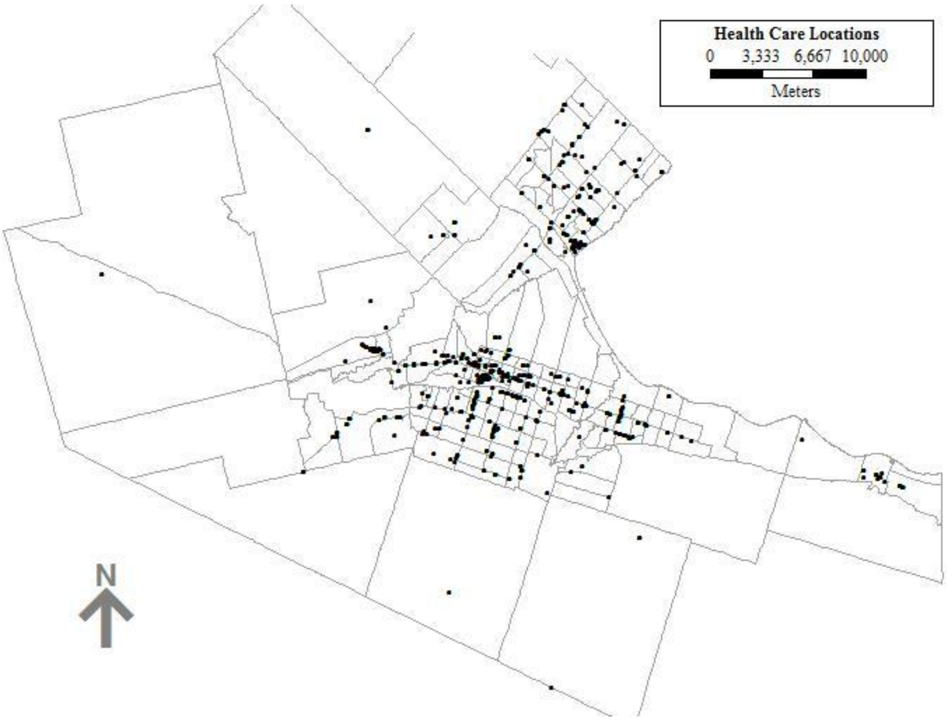


Figure 51: Distribution of health care locations in Hamilton

5.4.3 Accessibility to Health Care by Age and Vehicle Ownership

Accessibility measures are calculated for access to health care providers, and the results are shown in Figure 52. In line with the spatial distribution of opportunities, the levels of accessibility tend to be high in the central part of the region. Towards the suburbs, seniors and non-seniors alike tend to travel longer distances (see Chapter 4). However, in many cases, longer travel distances remain insufficient to reach many health care locations.

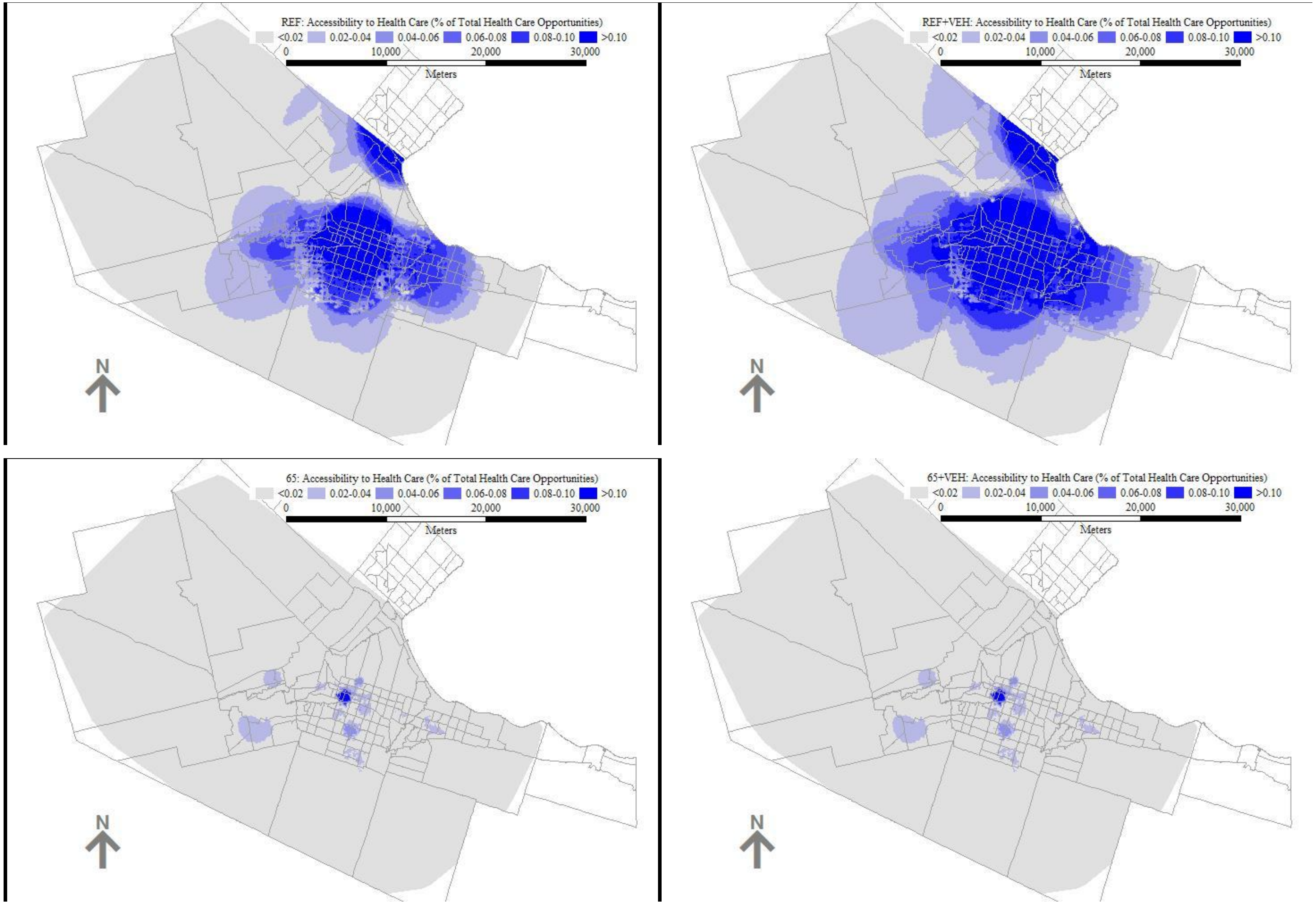


Figure 52: Accessibility to health care by age and vehicle ownership

In particular, the accessibility patterns show that besides a restricted area near the center of town, seniors face extremely low levels of accessibility to primary health care services. Whereas non-seniors see their accessibility levels increase with vehicle ownership, the effect of owning a vehicle is negligible for the case of seniors. The differences between these two populations with respect to health care opportunities are so stark that there is little point in formalizing the relationship by means of relative accessibility analysis. Clearly, the accessibility situation of seniors in the city is far from ideal.

5.4.4 Discussion

Analysis of accessibility to health care services in Hamilton from the perspective of seniors provides, of the case studies implemented in this chapter, the clearest indication of accessibility deprivation by a vulnerable group. Whereas the levels of accessibility for the reference group tend to be relatively high throughout the most densely populated parts of the city, seniors have lower accessibility even in central locations. Vehicle ownership improves the accessibility of non-seniors, but does not confer any discernible accessibility advantages to seniors. This result is in line with previous findings about the travel behavior of seniors who rely on their private vehicles (Mercado and Páez, 2008). While the analysis does not automatically imply that seniors have no access to health care services at all, it does indicate that health care service locations tend to be beyond the typical activity spaces of seniors. This raises concerns about the ability of seniors in Hamilton to meet their primary health care needs, a fact that may have broader implications, given the connections between primary health care and preventable emergency hospitalization. Clearly, more research in needed to clarify the relationships between accessibility and actual use of primary health care services.

CHAPTER 6 Shopping Participation: An Investigation of Time Use Patterns

Summary:

- The ability to **participate** in an **activity** is the product of both physical access, and a sufficient amount of available **time** to perform the activity.
- The combination of **mobility** and **individual-spatial** attributes **constrains time-use** patterns. Also, time spent on one activity limits the amount of available time to spend on another.
- **Activity duration** provides an indication of **ability** to **perform** daily activities.
- **Shopping durations** and **travel times** are modeled using a **simultaneous equations** approach.
- **Estimates** of shopping and trip durations represent activity participation trends for different **population groups** with different **activity profiles**.
- The **elderly** spend more time on shopping related travel, and less time actually shopping.
- **Household income** increases the amount of time spent shopping.
- **Lone-parent** status does not appear to impact shopping durations.
- Trip times are decreased for holders of **drivers licenses**.

6.1 Background and Objectives

The final phenomenon investigated in this report is the interplay between mobility, time use, and exclusion. Situating this objective within the operational framework Figure 53, we are looking at the connection between mobility and time use while simultaneously investigating the direct connections between individual-spatial attributes and time use. A majority of the research on social exclusion reported in the literature to date, including that reviewed and completed in the preceding sections, has been concerned with the *spatial* aspects of transportation and accessibility. Bittman (2002) brings a different perspective to the problem when he states, in the context of participation in leisure activities, that "the ability to participate in leisure is the product of both access to leisure goods and services, and a sufficient amount of leisure time". This insight, of course, applies to a host of other activities besides leisure, and while research on the topic in the field of transportation has generated valuable information regarding access to opportunities, there have only been glimpses so far regarding the potential of more in depth investigations of the temporal dimension of mobility and exclusion. This is the case of Lyons (2003), who mirrors the views of Bittman when reflecting, in a paper that forms part of a special issue on Transportation and Social Exclusion (Hine, 2003), that the combined effect of time use, management, and constraints, is one of five factors that govern the understanding and influencing of exclusion. Likewise, Kenyon (2003) identifies time poverty as a one of nine dimensions of exclusion. These early pointers towards the relevance of time use perspectives notwithstanding, there are still very few examples of time use pattern analysis applied to social exclusion.

In this section, a time use perspective is adopted and applied to the analysis of shopping activities and the social exclusionary implications of time use patterns. In other words, attention is now turned to the temporal constraints that may affect activity participation. There are several reasons why shopping activities are germane to social exclusion research. First, shopping for groceries, pharmaceutical needs, and everyday items such as clothing are essential activities for sustaining life. Second, and especially in North America, shopping is a primary social and leisure activity. Third, access to medical, financial, and government services is essential to the entire population but perhaps even more so to populations at risk. Finally, travel pertaining to shopping for goods and services represents a growing fraction of overall travel demand indicating the growing significance of this activity to the members of society.

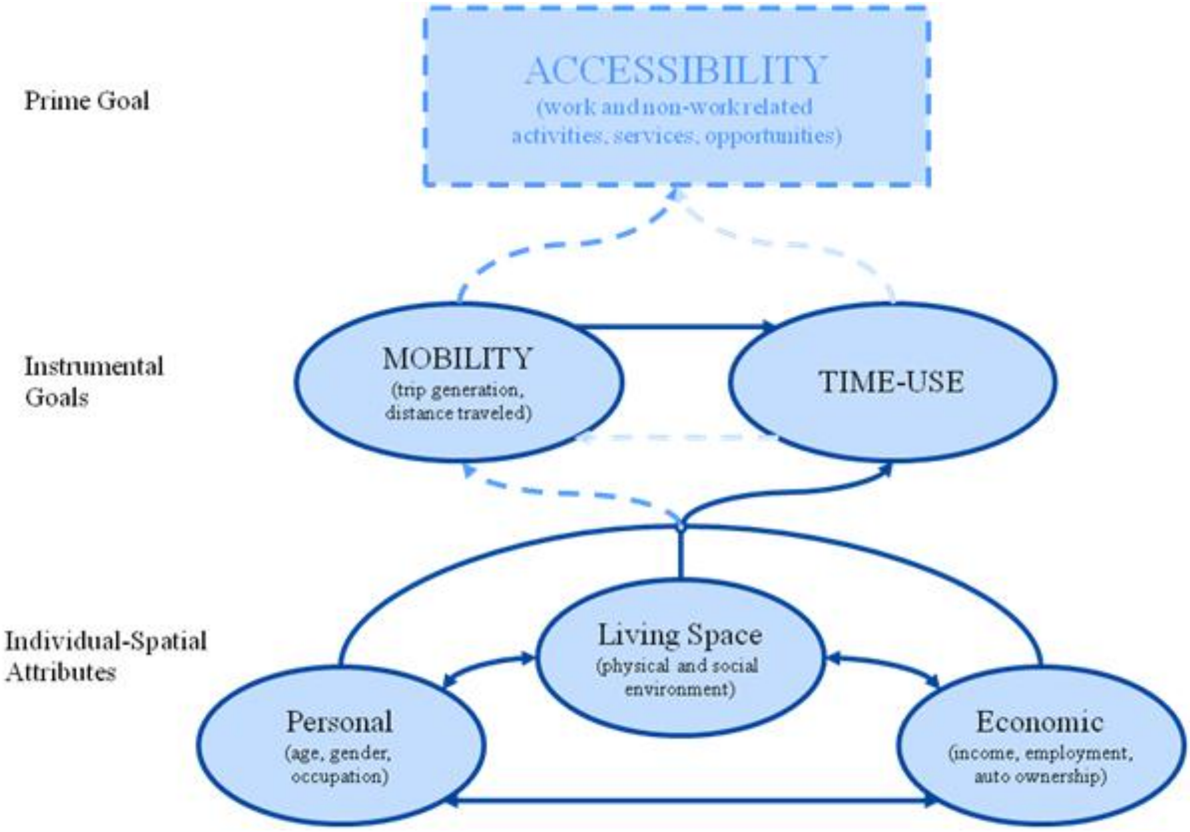


Figure 53: Conceptual framework: Time Use

6.1.1 Time Use Approaches

There is a growing awareness that the subtleties of accessibility, mobility and time constraints must be brought into the equation to in order to derive a more complete representation of the system of exclusion (Lucas et al, 2001; Cass et al, 2005; Lyons, 2003). This necessitates an integrated approach to recognizing the individual constraints on mobility and accessibility with respect to activity patterns, socioeconomic status, demographics, and time use. The time use approach provides a perspective of the temporal context of at-risk population segments that complements the previously discussed spatial perspectives.

The link between time-use and transportation analysis was first hypothesized by Javeau (1972) who theorized a direct relationship between traffic density and the time constraint associated with compulsory travel. Time use approaches share a vital connection with the activity based approach to transportation analysis. This conceptual system of activity analysis in turn draws heavily from models of temporal-spatial behavior, notably time-geography (Hägerstrand, 1970; Miller, 2005; Neutens et al, 2008), which part from the observation that space-time behavior is conditioned by time budget constraints and the necessity to participate in activities at fixed locations.

6.1.2 Data for Analysis

As previously noted, the entire GSS survey contains more than 19,000 respondents over the age of 15 from across the country, of whom about half were asked questions pertaining to transportation, accessibility and social networks. Of these, 2,108 resided in Toronto, Montreal or Hamilton. After removing respondents with extreme valued durations (greater than 3 standard deviations from the mean) and selecting those that performed shopping activities and shopping trips (see Section 4), a final sample for analysis was obtained consisting of 685 respondents. Numerical descriptions of the categorical control variables and the continuous variables used in the analysis appear in Table 8 and Table 9.

Table 8: Descriptive statistics for categorical variables

Variable	**n**	**%**	**Variable**	**n**	**%**
Age: 15-20 years	14	2.0%	Personal income: $60K-$80K	55	8.0%
Age: 20-35 year	171	25.0%	Personal income: $80K-$100K	9	1.3%
Age: 36-50 years	221	32.3%	Personal income: Greater than $100K	33	4.8%
Age: 51-64 years	164	23.9%	Personal income: Unknown	178	26.0%
Age: over 65 years	115	16.8%	Family status: Single	144	21.0%
Female	415	60.6%	Family status: Couple	191	27.9%
Employment: Full time	317	46.3%	Family status: Couple with kids	220	32.1%
Employment: Part time	55	8.0%	Family status: Child with parents	51	7.4%
Employment: Student	44	6.4%	Family status: Single parent	60	8.8%
Employment: Not employed	259	37.8%	Family status: Child with only 1 parent	18	2.6%
Employment: Unknown	10	1.5%	Toronto	341	49.8%
Household income: less than $20K	51	7.4%	Montreal	299	43.6%
Household income: $20K-$40K	72	10.5%	Hamilton	45	6.6%
Household income: $40K-$60K	103	15.0%	Survey day: Monday-Friday	433	63.2%
Household income: $60K-$80K	104	15.2%	Survey day: Saturday	149	21.8%
Household income: $80K-$100K	58	8.5%	Survey day: Sunday	103	15.0%
Household income: Greater than $100K	123	18.0%	Has drivers license	561	81.9%
Household income: Unknown	174	25.4%	Access to vehicle: all the time	453	66.1%
Personal income: less than $20K	150	21.9%	Access to vehicle: part of the time	88	12.8%
Personal income: $20K-$40K	164	23.9%	Access to public transport	600	87.6%
Personal income: $40K-$60K	96	14.0%			

Table 9: Descriptive statistics for continuous variables

Variable	Mean	SD	p25	p50	p75
SS duration	98.6	83.0	35	75	130
SS trip duration	38.5	27.1	20	30	50
WKEDU duration	138.5	218.7	0	0	285
WKEDU trip duration	13.5	29.2	0	0	10
SOCIAL duration	143.0	150.9	0	90	230
SOCIAL trip duration	18.0	36.9	0	0	20
DOMCARE duration	792.5	190.6	650	790	930
DOMCARE trip duration	11.5	27.8	0	0	10
Driver duration	51.5	58.4	0	35	80
Passenger duration	12.5	28.7	0	0	10
Public transportation duration	10.5	31.5	0	0	0
Other mode duration	1.6	14.6	0	0	0
Walking and bicycling duration	8.9	22.9	0	0	5
Driver percent	0.6	0.5	0	1	1
Passenger percent	0.2	0.3	0	0	0.1
Public transportation percent	0.1	0.3	0	0	0
Other mode percent	0.0	0.1	0	0	0
Walking and bicycling percent	0.1	0.3	0	0	0.0
Distance to Toronto CBD[a]	10.9	14.7	0	0	18.9
Distance to Montreal CBD[b]	7.2	11.3	0	0	10.8
Distance to Hamilton CBD[c]	0.6	2.6	0	0	0
Factor: Social Enjoyment	0.0	1.0	-0.8	-0.2	0.7
Factor: Domestic Enjoyment	0.0	1.0	-0.7	0.1	0.7
Factor: Entertainment Enjoyment	0.1	1.0	-0.5	0.3	0.9
Factor: Shopping Enjoyment	0.0	1.0	-0.8	-0.2	0.7
Factor: Work Enjoyment	-0.1	0.9	-0.9	-0.5	0.4
Number of children 0-4 years at home	0.1	0.3	0	0	0
Number of children 5-12 years at home	0.2	0.6	0	0	0
Number of children 13-18 years at home	0.2	0.4	0	0	0

a. equals zero if respondent does not reside in Toronto; b. equals zero if respondent does not reside in Montreal; c. equals zero if respondent does not reside in Hamilton

6.2 Methods

Activity and trip durations are estimated simultaneously using a Simultaneous Equations Model or SEM (Greene, 2002). This model allows for the simultaneous estimation of multiple linear regression equations when the process in each equation (activity durations in this case), is dependent on another. In addition to modeling the impact of exogenous factors on activity durations, the model as implemented incorporates two types of endogenous relationships: trip/activity and activity/activity. The first pertains to the hypothesis that people decide their trip and activity durations simultaneously. For example, if one spends a great amount of time travelling to a shopping destination, it is likely that they would decide to spend more time shopping; in a sense to make the trip more worthwhile. Alternatively, it could be argued that people are not likely to spend a lot of time travelling when their desired shopping duration is small. This hypothesis is tested via the introduction of the shopping trip duration term on the right hand side of the shopping activity duration equation. The trip duration terms for the other three activity classes were similarly included on the right hand sides of their associated activity duration equations. The second type of endogeneity, activity/activity, is a result of the daily time budget constraint. Self-evidently, any time spent on one activity necessarily reduces the amount of time available to spend on another, but whether or not two activities can be thought of as compliments or substitutes will affect the size of the effect of one's duration on another. For example, a home-keeper may have long durations of grocery shopping and child-care relative to the primary income earner in a household who has more prolonged working durations. In this scenario, grocery shopping and child-care may be considered to be complimentary activities, while grocery shopping and working are substitutes. Over and above the fact that activity durations vary from person to person due to tastes, constraints, and socio-economic characteristics, the complimentary or substitute nature of sets of activities adds another layer of variation to be explored in the model.

Obtaining a proper model specification for eight simultaneous regressions with more than 60 exogenous variables is quite a large task that calls for the use of a supervised specification search algorithm. Given that forward stepwise regression is controversial due to omitted variable bias and path dependencies (Greene, 2002), it was deemed more appropriate to proceed with an equation by equation backward stepwise regression. The modeling strategy starts by including all of the exogenous variables and a selection of endogenous variables in each equation and proceeds by removing the variable with the highest *p*-value greater than 0.1 at each iteration. Note that the trip duration variables were only included on the right hand side of the equation that relates to its activity class. Furthermore, since the focus of this analysis is on the *shopping for goods and services* activity, the time spent on each of the other activities is included on the right hand side of the SS duration equation.

6.3 Results

The fact that the regression model can determine the impact of a factor while holding constant and separating out the impacts of other factors is its greatest advantage over simple descriptive statistics, and is especially useful in testing theories relating accessibility, mobility and socioeconomic conditions to measures of social exclusion in terms of time spent participating in a variety of daily activities. So, from a policy perspective, examining the individual impacts of factors should inform the policy design process. Accordingly, an objective of the analysis is to determine if the various sub-setting factors, namely age, income, and single parent status, are significant predictors of activity patters while controlling for a wide range of socioeconomic factors, transportation accessibility, personal mobility and the daily time budget constraint.

6.3.1 Model Summary

The model summary and fit statistics of the stepwise simultaneous equation regressions are in Table 10. Notice that the number of significant factors and the R^2 values vary greatly from equation to equation. Most importantly, the equations for the focal SS duration and SS trip duration achieve a level of fit commensurate with, if not slightly higher than, other models in the literature (Bhat, 1996; Páez et al, 2008; Rosen et al, 2004). All of the models are significantly more powerful predictors than their means as indicated by the χ^2 test results. In addition, the residuals show a high albeit varied amount of between-equation correlation, indicating that the selected three-stage method of estimation is indeed appropriate and required to increase efficiency of the estimators. It is interesting to note that the models are generally more accurate predictors of the activity durations themselves in comparison to their association trip durations. This indicates that the spatiality of the activity locations, which in turn induces travel times, is not captured very well by these models. Of course, it is very difficult to model travel times without understanding the landscape of activity opportunities available to each respondent. Alas, a more complete spatial analysis is not feasible due to the data sparseness for individual urban areas in the GSS database.

Table 10: Time-use model summary

Equation	**Obs**	**Params**	**RMSE**	R^2	**Adjusted** R^2	χ^2	***p*-value**
SS duration	685	16	0.88	0.1531	0.1328	206.3	0.0000
SS trip	685	14	0.72	0.1252	0.1069	108.1	0.0000
WKEDU duration	685	9	3.16	0.7285	0.7249	1233.9	0.0000
WKEDU trip	685	16	3.64	0.4036	0.3893	469.1	0.0000
DOMCARE duration	685	25	0.22	0.2598	0.2317	278.8	0.0000
DOMCARE TRIP	685	10	4.42	0.1115	0.0983	87.3	0.0000
SOCIAL duration	685	14	4.56	0.2462	0.2304	132.4	0.0000
SOCIAL trip	685	15	4.88	0.0609	0.0398	54.3	0.0000

6.3.2 Interpretation of Endogenous Effects

The coefficients retrieved by the final stepwise regression for the SS equations are listed in Table 11. The top half of the table pertains to the SS activity duration equation while the bottom contains the results for shopping trip durations. Notice the coefficients for the endogenous variables appearing on the right hand side of the equation. First, the SS trip duration variable is positive and significant, indicating that longer shopping trips result in longer shopping durations. Conversely, the coefficients for the other endogenous factors indicate that time spent working or at school, time spent socializing and time spent on domestic and personal care all reduce the amount of time spent shopping. Keeping in mind that the logarithms of all duration variables have been used in the models and not the distances themselves, the coefficients are considered elasticities and can be interpreted as follows: a 10% increase in SS travel duration will result in a 6.7% increase in SS duration; a 10% increase in WKEDU duration results in a 0.6% decrease in SS duration; a 10% increase in SOCIAL duration results in a 1% decrease in SS duration; and a 10% increase in DOMCARE duration results in a 9% decrease in SS duration. The fact that these elasticities largely reflect the relative lengths of the durations with respect to the total daily time budget is an important observation. To illustrate this point, observe in Table 9 that the median DOMCARE duration is nearly 13 hours, so a 10% change is likely to have a big effect on the amount of free time for other activities. Conversely, the median SOCIAL duration is 90 minutes, so a 10% change would not have a large impact on the amount of free time for other activities. Keeping this in mind, it is possible to examine the impact of working 4 hours versus 8 hours, the standard half- and full-time working day in Canada. The jump from 4 hours to 8 hours represents a 100% increase in WKEDU duration which according to the elasticity will result in a 5.5% decrease in SS duration, quite a small change given the very large change in time commitment. Since the elasticity of SS with respect to WKEDU is nearly zero, we can argue that the two activities are weak substitutes.

Table 11: Coefficients for the SS and SS trip duration models

Variable	Coefficient	Std. Err.	|z|	P>|z|
SS duration Equation				
Constant	8.038	1.900	4.23	0.0000
SS trip duration	0.669	0.079	8.51	0.0000
WKEDU duration	-0.055	0.012	4.67	0.0000
SOCIAL duration	-0.091	0.014	6.45	0.0000
DOMCARE duration	-0.943	0.267	3.53	0.0000
Age: 15-20 years	0.750	0.232	3.23	0.0010
Age: over 65 years	-0.788	0.179	4.41	0.0000
*Distance to Hamilton CBD	0.073	0.034	2.19	0.0290
Employment: Full time	-0.186	0.087	2.14	0.0320
Survey day: Saturday	0.238	0.085	2.80	0.0050
Hamilton	-0.289	0.135	2.15	0.0320
Has drivers license	-	-	-	-
*Age: over 65 years	0.372	0.188	1.98	0.0480
*Household income: less than $20K	-0.598	0.169	3.54	0.0000
*Personal income: less than $20K	0.383	0.103	3.72	0.0000
*Distance to Toronto CBD	0.011	0.004	2.73	0.0060
Access to public transport	0.321	0.114	2.83	0.0050
*Distance to Toronto CBD	-0.012	0.005	2.70	0.0070
SS trip duration Equation				
Constant	3.934	0.093	42.35	0.0000
Factor: Shopping Enjoyment	-0.079	0.027	2.87	0.0040
Age: 15-20 years	-1.107	0.214	5.17	0.0000
Age: over 65 years	0.165	0.100	1.65	0.0990
*Distance to Toronto CBD	-0.011	0.005	2.32	0.0200
Employment: Full time	-0.174	0.065	2.69	0.0070
Employment: Student	0.336	0.130	2.58	0.0100
Number of children 0-4 years at home	-0.199	0.096	2.08	0.0380
Montreal	-0.121	0.058	2.07	0.0380
Has drivers license	-0.422	0.081	5.18	0.0000
*Distance to Hamilton CBD	0.060	0.024	2.45	0.0140
Access to public transport	-	-	-	-
*Distance to Hamilton CBD	-0.092	0.025	3.62	0.0000
Access to vehicle: part of the time	0.162	0.082	1.98	0.0470
Walking and bicycling percent	-0.367	0.098	3.73	0.0000
Personal income: less than $20K	-	-	-	-
*Family status: Single parent	-0.611	0.211	2.90	0.0040

6.3.3 Interpretation of Exogenous Factors

Interpretation of the remaining coefficients, those for solely exogenous factors, is similar to that for ordinary least squares with a logged dependent variable. For the binary variables in the model, this means that the coefficients are simply a prediction of percentage change in duration with respect to a one unit change in the independent variable. For example, the coefficient for *Age: over 65 years* suggests that being a senior, holding all else equal, decreases daily SS duration by 79%. Furthermore, the interaction of being a senior and distance from the Hamilton CBD indicates that for seniors in Hamilton, SS durations increase at a rate of 7% per kilometer as respondents reside further and further away from the centre of the city.

Overall, the coefficients for the exogenous factors paint an interesting portrait of how shopping behavior varies with lifestyle and lifecycle stage. According to the models, we find that being a senior significantly reduces the amount of time spent shopping for goods and services, and at the same time, increases the length of trips associated with said activities. It is not in the scope of the model to determine if the increased travel times seniors face are due to accessibility and mobility restrictions or if simply they choose to travel further to reach their desired destinations. Further, the fact that being a senior tends to decrease SS durations is not necessarily indicative of a social issue but rather may just be an indication that seniors have different time-use preferences that include shorter SS durations. It is even more critical however to note that this model does not imply causation between longer SS travel times and shorter SS durations for seniors. Further follow-up studies should be used to determine the extent to which these hypotheses can be confirmed or denied.

The interaction between *Has drivers license* and *Age: over 65 years* suggests that the negative impact of being senior on SS durations is moderated by the possession of a drivers license. In particular, whereas the effect of having a driver's license in general is insignificant, we find that seniors without licenses tend to have 79% shorter SS durations and seniors with licenses only have 42% shorter durations. Curiously, possession of a drivers license significantly interacts with a number of relevant socioeconomic factors. For example, amongst licensed drivers, low personal income results in increased SS durations, whereas low household income results in greatly reduced SS durations. The income effect suggests that low-income members of households, presumably charged with shopping responsibilities for the household, have longer durations, while the effect of low income status at the household level is strong and negative. Why these effects are only significant for those respondents with driver licenses is unclear at this time, however this points to the notion that accessibility and mobility play important albeit somewhat complex roles in the duration of shopping and services activities.

Importantly, the coefficient for the single parent status indicator never achieved significance in the model for SS duration and was thus removed in the backward stepwise procedure. This suggests that upon explicitly controlling for socioeconomic factors, mobility, and time-use patterns, single-parent status by itself does not directly impact shopping durations.

As with SS duration, socioeconomic factors also significantly impact how long people spend travelling for goods and services. Holding all else equal, it is possible to see that teenagers spend significantly less time travelling for goods and services in comparison to the mean, while seniors spend significantly more time. The impact of being a senior, however, declines for Toronto residents as they live farther from the centre. This suggests that downtown seniors travel longer for goods and services compared to those in the suburbs. This is quite puzzling since it opposes the prevailing logic that activity dense downtowns require shorter trip times compared to the sparsely populated suburbs. It is important to remember when interpreting these results that there is no a priori reason to consider longer or shorter trip times as a positive or negative outcome, as this outcome may reflect a preference for suburban retail locations. At this point, the results merely serve to support the assertion that seniors in general have longer trip times, and this effect is strongest in the centre of Toronto.

Perhaps even more striking than the impact of age on travel times is the impact of low income single parent households. According to the model, being a low-income single parent reduces trip times by more than 60%. Similarly, for each child at home below the age of four, a parent's travel time is reduced by nearly 20%. A plausible explanation for this is that parents, especially single parents, cannot afford to spend much time travelling for goods and services given their extra demand for spending time on child and household care. We may use the contrary argument now to suggest that seniors have longer travel times merely because they have lots of free time, and so, they can afford to spend more time travelling for goods and services. Again, to be certain of this claim, more theory must be developed, ideally supported through additional qualitative research.

Finally, as expected, the general trend for mobility variables is that travel times decrease as mobility increases. This is evident in the 42% reduction in travel times afforded by having a driver's license, or the 16% increase for those who only have partial access to an automobile. Interestingly, we see that the effect of having a drivers license tapers off with distance to the CBD for Hamilton residents, indicating that being a licensed driver is a more significant factor for suburban dwellers compared to those in the centre of the city where public transit and walking are more viable modes of transport. Interestingly, we also see that as the percentage of time travelling by foot or bicycle increases, the amount of time spent travelling for goods and services decreases. This indicates that increased mobility afforded by the automobile, and decreased mobility afforded by foot and bicycle, both *reduce* the amount of time spent travelling for goods and services. Presumably, this can be explained by the spatial configuration of walkers and bikers, concentrated in urban areas, and within shorter distances to shopping opportunities. It is doubtful that walking and biking leads to shorter travel times for those living in the suburbs, but not surprising to find that it has a negative regression coefficient.

6.4 Conclusions

In order to provide a different perspective on the potential factors of social exclusion in Canadian cities, in this section the methods of time use and activity analysis were adopted to uncover the existence of significant variations in the patterns of time spent shopping for goods and services. Based on time use data drawn from the Canadian GSS, a three-stage regression approach was undertaken to allow for the simultaneous estimation of multiple activity durations thereby increasing efficiency and reducing endogeneity bias. The model results, coupled with a simple series of descriptive charts shown in Chapter 2, outlines an interesting and complex story of mobility and time use constraints that ultimately provides a more complete picture of the extent to which some of these factors may be involved in causing social exclusion.

The key findings from the regression analysis are:

- Duration in all other activities have a significant and negative impact on shopping duration.
- Being a senior significantly shortens shopping durations while lengthening trip durations.
- Low-household income decreases shopping durations, but low personal income seems to increase shopping duration.

- Being a low-income single parent has a negative effect on trip length.
- When holding other factors constant, being a single parent does not impact shopping duration.
- Having a drivers license decreases trip times for everyone, and increases shopping durations for seniors.
- Those who walk and bike more frequently, typically travel less time for goods and services.

One of the most interesting findings is that trip length has a positive impact on activity duration. This is not a new finding (Rosen et al, 2004; Schwanen et al, 2004), but deserves more discussion given this study's aim to identify a link between mobility, accessibility and exclusion. In particular, if we assume that longer trip durations are indicative of lower levels of access, and longer activity durations are indicative of less exclusion, then the positive coefficient suggests that lower accessibility is in fact associated with less exclusion. On its face, this is a contradiction of logic and theory, and serves as a reminder of how we should be interpreting the variables in our model. Lacking more in depth qualitative information, it is best to assume that trip duration is simply a complementary time-constraint and not necessarily an indicator of accessibility.

Finally, we note that the objective of the model developed is simply to highlight inequalities in activity patterns amongst three marginalized subgroups: seniors; low-income households; and single-parents. It is important to caution that while low duration and participation rates amongst certain segments of the population may be indicative of barriers to inclusion, typically models cannot identify the discrepancy between the required (or demanded) and achieved (or consumed) activity pattern. For example, longer travel times for shopping may indicate a willingness to travel further for specialty items rather than a lack of personal mobility and accessibility to activity locations. For this reason, while this work draws attention to potential areas for further study, it is premature to draw stronger conclusions about exclusion based on the analysis presented here. In this light, the contribution of this research is to determine the extent to which different marginalizing factors such as age, income, and family status cause reduced levels of participation in shopping activities for goods and services. In order to determine whether the patterns we have discovered truly represent exclusionary processes or if they are merely a realization of varying tastes and preferences for activities and travel, the results presented here should be complemented through additional qualitatively orientated research.

CHAPTER 7 Conclusions and Implications

7.1 Concluding Remarks

The present research project was conceived and implemented with the general objective of understanding the potential social exclusionary implications of the transportation situation in Canadian communities. The instrumental goal of the project was to clarify and document the mobility situation of vulnerable populations in three Canadian cities, paying attention to a host of socio-economic and demographic variables, the availability of mobility tools, and urban population density. The prime goal of the research was to identify the ways in which the mobility situation of individuals in three vulnerable groups affects their access to places associated with their daily needs, relative to the mainstream of society. Population groups considered in this study as vulnerable to mobility and accessibility limitations included seniors, single-parent families, as well as low income households in urban settings. Two different aspects of mobility were analyzed, namely trip generation (as a measure of out-of-home activity participation) and distance traveled (as a proxy for activity spaces). Furthermore, the accessibility situations of single parents, low income, and seniors, were analyzed with respect to employment in Toronto, food services in Montreal, and health care in Hamilton, respectively. In an attempt to be comprehensive, the study also delved into the temporal dimension of mobility and exclusion using the latest General Social Survey of Canada. This part of the report is in line with recent literature that, in addition to the spatial perspective, remarks on the importance of considering time-use patterns when analyzing transport-related social exclusion issues. Indeed, a person's activity participation would not only be affected by his/her ability to reach activity locations but also by the amount of time he/she has to participate in mandatory and preferred activities.

The study was grounded on the theoretical perspectives of spatial mismatch and social exclusion. These two paradigms share the view that transportation is an inextricable element of society that must be considered when trying to understand access deprivation to various economic and social opportunities. After an extensive review of the literature, the concept of social exclusion was adopted for its greater generality and inclusiveness, and used to develop an operational framework for this research, as depicted in Figure 1. Based on the dimensions of social exclusion identified in the literature, the study looked into various individual and spatial factors, including personal, living space and economic attributes, and how in isolation and combination these factors firstly influence mobility and time-use patterns, and ultimately, in combination with the opportunity landscape, determine accessibility.

Overall, this report fills an important gap in the knowledge and understanding of social exclusion issues in a Canadian context and creates a previously unavailable knowledge base to further delve into these issues. The study has not only looked into the mobility situation of the public in terms of the categorical approach (who are vulnerable – low-income people, seniors, single-parents) but also their spatial and temporal situations, that is the locational and time characteristics that influence people's movement and activity participation. Each component of the research adopted best-practice, or in the case of accessibility measures, state-of-the-art, methodological approaches that explicitly consider these important dimensions.

The following section synthesizes the general insights generated by the various research components reported in this study. Then, a discussion is made on the specific findings for each vulnerable population group studied. Finally, implications for policy and research are highlighted.

7.2 General Findings

Vulnerable population groups in this study displayed patterns of mobility, time-use, and access to employment and services that are different from the mainstream population. Between these groups, distinct patterns were observed. These are summarized and discussed in the following section. The study did not directly evaluate accessibility and outcomes (i.e. job success rates, income improvement, social integration, etc.) but the findings provide needed and valuable insights to better understand the current mobility situation and accessibility status of various population groups in three Canadian communities. The results also clarify the potential of differential mobility profiles to mediate those outcomes from a social inclusionary perspective.

Mobility patterns are influenced to a large extent by the geography of metropolitan regions. The built environment together with the availability transportation tools, dictate the degree of access to services. The study highlighted that the apparent mobility challenges are more marked in locations where the spatial distribution of opportunities is less favorable. Low-income, single parents and seniors appear to face situations of accessibility deprivation, and are thus more at risk of facing transport-related social exclusion, especially in places where access requires private mobility means and where other options are unfeasible, costly, or not available,. The analyses have identified precise geographic areas in the metropolitan areas of Hamilton, Toronto and Montreal where mobility and accessibility challenges are much more pronounced and would require greater attention in policy and planning.

People's travel behavior varies from community to community and from region to region. The various case studies of metropolitan areas in Ontario and Quebec demonstrated the varying mobility-related behavior patterns in terms of trip-making and distance traveled across urban areas. Significant regional differences between the two provinces and between urban areas in each of these provinces were highlighted in the study.

Time-use analysis of vulnerable groups has shown that aside from the individuals' demographic and socio-economic circumstances (i.e. age, income, family status), mobility situation affects time spent on accessing services or activities. The analysis clearly identifies the tradeoffs that individuals face in terms of activity participation. Among the mobility tools, possession of driving license was found to be negatively associated with trip times and positively associated with shopping duration for seniors, an effect that to some extent offsets the reduced shopping duration and increased trip length observed for seniors. In other words, access to this mobility tool for seniors suggests that less time can be spent reaching shopping destinations, leaving more time available for the activity at the destination. An intriguing time use picture emerges for low income households, for whom it is found a negative relationship with shopping duration but a positive association with shopping frequency.

7.3 Specific Findings on Vulnerable Population Groups

7.3.1 Seniors

Findings on the senior population in this study complement and ultimately expand recent results on the travel behavior of seniors in Canada (e.g. Newbold et al, 2005; Paez et al, 2007; Mercado and Páez, 2008). In said studies and the present one, seniors have been found in general to make fewer trips and travel shorter distances, although there tends to be a great degree of variability within this cohort. The results of the present study evinced additional findings with respect to the regional variation in travel behavior among this segment of the population and some insights with respect to shopping trips (see Table 12).

Table 12: Key study findings concerning seniors

Study Focus ***Seniors***	**Significant Findings**
Trip Making	Being senior is associated with reduced trip rates in the three regions.
	Trip rates are higher in central cities and lower in the suburbs in Hamilton and Montreal.
	In Toronto lower trip rates in the central city and higher in the central east end of the city.
	Vehicle ownership significantly increases the tendency towards more frequent trip making. This effect is above and beyond the direct impact of vehicle ownership for the population as a whole.
	The effect of transit is ambiguous: the net effect is negative for seniors in Hamilton, positive but small in Toronto, and clearly positive in Montreal.
Distance Traveled	Seniors in the three cities tend to have activity spaces that are smaller than the reference group. The only group that displays greater limitations is single parents in Montreal.
	The net effect of auto ownership, while generally positive for trip making, is negligible for seniors in Hamilton, negative for seniors in Toronto, and positive for those in Montreal.
	The effect of transit is ambiguous. There is no differential effect for seniors relative to the reference group in Hamilton and Toronto. In Montreal, the net effect is negative.
Access to Health Care (Hamilton)	With the exception of the central part of the city, accessibility to primary health care is extremely low for seniors in Hamilton. Health care opportunities tend to be beyond the typical geographical scope of mobility of seniors throughout most of the city.
Time Use	Seniors 75+ have higher participation rates for services
	Low income seniors have longer trip durations for shopping
	Short shopping duration, longer travel
	Seniors with driver license tend to have longer shopping duration

An interesting finding was that trips among the seniors relative to the younger population figured in Hamilton and Toronto but not in Montreal. The number of trips increases away from the city core in Toronto and Hamilton. The opposite trend was detected in Montreal. There was also lack of concordance between regions in terms of proximity to transit service. Greater access to transit service tends to increase trip frequency and lowers distance traveled in Montreal. The opposite is true in Toronto. Both cases are suggestive of the time budget tradeoffs involved in this process, namely that as the number of trips increases, there will be less time available for each individual trip. In contrast, there was no effect found in Hamilton. Car ownership was found to consistently increase distance traveled and trip-making in the three regions. Being a senior was found to be associated with reduced amount of time spent shopping for goods and services. However time spent on traveling to go shopping is longer among this group. The results of the analysis do not allow us to discern whether this is a reflection of preference, the mode chosen to undertake this activity, or the distance to shopping places.

7.3.2 Single Parents

Table 13 summarizes the key findings regarding single parents and their mobility patterns as well as access to jobs in the case of those residing in Toronto. The findings reflect important variations in mobility and accessibility patterns for this group between cities, and at a different level also within the Hamilton region. Distance traveled is significantly influenced by access to mobility tools, in particular private vehicles, and to some extent too by occupation status. The results of investigating the accessibility situation with respect to jobs, from the perspective of single parent households in Toronto, indicate that private mobility substantially increases access.

Table 13: Key study findings concerning single parent households

Study Focus ***Single Parent***	**Significant Findings**
Trip Making	Single parent households do not show differences in trip making behavior relative to the reference group in Toronto and Montreal. In Hamilton, the patterns are significantly different from the reference, and there is evidence of a large amount of geographical variability in the process. In Hamilton, where there are significant geographical differences, single parent households tend to make more trips the further away they are from the central parts of the city. Vehicle ownership is associated with more frequent trip making in Toronto and Hamilton, but not in Montreal. The effect is above and beyond the base-level effect of vehicle ownership. Transit does not have an effect in the mobility trends of this group, beyond the general effect, which is not consistent across three cities.
Distance Traveled	Single parent households have similar distance traveled patterns as the reference group in Hamilton. In Toronto and Montreal, they tend to have the smallest activity spaces of all vulnerable groups. Geographically, distance traveled tends to be more limited in the central part of Toronto, and along a band extending north and east from there. In Montreal, the pattern is one of concentric rings parting from Montreal's central city, with increasing estimated values towards the suburbs. Vehicle ownership does not confer any significant advantages or disadvantages relative to the reference group. A small positive effect of proximity to transit for the reference group is negated in the case of single parents.
Access to Jobs (Toronto)	Single parents have relatively high levels of accessibility to employment in the central areas of the city but face a situation of accessibility parity at best, or deprivation at worst in large parts of the city. The differences with respect to the reference group are slightly more pronounced for the case of access to profession/managerial jobs compared to service, trades, and blue collar occupations Auto owning single parent households have relatively better access to jobs than non-owning households
Time Use	Spends 20% less shopping, 20% more services Shorter shopping duration in poor household Low earners within households shop longer duration

7.3.3 Low Income

Table 14 details some key findings regarding the mobility patterns and the accessibility to food retail services of low-income people in Montreal. This is the only city where income information was available for analysis. The findings show that individuals in this population segment tend to undertake fewer trips, and also travel shorter distances compared to the reference group. While low income individuals benefit, like every other population group, from vehicle ownership, this positive impact is in fact smaller relative to the reference in terms of trip making, and negligible in terms of distance traveled. Proximity to transit, on the other hand, confers an additional advantage relative to the reference both in terms of trip making and distance traveled. An accessibility case study indicates that low income individuals enjoy parity or better relative access to food services in Montreal. While retail food is relatively more accessible in central Montreal, access to fast food is less centralized and better in large parts of the city. The results of the analysis pointed to several areas in the city of Montreal that could be classified as food deserts. Time use analysis indicates that low income individuals tend to undertake more frequent shopping trips, tend to spend more time traveling for this purpose, but the duration of shopping episodes was found to be significantly shorter.

Table 14: Key study findings concerning low income people

Study Focus *Low-Income*	**Significant Findings (Montreal only)**
Trip Making	Trip generation rates of low income people are found to be significantly lower than those of the reference group.
	There is a clear geographical trend, indicative of lower trip generation rates in the central parts of the region, increasing in the westward direction, and further decreasing towards the north.
	Vehicle ownership does not have an impact on the mobility levels of low income people. Lack of a vehicle, however, represents a net mobility loss.
	Transit has a positive, if highly localized, effect on trip making. This effect is above and beyond the mobility gains experienced in general by every population group.
Distance Traveled	Low income individuals display very similar distance traveled patterns to those of the reference group in much of the city, except towards the western edge of the region, where distance traveled plateaus sooner and decreases after that.
	Vehicle ownership does not confer any significant mobility benefit to this group, beyond that experienced by the general population. Proximity to transit, on the other hand gives a small but positive effect.
Time Use	Low income individuals tend to travel more frequently for shopping, to travel longer, but engage in shorter shopping episodes.
Food Access (Montreal)	Retail food services are highly concentrated in the central parts of the region. Combined with the patterns of mobility, i.e., distance traveled, this leads to high levels of accessibility there but very low levels of accessibility in the outlying parts of the region.
	Fast food establishments display a lower degree of centralization, and the accessibility patterns indicate that higher accessibility patterns are more persistent in broader parts of the city.
	Increased distance traveled in the suburbs, with vehicle ownership and otherwise, does not translate in substantial accessibility gains for residents of those areas.
	Access to fast food is somewhat more egalitarian, relative to access to retail food.

7.4 Implications for Policy and Research

In terms of informing the policy analysis process, this project was conceived as a knowledge-building exercise whose main objective was to identify policy issues. The evidence produced is clear about the mobility situation of three vulnerable groups. These groups in general have lower mobility levels compared to the reference group. Furthermore, three case studies demonstrate that lower mobility, relative to the norm (i.e. the reference group) has important impacts in terms of accessibility to various types of opportunities. Consideration of time budget constraints suggests that the spatial accessibility situation may in fact be somewhat optimistic for individuals who travel longer (and thus tend to have higher accessibility), especially in opportunity-poor areas. The results are consistent in terms of the lower accessibility levels of suburban areas. In these locations, it is quite possible that private mobility is required to sustain even such low levels of accessibility. Clearly, this study represents but a first step towards a fuller understanding of transportation and social exclusion in Canada. Nonetheless, a number of policy considerations begin to take shape. As well, further avenues for future investigation are indicated.

7.4.1 Policy

The operational framework clarifies the different routes available to improve accessibility, by improving the mobility situation of individuals, and/or by bringing opportunities closer to where they are. There are some factors that are beyond the scope of policy, since the aging process cannot, at least not yet, be stopped. Other factors on the other hand offer potential targets for policy intervention.

In terms of the promotion of mobility tools, there is evidence that private vehicles have the largest impact on mobility, and may be essential to maintain current (low) levels of accessibility in suburban areas. Mindful of this situation, programs that promote auto ownership and use exist in a number of countries (e.g. Fol et al, 2007; Wachs and Taylor, 1998). At the same time, automobility is associated with a number of environmental and economic issues related to the efficiency of resource consumption. More recently as well, there have been warnings that reliance on private mobility may contribute to decline in social capital and may thus entail other hidden costs that are not yet fully understood (see Farber and Páez, 2008). It is important to keep in mind the potential contradictions between environmental, economic, and social policy, vis-à-vis the promotion of private mobility. The evidence with respect to transit in terms of the effects on mobility is mixed, despite the considerable advantages of public transportation from an environmental and resource consumption perspective. This conclusion should not lose sight of the limitations of the analysis, in particular the definition of proximity to transit within 500 m of the place of residence. Regardless, if the objective is to help the accessibility situation and expand the range of employment or training opportunities of individuals, the results of the study argue strongly for the promotion and formulation of policies and programs that consider the specific needs and requirements of vulnerable populations. Consideration of the special circumstances of vulnerable groups is important to ensure that any policy efforts affect their targets effectively. Similarly, this study reported on the significant regional differences that exist in travel behavior of individuals living in the two provinces studied and between urban areas in each of these provinces. This pattern of results strengthens the need for geographic-based approaches in policy and planning.

Policies that improve both mobility and the spatial distribution of opportunities should continuously and consistently be promoted in planning programs and services for communities. This research has demonstrated how various places differ in their supply of job opportunities, food services, and health care, and how mobility situations can affect reaching these places of interest. Poverty, for instance, has been linked in this research to lower mobility, both in terms of activity participation and of activity spaces. Poverty alleviation programs can therefore, in addition to any other benefits, help to ameliorate the mobility and consequently the accessibility situation of this populations segment. There does not appear to be much difference in trip generation between single parents and couples with children, however, the activity spaces of single parents are shown to be considerably smaller. Support programs for single parents could involve more efficient transportation services, or alternatively, strategically located opportunities within their quotidian spaces. Likewise, seniors, who may face irreversible mobility challenges, could benefit from interventions that bring opportunities within their reach. A strong linkage of transportation and land use considerations in planning cannot be overemphasized as it will not only improve the ability of people (as human resources) to carry out daily life activities less stressfully but also advance their health and economic productivity.

7.4.2 Research Methods

This study has exploited various methods, in particular based on spatial techniques, to assess mobility and time-use patterns. In addition, the study implemented a novel way of measuring accessibility that allows for the comparative analysis of accessibility profiles. The study thus represents the state of the art in accessibility research. Measuring accessibility, however, continues to pose a challenge. The method used to calculate relative accessibility offers a relatively simple and flexible way to span the gap between place- and person-based accessibility (Miller, 2006). In its current implementation, however, the method does not yet fully establish a connection with more advanced measures of space-time accessibility. Furthermore, the link between trip generation and accessibility was implied but not explicitly made. Clearly, some groups display different trip generation patterns. For example, low income individuals, in addition to having the highest frequency of short trips, are also more likely to travel less frequently. As implemented, the measures may to some extent overstate the level of accessibility of those groups that tend to undertake fewer trips, and thus provide an overly optimistic estimate of their potential for reaching opportunities. Addressing this issue requires additional research that directly considers the potential (and most likely negative) correlations between number of trips and average distance traveled.

Time-use analysis undertaken in this study showed the extent to which different marginalizing factors such as age, income, and family status dampen down shopping for goods and services. Two challenges are outstanding. Establishing the connection between time use and mobility and between time use and accessibility is a necessary step to be taken. As well, it is of the utmost importance to clarify whether the patterns observed in shopping represent exclusionary processes or a reflection of varying tastes and preferences for activities and travel. Both quantitative and qualitatively orientated research will be useful to cast light on this issue.

7.4.3. Substantive Research

Figure 54 provides a picture of future substantive research needs. First, while the time use analysis reported in this document considers various aspects of mobility, the opposite is not true. In other words, by taking the perspective of overall, day-long patterns, the effect on mobility of time use constraints (even those unrelated to mobility) could not be assessed. There are reasons to believe that various temporal constraints could be very important. Consider as an example the case of single parents who need to devote more time to maintenance activities at home (fixing breakfast, overseeing bath time, school-related tasks, etc.) compared to other household structures that may benefit from a less onerous division of labor. While these activities do not relate directly to mobility, the time trade-offs may not be negligible in terms of their effect on mobility. This is, it is suggested, an additional area for future research.

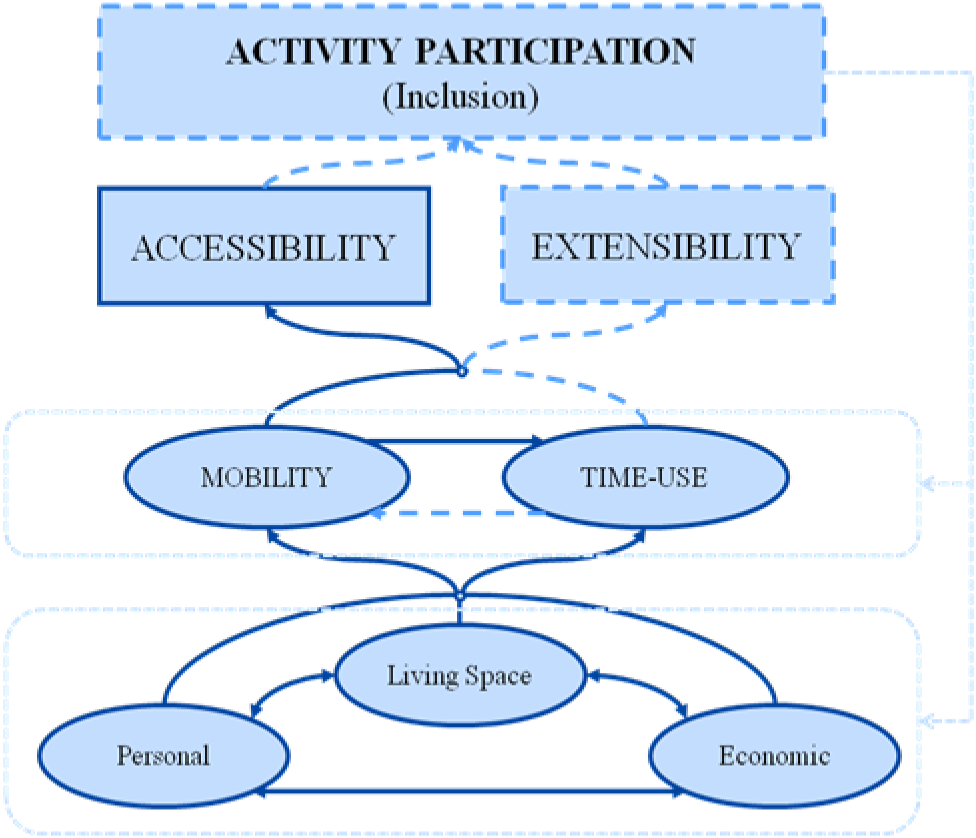


Figure 54: Suggestions for future research

The second item is concerned with the effect of time use on accessibility. Travel diary surveys available for this study are not designed as activity surveys – in other words, they record trips, destinations, purpose of trips, in addition to personal and household characteristics. While they are a rich source of information regarding the spatial dimension of travel behavior, they do not provide the kind of in-depth information about temporal behavior available in activity and time use surveys. The database used for investigating time use patterns (GSS), on the other hand, gives a wealth of information about temporal behavior for a cross-section of the Canadian population – however, despite including geographical information about respondents, the survey is very sparse in specific communities to enable the kind of spatial analysis that travel surveys permit. Given that accessibility depends not only on mobility and time use patterns, but also on the spatial distribution of opportunities, a challenge will be to link the temporal and spatial dimensions so that the effect of time commitments and constraints on access to opportunities can be assessed.

Thirdly, due to limitations imposed by the data available to us, in this research we have been concerned exclusively with physical access to opportunities, while paying no attention to the related notion of extensibility. Extensibility, as described by Miller (2006), depends on the ability to project presence beyond the confines of location in space and time, in order to create a parallel to accessibility that allows remote participation. This frequently, although not always (see Miller, 2005), involves the use of information and communication technologies. As noted before, the substitution potential of these technologies remains unclear, at least from a general population viewpoint (Mokhtarian, 2009). However their potential for groups that are at risk of social exclusion deserves to be investigated more in depth, especially for those cases where irreversible mobility limitations may render accessibility improvements difficult or unfeasible.

Finally, as previously noted, the present research did not explicitly address the effect of accessibility on economic outcomes. In other words, while a key objective for HRSDC is to ultimately improve the economic and well-being situation of the population, in this study the focus has been on potential access, not in the realization and consequences of opportunities. A reason for this delimitation of scope is that data are not readily available on economic outcomes that will at the same time provide insights about mobility. Travel diary surveys on the other hand, include information on occupation, but only as a snapshot of status at the time of the survey. An interesting challenge will be to determine whether individuals in those locations perceived as being at risk do indeed display worse economic outcomes than would otherwise be expected. While it seems possible to perform this type of analysis using aggregated Census data, individual-level analysis would require identifying new sources of data, or perhaps even collection of suitable data. One particular aspect that deserves attention within the context of transportation-related social inclusion is whether access to various mobility tools impacts employment decisions. This would require data on various alternatives, not only employment status, before it can be determined whether people's decision to take or decline employment opportunities is related to their mobility status (for example, taking a lower paying job that is closer to home, for a person lacking private transportation opportunities). While several studies have been conducted in an international context, notably in California, there is little to no research available on the topic for Canada. Given the importance of immigrants for the country's economic and social well-being, recent arrivals should be considered as a research priority. A parallel delimitation of scope is given in terms of access to non-economic opportunities, since the report does not establish a connection between potential accessibility, actual participation in this class of activities, and the effect of activity participation on health and well-being. Again, further research would benefit from information of actual dietary habits and health outcomes, health care utilization, satisfaction with life, etc., that could be linked to the mobility and accessibility profile of individuals. Currently this type of information is not available in a format that would allow detailed mobility and accessibility analysis to be conducted.

Social exclusionary processes are dynamic, and there are important feedback cycles that need to be investigated. A particularly salient aspect refers to the effect of activity participation on personal and spatial factors, which could directly and indirectly influence mobility and time use. A vicious circle could be a poverty trap, in which mobility and accessibility are negatively impacted by low income, preventing the individual from being fully engaged in economic and social life. The inability to participate would tend to perpetuate itself, if the individual lacks the resources to improve the conditions that could lead to better mobility and access. A virtuous cycle, on the other hand, could involve for instance poverty alleviation through the generation of employment income (participation in economic life), if this led to better mobility (e.g. vehicle ownership) and accessibility (e.g. a better residence close to a larger number of opportunities) conditions, and consequently to a greater ability for activity involvement. The cross-sectional approach implemented in this report is ill-suited for the investigation of such dynamic processes, and research would have to be conducted based on, to the best of our knowledge unavailable, longitudinal information.

Appendix A Ordered Probit Model

Trip generation is defined as the number of trips each individual makes over a determined period of time (usually a day, or a period during a day, i.e., peak morning hour). Although trip generation can be modeled using a number of different techniques, disaggregate frequency-based discrete choice models present a number of desirable properties that make them a tool of choice for the study of travel behavior. When the outcome variable is ordinal, as is the case of number of trips, the appropriate specification is an ordered probit or logit model. Ordinal models are discussed by Train (2003), within the context of decision making processes that involve various levels of a response that can be naturally ordered in sequence (i.e. should I make one more trip?). Conceptually, these processes associate a level of utility *U* with alternative outcomes. In the specific case of trip making decisions, the levels of utility faced by an individual could be as follows:

- If $U < \lambda_1$, then number of trips T =0
- If $\lambda_1 < U < \lambda_2$, then T=1
- If $\lambda_2 < U < \lambda_3$, then T=2
- If $U > \lambda_3$, then T≥3 (see figure below)

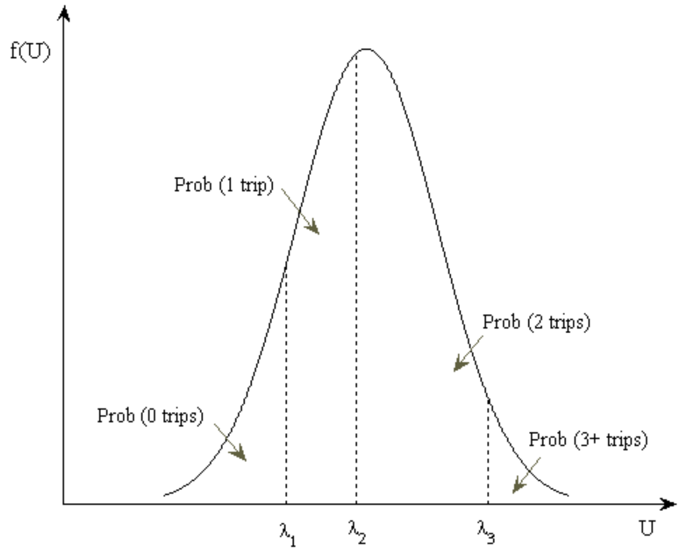


Figure: Distribution of utility based on number of trips

The utility of individual *i* is decomposed into systematic and random components:

$$U_i = \boldsymbol{X}_i \boldsymbol{\beta} + \varepsilon_i$$

where $\boldsymbol{X}_i$ is a vector of individual attributes, $\boldsymbol{\beta}$ is a set of coefficients to be estimated, and the λs are threshold coefficients, also estimable from the data, that mark the transitions between different ordinal categories. The error term ε_i captures unobserved/unobservable factors, measurement/observational errors, and other idiosyncratic variations. An ordered probit model assumes that ε_i follows a standard normal distribution. Utility U_i is used to derive expressions for the probability that an individual makes 0, 1, 2, or 3 or more trips, as follows:

$$\Pr(0 \cdot trips) = \Pr(U_i < \lambda_1)$$
$$= \Pr(\boldsymbol{X}_i\boldsymbol{\beta} + \varepsilon_i < \lambda_1) = \Pr(\varepsilon_i < \lambda_1 - \boldsymbol{X}_i\boldsymbol{\beta})$$

$$\Pr(1 \cdot trip) = \Pr(\lambda_1 < U_i < \lambda_2)$$
$$= \Pr(\lambda_1 < \boldsymbol{X}_i\boldsymbol{\beta} + \varepsilon_i < \lambda_2) = \Pr(\lambda_1 - \boldsymbol{X}_i\boldsymbol{\beta} < \varepsilon_i < \lambda_2 - \boldsymbol{X}_i\boldsymbol{\beta})$$
$$= \Pr(\varepsilon_i < \lambda_2 - \boldsymbol{X}_i\boldsymbol{\beta}) - \Pr(\varepsilon_i < \lambda_1 - \boldsymbol{X}_i\boldsymbol{\beta})$$

And so on.

The probabilistic statements so obtained can be used to derive a likelihood function, in other words, a probability distribution function seen as a function of the data points as opposed to a function of the coefficients. Typically, the likelihood function is transformed using the logarithmic operation to facilitate numerical optimization. Maximization of the function (i.e. estimation of the model) yields the vector of coefficients that maximize the information contents of the model.

Appendix B Multivariate Linear Regression

Analysis of mean distance traveled is based on linear regression models, a standard technique for the analysis of continuous variables. Regression models specify a set of relationships between a variable of interest, called the dependent variable, and a group of explanatory variables thought to correlate with the dependent variable. In addition, a random term is introduced to account for unobserved/unobservable factors and other unexplained variations. The model serves two key purposes. First, it is provides the basis for inference about the relationships initially assumed in the model, their strength and direction. And secondly, it can be used to estimate the expected value of the independent variable, conditional on the independent variables. More formally, a regression model takes the following form:

$$y_i = b_0 + \sum_{i=1}^{k} b_i x_i + \varepsilon_i$$

Where y_i is the observed value of the dependent variable for unit of observation i, and x_i is an explanatory variable. The coefficients b_0 and b_i quantify the relationship between the explanatory and dependent variables, and are interpreted as the amount of change expected in y when a factor x changes. The term ε_i is variously known as a residual, error term, or disturbance, and is assumed to capture all non-systematic variation in the process.

The coefficients of the model are estimated using the method of ordinary least squares. This method, under a suitable set of assumptions, can be used to obtain best unbiased linear estimators. Ordinary least squares operates on the principle of minimizing the sum of squared errors of the model, thus improving the fit of the model to the data. Using more compact matrix notation, this is done in the following way. The error terms are as shown below:

$$\boldsymbol{\varepsilon} = \boldsymbol{Y} - \mathbf{X}\boldsymbol{\beta}$$

The sum of the squares is the product of the error terms by its transpose:

$$\boldsymbol{\varepsilon}'\boldsymbol{\varepsilon} = \left(\boldsymbol{Y} - \mathbf{X}\boldsymbol{\beta}\right)' \left(\boldsymbol{Y} - \mathbf{X}\boldsymbol{\beta}\right)$$

The problem is to minimize the sum of squared errors as a function of the coefficients:

$$\min_{\beta} \boldsymbol{\varepsilon}'\boldsymbol{\varepsilon}$$

This results in coefficient estimates. Other components of the model, such as the variance can also be estimated, which lead to statistics useful to test for the significance coefficients, such as the F statistic and t-scores. Details concerning this technique can be found in standard statistics and econometric textbooks (Greene, 2002).

Appendix C Obtaining Spatially-varying Coefficients with the Expansion Method

The expansion method (Casetti, 1972), is a spatial analytical technique used to model contextual variations (e.g. variations attributable to location). The method operates on the principle of expanding the coefficients of an initial model, assumed to contain substantive knowledge of the process, as functions of expansion variables, which in geographical applications typically are the coordinates of the points. This principle can be rather simply illustrated using an example. Consider the following regression model with an initial specification that relates the variable y to a set of explanatory variables x, and a small amount of random variation ε:

$$y_i = \sum_{k=1}^{K} x_{ki}\beta_k + \varepsilon_i$$

In this model, the set of variables x_k incorporates the substantive knowledge about the process being modeled (the value of variable x_{1i} is usually set to 1 for all i to give a constant term). In the terminology of the method, this is called the initial model. The parameters of this model can be further developed by means of a polynomial expansion of a suitable degree, using the coordinates (u_i,v_i) of location i to take into account the effect of geographical context. To illustrate, consider the following linear expansion of a simple bivariate model (note the use of sub-index i in the expanded parameters):

$$\beta_{1i} = \beta_1^1 + \beta_1^2 u_i + \beta_1^3 v_i$$
$$\beta_{2i} = \beta_2^1 + \beta_2^2 u_i + \beta_2^3 v_i$$

The spatially expanded coefficients lead to what, in the terminology of the method, is called a terminal model:

$$y_i = \beta_{1i} + \beta_{2i}x_{2i} + \varepsilon_i = \beta_1^1 + \beta_1^2 u_i + \beta_1^3 v_i + \left(\beta_2^1 + \beta_2^2 u_i + \beta_2^3 v_i\right)x_{2i} + \varepsilon_i$$

Use of higher order expansions, and introduction of additional explanatory variables, is straightforward. Making suitable assumptions, the terminal model can be estimated using ordinary least squares (OLS) and the significance of the parameters can be tested in the usual way. Location specific estimates of the variable y ($\hat{y}$) can be obtained, since the expanded coefficients map the effect of variable x_i on y_i at location (u_i,v_i). Judicious use of the explanatory variables allows the estimates to produce specific profiles to reflect the socio-demographic, economic, and other relevant attributes of various population segments.

In the case of the ordered probit model, the expansions are achieved by redefining the utility in order to incorporate a combination of fixed (β) and spatial drift (α) coefficients as follows:

$$U_i = \mathbf{W}_{iz}\alpha_z + \mathbf{X}_i\beta + \varepsilon_i$$

The subscripts in the utility function denote decision maker i. Vector $\boldsymbol{W_i}$ includes m variables at the individual level that are associated with a vector of location-specific coefficients $\boldsymbol{\alpha}_z$ (including a constant). Each of m coefficients in this vector can be expanded to produce, for instance, a trend surface of order 1:

$$\alpha_{zm} = \alpha_{zm,1} + \alpha_{zm,2}u_z + \alpha_{zm,3}v_z$$

A trend surface of order 2 could be obtained as follows:

$$\alpha_{zm} = \alpha_{zm,1} + \alpha_{zm,2}u_z^2 + \alpha_{zm,3}u_z + \alpha_{zm,4}u_z v_z + \alpha_{zm,5}v_z + \alpha_{zm,6}v_z^2$$

The components of the location-specific coefficient are a region-wide (i.e. spatially constant) mean $\alpha_{zm,1}$, and other coefficients associated with the coordinates u_i (easting) and v_i (northing) in a polynomial expansion. In this way, the model incorporates the typical fixed coefficients (constant throughout the population) and coefficients that incorporate spatial variability (that is, they are specific to each location). Since the trend surface is linked to a variable in vector $\boldsymbol{W_i}$, a response surface for that variable can be examined in a geographically explicit way.

Appendix D Accessibility and Relative Accessibility Indicators

Comprehensive reviews of various measures of accessibility can be found in papers by Handy and Niemeier (1997) and Kwan (1998). As shown in these papers, a majority of measures employed in the literature can be defined generically as the summation of the product of a weight and an impedance function:

$$A^k(i) = \sum_j W_j^k K\left(\frac{c_{ij}}{\gamma}\right)$$

Accessibility, according to this widely used formulation, is the sum of opportunities of type *k* available at all locations *j*, from the standpoint of locaton *i*. W_j^k in the equation is a measure of the quantity and/or quality of opportunities available at *j*, whereas $K(\cdot)$ is a distance decay function that controls the friction of distance based on the distance/cost c_{ij} that separates location *j* from *i*. The friction of distance is furthermore controlled by a parameter γ that determines the rate of decay. The distance decay function projects a window over the space of the sample that, from a center at *i*, determines the spatial relationship between *i* and other locations (from not related, to different degrees of relatedeness). Different indicators of accessibility can be derived through the use of different distance decay functions. A commonly used accessibility indicator is an indicator of cumulative opportunities, when the function is as follows:

$$K = \begin{cases} 1 & \text{if } c_{ij} \le \gamma \\ 0 & \text{otherwise} \end{cases}$$

$K(\cdot)$ is in this case a non-increasing function that gives a weight of 1 to all instances of W_j^k within distance γ of point *i*, and zero to other cases. The accessibility measure then takes the following form:

$$A^k(i) = \sum_j W_j^k I\left(c_{ij} \le \gamma\right)$$

where $I(\cdot)$ is an indicator function that takes the value of 1 if the logical statement in the argument of the function is true and 0 otherwise. In other words, the level of accessibility of location *i* is the total number of opportunities of type *k* located at most at a distance/cost γ from i. An indicator of cumulative opportunities is attractive because its interpretation is in terms of a direct count of opportunities {O'Kelly, 2003 36 /id /pt "gravity-type measures in contrast are cost-discounted sums of opportunities; "}. One key finding in Kwan's (1998) comparison of various accessibility indicators is that measures in the gravity and cumulative opportunities families are more similar to each other than either is to other types of accessibility indicators.

The measure of cumulative opportunities can be adjusted by the total number of opportunities in the region to obtain the proportion of all opportunities accessible from location *i*:

$$A^{k}(i)=\frac{\sum_{j} W_{j}^{k} I\left(d_{ij} \leq \gamma\right)}{\sum_{j} W_{j}^{k}}$$

A value of $A^k(i)$ =0.1, for example, would indicate that of all opportunities of the same type in the region, 10% of them are accessible to individual *p* at *i*.

Implementation of the accessibility measure above requires that a critical value γ be determined. A review of the literature reveals that by far, the most common approach to do this is to use a fixed cut-off value that seems reasonable and/or adequate (e.g. Kwan, 1998; Church et al, 2000; Clarke et al, 2002; Social Exclusion Unit, 2003; Smoyer-Tomic et al, 2006; Burns and Inglis, 2007; Bertrand et al, 2008). Popular values are 500 m, 800 m, and 1 km, although there appears to be very limited empirical support, beyond convenience and/or expediency, for preferring any of these values over the others, or in fact any of these values at all. In addition to this, use of a blanket value assumes that the critical distance is uniform regardless of both location and the specific characteristics of an individual at that location. The evidence available (see for example Chapter 4) indicates that travel behavior is not uniform, but rather influenced by the profile of individual travelers and their spatial context. In particular, distance traveled depends on a host of socio-demographic (e.g. age, gender, household structure), economic (e.g. income, auto ownership status), and locational factors (e.g. place of residence, availability of transit services).

Suppose instead that a cut-off distance γ can be obtained for various locations and population segments of interest. In this case, a measure of cumulative opportunities specific to individual type *p* and location *i* (i.e. a person-place combination) could be defined as shown below:

$$A_{p}^{k}(i)=\frac{\sum_{j} W_{j}^{k} I\left(d_{ij} \leq \gamma_{pi}\right)}{\sum_{j} W_{j}^{k}}$$

Use of γ_{pi} now means that the level of accessibility will potentially vary between individuals with different characteristics, even at the same location. In addition, this also means that the friction of distance is not necessarily the same for identical individuals but at different locations. Use of a personal and locational specific critical value γ_{pi} allows the definition of a new class of relative accessibility deprivation indicators. Consider the following indicator that measures the relative levels of accessibility between individuals of different population segments, to the same type of opportunities:

$$RADI_{pq}^{k}\left(i\right)=\frac{A_{p}^{k}\left(i\right)}{A_{q}^{k}\left(i\right)}=\frac{\dfrac{\sum_{j}W_{j}^{k}I\left(d_{ij}^{k}\leq\gamma_{pi}\right)}{\sum_{j}W_{j}^{k}}}{\dfrac{\sum_{j}W_{j}^{k}I\left(d_{ij}^{k}\leq\gamma_{qi}\right)}{\sum_{j}W_{j}^{k}}}=\frac{\sum_{j}W_{j}^{k}I\left(d_{ij}^{k}\leq\gamma_{pi}\right)}{\sum_{j}W_{j}^{k}I\left(d_{ij}^{k}\leq\gamma_{qi}\right)}$$

Interpretation of the indicator above is also as a proportion, except that now it is of the number of opportunities of type *k* available to individual *p* at *i*, with respect to the number of opportunities of the same type available to an individual *q* at *i*. A second indicator can be defined that compares the levels of accessibility to different to different types of opportunities, say *k* and *l*, from the perspective of the same type of individual at location *i*:

$$RADI_{p}^{kl}\left(i\right)=\frac{A_{p}^{k}\left(i\right)}{A_{p}^{l}\left(i\right)}=\frac{\dfrac{\sum_{j}W_{j}^{k}I\left(d_{ij}^{k}\leq\gamma_{pi}\right)}{\sum_{j}W_{j}^{k}}}{\dfrac{\sum_{j}W_{j}^{l}I\left(d_{ij}^{l}\leq\gamma_{pi}\right)}{\sum_{j}W_{j}^{l}}}$$

In this case, the indicator measures the ratio of the proportion of opportunities of type *k* available to an individual typical of class *p* at *i*, to the proportion of opportunities of type *l* available to the same individual at the same location.

Implementation of the measures shown above still requires that the person-location specific critical values of γ be determined. An appealing solution is to use model-based estimates of distance traveled. The advantage of a modeling approach is that location and personal characteristics can be considered simultaneously within a multivariate framework to control for potential confounding factors. A model of distance traveled would provide estimates of distance specific to individual profile *p*, or $\hat{d}_p$. A spatially expanded model of distance traveled, with its spatially-varying coefficients, would in addition give estimates specific to a location and personal profile, or $\hat{d}_{pi}$. This estimates provide a fine grained description of the socio-economic and demographic characteristics of individuals, as well as of their locational situation. Replacing γ_{pi} in the equations above with model-based estimates of distance traveled $\hat{d}_{pi}$ makes the concept of relative accessibility operational. For further details on the methodological aspects of these measures, see Páez et al. (2009).

Appendix E Simultaneous Equations Model of Activity Durations

Drawing from the time- and budget-constrained framework for modeling activity demand, activities are conceptualized as goods from which the participant derives utility in accordance with the activity type and duration (Kockelman, 2001). Given that the allocation of one's time to an activity impacts the duration of participation in a second activity due to the daily time-budget constraint, the activities are inherently in competition with each other. If each activity's duration is modeled by a linear equation, then the set of activities can be modeled using a system of linear equations such as:

$$\begin{aligned} y_{t1} &= \gamma_1 y_t + \beta_1 x_t + \varepsilon_{t1} \\ y_{t2} &= \gamma_2 y_t + \beta_2 x_t + \varepsilon_{t2} \\ &\vdots \\ y_{tM} &= \gamma_M y_t + \beta_M x_t + \varepsilon_{tM} \end{aligned}$$

In this formulation, for a given observation *t*, each of the M activity durations, y_{tm}, is modeled as a linear and additive function of the other durations, y_t, a set of exogenous variables, $\mathbf{x_t}$, and a random disturbance denoted by $\varepsilon_{\mathbf{tm}}$. Some of the regression parameters γ_m and β_m are often constrained to simplify the model, or to better represent a priori knowledge of the system. Estimation may proceed in a variety of ways including: ordinary least squares; seemingly unrelated regression; instrumental variable regression; three-stage least squares (Greene, 2002); or via a structural equations approach Golob (2000). The set of simultaneous equations can be rewritten in matrix form as:

$$\mathbf{Y} = \mathbf{\Gamma Y} + \mathbf{BX} + \mathbf{E}$$

where:

$$[\mathbf{Y} \quad \mathbf{X} \quad \mathbf{E}] = \begin{bmatrix} y'_1 & x'_1 & \varepsilon'_1 \\ y'_2 & x'_2 & \varepsilon'_2 \\ \vdots & \vdots & \vdots \\ y'_T & x'_T & \varepsilon'_T \end{bmatrix}$$

$$\Gamma = \begin{bmatrix} \gamma_{11} & \cdots & \gamma_{1M} \\ \vdots & \ddots & \vdots \\ \gamma_{M1} & \cdots & \gamma_{MM} \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} \beta_{11} & \cdots & \beta_{1M} \\ \vdots & \ddots & \vdots \\ \beta_{K1} & \cdots & \beta_{KK} \end{bmatrix}$$

with T observations and $\mathbf{K}$ exogenous variables in the dataset.

Ordinary least squares estimates of the coefficients are inconsistent and biased since endogenous variables appear on the right hand side of the equation. A two-stage instrumental variables regression can be used to make the estimates consistent. Additionally if the disturbances are correlated between equations then the estimates are inefficient. In the case of activity durations, we can safely assume that the residuals are correlated across equations since there likely exist unmeasured factors which simultaneously impact the durations of multiple activities. A seemingly unrelated regression incorporates an estimated residual covariance matrix into a generalized least squares estimation of the coefficients in order to make the estimates efficient. When endogeneity and residual covariance need to be treated simultaneously, the three-stage regression method can be used to combine IV and SUR estimation into a single estimator.

Very simply, the three stages of the estimator consist on: (1) computing the intermediate forms of the endogenous variables using the instruments as predictors; (2) retrieving an estimate of the covariance matrix of the residuals arising from a regression of the endogenous factors on the exogenous factors and the intermediate form endogenous factors; and (3) estimating the coefficients of the model with a GLS regression using the estimated covariance matrix from the second step and the intermediate forms from the first (Zellner and Theil, 1962; Greene, 2002).

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References

ABRAHAMSON, P. (2003) Researching Poverty and Social Exclusion in Europe, *Journal of European Social Policy,* 13(3), 281 - 285.

ALSNIH, R., HENSHER, D.A. (2003) The mobility and accessibility expectations of seniors in an aging population, *Transportation Research Part A-Policy and Practice*, 37(10), 903 - 916.

ATKINSON, R., DAVOUDI, S. (2000) The concept of social exclusion in the European Union: Context, development and possibilities, *Journal of Common Market Studies*, 38(3), 427 - 448.

AUSTIN, S.B., MELLY, S.J., SANCHEZ, B.N., PATEL, A., BUKA, S., GORTMAKER, S.L. (2005) Clustering of fast-food restaurants around schools: A novel application of spatial statistics to the study of food environments, *American Journal of Public Health,* 95(9), 1575 - 1581.

AXHAUSEN, K.W., ZIMMERMANN, A., SCHONFELDER, S., RINDSFUSER, G., HAUPT, T. (2002) Observing the rhythms of daily life: A six-week travel diary, *Transportation*, 29(2), 95 - 124.

BADOE, D.A. (2007) Forecasting travel demand with alternatively structured models of trip frequency, *Transportation Planning and Technology,* 30(5), 455 - 475.

BADOE, D.A., CHEN, C. (2004) Modeling trip generation with data from single and two independent cross-sectional travel surveys, *Journal of Urban Planning and Development-Asce,* 130(4), 167 - 174.

BANISTER, D., BOWLING, A. (2004) Quality of life for the elderly - The transport dimension, *Transport Policy,* 11(2), 105 - 115.

BEAUMONT, J., LANG, T., LEATHER, S., MUCKLOW, C. (1995) *Report from the Policy Subgroup to the Nutrition Task Force: Low Income Project Team.* Watford: Institute of Grocery Distribution.

BEGG, I., BERGHMAN, J. (2002) Introduction: EU social (exclusion) policy revisited?, *Journal of European Social Policy,* 12(3), 179 - 194.

BELAND, D. (2007) The social exclusion discourse: ideas and policy change, *Policy and Politics*, 35(1), 123 - 139.

BERTRAND, L., THERIEN, F., CLOUTIER, M.S. (2008) Measuring and mapping disparities in access to fresh fruits and vegetables in Montreal, *Canadian Journal of Public Health-Revue Canadienne de Sante Publique,* 99(1), 6 - 11.

BHAT, C.R. (1996) A hazard-based duration model of shopping activity with nonparametric baseline specification and nonparametric control for unobserved heterogeneity, *Transportation Research Part B-Methodological*, 30(3), 189 - 207.

BHAT, C.R. (2005) A multiple discrete-continuous extreme value model: formulation and application to discretionary time-use decisions, *Transportation Research Part B-Methodological,* 39(8), 679 - 707.

BHAT, C.R., FRUSTI, T., ZHAO, H.M., SCHONFELDER, S., AXHAUSEN, K.W. (2004) Intershopping duration: an analysis using multiweek data, *Transportation Research Part B-Methodological,* 38(1), 39 - 60.

BHAT, C.R., KOPPELMAN, F.S. (1999) A retrospective and prospective survey of time-use research, *Transportation,* 26(2), 119 - 139.

BITTMAN, M. (2002) Social participation and family welfare: The money and time costs of leisure in Australia, *Social Policy & Administration,* 36(4), 408 - 425.

BLUMENBERG, E. (2004) En-gendering effective planning - Spatial mismatch, low-income women, and transportation policy, *Journal of the American Planning Association,* 70(3), 269 - 281.

BLUMENBERG, E., MANVILLE, M. (2004) Beyond the spatial mismatch: Welfare recipients and transportation policy, *Journal of Planning Literature*, 19(2), 182 - 205.

BLUMENBERG, E., ONG, P. (2001) Cars, buses, and jobs - Welfare participants and employment access in Los Angeles, *Sustainability and Environmental Concerns in Transportation 2001,* (1756), 22 - 31.

BLUMENBERG, E., SHIKI, K. (2003) How welfare recipients travel on public transit, and their accessibility to employment outside large urban centers, *Transportation Quarterly,* 57(2), 25 - 37.

BOSTOCK, L. (2001) Pathways of disadvantage? Walking as a mode of transport among low-income mothers, *Health & Social Care in the Community*, 9(1), 11 - 18.

BOURNE, L. (2003) *Social Change in Central Ontario.* Toronto: Neptis Foundation.

BULIUNG, R. and MORENCY, C. (2008) "Seeing is Believing": Exploring Opportunities for the Visualization of Spatiotemporal Dimensions of Activity-Travel and Land Use Processes, in: A Páez, J Le Gallo, R Buliung, and S Dall'Erba (Ed.) *Progress in Spatial Analysis: Theory and Computation, and Thematic Applications*pp. (forthcoming) -

BULIUNG, R.N., KANAROGLOU, P.S. (2007) Activity-travel behaviour research: Conceptual issues, state of the art, and emerging perspectives on behavioural analysis and simulation modelling, *Transport Reviews,* 27(2), 151 - 187.

BURCHARDT, T., LE GRAND, J., PIACHAUD, D. (2002) *Understanding Social Exclusion.* Oxford: Oxford University Press.

BURNS, C.M., INGLIS, A.D. (2007) Measuring food access in Melbourne: Access to healthy and fast foods by car, bus and foot in an urban municipality in Melbourne, *Health & Place,* 13(4), 877 - 885.

BUSH, S. (2005) *Forecasting 65+ Travel: An Integration of Cohort Analysis and Travel Demand Modeling* 84th Transportation Research Board Annual Meeting, Washington, D.C., 9 - 13 January.

CARAGATA, L. (2003) Neoconservative realities - The social and economic marginalization of Canadian women, *International Sociology,* 18(3), 559 - 580.

CASAS, I. (2007) Social exclusion and the disabled: An accessibility approach, *Professional Geographer,* 59(4), 463 - 477.

CASETTI, E. (1972) Generating Models by the Expansion Method: Applications to Geographic Research, *Geographical Analysis,* 28, 281 - 298.

CASS, N., SHOVE, E., URRY, J. (2005) Social exclusion, mobility and access, *Sociological Review,* 53(3), 539 - 555.

CERVERO, R., SANDOVAL, O.S., LANDIS, J. (2002) Transportation as a stimulus of welfare-to-work - Private versus public mobility, *Journal of Planning Education and Research,* 22(1), 50 - 63.

CHAPLEAU, R., MORENCY, C. (2005) *Dynamic Spatial Analysis of Urban Travel Survey Data using GIS* Paper presented at the 25th Annual ESRI International User Conference, San Diego, California,

CHAPLEAU, R., MORENCY, C., BOURGOIS, M. (2008) *Simple and Interactive Spatial Mobility Analysis Tool for Data Visualization, International Conference on Survey Methods in Transport: Harmonization and data comparability* Paper presented in the Workshop on Data Visualization Techniques, Annecy, France,

CHEADLE, A., PSATY, B.M., CURRY, S., WAGNER, E., DIEHR, P., KOEPSELL, T., KRISTAL, A. (1991) Community-Level Comparisons Between the Grocery Store Environment and Individual Dietary Practices, *Preventive Medicine,* 20(2), 250 - 261.

CHURCH, A., FROST, M., SULLIVAN, K. (2000) Transport and Social Exclusion in London, *Transport Policy,* 7(3), 195 - 205.

CLARKE, G., EYRE, H., GUY, C. (2002) Deriving indicators of access to food retail provision in British cities: Studies of Cardiff, Leeds and Bradford, *Urban Studies,* 39(11), 2041 - 2060.

CULLEN, I., GODSON, V. (2008) Urban networks: The structure of activity patterns, *Progress in Planning,* 4, 1 - 96.

DAGFINN, Å. (1978) Studies of Time-Use: Problems and Prospects, *Acta Sociologica (Taylor & Francis Ltd),* 21(2), 125 - 141.

DOBBS, L. (2005) Wedded to the car: women, employment and the importance of private transport, *Transport Policy,* 12(3), 266 - 278.

DOLAN, T.A., ATCHINSON, K., HUYNH, T.N. (2005) Access to Dental Care Among Older Adults in the United States, *Journal of Dental Education,* 69(9), 961 - 974.

DUGUNDJI, E.R., WALKER, J.L. (2005) Discrete choice with social and spatial network interdependencies - An empirical example using mixed generalized extreme value models with field and panel effects, *Travel Demand 2005,* (1921), 70 - 78.

ELLWOOD, D. (1986) The spatial mismatch hypothesis: are there teenage jobs missing in the ghetto?, in: R Freeman and H Holzer (Ed.) *The Black Youth Unemployment Crisis* (University of Chicago Press, Chicago) pp. 147 - 185.

ESCARCE, J.J., EPSTEIN, K.R., COLBY, D.C., SCHWARTZ, J.S. (1993) Racial differences in elderly's use of medical procedures and diagnostic tests, *American Journal of Public Health,* 83(7), 948 - 954.

EXWORTHY, M., PECKHAM, S. (2006) Access, choice and travel: Implications for health policy, *Social Policy & Administration,* 40(3), 267 - 287.

FANG, H.A. (2008) A discrete–continuous model of households' vehicle choice and usage, with an application to the effects of residential density, *Transportation Research Part B-Methodological,* 42(9), 736 - 758.

FARBER, S., PÁEZ, A. (2008) My car, my friends, and me: A preliminary investigation of automobility and social activity participation, *Journal of Transport Geography,* (forthcoming: doi:10.1016/j.jtrangeo.2008.07.008)

FARLEY, J.E. (1987) Disproportionate Black and Hispanic Unemployment in United-States Metropolitan-Areas - the Roles of Racial-Inequality, Segregation and Discrimination in Male Joblessness, *American Journal of Economics and Sociology,* 46(2), 129 - 150.

FITZPATRICK, A.L., POWE, N.R., COOPER, L.S., IVES, D.G., ROBBINS, J.A. (2004) Barriers to health care access among the elderly and who perceives them, *American Journal of Public Health,* 94(10), 1788 - 1794.

FOL, S., DUPUY, G., COUTARD, O. (2007) Transport policy and the car divide in the UK, the US and France: Beyond the environmental debate, *International Journal of Urban and Regional Research,* 31(4), 802 - 818.

FOTHERINGHAM, A.S., BRUNSDON, C. (1999) Local forms of spatial analysis, *Geographical Analysis,* 31(4), 340 - 358.

FRANK, L., BRADLEY, M., KAVAGE, S., CHAPMAN, J., LAWTON, T.K. (2008) Urban form, travel time, and cost relationships with tour complexity and mode choice, *Transportation,* 35(1), 37 - 54.

Frederick, J., 1995, *As Time Goes by...: Time Use by Canadians*, Statistics Canada

FRÉTIGNÉ, C. (2008) *Sociologie de l'exclusion.* Paris: L'Harmattan.

FUREY, S., STRUGNELL, C., MCILVEEN, H. (2001) An investigation of the potential existence of ``food deserts'' in rural and urban areas of Northern Ireland, *Agriculture and Human Values,* 18(4), 447 - 457.

GARASKY, S., FLETCHER, C.N., JENSEN, H.H. (2006) Transiting to work: The role of private transportation for low-income households, *Journal of Consumer Affairs,* 40(1), 64 - 89.

GARHAMMER, M. (1998) Time pressure in modern Germany, *Loisir & Societe-Society and Leisure,* 21(2), 327 - 352.

GIULIANO, G. (2003) Travel, location and race/ethnicity, *Transportation Research Part A-Policy and Practice,* 37(4), 351 - 372.

GLIEBE, J.P., KOPPELMAN, F.S. (2002) A model of joint activity participation between household members, *Transportation,* 29(1), 49 - 72.

GOBILLON, L., SELOD, H., ZENOU, Y. (2007) The mechanisms of spatial mismatch, *Urban Studies,* 44(12), 2401 - 2427.

GOLOB, T.F. (2000) A simultaneous model of household activity participation and trip chain generation, *Transportation Research Part B-Methodological*, 34(5), 355 - 376.

GOLOB, T.F., MCNALLY, M.G. (1997) A model of activity participation and travel interactions between household heads, *Transportation Research Part B-Methodological,* 31(3), 177 - 194.

GORMICK, M.E. (1999) The association of race/socioeconomic status and use of Medicare: A little-known failure in access to care, *Annals of the New York Academy of Sciences,* 896, 497 - 500.

GOULIAS, K.G. (2002) Multilevel analysis of daily time use and time allocation to activity types accounting for complex covariance structures using correlated random effects, *Transportation,* 29(1), 31 - 48.

GREENE, W.H. (2002) *Econometric Analysis 5th Edition.* Upper Saddle River: Prentice Hall.

HABIB, K.M.N., CARRASCO, J.A., MILLER, E.J. (2008) The social context of activity scheduling: A discrete-continuous model of the relationship between 'with whom' and episode start time and duration, *Transportation Research Record,* (forthcoming)

HÄGERSTRAND, T. (1970) What about people in regional science?, *Papers of the Regional Science Associaton*, 24, 7 - 21.

HANDLER, J.F. (2003) Social citizenship and workfare in the US and Western Europe: from status to contract, *Journal of European Social Policy,* 13(3), 229 - 243.

HANDY, S., NIEMEIER, D. (1997) Measuring Accessibility: An Exploration of Issues and Alternatives, *Environment and Planning A,* 29(7), 1175 - 1194.

HARVEY, A.S. (2004) Time Use and Activity Systems, in: DA Hensher, KJ Button, KE Haynes, and PR Stopher (Ed.) *Handbook of Transport Geography and Spatial Systems* (Elselvier, New York) pp. 627 - 646.

HARVEY, A.S., TAYLOR, M.E. (2000) Activity settings and travel behaviour: A social contact perspective, *Transportation,* 27(1), 53 - 73.

HECKMAN, J.J. (1979) Sample Selection Bias As A Specification Error, *Econometrica,* 47(1), 153 - 161.

HESS, D.B. (2005) Access to employment for adults in poverty in the Buffalo-Niagara region, *Urban Studies,* 42(7), 1177 - 1200.

HINE, J. (2003) Social exclusion and transport systems, *Transport Policy,* 10(4), 263 - 263.

HINE, J. and MITCHELL, F. (2003) *Transport Disadvantage and Social Exclusion: Exclusionary Mechanisms in Transport in Urban Scotland.* Aldershot: Ashgate Publishing.

HOLZER, H.J. (1991) The Spatial Mismatch Hypothesis - What Has the Evidence Shown, *Urban Studies,* 28(1), 105 - 122.

HSIA, J., KEMPER, E., SOFAER, S. (2009) Is insurance a more important determinant of health care access than perceived health? Evidence from the Women's Health Initiative, *Journal of Women's Health and Gender-Based Medicine,* 9(8), 881 - 889.

IHLANFELDT, K.R., SJOQUIST, D.L. (1990) Job Accessibility and Racial-Differences in Youth Employment Rates, *American Economic Review,* 80(1), 267 - 276.

INSTITUTE OF TRANSPORTATION ENGINEERS (2004) *Trip Generation Manual 7th Edition.* Washington,D.C.: ITE.

JAIN, J., GUIVER, J. (2001) Turning the car inside out: Transport, equity and environment, *Social Policy & Administration,* 35(5), 569 - 586.

JANES, J.R., BLACKMAN, D.K., BOLEN, J.C. (1999) Surveillance for use of preventive health-care services by older adults, 1995-1997, *MMWR CDC Surveillance Summary,* 48, 51 - 88.

JAVEAU, C. (1972) The trip to work: the application of the time-budget method to problems arising from commuting between residence and workplace, in: A Szalai (Ed.) *The Use of Time* (Mouton, The Hague)

Kahn, A. J. and Kamerman, S. B., 2003, *Beyond Child Poverty: The Social Exclusion of Children,* ICFP, New York

KAIN, J.F. (1968) Housing Segregation, Negro Employment, and Metropolitan Decentralization, *Quarterly Journal of Economics,* 82(2), 175 - 197.

KAIN, K. (1992) The spatial mismatch hypothesis: three decades later, *Housing Policy Debate,* 3, 371 - 460.

KAWABATA, M. (2003) Job access and employment among low-skilled autoless workers in US metropolitan areas, *Environment and Planning A,* 35(9), 1651 - 1668.

KAWABATA, M., SHEN, Q. (2007) Commuting inequality between cars and public transit: the case of the San Francisco Bay Area, 1990-2000, *Urban Studies,* 44(9), 1759 - 1780.

KELLY, B.D. (2006) The power gap: Freedom, power and mental illness, *Social Science & Medicine*, 63(8), 2118 - 2128.

KENYON, S. (2003) Understanding social exclusion and social inclusion, *Proceedings of the Institution of Civil Engineers-Municipal Engineer*, 156(2), 97 - 104.

KENYON, S., RAFFERTY, J., LYONS, G. (2003) Social exclusion and transport in the UK: A role for virtual accessibility in the alleviation of mobility-related social exclusion?, *Journal of Social Policy*, 32, 317 - 338.

KENYON, S., LYONS, G. (2007) Introducing multitasking to the study of travel and ICT: Examining its extent and assessing its potential importance, *Transportation Research Part A: Policy and Practice*, 41(2), 161 - 175.

KERVER, J.M., YANG, E.J., BIANCHI, L., SONG, W.O. (2003) Dietary patterns associated with risk factors for cardiovascular disease in healthy US adults, *American Journal of Clinical Nutrition*, 78(6), 1103 - 1110.

KHATTAK, A., AMERLYNCK, V.J., QUERCIA, R.G. (2000) Are Travel Times and Distances to Work Greater for Residents of Poor Urban Neighborhoods?, *Transportation Research Record*, 1718, 73 - 82.

KITAMURA, R., FUJII, S., PAS, E.I. (1997) Time-use data, analysis and modeling: toward the next generation of transportation planning methodologies, *Transport Policy*, 4(4), 225 - 235.

KLANFER, J. (1965) *L'Exclusion sociale: Étude de la marginalité dans les sociétés occidentales.* Paris: Bureau de Recherches sociales.

KOCKELMAN, K. (2001) A model for time- and budget-constrained activity demand analysis, *Transportation Research B*, 35(3), 255 - 269.

KUSHI, L.H., BYERS, T., DOYLE, C., BANDERA, E.V., MCCULLOUGH, M., GANSLER, T., ANDREWS, K.S., THUN, M.J. (2006) American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention: Reducing the risk of cancer with healthy food choices and physical activity, *Ca-A Cancer Journal for Clinicians*, 56(5), 254 - 281.

KWAN, M.P. (1998) Space-time and integral measures of individual accessibility: A comparative analysis using a point-based framework, *Geographical Analysis*, 30(3), 191 - 216.

KWAN, M.P. (1999) Gender, the home-work link, and space-time patterns of nonemployment activities, *Economic Geography*, 75(4), 370 - 394.

LAI, D.W.L., CHAU, S.B.Y. (2007) Predictors of Health Service Barriers for Older Chinese Immigrants in Canada, *Health and Social Work*, 32(1), 57 - 65.

LENOIR, R. (1974) *Les exclus: Un Français sur dix.* Paris: Le Seuil.

LITWIN, H., LANDAU, R. (2000) Social network type and social support among the old-old

97, *Journal of Aging Studies*, 14(2), 213 - 228.

LOVELL, V. (2002) Constructing social citizenship: The exclusion of African American women from unemployment insurance in the US, *Feminist Economics*, 8(2), 191 - 197.

LUCAS, K. (2004) *Running on Empty: Transport, Social Exclusion and Environmental Justice.* Bristol: The Policy Press.

Lucas, K., Grosvenor, T., and Simpson, R., 2001, *Transport, the environment, and social exclusion*, Joseph Roundtree Foundation, York

LYONS, G. (2003) The introduction of social exclusion into the field of travel behaviour, *Transport Policy*, 10(4), 339 - 342.

MACEK, N.M., KHATTAK, A.J., QUERCIA, R.G. (2001) *What is the effect of commute time on employment? Analysis of spatial patterns in New York metropolitan area.* WASHINGTON: TRANSPORTATION RESEARCH BOARD NATL RESEARCH COUNCIL.

MACPHERSON, S. (2004) Transport disadvantage and social exclusion: Exclusionary mechanisms in transport in urban Scotland, *Journal of Social Policy*, 33, 525 - 526.

MCCRAY, T., BRAIS, N. (2007) Exploring the role of transportation in fostering social exclusion: The use of GIS to support qualitative data, *Networks & Spatial Economics*, 7(4), 397 - 412.

MCLAFFERTY, S., PRESTON, V. (1992) Spatial Mismatch and Labor-Market Segmentation for African-American and Latina Women, *Economic Geography*, 68(4), 406 - 431.

MCNALLY, M. (2000) The Four-step Model, in: DA Hensher and KJ Button (Ed.) *Handbook of Transport Modelling* (Pergamon, Oxford) pp. 33 - 52.

MERCADO, R.G., PÁEZ, A. (2008) Determinants of distance traveled with a focus on the elderly: A multilevel analysis in the Hamilton CMA, Canada, *Journal of Transport Geography*, (In press. doi: 10.1016/j.jtrangeo.2008.04.12)

METZ, D. (2003) Limitations of transport policy: a rejoinder, *Transport Reviews*, 23(2), 243 - 246.

METZ, D.H. (2004) Mobility of older people and their quality of life, *Transport Policy*, 7, 149 - 152.

MILLER, E.J., ROORDA, M.J., CARRASCO, J.A. (2005) A tour-based model of travel mode choice, *Transportation*, 32(4), 399 - 422.

MILLER, H.J. (1991) Modeling Accessibility Using Space-Time Prism Concepts Within Geographical Information-Systems, *International Journal of Geographical Information Systems*, 5(3), 287 - 301.

MILLER, H.J. (1999) Potential contributions of spatial analysis to geographic information systems for transportation (GIS-T), *Geographical Analysis*, 31(4), 373 - 399.

MILLER, H.J. (2005) Necessary space-time conditions for human interaction, *Environment and Planning B: Planning and Design,* 32, 381 - 401.

MILLER, H.J. (2006) Social Exclusion in Space and Time, in: KW Axhausen (Ed.) *Moving through Nets: The Social and Physical Aspects of Travel* (Elsevier Science, Oxford) pp. 353 - 380.

MINGE-KLEVANA, W. (1980) Does Labor Time Decrease With Industrialization? A Survey of Time-Allocation Studies, *Current Anthropology,* 21(3), 279

MOKHTARIAN, P.L. (2009) If telecommunication is such a good substitute for travel, why does congestion continue to get worse?, *Transportation Letters,* 1(1), 1 - 17.

MORENCY, C., CHAPLEAU, R. (2008) *Age and its relation with home location, household structure and travel behaviors: 15 years of observation* 87th Annual Meeting of the Transportation Research Board, Washington, D.C., 17 - 13 January.

MORENCY, C., KESTENS, Y. (2007) *Measuring activity spaces of people, households, and population segments* 11th World Conference on Transport Research, Washington, D.C., 28 - 24 June.

MORLAND, K., WING, S., ROUX, A.D. (2002) The contextual effect of the local food environment on residents' diets: The atherosclerosis risk in communities study, *American Journal of Public Health,* 92(11), 1761 - 1767.

NEUTENS, T., VAN DE WEGHE, N., WITLOX, F., DE MAEYER, P. (2008) A three-dimensional network-based space-time prism, *Journal of Geographical Systems,* 10(1), 89 - 107.

NEWBOLD, K.B., SCOTT, D.M., SPINNEY, J.E.L., KANAROGLOU, P., PÁEZ, A. (2005) Travel behavior within Canada's older population: a cohort analysis, *Journal of Transport Geograhy,* 13(4), 340 - 351.

NEWBY, P., MULLER, D., HALLFRISCH, J., QIAO, N., ANDRES, R., TUCKER, K.L. (2003) Dietary patterns and changes in body mass index and waist circumference in adults, *American Journal of Clinical Nutrition,* 77(6), 1417 - 1425.

NEWSOME, T.H., WALCOTT, W.A., SMITH, P.D. (1998) Urban activity spaces: Illustrations and application of a conceptual model for integrating the time and space dimensions, *Transportation,* 25(4), 357 - 377.

O'KELLY, M.E., HORNER, M.W. (2003) Aggregate accessibility to population at the county level: U.S. 1940-2000, *Journal of Geographical Systems,* 5(1), 5 - 23.

ONG, P.M., MILLER, D. (2005) Spatial and transportation mismatch in Los Angeles, *Journal of Planning Education and Research,* 25(1), 43 - 56.

PÁEZ, A., HABIB, K.M.N., BONIN, J. (2008) *A joint ordinal-continuous model for episode generation and duration analysis*

PÁEZ, A., MERCADO, R.G., FARBER, S., MORENCY, C., ROORDA, M. (2009) Relative Accessibility Deprivation Indicators for Urban Settings: Definitions and Application to Food Deserts in Montreal, *Urban Studies*, (forthcoming)

PAEZ, A., SCOTT, D., POTOGLOU, D., KANAROGLOU, P., NEWBOLD, K.B. (2007) Elderly mobility: Demographic and spatial analysis of trip making in the Hamilton CMA, Canada, *Urban Studies,* 44(1), 123 - 146.

PÁEZ, A., SCOTT, D.M. (2004) Spatial Statistics for Urban Analysis: A Review of Techniques with Examples, *GeoJournal*, 61(1), 53 - 67.

PÁEZ, A., SCOTT, D.M. (2007) Social Influence on Travel Behavior: A Simulation Example of the Decision to Telecommute, *Environment and Planning A,* 39(3), 647 - 665.

PARKHURST, G. (2003) Social inclusion implications of park-and-ride, *Proceedings of the Institution of Civil Engineers-Municipal Engineer,* 156(2), 111 - 117.

PARKIN, M. (1979) *Marxism and Class Theory: A Bourgeois Critique.* London: Tavistock.

PATTON, C.V. and SAWICKI, D.S. (1993) *Basic Methods of Policy Analysis and Planning.* Englewoods Cliff: Prentice Hall.

PEARSON, T., RUSSELL, J., CAMPBELL, M.J., BARKER, M.E. (2005) Do 'food deserts' influence fruit and vegetable consumption? - a cross-sectional study, *Appetite*, 45(2), 195 - 197.

PENDYALA, R.M., GOULIAS, K.G. (2002) Time use and activity perspectives in travel behavior research, *Transportation,* 29(1), 1 - 4.

PHILLIPS, J., BERNARD, M., PHILLIPSON, C., OGG, J. (2000) Social support in later life: A study of three areas

77, *British Journal of Social Work*, 30(6), 837 - 853.

PISARSKI, A.E. (1999) *Transportation Planning, Policy and Data: Inextricable Linkages* Distinguished Lecture, Annual Meeting of the Transportation Research Board, Washington, D.C.,

PRESTON, J., RAJE, F. (2007) Accessibility, mobility and transport-related social exclusion, *Journal of Transport Geography*, 15(3), 151 - 160.

PRESTON, V., MCLAFFERTY, S., LIU, X.F. (1998) Geographical barriers to employment for American-born and immigrant workers, *Urban Studies,* 35(3), 529 - 545.

PUGH, M. (1998) *Barriers to Work: The Spatial Divide between Jobs and Welfare Recipients in Metropolitan Areas.* Washington, D.C.: The Brookings Institution.

RAI, R.K., BALMER, M., RIESER, M., VAZE, V.S., SCHONFELDER, S., AXHAUSEN, K.W. (2007) Capturing human activity spaces - New geometries, *Transportation Research Record*, (2021), 70 - 80.

RAJE, F. (2004) Engineering social exclusion? Poor transport links and severance, *Proceedings of the Institution of Civil Engineers-Municipal Engineer*, 157(4), 267 - 273.

RAPHAEL, S. and STOLL, M. (2002) *Modest progress: the narrowing spatial mismatch between Blacks and jobs in the 1990s.* Washington, D.C.: The Brookings Institution.

RITTNER, B., KIRK, A.B. (1995) Health-Care and Public Transportation Use by Poor and Frail Elderly People, *Social Work,* 40(3), 365 - 373.

ROBINSON, J.P. and GODBEY, G. (1997) *Time for Life: The Surprising Ways Americans Use Their Time.* University Park: Pen State Press.

ROORDA, M., MORENCY, C., WOO, K. (2008) Two Cities, Two Realities? A Closer Look at the Evolution of Trip Rates in Toronto and Montreal, *Transportation Research Record,* (forthcoming)

ROSEN, D., SHANKAR, V.N., ULFARSSON, G.F. (2004) Relationship of shopping activity duration and travel time with planning-level network and socioeconomic factors, *Travel Behavior and Values 2004,* (1894), 160 - 169.

ROSS, S.L., TOOTELL, G.M.B. (2004) Redlining, the Community Reinvestment Act, and private mortgage insurance, *Journal of Urban Economics,* 55(2), 278 - 297.

SANCHEZ, T.W. (1999) The connection between public transit and employment - The cases of Portland and Atlanta, *Journal of the American Planning Association,* 65(3), 284 - 296.

SANDEFUR, G.D., FAULKER, C., FRISCO, M., PARK, H. (2004) *Parental Involvement in Education: Another Form of Social Exclusion for Poor Families in the US?* Paper presented at the International Sociological Association/Research Committee on Social Stratification and Mobility, Neufchatel, Switzerland,

SCHLOSSBERG, M. (2006) Running on empty: Transport, social exclusion and environmental justice, *Journal of Urban Affairs,* 28(4), 421 - 423.

SCHMÖCKER, J.D., QUDDUS, M.A., NOLAND, R.B., BELL, M.G.H. (2005) *Estimating Trip Generation of Elderly and Disabled People: An Analysis of London Data* 84th Transportation Research Board Annual Meeting, Washington, D.C., 9 - 13 January.

SCHNEIDER, E.C., ZASLAVSKY, A.M., EPSTEIN, A.M. (2002) Racial disparities in the quality of care for enrolees in Medicare managed care, *Journal of the American Medical Association,* 287(10), 1288 - 1294.

SCHÖNFELDER, S., AXHAUSEN, K.W. (2003) Activity spaces: measures of social exclusion?, *Transport Policy,* 10(4), 273 - 286.

SCHWANEN, T., DIELEMAN, F.M., DIJST, M. (2004) The impact of metropolitan structure on commute behavior in the Netherlands: A multilevel approach, *Growth and Change,* 35(3), 304 - 333.

SCOTT, D.M., HORNER, M.W. (2008) Examining the role of urban form in shaping people's accessibility to opportunities: an exploratory spatial data analysis, *Journal of Transport and Land Use,* 1(2)

SCOTT, D.M., KANAROGLOU, P.S. (2002) An activity-episode generation model that captures interactions between household heads: development and empirical analysis, *Transportation Research Part B-Methodological*, 36(10), 875 - 896.

SELWYN, N., GORARD, S., WILLIAMS, S. (2001) Digital divide or digital opportunity? The role of technology in overcoming social exclusion in US education, *Educational Policy,* 15(2), 258 - 277.

SHEN, Q. (2001) A spatial analysis of job openings and access in a US metropolitan area, *Journal of the American Planning Association,* 67(1), 53 - 68.

SHEPHERD, J., HARDEN, A., REES, R., BRUNTON, G., GARCIA, J., OLIVER, S., OAKLEY, A. (2006) Young people and healthy eating: a systematic review of research on barriers and facilitators, *Health Education Research,* 21(2), 239 - 257.

SILVER, H. (1994) Social Exclusion and Social Solidarity - 3 Paradigms, *International Labour Review,* 133(5-6), 531 - 578.

SILVER, H., MILLER, S.M. (2003) Social exclusion: the European approach to Social disadvantage, *Indicators*, 3(3), 1 - 17.

SILVER, S., SHIELDS, J., WILSON, S. (2005) Restructuring of full-time workers: A case of transitional dislocation or social exclusion in Canada? Lessons from the 1990s, *Social Policy & Administration,* 39(7), 786 - 801.

SIMPSON, B. (2003) Making the connections: Final report on transport and social exclusion. Report by the social exclusion unit 2002, *Proceedings of the Institution of Civil Engineers-Municipal Engineer,* 156(2), 81 - 83.

SMITH, G.C. (1998) Change in elderly residential segregation in Canadian metropolitan areas, 1981-91, *Canadian Journal on Aging-Revue Canadienne du Vieillissement,* 17(1), 59 - 82.

SMOYER-TOMIC, K.E., SPENCE, J.C., AMRHEIN, C. (2006) Food deserts in the prairies? Supermarket accessibility and neighborhood need in Edmonton, Canada, *Professional Geographer,* 58(3), 307 - 326.

Social Development Canada, 2005, *Knowledge Plan: A Discussion Paper*, Knowledge and Research Directorate, SDC, Government of Canada, Ottawa

SOCIAL EXCLUSION UNIT (2003) *Making the Connections: Final Report on Transportation and Social Exclusion.* London: HMSO.

Squires, G., 1996, *Closing the racial gap? Mortgage lending and segregation in Milwaukee suburbs*, Fair Lending Coalition, Institute for Wisconsin's Future

Statistics Canada, 2006, *The 2005 General Social Survey - Cycle 19 Time Use: Public Use Microdata File Documentation and User Guide, Product No. 12M0019-GPE*

Stradling, S., Carreno, M., Ferguson, N., Rye, T., Halden, D., Davidson, P., Anable, J., Hope, S., Alder, B., Ryley, T., and Wigan, M., 2005, *Scottish Household Survey Topic Report: Accessibility and Transport*, Government of Scotland

TACKEN, M. (1998) Mobility of the elderly in time and space in the Netherlands: An analysis of the Dutch National Travel Survey, *Transportation,* 25(4), 379 - 393.

TOBLER, W.R. (1979) Smooth Pycnophylactic Interpolation for Geographical Regions, *Journal of the American Statistical Association,* 74(367), 519 - 530.

TODMAN, L.C. (2004) *Reflections on social exclusion: What is it? How is it different from U.S conceptualizations of disadvantage? And, why Americans might consider integrating it into U.S. social policy discourse?* Paper presented at the City Futures Conference, Chicago, 10 - 8 July.

TOOTELL, G.M.B. (1996) Redlining in Boston: Do mortgage lenders discriminate against neighborhoods?, *Quarterly Journal of Economics,* 111(4), 1049 - 1079.

TRAIN, K. (2003) *Discrete Choice Methods with Simulation.* Cambridge: Cambridge University Press.

TURNER, T., NIEMEIER, D. (1997) Travel to work and household responsibility: new evidence, *Transportation,* 24(4), 397 - 419.

VAN BERKEL, R. and HORNEMANN, M. (2002) *Active social policies in the EU: Inclusion through participation?* Bristol: The Policy Press.

WACHS, M., TAYLOR, B.D. (1998) Can transportation strategies help meet the welfare challenge?, *Journal of the American Planning Association,* 64(1), 15 - 19.

WAGLE, U.R. (2008) Multidimensional poverty: An alternative measurement approach for the United States?, *Social Science Research,* 37(2), 559 - 580.

WANG, F.H., LUO, W. (2005) Assessing spatial and nonspatial factors for healthcare access: towards an integrated approach to defining health professional shortage areas, *Health & Place*, 11(2), 131 - 146.

WASMER, E., ZENOU, Y. (2002) Does city structure affect job search and welfare?, *Journal of Urban Economics,* 51(3), 515 - 541.

WILSON, J. (1987) *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy.* Chicago: University of Chicago Press.

WRIGLEY, N. (2002) 'Food deserts' in British cities: Policy context and research priorities, *Urban Studies,* 39(11), 2029 - 2040.

YE, X., PENDYALA, R.M., GOTTARDI, G. (2007) An exploration of the relationship between mode choice and complexity of trip chaining patterns, *Transportation Research Part B-Methodological,* 41(1), 96 - 113.

ZELLNER, A., THEIL, H. (1962) Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Equations, *Econometrica,* 30(1), 54 - 78.