Divergent affordability:
Transit access and housing in North American cities

By

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

During the process of post-war Fordist suburban expansion, the American and Canadian city was expanded and built around the automobile as the dominant mode of transportation. This caused an inversion of the pattern of centrality and access in cities, and auto-accessible suburbs became the place of wealth and privilege, away from the city centre.

There is reason to believe that these patterns are changing in this century. A re-investment in downtowns along with a loss of middle-class manufacturing jobs and income is resulting in changing suburban socioeconomic geographies. If auto-oriented suburbs are becoming the new location of affordability and decline, this would result in an unprecedented situation: car-dependent social peripheralization.

This dissertation tests this possibility. Using statistics and spatial analysis, it presents public data on socioeconomics, urban form and public transit to try and understand the current geographies of housing affordability in relation to transit access in twenty large metropolitan regions.

This research is concerned with how the spatial polarization of housing affordability to suburban areas impacts access to public transit for lower-income households. In a comparative survey of twenty North American cities, I demonstrate that the lowest-cost home ownership is often found outside of the zone served by frequent transit networks, while the lowest-cost rental housing is fragmented across both transit networks and outside them. Half of the cities studied did not have enough frequent transit lines to offer an accessible network at all. The results show that in cities with transit systems that offer metropolitan-scale access, there is commonly a misalignment between affordable home ownership opportunities and frequent transit networks. When incomes and other socioeconomic and built-in environment variables are taken into account, the cost of owner-occupied housing is higher in transit-accessible areas. This is problematic from the perspectives of social justice and economic efficiency: cities will not offer fair access to opportunity if large segments of the population are priced out. The issue of isolated suburbanisms calls for adding social utility to the criteria for transit extension, as well as for innovative land use policy to encourage affordable transit-oriented intensification in these areas. While this analysis offers a snapshot of current conditions, further quantitative and qualitative research would add to our understanding of these issues.

This research suggests, at a comparative metropolitan scale in the North American context, that affordable home ownership is now often connected to automobile dependency and separated from access to alternative, less expensive mobilities. This lack of affordable access is a concern for social and environmental justice, for economic mobility and for personal and community agency.

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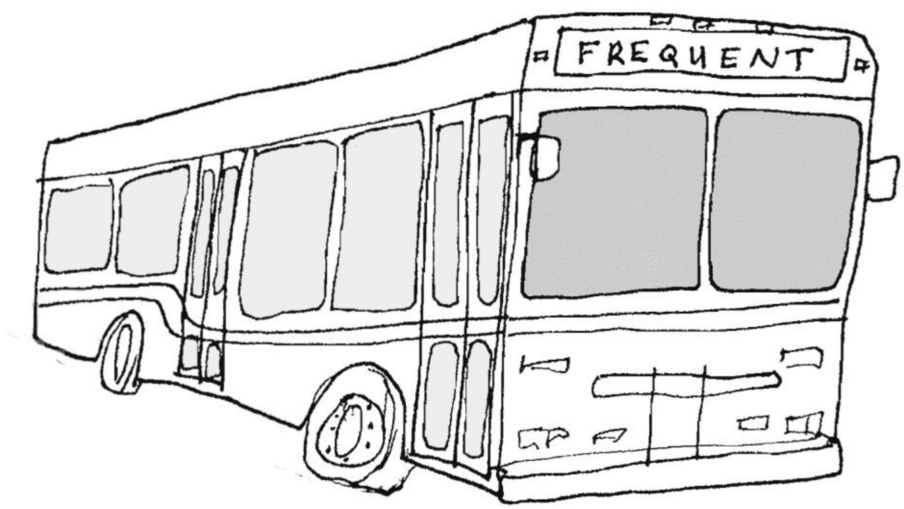

This research is dedicated to transit riders.

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Introduction

Housing and transportation costs combined form a significant amount of living costs for North American households. The cost of public transit is an order of magnitude less expensive than private car ownership, and so plays an important role in equalizing accessibility for lower-income households. However, residential location is also subject to economic forces. This research asks the question, "What is the current relationship of housing costs to transit network locations in large North American cities?"

Built environment and socioeconomic characteristics such as density, household income, car ownership, housing type and tenure, rent and housing costs are mapped against the network of frequent public transit routes in twenty American and Canadian metropolitan regions. The likelihood of living within a walkable distance to the frequent transit network based on these factors is modelled using logistic regression. The results show that the likelihood of access to the frequent transit network increases as house prices rise; in many metropolitan regions, there are large areas of affordable homes that are un- or under- served by convenient public transit. With some exceptions, the older centres of cities are more associated with robust transit networks, and the inner suburbs and outer centres are generally auto-dependent. As these suburban places diversify both in terms of urban form and socioeconomics, public transit networks have not kept up. The result is a mismatch of affordable housing and affordable transportation options. The auto-dependent nature of many suburbs makes this marginalization particularly challenging.

This dissertation is organized in four chapters. The first chapter is a literature review giving context to the research. It introduces concepts of urban form and access, touching on urban economics including land rent and gentrification, and the role of socioeconomics in shaping transportation demand. It goes on to explore concepts of equity with theory and case studies, and describes how transportation planning practice tools relate to questions of equity and inequity of access to the city.

The second chapter begins with the research question: what is the relationship between housing cost and public transit access in large North American cities? The methodology chosen for answering this research question includes spatial and statistical analysis of census and community survey data from twenty cities. When mapping transit networks, service frequency was chosen as a determining factor for accessibility. As non-work trips make up the majority of trips, and non-car-driving populations must take all trips by alternative modes, it is important to have a level of service frequency that doesn't require long wait times and that runs all day and not just at peak hours.

The third chapter shows the results. The results are presented in groups of cities, from those with strong transit networks to those with less extensive networks. A pattern of exclusion from transit of lower-cost home ownership is shown. There is a fairly consistent pattern of greater income inequality compared to housing cost differences inside and outside transit-accessible zones. When income and built environment factors are controlled for, the likelihood of transit access goes up as housing costs rise. This spatial and statistical analysis provides a perspective on affordability mismatch. There is a great amount of data presented as part of this analysis, and some of it has been moved to the Appendixes.

The fourth chapter focuses on the implications and possibilities emerging from this research. It thinks through possible strategies for improving affordable access in metropolitan regions, especially in auto-oriented suburbs, from both a land use and transportation perspective. It concludes with a description of further directions for research that could strengthen our understanding of the issue of affordable access in transforming suburbs.

This research explores the challenges and opportunities for extending the infrastructures of alternative mobilities into affordable postwar suburbs. The post-war suburb was built around the automobile as a way of organizing space and disciplining movement. This configuration is composed of wide, fast-moving arterials in superblocks, isolating areas of single-family homes and presuming car ownership. Today, these areas are becoming the new zones of affordability in cities, and this adds pressure and possibilities for transformation. Whatever form this transformation takes, it will be different from downtowns. What are the spatial and socioeconomic characteristics of these areas? How might flexibility allow for new types of mobility networks and built form?

In addition, transportation and land use planning methods are questioned in relation to the mismatch of housing and transportation affordability. In many ways, these methods overlook or marginalize the importance of affordability in coordinating land use and transportation plans. When combined with urban gentrification, this means that plans for transit-oriented development risk becoming inaccessible and unaffordable for those who would use transit the most.

A continuation of this vector of inquiry would investigate the possibilities for creating new metrics and ways of estimating demand that take land use and socioeconomics into better account. If transportation equity is defined as relatively equal access to opportunity regardless of mode, then the competitiveness of transit and active transportation like walking and cycling in relation to the car becomes a proxy for social justice.

A note on vocabulary: for the purpose of this dissertation, the term 'North American cities' is used to mean metropolitan regions in Canada and the United States. Mexican cities are not included in this research as they do not share the same history of post-WWII auto-orientation and suburbanization. Although the term 'city' traditionally refers to one large municipality like Los Angeles or Toronto, for this research the surrounding contiguous urbanized areas are included in the definition of city. For example, when referring to Los Angeles, this research refers to the surrounding metropolitan region including San Bernadino, Riverside, Ontario, and Orange counties; when referring to Toronto, it implies the inclusion of neighbouring municipalities of Mississauga, Brampton, Markham, etc. The shorthand 'city' is used to refer to the entire urbanized metropolitan region throughout this dissertation. This more accurately reflects the current nature of cities, which have grown regionally and expanded beyond existing political boundaries.

Chapter 1: Literature Review

Urban form and access

Cities are spaces of ongoing transformation. Neil Smith, in his work on gentrification, argued that gentrification in urban downtowns was a predictable process of a capitalist economy, and not an exception to suburban expansion (Smith N. , 1996; Smith N. , 1982). Development takes a large amount of capital, and in order for that capital investment to be paid back, the urban form of the development must stay the same for a number of years (usually over 30). This locks in the land use in that form, which has been called a 'spatial fix' by David Harvey. As time passes, the development goes through a process of 'devalorization', according to Smith. During this process, the land owners can choose to continue investing in the upkeep of the current form of development, or they neglect upkeep. After a time, the value of a potential change of use on that land is worth more than the current use, and this 'rent gap' makes re-development and re-investment worthwhile.

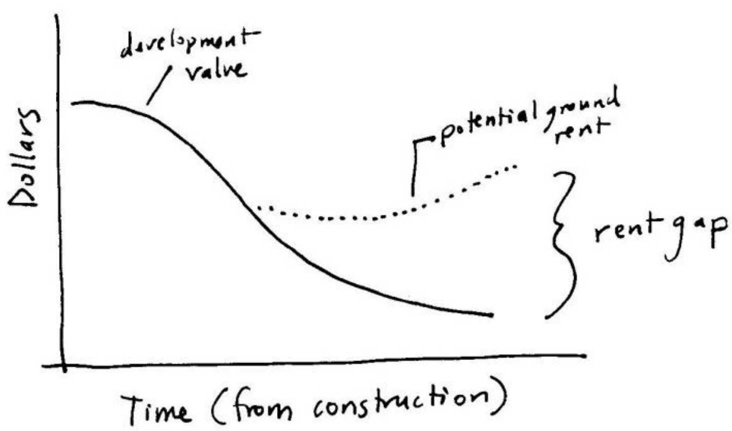


Figure 1: Rent Gap (modified from Neil Smith)

Urban downtowns in North America (and in other places, as Smith points out), have gone through a process of original development (residential neighbourhoods downtown), which have devalued over time, creating cheap rents and prices. At the same time, suburban expansion has been the focus of most development investment, locking in the suburbs into a particular 'spatial fix'. At a certain point, when the rent gap of the downtown neighbourhoods (potential income vs. actual income from the property) became large enough, it was inevitable in a capitalist economy where government did not intervene except to reinforce and encourage these trends, that gentrification, in the form of re-development and re-investment, would occur.

This theory is a modification of more traditional theories of urban form and land costs, which assumed that newer, suburban expansion would command high prices and attract the wealthy from older housing, by offering more space. The older, smaller, more central housing 'filtered down' to lower costs, attracting new immigrants and the poor (Lowry, 1960). The Alonso model (Alonso, 1964) posited that in a simple mono-centric city, land value would decline with distance from city centre, because the value of land related to access, and property closer to the main destination (CBD) would therefore cost more. Access depends upon mode of transportation, and so pre-car modes like walking, horse and buggy, and streetcars had a steeper land value curve. A car can go greater distances at a faster speed, and so the land value curve was extended out farther and became shallower. This research explores the possibility of a 'locked-in' Alonso model, where auto-dependent suburbanization becomes the locus for poverty.

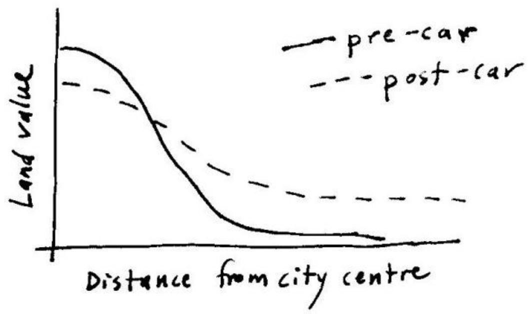


Figure 2: Alonso model: Land value in relation to distance from city centre, before and after car

The Chicago school of sociologists noticed that the central business district was surrounded by a ring of lower-cost, older housing and manufacturing that was attractive to immigrants and the poor, which would undergo periods of succession and transformation as groups moved out and others moved in. They saw the city as a series of concentric rings, with the CBD in the centre, the 'zone of transition', then a zone of older workingman's homes, a residential zone, and finally a commuter zone. The automobile enabled a great spread of population. Suburbs cost more than downtown living. The old land value theory becomes inverted, at least partially.

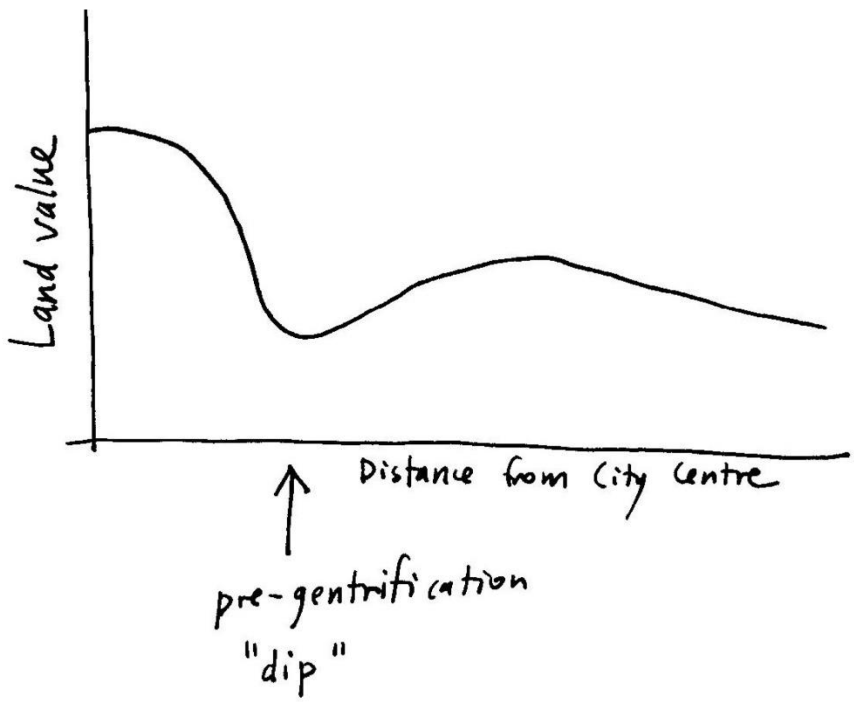


Figure 3: Pre-gentrification dip in the area of workingman's homes and the zone of transition

Of course, housing costs in the 'zone of transition' and in the workingman's homes were lower than those of more affluent neighbourhoods farther out. The Chicago school of urban sociologists generated these ideas in the 1920s and 30s by studying Chicago. Later, in the 1980s and 90s, urban scholars in Los Angeles modified this model again by observing Los Angeles (Dear & Flusty, 1998). They noticed that cities were no longer mono-centric, but polycentric, as the suburban outskirts influenced the centre. They also characterized the city as having 'ubiquitous social polarization', but rather than in a predictable zone of rings, this polarization was happening in patchwork forms all over the urbanized area, with some gated, high-security residential areas and other areas of poverty.

With the widespread adoption of the technology of the automobile in the North American context, however, this urban logic was partially undone. The concentrated zone was originally a 'many to one' origin-destination matrix, resulting in a hub-and-spoke network, where central land had economic primacy. With the advent of mass motorization, this relationship between land value and transportation changed, allowing many more destinations to become more accessible. This resulted in a flattening of the land value - accessibility gradient, lowering density and creating a dispersed land use pattern. The origin-destination matrix was changed from "many to one" to "many to many", as each point in the road network had potential for door-to-door accessibility to each other point (barring congestion, and given parking). Distance became less of an influence to the cost of land, and as land farther out from the city centre became serviced by infrastructure and accessible by car, it rose in value. Further, because cars take up much more space per traveler than other modes, requiring more road space and also parking space at both origin and destination, the higher-density city centres became more prone to traffic congestion with a shift to the automobile and lower-density suburban areas gained an accessibility advantage. Development at the peripheries offered the possibility of space for larger houses and separation from urban irritants.

The mobility offered by the car was unprecedented, and transformed the metropolitan region. This mobility has a prerequisite, which is car ownership. In the older city, real estate 'cycled down' as newer developments were built in outer areas with amenities like large lots and bigger houses. This left the older city with a more affordable housing stock. This housing affordability matched pre-existing transit service and attracted lower-income populations who could benefit from this affordable accessibility (Glaeser, Kahn, & Rappaport, 2008).

The transformative importance of this change in the logic of accessibility cannot be overstated. With the privately-owned vehicle as commonplace, every road becomes theoretically accessible at all times; a traveler no longer depends on the third-party transit operator to set the time (schedule) and place (routes/lines). Now, the onus is on the citizen to own and operate a car – mobility depends on it. This has an impact on both urban form and on household budgets. The first is no longer constrained by public modes of travel, and density changes from being necessary for accessibility to possibly a cause of congestion, due to the space required for cars. The second, household budgets, generally had been paying a decreasing percentage for basic needs like food, clothing and shelter over the twentieth century, and larger portions of growing discretionary incomes were able to be spent on transportation, especially as cars became priced within the realm of affordability and fuel energy cheap and plentiful.

This metropolitan postwar expansion in both countries resulted in two realms of urbanization in cities: one older, central zone characterized by higher-density, mixed use development with an established public transit system, and the second an extended, lower-density, auto-oriented realm (Filion, 2000). What happened to the older parts of cities, which were now at a disadvantage due to narrower streets, higher densities, and less capacity for cars? Because transit networks were here, people would not have to take on the extra financial burden of owning and operating a car. Lower-income families will pay more for housing in exchange for proximity to a transit line. Research tracking the socioeconomics of neighbourhoods before and after subway lines found in some cases that house prices would rise but incomes would fall, as people moved in who valued the new accessibility by transit, which demonstrated this trade-off (Glaeser, Kahn, & Rappaport, 2008). Perhaps to a greater extent in the United States, this transformation of cities was culturally accompanied by the racialization and stigmatization of downtowns and public transit concurrent with 'white flight' to the suburbs. Although Canada did not experience the same level of abandonment of its older city cores, these places were still areas of affordability that attracted immigrant populations who could use 'sweat equity' to improve the old housing stock.

After the Second World War, a growing middle class wanted single unit homes on large lots and cities expanded to accommodate this demand (Filion & Hammond, 2003). Those who could afford to moved to suburbs to have greater access to land, newer homes, better schools, and (originally) greater ease of movement enabled by the newly built highway and arterial systems. Industrial and corporate headquarters relocated away from the urban core, and cities lost their strategic function as mass manufacturing and consumer markets took the form of the suburban, auto-oriented spatial fix (Sassen, 2006). Governments in both Canada and the United States backed mortgage markets to make home ownership more accessible (Harvey, 2012). In comparison to pre-war cities, much development was auto-oriented with lower densities, wider streets and separate uses (Kim, 2007). The end result of this suburbanizing trend was an extended city where space and mobility are disciplined by the automobile, and land uses separated in arterial super-blocks or by highway exits. This extended zone is organized by Fordist ideas of production of space with parallels to assembly line production in factories where speed is secured by separating types of movement. The street becomes less a public space that accommodated many different types of movement patterns, and more a conduit for faster-moving private vehicles. Public space – the street – was increasingly designed for automobility (Sheller & Urry, 2000). Although still built around the automobile with separated uses, the suburbs built between the 1940s and 1970s in Canada were generally built at a higher density than those built during the same period in the United States (Filion et. al., 2004). After the 1970s until approximately 2000, suburban patterns of continuously larger lots and houses were common to both countries (Ibid).

Many suburbs have too low a density to support the level of frequent transit service that is necessary for auto-independent accessibility, or the clusters of density that do exist are surrounded by low-density areas. Where transit routes do exist, frequency is often sacrificed for coverage, leaving long wait times between vehicles (Walker, 2012). Suburban areas are associated with single-unit detached houses on large lots, because other types of dwelling – townhouses, and apartment buildings, for example – are often restricted by zoning or covenants. This makes suburbs a producer of housing affordability stress for those on the lower end of the income spectrum (Bunting, Walks, & Filion, 2004), in addition to being areas where mobility is dependent on automobile ownership and use.

Suburbs do not mix uses in the same way as urban cores, where residential, commercial and institutional uses are often within walking distance, if not in the same building. The land use pattern of suburbs is generally one of *superblocks*, a widely spaced grid of arterials where the interior of each large block is developed as a parcel of one type of land use (Sorensen, 2011). Destinations, like grocery stores, schools, jobs and other necessities are not designed to be within walking distance of residences and pedestrian infrastructure such as sidewalks and crossing lights are often absent. Although traffic within each superblock may be calmed by cul-de-sacs and parking lots, depending on use, the arterials themselves are wide and fast-flowing, with few or no mid-block crossing points. If suburbs, then, are becoming the location of the most affordable housing in a metropolitan region, this affordability is challenged by the cost of owning and operating a car (Lipman, 2006). Alternative mobilities such as public transit, walking and cycling are less present due to the auto-orientation of urban form and streets.

Of course, this two-zone characterization is a simplistic generalization; in reality, individual metropolitan areas are differentiated and suburbanization itself has become more complex and diverse. Toronto, for example, due to a former tax incentive for investors in rental housing, has a large number of high-density market rental towers scattered throughout both the downtown core and inner ring suburbs (Moos & Kramer, 2012; United Way Toronto, 2011). Cities in the American southwest, which grew mostly after WWII, have only small token areas representing the first zone and are almost entirely low-density and auto-oriented. In all cities, patterns of home prices vary according to spatial factors other than the distance from the city centre and age of construction – wealthier and more affordable neighbourhoods have always been spatially patterned according to other geographic and historical circumstances.

Post-Fordism

These trends described above are generally associated with the Fordist era, marked by a very large middle class and minimal income polarization, usually identified with the 1950s – 1970s. Since then, the hallmarks of the neo-liberal era have been smaller governments, a threatened middle class, loss of manufacturing jobs overseas, the rise of the service economy, the growing importance of the financial sector, and greater income polarization. During this time, two trends have counteracted the initial separation of city and suburb: the suburbs have become more diverse in many ways, and the old city has been the site of renewed investment and importance.

These structural, macro-economic changes have influenced the 'spatial fix' (Harvey, 1982) of metropolitan regions, complicating the urban-suburban dichotomy through forces such as the suburbanization of poverty, the attraction of the 'creative class' (Florida, 2002) to downtowns and resulting 'eco-gentrification' (Quastel, 2009). In particular, the diversification of the social, economic, and physical urban fabric of the suburbs has resulted in some scholars identifying these transformations as a 'post-suburban' phenomenon. Post-suburban theory describes the stigmatization, vulnerability and fragmentation of suburban spaces that challenge current institutional structures and actors to readjust traditional mechanisms of infrastructure provision and urban politics (Keil & Young, 2009; Soja, 2000; Lang, 2003; Phelps & Wood, 2011).

Beginning in the 1980s in major 'global' cities, expanded demand for top-end office, commercial and residential space led to rising prices and growing homelessness downtown as the city centre re-emerged as a site for global finance (Sassen, 2006). Sometimes called gentrification, this phenomenon involves the displacement of lower-income populations. With this movement from the older city, those displaced concurrently lose the amenities associated with the older city like a concentration of social services and pedestrian-accessible neighbourhoods. Access to the transit network is usually bundled together with other 'urban' goods in the literature on gentrification, so the specific change to the accessibility of the metropolitan area via public transit as a result of gentrification-driven displacement has not been researched explicitly.

In addition to greater socioeconomic diversity in extended metropolitan regions, there has also been a diversification of the built environment. Post-suburbia has been compositely characterized by:

- the greater mixing of land uses (residential, manufacturing, service, open space), the mixing of morphological elements, including urban elements like grids; polycentric urban structures;
- a breaking away from residential-only patterns and away from concentric radial patterns to more complex, scrambled, patchwork structures;
- more diversity than appreciated in terms of industry, infrastructure and amenities;
- and growth that coincides only imperfectly with existing local government boundaries (Wu & Phelps, 2008).

These post-suburban transformations have also been associated with 'declining' inner suburbs (lower incomes and housing costs) as well as different ideology and politics than the traditional suburban (Ibid). In short, it is the urbanization of suburbia. Of course, the underlying matrix of suburban form will be quite different from the previous, older urban forms, meaning that the post-suburban, post-Fordist city of the twenty-first century has quite different spatial, socioeconomic and political configurations.

Combined, these theories of urban economics help us to understand the current patterns of housing costs and transit access that this research investigates. If the combination of the neglect of urban neighbourhoods with subsequent re-investment has been the process of gentrification, then the affordable, spatially polarized isolated suburban neighbourhoods that are the focus of this research may currently be the locus of disinvestment and decline. Transit investments in these areas could help keep up these areas to prevent a large rent gap from forming, preserving their affordability and function in the long run. Of course, transit-induced gentrification is also a possibility, but the simultaneous extension of frequent routes into many areas at once to increase the network coverage would help prevent this possibility. For a further discussion of transit-induced gentrification, please see the section with this title.

Changes in urban planning theory – 'smart growth' and intensification

In response to mass motorization and auto-dependent urban form, metropolitan plans have increasingly adopted ideas of 'smart growth' and transit-oriented development. Citing congestion, air pollution, and infrastructure efficiency, many long-range plans call for more sustainable transportation-land use configurations. These ideas include encouraging intensification around public transit, improving multimodal transportation options including walking and cycling, mixed use and higher density development.

In both Canada and the United States, land use planning is under local jurisdiction. However, in the United States, the Federal Government shapes transportation policy through funding formulas. Legislation beginning with the *Intermodal Surface Transportation Efficiency Act* of 1991 (ISTEA), and continuing with the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* of 2005 (usually shortened to SAFETEA-LU), was created to coordinate funding with growth policies. This has required Metropolitan Planning Organizations to take air quality, multimodal networks, equity, and environmental justice into consideration (de Zeeuw & Flusche, 2011; Goldman & Deakin, 2000; Wolf & Fenwick, 2003; Nelson et. al., 2004; Olson, 2000; Vogel & Nezeldewicz, 2002; Wadell et. al., 2007). Most notably, these laws have gradually pushed transportation planning to address how land use might be shaped as well as served by transportation projects. In Canada, there is also evidence of the coordination of land use and transportation at the scale of the metropolitan region (Taylor & Burchfield, 2010; Filion & Kramer, 2012; Filion & Kramer, 2011); this is not driven by federal legislation, but through the efforts of provincial and regional governments.

There are two overlapping trends in post-war development in the North American metropolis. The first is one of suburbanization and auto-oriented growth extending outside the older, transit-oriented urban cores. In this trend, the higher value is on larger lots and bigger houses, with greater privacy and an emphasis on a retreat from the public realm. The second is one of intensification and re-development, where urbanism regains its value. Given these two counter-trends – one of a centrifugal and dispersing nature, associated with the Fordist era, which left behind a transit network serving core lower-income populations, and the second of the re-emergence of city centres as places of investment and gentrification, as well as transit-oriented intensification in suburban areas, the research questions emerge. Where are the areas of lowest-cost housing in metropolitan regions today? What are their densities and built form characteristics? And where are they located in relation to public transit networks?

Access to the city: Structural issues

Socioeconomics and Transit Demand

Qualities of the built environment, such as density, diversity of land use and housing types, urban design for a pedestrian experience, and the distance to and coverage offered by transit systems are important factors influencing transit ridership[1]. In an urban environment, it is difficult to isolate the effects of one variable from those of other variables (Boarnet & Crane, 2001). Attempts to measure the impacts of one variable, like density, on ridership are confounded by a multitude of factors like self-selection and income levels (Mokhtarian & Cao, 2008). There are many urbanized areas in large American and Canadian cities that fall below transit-supportive densities. There may be other reasons for sending transit service through lower-density areas, such as making important connections in the network or serving employment or commercial centres. These numbers are actually fairly generous in giving service, as frequent service has the capacity to cover much higher densities than this. It is the intersection of these minimum densities with socioeconomic attributes such as low income, low car ownership levels, and affordable housing that is the focus of the research. The combination of socioeconomics favourable to transit ridership with density will result in higher potential ridership than in wealthier, more auto-dependent areas of similar densities.

Although it is difficult to separate out the effects of the built environment on travel behavior from resident's self-selection and preferences, "to say that these outcomes are preferences or choices doesn't quite ring true. In many cases, poorer families choose to live where they do, or commute by a particular mode, only because they lack the range of choices available to wealthier families. To the extent that these outcomes represent household preferences, they are typically constrained preferences." (Cervero et. al., 2006, p29) For those who cannot afford a car, an auto-dependent urban form imposes a barrier. Bagley and Mokhtarian (2002) go so far as to conclude that once attitude, lifestyle, and socio-demographic variables are accounted for, neighbourhood type has little influence on travel behaviour. Socioeconomic characteristics including income and car ownership are often found to be more significant predictors of mode choice than the built environment. In a synthesis of 50 empirical studies, mode choice is found to be primarily a function of socioeconomics and secondarily a function of the built environment (Ewing & Cervero, 2001). A 10% increase in density resulted in a

[1] There is an extensive literature on the relationship between the built environment and transit. For a review of this literature, please see Appendix A.

0.7% increase in transit ridership, while a 10% increase in household income resulted in a 3% increase in automobile travel (Ibid). People with lower incomes are more likely to use alternative modes of transportation. People who use transit also have a tendency to live in more affordable and higher density housing units, where they are available. These relationships show the interactions between variables such as density, affordability, income, transit ridership, and transit service levels.

> Two points need to be made concerning the role of socioeconomic factors within integrated urban models. First, it is the interaction between socioeconomics and urban form which is central to the understanding and modeling of people's locational and activity/travel decision making. Different people will respond to different density levels/urban designs in different ways. It is, therefore, not a question of "which is more important", density or socioeconomics, in explaining behavior. Rather, it is a question of understanding how behavioral responses to changes in density, etc., will vary by socioeconomic characteristics.
>
> Second, given the importance of socioeconomic factors, it is imperative that they be explicitly represented within our modeling systems, and that our models be sufficiently disaggregated to properly capture their effects. This implies the need to include within model systems explicit representations of demographic trends and economic process. (Badoe & Miller, 2000, p. 254)

The socioeconomic characteristics of the population can be strong predictors of mode choice (Cervero & Duncan, 2003). Generally, low income households are associated with higher levels of transit use (Ewing & Cervero, 2001). Because of the importance of socioeconomic variables in mode choice, any study of the relationship of the built environment and the demand for transit must consider income and other cost-based economic influences. These confounding variables are impossible to ignore, and yet the links between transport and income have paradoxically been under-researched because they are so obvious (Preston J. , 2001). The social dimensions of urban transportation are often overlooked or implied in research on sustainable transportation (Boschmann & Kwan, 2008). While it is understood that income is an important factor in transit ridership, the way that it is incorporated into demand models may not be optimal (see 'Equity and Planning Practice' section below).

Income is influential in deciding people's travel choices; when cost is not a barrier, there is more choice of transportation options. People with higher incomes drive more and take transit less, even populations who self-select to urban areas and otherwise reject the suburban lifestyle. In a study of areas of gentrification in Toronto, Montreal and Vancouver, researchers found that gentrifiers had higher cycling and walking rates compared to neighbouring areas, but lower transit ridership and slightly higher car use (Danyluk & Ley, 2007). Median household income has a negative effect on the share of commutes made by transit, even after correcting for spatial auto-correlation. "As the income of the typical household in the zone increases, residents will have more alternatives available, most likely private mobility, and will as a consequence use less transit" (Moniruzzaman & Paez, 2012, p. 203). Households with lower incomes are more likely to have no drivers and/or no vehicles, and are also more likely to be regular transit users. As jobs become more flexible, workers are also more likely to have off-peak and off-direction commutes (Giuliano, 2005). Many are part-time workers with shifts at night, or who work in low-wage jobs in more dispersed, suburban areas (Deka, 2004).

The correlation of lower income with higher transit ridership makes sense, given the relative costs of transit compared to a car. The average car owner in the United States will spend $9,100 to own and operate a car in 2013 (American Automobile Association, 2013), and more in Canada due to higher gas prices. In large cities, the cost of an unlimited monthly transit pass in North America falls between $60-$120 (Keith, 2013), meaning annual costs are between $720 and $1440, which is significantly less expensive than a car for the solo traveller. Active transportation, like walking and cycling, are even less expensive. Transportation economists generally estimate the cost of a trip to be a combination of the direct costs (fare, gas, etc.) and the time costs. People with higher incomes have higher value of time (hourly rate of pay), and transit is usually slower than the car in most contexts.

Economics of transit demand

The economic side of transportation – specifically, the differing elasticity of demand for public transit based on income (the sensitivity of smaller wallets to the price differential between public transit compared to cars) is an important factor for transit planning. Travel by public transit has a significant time penalty in North American metros (Figure 4), which creates a disincentive to take transit. Because of this time penalty, public transit is often limited in competitiveness compared to the car. The value of time to various segments of the population differs; those with higher incomes in general attach a higher monetary value to their time, and are therefore less willing to tolerate the inconvenience of transit. Lower-income populations, however, are more willing (or rather compelled) to pay a time penalty rather than the financial one of car ownership. The attractiveness of transit then becomes a struggle between the competing elasticities of the value of time and the value of money. For those with less time and more money, transit is unattractive, and vice versa.

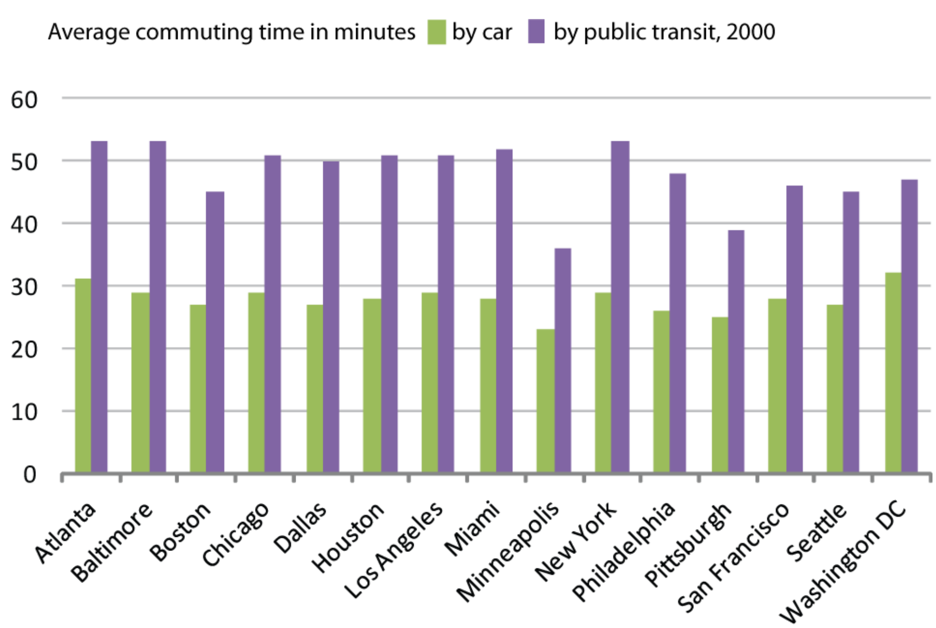
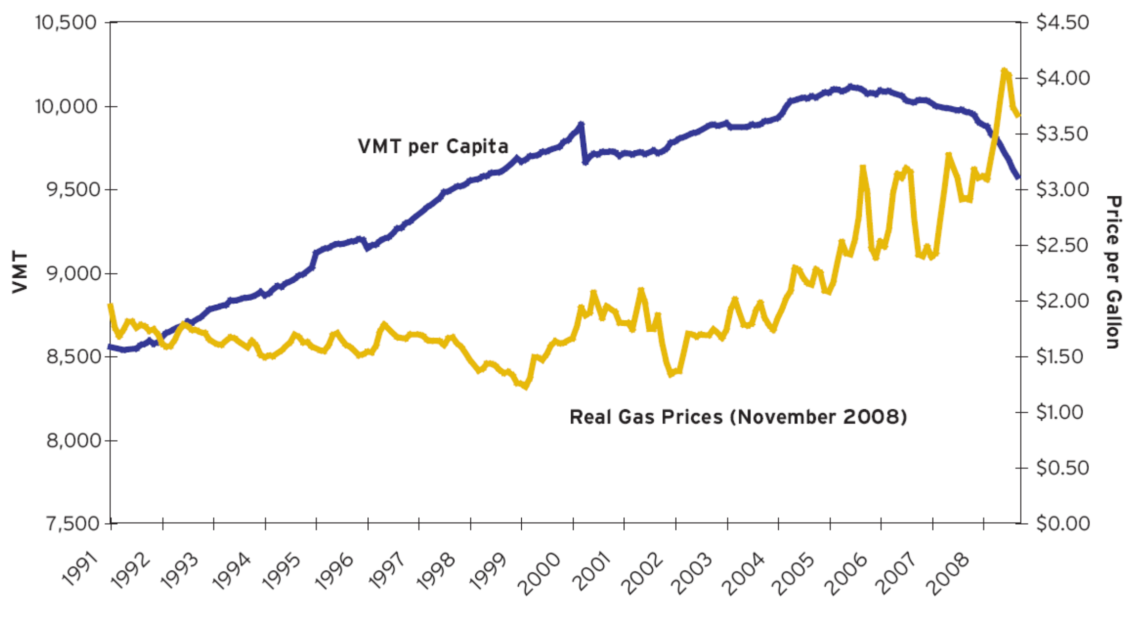


Figure 4: Time penalty of public transit compared to automobile (graph by author). Data from the 2000 Census, analysis by the Centre for Neighborhood Technology

Time spent waiting is perceived as longer than time spent travelling, regardless of one's income. Less frequent routes require consultation with a schedule before travel and restrict travel flexibility. If at all possible, people will try not to rely on these routes for transportation needs. Therefore, if transit agencies focus on extending service thinly over a low-density metro area, the time penalty increases as headways (the wait time between transit vehicles) increases, and the incentive to buy a car increases even more.

Automobile ownership is related to household location choices (work, live) and travel mode decisions. Households who live and work in low density areas will most likely be auto-dependent; households in denser, transit-oriented areas may opt to own one less car, which then commits them to alternative modes of travel for at least some trips. It is important to include auto ownership as a variable in a model of transportation-land use interaction (Badoe & Miller, 2000; Cervero, 2002). Even though a household may not own a car, they may have access to vehicles through sharing, borrowing, and getting rides (Lovejoy & Handy, 2008). However, the access is contingent on someone else's generosity, and therefore less convenient and stable as when a car is directly owned. Automobile ownership is both a factor of the built environment and of a household's socioeconomic status.

As discussed, unlimited transit ridership costs roughly 1/10th of the cost of average car ownership. The economics of public transit are more compelling for households that measure towards the lower end of the income spectrum that have less overall money to budget with.



Source: Traffic Volume Trends and Energy Information Administration

Figure 5: US vehicle miles traveled per capita, annualized and real gasoline pump prices, January 1991-September 2008 (Puentes & Tomer, 2008, p. 9)

Figure 5 shows that, as real gas prices rise, people eventually respond by driving less on average, with prices of $4/gallon being a stress point in the United States. In Canada, where gas prices are higher, transit ridership is also higher. If gas prices rise as suburban house values fall, some scholars see a risk that lower-income home owners in these areas will become 'locked in' to their location, without options to adjust to a more affordable lifestyle (Gusdorf & Hallegatte, 2007).

The changing commute

Rush hour is the time when the maximum capacity of transportation systems is tested. These morning and evening 'peak times' contain the largest volume of simultaneous trips, following the pattern of the nine-to-five work day. Commuters have long been the focus of transportation planning, although these trips do not make up the majority of all trips. "[T]ransportation policies [] largely reduce mobilities to car usage and the time-space organisation of employed men [], which largely ignores the spatio-temporalities of children, homemakers and old people" (Manderscheid, 2009). Journey to work trips make up around a fifth of all trips (McKenzie & Rapino, 2011), but are the only ones recorded in the Census data. One reason why these trips are given priority is because they tend to all happen around the same times – during morning and afternoon rush hours, at the 'peak travel time'. Therefore, these peak traffic volumes are often used as design standards for roads. "Commuting [] has historically defined peak travel demand, and in turn influenced the design of the transportation infrastructure. Work trips are also critical to transportation planning, and help determine the corridors served and the levels of transit service available" (McGuckin & Srinivasan, 2005).

The work trip is changing. Since the 1960s, trends such as the advent of working women, the growth of the single-person household, and the spread of residence and workplaces has contributed to large increases in vehicle ownership, vehicle use, and commuting time in all large metro areas in the United State (Ibid). Work trips have gone from 25% of all trips in 1969 to 16% in 2001, although many non-work trips are linked into the work trip. The peak travel times are spreading to shoulder times and evening traffic is growing (Ibid).

Suburban vulnerable populations (the elderly, disabled, those with limited means, and single parents) face mobility challenges different from the mainstream population. "[there is] evidence of significant interactions between location, various demographic factors, and mobility tools. More specifically, the results evince patterns of mobility that are significantly different [for these vulnerable populations] from the mainstream population, particularly in suburban settings, in ways that are indicative of mobility challenges" (Morency et. al., 2011).

What if higher density and lower income areas are not aligned? If the growing numbers of poor and 'middle-class' households are being pushed from traditional higher-density transit catchments into auto-dependent areas due to housing affordability issues, what impacts would this have on transit provision and ridership? The worst-case scenario for both equity and efficiency would be the complete auto-dependence of poverty, resulting in marginalization from the public realm and its opportunities, as well as the loss of transit ridership.

In Canadian cities (specifically Montreal, Toronto and Vancouver), research has shown downtown gentrification to be associated with declining levels of social mix, ethnic diversity, and immigration concentration (Walker, 2008). These economic forces that are gradually transforming the older cities are also resulting in spatial-economic polarization as the share of lower-income populations decrease downtown and increase in the inner suburbs, resulting in a loss of middle-income neighbourhoods in the city of Toronto (Hulchanski, 2010; Walks, 2006; Walks, 2001). A rising demand for, coupled with a limited supply of, houses in the city, together with new construction being focused almost exclusively on the higher-end condo market, contributes to a lack of affordable housing (Harvey, 2012). The resulting trade-off between housing and transportation costs in choosing residential location in metropolitan regions has been analyzed in the United States (Lipman, 2006). Transit systems in turn face a potential loss of ridership if transit-dependent populations are expelled to the dispersed zone, especially if they are replaced by populations who shun transit.

What are the transportation habits of downtown gentrifiers? Sometimes called the “creative class” – referring to professional white-collar jobs rather than artists - (Florida, 2002), the college-educated professionals who are part of the infusion of investment in downtowns and older cities are also theoretically aligned with values of sustainability. They value urbanism for its own sake and embrace the aesthetic of crowds and converted warehouses. Does this commitment extend to riding transit? In a study of areas of gentrification in Toronto, Montreal and Vancouver, researchers found that gentrifiers had higher cycling and walking rates compared to neighbouring areas, but lower transit ridership and slightly higher car use (Danyluk & Ley, 2007). They theorize that this paradox may be explained by transit’s inability to compete with cycling, walking or driving for convenience. Unlike poorer populations, these newer populations are willing and able to pay for convenience. Given the poor mode competitiveness of transit networks in most metro areas (with the exception of New York and perhaps a few other places where congestion makes rapid transit competitive), it is not surprising that urban gentrifiers’ public-transit aversion matches that of other middle class populations, despite their downtown ideals.

There is evidence that today, young adults are deciding on residential locations and commuting patterns in a different context than previous generations (Moos, 2012). There is less affordable rental housing available. The job market contains greater inter-generational inequalities, with a shift towards the service sector and declining real incomes (Ibid). Household sizes are smaller. In Vancouver, young adults are more likely to live in attached, row houses and apartments in amenity-rich, transit-accessible neighbourhoods until they have children, at which point they are moving to areas where they can afford single-family homes. The cost of this relocation is in a longer, automobile oriented commute (Ibid). Downtowns are becoming more desirable and being marketed as ‘eco-friendly’ and ‘sustainable’. This is leading to greater gentrification of these areas, making these areas less affordable. This trend has been termed ‘eco-gentrification’ (Quastel, 2009; Quastel, Moos, & Lynch, 2012).

Housing costs

In the 1880s, "one week's wage for one month's rent" was used to describe what workers could expect to pay for housing (Hulchanski, 1995). The average expenditure on housing for all Canadians in 1969 was 17 percent of income (Hulchanski, 2010). The current 'rule of thumb' for housing affordability is around 30 percent, above which a lower-income household could be considered to be under housing stress. An analysis by the American Center for Housing Policy investigated the costs of housing and transportation for "working families", defined as households with income between $20,000 and $50,000, for whom these combined percentages have a larger impact. Between 2008 and 2009, nearly one in four working households spends more than half their income on housing costs (Wardrip, 2011). Despite falling home values, housing affordability worsened significantly for both owners and renters during this time (ibid).

Table 1: Percent of working households spending more than half of income on housing costs, 2009

Atlanta	24%
Boston	23%
Chicago	26%
Dallas	20%
Houston	22%
Los Angeles	37%
Miami	42%
Minneapolis	18%
New York	32%
Philadelphia	20%
Pittsburgh	15%
San Francisco	29%
Seattle	22%
Washington-Baltimore	21%

(Wardrip, 2011, p. 7)

In Canada, average home prices are highest in Vancouver (over $600,000), Toronto ($480,000), and Calgary ($420,000) (Canadian Real Estate Association, 2012) and continue to rise. Aggregate Canadian urban home price indexes have risen to over 150% of 2005 prices (Multiple Listings Service Canada, 2013). During the same time, the consumer price index in Canada rose considerably less, to 120% in 2012 from 2002 prices (Statistics Canada, 2012). Median household income in Canada was just under $70,000 in 2010. If a family making this much income bought a house for $500,000, paid 10% down and had a mortgage interest rate of 4% over 20 years, they would be paying approximately $3,000/month for their house, not including repairs, taxes and mortgage insurance. This alone would take up half of their income.

Combined housing and transportation costs tend to take a consistent percent of the household budgets of working families (those with low to moderate incomes) – around 60 percent, according to a report on housing and transportation costs in the United States (Lipman, 2006) There is greater variation in these numbers when the costs of housing and transportation are taken separately demonstrating that households make trade-offs between housing and transportation costs (Figure 6). For the group with *lower* incomes ($20,000 to $35,000), residing in central cities offered a significant discount on transportation costs, suggesting that access to destinations in the range of transit, walking or cycling was an important option to alleviate budget stress (Figure 7). In metros where more working families commuted by public transit, total average household expenditures on transportation dropped, supporting this conclusion (Figure 8). Cities with higher average transit commuting rates have lower average amounts spent on transportation costs by working families.

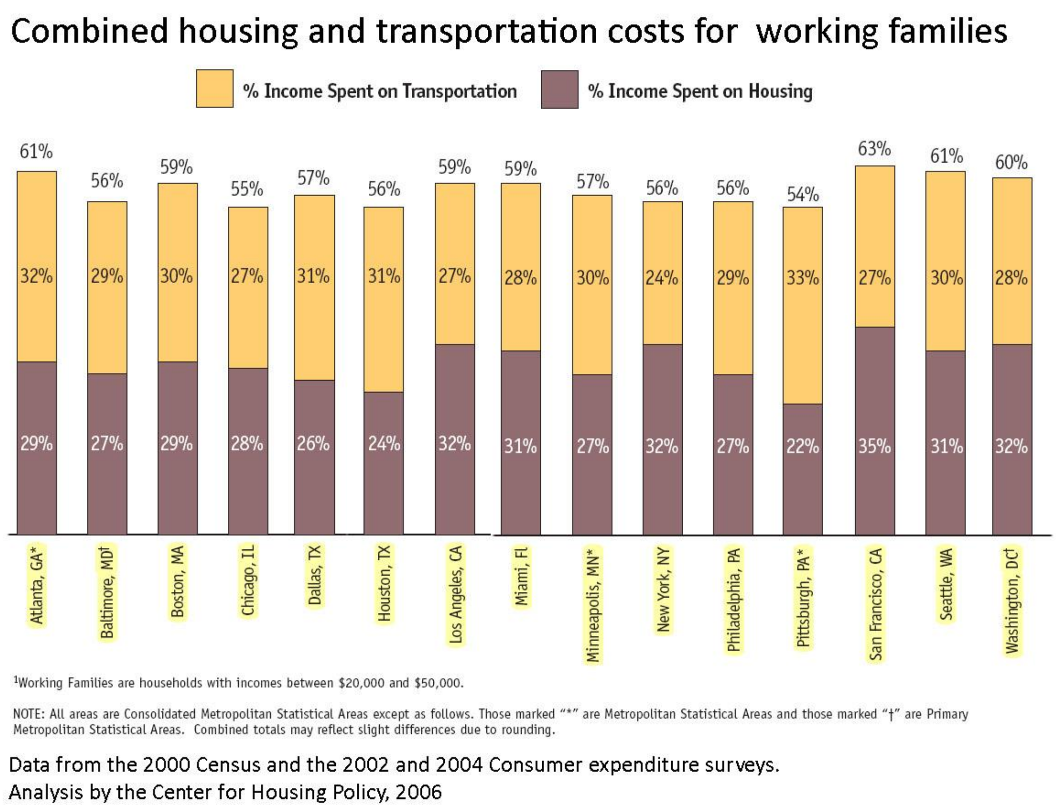


Figure 6: Combined housing and transportation costs for working families (Lipman, 2006)

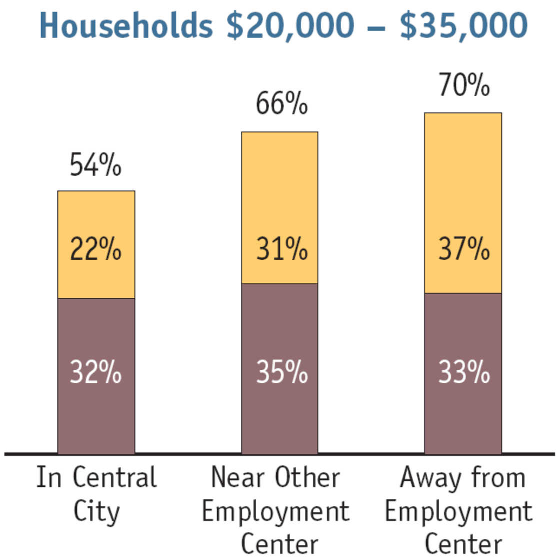


Figure 7: Combined housing and transportation costs for households with incomes between $20,000 and $35,000 (Lipman, 2006)

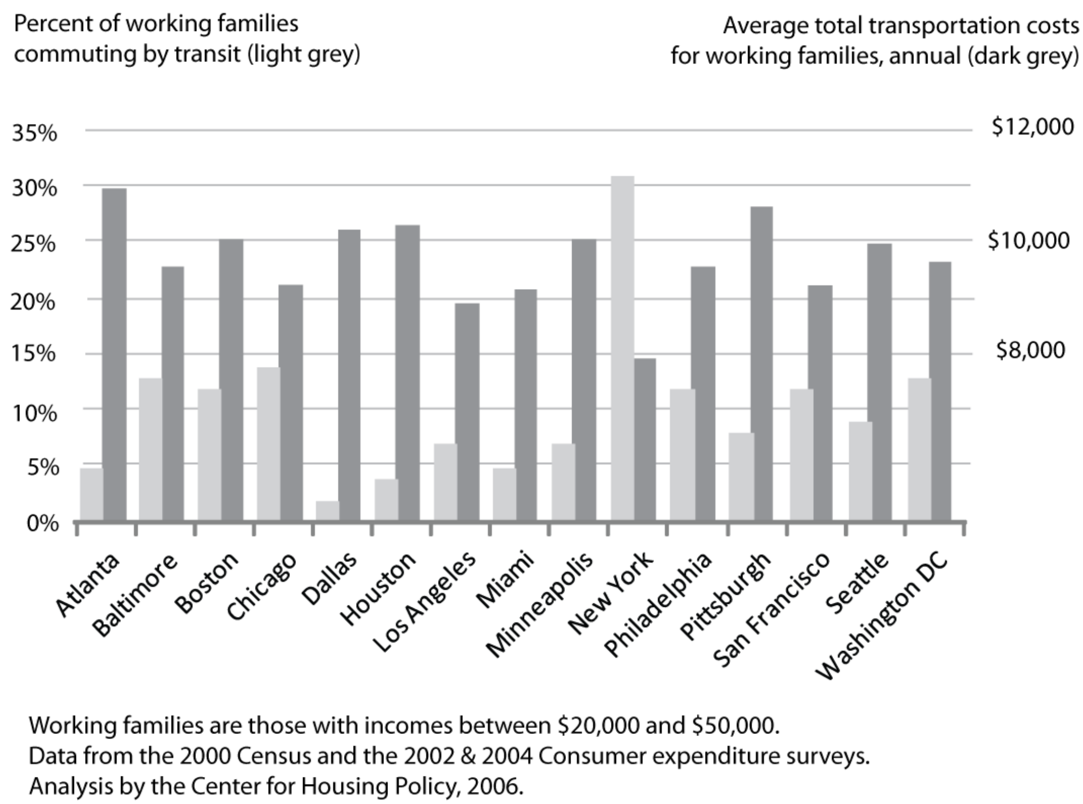


Figure 8: The impacts of commuting by transit on household transportation savings (graph by author)

The findings in the above 2006 "Heavy Load" report were recently updated in a report called "Losing Ground" that tracks post-recession trends in housing and transportation costs (Hickey et. al., 2012). Housing and transportation costs rose faster than incomes during the 2000s in each of the 25 largest metropolitan areas. Between 2000 and 2010, average housing costs increased by 52% and transportation costs by 33% in the 25 largest metropolitan regions, faster than average income growth of 25%, despite the economic downturn. Households earning 50 to 100 percent of the median income in their metropolitan area pay 59% of their income for housing and transportation. In metro areas where good public transit exists, such as Washington DC, Boston, and San Francisco, the impact of transportation costs on household budgets was mitigated. However, in auto-oriented metros with lower average incomes like Miami and Los Angeles, combined cost burdens are very high, ranging from 65 to 72 percent of household income. Homeowners of moderate incomes carry heavier cost burdens than renters; for a typical moderate-income renter, combined housing and transportation costs add up to an average of 55 percent of income, while this rises to 72 percent of income for moderate-income homeowners.

Income, employment and labour

The changing nature of labour is creating a more flexible, expendable, part-time and structurally underemployed workforce, in the context of rising productivity made possible by robots and computers (Krugman, 2012; Frase, 2012; Kaminska, 2012). The increasing globalization of manufacturing, service and even research and development as Asia, Eastern Europe, Africa and Latin America continue to develop economically has also impacted employment in North America. Cheap goods are generally available from the global market, which suppresses the demand for local manufacturing. This shift to a service-based economy has been initially welcomed in some quarters as the rise of the 'creative class' (Florida, 2002) where theoretically well-paying, professional jobs draw highly educated young people to cities. However, this shift also entails a large growth in retail and other lower-paid service jobs that often do not pay well and where workers lack agency (Ibid). This point is important from a transportation perspective. As more jobs are part-time and flexible with less long-term security, the old pattern of a stable and long-term home-to-job commute with plenty of income to cover the costs of a private car may be less matched to the reality of newer trends in travel, living and work.

Employment income has become more precarious as self-employment and part-time work increase, meaning more instability in income. Hourly earnings gains are not keeping up with inflation (Sauvé, 2012). The cost of living is rising in Canada, with shelter at 28% and transportation at 19% of household budgets in 2009. Shelter and transportation costs both increased faster than the rate of inflation, with shelter costs increasing by 27% and transportation costs increasing 25% between 2002-2011, both above the overall consumer price index (CPI) rise of 20% for the same time period. The driving-related costs of gasoline (70%), insurance (60%), parking (60%), and drivers' licenses (54%) all increased considerably over the CPI. Public transit fares also rose above inflation at 26%. These trends point to a tighter budget situation for many Canadian households going forward for some time.

In the American context, trends of income inequality have become well known to the point of entering the political debate, and post-recession employment trends point to historically high levels of unemployment and underemployment, which has also entered the political debate (Krugman, 2012b). Even as productivity has risen, incomes have not tracked this rise. At the same time, the cost of housing has risen 56% between 1990 and 2008, as real family incomes rose only 20% (Bernstein, 2010). The differences from Canada may be that the housing bubble was intrinsically tied into the cause of the recession which began in 2008, and so housing prices have not maintained the same growth as in Canada since then. In fact, there have been a large number of foreclosures and 'underwater mortgages' that have impacted households, especially middle- and lower- income households.

Suburbanization of Poverty

If the renewed economic importance of central cities has been attracting middle and upper income households back to cities while, in some cases, expelling lower income populations through increased housing costs, what has been happening in the extended zone? The outer suburbs have long been attracting both jobs and residents and continue to do so (Lee S. , 2011). Autocentric peripheries are in the process of reconfiguration into polycentric clusters, nodes and patchworks of uneven urbanism (Brenner, 2000). Suburban centres draw activity and density, resulting in a polycentric metropolitan form instead of a mono-centric one. Transit systems have not kept up with this suburban intensification, however, and often higher-density suburban nodes are not pedestrian-friendly or connected well with transit (Filion, 2009). Ideally, the transit network would respond by linking centres to each other with high capacity links, and feeding each centre with high-frequency, medium capacity local service to increase transit competitiveness (Casello, 2007), but in most cases it has yet to do so.

In metro areas that are predominantly autocentric, the intensification of suburbs has resulted in worsening congestion and therefore worsening accessibility by car. Although accessibility by transit is generally dismal in the dispersed realm, the combination of worsening congestion together with transit improvements is showing slight improvements in accessibility by transit compared to auto mobility in the dispersed realms of the San Francisco Bay area (Kawabata & Shen, 2007). As with other case studies, one can't know definitively if this is true in other places; but it may be indicative of larger trends, especially if the city in question has comparable attributes to other cities.

At the same time as suburban areas are experiencing polycentric intensification, they are also becoming more diverse than in the past. In the United States, more Asian and Hispanic people are living in suburbs than previously (Roberts, 2012). However, this doesn't necessarily mean more integrated neighborhoods; in some cases, this takes the form of 'ethnoburbs', ethnic enclaves in suburbia (Ghosh, 2007; Preston & Lo, 2000; Good, 2005; Li, 1999). Black-white segregation is still apparent in American metros (Fischer, 2011); the average black resident lives in a neighbourhood that is 45% black and 36% white, while the average white resident lives in a neighbourhood that is 78% white and 7% black (Roberts, 2012). However, the middle class is not as exclusively white as it was previously.

Like ethnic and racial spatial patterns, there have always been differentiated patterns of spatial socioeconomics in cities – rich areas and poor ones – but the combination of the dispersed, auto-oriented realm with poverty is a relatively new one. This is the reverse of 'spatial mismatch', a concept that focuses on the presence of jobs in the suburbs and jobless populations in the cities. Socio-economic segregation and the pattern of increasing spatial-economic polarization have not received the same scholarly attention as racial segregation in America (Lee S. , 2011), but some research does exist. The recession that began in 2008 after the sub-prime mortgage crisis was the first in North America where a majority of the poor in metropolitan areas lived in suburban areas. Although suburban poverty *rates* remain lower than urban ones, the scale of suburbanization means that the absolute number of poor living in suburbs is now higher (Ibid).

The combination of the suburbanization of poverty, the decline of incomes in inner suburbs, and the gentrification of inner cities due to a rising demand for urban living could threaten the access-affordability connection that has been the silver lining of downtown abandonment in the post-war context. This could have serious implications for access to transit for lower-income populations, and for the ridership of transit systems. In a wider context, this trend could threaten the economic and environmental sustainability of urban regions in North America, as those households who can't afford downtown housing costs are driven to less transit-accessible areas, where they would be dependent on cars forced to either lose the substantial savings of being a car-free household or lose access to opportunities at a metropolitan scale. The confluence of suburban affordability and urban gentrification would exacerbate social injustice through a lack of mobility and access for populations excluded from urban opportunities. These are the questions that the following research addresses. This research builds on areas between the literatures of social justice, mobility and access, land use and transportation connections, and spatial socioeconomics. In addressing the connections between these literatures, this research addresses a gap in the literature. Although there are extensive and important bodies of research on the following topics (land use in relation to transportation; gentrification; socioeconomics and transit ridership; the suburbanization of poverty and the decline of the inner suburbs), the juxtaposition of these literatures, where spatial socioeconomics converge with questions of mobility, accessibility, and transportation, are only beginning to be explored.

Equity and agency

Exclusive automobility

Why is access to the city important? According to sociological urban theorists, cities are strategic terrain where various forms of power are engaged, both by advantaged and disadvantaged actors (Sassen, 2006). "Today's citizenship practices have to do with the production of 'presence' of those without power and a politics that claims rights to the city." (p 315) The city is a public space and a stage; access to the city allows the disadvantaged to gain presence, without which they would be invisible. This access to urban life has been theorized as a 'right to the city' (Lefebvre, 1968; Harvey, 2008), and exclusion from this access can result from economic barriers such as a lack of affordability as well as physical and political barriers. Urban public space creates a 'cosmopolitan canopy' under which differences and diversities are given a safe space to represent and interact (Anderson, 2011), the kind of space that isn't available in other areas. City streets are public places where people mix; they are also used as the route to access work, claim resources, and create identity. Public transit both creates access to public space and is also a kind of stage and public space in itself.

Transportation is an important part of access. It offers freedom of movement, the ability to access opportunities, to claim the city, and to access public space. The nature of public urban space itself is shaped by transportation; there is a difference between the kinds of public spaces in an auto-dependent area versus the kinds of public spaces in an area that allows multiple modes of transportation.

Auto-oriented urban form transforms public space into space organized around private vehicles, and thus changes the nature of that space. A journey by public transit starts and ends with a walk, and pedestrians animate public spaces. A car is a private capsule, and shifts public roads into conduits for private vehicles. Unlike other modes, the automobile is a private form of transportation which has the effect of transforming the public space of the road into an aggregated flow of private spaces. This transformation goes beyond the private space of the car to transform the whole environment. In the more dispersed, auto-dependent zone, land uses are separated, making driving necessary. The space required by the car (per person), both on the road and at the origin and destination parking lots, requires a super-sizing of the land area needed, resulting in lower density urban form. The volumes and speed required to make transport by private vehicles efficient contributes to making the other modes inefficient, so there is a tension between having a pedestrian infrastructure, mixed use, accessibility by foot and having an efficient car system. In suburban areas of cities, the car is the primary unit around which space is designed, which has radical implications for the experience of that space by people and for the access to the amenities of that space by people, especially those who don't travel by car (Freund & Martin, 2007). Freund and Martin describe how places that are primarily designed for the car lead to a constant state of tension, in pedestrians, cyclists, and drivers. These auto-oriented spaces do not facilitate play or relaxation, or slower forms of movement. The flâneur would have difficulty in discovering the city in an auto-dominated realm. Pedestrians are more likely to be killed on wider arterials with high speed traffic, which often lack sidewalks and opportunities for safe crossing (Ernst, Lang, & Davis, 2011). This is a sort of tragedy of the commons where the individual private desire for unlimited mobility (represented by the car) can lead to congestion while also restricting alternative forms of mobility. This interdependency of urban form and automobile technology has been called a system of " 'quasi-private' mobility that subordinates other mobilities of walking, cycling, travelling by rail and so on, and reorganizes how people negotiate the opportunities for, and constraints upon, work, family life, childhood, leisure and pleasure" (Urry, 2004, p. 26). This system disciplines and dominates urban space, in a "distinct combination of flexibility *and* coercion" (Sheller & Urry, 2000, p. 739) that leaves those without a car lacking.

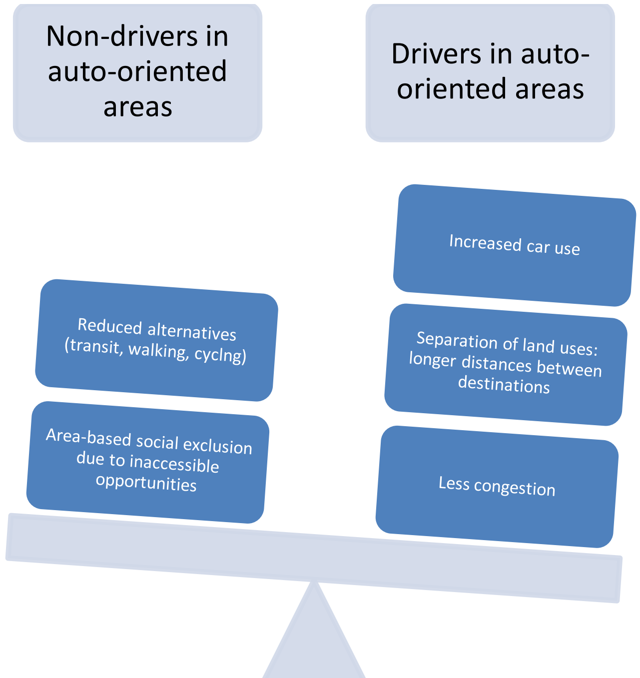
Some researchers advocate that the benefits of auto-oriented development outweigh the costs; many people like the space afforded by low-density development and find the cost of automobiles worth paying for the convenience they offer (Gordon & Richardson, 1997; Gordon & Richardson, 2000). The democratization of the car led to the "extension of human habitats, the dispersal of places across space, the opportunity to escape certain locales and form new socialities, and the fragmentation of temporal flows" where the freeway becomes a vector instead of a place (Sheller & Urry, 2000, p. 742). However, a consequence of this land form is that it generally cannot support an efficient transit service, and mobility in these areas is often limited to private vehicles, whose infrastructures form literal barriers to other types of mobility, as well as putting 'significant distances' between previously proximate destinations. "Automobility thus coerces people into an intense flexibility" (Ibid, p. 744), if they can afford it. Those who cannot are coerced into an even greater inflexibility.

Marginalization to auto-dependent zones not only has an impact on the household budget, but also on the thickness of amenities within walking distance, the general separation of uses making driving necessary to reach destinations, which may have health impacts (Frank & Engelke, 2005; Freund & Martin, 2007). There is a concern about accessibility by senior citizens, children under sixteen and adults who don't have a driver's license, any family who can't afford more than one car as well as anyone with physical challenges who is unable to drive. It takes a certain amount of resources to own and operate a car and there are quite a few population groups who don't have access to these resources for various reasons, whether these reasons are power dynamics, gender, finances, age, health or ability. This marginalization in an auto-dependent situation can be mitigated by access to alternative forms of mobility, such as public transit, walking, and cycling. It can also be mitigated through the availability of nearby amenities, which comes with density and mixed use.

The economic aspects of this marginalization are often a proxy for other kinds of marginalization; people with more financial resources can overcome other limitations on mobility – for example, an elderly person who can't drive but who has access to financial resources can hire a taxi or a driver, and won't rely as much on public transportation. The poor are more intensive users of public transit, walking and cycling modes; as a result, they spend much more time traveling fewer miles than those with cars. This time cost restricts social activity space and limits opportunities for those without cars in auto-oriented areas. This time cost helps explain why the poor make fewer trips. The auto-oriented suburb, then, creates a space of "unequal material infrastructures of connectivity [that] prescribe possible *patterns of movement*" (Manderscheid, 2009, p. 31). Although the street network is open to all, in an auto-centric area mobility becomes contingent on "unequally available prerequisites" (Ibid, p43), namely car ownership. Without public transit, pedestrian or cycling infrastructures, these alternative modes become unsafe, inconvenient or both.

Mobility is not the only marker of accessibility. In amenity-rich areas where walking, cycling and transit are convenient, distance traveled is not necessarily correlated with access. "City centres are typically characterized by a high concentration of infrastructures and opportunities, thus representing some kind of node which appears to reduce the need to travel" (Ibid, p31). Accessibility can also be defined to include "the power to move other people and goods and to include virtual and imaginative movement" (Ibid, p34), for example the ability to require people to come to you, to ship goods through courier services , and the ability to access the internet and other information databases. Again, these abilities rely on money to enable access.

Figure 9: Access differential by mode in auto-oriented areas



Modified from *Car Dependency and Social Exclusion*, (Pickup & Giuliano, 2005) , p.41

A city like Los Angeles, despite high gross densities, is difficult to serve effectively with transit as the density is spread relatively evenly over the entire metropolitan region, without being focused in centres and along corridors (Gordon & Richardson, 1996). This highlights the important choices that communities have in making the land use and transit connection. The type of urban form provides the foundation for the type of transportation mode and vice versa.

Public transit itself is an extension of public space. Public transit is an important alternative to the private vehicle, both practically and symbolically as a public mode that belongs to everyone. It works best in the kind of space where people walk and where there are places for people to gather outside. Public urban space is the most public and urban where it is safe to walk, where movement is slower, where density is higher, where there are eyes on the street (Jacobs, 1961), where there is pedestrian infrastructure such as sidewalks and crosswalks. Public transit networks were originally built into the older city, where there is a network of streets (grid density) which allows multiple routes between A and B by foot or bicycle, and where there are significant thresholds of density to support amenities and public transit services.

> Public transit has long served the poor, offering a form of mobility that is not dependent on automobile ownership. Subsidization of public transit historically has been based on two often conflicting objectives: (a) to provide a basic level of mobility for all persons, but especially for the transportation disadvantaged, and (b) to provide an effective substitute for the private car to reduce automobile travel and its associated externalities, including traffic congestion, air pollution, and urban sprawl. [] Transit investment has been aimed at attracting the discretionary user rather than the transit dependent, at creating new markets rather than

> retaining existing markets, and at modes rather than service attributes. Yet numerous surveys make clear that safe-reliable, and frequent service offered at low fares would significantly expand the market for transit. This suggests that fixed-route transit should be concentrated in high-density and high-poverty areas where it can be effective. [This] will improve the attractiveness of public transit for both transit dependents and choice riders, and is the only means for accomplishing transit policy's dual objectives (Giuliano, 2005, pp. 63,69).

But what happens if high-poverty areas are not high density? What if areas originally built around the automobile become the new location of housing affordability? How do the two objectives of public transit as described above, to provide mobility and to moderate the negative externalities of the car, fit into a new socioeconomic landscape of dispersed, marginalized, and auto-oriented affordability?

Borrowing from other literatures: Social exclusion, spatial mismatch and environmental justice

Two urban planning literatures have discussed the role of public transit in mediating poverty through providing access to opportunities: the concept of 'social exclusion' in the UK and the 'spatial mismatch' hypothesis in the United States. A third, "environmental justice", brings in the concept of civil rights to the spatial placement of infrastructure, but focuses on the negative externalities of infrastructure rather than its benefits. The first two literatures focus on access to opportunity for marginalized populations, but in different ways. The spatial mismatch literature describes how urban racialized populations in the American context, living in affordable housing in downtown urban areas, often don't have access to employment opportunities – specifically, low-wage service jobs – which are more and more located in dispersed suburban locations. These decentralized destinations, along with the reverse commutes they require for downtown residents, are termed a 'spatial mismatch'. This literature also makes the point that the problem of access to jobs is more than spatial access, and includes factors like employers' (potentially discriminating) hiring practices, the lack of metropolitan-level opportunities as well as job seekers' imperfect knowledge of these opportunities (Preston & McLafferty, 1999). Increased density of economic and social activity near job seekers (Chapple, 2001) or the provision of affordable housing near job clusters (Levine, 1998) are non-transportation options put forward to alleviate this mismatch. Some researchers suggest that if an area of employment location is not transit-supportive, the more direct way of correcting the mismatch and providing access would be to subsidize auto ownership or taxi fare (Grengs, 2001). However, public transit is acknowledged in many circumstances to be a potential connector between areas of affordable housing and employment opportunities for low-income job seekers. The demonstrated choice of lower-income populations in many cases to value and live near public transit routes (Glaeser, Kahn, & Rappaport, 2008) attests to the value of transit for these populations. Spatial mismatch does not address the issue of lower-income populations living in autocentric areas; the populations of interest to this literature are assumed to live in old city centres.

'Social exclusion' is a term that refers to the exclusion of any populations from the benefits and resources available in society. This exclusion could have many different causes, but the lack of public transit infrastructure and access to the metropolitan region through public transit is recognized as one (Preston J. , 2009; Preston & Raje, 2007). Social exclusion is broad enough to encompass class differences and social barriers; a focus on access does not always mean literal access through physical mobility, but can often mean figurative access and economic mobility.

Environmental justice is concerned with equity in infrastructure disbursement, but mostly with the equity of distribution of the *negative* impacts from infrastructure projects (such as the location of highways, sewage plants, or garbage dumps in poorer neighbourhoods). The focus of the environmental justice movement has been on the disproportionate targeting of disadvantaged neighbourhoods with negative externalities of infrastructure, rather than targeting these neighbourhoods with advantageous 'alternative' transportation infrastructure (Schweitzer & Valenzuela, 2004). However, it has opened the door to an infrastructural analysis that explicitly considers spatial socioeconomics – income, race, and housing affordability.

These three literatures of social exclusion, spatial mismatch, and environmental justice, highlight concerns of spatial patterns of inequality and access in urbanized environments. Although they do not specifically refer to the misalignment of public transit networks with affordable suburbs, the concepts of spatial justice that they offer could be borrowed and applied to this issue. The ethics of these literatures, if not the specifics, are relevant here.

Apart from literatures, there are several case studies that are relevant to this discussion; specifically the Los Angeles Bus Riders' Union vs. the MTA court case, and social urbanism in Medellin and other South American cities. Although very different, both are activist-based actions that work to extend or strengthen transit services to poorer areas.

Bus Riders' Union: Technology-specific activism

In October 1996 a class action lawsuit led by the Bus Riders' Union was decided against the Los Angeles Metropolitan Transit Authority. It was an argument about how to allocate transit service and resources. The Bus Riders' Union wanted a needs-based service allocation, which challenged the traditional allocation of service on the basis of geographical area and political boundaries. The bus system in Los Angeles provides a gridded mesh of service to poorer areas in the older southern part of the city. At the time, the MTA was planning to extend rail service into wealthier suburban areas, which would have pulled funds away from the overcrowded bus system. During the trial, it was demonstrated that each Metrolink (suburban commuter rail) trip was subsidized at a rate of more than $21 while the figure for a bus trip was a little over $1 (Soja, 2010). This case acknowledged an uneven geography of transit need and allowed the MTA to justify planning routes based on this geography of need rather than a district-to-district equity policy blind to socioeconomics and built environment factors.

This case created a limited awareness in transportation planning circles about the importance of responding to socioeconomic need when planning transportation systems, and specifically an appreciation for the bus routes that are the workhorses of transit networks. However, because the case was built on a civil rights framework, the *economic* benefit to transit agencies through increased efficiencies (more ridership per dollar spent) was not the main message that was communicated to transit agencies. Transit agencies may have seen the outcome of the court case to be a threat rather than an opportunity. It would require them to consider race and poverty when allocating service, and prevent them from transferring operating dollars (i.e. for bus riders) into capital investments (i.e. to build new LRT). However, this requirement to consider race and class (and by implication, need) has been dismantled in subsequent challenges (Soja, 2010), and the issue of service cuts to overcrowded lines running in poorer areas in Los Angeles is still relevant, even as a recent referendum approved a sales tax increase for capital expansion of rail rapid transit lines .

Aside from proving the value of needs-based service allocation, this case was interesting for pitting one transit technology, rail, against another, the bus. This tension is evocative of the two purposes of transit in the North American city – to serve non-car owners on the one hand and to coax car owners out of their cars to alleviate congestion and pollution on the other (Giuliano, 2005). Commuter rail service has long competed with core system service for funding, with the former serving wealthier populations with greater access to cars and the latter serving transit-dependent populations who are disproportionally poor and racialized (Pucher, 1982). Wealthier communities often have greater political clout and can lobby for transit dollars, even though central city services require lower subsidies (Garrett & Taylor, 1999). It has long been recognized that bus service cross-subsidizes rail service, as the latter has higher capital costs. Local bus route service is slower than rapid transit technologies like subway, rail, LRT, and BRT. Bus riders tend to be lower income, and the opposite with commuter rail. “It has been widely hypothesized that transit systems have in fact tended to regard their low-income patrons as a captive market”, ripe for price discrimination, and “there are no explicit legal sanctions against policies that harm low-income groups in general”(Pucher, 1982, pp. 316-315). The Bus Riders’ Union case successfully imposed a legal sanction against such harmful policies in 1996. However, the case was built on a civil rights framework (racial discrimination) under the Civil Rights Act, rather than on a framework of directing service to low-income populations (in this case, the bus riders were both minorities and poor). It appears then that Pucher’s statement about low-income populations being unprotected from discriminatory practices remains true.

However, the difficulty of applying this example to the findings of this research is that it in effect pits inner-city bus service against suburban transit expansion. The politicization of modes of transportation and the rhetoric of competition between suburb and city is not helpful in solving regional transportation issues. In the case of LA, it is clear from this research that there are large areas of affordable housing in suburban communities like San Bernadino and Riverside that are underserved by transit. The challenge of extending effective service to these areas should not be eclipsed entirely by the legitimate need to maintain service to downtown populations. A regional transit system will need to extend effective service region-wide, especially in affordable areas. The specific technology chosen for this network extension, whether rail or bus, should depend on ridership demand. This research argues for sensitivity to spatial socioeconomics, with appropriate technologies located according to ridership demand.

Social urbanism: Transportation and civil rights in South American cities

South American Bus Rapid Transit (BRT) systems are embedded in a political culture of public improvements that combine utilitarian arguments for the greater good with targeted services to marginalized areas. For example, Enrique Peñalosa, the Mayor of Bogotá who was instrumental in implementing the TransMilenio BRT system there, speaks of road space in the context of civil rights and social justice. He has said that a bus carrying 100 people has the right to just as much road space as 100 cars carrying 1 person each; this logic justifies separated lanes for BRT (Hustwit, 2011). As part of this logic, bicycle routes to poorer neighbourhoods are paved before local roads, to give 'dignity' to people who would have been ashamed of cycling before, to recognize through mobility and spatial design that they are equal to a wealthier person in a Mercedes (Ibid). This deliberate linking of a person's dignity and right to space and access in relation to alternative modes, and the consideration of economic factors of inequity is widely used and accepted in the political rhetoric of South and Central American cities. Medellín, the second-largest city in Columbia, has embarked on an ambitious group of linked projects under the rubric of 'social urbanism', where public spaces, libraries, squares, and sports facilities have been built in socially and economically marginalized neighbourhoods using revenues from a public electric utility. In addition, some of these same neighbourhoods have been linked to the rest of the city with metrocables, public transit pods that transport people up to hillside favelas. This has vastly improved the convenience of access between these places and the rest of the city (Brand & Davila, 2011; Kimmelmann, 2012). A similar strategy has been employed in Rio de Janeiro and Caracas, where metrocables have been built to connect to hillside favelas. In directing infrastructure and public space improvements to areas of spatial and socioeconomic inequality, social urbanism offers an example for North American metropolitan regions with rhetoric to match.

Concepts of Equity

In order to justify targeting transit service to neighbourhoods based on need, the concept of equity in service delivery must be re-examined. There are several ways to define equity in terms of infrastructure. A public good is one that cannot be efficiently provided by the private sector because it is too expensive to make a profit and still remain affordable, and where use cannot be restricted. Public goods are essential for the functioning of society and often provide positive externalities, which make the use of taxation to pay for them acceptable. Transportation is a hybrid good, both public and private. Roads are public infrastructure, but vehicles using these roads are private goods. Public transit is also a hybrid good, in that users are charged a fare but that it provides positive externalities such as access for non-drivers, congestion relief, and environmental benefits. At this time in North America, public transit cannot be profitably provided by the private sector and still extend service.

The ideal of modern infrastructure is one of equal access for every person, regardless of location or socioeconomics. This goal of universal coverage is already achieved in North American cities for a number of infrastructure services – water, electrical and sewage, for example – as a result of the process of reforms in the early industrial city. These, along with roads, are all examples of linear infrastructure, whether the line is a wire cable, a road, or a pipe. For these types of infrastructure networks, any person who is connected to the network theoretically has unlimited access to that infrastructural good, regardless of time of day. The per capita cost of linear infrastructure is lower in areas of higher density. Transportation infrastructure, including roads and the buses on them and subways below, is also a form of linear infrastructure.

For transportation, the good offered is access to other places. For car drivers, there is theoretical access to every destination connected by the road network, at any time of day. Congestion and tolls are both possible limitations to this perfect access. Anyone who doesn't have a driver's license and the means to own and operate a car is excluded from this perfect access and must rely on alternative modes of transportation, such as carpooling, walking, cycling, and public transit. Walking and cycling are similar to driving in that they are modes with individual agency; they do not depend on location and timing of routes and frequencies. These "active" modes – walking and cycling – *do* require infrastructure that is often lacking, such as sidewalks, crosswalks, bike lanes and bike parking posts. Because these modes are often used in conjunction with public transit, as the first and last mile modes to get to and from the transit stop or station, the lack of infrastructure can negatively impact transit use , just as its presence ameliorates transit use. The public transit mode, due to its coordinated, shared nature, cannot offer equal service levels on every road at every time. For both cost and network function considerations, because of the need to decide routes and frequencies, transit is responsive to public demand. Demand is greater along some lines than others, and to a greater or lesser extent, service levels (capacity, technology, and frequency) responds to this variation in demand with a variation in levels of service.

Because of transit's role as an alternative mode for people who don't have access to a car for reasons of age, ability, or income, transit systems have constantly been struggling to provide accessibility with limited means. There are two aspects of accessibility – accessibility TO transit (the walking distance to the nearest transit line), and accessibility BY transit (the coverage of destinations in the urbanized area) (Moniruzzaman & Paez, 2012). The struggle for transit agencies involves the attempt to provide maximum coverage, but that often comes at the expense of frequency (Walker, 2012). Accessibility by transit has both a spatial aspect, which can be seen on a route map, and also a temporal aspect, which is visible in the schedule. This temporal aspect is easy to overlook when looking at a transit system map: unless routes are drawn according to frequency (with thicker lines for very frequent lines, and dashed lines for infrequent routes, for example), the temporal aspect of service is invisible. It could seem as if accessibility by transit is quite extensive, when in reality, because of the infrequent scheduling of lines, the potential for movement from origin to destination by transit is limited by long wait times and transfers.

Travel is not purely a function of necessity; people like to move (Mokhtarian, Salomon, & Redmond, 2001). Once people have invested in a car, they tend to use it. Those who do not own cars do not have the opportunity to take advantage of the extensive connectivity facilitated by the road network, unless it is by taxi, rental car, walking or cycling. This makes the current transportation system two-tiered; the highest level of accessibility is available only to those who can afford to make the initial investment in a vehicle. The next level of service, transit, is less expensive but also much less connected and extensive. The free modes, that is, the ones with no out-of-pocket expenses, are walking and cycling. Due to the lower speeds of these modes, they are even more limited to local connectivity. Walking is best for trips of around one kilometer, and cycling for trips of less than five kilometers. Travel time is the strongest predictor of mode choice (Frank et. al., 2008). Given the difficulty of providing accessibility by transit in a car-dominated system, how can scarce transit resources most beneficially be designed? This is often framed as a question of equity rather than maximizing ridership. The results of this allocation by differing concepts of equity can have profound implications for the viability and accessibility of transit systems on the ground, sometimes in perverse ways.

Equity can be defined in competing and contradictory ways in transportation economics (Taylor B. , 2004). These definitions depend on the unit of analysis as well as the type of equity being considered (see table).

Table 2: Different definitions of equity in transportation planning

UNIT OF ANALYSIS	TYPE OF EQUITY		
	Market equity	Opportunity equity	**Outcome equity**
Geographic			
States, counties, legislative districts, etc.	Transportation spending matches revenues collected, in each jurisdiction.	Transportation spending is equal in each jurisdiction.	Spending in each jurisdiction produces equal levels of service and capacity.
Group			
Modal interests (i.e. commuter rail vs. local bus), racial/ethnic groups, etc.	Transportation benefits in proportion to taxes paid.	Each group receives a proportionally equal share of transportation resources	Transportation spending produces equal levels of access or mobility across groups
Individual			
Residents, voters, travelers, etc.	Taxes and user fees proportional to the costs imposed on society, by each individual.	Transportation spending per person is equal.	Transportation spending equalizes individual levels of access or mobility.

Source: Taylor B, 2004, p 300

As Taylor (2004) describes, politicians tend to focus on geographic equity; interest groups on group equity; and scholars on individual equity (p300). Because politics decides transit spending, the emphasis is often on geographic opportunity equity (an equal amount spent in each area) rather than individual or group equities based on market or outcome calculations. This can privilege rural areas over urban as well as smaller provinces or states over larger ones. Public transit ridership is concentrated in larger metropolitan regions, but funds are often distributed by transit agency, not by ridership, meaning the per-trip subsidy in areas of high transit use is often much smaller than in areas of low ridership (Ibid, p301). Politically visible projects and equipment are often favored over ongoing operational efficiency (Ibid, 314).

With the goal of maximizing the mobility utility of a region, several types of equity could be considered. The first is individual market equity, where taxes and user fees would be proportional to the costs imposed on society by each individual. For example, a car user would pay taxes and fees based on how much marginal cost their driving has on a region. This could vary by time of day and congestion levels, and also by distance travelled. It could also vary by the amount of pollution generated and the amount of space required by their car. There are multiple methods for capturing these costs, including GPS-based systems, road tolls, gas taxes, and parking fees. A transit user would pay a fare based on the impact their trip has on the city; again, this could vary by distance or time of day to shape behavior and encourage off-peak travel, and could benefit from increased ridership and network efficiencies. This fee is generally collected by transit fares, whether prepaid tickets or metro-cards that calculate and deduct fare automatically. This type of equity doesn't consider the individual's ability to pay, like progressive income taxes do. However, the inclusion of externalities in the cost of travel would incentivize the use of modes that have positive externalities and provide a disincentive for modes with negative externalities. This has the benefit of improving overall mobility and lessening both pollution and congestion. Because modes like walking and cycling have very few negative externalities, this type of equity calculation would improve health outcomes and favour less expensive and more environmentally benign modes of transportation. In this way, individual market equity could be the source of funding for transportation goods. In this way, modal competitiveness (equal accessibility by mode) could become a kind of proxy for social justice.

Transit competitiveness

The second half of this equation is how this money is spent, and this could be decided using the metric of individual outcome equity. In this metric, transportation spending decisions equalize mobility and access for each individual as much as possible. This would take the revenues collected from the first (market) equity above, and govern the spending decisions. This type of equity is more difficult to describe, because at its ideal it would provide every individual, regardless of ability, income, or location, with a similar access. What does this mean? Currently, as described above, access in suburban areas privileges and necessitates the private automobile. In urban areas, there is greater modal equity, and it is possible to access destinations by transit, walking, cycling, or car. Equalizing mobility and access for each individual would necessitate investment in complete and seamless networks across modes. In the North American metropolis, the bulk of this investment would be focused on improving access by alternative modes in auto-centric areas. If this type of equity was successful, those who do not have access to a car would have mobility alternatives available, regardless of their origin and destination.

These two types of equity, market- and outcome-based at the individual level, would together address the affordability paradox. Market equity could be used as a standard to calculate the cost of trips by various modes, and outcome equity could be used to determine infrastructure investments.

Mass motorization was made possible through rising incomes and the increasing affordability of cars and single-unit detached houses, as well as the infrastructure of the highway system (Pucher, 2004). As houses and cars begin to become less affordable, a shift away from mass motorization would be dependent on public transit, walking and cycling infrastructure being in place, just as the highway system was necessary to allow mass motorization.

Ecology, automobility, and exclusion

While spatial inequity used to be embodied by 'inner city ghettos' in the North American context, this is changing.

> As suburbs, inner cities and the many different places in between are changing, so does the appearance and perception of social inequity. Some of the core urban areas are subject to renewal and upgrading, whereas others remain stagnating or continue to decline. Also suburbs are undergoing certain life cycles, according to age, life situation and preferences of their inhabitants. This particular change is already visible in the first and second generation of single-family suburbs e.g. in many Western European suburban areas, also in North America. In the case these suburbs are located in remote areas with low density and poor supply of infrastructure and services, demographic change, dropping real estate prices and rising energy costs may contribute to new forms of suburban social inequity. (Hesse & Scheiner, 2009)

In many global cities, the central city has long commanded higher land prices, and marginalization has followed a spatial pattern at the literal margins and peripheries of cities in the form of South American favelas, Turkish gecekondus, and Parisian banlieues. If North American post-war suburbs are becoming more affordable than city centres, then the North American metropolis will revert to the privileging of the centre that other global cities already have, and that older North American cities had before the automobile subverted that particular spatial logic. However, there is one big difference between North American suburbs and other global city peripheries – unlike gecekondus and favelas and slums, North American non-central areas were built around the automobile. The challenge of a post-war suburban landscape of affordability is therefore the continuation of car-dependency even as socioeconomic landscapes transform.

Ecology and social justice will be at odds when only the wealthy can afford a 'green lifestyle'. Eco-gentrification is difficult to prevent if the demand for downtown housing and attendant lifestyle is strong. A complimentary suburban transformation has the potential to counter or balance this trend. If the challenge is met, and suburbs are able to transform to offer transportation alternatives as well as housing flexibility (affordable mix of housing options), then this could put the North American city on a more sustainable path, both ecologically and socially. It is unclear how the pressures to transform will play out.

Social utility: A hybrid theory for a hybrid city

This review of the literature shows the possibility for a hybrid theory to address the affordability paradox posed by the research. If 'environmental justice' and 'spatial mismatch' concepts are too narrow to provide a theoretical framework for this research on affordability and accessibility, then perhaps 'social exclusion' is too broad a concept. However, these concepts can be borrowed and rethought. Spatial mismatch could be extended from simply the mismatch between downtown affordable homes and suburban service jobs to include the concept of suburban affordable homes and lack of access to metropolitan-wide opportunities. Environmental justice could be expanded to consider not just mitigating the negative effects of infrastructure location on marginalized populations, but also extending transit infrastructure and mobility options to these populations. In addition, this hybrid theory of social utility can draw from activist practices to adapt a theory of civil rights and transportation, as evidenced by social urbanism and the Bus Riders' Union, towards a multimodal, hybrid suburbanism.

The economy of a city-region depends on accessibility for all income levels and areas. Suburbs have been largely designed around the concept of private space, but the affordability paradox as demonstrated by this research problematizes this concept and offers the opportunity for a hybrid private-public realm in these areas, through the extension of frequent transit networks and targeted intensification.

Even as this research has taken the importance of economics as its underlying premise, the strategies for responding to the affordability paradox should also acknowledge the importance of economics. Equity defined by market and outcome on the individual level would make use of economic incentives and disincentives to invest in alternative mobilities in affordable suburbias.

Chapter 2: Methods

Research questions

Because of the particular history of North American post-war urban development, one would expect that frequent transit networks would continue to be aligned with older areas of cities. Given the changes transforming metropolitan areas in a post-suburban context, including the re-emergence of central cities as the locus of re-investment and gentrification and the socioeconomic diversification of the suburbs, some suburban areas may be becoming the new location of affordable housing. I expect that, given the suburban form difficulties as well as the Post-Fordist dis-investment in public infrastructure, that the transit network has mostly not been expanded to these areas.

The research question is one of affordability is relation to accessibility. What is the current alignment of frequent transit networks to affordable housing? Taking the built environment into account, how are socioeconomics spatially manifest in metropolitan regions, and how does this relate to mobility and access?

To begin to answer this question, this research will empirically explore conditions across a number of metropolitan regions, using combined spatial and statistical analyses to improve our understanding of these issues of affordability and access.

Methods

Each step in the methodology, along with methodological weaknesses, are discussed in this chapter. But first, a brief summary:

Transit networks are mapped in relation to neighbourhood-level data on socioeconomics and urban form. Neighbourhoods are divided into ones with access to frequent transit and ones without access. The results are used to run a logistic regression model for each city, to determine the influence of different variables, especially housing costs, on access to transit. Descriptive statistics compare socioeconomics and urban form inside and outside the transit network zone.

North American cities were selected based on their transit systems, ridership, and size. In all, twenty cities are included. As mentioned previously, cities here refer to the entire contiguous metropolitan region, regardless of political boundaries; North America refers exclusively to Canada and the United States, as these places have a similar shared history of urban form, development, automobility, and suburbanization[2].

Transit routes that run frequently, with headways between vehicles of 15 minutes or less between 7am and 7pm Monday – Friday, are mapped to show a 'frequent transit network' (FTN) for each city. This frequent network, which can include routes of many different transit types from subways to local buses, represents the convenient

[2] For a discussion of some of the influential differences between Canada and the United States in terms of urban form and governance, please see "Differences between Canadian and American Cities".

transit network that can be accessed without referring to a schedule and without long wait times. A buffer representing the walking distance to these routes is used to map the zone of the city that is accessible to frequent transit. This area is referred to as the frequent transit-shed or zone. Transit access in this research focuses on access *to* transit from residential origins, and does not include a measure of access *by* transit to various destinations. This choice of accessibility metric is further discussed in the following pages.

Detailed data from Statistics Canada and the American Census Bureau are imported at a fine scale, which allows them to be coded as either falling inside or outside of the frequent transit-shed. This allows the difference in a number of different household and individual characteristics, from car ownership to income to housing costs, to be described for areas with and without transit access. A regression analysis tests these descriptions by holding urban form and socioeconomic variables constant to isolate the relative relationship of each to the likelihood of transit access. This logistic regression uses transit access as the outcome variable, and measures how the likelihood of transit access changes as each of the independent variables change. This allows the analysis to compare the descriptive statistics, where transit-accessible zones are still the location for a greater diversity of households and incomes, with the cost of housing once income and other socioeconomic differences are accounted for.

Spatial patterns of housing cost, including rent and home values, are mapped in relation to the FTN. These reveal areas of low-cost rental and home ownership with and without access to transit.

Alternative methods considered

These methods – mapping, descriptive statistics and logistic regression analysis – are certainly not the only methods that could be used to interrogate the issues of interest. Several other possibilities were considered for this research. If distance to transit had been used as a continuous dependent variable, then OLS (ordinary least squares) regression could have been used. Instead, a binary outcome variable (yes/no) was chosen to represent access to transit, because most people are not willing to walk beyond a kilometer to access transit.

Unlike lab experiments, where variables can be controlled, urban environments have many variables that relate to each other, and this brings up the issue of multicollinearity. One way to avoid this is to use Principle Component Analysis to group related variables. However, this also means that you lose the ability to measure the influence of individual variables. Instead, the model was tested for multicollinearity using the VIF (variance inflation factor) method, and this showed that multicollinearity was low enough not to invalidate the results (See Appendix B).

In mapping the lowest-cost housing in relation to transit networks, spatial statistics such as Local Indicators of Spatial Association (based on Local Moran's I), were considered. These mapped clusters and outliers of lower-cost housing. However, the choice was made to instead map the lowest quarter (first quartile) of housing costs in each city, so that areas that were neither clusters nor outliers but were still relatively affordable wouldn't be missed.

Finally, this research relies on quantitative methods almost exclusively. Qualitative methods such as fieldwork, interviews, and site analysis would certainly add to our understanding. This research is meant as an initial baseline that establishes the incomplete outlines of these affordability and accessibility issues.

Selecting cities

This research looks at housing affordability as it relates to transit access in twenty metropolitan regions in Canada and the United States. North American sites were chosen because North American cities (excepting Mexico) achieved mass motorization earlier than anywhere else, and this is linked to a post-war suburban form; because of this, North American metropolitan regions are more vulnerable to an affordability-access gap because they are more dependent on the automobile for mass transportation. The reason to look at multiple cities rather than one or two is to test the affordability-accessibility question across North America, to ensure that the empirical results are generalizable and not reflective of the unique attributes of a particular city. The cities were chosen from a larger group of all metropolitan regions in Canada and the United States that have populations of over one million people; cities smaller than this do not usually support extensive public transit networks in a North American context. An iterative selection process was applied to this larger group of over fifty cities. First, the ten largest metro regions in this group were included, so as not to exclude any very large city from consideration, given that larger cities are more amenable to efficient public transit systems, theoretically. This section of large cities includes Atlanta, Baltimore-Washington DC, Chicago, Dallas, Houston, Los Angeles, Miami, New York City, Philadelphia and San Francisco. Next, cities with transit commuting rates of over 10% were included, to make certain to capture cities that may have smaller populations but where transit systems play an important role in transportation. This added Boston, Calgary, Edmonton, Montreal, Ottawa, Toronto and Vancouver to the group. To be certain that no cities with significant transit ridership were missed, another criteria of total transit riders was added: any city with over 500,000 daily riders was included. This criterion didn’t add any new cities to the group. Similarly, any city with a heavy rail rapid transit system, like a subway, elevated rail or SkyTrain, was added. Again, this didn’t add any new cities. Finally, in the interest of testing some smaller cities that had light rail systems, several cities of this group were chosen: Minneapolis-St Paul, Pittsburgh, and Seattle. Although there are many such smaller cities, only three were chosen in order to keep the number of cities to a reasonable size. Minneapolis-St Paul offers an example of a relatively prosperous Midwest city; Pittsburgh offers a former industrial ‘rust-belt’ city in the process of reinvention; and Seattle would offer a Pacific Northwest example where resource extraction and shipping meet a culture of environmentalism. Table 3 shows a complete list of the metros considered and how they meet each of the criteria, with the selected metros shaded. This brings the total number of metropolitan regions to twenty. This selection process is meant choose a group of cities for study that can offer as complete and thorough a sample as possible, without becoming too unwieldy.

Table 3: The selection process for metropolitan regions to be studied

Over 1 million people	Size (10 largest metros)	Transit commuting share (Over 10%)	Total transit riders (over 500,000)	Heavy rail cities (subway / skytrain / EL)	Light rail cities (without subways)
METRO AREA					
Atlanta	●			●	
Austin					
Baltimore - Washington DC	●	●	●	●	
Birmingham					
Boston		●	●	●	
Buffalo					●
Calgary		●			●
Charlotte					●
Chicago	●	●	●	●	
Cincinnati					
Cleveland					●
Columbus					
Dallas	●				
Denver					●
Detroit					
Edmonton		●			●
Hartford					
Houston	●				●
Indianapolis					
Jacksonville					
Kansas City					
Los Angeles	●		●	●	
Las Vegas					
Louisville					
Memphis					
Miami	●			●	
Milwaukee					
Minneapolis-St Paul					●
Montreal		●	●	●	
Nashville					
New Orleans					
New York City	●	●	●	●	
Oklahoma City					
Orlando					
Ottawa		●			●
Philadelphia	●		●	●	
Phoenix					●
Pittsburgh					●
Portland					●
Providence					
Raleigh					
Richmond					
Rochester					
Sacramento					●
San Antonio					
San Diego					●
San Francisco - San Jose	●	●	●	●	
Seattle					●
Salt Lake City					●
St Louis					
Tampa Bay					
Toronto		●	●	●	
Tucson					
Vancouver		●		●	
Virginia Beach					

Metropolitan geographies

Because the research question is interested in measuring affordability and accessibility in an entire contiguous urbanized area, this precludes using political boundaries for identifying geographic study areas. A metropolitan region consists of at least one core city and its surrounding suburbs and smaller centres, which can contain multiple municipal governments and cross state or provincial boundaries. In a typical North American city, it is common for people to live in one area and travel to other locations in the region for work and other reasons. Recognizing this functional integration of regions, the United States Census Bureau and Statistics Canada have defined metropolitan regions by using several criteria, including contiguous urbanization and commuting patterns. This categorization proves useful for this research. The Census Bureau states that "the general concept of a metropolitan area is that of a core area containing a large population nucleus, together with adjacent communities that have a high degree of economic and social integration with that core" (U.S. Census Bureau). In Canada, these metropolitan regions are called Census Metropolitan Areas (CMAs); in the United States, they are called Metropolitan Statistical Areas (MSAs). When MSAs have a population of over 1 million, they are called Primary Metropolitan Statistical Areas (PMSAs). Where several PMSAs are close enough together to share contiguous urbanized areas as well as commuting-sheds, they are grouped together to form a Consolidated Metropolitan Statistical Area (CMSA). Of the fourteen American cities included in this study, ten are classified as CMSAs, with at least one secondary city as part of the area. These include Dallas (Fort Worth), Boston, Washington DC (Baltimore), Philadelphia, New York, Miami, Chicago, Houston, Los Angeles (inland Empire), and San Francisco (San Jose). These categories, while not adhering to popular conceptions of city definitions, reflect the changing reality of urbanization. While political boundaries of cities and administrations often impact infrastructure patterns, economic activity and travel patterns go across the entire metropolitan region. Metropolitan regions are increasingly being recognized as the scale at which many infrastructure sustainability issues, from green space to water systems to transportation, are operating (Macdonald & Keil, 2012). Infrastructural networks commonly bypass traditional administrative boundaries, even as they connect and define a city-regional scale (McFarlande & Rutherford, 2008). At the same time, not all areas in a metropolitan region necessarily have equal access to infrastructural services; this has been described as 'splintered urbanism' (Graham & Marvin, 2001). If the political boundary of the city itself, not including its contiguous suburbs, was used to define the study area, then the potential marginalization through unequal service levels and fragmented transit networks would be missed. It is important to include these contiguous areas as part of the study; it is often these areas that are of particular concern for the affordability-accessibility question that this research addresses.

Defining urbanized areas within metropolitan regions

Residential density is an important variable to consider in this analysis and to control for in the regression model. In order to accurately measure residential density, it is important that only urbanized areas are included in the area-based calculation. Otherwise, large parks, golf courses, large exurban lots, farms, and airports could dilute the density calculations, making average densities seem lower than they are. The boundaries of the metropolitan areas, as drawn by the US Census Bureau and Statistics Canada, are in one piece and do not account for large areas inside the boundary that are not urbanized. In order to correct for this, a 'Swiss cheese' boundary is necessary, which subtracts these un-urbanized areas from the larger area, leaving holes behind. Urbanized areas include any residential, commercial or industrial use of land within the metropolitan area, but do not include large parks, bodies of water, or rural areas. The US Census Bureau provides just such a shapefile of urbanized areas for use in GIS; this can be overlaid on the metropolitan boundary, in order to exclude data points that fall within the metropolitan boundary but are not in urbanized areas. This urbanized shapefile was checked using Google Earth to confirm that only urbanized areas were included, and it was found to be highly accurate. Thus, the residential population and household counts are only included for urbanized areas within metropolitan boundaries to ensure that density calculations are net density, not gross density, and reflect the reality on the ground. Statistics Canada also provides an 'urbanized area' shapefile, but when this was checked against satellite imagery on Google Earth, it was found to be quite inaccurate. The 'urbanized areas' in the Canadian case included farms, golf courses, and other non-urbanized areas within Census Metropolitan Areas. Therefore these files were not used. Instead, accurate 'Swiss cheese' maps of the urbanized areas in Calgary, Toronto and Vancouver were attained from the Neptis Foundation, a Toronto-based nonpartisan research organization that examines urban issues. The Neptis Foundation had painstakingly put together these files for a report comparing urban growth patterns and regional growth policies in these three cities (Taylor & Burchfield, 2010). These urbanized boundaries had been compiled to match the year 2001, and so they needed to be updated to reflect any further urbanization in these three cities since then. This was done by projecting the file on Google Earth and adding newer developments. For the remaining three Canadian cities (Montreal, Ottawa, and Edmonton) these urbanized area maps were created by hand/mouse using Google Earth to define urbanized areas within CMA boundaries.

Mapping transit access

This research is concerned with accessibility to the metropolitan region in general – to both jobs and other destinations – by frequent (convenient) public transit. The measurement of how much of the urbanized area, how much of the population and how many households fall within the transit-shed of the frequent network will be used as a rough proxy for metro accessibility. This is not a perfect measure of accessibility, but for lack of a detailed travel survey that includes origins, destinations and modes for all trips across a region. These kinds of travel surveys are available for some metropolitan regions, but do not have the same sample sizes as the data provided by the American Community Survey and Canadian long form Census, and they are not available consistently for all the metropolitan regions in this study. This research opts for a more general approximation of access by transit in exchange for the variety and consistency of local-level built environment and socioeconomic data available through the Canadian Census and American Community Survey.

Accessibility is the ease with which people at a specific location can reach urban activities and opportunities (Kwan & Weber, 2008). Accessibility to public transit is measured across space and time. The temporal *frequency* of a route is as important as the spatial *coverage* of a route. There are many different methods possible for measuring access to and by public transit. To complicate matters further, coverage can be measured in several different ways, from the area covered to the number of people or origins and destinations covered. Accessibility *to* and *by* transit – how close transit is to an origin, and what destinations it can access – are two important aspects of transit accessibility (Moniruzzaman & Paez, 2012). The temporal aspects of transit access include both waiting times (influenced by both the frequency and reliability of service) and the speed of travel along a route (influenced by the type of technology and alignment). Despite this complexity, a measurement of accessibility by public transit must be determined for the purposes of this research.

There are many ways to define and measure accessibility (Handy & Neimeier, 1997; Talen & Anselin, 1998). One method of measuring transit access is to create an index of transit service and calculate it for each spatial unit. This method has been used to assign a transit score to each neighbourhood based on how often a bus, subway or streetcar stops there in a specific hour, with buses being given less weight than streetcars, and subways the most (Martin Prosperity Institute, 2011). This results in a continuous surface of transit scores across a region. Another measure of transit availability is LITA, a Local Index of Transit Availability developed for the Sacramento Local Government Commission. This calculation incorporates the total seats on a line, the length of a line in route miles, the total population along the line, total daily vehicles along a line, and the number of stops along a line. This calculation is done for each census tract (Wells & Thill, 2011).

In practice, there are thresholds of distance and waiting time that limit the convenience of transit access beyond which the cost in time is too great. Once transit service frequencies are too low or distance to transit routes are too far, then transit modes become unfeasible in practice. Therefore, a binary measure of access was chosen over a continuous transit score. This binary measure (yes or no) would take into account both the frequency of service and the distance to transit from home locations (origins).

Other accessibility measures used by researchers include opportunity measures, which count the number of destinations within a given distance; gravity-based measures, which weigh impedances to travel such as time and cost (frictions); and utility-based measures, which look at travel alternatives according to the utility they offer to a specific traveler (Wells & Thill, 2011; Handy & Neimeier, 1997). These sophisticated methods require data on individual travelers, destinations, and impedances, and involve data-intensive comparisons of network options. Data of this detailed level is not consistently available across all 20 study areas.

Many studies of accessibility have focused on either regional accessibility (Can a person travel across an entire metro?) or local accessibility (What destinations are available in a neighbourhood?), but research has found that a person's 'individual city' can span a variety of scales (Kwan & Weber, 2008). Some measures of accessibility focus on job accessibility. Employment locations vary from metro to metro, with some places like Miami having very dispersed employment and others like New York having centralized employment (Haas et. al., 2006). Working families – those with at least full-time minimum wage, where wages and salaries represent at least half of income, and with a total household income of less than or equal to 120 percent area median income – are more likely to work throughout the metropolitan area, rather than in employment clusters like higher income workers (Cervero, Chapple, Landis, & Wachs, 2006). Because this research is interested in issues of affordability and access, and also for lack of consistent data on non-residential destinations, the accessibility measurement will not be limited to employment clusters, but rather to the areas of the metro as a whole that can be accessed or not accessed by frequent transit.

Measuring the geographic coverage of transit service – the number and types of households within walking distance of a transit route – takes advantage of GIS' capability of linking data to spatial attributes and allows research to tap into the breadth and depth of variables available through the census. This approach has been used to measure access to grocery stores by transit (Grengs, 2001) and to measure the influence of transit access on ridership at the dissemination area level in Hamilton (Moniruzzaman & Paez, 2012). Although no accessibility metric is perfect or complete, these precedents help justify this method's use for the purpose of this research.

Frequent transit networks

Why take frequency and span of service into account when mapping the transit networks? Why not just include the entire transit system, including commuter rail and infrequent local bus routes? In many cities, the system map covers much – most – of the urbanized area, but doesn't give an idea of true accessibility by transit. Wait times are recognized as one of the most inconvenient and anxiety-producing parts of a journey by transit; in fact, transit agencies weight these minutes much higher than minutes spent travelling, multiplying the wait times by two or more when calculating the time cost of a journey (Dawson, 2012; Miller, 2012). Recognizing a frequency threshold of service is necessary to define a way of getting around which offers a realistically convenient alternative to traveling by car. Frequency is an invisible asset in a transit system – one that can't usually be seen by glancing at a network map, but which defines the convenience and viability of a transit system (Walker, 2012).

The frequent transit network is based on the concept of transit frequency being an important and often overlooked aspect of transit accessibility. On a map of transit routes in a metro, lines for each route are usually shown equally, sometimes with a differentiation between types of transit technology – like bus, light rail, or subway – but no visual notation or symbol to indicate the frequency of the route. How often does it come by? This aspect of the route, known as *headways* (the number of minutes between each trip) in transportation planning parlance, is key to determining the relative convenience or difficulty of reaching a destination by transit. Transit of a certain frequency allows the rider not to consult a schedule, but to simply show up on the route and catch the next vehicle to arrive. If a route is not frequent, if it comes every half hour or hour, then one's personal schedule must be built around the bus schedule, and if that bus is missed, then the journey is delayed or abandoned.

In mapping frequent transit networks, this research selected only transit lines that have headways of fifteen minutes or shorter over a span of service from 7am to 7pm on weekdays. Fifteen minutes seems to the longest average time that people are willing to wait for transit (Walker, 2012). Shorter headways are better and reduce wait times; unfortunately, a maximum headway of 10 minutes would have dramatically cut down the number of transit routes in many cities that qualified for inclusion. Even using fifteen-minute headways resulted in some cities not having a true network of frequent lines (see 'Weak Transit Cities' in Results).

A continuous all-day span of frequent service reflects the way transit is used; if it is to be an alternative personal mobility system to a car, it must offer accessibility for more than just rush hour. Lines that serve a diffuse mixture of trip patterns can have remarkably little peaking, with people riding these lines in volume in both directions all day. Dense areas show a much stronger market for all-day service. Work trips make up fewer than half of all trips, but work trips are the ones that tend to contribute to peak AM and PM rush hours. Rather than include only peak times in the frequency requirements, all-day service was measured so as not to miss all the other, non-work, majority of trips.

Regional (commuter) rail

There is also an argument to be made for including non-frequent commuter rail lines. These typically have frequent service during peak hours but not all-day, and they extend much farther into suburban territory than other types of transit lines. Commuter rail is sometimes available for the same fare as other transit, while in other cases it has a separate, higher fare. These lines are often quite rapid, and allow for larger distances to be covered between stops. Commuter rail is a valuable link for suburban areas to reach urban areas, and once there, people can transfer to the frequent transit network and have access to all those destinations. To test and see how the inclusion of commuter rail would impact the results, commuter rail in Boston and Philadelphia were added to the networks and compared with FTN results (Appendix E).

When mapping these frequent lines, the type of transit was noted, whether local bus, streetcar, light rail, bus rapid transit, express bus, ferry, subway, elevated rail, or sky train. These were divided into two categories: rapid transit, which travels at higher speeds and makes fewer stops; and local transit, which travels in mixed traffic and has stops at regular (usually around 500m) spacing. Rapid transit included light rail transit (LRT) in dedicated lanes, bus rapid transit (BRT), subways and elevated trains. Local transit included any mode in mixed traffic, mostly buses and older streetcars. Rapid transit lines are mapped with a dot at every stop, as stops tend to be farther apart, whereas local lines are mapped as continuous lines, because they tend to have stops approximately every half kilometer.

Frequent transit networks were mapped for each metropolitan region[3]. The frequent routes were identified by reading the schedules of each route for all relevant transit agencies. Many metropolitan regions are served by multiple transit agencies – some metros include multiple municipalities, some straddle state or provincial boundaries, and commuter rail is often run by a separate transit agency as well. Every effort was made to find and include all of these agencies when mapping the frequent transit networks in each region.

Once the data and transit networks had been mapped for each metro area, the areas within walking distance to the frequent transit network were defined. To determine which parts of the metro are walkable to the frequent transit network, research on how far people will walk to take transit was queried. The rule of thumb used by transit planners is generally 400m for local bus routes, and 800m for rapid transit stations. Some research, however, shows that people will walk up to a kilometer to access transit – it depends on how interesting the walk is, and on the person's tolerance for walking. A common standard used for walking distance to a rapid transit station is ½ mile (800 m), but the distance people are willing to walk of course varies by person, and this may be a conservative estimate (Canepa, 2007). The distances used for this research were 500m for local routes and 1000m for rapid transit stations, respectively. The more generous distances are chosen partly because people dependent on transit (or auto-independent people) will walk farther to access transit, and partly because a slightly more inclusive buffer is more likely to capture the centre of areas that are close to frequent transit. Given a radius of one kilometer around each rapid transit station and 500 meters from each continuous (local, with stops located close together) bus or streetcar line, the viable walking distance to the frequent transit

[3] Although digital map files (shapefiles) for transit routes are not generally available yet on open data initiatives, some transit agencies have begun to share their route and schedule data in a Google-friendly GTFS (general transit feed specification) version, which includes the latitude and longitude data for the route. This in turn can be re-coded as a Google Map file (KML), which can then be converted into a shapefile (SHP) by ArcGIS. Where the GTFS data was available, this method was used to map the routes. Where GTFS data was not available for mapping, a system map was geo-referenced in ArcMap and the frequent routes were drawn by hand (mouse). In the future, this method could be automated by using the frequency information encoded in GTFS files, but this would involve writing code, which was beyond the researcher's current capability.

network was defined. All the areas that fall within this buffer are defined as having access to the frequent transit network (Figure 10).

Figure 10: The buffer function shows walking distance to frequent transit lines in Montreal. This FTN-shed is the defined area of accessibility.

In this way, a person's residential location (the origin of a trip or chain of trips, and the destination at the end of a day) is either *in* or *out* of the frequent transit zone; either it is accessible to the frequent transit network, or it is not. It would have been possible to use a continuous distance-based measure to transit instead of a binary one, which would have made regression analysis simpler, but this would not have reflected the reality of how people use transit. There are certain distances beyond which it is too far to access conveniently by foot.

This method of measuring transit accessibility takes both space and time into account by considering coverage and frequency. The coverage is measured as a zone within walkable distance to and from transit; it addresses origins and destinations simultaneously. Frequency is measured by selecting routes that run all-day with maximum headways of fifteen minutes. The speed of travel is not factored into this, except in allowing greater walking distances to rapid transit. The resulting binary measure of access (yes or no) becomes an outcome variable for logistic regression analysis.

Data selection

The American Community Survey (ACS) is an ongoing annual statistical survey that samples a small percentage of the population, spread evenly across the country according to population. It asks questions about age, sex, race, family and relationships, income and benefits, health insurance, education, veteran status, disabilities, employment and commuting mode, and housing location and expenses. Three and a half million households are sent the survey every year, and they are legally obligated to fill it out, like the Census. The ACS has replaced the long form census in the United States, which used to be administered with the Census every 10 years; the last long form census was administered in 2000, and collection of the ACS for this purpose started in 2005. Every year starting in 2010, data from the past 5 years is bundled into summary data that makes a statistically valid 20% sample of the entire American population. The first 5-year summary data was available in 2010, and it includes data collected between 2005 and 2009. The benefit of using this rolling survey method is that the 5-year summary data can be updated every year; the drawback is that it doesn't provide a snapshot in time, like the census, but rather a 5-year window.

In Canada, the long form census asks similar questions to the ACS, collecting data on household size, characteristics, ethnicity, immigration status, language, citizenship, income, employment, journey-to-work, and housing age, cost and tenure. The Canadian Census is taken every five years, with the most recent one in 2011. However, the 2011 Census was conducted without a mandatory long form census, due to a decision by the government to make it voluntary, which decreases the reliability and accuracy of the data. There is concern that a voluntary survey is less likely to be filled out by the rich and poor. The 2006 long form census data was taken when it was still a legal requirement, and so is an accurate 20% sample of the Canadian population. The drawback to using this data is that it is not the most recent data and follow-up studies will not be comparable, unless the decision about the long form census is reversed in time for the 2016 census.

Despite these drawbacks, this data is the most broadly available, dependable and accurate data aggregated to the most detailed geographical units that are comparable across all the metro regions in the study area. It can offer a variety of comparable variables including socioeconomic, transportation and urban form variables. The review of the literature has revealed the importance of including both urban form and socioeconomics when researching transportation issues.

Data geographies

Both the American Community Survey summary data (2005-2009) and the Canadian long form census (2006) are available for all of the study areas at a relatively detailed geographic scale. For privacy reasons, there is some aggregation of data. In the United States, the smallest geography that 5-year summary ACS data is available for is the Block Group. A block group consists of between 600 and 3,000 people, with an optimal size of 1,500 people. The mean population in the Block Groups for all urbanized metropolitan areas in the study is 1,424 people. In Canada, the smallest unit for long form data is the Dissemination Area, with consists of between 400 and 700 people; the mean population for the Dissemination Areas in the study is 635 people. This is even more finely grained than the ACS data. The next geographic scale available is the Census Tract, which is not fine-grained enough to measure relatively accurate walking distances to frequent transit.

The geographical area that a Block Group or Dissemination Area covers varies with residential density; groups with higher densities will have smaller footprints. Generally, when drawing the boundaries, an effort is made to capture areas of similar characteristics (urban form) within each group by the US Census Bureau and Statistics Canada. For example, a large high-rise apartment neighbourhood and a neighbourhood of single-family homes would generally not be grouped together. The average size of Block Groups in the study is one square kilometer; the average size of Dissemination areas in the study is 0.24 km^2, reflecting the higher average densities in Canadian cities as well as the smaller numbers of people in Dissemination Areas as compared to Block Groups. The geometric centre of each area (called a centroid) is used to map the data in point form. These data points are then used to determine if an area falls within walking distance of the Frequent Transit Network (Figure 11). It is possible that centroids falling just inside the distance buffer would represent areas where part of the households would be located slightly outside the transit-shed, despite being labeled as having access; similarly, areas where the centroid falls just outside of the buffer would have less than half of the area inside of the transit-shed, but would not count as accessible to the FTN. The alternative method would be to assume that households are evenly spread over each Block Group or Dissemination Area, and then divide the borderline groups by area falling within and outside of the transit-shed. This would be an extremely time-consuming and complex process, given the large amount of data and metropolitan areas and the variety of types of variables (some as counts, some as medians or averages), and it would not necessarily improve the accuracy of the accessibility calculation to the extent of making it worthwhile. Instead, a small amount of error in calculating access to transit along the boundaries of the transit-shed is assumed.

Figure 11: each dot represents the centre point of a Dissemination Area in Montreal. The black dots are accessible to the Frequent Transit Network, because they are located within the walkable distance buffer. The grey dots fall outside this zone.

Logistic Regression

Once the frequent transit networks have been mapped, and each Block Group and Dissemination Area coded as either having access to the FTN or not, then it becomes possible to build a regression model to test the relationship between transit accessibility and housing affordability, while taking other variables into account. Access to transit is the dependent variable, also called the outcome variable. Housing affordability is an independent variable, and other variables can be included as control variables. The outcome variable, transit access, is a binary variable; that is, it is coded in the form of a Yes or No (1 or 0). Standard regression analysis requires a continuous outcome variable. Logistic regression analysis can be used when the outcome variable is binary, as in this case.

Multivariate logistic regression is a useful tool for estimating the impact of variables on the likelihood of certain binary outcomes, and has many precedents in research. In the urban studies context, this method was used to measure the probability of home-office workers living in single family dwellings rather than other, more compact, forms of housing (Moos & Skaburskis, 2008). Logistic regression was also used to predict the probability of various explanatory variables on people's choice to move to a Transit-Oriented Development (Lund, 2006). Logistic regression has been used to model the impacts of urban form on physical activity (Schmid et. al., 2013; Berrigan & Troiano, 2013; Frank et. al., 2007; Kerr et. al., 2007) and on travel mode (Schlossberg et. al., 2006). In addition to addressing questions of urban form, logistic regression has been used by researchers to address issues of transportation mode (Syed & Khan, 2000; Freeman, 2001) and of socioeconomics (Dunlop, Coyte, & McIsaac, 2000; Novotny et. al., 1988; Story, et. al., 1995). Logistic regression has been chosen as a method to measure questions of *access* to health care (Newacheck, Hughes, & Stoddard, 1996), home ownership (Edwards, 2001), and to food (Lee & Frongillo, 2001). In addition, there are multiple examples of logistic regression being used in conjunction with a spatial GIS analysis, specifically to model landslide susceptibility (Ayalew & Yamagishi, 2005; Ohlmacher & Davis, 2003; Lee S. , 2005).

In the case of this research, a multivariate logistic regression model is used to estimate the likelihood of access to the frequent transit network, across a number of different socioeconomic and built form variables, with special interest in the cost of housing.

Choosing variables and building a model

Based on the literature review, it was important to include variables that represent urban form, socioeconomics, and transportation. To build the model for this research, all the variables that are available that could be relevant have been tested for inclusion. In a normal regression model the R^2 value could be used to estimate goodness of fit; however, in logistic regression, this is calculated as Pseudo R squared and is not an accurate way to measure goodness of fit (Wooldridge, 2009). Instead, the model was fit by testing each variable to see if it improved the chi square test.

Table 4: Variables that can be calculated from the American Community Survey and Canadian Census for transportation, income, poverty, housing type, tenure and housing costs

	VARIABLES	DESCRIPTION	USA	CAN
Transportation	Transit ridership	Percent of people taking public transit to work	•	•
	Vehicles available	Percent of households with no vehicle available	•	
	Transit travel times	Percent of transit commutes that are over 30 minutes long	•	
Income and Housing Costs	Home values	The median/average estimated worth of owner-occupied housing, hundreds of thousands of dollars	•	•

	Rent*	The median/average amount spent on rent, monthly, hundreds of dollars	•	•
	Owner costs	The median/average amount spend on owner costs per month, including mortgage and utilities, in hundreds of dollars	•	•
		Median percent of income spent on rent or owner costs	•	
		Percent of households spending more than 30% of income on rent or owner costs		•
	Income	Median annual pre-tax household income, thousands of dollars	•	•
	Poverty*	Percent of households with incomes below the low income cut off (LICO)		•
		Percent of impoverished households	•	
		Percent of at-risk households (under 200% of poverty income)	•	
		Percent of poor households (at risk or impoverished)	•	
	Household type	percent of one-person households	•	•
	Household size	Average household size		•
Built Environment	Density	gross residential density	•	•
	Home type diversity	Percent detached single-family homes	•	•
	Tenure	Percent rental housing	•	•
	Age of building	Median age of building	•	
		Percent of housing units built before 1961		•

*The variables with a star have many fewer observations available compared with other variables.

The majority of variables are the same in both Canada and the United States. Some, like the age of buildings, percent of income spent on housing and poverty levels, are comparable but not identical because they are measured differently. Others, like the number of vehicles available to a household, are only available in the United States.

The model needs to include economic variables like housing cost and income, built environment variables that can control for differences in urban form, and transportation variables where possible. The appropriateness of possible variables for each of these categories is discussed below.

Housing costs: Tenure and home value

As discussed above, the cost of housing is a major component of measuring affordability in a metro. There are strong economic forces that sort metro areas based on where people can afford to live. Affordability is a relative term, relative both to income as well to the metro in question, which is why income is also included as a variable and the logistic regression is run separately for each metro. How best can we measure housing costs? Both the United States and Canada collect data on the cost of rent, the major housing-related payments (mortgage, utilities and property taxes) of owner-occupied households, and also the estimated value of owner-occupied housing. In Canadian data, these are expressed only as averages for each dissemination area. American data is more expansive, including both the counts of households in a variety of rent/housing costs brackets, as well as the median. Housing costs are further broken down by mortgage status, for households with and without a mortgage. Mortgage status is also a separate variable, sorting households without a mortgage, with one mortgage, two mortgages, a loan on the value of the house (like a home equity line of credit), or both a second mortgage and a loan. In this way the relative stress (or "underwater potential") of the household could be deduced. In addition, the American Community Survey also measures the median rent and housing costs as a percent of median household income for each block group. Canada records the number of households paying more than 30% of their income in rent or housing costs. Given the number of variables representing housing cost to choose from, which most concisely and accurately describes the cost of housing?

Some available variables, like median rent and poverty rates, could not be included as they had many missing values in the database, making the results less robust. It is possible that in some areas, the number of rental units and households in poverty were small enough to be suppressed for privacy reasons. If these variables are included in the model, the overall explanatory value of the model goes down because the variable with the lowest number of observations determines the total observations that can be included in the analysis. For all the American variables, the median rent and rent to income ratio have notably lower observation counts than the other variables considered for the model, such as home value. In Canadian data, the number of observations for rent is also noticeably lower than for any other variable. This is unfortunate, as rent is an important part of housing affordability. Although rent was not included in the main regression analysis, I ran a second regression model including rent on a few test cities to have a small idea of how the cost of rent relates to transit access. These results can be found in Appendix D.

Tenure is reliably collected for all areas. To find a variable to substitute for rent, the percentage of housing units that are rented in each area can be included. There is strong correlation across all the metro data between areas with high rates of rental housing and lower incomes (see correlations in Appendix C). In all cities, areas with high percentages of rental housing are more than 50% correlated with non-detached housing types and inversely correlated to income. This suggests strongly that clusters of rental housing provide an important stock of affordable housing for lower-income populations. Because average rent itself cannot be used as a control variable, the percentage of housing units in an area that are of rental tenure can give an indication of the availability of affordable rental housing. Percent rental is used as a substitute variable in place of rent. This is an important part of the affordable housing measurement.

There are a number of ways to measure the affordability of owner-occupied homes. The first is owner costs, in absolute terms or in proportion to incomes. Home ownership is both a way to secure a place to live and also a way to invest and save money for the future: it has both use value and exchange value. This is different than rented housing, which has only use value to its tenants. Because of this double value, it is more difficult to calculate affordability for home ownership. A household may decide to spend more than 30% of their income on mortgage payments in order to build equity. Many households use home ownership as a vehicle for 'forced savings', when it is difficult to make regular savings deposits to other investments. This may not mean that their house is unaffordable for them. Percentage of income is a relative measure; a high income household may be able to afford to spend 40% of their income on mortgage payments, because they'll still have a large absolute amount left over. A household spending over 30% of income on housing costs could just as easily be a low-income household struggling to cover groceries and transportation costs or a household in the middle-upper income bracket who has decided to buy a house as a long-term investment strategy, and does not have any trouble paying other bills (food and clothes and transportation) with the remainder of their income. Sixty percent of $20,000 is a much different amount than 60% of $200,000. “Any attempt to reduce affordability of housing to a single percentage of income – no matter how low or high – simply does not correspond to the reality of fundamental and obvious differences among households” (Hulchanski, 1995, p.12).

Absolute monthly owner costs could vary dramatically within the same type of housing, depending on the mortgage status of the household. This in turn can vary by life stage, income, and the relative frugality or spendthrift habits of home owners. For example, a retired couple on a fixed income could have paid off the mortgage in its entirety, or a wealthy family could also be mortgage-free. Using the monthly owner costs for these households would mistakenly give the impression that these homes were very affordable. A young family could have a sizable mortgage and monthly payments. The size of the mortgage itself could vary depending on how much of a down payment a household is able to save. Because owner costs can vary by income and demographics, it is not an accurate way to measure housing affordability in an area. This leaves home value as a variable to represent housing affordability.

Home value, as collected in these survey data, is an estimated current market value of the home by the homeowner. Home value is independent of mortgage status or relative income and so is the most appropriate available measurement of affordability. The median home values in each metropolitan region are divided into quartiles. The first quartile are the lowest 25% of home values in a metro area. This measure identifies areas of relative affordability. This allows a variation in housing cost between cities; housing costs in Pittsburgh are not comparable to housing costs in San Francisco, so the use of absolute thresholds of affordability across the nation would be problematic. Canadian sums are measured in Canadian dollars (for 2005, when the data was collected) and American sums are measured in American dollars (for between the years 2005-2009, when the data was collected). The dollar exchange value between the two countries is roughly equivalent, and this is a relatively stable relationship, so they have not been translated into common currency.

Figure 12: Quartiles of home values for each metropolitan region. Canadian cities in 2005 $CAD; American cities in 2005-2009 $USD. American values are median for an area, where Canadian values are averages, as medians are not available.

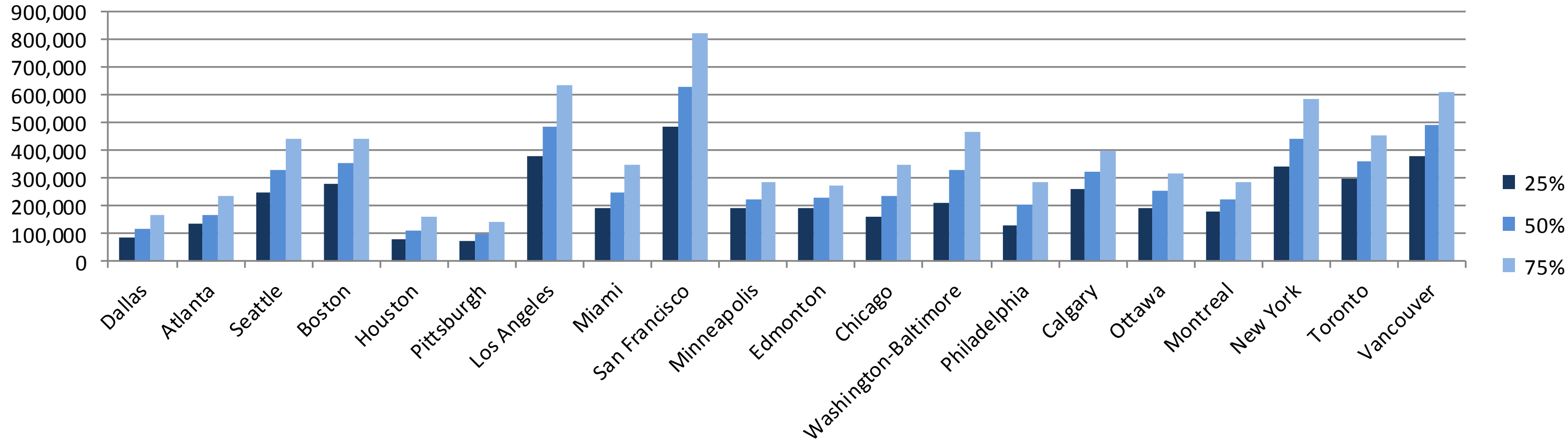


Figure 13: Quartile values for rent in each metropolitan region. American cities show median rent in USD; Canadian cities show average rent in CAD

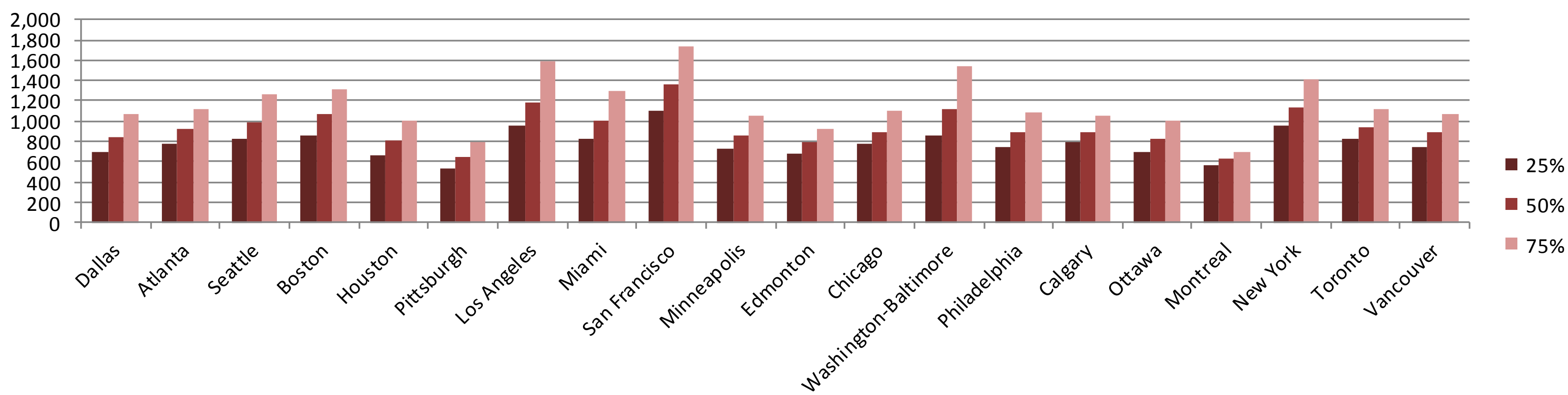
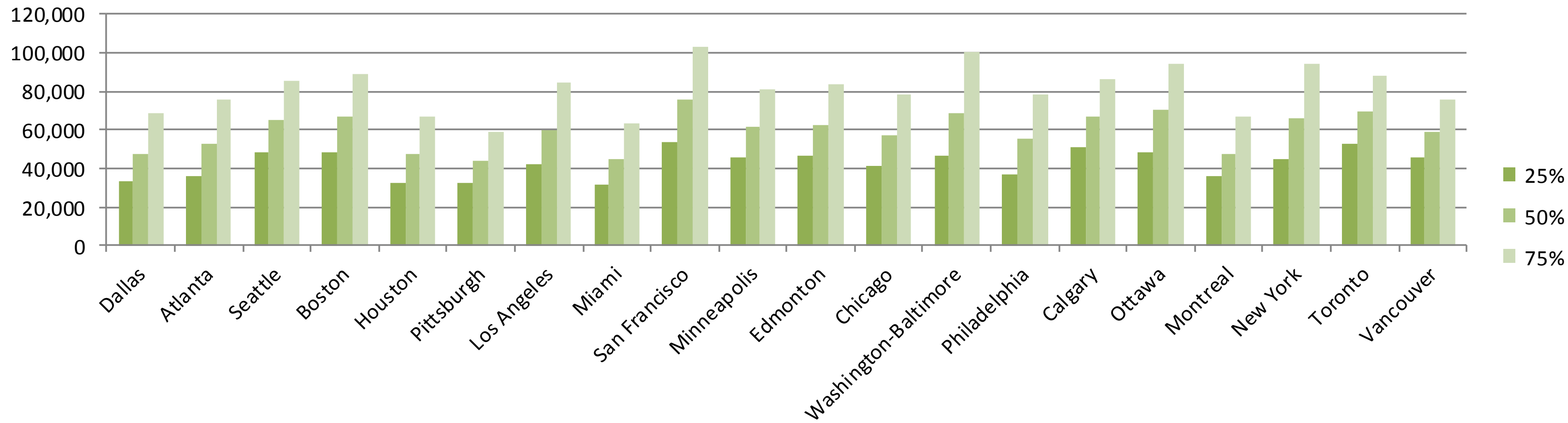


Figure 14: Median household income, quartiles, by Metro area



There is a great variation in home values from city to city: San Francisco's median home values are six times Pittsburgh's, almost an order of magnitude between the most expensive and least expensive city. Although incomes do vary from city to city as well, the variation in incomes is not nearly as great as the variation in home prices.

Control variables: income

The question for this variable is how to best to represent the wealth-poverty spectrum in the model. Similar to median rent, poverty rates could not be included as they had many missing values in the database, making the results less robust. In addition, there are problems with poverty calculation methods. The current poverty calculation in the United States is flawed: it counts cash alone as income, not including benefits like food stamps, housing vouchers or Medicare (DeParle, Gebeloff, & Tavernise, 2011). It also ignores taxes and medical costs. It was originally created as a multiple of food costs, which is no longer an accurate measure as food costs are not as large a part of a household budget as they were in the past (Ibid). Finally, and most importantly for the purposes of this research, the poverty calculation does not take into account the different cost of living in different metropolitan regions. The low income cut-off (LICO) used by Statistics Canada does adjust for family size and metropolitan size, allowing a larger cost of living in larger metros. However, all metro areas of over 500,000 people use the same measure. The low income cut-off measure is calculated as the level at which families spend 20% more of than the average amount of pre-tax income on food, shelter and clothing (Statistics Canada, 2012). Given that there still are considerable cost of living differences in cities of over 500,000 people, especially housing costs, this measure does not accurately reflect regional and city differences in financial burdens. For example, there is evidence that income-specific grocery cost indexes are 20 percent higher for low-income households in a wealthy city than they are in a poorer city (Handbury, 2012). Because of these differences, an absolute low-income or poverty line would not be appropriate to represent income in the model. In addition, this doesn't capture the near-poor, those in the 'middle class' who are part of the spectrum of incomes who may benefit from transit access.

The alternative is to take median household income for all the groups in a city, and divide it into quartiles *by metro*, with 1 being low income and 4 being high income. Like the use of quartiles for home value, this transforms the household income variable into a factor variable, making a polytomous variable that could be interpreted in a fairly straightforward way in logistic regression. For example, if the first quartile was low income, then we could measure the probability of being in the FTN if you are in the low income quartile in a specific city. A quartile means that it includes ¼ of the groups in the metro – the boundaries of the quartile (say, $10,000 - $50,000 annual household income) will vary from metro to metro. In this way, the different cost of living in each city will be accounted for, while also allowing for an inter-metro comparison, and even an international metro comparison. Given the options, this was chosen as an appropriate alternative for capturing income. Household income was chosen rather than individual income, to take into account that there may be members of a household, like home-makers, who work part time and earn low incomes but are still part of a higher-income household and have access to household vehicles.

Other socioeconomic control variables

Other socioeconomic control variables could include race or ethnicity, culture, immigration status, age, and gender.

Gender and Age

Although an increasing number of trips made by women have contributed in a large part to the growth in overall trips in post-war North America as women joined the formal, paid workforce at unprecedented rates, women still make fewer trips and travel shorter distances than men, are less likely to own a car and less likely to drive. Gender interacts in expected ways with race and income identities. Minority women depend more heavily on public transit to access jobs than any other gender and ethnic groups (McLafferty & Preston, 1996; McLafferty & Preston, 1992). Women who work and do not take care of children may have higher incomes and very similar driving patterns to that of similar-income men. Wage inequality means that women on average have lower incomes than men. Immigrant, poor and minority women are the most likely of all socioeconomic categories to take the bus (Lau, 2007). For these reasons, feminist geographers suggest that privileging the automobile at the expense of transit is the same as privileging wealthy, white male travel demand (Domosh & Seager, 2001).

Women are more likely than men to 'trip chain', that is, use linked trips to reach multiple destinations. Examining voluntary travel surveys, Statistics Canada found that the longer the trip chain (the greater number of trip stages involved in a complete tour), the greater the likelihood that the driver was female (Baldwin & Fagan, 2008). Women led in driving to schools or daycares, as well as shopping centres, banks and other places of business. This indicates that women combine commuting to work with other household duties, especially involving children. Men's trip chains were more likely to involve leisure, entertainment, recreational facilities and restaurants. This could reflect a continuing unbalance of work as women increasingly participate in the paid workforce while maintaining the main burden of unpaid homemaking work. Trip chaining becomes more problematic on public transit networks, with regard to increased waiting time between transfers, the need to pay multiple fares where time transfers or passes are not available, and the extra complication of traveling with children or large heavy packages like groceries. If women are doing more of these tasks, then the focus on serving the commuter and the journey to work trip by transit agencies would disservice these other types of trips, which have more diverse destinations and may happen at 'shoulder' times just before or after peak travel times.

Age has long been associated with transit use in several ways: teenagers and students, who may not have a license and access to a car, depend on transit; similarly, seniors, who may no longer be able to drive, also depend on transit to a greater extent than other populations. An analysis of distance traveled in Hamilton as a measure of accessibility found that being a senior (over 65) "essentially cancels the benefit of owning a vehicle"; travel distances for this group are extremely circumscribed (Morency et. al., 2011). However, this pattern may be changing with upcoming senior generations. Baby boomers are associated with car-centric lifestyles, coinciding with both increased female participation in the workforce and suburbanization trends. 'Retired' people ages 55-59 made almost half as many weekday work trips as a fully employed person in the same age category did in 2001 (McGuckin & Srinivasan, 2005). Generally, as people age, they tend to rely more on public transit; however, the baby boomer generation is healthier and living longer than their parents, and as a result may continue to drive, and work, well into retirement. Even if they drive at more advanced ages, this large generation will eventually stop driving; some are even now choosing to trade suburban homes and cars for downtown condos and alternative modes of transportation. Of course, age interacts with income to result in different options. Wealthier seniors may have access to taxis and drivers even as they stop driving, while less affluent seniors may depend on public transit.

Students are a large transit-using demographic. For some students, this may be the first time that they have ever taken a bus, and their exposure to public transit at a time in their lives when possible lifestyles and habits are forming. Certainly, there is increasing financial incentive for students to continue without a car after school. Growing student debt and larger percentages of students going to university combine to create a greater cost burden and lower job expectations for students now than in the past.

> Even though college-educated workers tend, on average, to earn higher incomes than their less-educated counterparts, young college-educated workers have not escaped the pressure of wage stagnation. In the last decade, the average annual earnings of workers ages 25 to 34 [in the United States] with Bachelor's degrees fell by 15%. New graduates, meanwhile, saw their average debt load increase by 24%. [] In June 2010, total outstanding student loan debt became larger than total outstanding credit card debt for the first time in the country's history, and in the spring of 2012 this figure surpassed the astonishing figure of $1 trillion (Maisano, 2013).

Declaring bankruptcy will not discharge student loan debt in the United States, or until seven years after ceasing to be a student in Canada. Ongoing debt payments may delay the purchase of big-ticket items like cars and houses for the post-student demographic. The trends in both Canada and the United States for Generations X and Y (those currently under 40), show that this demographic is accumulating less wealth than previous generations (Steuele et. al., 2013; Carrick, 2013). This is due to reduced job prospects, lower rates of home ownership and pension savings, and higher education costs.

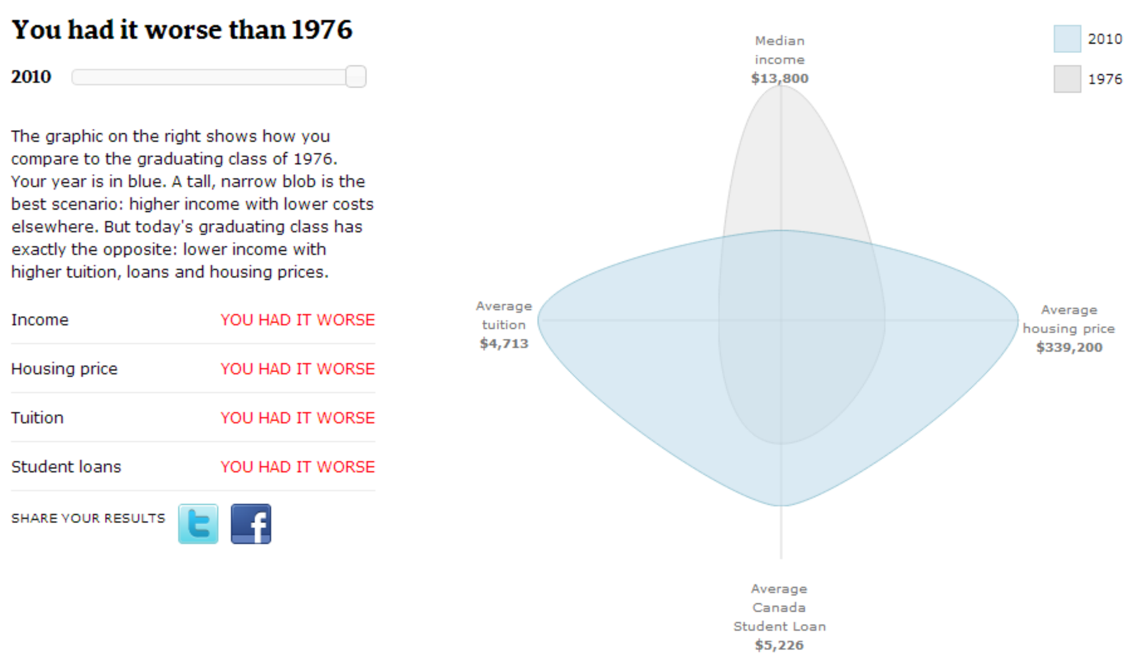


Figure 15: A comparison of average income and costs for young people based on the year of graduation, based on Statistics Canada data. (Carrick & Thompson, The 'Who had it worse' Time Machine, 2013)

To summarize, both students and seniors have higher-than-average rates public transit ridership. Looking ahead, seniors may drive for longer and students may take transit for longer than in the past, but both of these demographics will continue to be an important source of public transit ridership.

Unlike other socioeconomic characteristics like race and income, gender is not significantly spatially differentiated in metropolitan regions. Except for rare cases like remote mining towns with mostly male populations, most neighbourhoods are composed of relatively equal numbers of both women and men. Because of this, gender was not included as a variable in the spatial analysis and related regression model. Although the residential location of students and seniors could possibly be spatially differentiated in metropolitan regions (some neighbourhoods near universities are known as 'student ghettos' and other neighbourhoods have clusters of retirement homes), age was likewise not included as a variable in the model. It is difficult to pinpoint specific age categories that could be reliably labeled as 'student', as not everyone attends university and as more and more students, into their thirties, take extended degrees, . Similarly, with seniors, it is difficult to categorize an entire age bracket as having the same mobility needs and abilities, as people age at different rates and in different circumstances. Because immigrants tend to match the travel habits of the general population the longer they live in a place, immigration status is also not included in the model. Culture, while certainly influential in travel behaviour, is not captured by the American Community Survey or Canadian Census.

Race, ethnicity, and immigration status

A spatial analysis of the Nationwide Personal Travel Survey finds that transit use is not only related to household income, but also to ethnicity and immigrant status (Giuliano, 2003). Transit use is still racialized: white people have the lowest rate of commuting by transit in the United States (3.2%) while black people have the highest (11.5%) (McKenzie & Rapino, 2011). Race and ethnicity are included in the model because they have been shown to have distinct impacts on travel behaviour in the North American context, even after income and other variables are controlled for. Although race and ethnicity may be seen as cultural constructs, these cultural constructs have real structural impacts on the dynamics of urban systems. Race and ethnicity are conceptualized differently in Canada and the United States. The American Community Survey first asks a person to identify if they are Hispanic or not. After this, they are asked to identify their race as either white, black, Asian, Pacific Islander, or other. The Canadian census asks a person to identify their ethnicity or ethnicities (a person can choose more than one) from a very detailed set of possibilities including location-based criteria like Canadian or Quebecois, European, Middle Eastern, South, East, and Southeast Asian, African, Caribbean, Oceanian, and Latin American. It also has a second question asking a person if they are a member of a 'visual minority', presumably based on a non-white skin colour. These options are 'not a visual minority', or, within the visual minority category, a variety of options including Black, various Asian identities, Latin American, Arab, etc. There is a separate question for Aboriginal identity.

To avoid multicollinearity, only one variable representing race/ethnicity could be included in the model. Because overall, whites are both in the majority and in most contexts are the locus of privilege, the percentage of white people in each neighbourhood was used as the variable to represent race/ethnicity. Where this percentage is lower, this indicates a more diverse area (and relates to Anderson's Cosmopolitan Canopy idea), and where high, it indicates a racially homogenous area. When tested using the Chi Square test, which can be used to compare the fit of one model to another, the model was a slightly better fit with this variable included.

Recent immigrants in both Canada and the United States are more likely to take public transit, despite differing origins (mostly Asian in Canada and Hispanic in America). In America, the foreign-born are "much more likely to use transit, carpool, walk and bicycle" than the general population (Chatman & Klein, 2009, p. 312). In Canada, recent immigrants are much more likely to commute to work by transit than Canadian-born persons, even when controlling for demographic characteristics, income, commute distance and residential distance from the city centre (Heisz & Schellenberg, 2004). But over time, in both places, as these populations acclimatize, they also become more similar in their travel behavior to the general population.

Given that many variables are measured at the household level, including housing costs, tenure, and income, it is important to control for household size. One-person households may have lower incomes while not actually facing affordability burdens. The percent of one-person households in each area was calculated to create a continuous variable that accounts for household size.

Chapter 3: Results and findings

The results are presented city-by-city, and then afterwards a cross-cities comparison of findings are discussed.

The results are presented city by city and organized into three categories. The reason for dividing the cities into different categories reflects the different role of transit systems in each category. Accessibility to the frequent transit network means very different things in different cities. Although all coverage is partial, the first category contains cities that have fairly extensive and robust transit systems in place. This overall coverage is a proxy for destination accessibility offered by the transit system.

Within this group of cities, there exists a spectrum in the relationship of affordable housing to frequent transit networks, from good alignment to mis-alignment. This category is called ‘strong transit cities’, and includes ten of the metropolitan regions. These ten cities have enough frequent transit lines to form a network that covers a good portion of the region. These ‘strong transit’ cities have fairly extensive transit networks coinciding with large older core areas. These ten cities are presented in the order of alignment between affordable housing and transit access, from highly aligned to highly misaligned.

Seven other cities in this research have less comprehensive frequent transit networks and supportive urban form. These smaller collections of routes do not form a ‘network’ in the sense of providing a comprehensive or convenient means of travel or access to destinations by transit. These cities also have small downtown cores that are an exception in a large low-density, auto-oriented urbanized region. This category is called ‘weak transit cities’, and the patterns of spatial socioeconomics in these cities are less relevant to the research question, given the lack of convenient frequent transit network. These cities are presented in order of relative FTN network coverage, from best to worst coverage. The remaining three cities have transit networks that fall somewhere between strong and weak, and are called ‘partial transit cities’. These are presented in the middle.

Each metropolitan region is presented with five pages of results. The first page shows the logistic regression results for the metro, with odds ratios for each variable (greater than one means a greater likelihood of access to the FTN; less than one means less). The odds ratios are mapped on a logarithmic scale to reflect the relative influences of each variable on the likelihood of transit access. The second page is a chart and graph showing the marginal probabilities of access to the FTN across income and home value quartiles, compared to the overall baseline probability of access in the region. The third page is a map showing the Frequent Transit Network and the location of first-quartile (affordable) rented and owned homes in the region. The fourth page contains a table describing the differences in average characteristics of areas within walking distance to the frequent transit network and areas outside of this transit-shed, across a number of variables. These variables include urban-form-like residential density, detached buildings, rental tenure, mid- and high-rise buildings, and age of buildings; transportation variables like journey to work data and households without a vehicle; and socioeconomic variables like ethnic/racial diversity, rent, owner costs, income and poverty rates. At the bottom, there are two pie charts showing the percent of all households located within walking distance to the FTN, and the percent of low-income households within this transit-shed. This is a rough measure of coverage and accessibility. The fifth page contains notes about the metro area’s results.

Most results are presented in-text. However, some of the supplementary analysis is shown in Appendix B: Variable Correlations and Coverage Statistics, to streamline this section. To better capture overall accessibility by frequent transit, detailed coverage statistics for each city were run to count both the number of households and percentage of households covered by the frequent transit network (FTN). Coverage of first-quartile home values and rent costs were also calculated, and these coverages were then also broken down by residential density categories to see what the urban form of accessible and non-accessible areas was. In addition, correlations between variables included in the model and those not included for methodological reasons, like poverty and rent, are shown in this appendix.

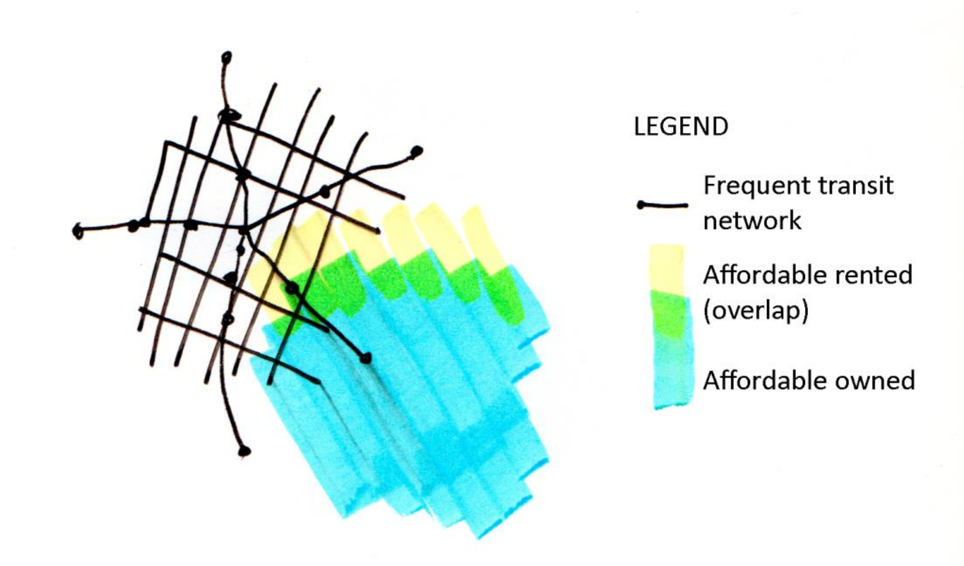
Once these findings are presented, an analysis of the overall findings is discussed.

Strong transit cities

With various degrees of alignment between affordable housing and accessible transit

Within the first 'strong transit' typology, there are varying degrees of alignment between these frequent transit networks and the location of relatively affordable housing. The degree of misalignment can take on different forms, from the distant affordable towns surrounding Boston (polycentric misalignment) to the extension of affordable areas to the south of Chicago, beyond the reach of the FTN (contiguous misalignment), to a combination of contiguous and polycentric misalignment as exhibited in San Francisco. Regardless of what form the pattern takes, some metropolitan regions have a much more effective alignment of affordable housing and frequent transit networks, like Philadelphia, which aside from a small core of gentrification in the downtown, has almost no misalignment of affordability away from the FTN.

Figure 16: Illustrating the concept of a transit access – housing affordability gap, where the affordable housing is not aligned well with the frequent transit network



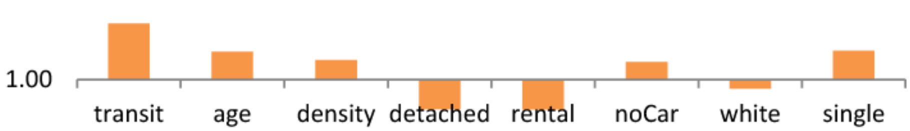
In regions that display a more distinct misalignment, there is a pronounced distinction by tenure. In many of these regions, affordable rental housing remains within the FTN-sheds, while affordable owned homes are less likely to be accessible to frequent transit. These patterns can be clearly observed in the maps of regions like New York, Montreal, Los Angeles, and Boston. Affordable rental housing may be located in mid- or high-rise buildings and offer smaller living space; these buildings may be more likely to be located in conjunction with frequent transit networks. Affordable owned housing, however, may take the form of modest houses in post-war suburbs, and so be less likely to coincide with frequent transit networks. The metropolitan regions are ordered by the extent of this misalignment, from the most alignment of affordable housing with accessible transit to the greatest degree of misalignment.

Philadelphia (Pop 4 million)

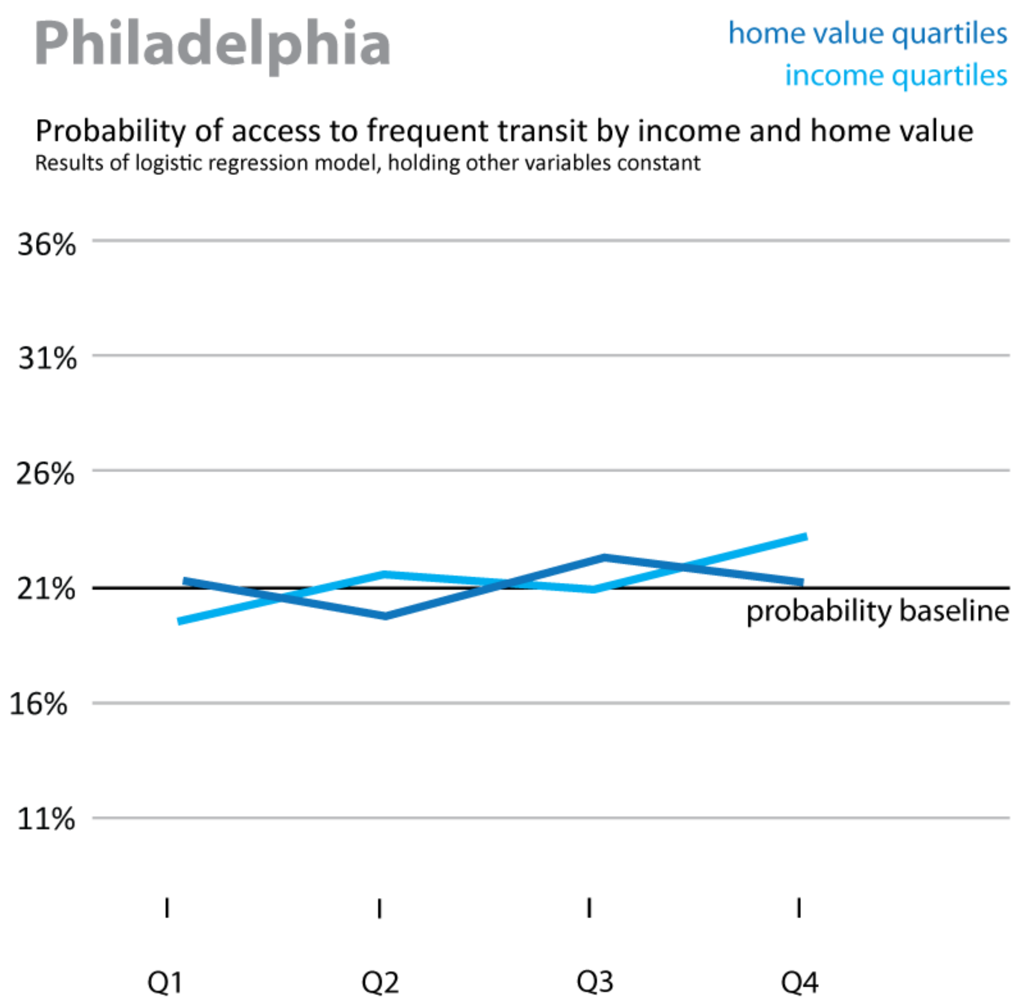
PHILADELPHIA		
Logistic regression	Number of obs	4,075,966
	LR chi2(14)	2179132.0 7
	Prob > chi2	0.00
Log likelihood = - 1009513.8	Pseudo R2	0.52

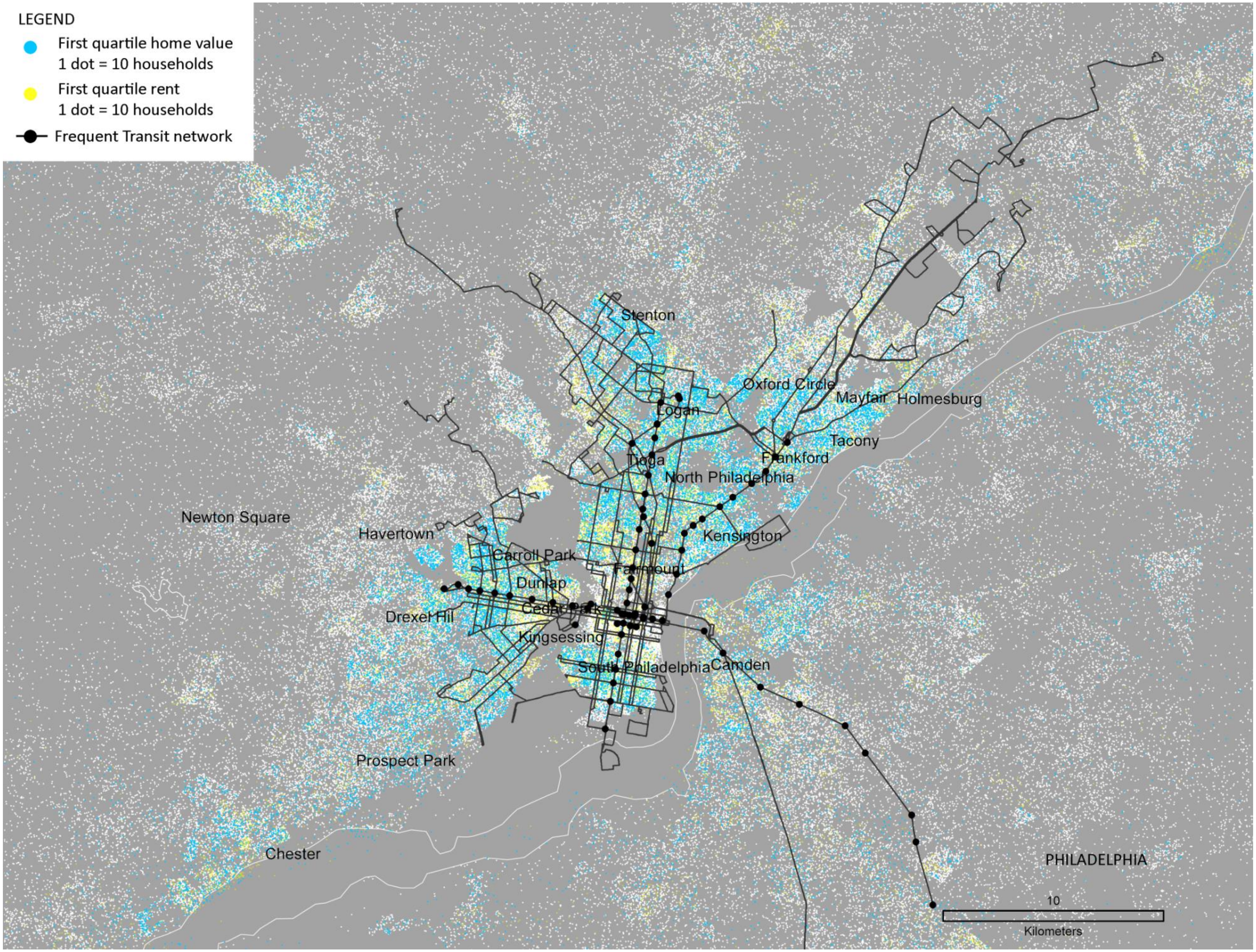
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.65**	0.003	284.83	0.00	1.64	1.65
Household income	Quartiles						
(median)	2	**1.33**	0.008	49.08	0.00	1.32	1.35
	3	**1.25**	0.009	29.62	0.00	1.23	1.27
	4	**1.73**	0.017	57.26	0.00	1.70	1.77
Home value	Quartiles						
(median)	2	**0.82**	0.005	-33.95	0.00	0.81	0.83
	3	**1.21**	0.009	27.43	0.00	1.20	1.23
	4	**1.00**	0.009	0.09	0.93	0.98	1.02
Age of building	10 years	**1.28**	0.002	164.83	0.00	1.28	1.28
Residential density	+ 1,000 pp/km^2	**1.19**	0.001	265.66	0.00	1.19	1.19
Detached homes	+ 10%	**0.77**	0.001	-259.59	0.00	0.77	0.77
Rental housing tenure	+ 10%	**0.77**	0.001	-236.02	0.00	0.77	0.77
No car	+ 10%	**1.17**	0.002	93.87	0.00	1.17	1.17
Race (white)	+ 10%	**0.92**	0.001	-99.03	0.00	0.92	0.92
One-person households	+ 10%	**1.29**	0.002	162.92	0.00	1.29	1.30
_cons		**0.04**	0.001	-238.74	0.00	0.04	0.05

Odds ratios (mapped on a logarithmic scale)



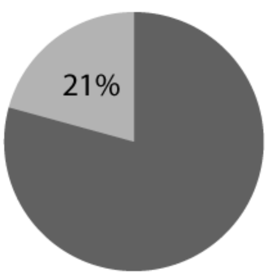
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.21**	**0.000**	**1585.84**	**0.00**	**0.21**	**0.21**
BY INCOME QUARTILES	1	0.20	0.000	663.30	0.00	0.20	0.20
	2	0.22	0.000	912.84	0.00	0.21	0.22
	3	0.21	0.000	693.86	0.00	0.21	0.21
	4	0.23	0.000	475.06	0.00	0.23	0.24
BY HOME VALUE QUARTILES	1	0.21	0.000	668.46	0.00	0.21	0.21
	2	0.20	0.000	830.44	0.00	0.20	0.20
	3	0.23	0.000	711.31	0.00	0.23	0.23
	4	0.21	0.000	476.41	0.00	0.21	0.21



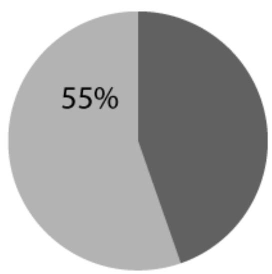

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Stenton
Oxford Circle
Mayfair
Holmesburg
Logan
Tacony
Tioga
Frankford
North Philadelphia
Newton Square
Havertown
Kensington
Carroll Park
Fairmount
Dunlap
Drexel Hil
Cedar Park
Kingsessing
South Philadelphia
Camden
Prospect Park
Chester
PHILADELPHIA
10
Kilometers

PHILADELPHIA: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	3,498	1,976	9,098	White	%	67	75	36
Single detached buildings	%	47	56	14	Black	%	20	13	47
Rental tenure	%	30	27	42	Hispanic	%	7	7	10
Over 20 units in building	%	7	7	8	Asian	%	4	4	5
Median age of buildings	years	47	44	61	Other	%	2	2	2
Commuters by car	%	83	87	63	One-person households	%	29	27	36
Commuters by transit	%	9	5	26	Median rent	$ USD	997	1,048	821
Walking commuters	%	3	3	6	Median monthly owner costs	$ USD	1,388	1,505	933
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	243,275	267,680	147,656
Transit by bus	%	60	49	70	Median income spent on rent	%	33	32	35
Transit by subway/el	%	15	13	17	Median income spent on costs	%	24	24	24
Transit by commuter rail	%	23	37	10	Median household income	$ USD	64,564	70,675	41,192
					Income below the poverty line	%	11	8	23
Households with no vehicle	%	13	8	31	Income less than twice poverty	%	14	13	20



Households with FTN access



Lower-income (Q1) households with FTN access

Philadelphia Notes

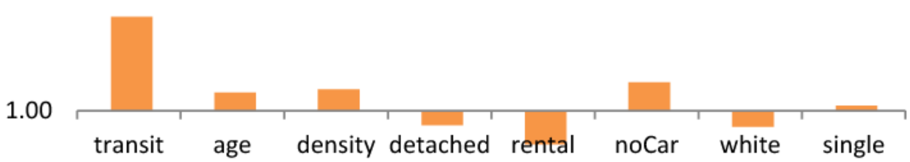
Although the network is not comprehensive enough to fill all the gaps in its coverage area, Philadelphia is a city where affordability and transit access are generally aligned, densities are higher and distances are smaller than in other cities. The FTN has strong east-west and north-south axes which cross in the downtown core. A looser network covers a larger area. While the downtown core where the axes meet is not affordable, most of the other areas covered by the FTN are.

The FTN in Philadelphia serves a large, high-density core with very few single detached residences, high rental tenure, older buildings and healthy transit commuting rates. This area is home to large numbers of African-Americans and is generally more diverse than outside the FTN. The median home value is lower inside the FTN zone, as is rent, owner costs, and, dramatically, household income. Over 40% of households in the FTN have incomes of less than double the poverty line. However, when other variables are held constant, the likelihood of FTN access decreases as rental tenure rates increase in an area, and increases with income above the lowest quartile.

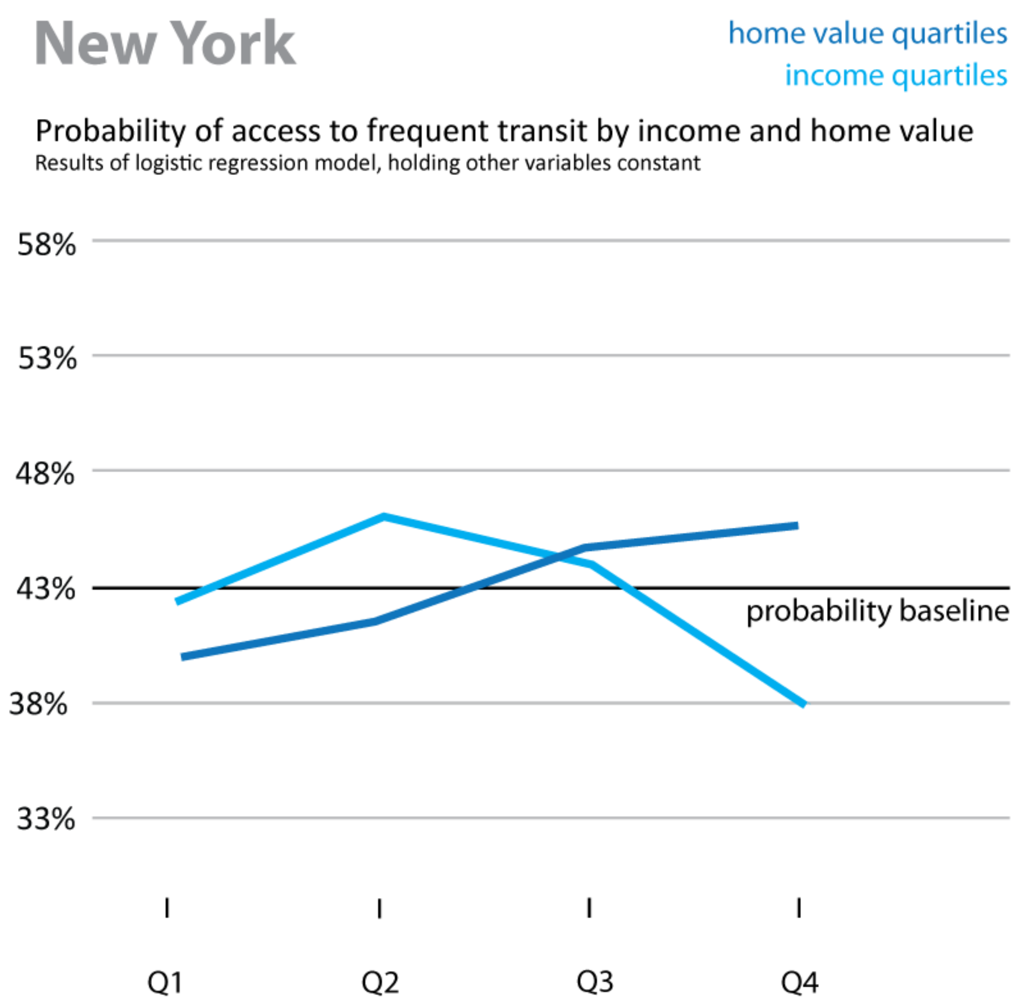
New York (pop. 17.1 million)

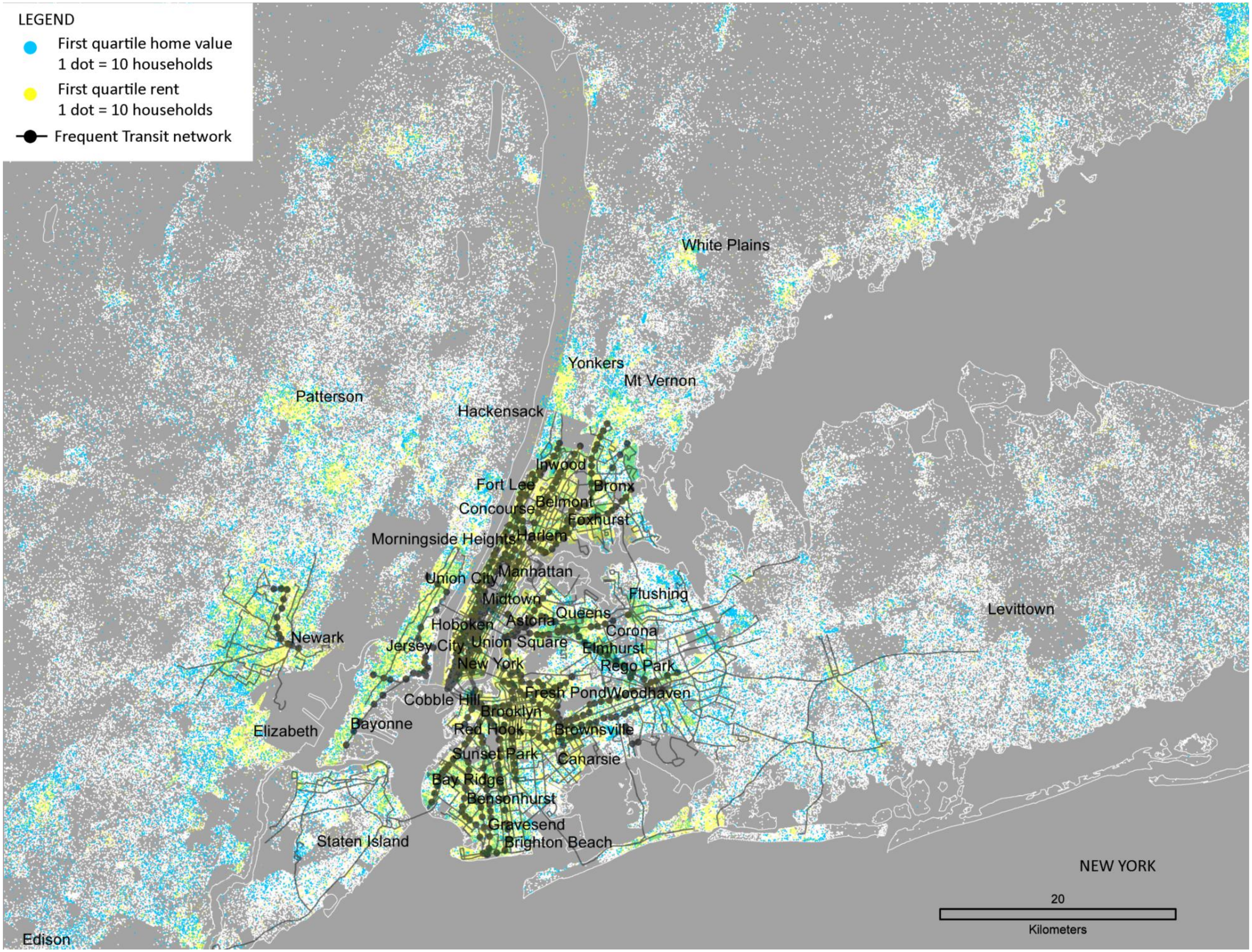
NEW YORK								
Logistic regression	Number of obs	15,853,842						
	LR chi2(14)	16100000.00						
	Prob > chi2	0.00						
Log likelihood = -2752091.4	Pseudo R2	0.75						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]	
Transit commuters	+ 10%	**2.32**	0.002	902.81	0.00	2.31	2.32	
Household income	Quartiles							
(median)	2	**1.80**	0.006	165.81	0.00	1.79	1.81	
	3	**1.39**	0.006	76.59	0.00	1.38	1.40	
	4	**0.39**	0.002	-170.59	0.00	0.39	0.40	
Home value	Quartiles							
(median)	2	**1.31**	0.004	84.69	0.00	1.30	1.32	
	3	**2.45**	0.009	256.08	0.00	2.43	2.46	
	4	**3.05**	0.013	256.26	0.00	3.03	3.08	
Age of building	10 years	**1.18**	0.001	176.75	0.00	1.17	1.18	
Residential density	+ 1,000 people/km^2	**1.21**	0.000	613.00	0.00	1.21	1.21	
Detached homes	+ 10%	**0.88**	0.001	-193.28	0.00	0.88	0.88	
Rental housing tenure	+ 10%	**0.74**	0.001	-359.85	0.00	0.74	0.74	
No car	+ 10%	**1.29**	0.001	257.29	0.00	1.28	1.29	
Race (white)	+ 10%	**0.87**	0.000	-303.35	0.00	0.87	0.87	
One-person households	+ 10%	**1.05**	0.001	46.70	0.00	1.04	1.05	
_cons		**0.03**	0.000	-410.11	0.00	0.03	0.03	

Odds ratios (graphed on a logarithmic scale)



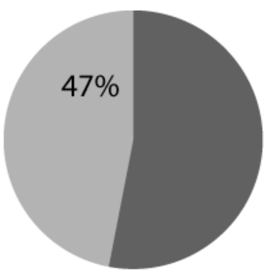
PREDICTIVE MARGINS (PROBABILITY, VCE MODEL)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.43**	**0.000**	**7598.44**	**0.00**	**0.43**	**0.43**
BY INCOME QUARTILES	1	0.42	0.000	2446.41	0.00	0.42	0.42
	2	0.46	0.000	3158.66	0.00	0.46	0.46
	3	0.44	0.000	3578.71	0.00	0.44	0.44
	4	0.38	0.000	2391.72	0.00	0.38	0.38
BY HOME VALUE QUARTILES	1	0.40	0.000	3695.64	0.00	0.40	0.40
	2	0.42	0.000	3925.81	0.00	0.42	0.42
	3	0.45	0.000	3486.62	0.00	0.45	0.45
	4	0.46	0.000	2472.03	0.00	0.46	0.46



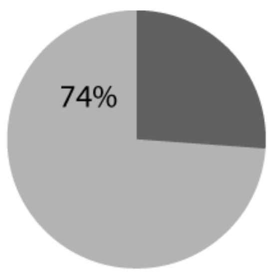

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
White Plains
Yonkers
Mt Vernon
Patterson
Hackensack
Inwood
Fort Lee
Bronx
Concourse
Belmont
Foxhurst
Morningside Heights
Harlem
Union City
Manhattan
Flushing
Midtown
Levittown
Queens
Hoboken
Astoria
Newark
Corona
Jersey City
Union Square
Elmhurst
New York
Rego Park
Fresh Pond
Woodhaven
Cobble Hill
Brooklyn
Bayonne
Red Hook
Brownsville
Elizabeth
Sunset Park
Canarsie
Bay Ridge
Bensonhurst
Gravesend
Staten Island
Brighton Beach
NEW YORK
20
Kilometers
Edison

NEW YORK: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	14,270	2,841	27,748	White	%	52	67	34
Single detached buildings	%	38	62	11	Black	%	17	10	24
Rental tenure	%	46	28	67	Hispanic	%	21	15	28
Over 20 units in building	%	25	8	44	Asian	%	9	7	11
Median age of buildings	years	54	48	60	Other	%	2	2	2
Commuters by car	%	59	82	31	One-person households	%	28	24	33
Commuters by transit	%	29	10	52	Median rent	$ USD	1,199	1,278	1,128
Walking commuters	%	6	3	10	Median monthly owner costs	$ USD	1,922	2,027	1,788
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	474,651	433,671	526,982
Transit by bus	%	28	42	25	Median income spent on rent	%	32	33	32
Transit by subway/el	%	58	10	70	Median income spent on costs	%	27	27	27
Transit by commuter rail	%	12	46	4	Median household income	$ USD	71,356	84,084	56,980
					Income below the poverty line	%	12	7	18
Households with no vehicle	%	30	9	53	Income less than twice poverty	%	15	11	18



Households with FTN access



Lower-income (Q1) households with FTN access

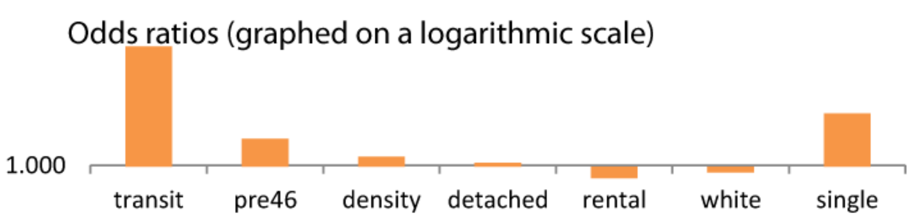
Notes on New York

New York City offers very little affordable ownership opportunities within the frequent transit-shed, but there are considerable first-quartile rental opportunities within this zone. The map demonstrates the networked density of frequent subway lines covering New York and most of its boroughs. While there are (regionally) affordable rents available in the FTN-shed, there are very few affordable home ownership opportunities. See Section 3 for a discussion on the 'inherent affordability' of the Bronx housing typologies.

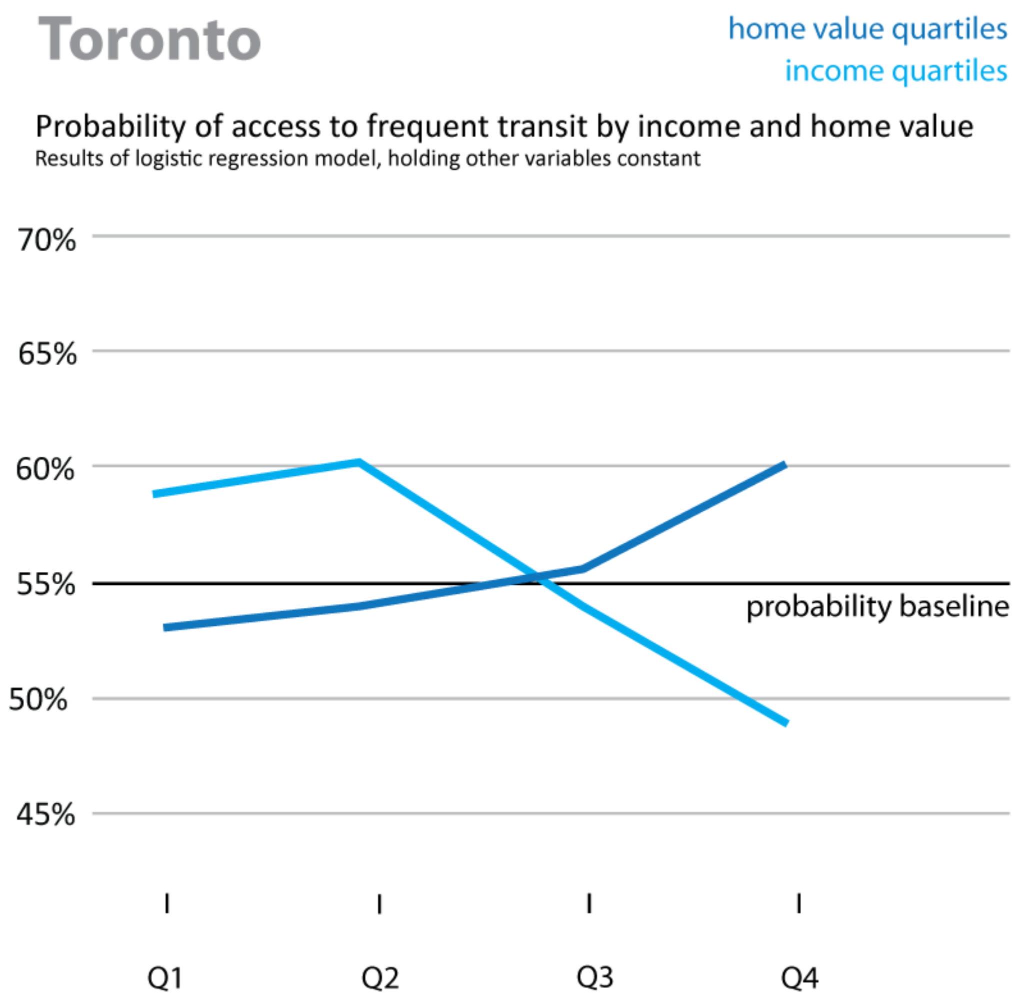
The density in the FTN zone in New York is phenomenally high at 27,700 people/square kilometer. There is no comparison in North America: Toronto and Montreal, the other relatively high-density FTN zones in this analysis, have densities of less than half of this. More than half of the commuters in this transit-shed take transit to work, with subways carrying the majority of these trips. More than half of households in the FTN do not have access to a vehicle. The FTN zone is notably more diverse than outside, with one third white and almost an equal amount Hispanic, one quarter black, and one tenth Asian inhabitants. Two thirds of housing units in the FTN are rented. Home prices are higher in the FTN by almost $100,000, and median household incomes are almost $30,000 lower. The logistic regression shows higher odds of FTN access for middle-incomes and higher-home values than the base. Only the top quartile of incomes is more likely to live outside the FTN zone.

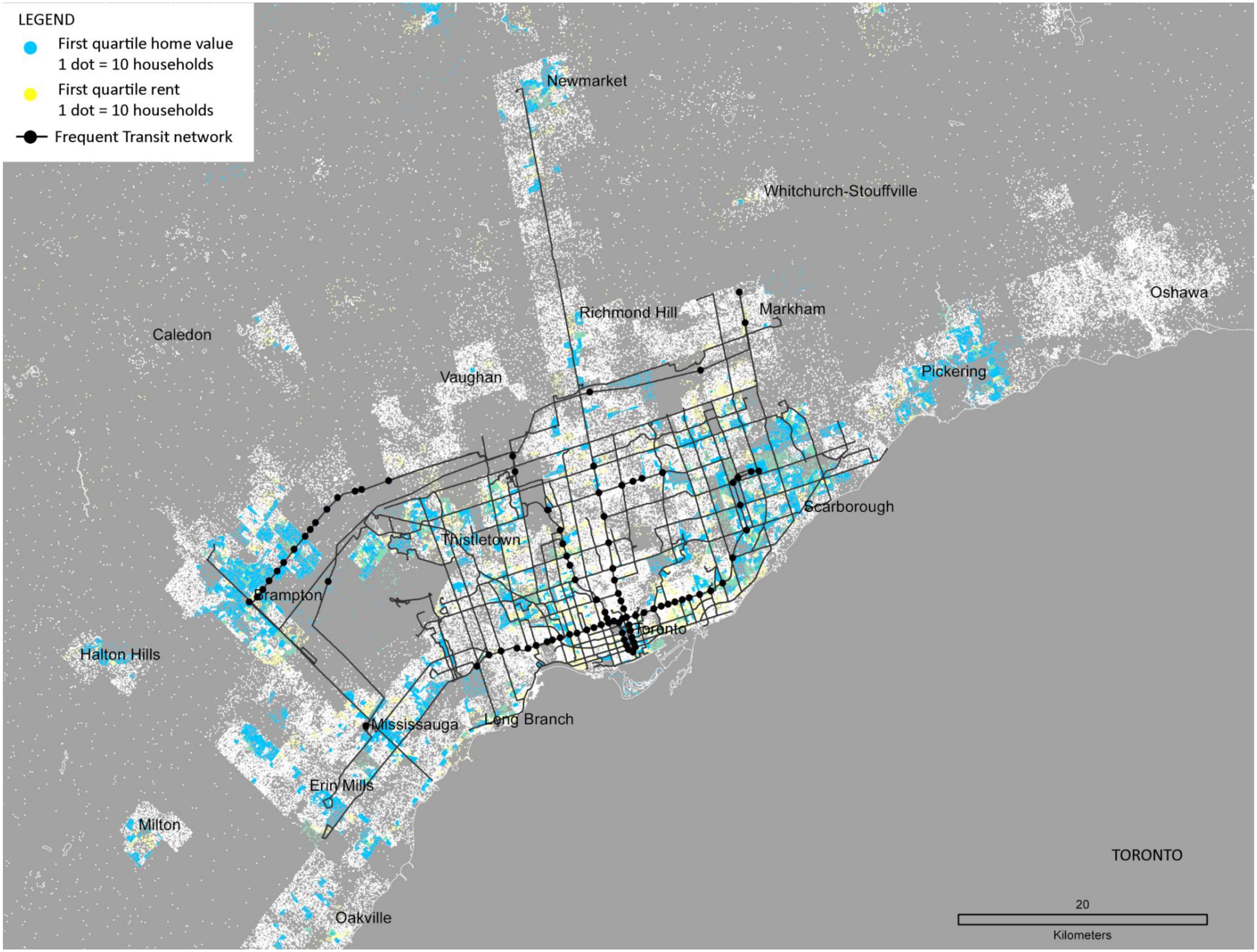
Toronto (pop. 4.3 million)

TORONTO							
Logistic regression	Number of obs	3,992,219					
	LR chi2(13)	2272091.00					
	Prob > chi2	0.00					
Log likelihood = -1608533.4	Pseudo R2	0.41					
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**2.93**	0.00	657.32	0.00	2.92	2.93
Median household income	Quartiles						
	2	**1.12**	0.01	22.56	0.00	1.11	1.13
	3	**0.71**	0.00	-58.81	0.00	0.71	0.72
	4	**0.49**	0.00	-106.39	0.00	0.48	0.50
Median home value	Quartiles						
	2	**1.06**	0.00	13.61	0.00	1.05	1.06
	3	**1.24**	0.01	50.82	0.00	1.23	1.26
	4	**1.75**	0.01	112.05	0.00	1.73	1.77
Pre-1946 buildings	+ 10%	**1.28**	0.00	213.44	0.00	1.28	1.28
Residential Density	+ 1,000 people/km^2	**1.09**	0.00	199.94	0.00	1.09	1.09
Detached homes	+ 10%	**1.03**	0.00	52.31	0.00	1.03	1.04
Rental tenure	+ 10%	**0.90**	0.00	-105.39	0.00	0.90	0.90
Race (white)	+ 10%	**0.95**	0.00	-77.13	0.00	0.95	0.95
One-person households	+ 10%	**1.61**	0.00	254.82	0.00	1.60	1.62
_cons		**0.05**	0.00	-347.83	0.00	0.04	0.05



PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.55**	**0.00**	**3069.93**	**0.00**	**0.55**	**0.55**
BY INCOME QUARTILES	1	0.59	0.00	908.79	0.00	0.59	0.59
	2	0.60	0.00	1481.75	0.00	0.60	0.60
	3	0.54	0.00	1453.57	0.00	0.54	0.54
	4	0.49	0.00	999.40	0.00	0.49	0.49
BY HOME VALUE QUARTILES	1	0.53	0.00	1428.24	0.00	0.53	0.53
	2	0.54	0.00	1517.59	0.00	0.54	0.54
	3	0.56	0.00	1548.68	0.00	0.56	0.56
	4	0.60	0.00	1350.79	0.00	0.60	0.60

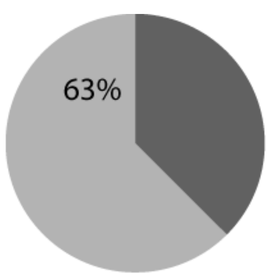



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Newmarket
Whitchurch-Stouffville
Oshawa
Richmond Hill
Markham
Caledon
Vaughan
Pickering
Scarborough
Thistletown
Brampton
Toronto
Halton Hills
Mississauga
Long Branch
Erin Mills
Milton
TORONTO
20
Kilometers
Oakville

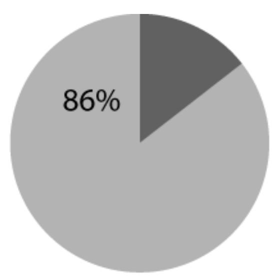
TORONTO: Statistics

Variable	Units	Mean	FTN Access NO	FTN Access YES
Urban form & transportation				
Residential density (people)	/km^2	8,849	4,542	12,071
Rental tenure	%	34	16	44
Units built before 1946	%	12	3	18
Detached homes	%	39	59	27
Over 5 stories in building	%	12	6	16
Commuters by car	%	69	83	58
Commuters by transit	%	24	13	32
Walking commuters	%	5	3	7
Cycling commuters	%	1	0	2

Variable	Units	Mean	FTN Access NO	FTN Access YES
Socioeconomics				
White	%	56	60	53
Black	%	7	6	7
Latin American	%	2	1	2
Asian	%	33	30	34
Other	%	2	2	2
Low income households	%	20	13	24
> 30% of income on housing	%	33	29	36
Median household income	$ CAD	67,207	81,948	58,358
Average rent	$ CAD	999	1,060	977
Average value of owned unit	$ CAD	387,555	386,846	388,016
Average monthly owner costs	%	1,367	1,432	1,325
	%	24	14	30
One-person households				



Households with FTN access



Lower-income (Q1) households with FTN access

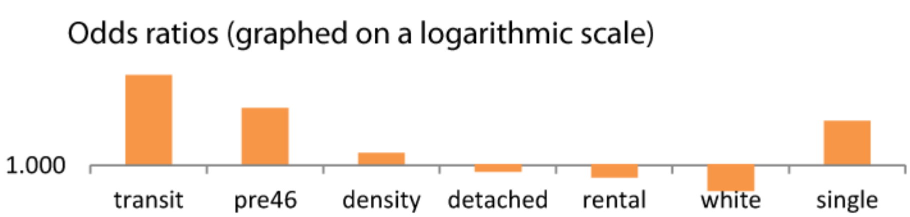
Toronto Notes

Toronto's subway network consists of north-running and east-west lines converging on the downtown. A loose grid of frequent bus routes feeds stretches over the rest of the city, but does not extend completely into contiguous municipalities. The majority of the FTN-shed is less affordable, excepting the northeast and northwest. In Toronto, the likelihood of access is greater for the lower-income households than higher-income ones. The opposite is true for home values.

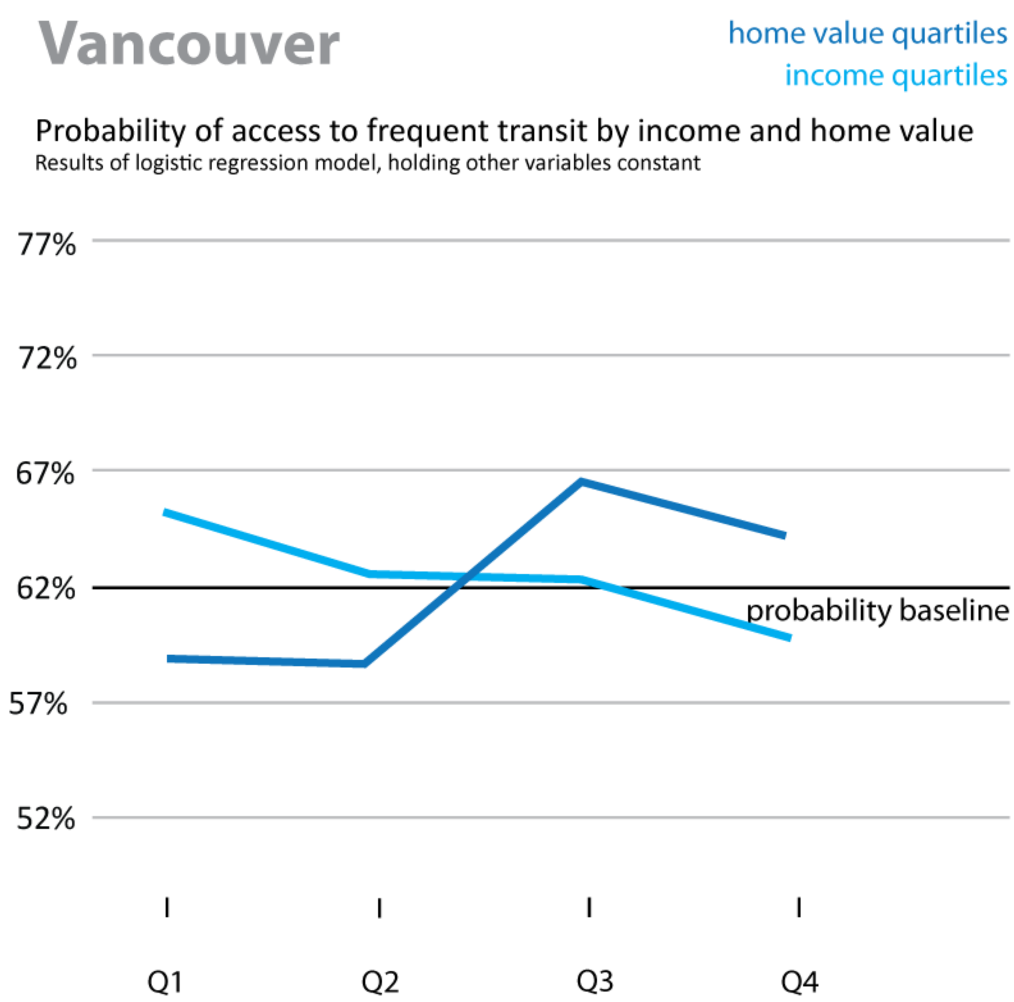
Detached homes are slightly more likely to have access as their percentages in an area increase, reflecting the large number of these types of houses in Toronto's urban fabric. The FTN zone has more rental units and more homes in mid- and high-rise buildings, as well as a larger percentage of pre-war housing. Median household incomes are significantly lower in the FTN zone, but the average value of a unit is higher. Although more than half of people in metropolitan Toronto live within walking distance to frequent transit, commuting rates in the FTN are just under one-third, with more than half of commuters driving to work. Although the FTN has good coverage in Toronto, the bus and streetcar routes often run in mixed traffic, and congestion slows the pace of travel. Higher rates of rental tenure in an area actually lower the odds of FTN access, perhaps reflecting the large number of high-rise rental units that were built in the inner suburbs (see Appendix F).

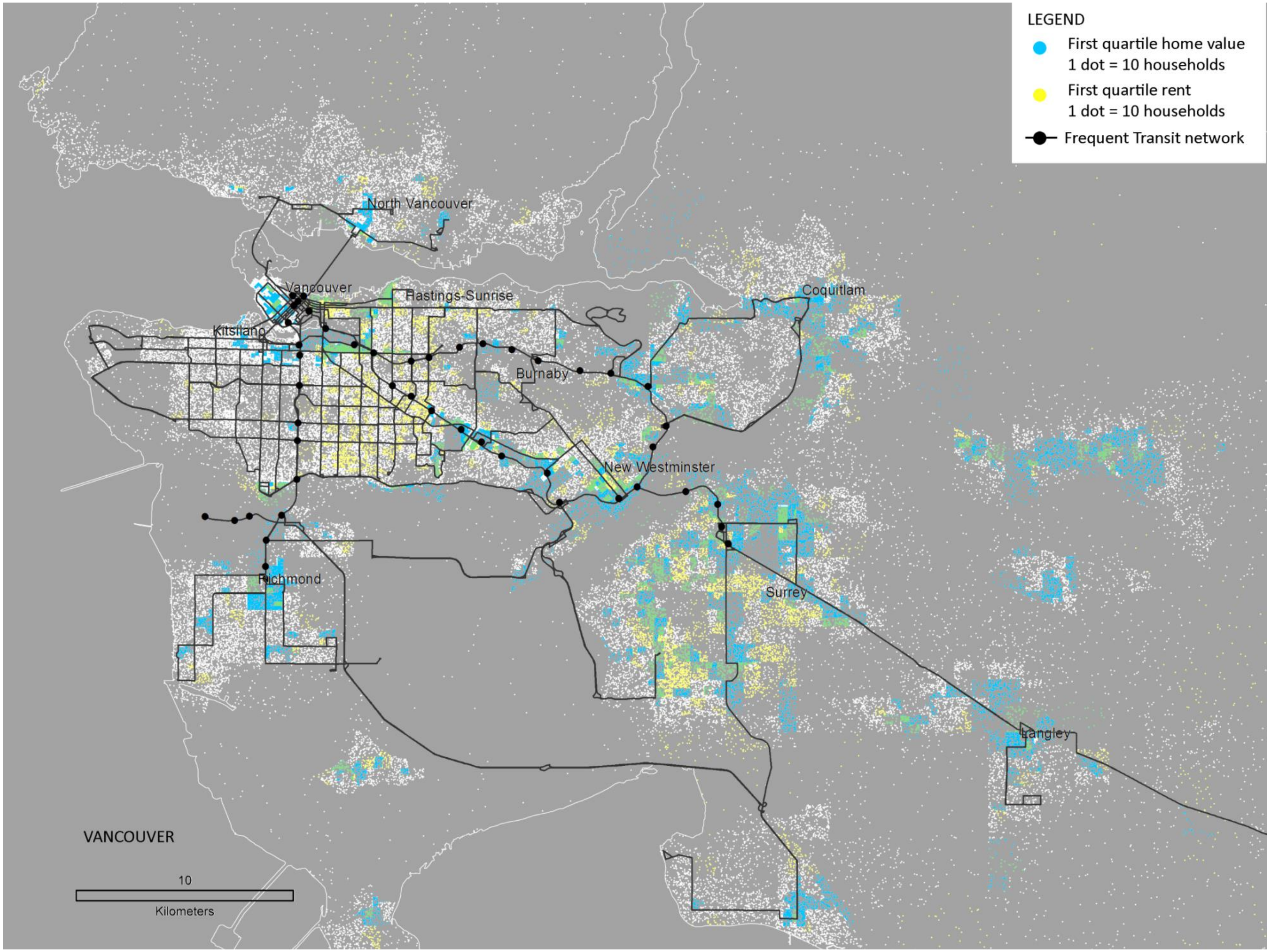
Vancouver (pop. 1.8 million)

VANCOUVER							
Logistic regression	Number of obs	1,696,092					
	LR chi2(13)	813786.00					
	Prob > chi2	0.00					
Log likelihood = -718273.43	Pseudo R2	0.36					
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**2.21**	0.01	273.87	0.00	2.19	2.22
Median household income	Quartiles						
	2	**0.84**	0.01	-24.66	0.00	0.82	0.85
	3	**0.82**	0.01	-25.08	0.00	0.81	0.83
	4	**0.70**	0.01	-37.40	0.00	0.69	0.71
Median home value	Quartiles						
	2	**0.98**	0.01	-3.67	0.00	0.96	0.99
	3	**1.71**	0.01	73.61	0.00	1.69	1.74
	4	**1.48**	0.01	51.84	0.00	1.46	1.50
Pre-1946 buildings	+ 10%	**1.65**	0.00	226.79	0.00	1.64	1.65
Residential Density	+ 1,000 people/km^2	**1.11**	0.00	129.33	0.00	1.10	1.11
Detached homes	+ 10%	**0.93**	0.00	-57.34	0.00	0.93	0.94
Rental tenure	+ 10%	**0.89**	0.00	-76.53	0.00	0.89	0.89
Race (white)	+ 10%	**0.79**	0.00	-211.96	0.00	0.78	0.79
One-person households	+ 10%	**1.47**	0.00	140.07	0.00	1.46	1.48
_cons		**0.68**	0.01	-28.82	0.00	0.66	0.70

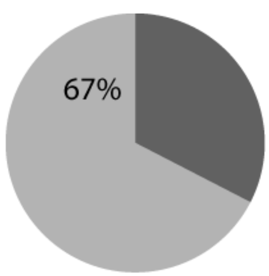


PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.62**	**0.00**	**2186.88**	**0.00**	**0.62**	**0.62**
BY INCOME QUARTILES	1	0.65	0.00	708.59	0.00	0.65	0.65
	2	0.62	0.00	1021.77	0.00	0.62	0.63
	3	0.62	0.00	1150.32	0.00	0.62	0.62
	4	0.60	0.00	807.96	0.00	0.60	0.60
BY HOME VALUE QUARTILES	1	0.59	0.00	863.56	0.00	0.59	0.59
	2	0.59	0.00	1021.05	0.00	0.59	0.59
	3	0.67	0.00	1076.50	0.00	0.66	0.67
	4	0.65	0.00	1012.14	0.00	0.64	0.65

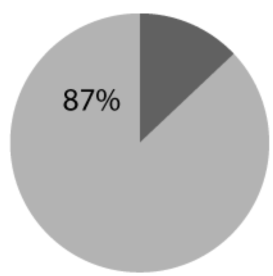



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
North Vancouver
Vancouver
Hastings-Sunrise
Kitsilano
Coquitlam
Burnaby
New Westminster
Richmond
Surrey
Langley
VANCOUVER
10
Kilometers

VANCOUVER: Statistics									
Variable	Units	Mean	FTN Access		Variable		Mean	FTN Access	
Urban form & transportation			**NO**	**YES**	**Socioeconomics**			**NO**	**YES**
Residential density (people)	/km^2	6,571	3,578	8,336	White	%	57	66	51
Rental tenure	%	37	21	45	Black	%	1	1	1
Units built before 1946	%	9	4	11	Latin American	%	1	1	1
Detached homes	%	33	55	23	Asian	%	40	32	45
Over 5 stories in building	%	29	15	35	Other	%	1	1	1
Commuters by car	%	73	85	65	Low income households	%	23	16	26
Commuters by transit	%	18	10	22	> 30% of income on housing	%	33	28	35
Walking commuters	%	6	3	9	Median household income	$ CAD	57,612	71,086	51,131
Cycling commuters	%	2	1	2	Average rent	$ CAD	937	971	924
					Average value of owned unit	$ CAD	489,718	513,530	477,721
					Average monthly owner costs	%	1,196	1,297	1,144
					One-person households	%	29	19	34



Households with FTN access



Lower-income (Q1) households with FTN access

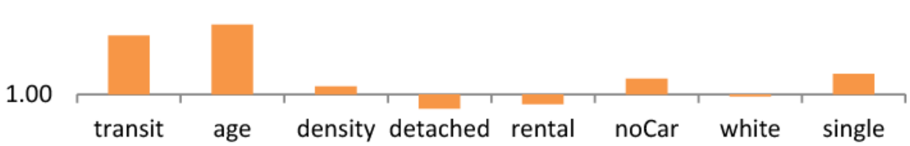
The map shows a fairly extensive grid of frequent bus lines covering the city of Vancouver, and SkyTrain (rapid transit) lines traveling from the downtown southeast to Surrey and south to Richmond and the airport. There are affordable rental units scattered throughout east Vancouver and concentrations of (relatively) affordable high density owned units in the west end of Vancouver's downtown and in downtown Richmond. However, there is also a significant amount of affordable rented and owned units in Surrey, the bulk of which are not accessible to frequent transit. Absolute (non-relative) affordability in Vancouver is low.

Vancouver has very good FTN coverage, with over 60% of people living within walking distance to frequent routes. Home prices and incomes are less in the FTN, as are rents and owner costs, but barely. Transit commuting rates (22%) and residential density (8,300 people/sq km) in the FTN are less than could be expected. The logistic regression reveals that odds of FTN access increase with home values but decrease with median incomes, when other variables are accounted for.

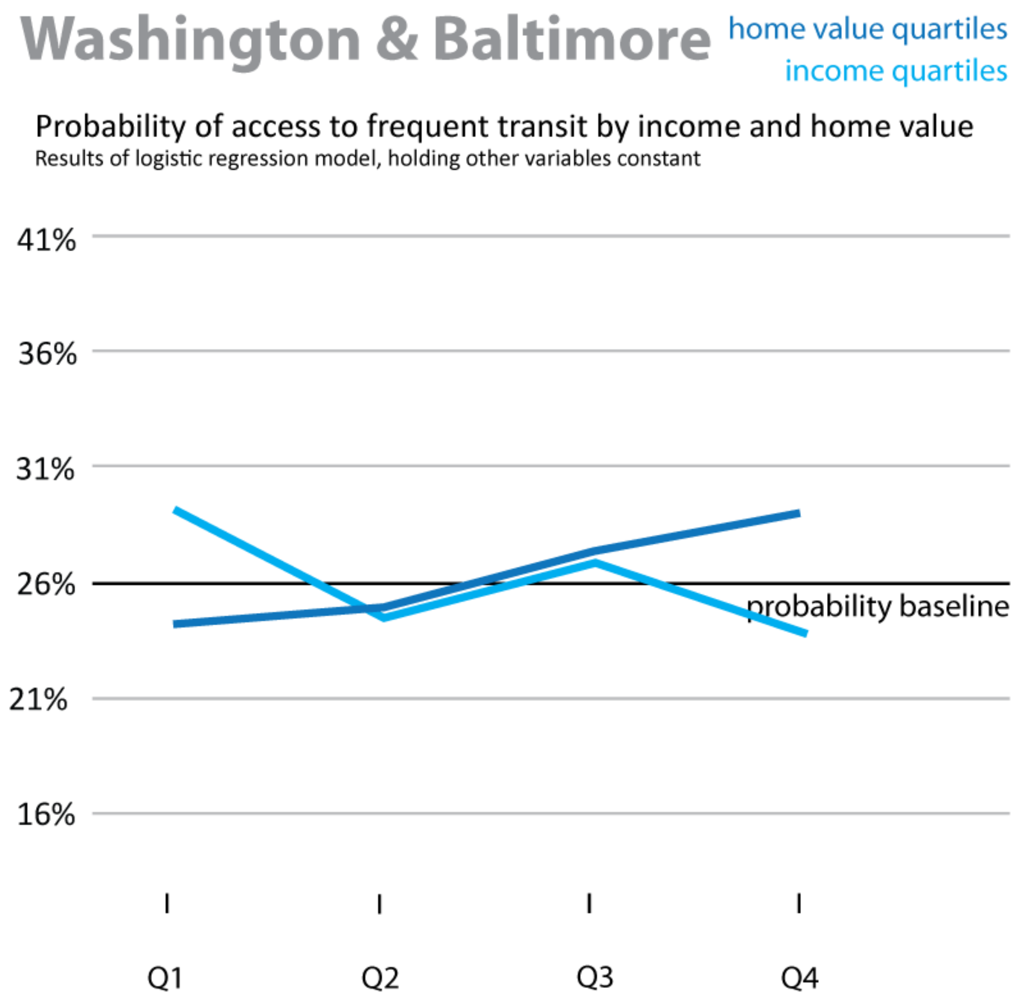
Washington and Baltimore (pop. 4.5 million)

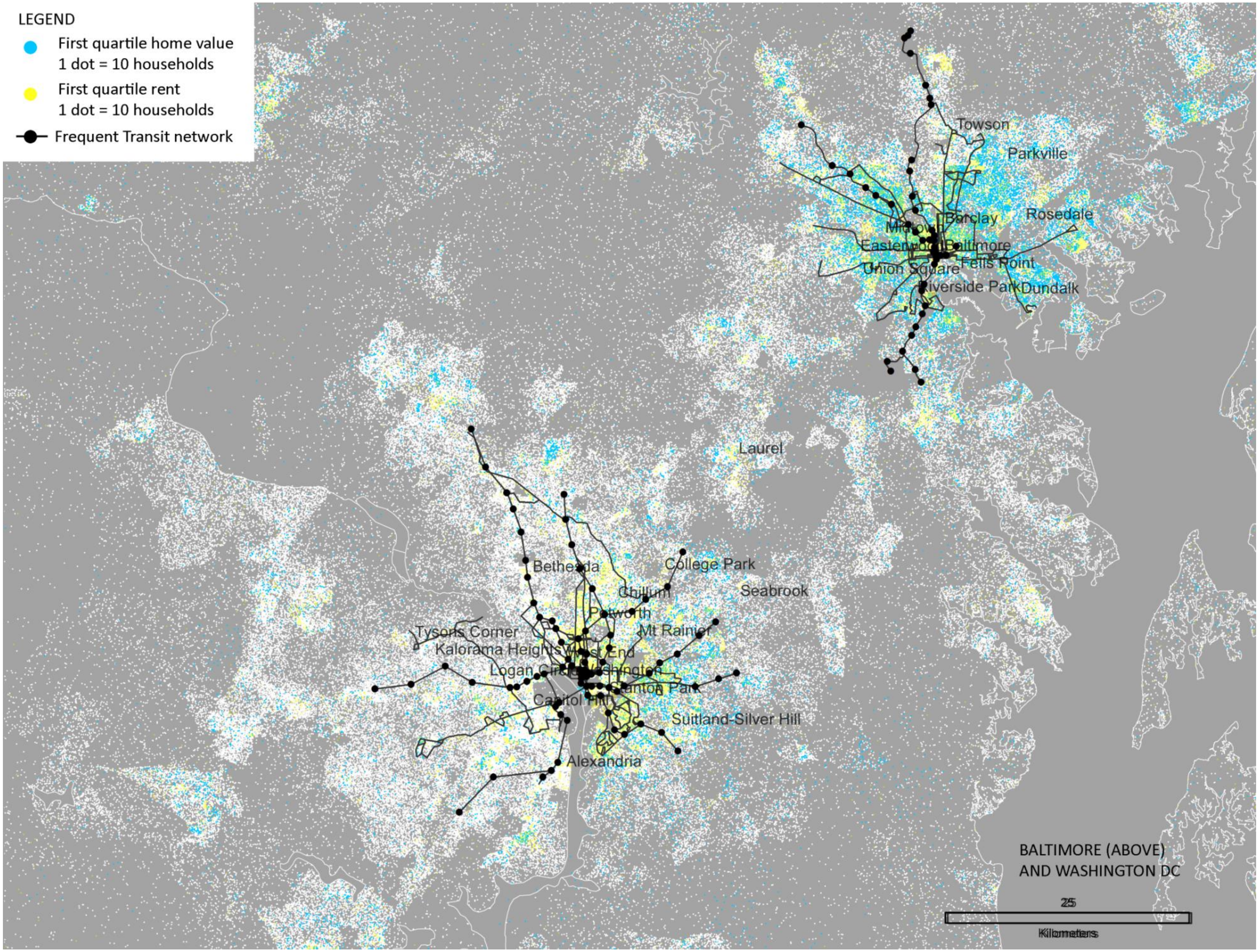
WASHINGTON - BALTIMORE							
Logistic regression	Number of obs	4,346,825					
	LR chi2(14)	2038913.94					
	Prob > chi2	0.00					
Log likelihood = - 1479630.4	Pseudo R2	0.41					
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.69**	0.003	344.84	0.00	1.68	1.69
Household income (median)	Quartiles						
	2	**0.67**	0.003	-86.68	0.00	0.66	0.68
	3	**0.85**	0.005	-26.77	0.00	0.84	0.86
	4	**0.64**	0.005	-55.68	0.00	0.63	0.65
Home value (median)	Quartiles						
	2	**1.07**	0.005	14.22	0.00	1.06	1.08
	3	**1.40**	0.008	61.20	0.00	1.38	1.41
	4	**1.65**	0.011	73.42	0.00	1.62	1.67
Age of building	10 years	**1.86**	0.002	510.98	0.00	1.85	1.86
Residential density	+ 1,000 people/km^2	**1.07**	0.001	119.31	0.00	1.07	1.08
Detached homes	+ 10%	**0.88**	0.001	-172.16	0.00	0.88	0.88
Rental housing tenure	+ 10%	**0.92**	0.001	-89.10	0.00	0.92	0.92
No car	+ 10%	**1.15**	0.002	101.37	0.00	1.15	1.15
Race (white)	+ 10%	**0.98**	0.001	-27.63	0.00	0.98	0.98
One-person households	+ 10%	**1.20**	0.001	147.38	0.00	1.20	1.20
_cons		**0.01**	0.000	-478.07	0.00	0.01	0.01

Odds ratios (graphed on a logarithmic scale)



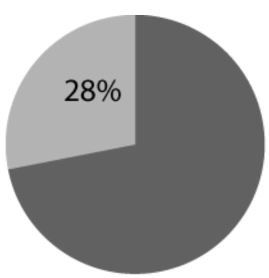
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.26**	**0.000**	**1687.57**	**0.00**	**0.26**	**0.26**
BY INCOME QUARTILES	1	0.29	0.000	599.97	0.00	0.29	0.29
	2	0.25	0.000	804.47	0.00	0.24	0.25
	3	0.27	0.000	720.66	0.00	0.27	0.27
	4	0.24	0.001	440.64	0.00	0.24	0.24
BY HOME VALUE QUARTILES	1	0.24	0.000	682.08	0.00	0.24	0.24
	2	0.25	0.000	820.89	0.00	0.25	0.25
	3	0.28	0.000	781.14	0.00	0.28	0.28
	4	0.29	0.000	589.98	0.00	0.29	0.29



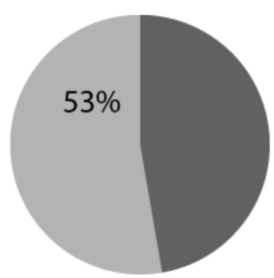

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Towson
Parkville
Barclay
Rosedale
Baltimore
Fells Point
Union Square
Riverside Park
Dundalk
Laurel
Bethesda
College Park
Chillum
Seabrook
Petworth
Mt Rainier
Tysons Corner
Kalorama Heights
Logan Circle
Capitol Hill
Suitland-Silver Hill
Alexandria
BALTIMORE (ABOVE)
AND WASHINGTON DC
25
Kilometers

WASHINGTON &BALTIMORE:
Statistics

			FTN Access					FTN Access	
Urban form & transportation	Units	Mean	NO	YES	**Socioeconomic**	Units	Mean	NO	YES
Residential density (people)	$/km^2$	3,217	2,198	6,037	White	%	51	56	37
Single detached buildings	%	44	53	22	Black	%	31	25	47
Rental tenure	%	36	30	50	Hispanic	%	10	9	10
Over 20 units in building	%	11	7	22	Asian	%	6	6	4
Median age of buildings	years	43	38	55	Other	%	2	2	2
Commuters by car	%	78	84	61	One-person households	%	31	27	40
Commuters by transit	%	14	9	26	Median rent	$ USD	1,228	1,289	1,085
Walking commuters	%	3	2	7	Median monthly owner costs	$ USD	1,720	1,774	1,578
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	373,898	382,312	351,946
Transit by bus	%	47	44	50	Median income spent on rent	%	31	31	32
Transit by subway/el	%	47	48	46	Median income spent on costs	%	23	23	24
Transit by commuter rail	%	5	7	3	Median household income	$ USD	78,065	84,352	61,958
					Income below the poverty line	%	10	8	16
Households with no vehicle	%	13	8	26	Income less than twice poverty	%	13	12	16



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on Washington and Baltimore

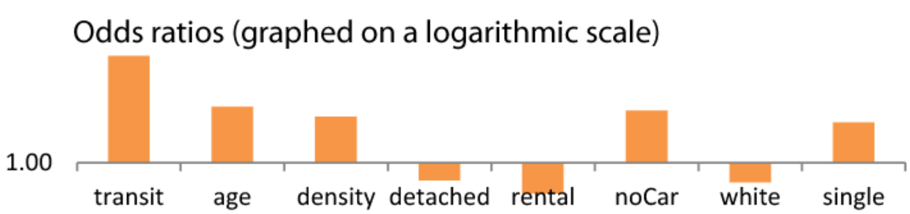
The map shows almost no affordability in Washington, except some east side rental, whereas by comparison Baltimore homes are mostly affordable. This is a unique case of two cities being measured as one region. Both have transit systems, but they don't connect to each other frequently. The two downtowns are more than 50km apart, and there is no frequent transit connection between the two.

Washington is the location of the federal government and so more prosperous than Baltimore, whose economy, founded on shipping and industry, has declined. When the pooled home values from both cities are mapped in quartiles, Baltimore is almost entirely composed of regionally affordable rented and owned homes, while Washington is limited to mostly affordable rental on the east side. Both cities have hub-and-spoke patterned subway systems, but Washington's has more spokes and Baltimore has only three. Both cities also have some frequent local bus lines, with Washington's more developed on the east side, but neither bus network provides the grid pattern that would allow for fuller metropolitan access feeding into the subway lines.

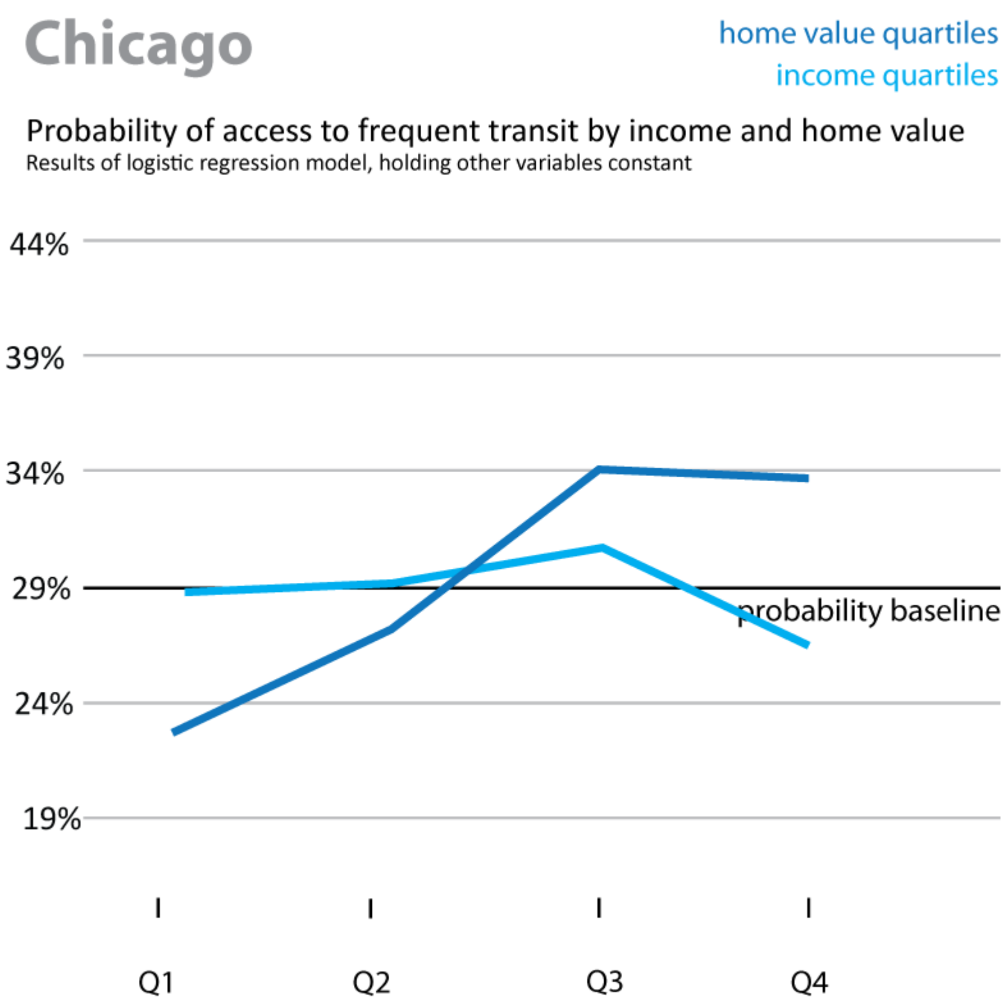
Incomes, home prices, housing costs, and rent are all lower in the frequent transit network zone in Baltimore and Washington. Density, attached buildings, rental tenure and high-rise units are more prevalent here as well. Transit commuting rates approach 30% in the FTN zone, with bus and subway carrying almost equal numbers of commuters. However, the odds ratios show that as home values rise, with all other variables held constant, FTN access becomes more likely, even though it becomes less likely as incomes rise. For every 10% increase in white, black or Hispanic residents, an area is less likely to have transit access, suggesting that areas with greater diversity are better served.

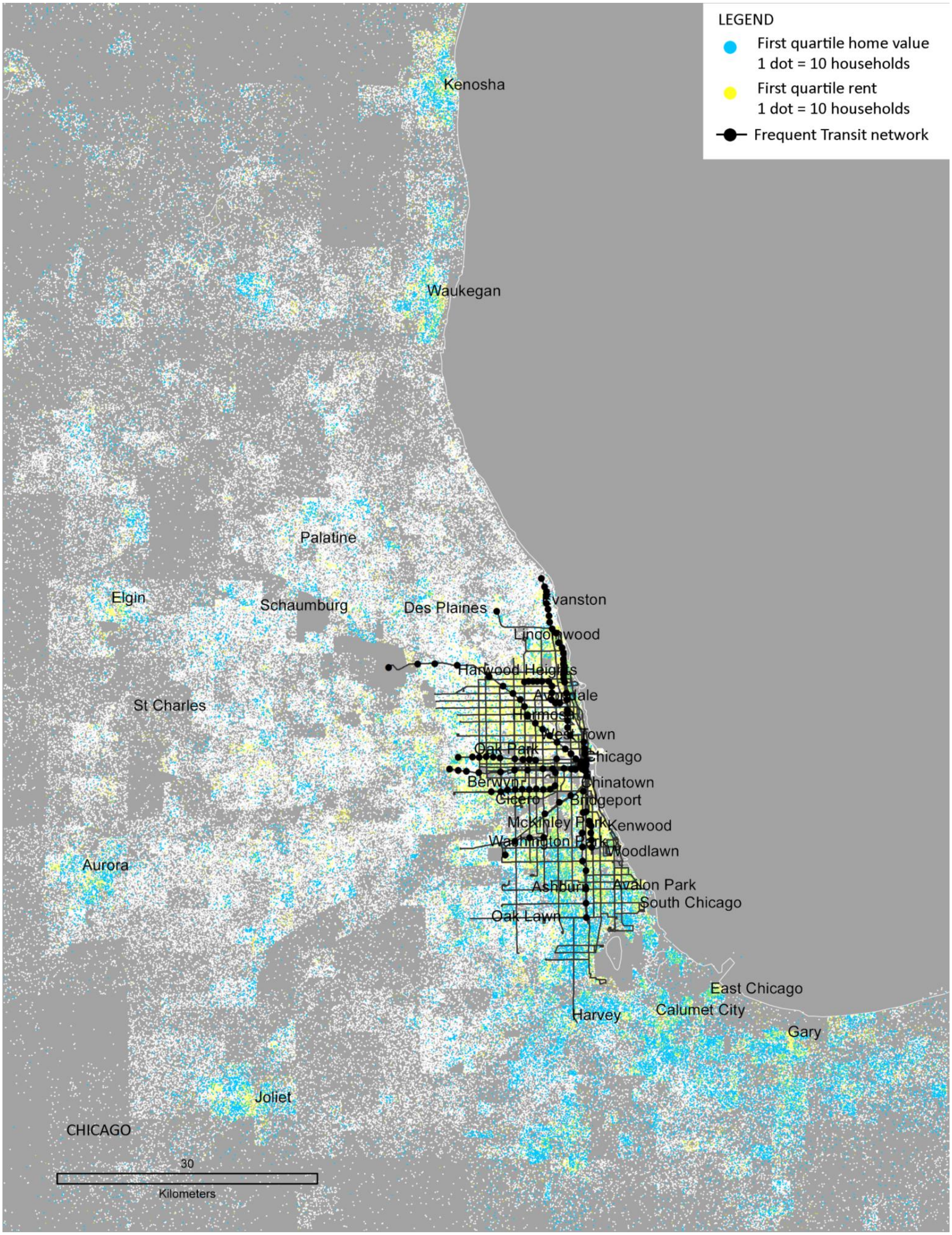
Chicago (pop. 5.8 million)

CHICAGO							
Logistic regression	Number of obs	5,794,682					
	LR chi2(14)	4704186.33					
	Prob > chi2	0.00					
Log likelihood = -1137161.3	Pseudo R2	0.67					
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**2.59**	0.005	498.04	0.00	2.58	2.60
Household income (median)	Quartiles						
	2	**1.07**	0.006	12.29	0.00	1.06	1.08
	3	**1.46**	0.009	59.60	0.00	1.44	1.48
	4	**0.67**	0.006	-46.82	0.00	0.66	0.69
Home value (median)	Quartiles						
	2	**2.24**	0.012	147.74	0.00	2.21	2.26
	3	**6.55**	0.041	300.82	0.00	6.47	6.63
	4	**6.26**	0.048	238.19	0.00	6.17	6.36
Age of building	10 years	**1.65**	0.002	343.43	0.00	1.64	1.65
Residential density	+ 1,000 people/km^2	**1.51**	0.001	526.40	0.00	1.50	1.51
Detached homes	+ 10%	**0.86**	0.001	-152.75	0.00	0.85	0.86
Rental housing tenure	+ 10%	**0.76**	0.001	-195.44	0.00	0.76	0.76
No car	+ 10%	**1.59**	0.003	237.93	0.00	1.58	1.60
Race (white)	+ 10%	**0.84**	0.001	-202.83	0.00	0.84	0.84
One-person households	+ 10%	**1.43**	0.002	213.13	0.00	1.43	1.44
_cons		**0.00**	0.000	-442.80	0.00	0.00	0.00



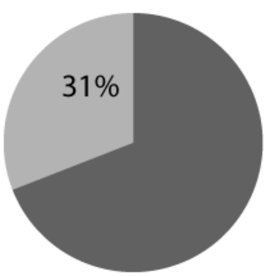
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.29**	**0.000**	**2906.17**	**0.00**	**0.29**	**0.29**
BY INCOME QUARTILES	1	0.29	0.000	1110.32	0.00	0.29	0.29
	2	0.29	0.000	1499.10	0.00	0.29	0.29
	3	0.31	0.000	1408.08	0.00	0.31	0.31
	4	0.27	0.000	890.25	0.00	0.27	0.27
BY HOME VALUE QUARTILES	1	0.23	0.000	1045.69	0.00	0.23	0.23
	2	0.27	0.000	1390.58	0.00	0.27	0.27
	3	0.34	0.000	1395.70	0.00	0.34	0.34
	4	0.34	0.000	964.46	0.00	0.34	0.34



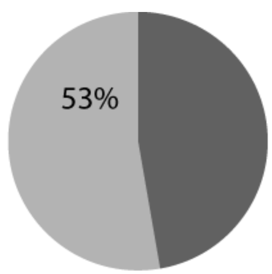

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Kenosha
Waukegan
Palatine
Elgin
Schaumburg
Des Plaines
Evanston
Lincolnwood
Harwood Heights
Avondale
Hermosa
West Town
St Charles
Oak Park
Chicago
Berwyn
Chinatown
Cicero
Bridgeport
McKinley Park
Kenwood
Washington Park
Woodlawn
Aurora
Ashburn
Avalon Park
South Chicago
Oak Lawn
East Chicago
Calumet City
Harvey
Gary
Joliet
CHICAGO
30
Kilometers

CHICAGO: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	4,101	2,167	8,832	White	%	55	63	36
Single detached buildings	%	54	66	26	Black	%	19	13	32
Rental tenure	%	32	24	52	Hispanic	%	20	17	26
Over 20 units in building	%	11	7	22	Asian	%	5	5	4
Median age of buildings	years	48	42	60	Other	%	1	1	2
Commuters by car	%	80	87	61	One-person households	%	28	25	36
Commuters by transit	%	12	6	26	Median rent	$ USD	996	1,018	956
Walking commuters	%	3	2	6	Median monthly owner costs	$ USD	1,611	1,546	1,755
Cycling commuters	%	1	0	1	Median value of owned unit	$ USD	286,471	271,637	319,879
Transit by bus	%	42	23	53	Median income spent on rent	%	33	33	32
Transit by subway/el	%	30	14	39	Median income spent on costs	%	26	25	28
Transit by commuter rail	%	28	62	7	Median household income	$ USD	65,234	70,476	53,524
					Income below the poverty line	%	12	10	18
Households with no vehicle	%	12	6	25	Income less than twice poverty	%	16	15	19



Households with FTN access



Lower-income (Q1) households with FTN access

Chicago Notes

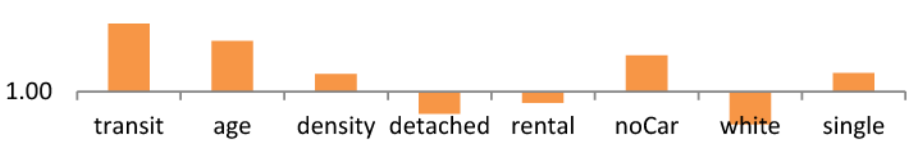
Chicago's FTN is a grid of frequent bus lines supporting a hub-and-spoke El (elevated rapid transit) system centred on the downtown core. This network covers areas of affordable rental housing throughout, as well as some affordable owned home neighbourhoods in the south. However, the bulk of affordable owned homes are contiguous to the south and southeast of Chicago, curving around Lake Michigan and reaching Gary, Indiana. In addition, there are some affordable satellite towns like Joliet, Aurora, and Waukegan, but at more than 50 km distance from downtown.

Chicago's FTN serves almost 30% of its population, and has a transit commuting rate of 26% in this area, balanced between buses and subways. Median rent and household incomes are slightly lower in the FTN, but home values are considerably higher. As expected, density, attached buildings, high-rise units and rental tenure rates are all higher in the FTN than outside it, and fully 25% of households in the FTN do not have a vehicle. Holding other influences constant, the likelihood of FTN access is higher for middle-income households than for lower-income ones, but lower still for high-income households. Areas with high home values have better odds of FTN service than first-quartile home values. All else equal, areas with higher rates of rental tenure are *less* likely to be in the FTN.

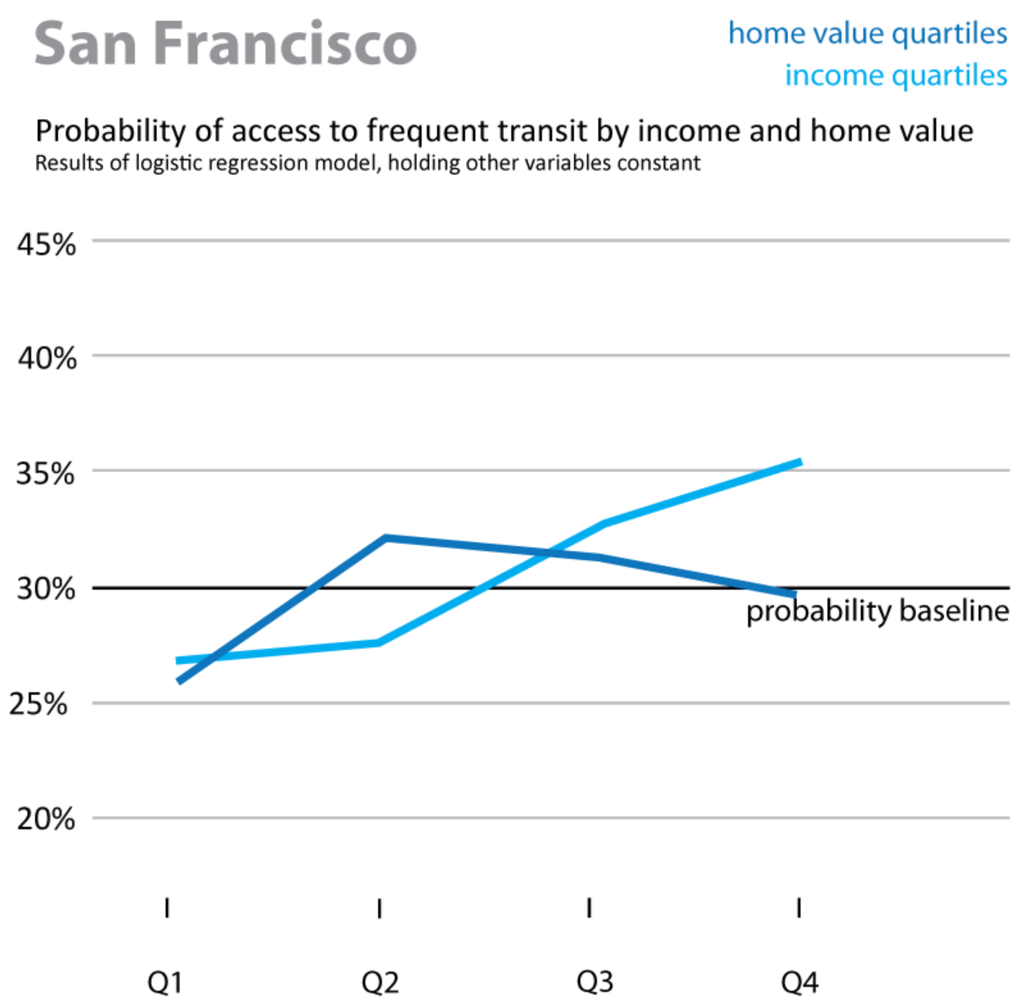
San Francisco (pop. 5.1 million)

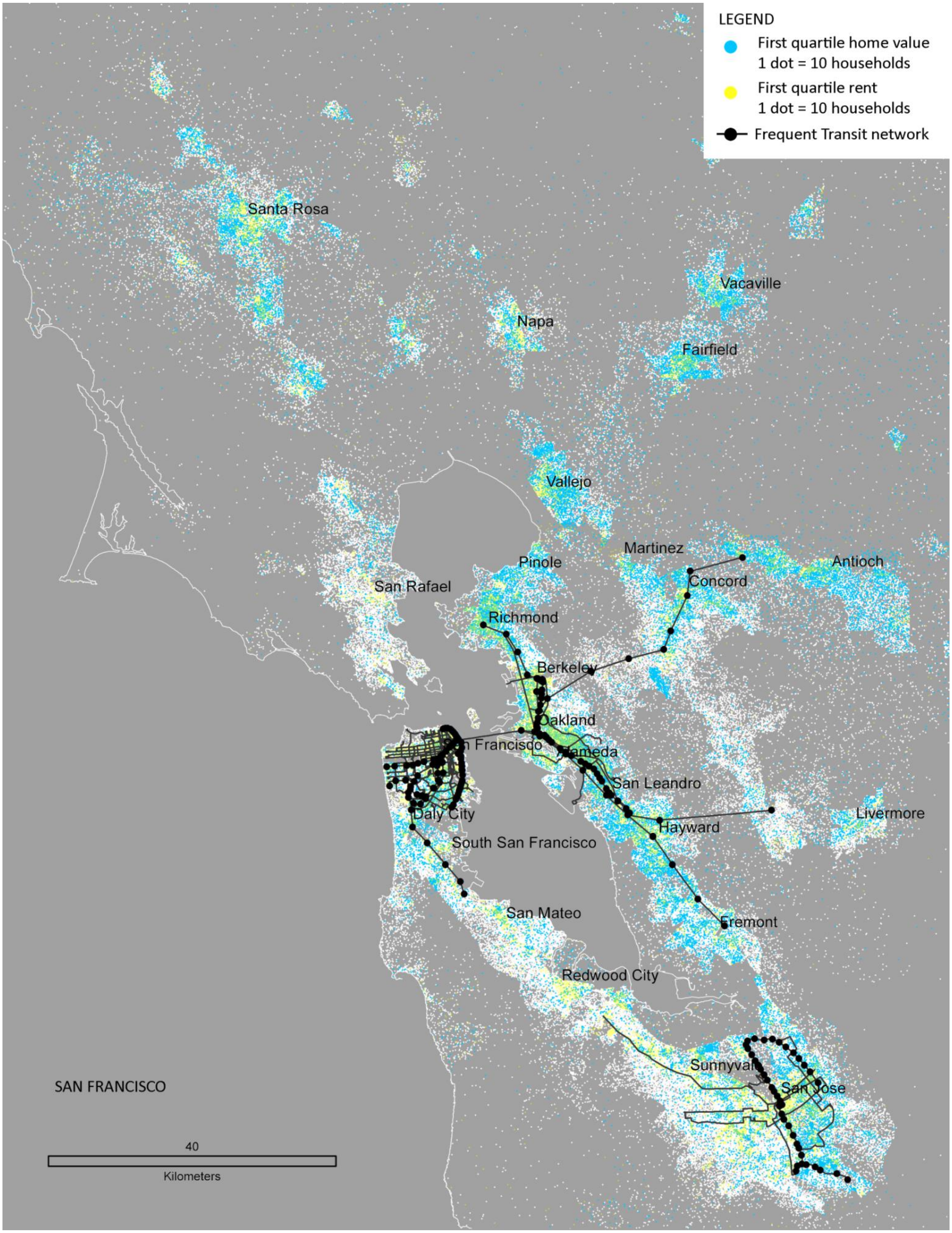
SAN FRANCISCO								
Logistic regression	Number of obs	4,976,508						
	LR chi2(14)	2434019.52						
	Prob > chi2	0.00						
Log likelihood = -1821541.3	Pseudo R2	0.40						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]	
Transit commuters	+ 10%	**1.83**	0.003	363.63	0.00	1.82	1.84	
Household income (median)	Quartiles							
	2	**1.08**	0.004	18.21	0.00	1.07	1.08	
	3	**1.73**	0.008	111.93	0.00	1.71	1.75	
	4	**2.10**	0.013	119.32	0.00	2.08	2.13	
Home value (median)	Quartiles							
	2	**1.76**	0.007	150.16	0.00	1.75	1.78	
	3	**1.65**	0.007	114.80	0.00	1.64	1.67	
	4	**1.43**	0.008	61.81	0.00	1.41	1.44	
Age of building	10 years	**1.57**	0.002	373.97	0.00	1.56	1.57	
Residential density	+ 1,000 people/km^2	**1.17**	0.001	259.49	0.00	1.17	1.17	
Detached homes	+ 10%	**0.82**	0.001	-237.39	0.00	0.82	0.82	
Rental housing tenure	+ 10%	**0.91**	0.001	-103.37	0.00	0.90	0.91	
No car	+ 10%	**1.38**	0.003	166.11	0.00	1.38	1.39	
Race (white)	+ 10%	**0.75**	0.001	-361.26	0.00	0.75	0.75	
One-person households	+ 10%	**1.18**	0.002	121.34	0.00	1.18	1.18	
_cons		**0.05**	0.000	-309.60	0.00	0.05	0.05	

Odds ratios (mapped on a logarithmic scale)



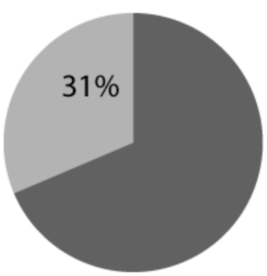
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.30**	**0.000**	**1982.11**	**0.00**	**0.30**	**0.30**
BY INCOME QUARTILES	1	0.27	0.000	855.27	0.00	0.27	0.27
	2	0.28	0.000	1048.09	0.00	0.28	0.28
	3	0.33	0.000	984.81	0.00	0.33	0.33
	4	0.35	0.000	708.97	0.00	0.35	0.35
BY HOME VALUE QUARTILES	1	0.26	0.000	871.49	0.00	0.26	0.26
	2	0.32	0.000	1079.08	0.00	0.32	0.32
	3	0.32	0.000	979.48	0.00	0.32	0.32
	4	0.30	0.000	638.60	0.00	0.30	0.30



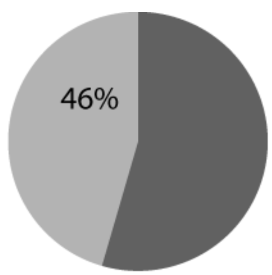

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Santa Rosa
Vacaville
Napa
Fairfield
Vallejo
Martinez
Antioch
Pinole
Concord
San Rafael
Richmond
Berkeley
Oakland
San Francisco
Alameda
San Leandro
Livermore
Daly City
Hayward
South San Francisco
San Mateo
Fremont
Redwood City
Sunnyvale
San Jose
SAN FRANCISCO
40
Kilometers

SAN FRANCISCO: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	4,500	3,075	7,760	White	%	45	49	36
Single detached buildings	%	54	63	34	Black	%	7	5	10
Rental tenure	%	42	36	57	Hispanic	%	23	22	24
Over 20 units in building	%	12	9	18	Asian	%	22	20	27
Median age of buildings	years	46	41	55	Other	%	4	4	4
Commuters by car	%	78	85	63	One-person households	%	28	25	34
Commuters by transit	%	10	6	21	Median rent	$ USD	1,403	1,454	1,298
Walking commuters	%	4	2	6	Median monthly owner costs	$ USD	2,264	2,278	2,232
Cycling commuters	%	1	1	2	Median value of owned unit	$ USD	652,493	649,650	658,877
Transit by bus	%	56	48	61	Median income spent on rent	%	31	31	31
Transit by subway/el	%	31	36	28	Median income spent on costs	%	27	27	28
Transit by commuter rail	%	7	12	4	Median household income	$ USD	81,302	86,886	69,101
					Income below the poverty line	%	10	8	13
Households with no vehicle	%	10	5	19	Income less than twice poverty	%	14	12	16



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on San Francisco

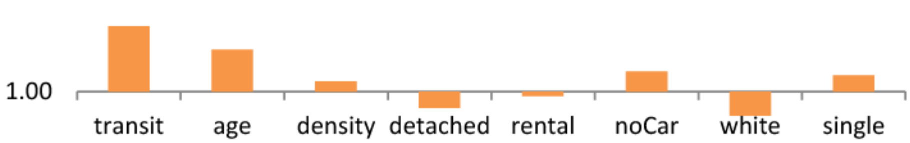
The map shows the densest transit coverage in the city of San Francisco; the Bay Area Rapid Transit crosses the bay to Oakland and beyond, where the network becomes a few parallel routes. To the south, San Jose has a U-shaped light rail line with some frequent local bus lines, but the San Jose system is not connected frequently with San Francisco or the east Bay.

Although median incomes are less in the FTN, after controlling for other variables, the odds of FTN access increase with higher income quartiles. Housing costs and rent are slightly lower in the FTN, but home values are higher, suggesting rising housing prices. The cost of housing in the San Francisco metropolitan region is the highest among all the metro regions studied.

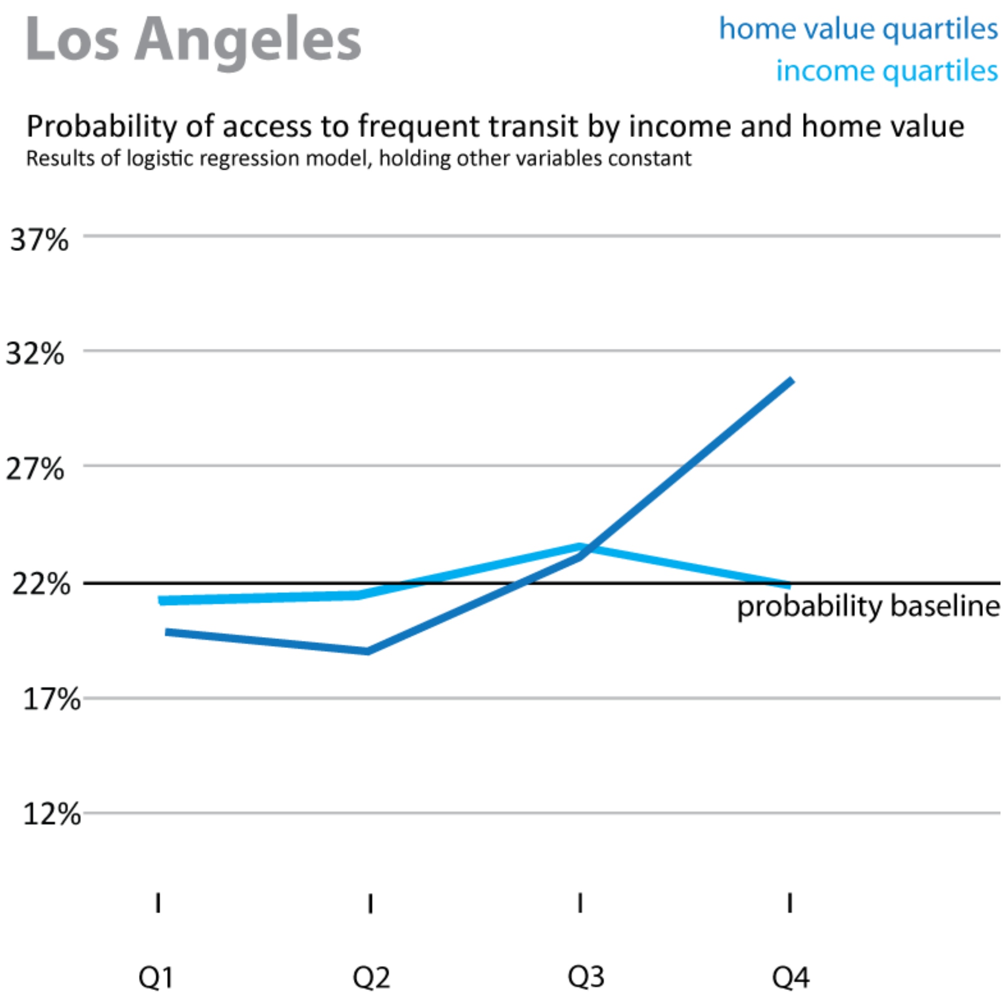
Los Angeles (pop. 11.8 million)

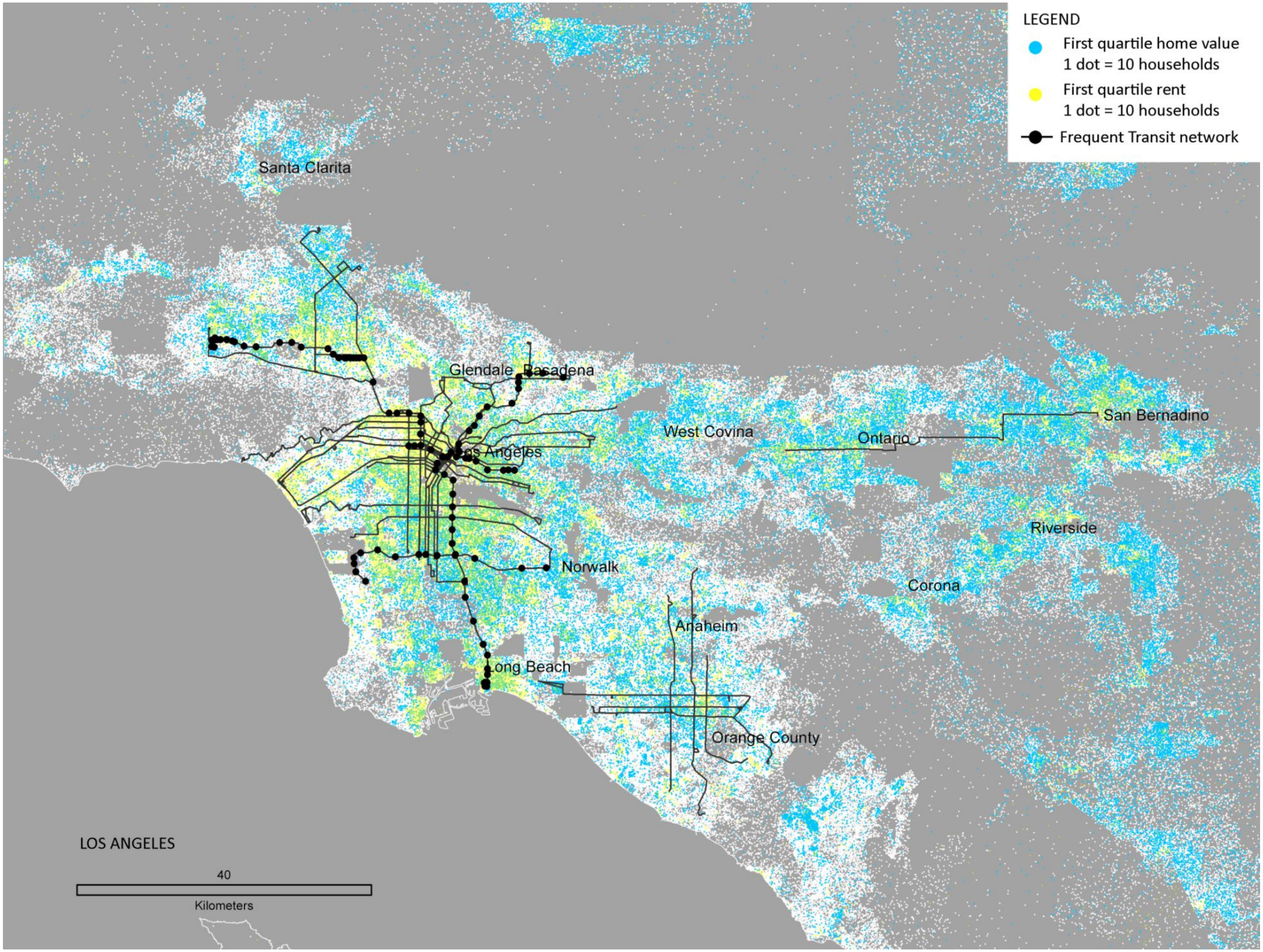
LOS ANGELES								
Logistic regression	Number of obs	11,225,226						
	LR chi2(14)	2914710.96						
	Prob > chi2	0.00						
Log likelihood = -4423414	Pseudo R2	0.25						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.79**	0.003	403.48	0.00	1.78	1.79
Household income	Quartiles						
(median)	2	**1.03**	0.002	13.07	0.00	1.03	1.04
	3	**1.21**	0.004	62.36	0.00	1.21	1.22
	4	**1.06**	0.005	13.68	0.00	1.05	1.07
Home value	Quartiles						
(median)	2	**0.95**	0.002	-24.13	0.00	0.94	0.95
	3	**1.30**	0.003	100.44	0.00	1.29	1.31
	4	**2.29**	0.008	233.10	0.00	2.27	2.30
Age of building	10 years	**1.45**	0.001	449.18	0.00	1.45	1.46
Residential density	+ 1,000 people/km^2	**1.09**	0.000	301.84	0.00	1.09	1.10
Detached homes	+ 10%	**0.86**	0.000	-258.56	0.00	0.86	0.86
Rental housing tenure	+ 10%	**0.96**	0.001	-64.04	0.00	0.96	0.96
No car	+ 10%	**1.20**	0.001	147.83	0.00	1.19	1.20
Race (white)	+ 10%	**0.81**	0.000	-399.56	0.00	0.81	0.81
One-person households	+ 10%	**1.16**	0.001	174.31	0.00	1.15	1.16
_cons		**0.05**	0.000	-454.77	0.00	0.05	0.05

Odds ratios (graphed on a logarithmic scale)



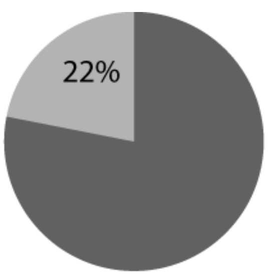
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.22**	**0.000**	**2074.45**	**0.00**	**0.22**	**0.22**
BY INCOME QUARTILES	1	0.21	0.000	953.60	0.00	0.21	0.21
	2	0.21	0.000	1147.70	0.00	0.21	0.21
	3	0.23	0.000	920.62	0.00	0.23	0.23
	4	0.22	0.000	521.68	0.00	0.22	0.22
BY HOME VALUE QUARTILES	1	0.20	0.000	1035.00	0.00	0.20	0.20
	2	0.19	0.000	1097.47	0.00	0.19	0.19
	3	0.23	0.000	1014.26	0.00	0.23	0.23
	4	0.31	0.000	767.57	0.00	0.31	0.31



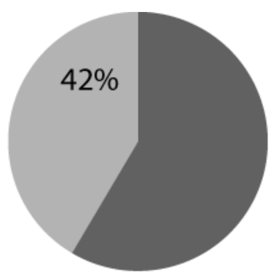

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Santa Clarita
Glendale
Pasadena
Los Angeles
West Covina
Ontario
San Bernadino
Riverside
Corona
Norwalk
Anaheim
Long Beach
Orange County
LOS ANGELES
40
Kilometers

LOS ANGELES: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	4,805	3,863	8,014	White	%	34	38	19
Single detached buildings	%	55	60	38	Black	%	7	6	8
Rental tenure	%	45	39	64	Hispanic	%	44	40	58
Over 20 units in building	%	12	10	21	Asian	%	13	13	13
Median age of buildings	%	43	41	50	Other	%	3	3	2
Commuters by car	%	86	88	79	One-person households	%	23	22	27
Commuters by transit	%	5	3	12	Median rent	$ USD	1,289	1,344	1,102
Walking commuters	%	2	2	4	Median monthly owner costs	$ USD	1,935	1,959	1,844
Cycling commuters	%	1	1	1	Median value of owned unit	$ USD	522,952	528,269	502,619
Transit by bus	%	91	86	95	Median income spent on rent	%	34	34	35
Transit by subway/el	%	4	4	3	Median income spent on costs	%	29	28	31
Transit by commuter rail	%	5	9	1	Median household income	$ USD	66,130	70,875	49,212
					Income below the poverty line	%	13	12	20
Households with no vehicle	%	8	6	14	Income less than twice poverty	%	19	18	25



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on Los Angeles

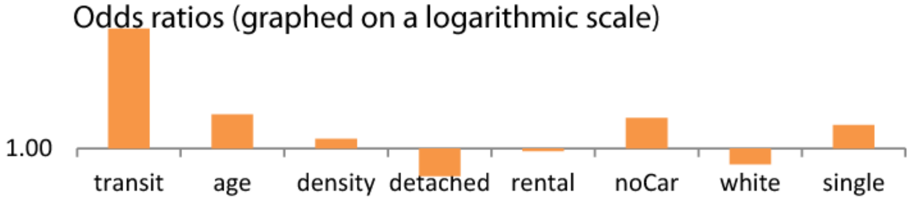
The frequent transit lines in Los Angeles itself are quite networked; however, this doesn't extend to the adjacent cities in the Inland Empire like Riverside, Ontario and San Bernadino. The latter offer the majority of affordable home ownership opportunities. East Los Angeles itself offers affordable rental opportunities, blending into affordable home ownership to the south. The distances in this consolidated MSA are large.

Although LA's FTN zone covers 23% of the population, that still leaves over 9 million people without access to it. As noted by other urban scholars, LA's residential density is actually quite high for an auto-oriented city; this offers an opportunity of sorts for extending transit. As in other metros, the buildings inside the FTN zone tend to have more rental units, more high-rise, and to be older. The odds of FTN access are slightly higher for 3rd and 4th quartile incomes and twice as high for 4th quartile home values as 1st quartile home values, but lower-middle home values have lower chances of being inside of the FTN zone than the base.

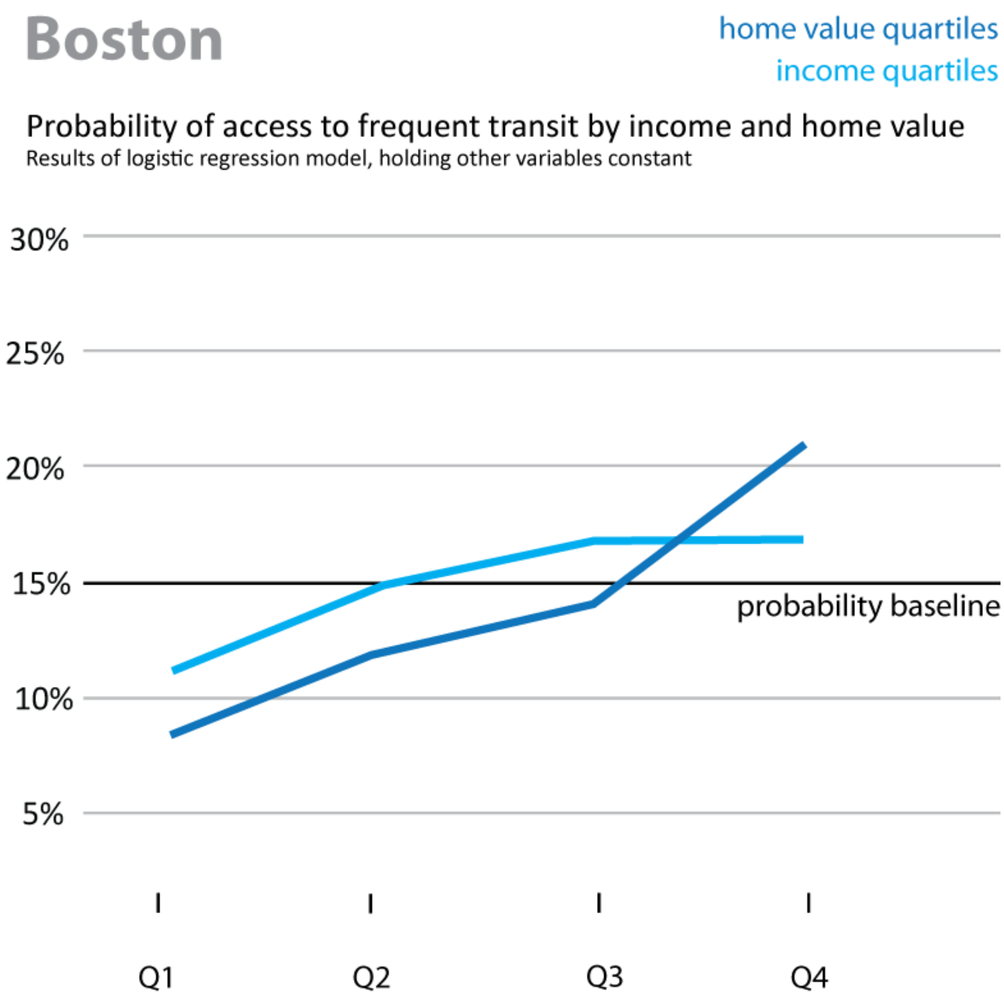
Boston (pop. 3.9 million)

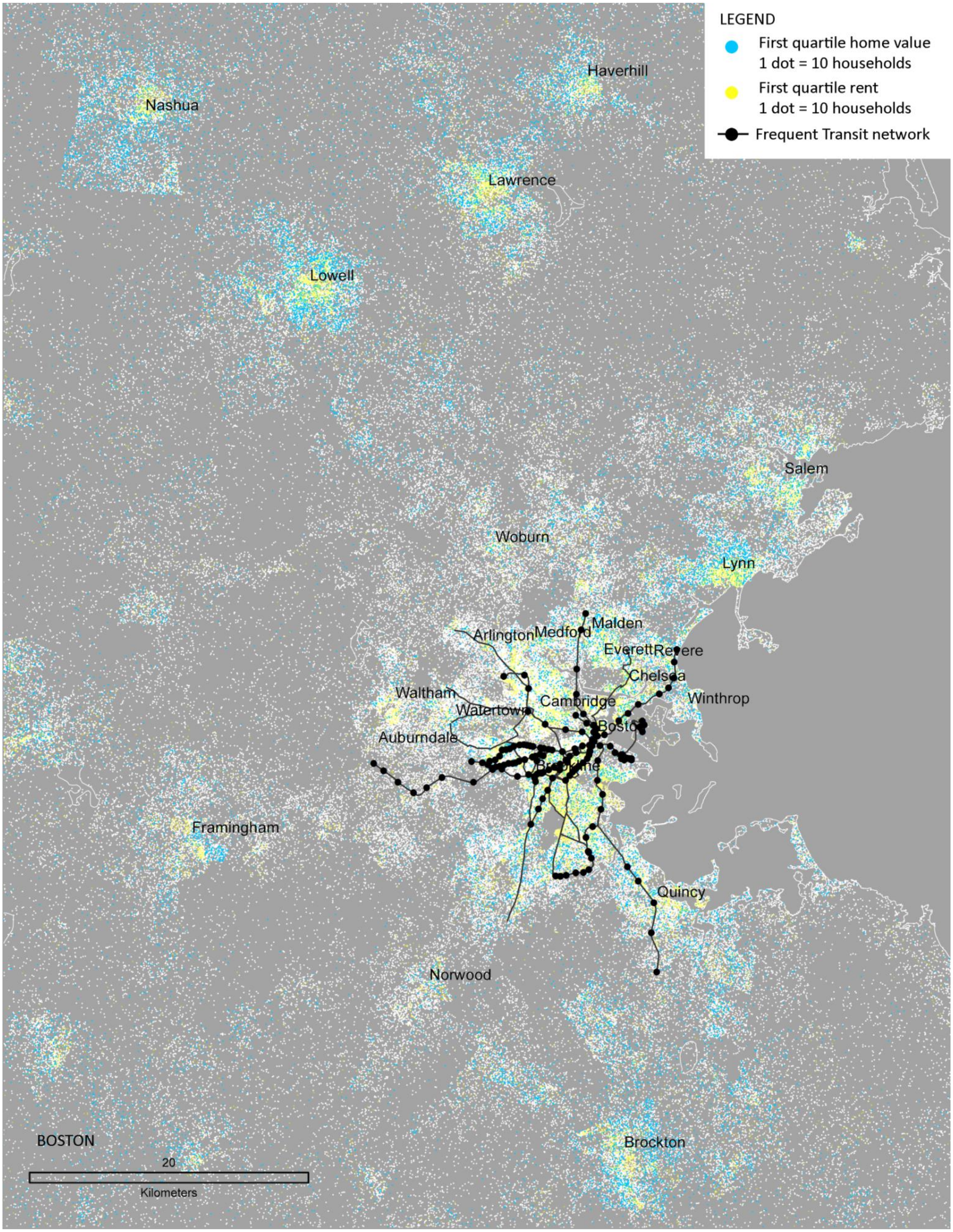
BOSTON								
Logistic regression	Number of obs	3,810,000						
	LR chi2(14)	2075584.88						
	Prob > chi2	0.00						
Log likelihood = -567023.38	Pseudo R2	0.65						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**2.90**	0.007	443.73	0.00	2.88	2.91
Household income (median)	Quartiles						
	2	**2.81**	0.023	126.55	0.00	2.76	2.85
	3	**4.75**	0.045	163.86	0.00	4.67	4.84
	4	**4.80**	0.057	132.65	0.00	4.69	4.91
Home value (median)	Quartiles						
	2	**2.89**	0.031	97.98	0.00	2.83	2.95
	3	**4.84**	0.051	150.40	0.00	4.74	4.94
	4	**19.33**	0.212	270.28	0.00	18.92	19.75
Age of building	10 years	**1.35**	0.003	139.58	0.00	1.35	1.36
Residential density	+ 1,000 people/km^2	**1.09**	0.001	109.56	0.00	1.09	1.09
Detached homes	+ 10%	**0.78**	0.001	-133.65	0.00	0.78	0.78
Rental housing tenure	+ 10%	**0.98**	0.002	-11.27	0.00	0.97	0.98
No car	+ 10%	**1.31**	0.003	116.20	0.00	1.31	1.32
Race (white)	+ 10%	**0.87**	0.001	-110.26	0.00	0.87	0.87
One-person households	+ 10%	**1.23**	0.003	93.16	0.00	1.23	1.24
_cons		**0.00**	0.000	-276.21	0.00	0.00	0.00

Odds ratios (graphed on a logarithmic scale)



PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.15**	**0.000**	**1409.80**	**0.00**	**0.15**	**0.15**
BY INCOME QUARTILES	1	0.11	0.000	549.74	0.00	0.11	0.11
	2	0.15	0.000	739.09	0.00	0.15	0.15
	3	0.17	0.000	687.16	0.00	0.17	0.17
	4	0.17	0.000	502.20	0.00	0.17	0.18
BY HOME VALUE QUARTILES	1	0.08	0.000	296.44	0.00	0.08	0.08
	2	0.12	0.000	522.35	0.00	0.12	0.12
	3	0.14	0.000	691.94	0.00	0.14	0.14
	4	0.22	0.000	652.12	0.00	0.22	0.22

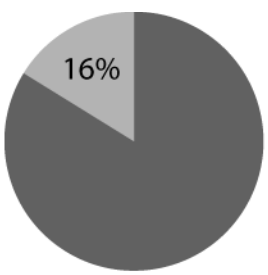



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Haverhill
Nashua
Lawrence
Lowell
Salem
Woburn
Lynn
Malden
Arlington
Medford
Everett
Revere
Chelsea
Winthrop
Waltham
Cambridge
Watertown
Auburndale
Framingham
Quincy
Norwood
BOSTON
20
Kilometers
Brockton

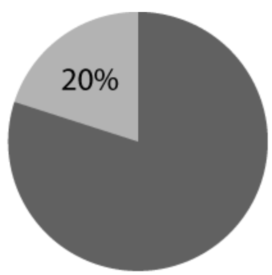
BOSTON: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	3,379	2,188	9,836
Single detached buildings	%	48	55	15
Rental tenure	%	37	33	60
Over 20 units in building	%	10	8	21
Median age of buildings	years	54	52	64
Commuters by car	%	80	87	48
Commuters by transit	%	10	6	32
Walking commuters	%	4	3	13
Cycling commuters	%	1	0	3
Transit by bus	%	34	34	35
Transit by subway/el	%	44	31	56
Transit by commuter rail	%	16	31	3
Households with no vehicle	%	12	9	30

Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
White	%	77	81	58
Black	%	6	5	16
Hispanic	%	9	8	12
Asian	%	5	4	10
Other	%	2	2	3
One-person households	%	29	27	37
Median rent	$ USD	1,098	1,056	1,283
Median monthly owner costs	$ USD	1,771	1,739	1,942
Median value of owned unit	$ USD	384,706	365,559	487,355
Median income spent on rent	%	32	32	31
Median income spent on costs	%	26	26	26
Median household income	$ USD	71,004	72,001	65,840
Income below the poverty line	%	10	9	17
Income less than twice poverty	%	12	12	14



Households with FTN access



Lower-income (Q1) households with FTN access

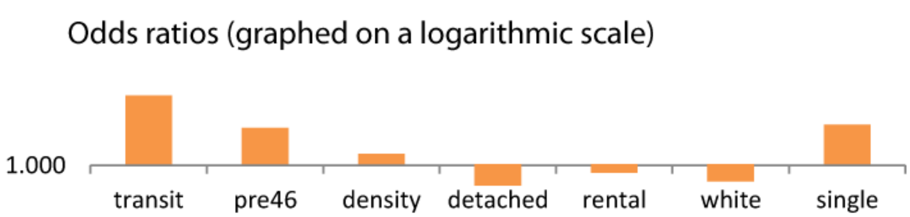
Boston Notes

The map shows rapid transit-density in the city of Boston, which also offers a considerable spread of affordable rental housing. But most of the affordable home ownership opportunities (as well as clusters of affordable rental housing) are located in outlying towns in the metropolitan region, like Nashua, Lynn, Lowell, Brockton, Lawrence, and Haverhill. A few of these, like Lynn and Salem, may be close enough to connect effectively with Boston through frequent rapid transit, but most are more than 20km from Boston, separated by areas of very low density.

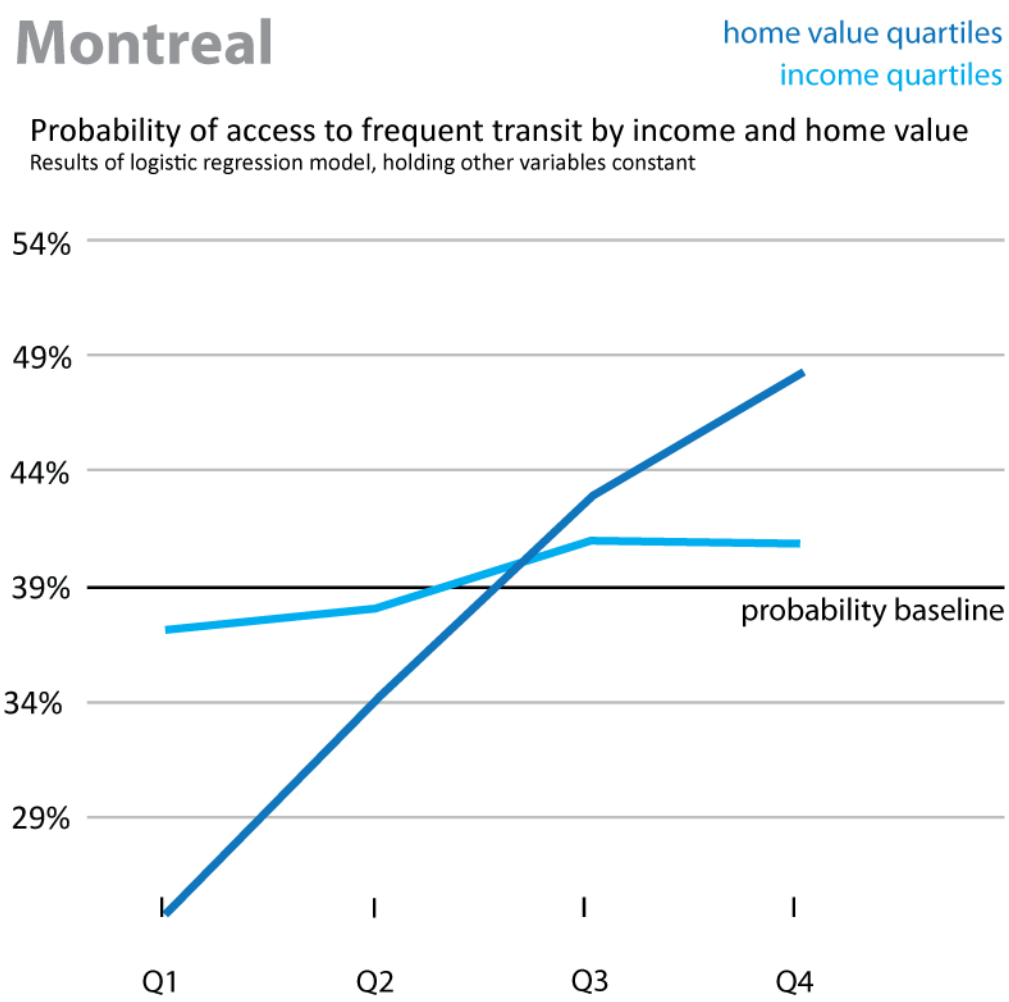
The densities inside the FTN zone are very high in Boston; this area has a largely older, non-detached urban fabric represented by the traditional 'three-deckers', stacked flats similar in function to Montreal's triplexes. A mixture of these urban forms and single-family houses can be seen in the surrounding towns as well, like in the photo below. This fabric supports higher rates of alternative modes, including walking, cycling, and a subway-dominated transit system, allowing more houses to go without cars. However, home values, rent and owner costs are all higher in the FTN. This finding is supported in the logistic regression analysis, which shows considerably higher odds ratios in higher income and home value quartiles compared to the base quartile for each. Higher home values in particular are more likely to have access to the FTN. This confirms a concern about affordability; more than 80% of the residential population does not live within walking distance of the frequent transit network.

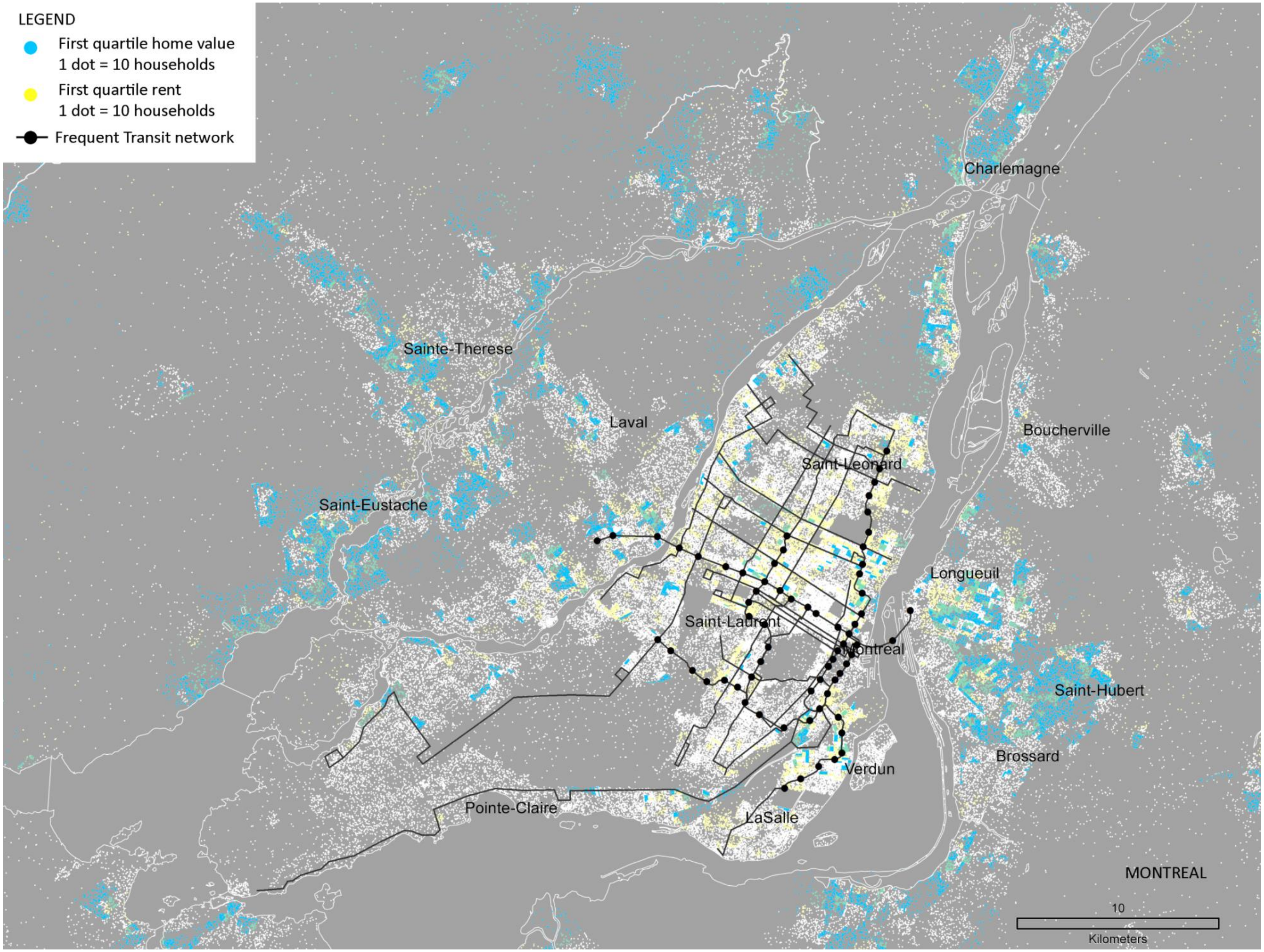
Montreal (pop. 3.2 million)

MONTREAL								
Logistic regression	Number of obs	3,009,162						
	LR chi2(13)	2162530.58						
	Prob > chi2	0.00						
Log likelihood = -935351.47	Pseudo R2	0.54						
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.		Interval]
Transit commuters	+ 10%	**1.84**	0.00	334.74	0.00	1.83		1.85
Median household income	Quartiles							
	2	**1.08**	0.01	13.29	0.00	1.07		1.09
	3	**1.50**	0.01	54.26	0.00	1.48		1.52
	4	**1.45**	0.01	36.57	0.00	1.42		1.48
Median home value	Quartiles							
	2	**2.81**	0.02	157.83	0.00	2.78		2.85
	3	**6.17**	0.04	281.48	0.00	6.10		6.25
	4	**9.76**	0.07	342.15	0.00	9.64		9.89
Pre-1946 buildings	+ 10%	**1.38**	0.00	259.72	0.00	1.38		1.38
Residential Density	+ 1,000 people/km^2	**1.09**	0.00	188.24	0.00	1.09		1.10
Detached homes	+ 10%	**0.83**	0.00	-176.25	0.00	0.82		0.83
Rental tenure	+ 10%	**0.93**	0.00	-56.26	0.00	0.92		0.93
Race (white)	+ 10%	**0.86**	0.00	-106.04	0.00	0.86		0.86
One-person households	+ 10%	**1.42**	0.00	164.29	0.00	1.42		1.43
_cons		**0.03**	0.00	-210.16	0.00	0.03		0.03

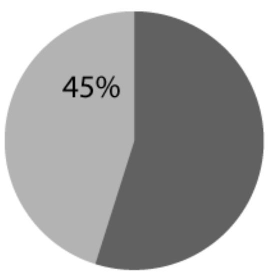


PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.39**	**0.00**	**2209.06**	**0.00**	**0.39**	**0.39**
BY INCOME QUARTILES	1	0.38	0.00	819.68	0.00	0.37	0.38
	2	0.38	0.00	1193.27	0.00	0.38	0.38
	3	0.41	0.00	1099.32	0.00	0.41	0.41
	4	0.41	0.00	681.99	0.00	0.41	0.41
BY HOME VALUE QUARTILES	1	0.24	0.00	468.43	0.00	0.24	0.24
	2	0.34	0.00	858.21	0.00	0.34	0.35
	3	0.43	0.00	1094.20	0.00	0.43	0.43
	4	0.48	0.00	1136.60	0.00	0.48	0.49

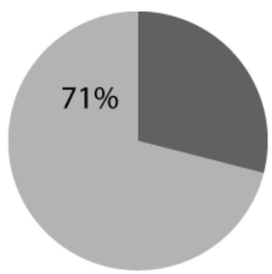



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Charlemagne
Sainte-Therese
Laval
Boucherville
Saint-Leonard
Saint-Eustache
Longueuil
Saint-Laurent
Montreal
Saint-Hubert
Brossard
Verdun
Pointe-Claire
LaSalle
MONTREAL
10
Kilometers

MONTREAL: Statistics									
Variable	Units	Mean	FTN Access		Variable		Mean	FTN Access	
Urban form & transportation			**NO**	**YES**	**Socioeconomics**			**NO**	**YES**
Residential density (people)	/km^2	7,681	4,612	12,095	White	%	82	88	74
Rental tenure	%	50	34	68	Black	%	5	4	7
Units built before 1946	%	13	5	23	Latin American	%	2	1	3
Detached homes	%	28	46	6	Asian	%	10	7	15
Over 5 stories in building	%	45	32	61	Other	%	0	0	1
Commuters by car	%	68	79	50	Low income households	%	24	17	33
Commuters by transit	%	23	15	36	> 30% of income on housing	%	27	22	34
Walking commuters	%	6	4	9	Median household income	$ CAD	50,638	58,874	40,634
Cycling commuters	%	2	1	3	Average rent	$ CAD	669	665	672
					Average value of owned unit	$ CAD	254,248	222,384	295,463
					Average monthly owner costs	%	976	933	1,032
					One-person households	%	33	26	41



Households with FTN access



Lower-income (Q1) households with FTN access

Montreal Notes

Montreal shows a distinct misalignment of affordable housing and frequent transit access, with most of the affordable home ownership being located outside of the FTN transit-shed. Although there is some affordable rental housing in the FTN-shed, the bulk of affordable owned housing is found in surrounding suburbs like Longueuil, St-Hubert, St-Therese and St-Eustache. The probability of access to frequent transit for first-quartile homes is less than 25%, compared to an overall probability baseline of 39%.

Walking (9%) and transit (36%) commuting rates are high in the FTN zone in Montreal, where only half of commuters drive to work. This zone is also more ethnically diverse, and has higher numbers of low income and one-person households. The built form in the FTN zone is remarkable: density is 12,000 people/square kilometer, 68% of housing units are rented, and only 6% are detached. The FTN zone covers just over 40% of Montreal’s population.

The partial transit city

<u>Cities with medium cores, extensive spread and some degree of misalignment</u>

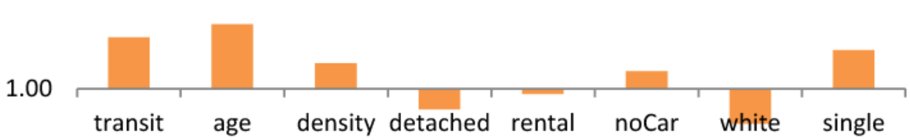
This moderate transit typology shows cities with medium cores and transit networks, extensive spread, and some degree of dislocation between affordable and accessible. These three cities, Seattle, Miami, and Ottawa, did not clearly fit in either the 'strong transit' or 'weak transit' typologies, but exhibited characteristics of both. Like Chicago, Miami is a city that runs north-south along a large body of water and has a good deal of high-density affordable rental housing downtown. They share a distinct spatial north-south polarization, with affordable owned housing located in the south of Chicago and to the north of Miami, and these areas are significantly misaligned from transit access in both cases. However, Chicago's transit network, where it does provide coverage, is much more comprehensive, and its urban form is much more urban than suburban. Miami's affordable areas are lower-density than Chicago's and share characteristics with Houston, Dallas, and other 'weak transit' cities. Seattle shares similarities to San Francisco in its downtown transit network and satellite/contiguous areas of affordability that are partially covered by the transit network. However, it also shares weak transit characteristics and the transit network coverage is much smaller than San Francisco's. Like Montreal, Ottawa's affordable home-owning suburbs are separated from its transit network by a river as well as jurisdictional boundaries; unlike Montreal, Ottawa is a much more suburban city whose BRT and bus frequent lines do not form as complete a network. These three moderate transit cities are presented from largest to smallest.

Seattle (pop. 2.6 million)

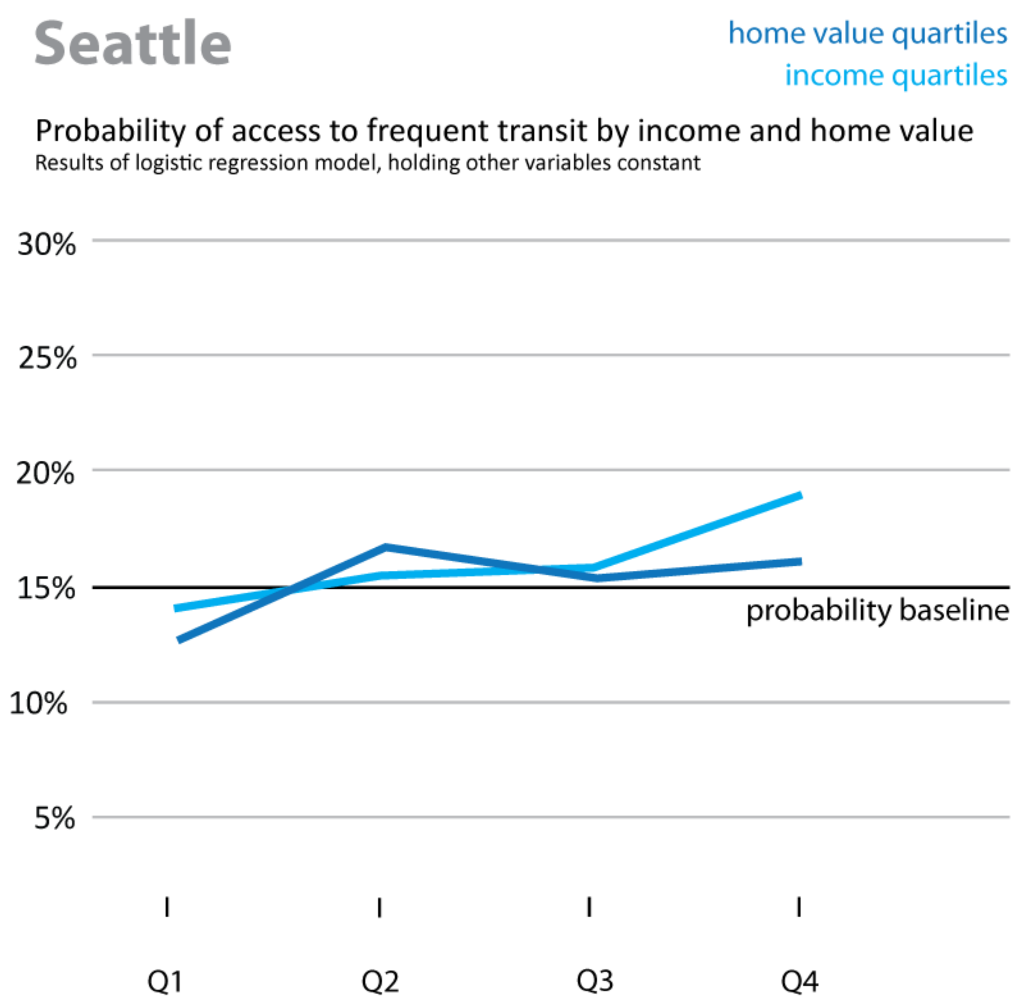
SEATTLE		
Logistic regression	Number of obs	2,520,541
	LR chi2(14)	784366.73
	Prob > chi2	0.00
Log likelihood = -686907.84	Pseudo R2	0.36

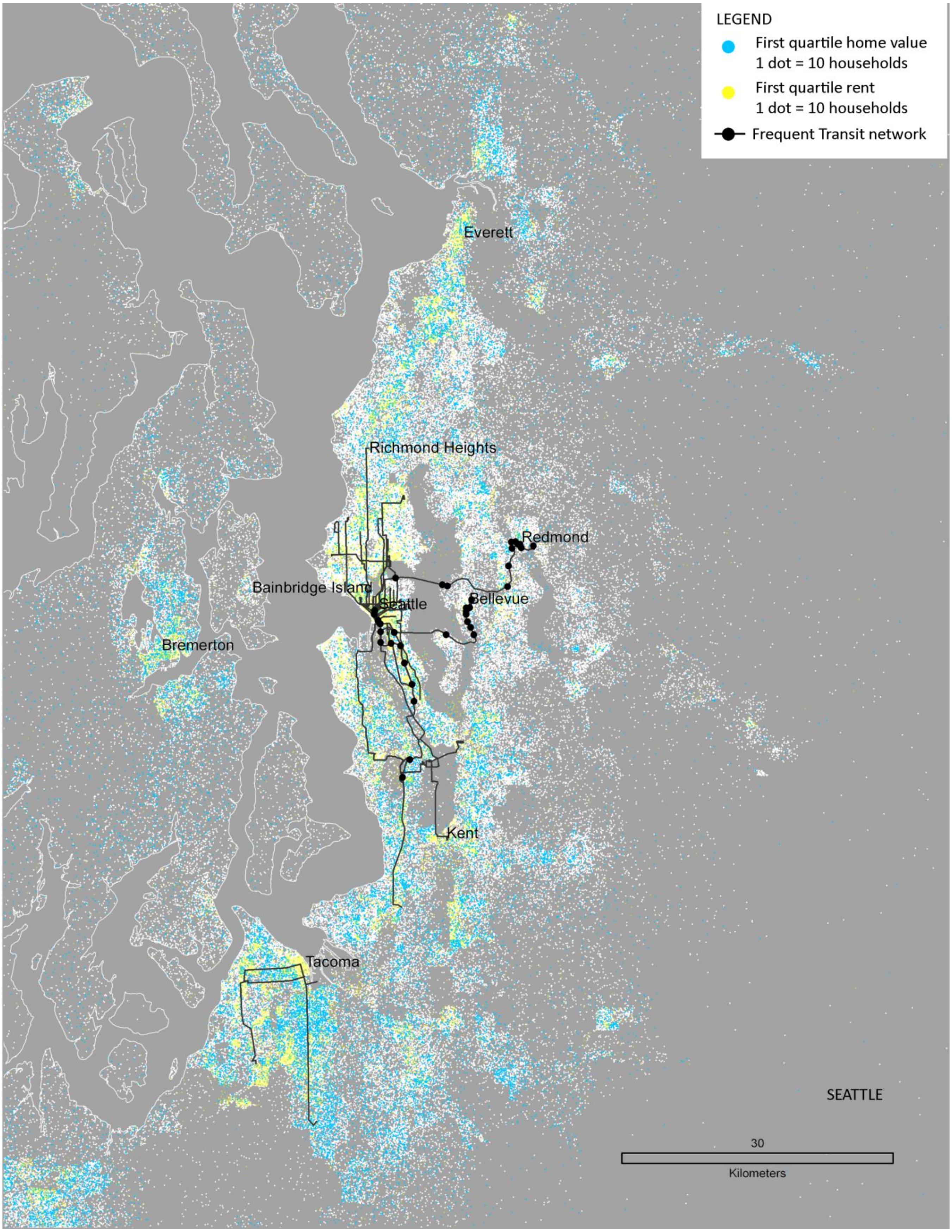
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.58**	0.005	154.91	0.00	1.57	1.59
Household income (median)	Quartiles						
	2	**1.29**	0.009	37.53	0.00	1.27	1.30
	3	**1.36**	0.011	38.37	0.00	1.34	1.39
	4	**1.96**	0.021	61.04	0.00	1.91	2.00
Home value (median)	Quartiles						
	2	**1.59**	0.010	72.05	0.00	1.57	1.61
	3	**1.42**	0.010	48.81	0.00	1.40	1.44
	4	**1.51**	0.013	49.89	0.00	1.49	1.54
Age of building	10 years	**1.78**	0.003	317.95	0.00	1.77	1.79
Residential density	+ 1,000 people/km^2	**1.26**	0.002	165.97	0.00	1.25	1.26
Detached homes	+ 10%	**0.83**	0.001	-106.07	0.00	0.83	0.84
Rental housing tenure	+ 10%	**0.96**	0.002	-23.31	0.00	0.95	0.96
No car	+ 10%	**1.17**	0.004	51.76	0.00	1.16	1.18
Race (white)	+ 10%	**0.73**	0.001	-226.70	0.00	0.73	0.74
One-person households	+ 10%	**1.41**	0.003	158.93	0.00	1.41	1.42
_cons		**0.03**	0.001	-177.57	0.00	0.03	0.03

Odds ratios (mapped on a logarithmic scale)



PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.15**	**0.000**	**850.45**	**0.00**	**0.15**	**0.15**
BY INCOME QUARTILES	1	0.14	0.000	388.05	0.00	0.14	0.14
	2	0.16	0.000	443.66	0.00	0.15	0.16
	3	0.16	0.000	372.00	0.00	0.16	0.16
	4	0.19	0.001	258.32	0.00	0.19	0.19
BY HOME VALUE QUARTILES	1	0.13	0.000	368.67	0.00	0.13	0.13
	2	0.17	0.000	397.20	0.00	0.17	0.17
	3	0.16	0.000	396.10	0.00	0.16	0.16
	4	0.16	0.000	339.61	0.00	0.16	0.16

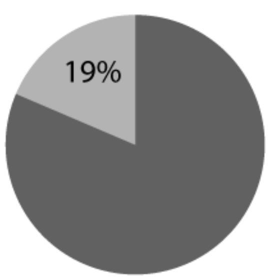



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Everett
Richmond Heights
Redmond
Bainbridge Island
Seattle
Bellevue
Bremerton
Kent
Tacoma
SEATTLE
30
Kilometers

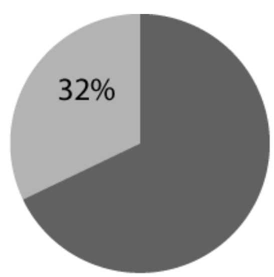
SEATTLE: Statistics

			FTN Access	
Urban form & transportation	Units	Mean	NO	YES
Residential density (people)	/km^2	2,168	1,724	4,522
Single detached buildings	%	59	65	34
Rental tenure	%	39	34	61
Over 20 units in building	%	13	8	32
Median age of buildings	years	36	34	45
Commuters by car	%	81	85	65
Commuters by transit	%	8	6	17
Walking commuters	%	4	2	10
Cycling commuters	%	1	1	2
Transit by bus	%	93	89	99
Transit by subway/el	%	0	0	0
Transit by commuter rail	%	3	4	0
Households with no vehicle	%	8	5	18

			FTN Access	
Socioeconomic	Units	Mean	NO	YES
White	%	71	73	64
Black	%	5	5	10
Hispanic	%	8	7	8
Asian	%	10	10	13
Other	%	6	5	6
One-person households	%	31	27	46
Median rent	$ USD	1,061	1,089	949
Median monthly owner costs	$ USD	1,647	1,643	1,666
Median value of owned unit	$ USD	359,144	354,512	380,199
Median income spent on rent	%	31	31	30
Median income spent on costs	%	25	24	26
Median household income	$ USD	66,420	69,333	53,654
Income below the poverty line	%	11	10	17
Income less than twice poverty	%	14	13	16



Households with FTN access



Lower-income (Q1) households with FTN access

Seattle Notes

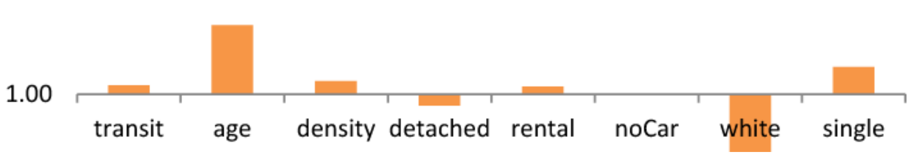
The largest groups of regional affordable housing are found south of Seattle, near the airport in Tacoma, and north of Seattle in Everett. Although Tacoma has frequent local bus routes, there is no frequent rapid transit connection between Tacoma and Seattle's network, which similarly does not extend to Everett. Seattle offers affordable rental homes but most affordable owned homes are out of reach of its frequent transit-shed. Seattle metropolitan region shows aspects of misalignment – in the large amount of affordable housing in Tacoma, mostly inaccessible to frequent transit – but also of low-density spread.

Seattle's FTN zone covers just 16% of the population. Within this zone, the buildings are older (by 10 years on average), residential density is considerably higher, and there are more rental units available, often in high-rise buildings. Transit commuting rates are higher, on a system that is mostly bus-based. Median rent is lower in the FTN but unit prices are higher. The logistic regression shows higher likelihoods of FTN access as incomes and home values rise, with slightly lower likelihoods as the number of rental units in an area rise.

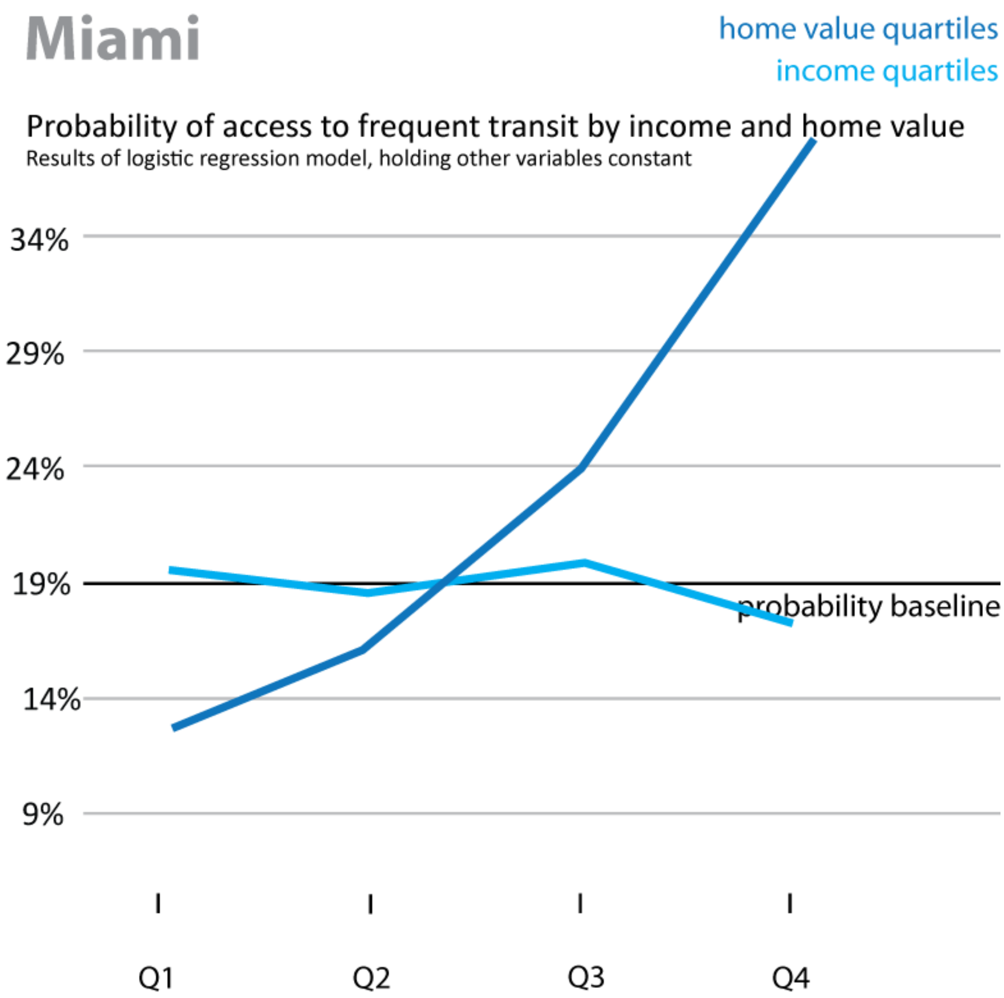
Miami (pop. 2.0 million)

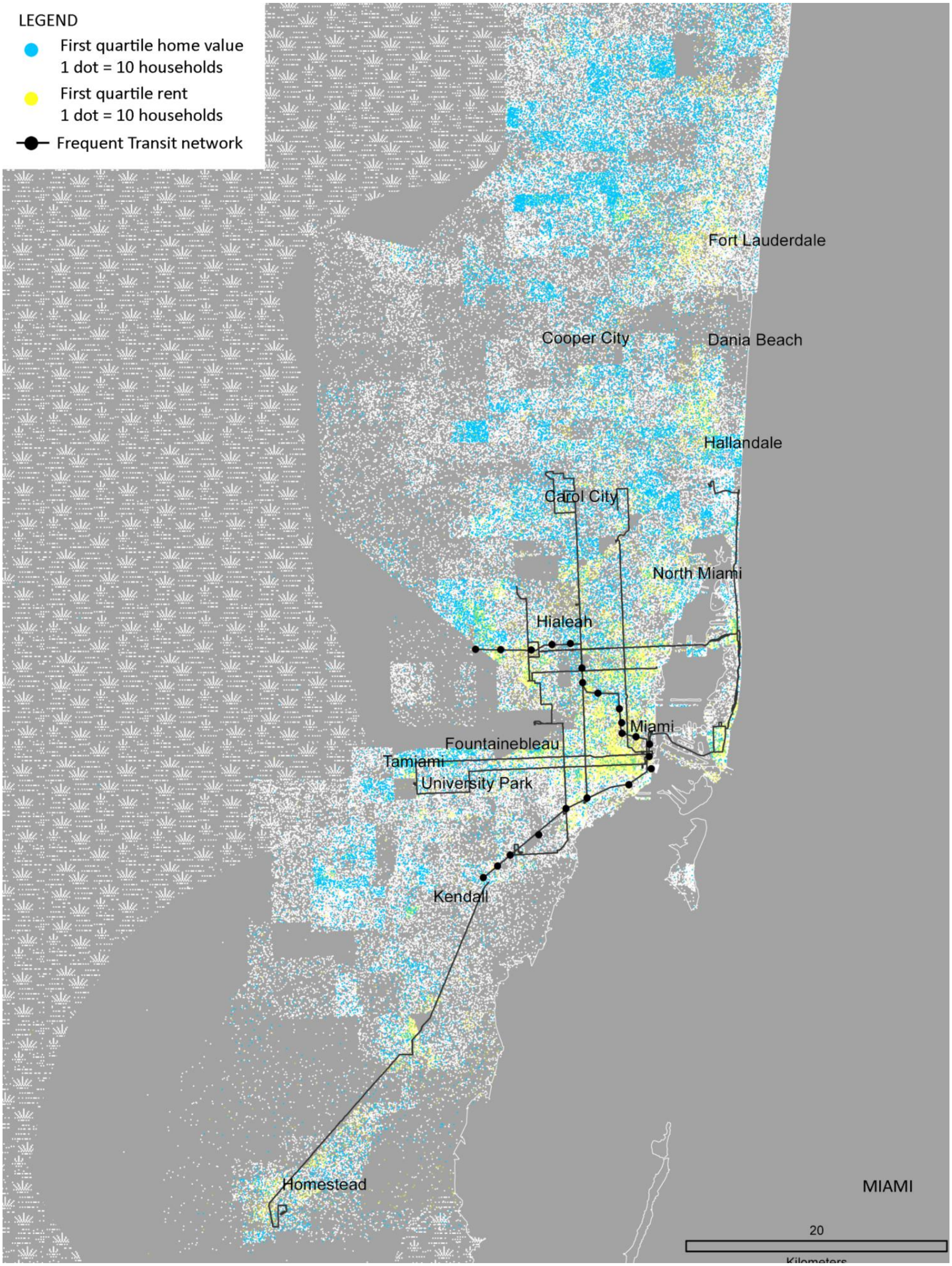
MIAMI								
Logistic regression	Number of obs	1,921,904						
	LR chi2(14)	563039.54						
	Prob > chi2	0.00						
Log likelihood = -651773.01	Pseudo R2	0.30						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.08**	0.003	26.05	0.00	1.08	1.09
Household income (median)	Quartiles						
	2	**0.93**	0.006	-10.77	0.00	0.92	0.95
	3	**1.05**	0.009	5.47	0.00	1.03	1.06
	4	**0.78**	0.009	-20.39	0.00	0.76	0.80
Home value (median)	Quartiles						
	2	**1.49**	0.010	61.70	0.00	1.47	1.50
	3	**3.04**	0.021	161.60	0.00	3.00	3.08
	4	**9.79**	0.102	219.43	0.00	9.59	9.99
Age of building	10 years	**1.85**	0.005	228.23	0.00	1.84	1.86
Residential density	+ 1,000 people/km^2	**1.12**	0.001	113.77	0.00	1.12	1.12
Detached homes	+ 10%	**0.90**	0.001	-68.52	0.00	0.90	0.91
Rental housing tenure	+ 10%	**1.07**	0.002	40.41	0.00	1.07	1.07
No car	+ 10%	**1.00**	0.003	-0.78	0.44	0.99	1.00
Race (white)	+ 10%	**0.60**	0.001	-278.98	0.00	0.59	0.60
One-person households	+ 10%	**1.28**	0.003	106.72	0.00	1.27	1.28
_cons		**0.01**	0.000	-254.82	0.00	0.01	0.01

Odds ratios (graphed on a logarithmic scale)



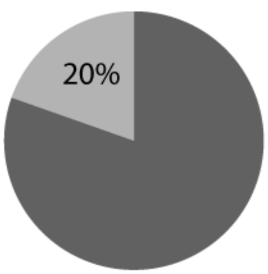
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.19**	**0.000**	**802.72**	**0.00**	**0.19**	**0.19**
BY INCOME QUARTILES	1	0.19	0.001	347.85	0.00	0.19	0.20
	2	0.19	0.000	426.48	0.00	0.19	0.19
	3	0.20	0.001	350.43	0.00	0.20	0.20
	4	0.17	0.001	183.23	0.00	0.17	0.17
BY HOME VALUE QUARTILES	1	0.13	0.000	347.11	0.00	0.13	0.13
	2	0.16	0.000	398.03	0.00	0.16	0.16
	3	0.24	0.001	458.26	0.00	0.24	0.24
	4	0.39	0.001	376.07	0.00	0.39	0.39



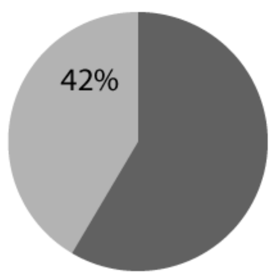

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Fort Lauderdale
Cooper City
Dania Beach
Hallandale
Carol City
North Miami
Hialeah
Miami
Fountainebleau
Tamiami
University Park
Kendall
Homestead
MIAMI
20

MIAMI: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	3,145	2,729	4,872	White	%	31	36	11
Single detached buildings	%	49	51	42	Black	%	26	26	24
Rental tenure	%	36	31	55	Hispanic	%	39	34	63
Over 20 units in building	%	21	21	22	Asian	%	2	2	1
Median age of buildings	years	36	34	45	Other	%	1	2	1
Commuters by car	%	88	89	83	One-person households	%	27	26	29
Commuters by transit	%	5	4	10	Median rent	$ USD	1,136	1,186	944
Walking commuters	%	2	1	3	Median monthly owner costs	$ USD	1,459	1,498	1,291
Cycling commuters	%	0	0	0	Median value of owned unit	$ USD	284,940	286,361	278,798
Transit by bus	%	90	90	90	Median income spent on rent	%	38	37	38
Transit by subway/el	%	5	5	5	Median income spent on costs	%	30	30	32
Transit by commuter rail	%	5	5	5	Median household income	$ USD	52,049	55,458	38,054
					Income below the poverty line	%	16	14	24
Households with no vehicle	%	9	8	16	Income less than twice poverty	%	22	20	27



Households with FTN access



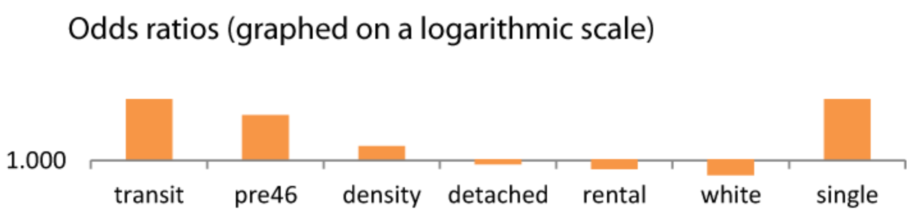
Lower-income (Q1) households with FTN access

Miami Notes

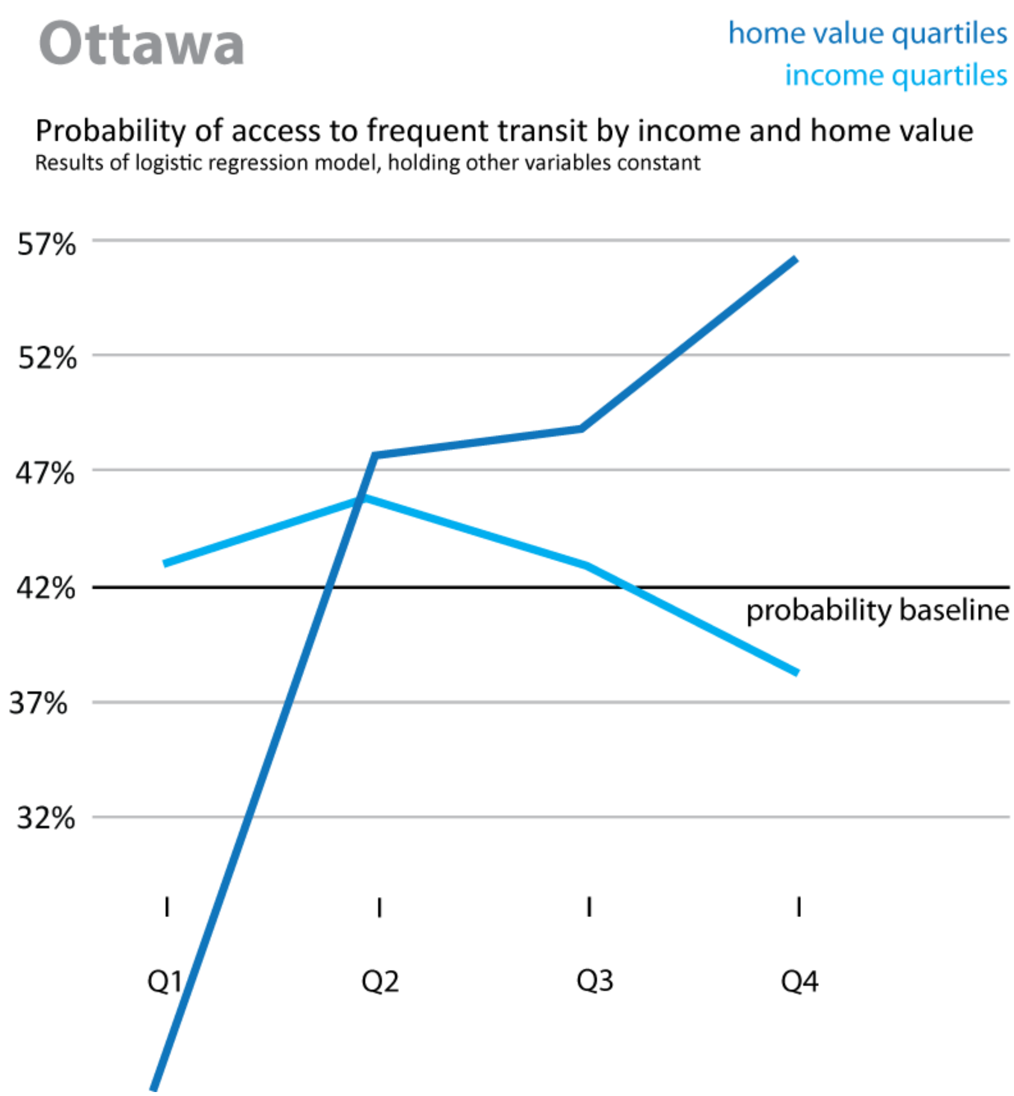
Like Seattle, Miami shows aspects of misalignment (most affordable housing in underserved north, with a similar 'contiguous misalignment' pattern to Chicago) and weak transit (low density, minimal network) cities. The map shows that most of Miami's affordable owned homes are to the north, from North Miami to Fort Lauderdale. There are centralized clusters of affordable rental housing in downtown Miami and Fort Lauderdale.

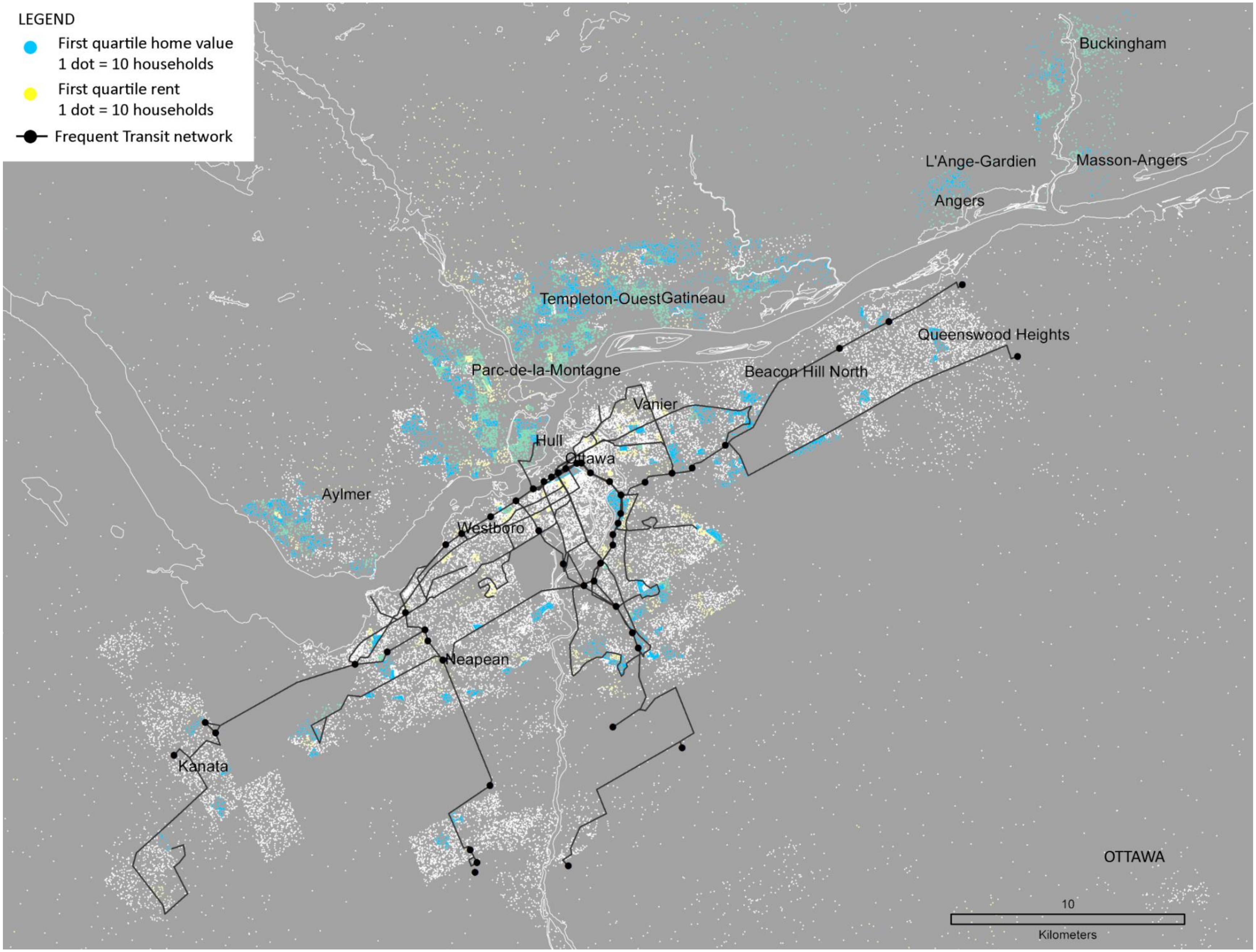
Miami's FTN zone has lower median rents, owner costs, home values, and incomes, as well as higher poverty and near-poverty levels. Density is higher, and there are more rental and attached units, and older buildings. The percentage of the population covered by the FTN is just under 20%. However, holding the effects of other variables constant, higher home values have an increasing likelihood of FTN service. This suggests that the FTN zone covers both areas of affordable housing as well as areas of more expensive developments.

OTTAWA							
Logistic regression	Number of obs	843,072					
	LR chi2(13)	354547.83					
	Prob > chi2	0.00					
Log likelihood = -396327.21	Pseudo R2	0.31					
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**1.71**	0.01	162.58	0.00	1.70	1.72
Median household income	Quartiles						
	2	**1.17**	0.01	13.49	0.00	1.14	1.19
	3	**0.99**	0.01	-0.87	0.38	0.96	1.02
	4	**0.72**	0.01	-19.61	0.00	0.70	0.75
Median home value	Quartiles						
	2	**7.84**	0.08	214.05	0.00	7.69	7.99
	3	**8.43**	0.09	202.66	0.00	8.26	8.61
	4	**13.36**	0.16	215.90	0.00	13.05	13.67
Pre-1946 buildings	+ 10%	**1.48**	0.00	155.65	0.00	1.48	1.49
Residential Density	+ 1,000 people/km^2	**1.12**	0.00	99.63	0.00	1.12	1.12
Detached homes	+ 10%	**0.95**	0.00	-32.10	0.00	0.95	0.96
Rental tenure	+ 10%	**0.92**	0.00	-42.00	0.00	0.91	0.92
Race (white)	+ 10%	**0.87**	0.00	-60.52	0.00	0.86	0.87
One-person households	+ 10%	**1.71**	0.01	156.27	0.00	1.70	1.72
_cons		**0.03**	0.00	-132.72	0.00	0.02	0.03



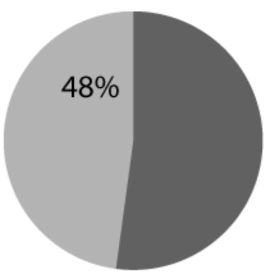
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.42**	**0.00**	**981.88**	**0.00**	**0.42**	**0.42**
BY INCOME QUARTILES	1	0.43	0.00	240.14	0.00	0.43	0.43
	2	0.46	0.00	423.80	0.00	0.45	0.46
	3	0.43	0.00	469.09	0.00	0.43	0.43
	4	0.38	0.00	330.65	0.00	0.38	0.38
BY HOME VALUE QUARTILES	1	0.20	0.00	279.24	0.00	0.20	0.20
	2	0.47	0.00	534.24	0.00	0.47	0.48
	3	0.49	0.00	545.67	0.00	0.48	0.49
	4	0.56	0.00	483.74	0.00	0.56	0.56



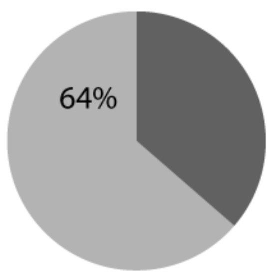

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Buckingham
L'Ange-Gardien
Masson-Angers
Angers
Templeton-Ouest
Gatineau
Queenswood Heights
Beacon Hill North
Parc-de-la-Montagne
Vanier
Hull
Ottawa
Aylmer
Westboro
Neapean
Kanata
OTTAWA
10
Kilometers

Ottawa (pop 0.9 million)

OTTAWA: Statistics									
Variable	Units	Mean	FTN Access		Variable		Mean	FTN Access	
Urban form & transportation			**NO**	**YES**	**Socioeconomics**			**NO**	**YES**
Residential density (people)	/km^2	4,828	3,567	6,437	White	%	82	85	78
Rental tenure	%	37	25	49	Black	%	5	3	6
Units built before 1946	%	9	3	14	Latin American	%	1	1	1
Detached homes	%	39	50	27	Asian	%	12	11	14
Over 5 stories in building	%	16	15	17	Other	%	1	0	1
Commuters by car	%	67	74	56	Low income households	%	18	13	23
Commuters by transit	%	22	19	26	> 30% of income on housing	%	24	19	29
Walking commuters	%	8	4	13	Median household income	$ CAD	68,707	76,293	60,424
Cycling commuters	%	2	2	3	Average rent	$ CAD	878	866	887
					Average value of owned unit	$ CAD	261,401	240,189	286,176
					Average monthly owner costs	%	1,118	1,095	1,144
					One-person households	%	29	22	36



Households with FTN access



Lower-income (Q1) households with FTN access

Ottawa Notes

Although Ottawa has a fairly extensive network for a city of its size, it also shows a distinct misalignment between affordability and access, similar in degree to Montreal. Ottawa runs several east-west and south bus rapid transit lines which are supported by some frequent local bus routes. North of the river in Quebec's Gatineau, there are no frequent transit routes except for a small extension from Ottawa to Hull. North of the river is the location of almost all of the region's affordable owned and rented housing.

In Ottawa, FTN coverage approaches half of the population. Density in the FTN is higher, and almost half of the housing units in this zone are rented; more than half are attached or multi-unit. Commuting rates by transit are 26% inside and 19% outside the FTN, validating the draw of an extensive system. The FTN zone serves areas of lower incomes, but higher housing costs, rent and home prices. The odds of a high-value home having transit access is over 14 times that of a low-value home, and almost 8-9 times for mid-value homes, all else being equal. This suggests great disparity of wealth in the areas served by the FTN zone.

Weak transit cities

<u>Low-density with small cores and limited transit networks</u>

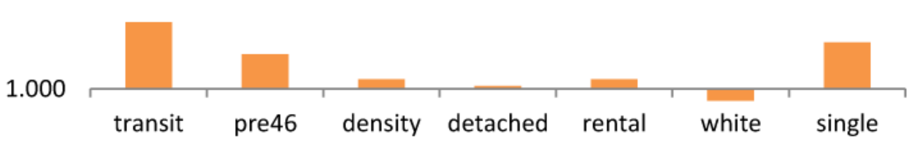
These seven cities include larger cities like Dallas and smaller ones like Edmonton. What they have in common is a kind of urban form that has been built around the automobile and is spread out over a large area. They all do have core downtown areas with some high-density buildings, but these areas tend to be relatively small compared to the rest of the region. Of course, all North American cities have some degree of 'spread', but unlike the 'strong transit' and 'moderate transit' cities profiled previously, these cities are largely defined by it. They have a higher ratio of 'spread' to core, or as discussed in Section A, of the dispersed zone to the compact zone.

What is especially noticeable about this group is that size isn't the defining factor for network effectiveness. Calgary, with less than 1 million people, has the best coverage of this group. Its five spokes of light rail and one shorter frequent bus line manage to cover one-third of all households in the region, and over half of low-income households. Compare this to Houston, which has 3 times the population but whose coverage rates are roughly half of Calgary's. Both are essentially suburban cities, but Calgary is helped by an average density that is double that of Houston's. These cities are presented in order by coverage.

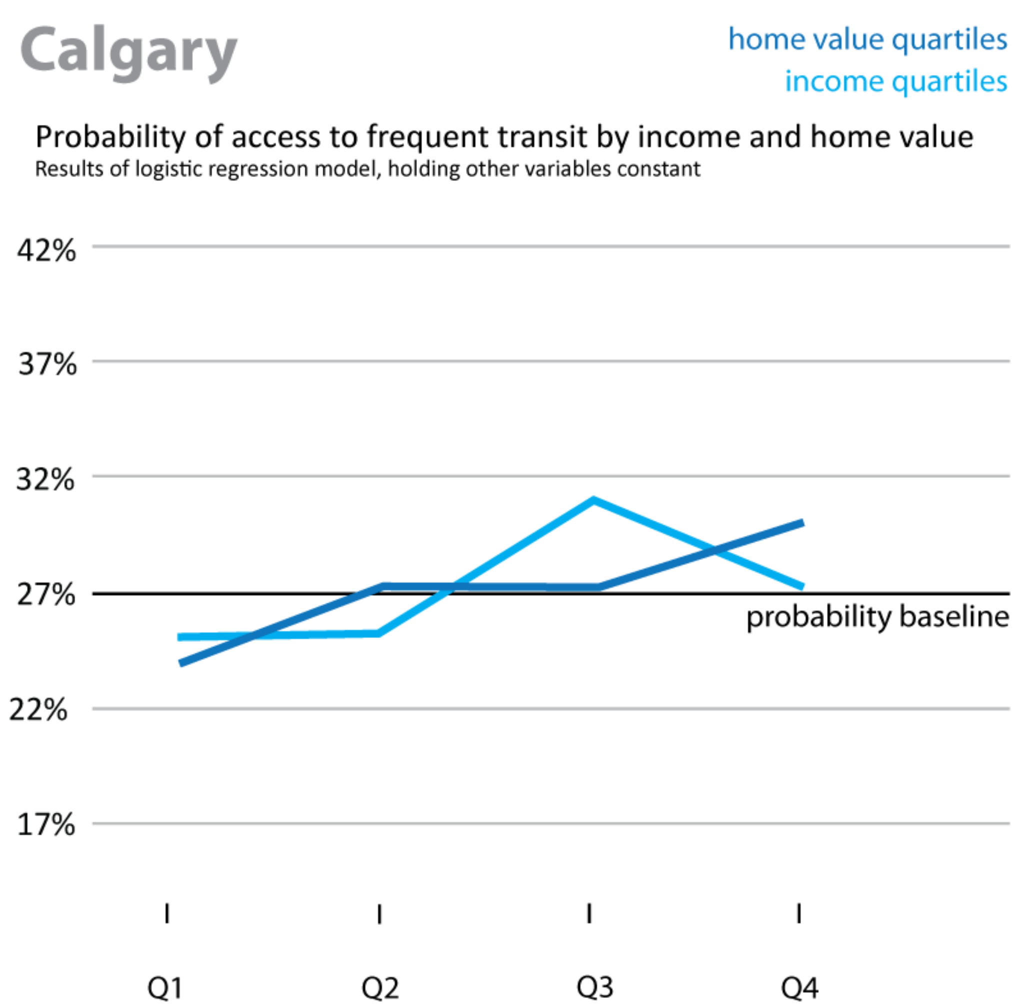
Calgary (pop. 0.9 million)

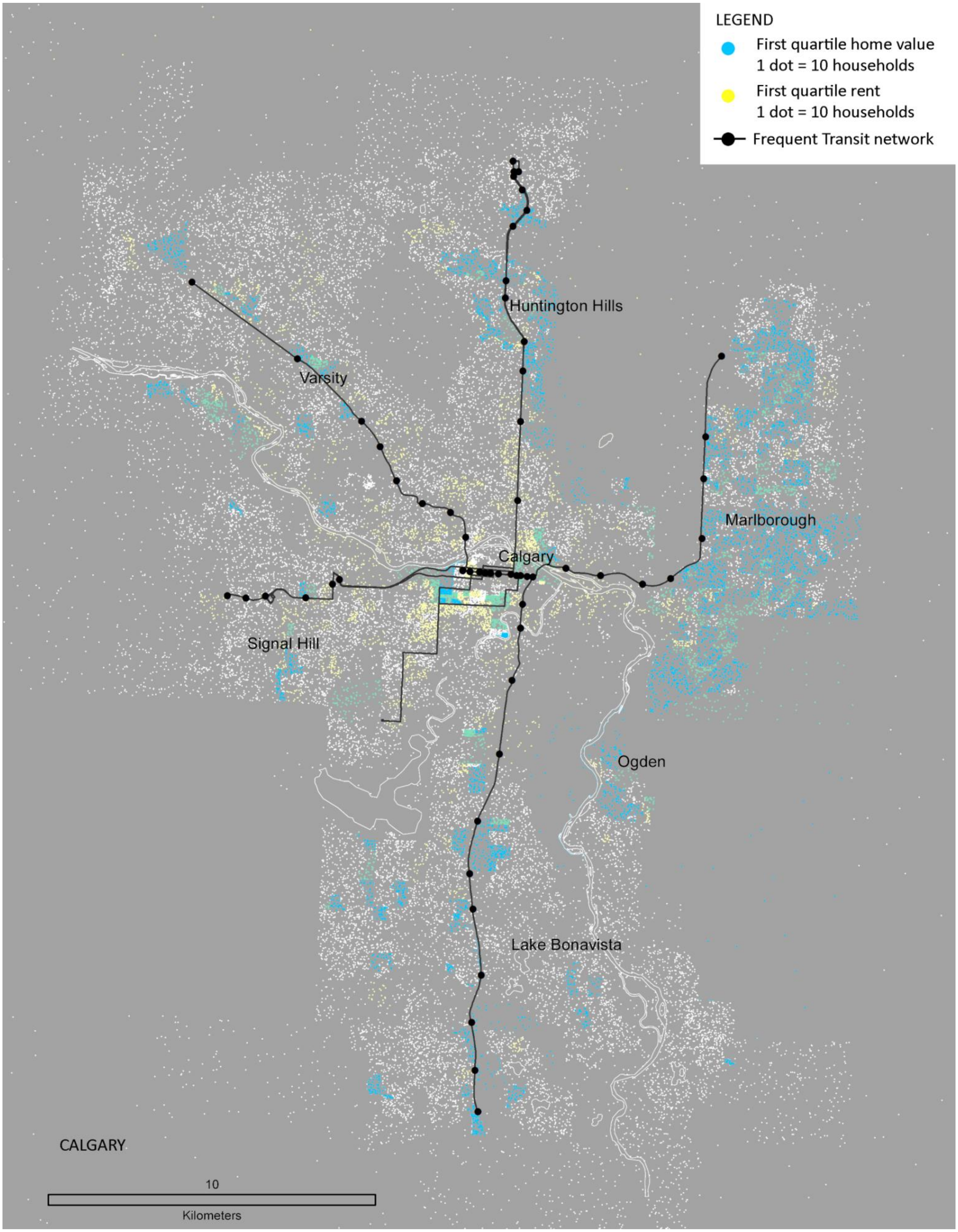
CALGARY								
Logistic regression	Number of obs	888,526						
	LR chi2(13)	179097.20						
	Prob > chi2	0.00						
Log likelihood = -428703.96	Pseudo R2	0.17						
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.		Interval]
Transit commuters	+ 10%	**1.81**	0.01	145.62	0.00	1.80		1.83
Median household income	Quartiles							
	2	**1.03**	0.01	2.77	0.01	1.01		1.04
	3	**1.45**	0.02	32.27	0.00	1.42		1.49
	4	**1.16**	0.02	10.56	0.00	1.13		1.20
Median home value	Quartiles							
	2	**1.25**	0.01	25.94	0.00	1.23		1.27
	3	**1.25**	0.01	24.96	0.00	1.23		1.27
	4	**1.52**	0.01	42.81	0.00	1.49		1.54
Pre-1946 buildings	+ 10%	**1.36**	0.00	96.57	0.00	1.35		1.37
Residential Density	+ 1,000 people/km^2	**1.09**	0.00	71.96	0.00	1.09		1.09
Detached homes	+ 10%	**1.03**	0.00	15.01	0.00	1.02		1.03
Rental tenure	+ 10%	**1.09**	0.00	40.08	0.00	1.08		1.09
Race (white)	+ 10%	**0.90**	0.00	-61.28	0.00	0.90		0.90
One-person households	+ 10%	**1.51**	0.01	122.09	0.00	1.50		1.52
_cons		**0.03**	0.00	-135.18	0.00	0.03		0.04

Odds ratios (graphed on a logarithmic scale)

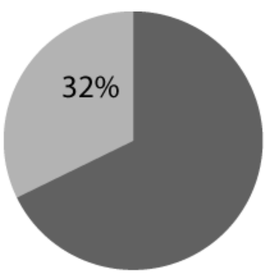


PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.27**	**0.00**	**644.34**	**0.00**	**0.27**	**0.27**
BY INCOME QUARTILES	1	0.25	0.00	218.26	0.00	0.25	0.25
	2	0.25	0.00	312.99	0.00	0.25	0.25
	3	0.31	0.00	322.25	0.00	0.31	0.31
	4	0.27	0.00	211.94	0.00	0.27	0.27
BY HOME VALUE QUARTILES	1	0.24	0.00	263.01	0.00	0.24	0.24
	2	0.27	0.00	304.50	0.00	0.27	0.27
	3	0.27	0.00	322.57	0.00	0.27	0.27
	4	0.30	0.00	298.41	0.00	0.30	0.30

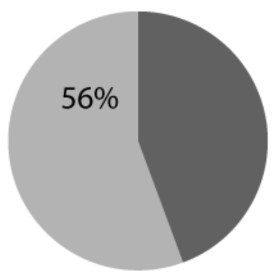



LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Huntington Hills
Varsity
Marlborough
Calgary
Signal Hill
Ogden
Lake Bonavista
CALGARY
10
Kilometers

CALGARY: Statistics									
Variable	Units	Mean	FTN Access		Variable		Mean	FTN Access	
Urban form & transportation			**NO**	**YES**	**Socioeconomics**			**NO**	**YES**
Residential density (people)	/km^2	3,977	3,331	5,640	White	%	77	78	76
Rental tenure	%	28	20	44	Black	%	2	2	2
Units built before 1946	%	4	2	7	Latin American	%	1	1	1
Detached homes	%	57	66	38	Asian	%	18	18	19
Over 5 stories in building	%	16	12	24	Other	%	1	1	1
Commuters by car	%	75	80	64	Low income households	%	15	13	20
Commuters by transit	%	16	15	20	> 30% of income on housing	%	25	22	29
Walking commuters	%	6	3	12	Median household income	$ CAD	70,833	76,519	58,898
Cycling commuters	%	1	1	2	Average rent	$ CAD	955	990	895
					Average value of owned unit	$ CAD	353,774	354,428	352,318
					Average monthly owner costs	%	1,143	1,154	1,118
					One-person households	%	26	21	37



Households with FTN access



Lower-income (Q1) households with FTN access

Calgary Notes

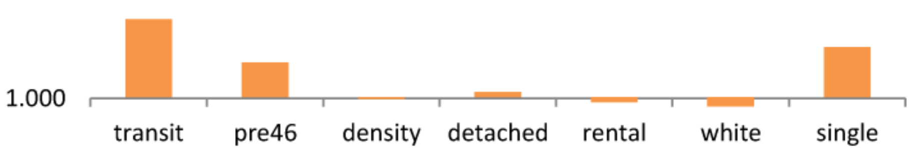
Calgary is a city with a small, high-density downtown surrounded by a much larger, lower-density urbanized area. It has a hub-and-spoke LRT system with 5 arms, which reach some areas of affordable housing. The largest suburban affordable area is in the east around Marlborough, but most of it does not fall into the frequent transit-shed.

Although mostly built post-war, and having a large proportion of detached homes and car commuting, Calgary has an FTN that serves over a quarter of the population. This FTN zone has lower household incomes, lower rents and slightly lower home values and costs. Transit commuting in the FTN zone is 20%, but it is 15% outside the FTN zone, demonstrating that transit use is a well-accepted, if minority, option. The ethnic composition is not very different inside and outside of the FTN zone. The odds ratios in the logistic regression model are all above zero, showing that all else equal, the likelihood of FTN access increases with every variable’s increase, most notably income and home value.

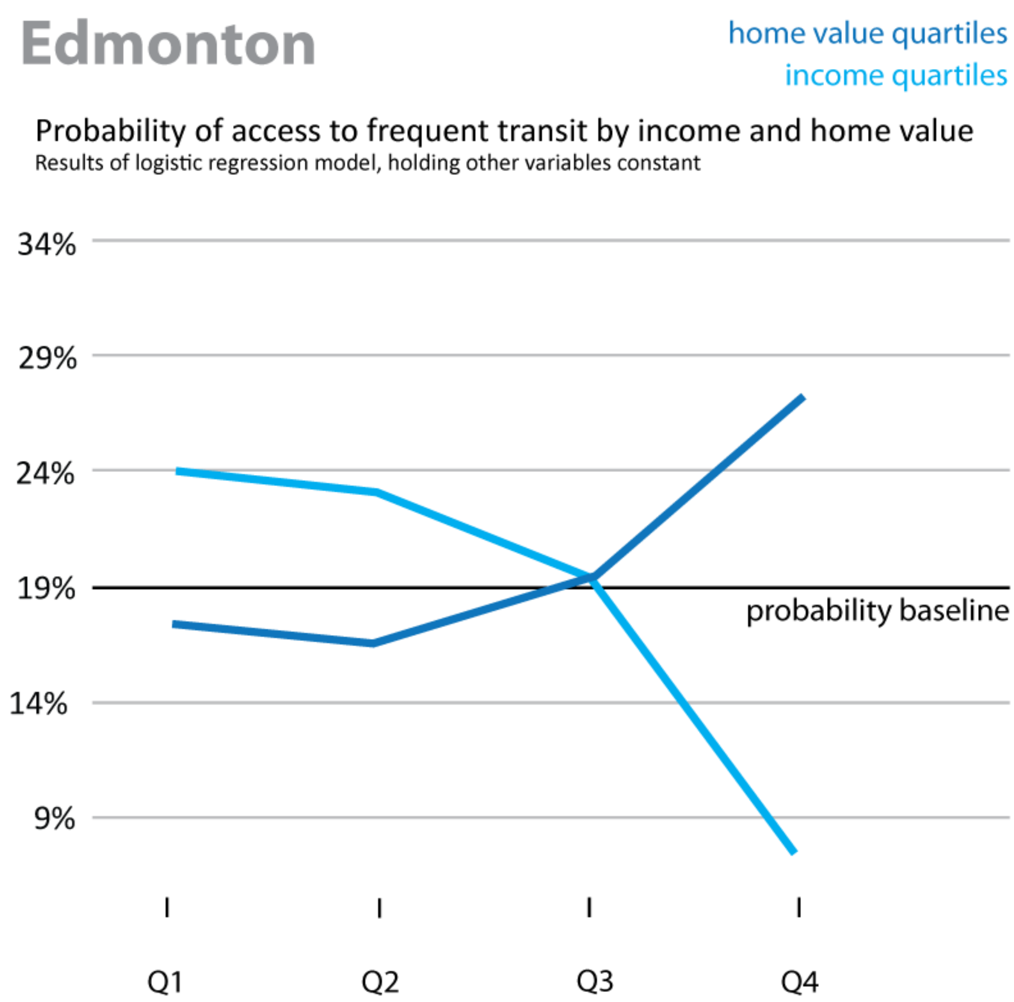
Edmonton (pop. 0.8 million)

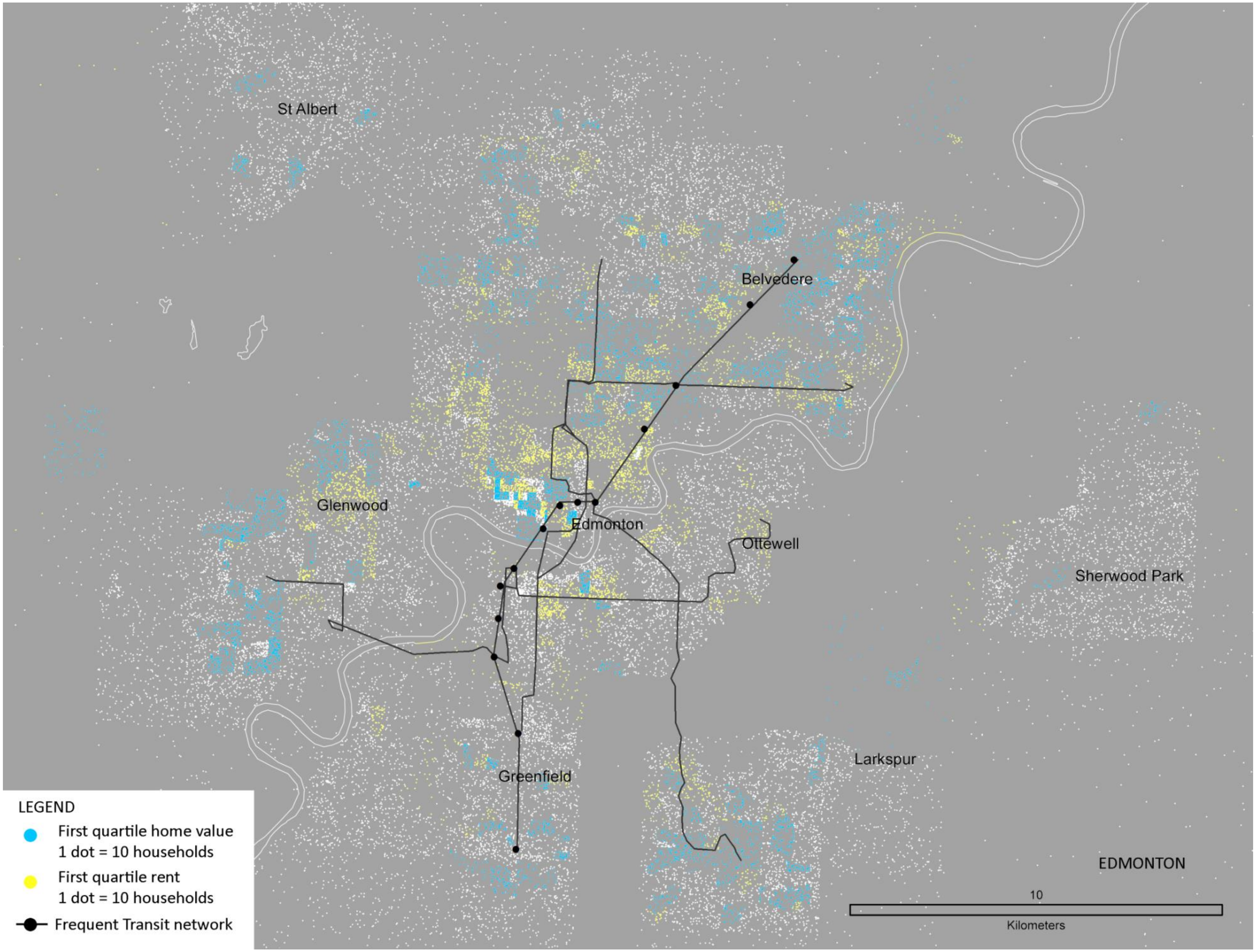
EDMONTON							
Logistic regression	Number of obs	799,033					
	LR chi2(13)	186822.77					
	Prob > chi2	0.00					
Log likelihood = -298571.72	Pseudo R2	0.24					
ftn	Incremental Units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]
Transit commuters	+ 10%	**2.00**	0.01	144.16	0.00	1.98	2.02
Median household income	Quartiles						
	2	**0.95**	0.01	-5.20	0.00	0.93	0.97
	3	**0.72**	0.01	-23.12	0.00	0.70	0.74
	4	**0.18**	0.00	-86.32	0.00	0.17	0.18
Median home value	Quartiles						
	2	**0.95**	0.01	-5.57	0.00	0.93	0.97
	3	**1.20**	0.01	18.90	0.00	1.18	1.22
	4	**2.19**	0.03	68.56	0.00	2.14	2.24
Pre-1946 buildings	+ 10%	**1.36**	0.00	87.36	0.00	1.35	1.37
Residential Density	+ 1,000 people/km^2	**0.98**	0.00	-15.54	0.00	0.98	0.99
Detached homes	+ 10%	**1.05**	0.00	24.41	0.00	1.04	1.05
Rental tenure	+ 10%	**0.96**	0.00	-19.01	0.00	0.95	0.96
Race (white)	+ 10%	**0.92**	0.00	-30.60	0.00	0.91	0.92
One-person households	+ 10%	**1.56**	0.01	128.28	0.00	1.55	1.57
_cons		**0.05**	0.00	-105.57	0.00	0.05	0.06

Odds ratios (graphed on a logarithmic scale)



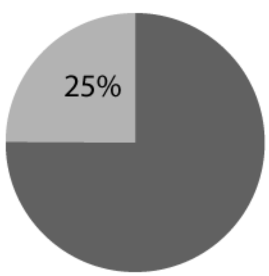
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.19**	**0.00**	**505.18**	**0.00**	**0.19**	**0.19**
BY INCOME QUARTILES	1	0.24	0.00	170.21	0.00	0.24	0.24
	2	0.23	0.00	255.77	0.00	0.23	0.24
	3	0.20	0.00	180.31	0.00	0.19	0.20
	4	0.07	0.00	77.31	0.00	0.07	0.07
BY HOME VALUE QUARTILES	1	0.17	0.00	265.84	0.00	0.17	0.18
	2	0.17	0.00	228.75	0.00	0.17	0.17
	3	0.19	0.00	241.54	0.00	0.19	0.20
	4	0.27	0.00	227.32	0.00	0.27	0.27



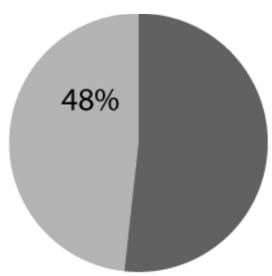

St Albert
Belvedere
Glenwood
Edmonton
Ottewell
Sherwood Park
Larkspur
Greenfield
LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
EDMONTON
10
Kilometers

EDMONTON: Statistics

Variable	Units	Mean	FTN Access		Variable		Mean	FTN Access	
Urban form & transportation			**NO**	**YES**	**Socioeconomics**			**NO**	**YES**
Residential density (people)	/km^2	3,623	3,245	5,039	White	%	82	83	79
Rental tenure	%	35	28	55	Black	%	2	2	3
Units built before 1946	%	4	2	8	Latin American	%	1	1	1
Detached homes	%	53	60	32	Asian	%	14	14	15
Over 5 stories in building	%	22	18	33	Other	%	1	1	1
Commuters by car	%	80	84	66	Low income households	%	17	14	27
Commuters by transit	%	11	9	17	> 30% of income on housing	%	23	21	31
Walking commuters	%	6	4	12	Median household income	$CAD	63,699	69,529	46,230
Cycling commuters	%	1	1	2	Average rent	$CAD	832	865	759
					Average value of owned unit	$CAD	242,229	245,725	230,412
					Average monthly owner costs	%	986	1,006	919
					One-person households	%	29	24	42



Households with FTN access



Lower-income (Q1) households with FTN access

Edmonton Notes

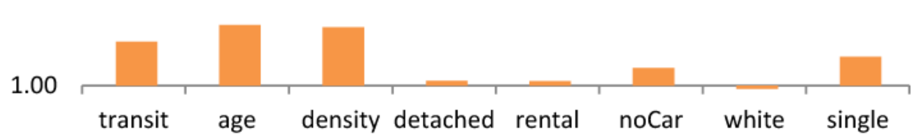
Edmonton’s LRT travels diagonally from the low-density, affordable northeast, through the small downtown, to the low-density, less affordable south. Although it is not extensive enough to be called a network, there are several frequent bus lines feeding the LRT.

Edmonton’s urban form has higher density, more rental tenure, more attached and high-rise homes in the area served by the FTN. Transit commuting rates in the FTN are 17%. The median household income and average rent are lower in this area, as are home values and owner costs. In this sense, Edmonton appears to be a classic example of transit serving a small, more affordable core while the surrounding areas are more suburban and auto-dependent. The odds of higher-income households living in the FTN are lower, although as home values increase, so do the odds of FTN access, all else being equal. This suggests an FTN zone with both high- and low-market housing.

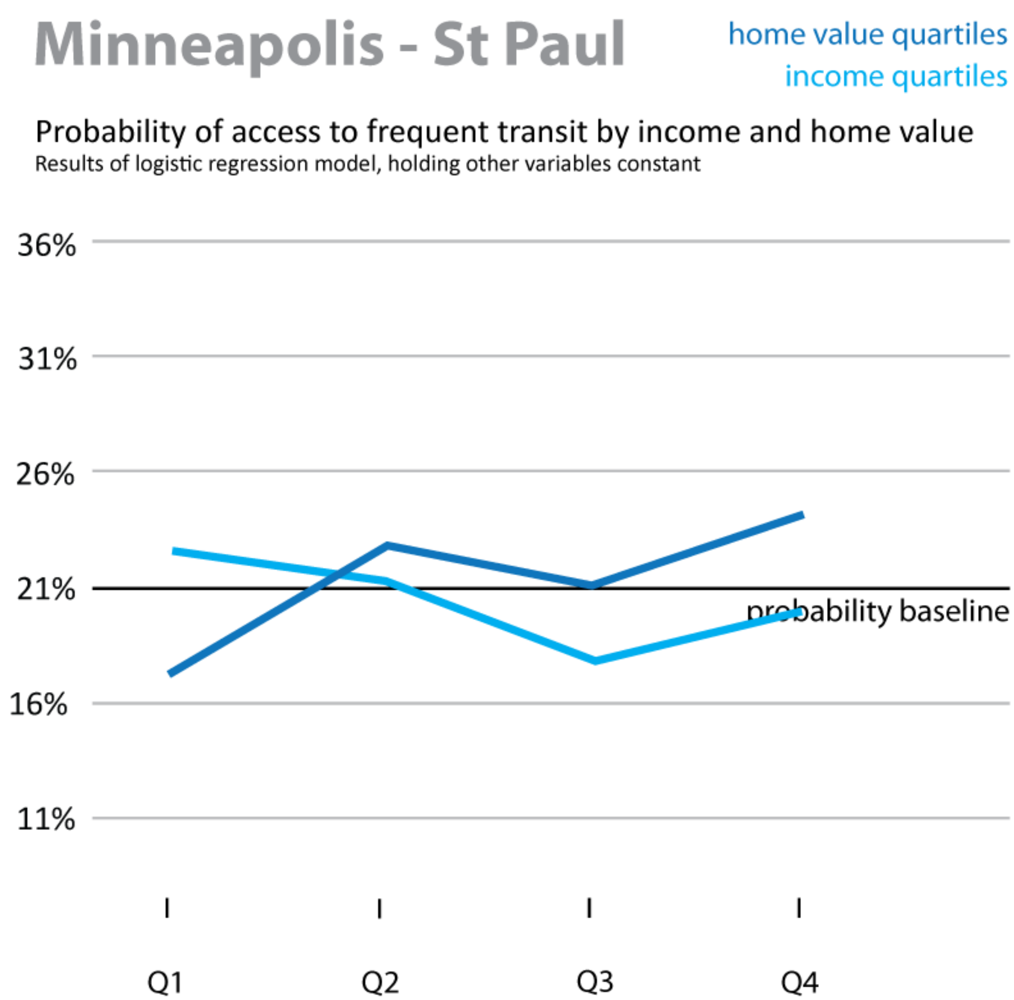
Minneapolis – St Paul (pop 2.3 million)

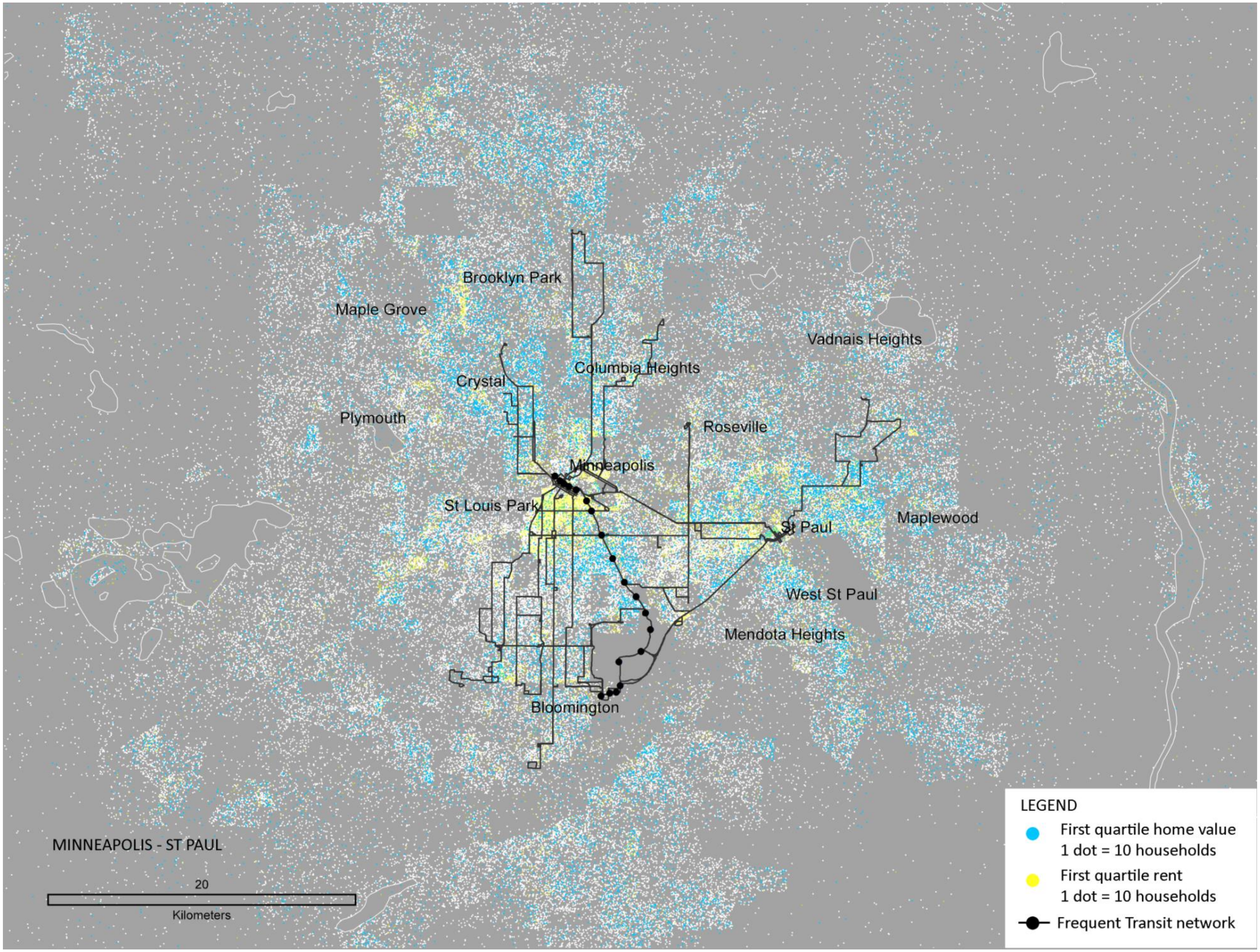
MINNEAPOLIS-ST PAUL								
Logistic regression	Number of obs	2,185,288						
	LR chi2(14)	892272.00						
	Prob > chi2	0.00						
Log likelihood = -670596.47	Pseudo R2	0.40						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.		Interval]
Transit commuters	+ 10%	**1.48**	0.005	104.80	0.00	1.47		1.49
Household income (median)	Quartiles							
	2	**0.86**	0.006	-21.52	0.00	0.85		0.87
	3	**0.63**	0.006	-50.85	0.00	0.62		0.64
	4	**0.77**	0.009	-22.31	0.00	0.75		0.79
Home value (median)	Quartiles							
	2	**1.94**	0.012	105.17	0.00	1.91		1.96
	3	**1.59**	0.012	63.79	0.00	1.57		1.61
	4	**2.17**	0.019	87.07	0.00	2.13		2.21
Age of building	10 years	**1.71**	0.003	299.69	0.00	1.71		1.72
Residential density	+ 1,000 people/km^2	**1.68**	0.004	236.66	0.00	1.67		1.69
Detached homes	+ 10%	**1.04**	0.002	22.27	0.00	1.04		1.05
Rental housing tenure	+ 10%	**1.04**	0.002	19.03	0.00	1.04		1.05
No car	+ 10%	**1.17**	0.003	55.15	0.00	1.16		1.18
Race (white)	+ 10%	**0.97**	0.001	-19.60	0.00	0.97		0.97
One-person households	+ 10%	**1.29**	0.003	119.75	0.00	1.29		1.30
_cons		**0.00**	0.000	-291.70	0.00	0.00		0.00

Odds ratios (graphed on a logarithmic scale)



PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.21**	**0.000**	**1002.60**	**0.00**	**0.21**	**0.21**
BY INCOME QUARTILES	1	0.23	0.001	381.11	0.00	0.23	0.23
	2	0.21	0.000	521.33	0.00	0.21	0.21
	3	0.18	0.000	372.11	0.00	0.18	0.18
	4	0.20	0.001	270.58	0.00	0.20	0.20
BY HOME VALUE QUARTILES	1	0.17	0.000	458.27	0.00	0.17	0.17
	2	0.23	0.000	547.05	0.00	0.23	0.23
	3	0.21	0.000	457.52	0.00	0.21	0.21
	4	0.24	0.001	381.06	0.00	0.24	0.24

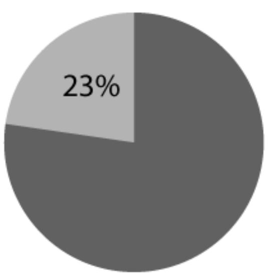



Brooklyn Park
Maple Grove
Vadnais Heights
Columbia Heights
Crystal
Plymouth
Roseville
Minneapolis
St Louis Park
St Paul
Maplewood
West St Paul
Mendota Heights
Bloomington
MINNEAPOLIS - ST PAUL
20
Kilometers
LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network

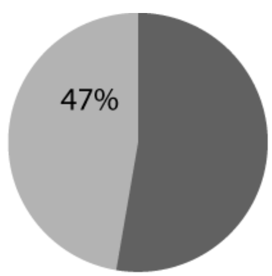
MINNEAPOLIS – ST PAUL:
Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	1,781	1,320	3,491
Single detached buildings	%	59	62	49
Rental tenure	%	29	24	46
Over 20 units in building	%	16	14	22
Median age of buildings	years	40	35	57
Commuters by car	%	86	89	76
Commuters by transit	%	5	4	11
Walking commuters	%	2	2	5
Cycling commuters	%	1	1	2
Transit by bus	%	95	96	93
Transit by subway/el	%	2	2	3
Transit by commuter rail	%	2	2	3
Households with no vehicle	%	8	6	16

Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
White	%	79	82	67
Black	%	7	6	14
Hispanic	%	5	5	9
Asian	%	6	5	7
Other	%	3	3	4
One-person households	%	30	27	40
Median rent	$ USD	941	975	843
Median monthly owner costs	$ USD	1,464	1,484	1,394
Median value of owned unit	$ USD	255,034	259,065	240,888
Median income spent on rent	%	32	32	32
Median income spent on costs	%	23	23	24
Median household income	$ USD	66,254	70,782	50,847
Income below the poverty line	%	10	8	19
Income less than twice poverty	%	13	12	17



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on Minneapolis and St Paul

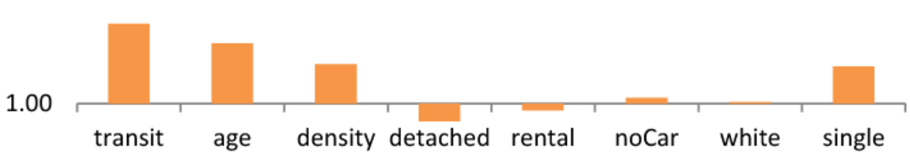
Affordable owned homes can be found in both north and south Minneapolis and throughout St Paul. The most prominent group of affordable rental homes is found south of the downtown. Although there is a loose network of frequent local bus lines reaching into parts of the metropolitan region, the backbone is the light rail line that runs between the airport and the downtown.

Unlike many of the other metros in this analysis, the odds of having access to the FTN in Minneapolis-St Paul decrease as income increases; however, the odds increase as home value increases, all other variables being held constant. This could be explained by the FTN serving both high-end residential areas as well as high-rise rental affordable areas. The median household income is considerably lower in the FTN, and poverty rates are higher. Density and transit commuting rates are both more than double in the FTN zone than outside it, but are both relatively low compared to other cities.

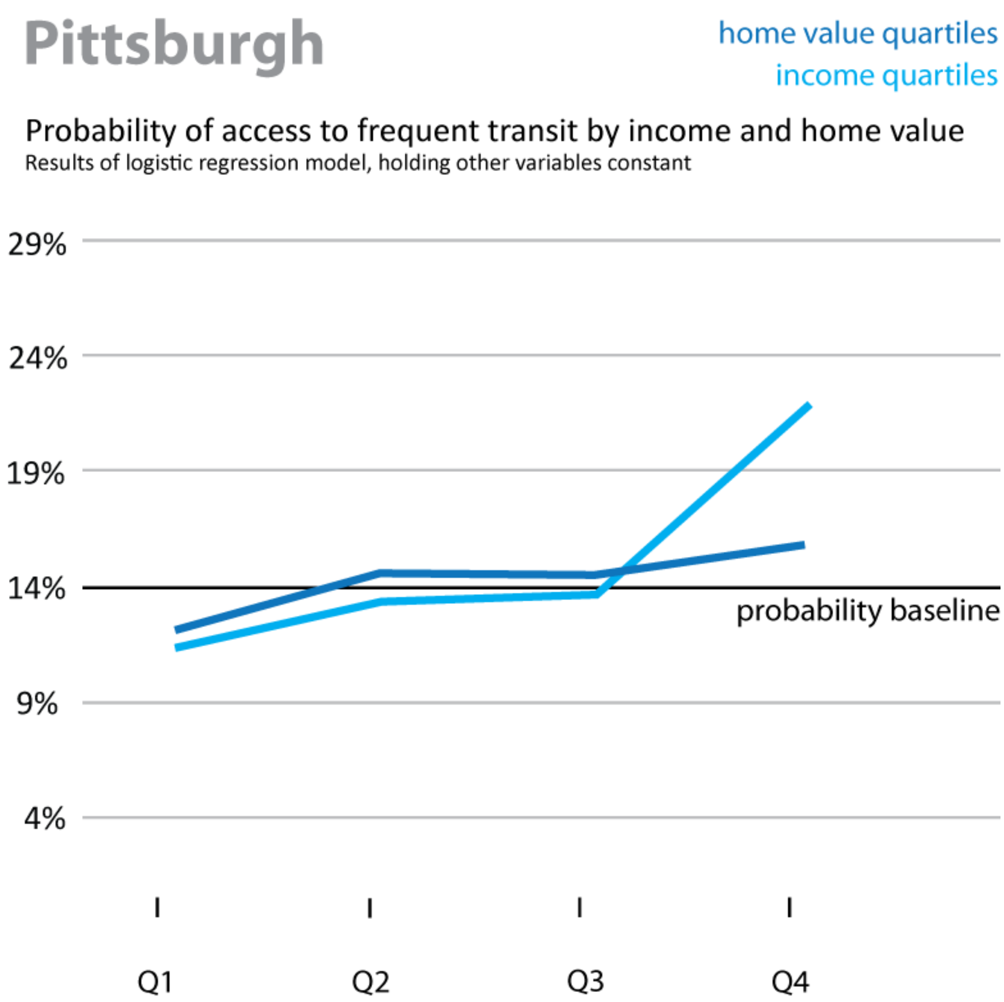
Pittsburgh (1.4 million)

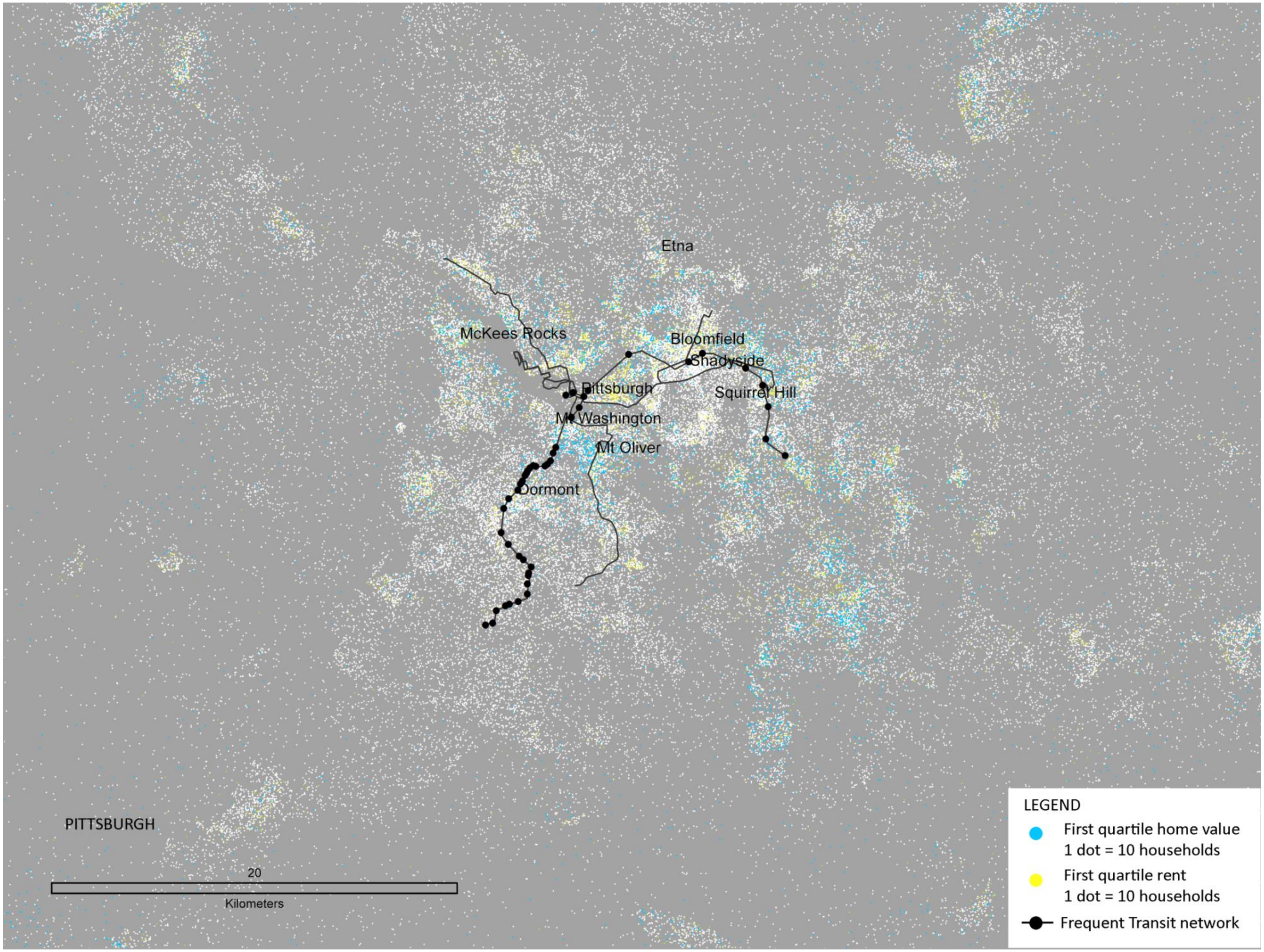
PITTSBURGH								
Logistic regression	Number of obs	1,406,839						
	LR chi2(14)	433191.99						
	Prob > chi2	0.00						
Log likelihood = -356265.87	Pseudo R2	0.38						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]	
Transit commuters	+ 10%	**2.03**	0.007	212.07	0.00	2.02	2.05	
Household income (median)	Quartiles							
	2	**1.37**	0.013	33.53	0.00	1.34	1.39	
	3	**1.48**	0.017	33.35	0.00	1.45	1.52	
	4	**3.91**	0.060	89.13	0.00	3.79	4.03	
Home value (median)	Quartiles							
	2	**1.46**	0.014	40.21	0.00	1.43	1.48	
	3	**1.44**	0.016	33.46	0.00	1.41	1.47	
	4	**1.76**	0.021	46.14	0.00	1.71	1.80	
Age of building	10 years	**1.71**	0.006	162.17	0.00	1.70	1.72	
Residential density	+ 1,000 people/km^2	**1.42**	0.003	167.37	0.00	1.41	1.43	
Detached homes	+ 10%	**0.85**	0.002	-64.53	0.00	0.85	0.86	
Rental housing tenure	+ 10%	**0.94**	0.003	-21.17	0.00	0.94	0.95	
No car	+ 10%	**1.05**	0.003	17.99	0.00	1.05	1.06	
Race (white)	+ 10%	**1.02**	0.002	9.03	0.00	1.01	1.02	
One-person households	+ 10%	**1.39**	0.004	104.49	0.00	1.38	1.40	
_cons		**0.00**	0.000	-206.32	0.00	0.00	0.00	

Odds ratios (mapped on a logarithmic scale)



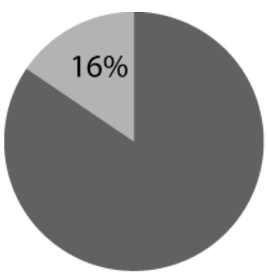
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.14**	**0.000**	**614.90**	**0.00**	**0.14**	**0.14**
BY INCOME QUARTILES	1	0.11	0.000	270.54	0.00	0.11	0.12
	2	0.13	0.000	328.48	0.00	0.13	0.14
	3	0.14	0.001	257.55	0.00	0.14	0.14
	4	0.22	0.001	223.53	0.00	0.22	0.22
BY HOME VALUE QUARTILES	1	0.12	0.000	260.42	0.00	0.12	0.12
	2	0.15	0.000	302.76	0.00	0.15	0.15
	3	0.15	0.001	268.76	0.00	0.14	0.15
	4	0.16	0.001	246.27	0.00	0.16	0.16



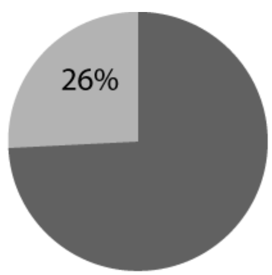

Etna
McKees Rocks
Bloomfield
Shadyside
Pittsburgh
Squirrel Hill
Mt Washington
Mt Oliver
Dormont
PITTSBURGH
20
Kilometers
LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network

PITTSBURGH: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	**Socioeconomic**	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	1,822	1,442	4,018	White	%	85	88	70
Single detached buildings	%	64	68	42	Black	%	10	8	22
Rental tenure	%	33	29	52	Hispanic	%	1	1	2
Over 20 units in building	%	7	6	15	Asian	%	2	1	4
Median age of buildings	years	54	53	63	Other	%	2	2	2
Commuters by car	%	83	87	63	One-person households	%	35	33	45
Commuters by transit	%	8	6	21	Median rent	$ USD	700	700	704
Walking commuters	%	5	3	11	Median monthly owner costs	$ USD	936	927	990
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	120,534	120,354	121,538
Transit by bus	%	93	94	91	Median income spent on rent	%	31	30	32
Transit by subway/el	%	3	2	3	Median income spent on costs	%	20	20	21
Transit by commuter rail	%	0	0	0	Median household income	$ USD	49,872	51,684	39,994
					Income below the poverty line	%	13	12	20
Households with no vehicle	%	14	12	25	Income less than twice poverty	%	18	17	19



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on Pittsburgh

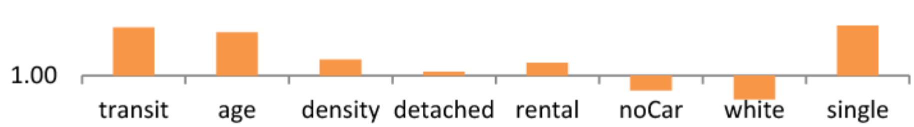
Pittsburgh is hilly and the street grids break apart like puzzle pieces, with rivers meandering through. It is not obvious how to organize a connective bus network.

Like other, larger metros, Pittsburgh's FTN zone serves areas with more rental, high-rise, and older buildings, and fewer detached homes. Transit commuting rates are above 20% in the FTN and car commuting rates are lower. Despite median incomes being lower in the FTN, housing costs are higher across a number of measures. The regression analysis confirms an affordability issue, showing increased odds ratios for higher income and home value quartiles.

Houston (pop. 2.9 million)

HOUSTON								
Logistic regression	Number of obs		2,719,525					
	LR chi2(14)		397081.54					
	Prob > chi2		0.00					
Log likelihood = -768345.75	Pseudo R2		0.21					
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.	Interval]	
Transit commuters	+ 10%	**1.53**	0.006	116.75	0.00	1.52	1.55	
Household income (median)	Quartiles							
	2	**0.78**	0.005	-40.61	0.00	0.77	0.79	
	3	**1.11**	0.009	13.59	0.00	1.10	1.13	
	4	**1.10**	0.013	8.09	0.00	1.07	1.12	
Home value (median)	Quartiles							
	2	**0.79**	0.005	-38.62	0.00	0.78	0.80	
	3	**1.09**	0.008	12.29	0.00	1.08	1.11	
	4	**2.62**	0.022	115.76	0.00	2.58	2.66	
Age of building	10 years	**1.47**	0.003	210.45	0.00	1.46	1.47	
Residential density	+ 1,000 people/km^2	**1.15**	0.002	101.00	0.00	1.15	1.16	
Detached homes	+ 10%	**1.04**	0.002	22.83	0.00	1.03	1.04	
Rental housing tenure	+ 10%	**1.12**	0.002	60.63	0.00	1.12	1.13	
No car	+ 10%	**0.88**	0.002	-50.45	0.00	0.87	0.88	
Race (white)	+ 10%	**0.81**	0.001	-152.00	0.00	0.81	0.81	
One-person households	+ 10%	**1.56**	0.003	244.48	0.00	1.55	1.56	
_cons		**0.01**	0.000	-278.86	0.00	0.00	0.01	

Odds ratios (graphed on a logarithmic scale)

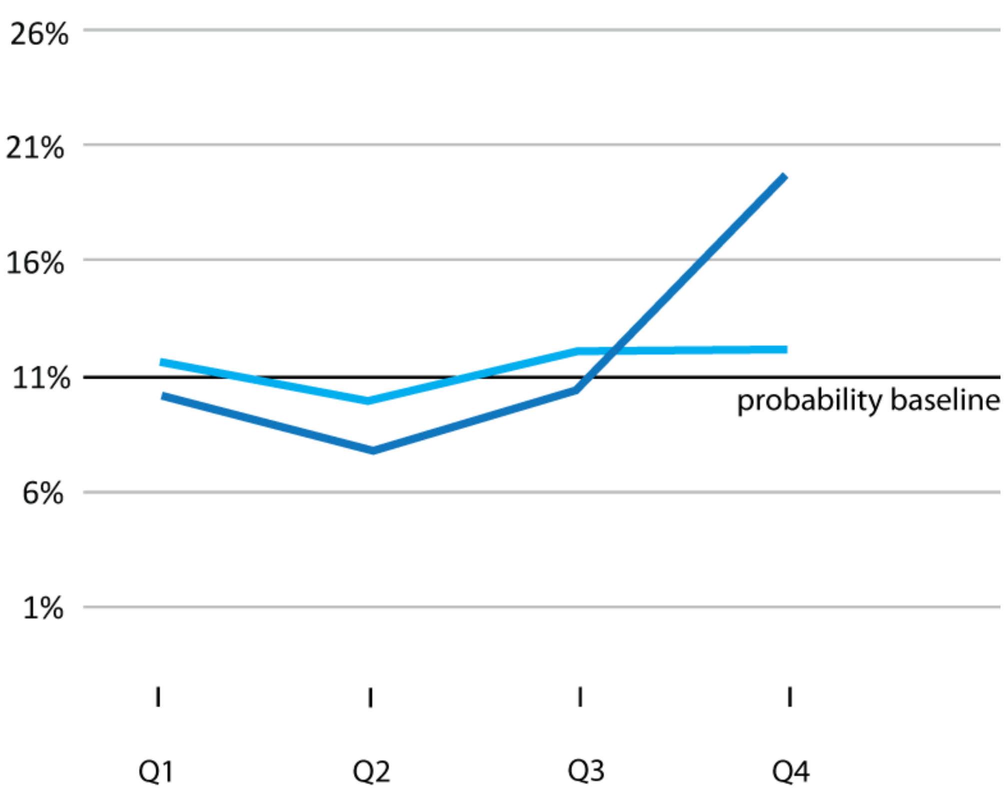


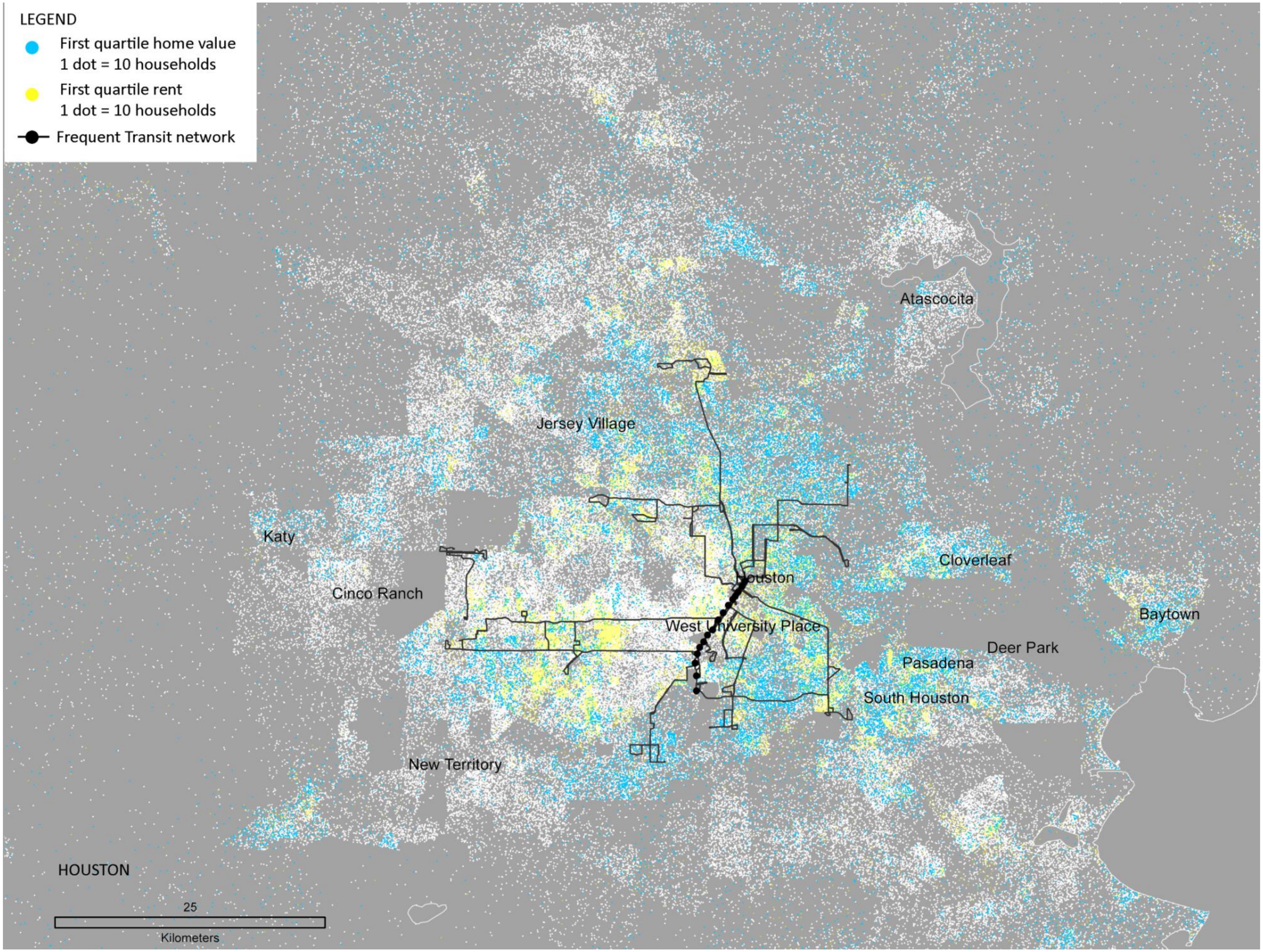
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.11**	**0.000**	**655.62**	**0.00**	**0.11**	**0.11**
BY INCOME QUARTILES	1	0.12	0.000	301.68	0.00	0.12	0.12
	2	0.10	0.000	298.29	0.00	0.10	0.10
	3	0.13	0.000	278.71	0.00	0.12	0.13
	4	0.12	0.001	167.40	0.00	0.12	0.13
BY HOME VALUE QUARTILES	1	0.10	0.000	296.17	0.00	0.10	0.10
	2	0.08	0.000	285.86	0.00	0.08	0.08
	3	0.11	0.000	271.31	0.00	0.11	0.11
	4	0.20	0.001	280.98	0.00	0.20	0.20

Houston

Probability of access to frequent transit by income and home value

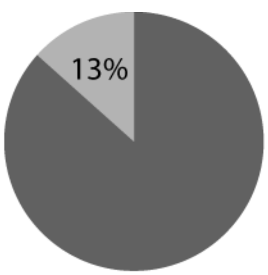
Results of logistic regression model, holding other variables constant



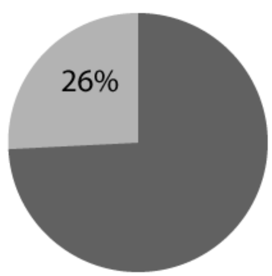

LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Atascocita
Jersey Village
Katy
Cloverleaf
Houston
Cinco Ranch
Baytown
West University Place
Deer Park
Pasadena
South Houston
New Territory
HOUSTON
25
Kilometers

HOUSTON: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES	Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	2,057	1,944	2,873	White	%	38	40	26
Single detached buildings	%	62	64	46	Black	%	18	17	26
Rental tenure	%	41	38	59	Hispanic	%	37	36	41
Over 20 units in building	%	11	9	18	Asian	%	5	5	5
Median age of buildings	%	33	32	39	Other	%	1	1	1
Commuters by car	%	90	91	85	One-person households	%	26	24	37
Commuters by transit	%	3	3	6	Median rent	$ USD	917	929	843
Walking commuters	%	2	2	3	Median monthly owner costs	$ USD	1,220	1,216	1,244
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	159,099	154,540	190,747
Transit by bus	%	97	98	94	Median income spent on rent	%	31	31	32
Transit by subway/el	%	1	1	2	Median income spent on costs	%	21	21	22
Transit by commuter rail	%	1	0	2	Median household income	$ USD	58,918	60,854	46,376
					Income below the poverty line	%	17	16	22
Households with no vehicle	%	7	7	12	Income less than twice poverty	%	21	21	24



Households with FTN access



Lower-income (Q1) households with FTN access

Notes on Houston

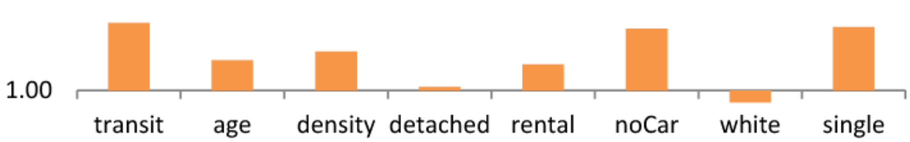
The map shows the location of affordable home ownership mostly in areas to the southeast and southwest of downtown Houston, and are low-density and auto-oriented (photo). The largest cluster of affordable rental housing is located west of downtown. The light rail runs between the university and the downtown.

Houston's transit system only carries a small fraction of commuters, even in the FTN zone. The difference between the FTN zone and outside it is small when comparing urban form variables, rents and housing costs. However residential density is considerably higher and incomes considerably lower in the FTN; this coincides with higher housing values. Although modest because of small coverage, this FTN zone nevertheless displays similar housing affordability issues as in other metros. Households without a car and households with second-quartile (lower-middle) incomes are less likely to live within walking distance to the FTN.

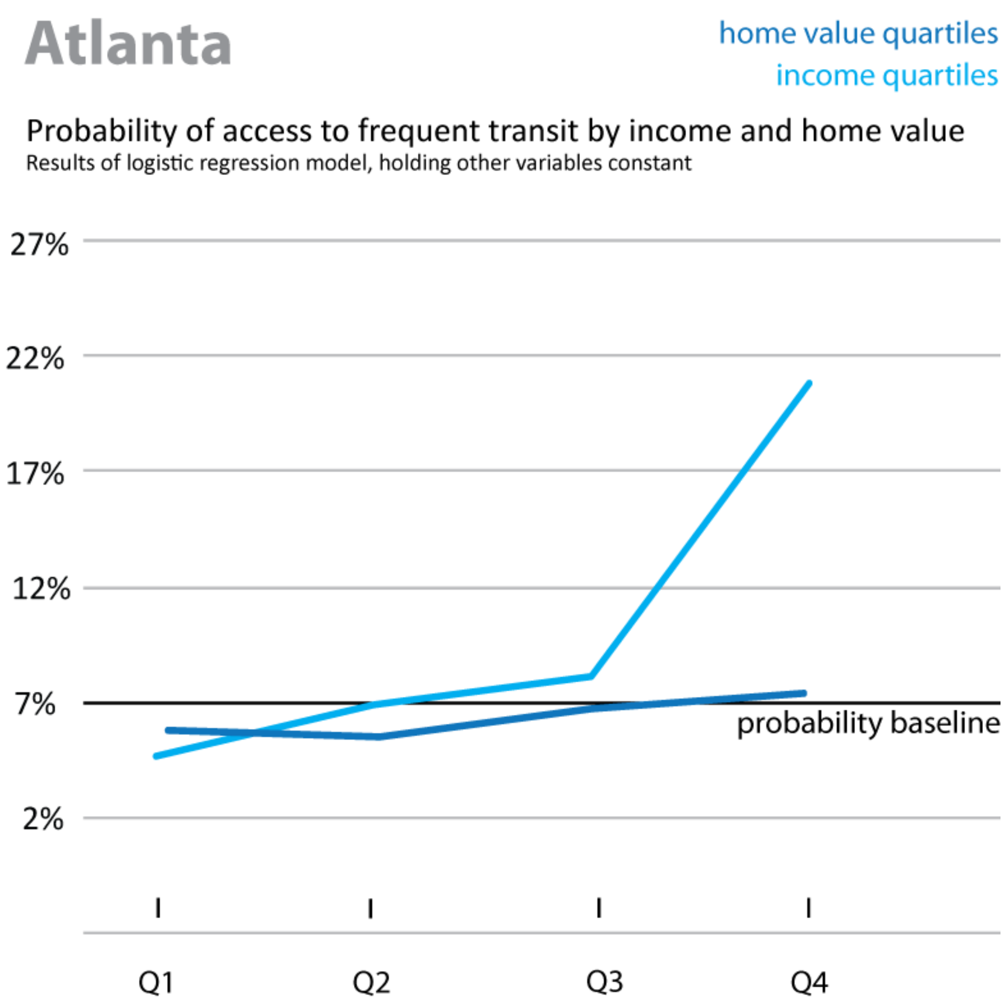
Atlanta (pop. 1.9 million)

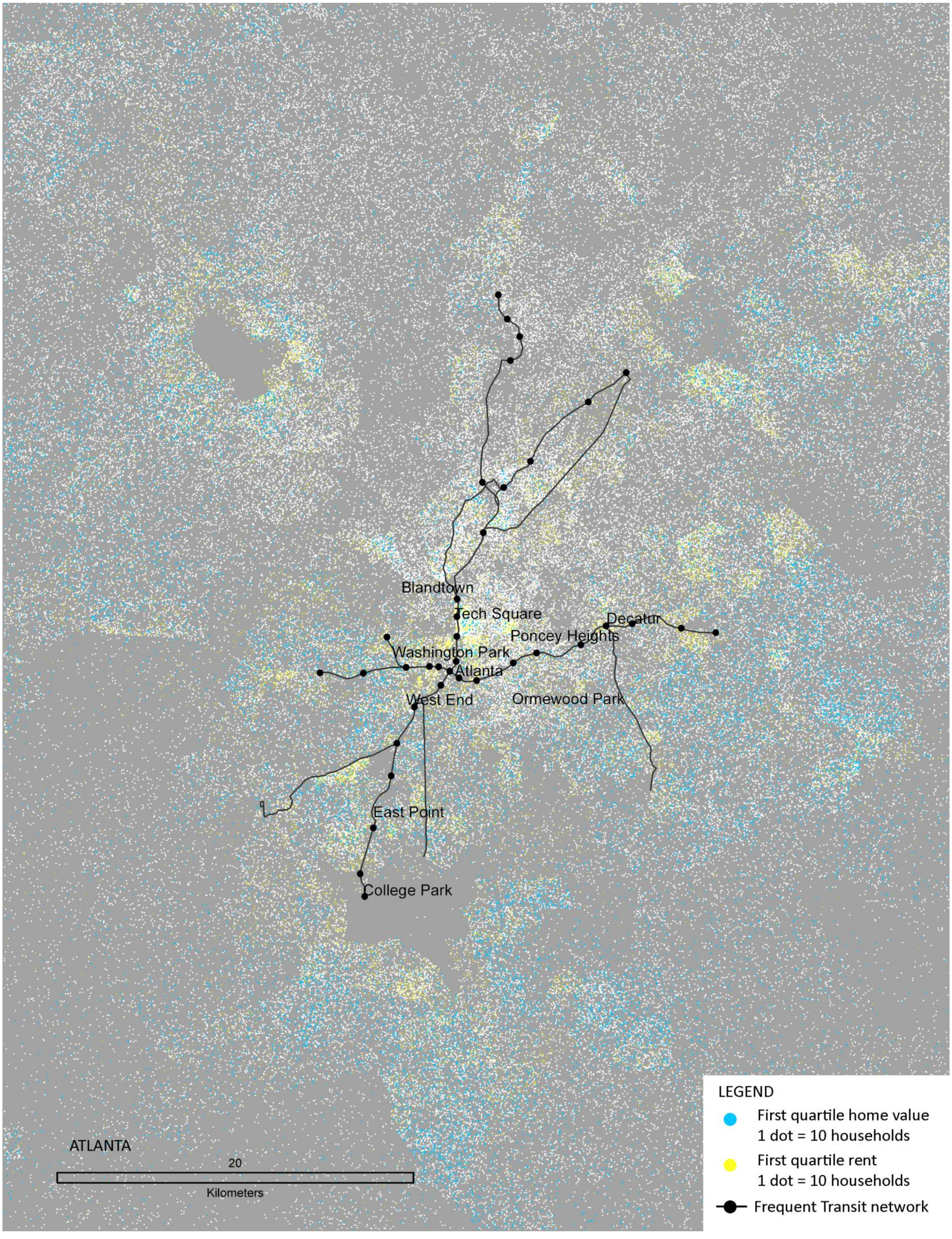
ATLANTA								
Logistic regression	Number of obs		1,822,686					
	LR chi2(14)	375542.62						
	Prob > chi2		0					
Log likelihood = -252806.84	Pseudo R2	0.4262						
	Incremental units	**Odds Ratio**	Std. Err.	z	P>z	[95% Conf.		Interval]
Transit commuters	+ 10%	**1.82**	0.008	142.27	0.00	1.80		1.83
Household income (median)	Quartiles							
	2	**2.16**	0.026	63.30	0.00	2.11		2.21
	3	**3.06**	0.055	62.08	0.00	2.96		3.17
	4	**24.34**	0.553	140.47	0.00	23.28		25.45
Home value (median)	Quartiles							
	2	**0.94**	0.012	-5.11	0.00	0.92		0.96
	3	**1.26**	0.017	17.63	0.00	1.23		1.29
	4	**1.49**	0.024	25.20	0.00	1.45		1.54
Age of building	10 years	**1.31**	0.003	101.27	0.00	1.30		1.32
Residential density	+ 1,000 people/km^2	**1.41**	0.004	131.86	0.00	1.40		1.42
Detached homes	+ 10%	**1.03**	0.003	11.71	0.00	1.03		1.04
Rental housing tenure	+ 10%	**1.26**	0.004	65.02	0.00	1.25		1.27
No car	+ 10%	**1.73**	0.006	148.78	0.00	1.71		1.74
Race (white)	+ 10%	**0.90**	0.002	-40.61	0.00	0.90		0.91
One-person households	+ 10%	**1.75**	0.006	166.34	0.00	1.74		1.77
_cons		**0.00**	0.000	-241.69	0.00	0.00		0.00

Odds ratios (graphed on a logarithmic scale)



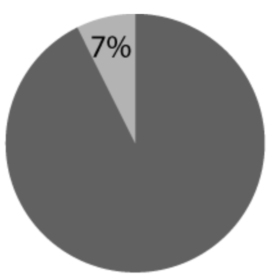
PREDICTIVE MARGINS (PROBABILITY)		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
CONSTANT		**0.07**	**0.000**	**450.31**	**0.00**	**0.07**	**0.07**
BY INCOME QUARTILES	1	0.04	0.000	234.20	0.00	0.04	0.04
	2	0.06	0.000	227.62	0.00	0.06	0.07
	3	0.08	0.001	152.65	0.00	0.08	0.08
	4	0.20	0.001	167.33	0.00	0.20	0.21
BY HOME VALUE QUARTILES	1	0.06	0.000	183.15	0.00	0.06	0.06
	2	0.06	0.000	147.70	0.00	0.06	0.06
	3	0.07	0.000	187.31	0.00	0.07	0.07
	4	0.07	0.000	179.18	0.00	0.07	0.08



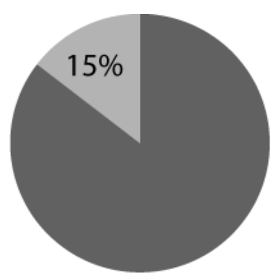

Blandtown
Tech Square
Decatur
Poncey Heights
Washington Park
Atlanta
West End
Ormewood Park
East Point
College Park
ATLANTA
20
Kilometers
LEGEND
First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network

ATLANTA: Statistics

			FTN Access					FTN Access	
Urban form & transportation	Units	Mean	NO	YES	**Socioeconomic**	Units	Mean	NO	YES
Residential density (people)	/km^2	1,268	1,142	3,021	White	%	46	47	38
Single detached buildings	%	66	69	39	Black	%	39	38	49
Rental tenure	%	34	32	55	Hispanic	%	10	10	8
Over 20 units in building	%	7	6	26	Asian	%	4	4	4
Median age of buildings	years	30	29	41	Other	%	2	2	1
Commuters by car	%	86	88	69	One-person households	%	29	28	48
Commuters by transit	%	5	4	16	Median rent	$ USD	998	1,010	859
Walking commuters	%	2	1	5	Median monthly owner costs	$ USD	1,408	1,393	1,601
Cycling commuters	%	0	0	1	Median value of owned unit	$ USD	216,915	213,128	266,292
Transit by bus	%	74	76	65	Median income spent on rent	%	33	33	33
Transit by subway/el	%	22	20	31	Median income spent on costs	%	23	23	25
Transit by commuter rail	%	3	3	2	Median household income	$ USD	61,806	62,546	52,473
					Income below the poverty line	%	15	14	26
Households with no vehicle	%	8	7	21	Income less than twice poverty	%	18	18	17



Households with FTN access



Lower-income (Q1) households with FTN access

Atlanta Notes

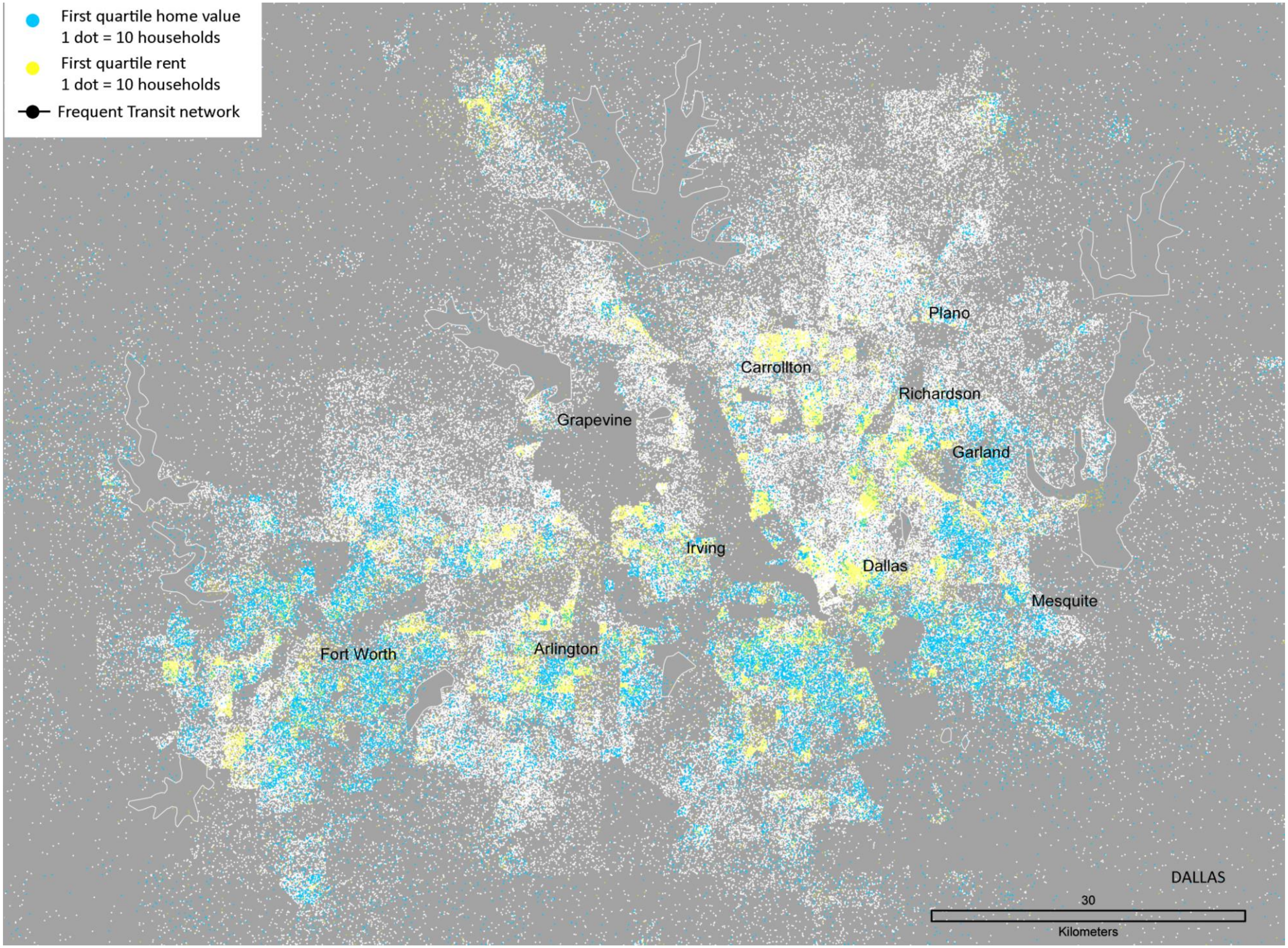
Low-density neighbourhoods of modest houses, some on streets without sidewalks, are a challenge for feasible frequent transit service. Despite this, Atlanta's MARTA (rapid transit) extends along north-south and east-west axes, meeting downtown.

Atlanta's FTN serves 7% of the population. However, Atlanta has higher residential density in the FTN zone, due to the large numbers of rented, high-rise homes in this zone. The FTN zone also contains many households without a vehicle, has higher poverty levels, and lower median incomes.

Even though owned homes are more expensive in the FTN zone, rent is less expensive, suggesting that affordable rental housing is aligned well with the frequent transit network and is a large contributor to the higher ridership rates in this zone. The transit commuting rate is much higher inside the FTN zone than outside it, an intuitive pattern that repeats in most metros, confirming the importance of frequency in attracting transit ridership. The logistic regression (next) reveals a more nuanced picture of the FTN, however. The likelihood of FTN access increases as income increases, and the top half of home prices are more likely to be in the FTN than outside it. This shows that the FTN zone serves both areas of affordable, high-rise rented homes as well as areas of high-income, higher-priced detached homes.

Dallas (pop. 3.5 million)

Because Dallas has no frequent transit lines, the metro-level variable means are the same as the mean in the area without frequent transit access. Dallas has very high car use and relatively low housing prices, as well as relatively low median incomes. Without an FTN, there is no outcome variable and logistic regression is not possible. The map shows that affordable owned homes are spread throughout the south and southeast of Dallas as well in nearby Arlington and throughout Fort Worth. The higher-density core of Dallas is not the site of affordable home ownership. Affordable rental units are generally in high-density clusters but these clusters are scattered in a fragmented pattern in the metropolitan region. The distances in this region are quite large. Any effective frequent transit network would face the challenge of this spread.



First quartile home value
1 dot = 10 households
First quartile rent
1 dot = 10 households
Frequent Transit network
Plano
Carrollton
Richardson
Grapevine
Garland
Irving
Dallas
Mesquite
Fort Worth
Arlington
DALLAS
30
Kilometers

DALLAS: Statistics

Urban form & transportation	Units	Mean	FTN Access NO	FTN Access YES
Residential density (people)	/km^2	2,306	2,306	
Single detached buildings	%	65	65	
Rental tenure	%	39	39	
Over 20 units in building	%	9	9	
Median age of buildings	years	33	33	
Commuters by car	%	91	91	
Commuters by transit	%	2	2	
Walking commuters	%	2	2	
Cycling commuters	%	0	0	
Transit by bus	%	78	78	
Transit by subway/el	%	8	8	
Transit by commuter rail	%	13	13	
Households with no vehicle	%	6	6	

Socioeconomic	Units	Mean	FTN Access NO	FTN Access YES
White	%	46	46	
Black	%	16	16	
Hispanic	%	32	32	
Asian	%	4	4	
Other	%	2	2	
One-person households	%	26	26	
Median rent	$ USD	945	945	
Median monthly owner costs	$ USD	1,310	1,310	
Median value of owned unit	$ USD	159,754	159,754	
Median income spent on rent	%	32	32	
Median income spent on costs	%	22	22	
Median household income	$ USD	58,644	58,644	
Income below the poverty line	%	15	15	
Income less than twice poverty	%	21	21	

Research findings analysis

A comparison of the results from individual metros allows for common trends to be identified. Although there is considerable diversity (of housing types, prices, and people) within FTN zones, there is a gap between access and affordability in many cities, where affordable housing, especially affordable home ownership, is not well aligned with frequent transit service. Although this misalignment is found in varying degrees in different cities, no city had a strong positive relationship between housing affordability and transit access once other variables are held constant. This is the key finding of this research.

The descriptive statistics tell a story of transit networks that cover areas of great diversity; a diversity of housing types, people, incomes, and lifestyles. These areas, often the older parts of cities covered by legacy transit systems, tend to have higher densities, more rental housing, and less vehicle dependency. In all cities, these FTN zones had a greater share of poverty and lower-income households; median household income in FTN zones is consistently lower than outside. However, the presence of lower incomes does not necessarily mean lower housing costs, especially in areas that have experienced gentrification. In many cities, the median housing costs were also lower in the FTN zone than outside it. This may reflect that homes outside of the FTN zone tend to be larger, but it would also seem to prove a correspondence between housing affordability and transit access. However, the difference between housing costs inside and outside the FTN is generally much slighter than the difference in incomes; and in some cities, housing costs are higher in the FTN despite much lower median incomes.

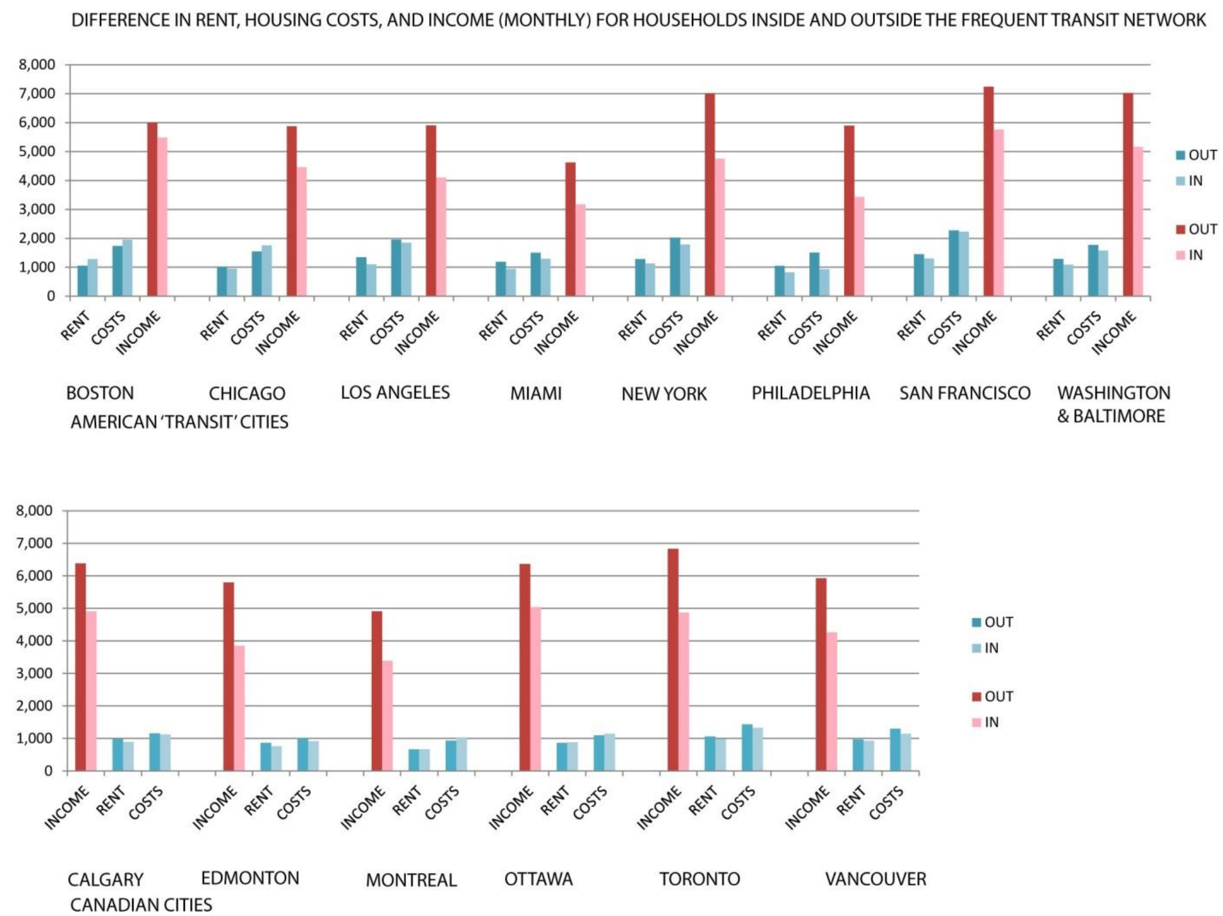


Figure 17: Greater variance in income compared to housing costs

The logistic regression confirms a discrepancy between incomes and housing costs in FTN zones. By holding income at the mean, housing costs are shown to rise consistently with the likelihood of transit access. Even in the most equitable city in this analysis, Philadelphia, which has the best alignment of transit network to affordable housing, once income differences and other variables are taken into account, the likelihood of access is steady as home prices rise. The logistic regression can reveal what is hidden at first glance in the descriptive statistics.

The maps fill in this story visually by locating the areas of affordable home ownership and rental housing in relation to transit networks. In most cities, segments of the larger auto-oriented city without transit access house the bulk of lower-cost home ownership opportunities, while affordable rental housing is more fragmented and scattered inside and outside the FTN zone.

Secondly, access to frequent transit networks mean different things in different cities. In strong transit cities, access to these networks unlocks large areas of the city in a much more affordable way than by car. However, in weak transit cities, frequent transit networks do not offer adequate coverage, and so access to the FTN in these cities may not mean greater affordable access to opportunity. The following section will look at the trends across cities in more detail.

Housing costs: Home ownership and transit access

How does transit access relate to housing costs? The direction of change in marginal probabilities for access to transit across home value quartiles offers the key to answering the research question. None of the cities in this research had a general and consistent downward trend in the likelihood of access as home values increase. Households who own a lower-cost home are less likely to have access to frequent transit networks, all else being equal, creating a tension between housing and transportation affordability. This is the major finding of this research.

There is some variation in the general upward trend of increased transit access as home values increase, all else being equal. The cities that had a consistent increase from Q1 to Q2 to Q3 to Q4 are New York, Washington-Baltimore, Montreal, Boston, Miami, Ottawa, and Calgary. The steepness of this rise varies, with the greatest rise being in Ottawa, where the difference of probability of transit access between Q1 and Q4 homes is a full 37 points. This is explained by the fact that the majority of Q1 housing in Ottawa is located on the Gatineau side of the river, where there are virtually no frequent transit lines. The next steepest rise is found in Montreal, with a 25 point difference in probability of access between Q1 and Q4. Again, this is a result of the majority of Q1 housing being found outside of the reach of the frequent transit network. The biggest inter-quartile jump in probability of access in both of these cities is between Q1 and Q2 housing. Miami has an 18-point rise in probability of access between Q1 and Q4, with the greatest difference between Q3 and Q4. This suggests that the FTN serves an area that includes more Q4 (expensive) housing than other types of housing, when all other variables such as income and age of housing are accounted for. The remaining cities had some small decreases between quartiles, despite overall rising trends. For example, in Los Angeles, the probability of transit access for Q1 homes is 21%. For Q2 homes, it dips to 19%, rises again to 22% for Q3 homes, and rises even more to 30% for Q4 homes, all against a baseline probability of 22%. In this case, the least expensive homes are slightly more likely than the next cost bracket up to have transit access, but the top half of home values have greater likelihood of access to transit than the bottom half. San Francisco is another example, where Q1 homes have a 27% probability of being served by frequent transit. Q2 homes have a 32% chance, while Q3 and Q4 decline slightly to 31% and 29%, respectively. In this case, second quartile homes have the greatest likelihood of FTN access, but first quartile ones still have the least likelihood. This is illustrated by the map, which shows large areas of costly homes in west San Jose that are not served by transit, and also many areas of Q1 homes south of Oakland and in multiple nearby centres such as Antioch and Pinole. Seattle has a similar pattern, where Q1 homes are least likely and Q2 homes are most likely to have transit access. The only city that doesn't have a clear overall rise in probability of transit access as housing costs rise is Philadelphia. Here, the pattern is as follows: 21-20-22-21 across the four quartiles. In this case, although Q3 has slightly greater likelihood of transit access and Q2 has slightly less probability than the baseline, there is little variation. In no case is there a clear overall decrease in probability of access across all quartiles, and this shows that housing affordability, at least when it comes to home ownership, has an accessibility problem.

The importance of using regression analysis to control for variables becomes evident when comparing regression results to descriptive statistics. For example, as discussed in the previous paragraph, the logistic regression model estimates the probability of access for the lowest-cost half of owned homes

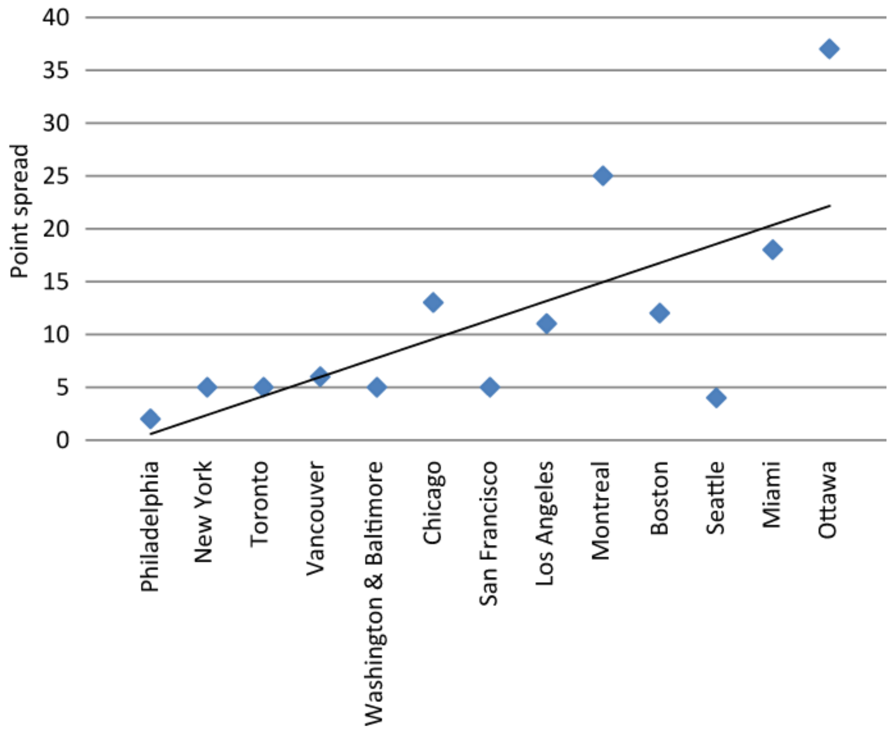
(Q1 and Q2) to be less than for the higher-cost half (Q3 and Q4), all else being equal, suggesting that there is an affordability issue in relation to transit access. But the descriptive statistics show that the median value for homes inside the FTN is often *lower* than outside it. Median monthly owner costs and rent are also sometimes slightly lower in the FTN than outside it. However, median incomes inside the FTN are generally considerably lower than outside with higher poverty rates inside the FTN than outside it. While the median home value is often slightly higher outside the FTN, the median income is often considerably higher. In this typical pattern, unsurprisingly, despite the cheaper housing, households in the FTN spend a higher percent of their income on housing costs and rent. When the logistic regression model accounts for this difference in income, the resulting probability of access by home value shows an affordability and access issue.

Rental housing is not included in the model due to constrained data. The maps show that there is often still Q1 rental housing available in areas with access to frequent transit, but that there are also underserved Q1 rental housing clusters. The pattern of affordable rental housing availability is more fragmented in most cities, scattered throughout the metropolitan region. This contrasts to affordable home ownership's tendency to be located in specific quarters of cities.

Equity of access by home value

The 'strong transit' and 'moderate transit' cities offer an interesting observation on the polarization of housing cost and transit access within metropolitan regions with decent to robust frequent transit networks. Figure 18 below shows cities in order of alignment, from Philadelphia with its good alignment between affordable home ownership to Ottawa, with its almost entire disconnection between the two. When this spectrum of alignment is charted against the largest difference in probability of transit access between different housing costs, a pattern is revealed. As the degree of misalignment between transit access and affordable home ownership rises, so does the difference in likelihood of transit access by housing costs. This is not intuitive: one would think that the difference in likelihood of transit access by housing cost would rise if transit and affordable housing were tightly aligned, as in Philadelphia. However, the better the access of transit to affordable home ownership in a city, the more equal the access across homes of all costs. This pattern suggests that when transit networks are aligned with affordable housing, it is generally in areas of mixed affordability and a diversity of housing options and costs. When transit networks are aligned with exclusively expensive areas, or avoid the most affordable areas altogether, the *overall* equity of access worsens – not just for low-income populations.

Figure 18: Point spread in marginal probabilities across home value quartiles



Housing costs and gentrification in FTN zones

Gentrification is a process that takes place over a period of time (see Chapter 1), and because there is considerable inertia in home ownership (people don't all move at once), it can be a slow process. A longitudinal analysis would be needed to definitively demonstrate the direction and pace of change. Because this research is only a snapshot in time, it is not possible to identify the process of gentrification. Without a longitudinal analysis, it would be difficult to differentiate gentrified areas from areas that were *always* wealthy and expensive. It is possible that housing costs have changed since then, given the impacts of the recession in the both countries.

So what do the numbers indicate? All FTN zones have lower median incomes, often considerably lower. This confirms the value of transit for lower-income households and in some cases the willingness to pay more for housing in exchange for savings in transportation costs, as has been demonstrated in previous research on the economics of transportation and housing trade-offs (Glaeser, Kahn, & Rappaport, 2008). Poverty rates are generally higher in FTN zones, and FTN zones are associated with older areas of cities and with urban characteristics like higher density and fewer detached houses. This confirms that a widespread 'suburbanization of poverty' has not yet occurred. However, the cost of housing in central cities is relatively high for many of the strong transit cities, and the combination of low incomes and high housing costs in transit-rich areas is a concern.

Some FTN zones also have slightly lower home values, monthly owner costs, and rents as well – for example, Los Angeles. This does not necessarily indicate that there is no affordability-accessibility issue in these regions. It *may* indicate either a less severe issue (as in Philadelphia) or a weak transit network (like some weak transit cities). However, these indicators should not stand alone without the regression analysis and wider attention to context. For example, Vancouver has some of the highest housing costs of all cities, highest of the Canadian cities. But there are a cluster of Q1 units in the False Creek area near downtown, well served by transit. These units are condos, and so offer much less space than other types of owned housing units. On a per-square foot basis, they are likely as expensive as or more expensive than suburban homes, and hold smaller household sizes on average.

Table 5: Median incomes, home values, monthly owner costs, and rent inside the FTN zone compared to outside it. A minus sign indicates a lower value inside the FTN; a plus sign indicates a higher value inside the FTN

	income	home value	owner costs	rent
strong transit cities				
Philadelphia	-	-	-	-
New York	-	+	-	-
Toronto	-	+	-	-
Vancouver	-	-	-	-
Washington & Baltimore	-	-	-	-
Chicago	-	+	+	-
San Francisco	-	+	-	-
Los Angeles	-	-	-	-
Boston	-	+	+	+
Montreal	-	+	+	+
moderate transit cities				
Seattle	-	+	+	-
Miami	-	-	-	-
Ottawa	-	+	+	+
weak transit cities				
Calgary	-	-	-	-
Edmonton	-	-	-	-
Minneapolis-St Paul	-	-	-	-
Pittsburgh	-	+	+	+
Houston	-	+	+	-
Atlanta	-	+	+	-
Dallas				

FTN zones with lower incomes but higher home values and owner costs are seen in Chicago, Montreal, Boston, Seattle and Ottawa (not including weak transit cities). This may indicates the potential for future gentrification, as people move out of the area and are replaced by households with higher incomes, more able to afford the higher cost of housing. However, this may also be interpreted as housing affordability stress, where lower-income households take on debt in order to purchase a home in the FTN zone. This indicates the value of transit as an amenity for lower-incomes households. Given the higher monthly owner costs, which reflect the size of mortgage payments, it may also indicate that households may be taking on amounts of debt whose servicing will weigh as a burden on them for years to come. The opportunity cost of taking on this amount of debt would be high, preventing households from accessing other goods and services of value that can contribute to a higher quality-of-life.

Three remaining cities, New York, Toronto, and San Francisco, have indications of potential for more rapid future gentrification across FTN zones. These indications include lower incomes, higher home values, and *lower owner* costs. Lower median owner costs would indicate households that bought their homes in the past when prices were lower, and/or have paid off most or the entire mortgage. These households, if they also have low incomes, could fit the expression 'house rich and cash poor'. When they do eventually sell their homes for a much larger amount they will move elsewhere, presumably where housing prices are less expensive, in this case most likely outside of the FTN zone. The people who replace them will need to have higher incomes to afford the higher cost of homes.

The patterns described in this section are characterized as indicating the *potential* for gentrification. Given the limits of this study, it is not possible to confirm for certain that gentrification is in process in the cities described above, although given the indications some extent of gentrification seems likely. Other research is tracking these trends. However, this research is able to demonstrate unequivocally the existence of housing affordability *stress* in FTN zones, through the combination of low incomes and higher housing costs.

Housing affordability stress is created when exchange value trumps use value of housing. The use value of homes in the FTN zone is greater for lower-income households, due to the proximity of transit; however, the exchange value is the value that sets the market price, and it will rise to highest level that the market can bear. In this case, higher-income households have a greater ability to pay for the rising exchange value of properties in the FTN, despite the use value of transit being worth relatively less to these households. This results in gentrification, without the ecological benefits of high transit use.

An obvious question arises given these findings: Why are housing prices higher in FTN zones, after other variables are accounted for? Is housing affordability stress in FTN zones a result of frequent transit service, or other trends? The former would indicate that the existence of frequent transit service in a neighbourhood would be enough to drive up the cost of housing in that neighbourhood to the extent of making the neighbourhood unaffordable for those who value the transit service the most. If this is true, then attempting to extend frequent transit service to affordable neighbourhoods would be an unsuccessful policy in the long run. The residents would benefit from rising prices by selling or renting out their homes and moving elsewhere. In this scenario, transit's added-value alone attracts higher-income households. However, given the extensive documentation of gentrification in the literature, along with global re-investment in major cities in the post-Fordist context, along with the proven relationship between low income and transit ridership, the higher costs in FTN zones are more likely a result of the coincidence of transit networks with older areas of the city, rather than a result of the presence of transit itself.

Insecurity of tenure

Rents are lower in the FTN zones of most cities, with the exception of Montreal, Boston and Pittsburgh. It is notable that Montreal and Boston have higher rental costs in the FTN, given that both cities have traditional urban fabrics of relatively spacious, low- to mid-rise stacked rental flats. This may indicate that rental housing stocks in other cities' FTN zones are less desirable, as rental units may be more likely to be older or smaller, or in basements of owned homes. Rents may be partially protected, as in Toronto, where landlords are limited to annual rent increases not greater than inflation for continuous tenants; however, if the tenants move out, there is no restriction on raising the rent as much as the market can bear for the next rental contract, and rented condo units have no rental protection at all. There may also be planning restrictions that require rental housing that is torn down to be replaced by equal numbers of rental units. These policies may help to keep rent costs down in FTN zones where a large number of rental units exist. However, these policies also have the impact of making the building of new rental housing less attractive to developers.

Rental housing stock is an invaluable source of affordable housing for in metropolitan regions, especially in FTN zones where the cost of owning a home is beyond the reach of lower-income households. Rental tenure is by its nature more vulnerable to change, however; tenants do not have the same rights and protection as owners. Where rents are low and/or protected, in shabbier buildings or post-industrial spaces, and where housing prices are rising to make the land more valuable, there is pressure to convert rental units to condos or other forms of owned housing. This is taking place in Montreal, where rental triplexes are now allowed by the condo act to be legally stratified and sold separately. In general, it is enough to say about rental housing in FTN zones that it provides an important source of affordable housing and that it is vulnerable to potential gentrification trends.

Security of tenure is less threatened in the case of home ownership, even though a mortgage may be seen as renting from a bank. The recent housing crisis in the United States has demonstrated through the high number of foreclosures and underwater mortgages that home ownership is also vulnerable in some circumstances. Whether there are possible policy options for governments to moderate the worst excesses of the housing market, or at least not encourage them through monetary and other policies, is discussed further in the following chapters.

Jurisdictional boundaries as a barriers to metropolitan-wide transit networks

Through the process of mapping frequent transit networks, it was observed that service discrepancies tend to follow jurisdictional boundaries with remarkable consistency in several cases. This is hypothesized to be because metropolitan regions with multiple municipalities and transit authorities would have greater difficulty coordinating transit services across these boundaries.

Ottawa is a good example of this, where Gatineau's transit system (Société de Transport de l'Outaouais) is run separately from Ottawa's OC Transpo. This separation of agency may explain the discrepancy between the wide coverage of the frequent bus rapid transit on the Ottawa side, compared with the dearth of frequent service on the Gatineau side. Other jurisdictional boundary examples include the New Jersey portion of Philadelphia, as opposed to the better served Pennsylvania side; Newark in the New York metropolitan context; Brampton and Mississauga in Toronto; Fort Lauderdale in north Miami; Gary, Indiana in the Chicago context; and the limits of the Société de Transport de Montréal to extend to neighbouring municipalities. This is by no means a complete or exhaustive list. Another related but slightly different phenomenon is one of fragmented systems, where the main central metropolitan network does not connect to frequent transit lines in neighbouring centres. Examples of this include Tacoma and Seattle, San Jose and San Francisco, Washington and Baltimore, Orange County and the Inland Empire and Los Angeles.

Examples of the opposite, where unified metropolitan governance and/or transit agency jurisdiction produces better regional coverage, can also be found. The City of Toronto is one such example, where the Toronto Transit Commission (TTC) extended services to inner suburbs like Scarborough, Etobicoke and North York with the creation of Metro Toronto (a second-tier regional governance structure) in 1954. Within the boundaries of the amalgamated City, there are still some service discrepancies where the older parts of the city were built around transit networks, but there is remarkable coverage of the inner suburbs by a grid of frequent bus routes. One other example is Calgary, which is a large unified municipality whose boundaries, until recently, contained its urbanized areas. In both cases, although the cities are small and the transit networks are not comprehensive, there does not seem to be the same kind of observable discrepancies in coverage across areas in these cities. This contrasts to similarly auto-oriented cities like Houston and Dallas, where the tradition of independent unincorporated suburbs is strong. A final case study is Vancouver, where a unified transit agency, TransLink, is responsible for covering the entire region; however, the municipalities are still independent. This tension may explain why the frequent transit network has been extended to some parts of neighbouring municipalities like Richmond and Surrey, but also why this coverage is not nearly as comprehensive or complete as in Vancouver proper.

The effect of jurisdiction and political or transit agency boundaries was not included as a variable in the logistic regression model. Nevertheless, it may influence the likelihood of frequent transit access. This question of political geography is worthy of further inquiry and attention, and fits within the ongoing debate on the efficacy and desirability of metropolitan-scale governance.

Differences between Canadian and American cities

It is clear from the data that Canadian cities have higher overall rates of transit use and transit accessibility, and more complete transit coverage. Some reasons for this could be in urban form differences, as Canadian cities tend to have overall higher urban densities and more mixed use development, which results in shorter trip distances. Canadian inner ring suburbs tend to be higher-density (Filion P. , McSpurren, Bunting, & Tse, 2004). The suburbs built in the last two decades of the twentieth century were similarly low-density and large houses across both countries. The housing built since then may have higher densities in some cities, depending on land use policy and plans. In both countries, government policy has supported home ownership, but an equivalent of the American mortgage interest tax deduction does not exist in Canada.

Urban form is not the only determinant of transit viability. Edmonton and Calgary both have relatively high levels of transit use and coverage compared to American cities of similar size and dispersed auto-oriented urban form. Other reasons for higher transit use may be the historically lower incomes in Canada, the historically greater redistributive role of taxes, and less 'white flight' and transit stigmatization. The costs of owning, driving and parking a car are also higher in Canada, due to higher duties and gas taxes as well as a greater willingness to charge for parking. These reasons were cited to explain the higher cycling rates in Canadian cities (Pucher & Beuhler, 2006) but could equally be applied to higher transit rates. In Canada, redistributive tax policies result in a more equal society. Rather than a severely poor transit-dependent underclass, Canadian transit users are more likely to have a spectrum of incomes. Although transit is stigmatized in Canada, it may be less so than in the United States. In some ways, Canada has been characterized as culturally located between Europe and the United States; a greater acceptance of public transit and other public amenities such as health care may support this view. On the whole, however, both Canada and the United States share a history of mid-century development around automobility to a much greater extent than other places in the world.

What remains: The affordable suburb without frequent transit access

If FTN transit-sheds have been confirmed as areas of housing affordability stress, then this research has also revealed the corollary, which is the affordable suburb without frequent transit access. While not every area outside of FTN zones is affordable, there are large areas of Q1 home values and affordable rental clusters outside of the FTN catchment in each of the metropolitan regions tested.

Urbanized areas without frequent transit service tend to be lower-density, newer, with more detached housing. These areas tend to have fewer rental homes, larger houses , higher car ownership rates, and to be less racially or ethnically diverse overall, especially in majority-white metropolitan regions. When these characteristics are combined with lower housing costs, what is the resulting demand and potential for frequent public transportation networks? This question will be addressed in the following section.

The importance of frequency

Where transit lines run frequently, people are more likely to use transit . The direction or causality of this relationship – whether transit lines run frequently where there are more transit riders, or people ride transit because it runs more frequently – is not known from these results. Both of these reasons most likely contribute to the explanation for these strong results. In some cities, this relationship is particularly strong. In Toronto, for example, for every ten percent increase in transit commuters in an area, the likelihood of proximity to frequent transit triples. If the research question was focused on this relationship, it would be interesting to run marginal probabilities in each city to see how the probability of access varies at different percentages of transit commuting. While this strong relationship between access to the frequent transit network and transit ridership may seem obvious, it confirms a basic assumption of the research. Route frequency makes a difference to transit ridership.

Comparison of control variable results across cities

The logistic regression tests relationships of individual variables to transit access, while holding all other variables constant. The likelihood of transit access rises or falls with the increase in each variable of the logistic regression. If the odds ratio is greater than one, the likelihood increases as the variable increases; if the odds ratio is less than one, the likelihood of access decreases as the variable increases. Tables 6 and 7 compare the direction of likelihood across variables and cities.

Table 6: The direction of logistic regression odds ratios for control variables, in "strong transit" metros. A negative sign is less likely to have transit access as the variable increases.

	Philadelphia	New York	Toronto	Vancouver	Washington & Baltimore	Chicago	San Francisco	Los Angeles	Montreal	Boston
Age of buildings	+	+	+	+	+	+	+	+	+	+
Density	+	+	+	+	+	+	+	+	+	+
Detached	-	-	+	-	-	-	-	-	-	-
Rental	-	-	-	-	-	-	-	-	-	-
No car	+	+			+	+	+	+		+
White	-	-	-	-	-	-	-	-	-	-
One-person hh	+	+	+	+	+	+	+	+	+	+

In all 'strong transit' cities, transit access likelihood is positively associated with the age of buildings. This confirms the hypothesis that the best transit networks are located in areas of the city that were built pre-WWII. In all cities, transit access likelihood increases with density as well. In all but Toronto, access likelihood also decreases with the percent of detached houses in a neighbourhood. Strikingly, in all 'strong transit' cities, transit access becomes less likely as the percent of rental housing in a neighbourhood increases. As discussed in the methods section, this variable is correlated with rental affordability. This result is discussed under the heading 'Rental housing concentrations'. Naturally, FTN access likelihood is positively associated with car-free households where this data is available. The results are consistent when it comes to neighbourhood-level racial or ethnic diversity; the more homogenously white a neighbourhood, the less likely it is to have frequent transit access. This speaks to the diversity of FTN zones, as noted. More one-person households herald higher likelihoods of transit access, which may reflect the housing types available in the FTN transit-shed. Other than the rental housing concentrations, these results are as expected and confirm the link between older, denser, areas with a greater housing type diversity and frequent transit access.

Table 7: Regression results for control variables in "moderate transit" and "weak transit" metros

	Seattle	Miami	Ottawa	Calgary	Edmonton	Minneapolis-St Paul	Pittsburgh	Houston	Atlanta	Dallas
Age of buildings	+	+	+	+	+	+	+	+	+	
Density	+	+	+	+		+	+	+	+	
Detached	-	-	-	+	+	+	-	+	+	
Rental	-	+	-	+	-	+	-	+	+	
No car	+					+	+	-	+	
White	-	-	-	-	-	-		-	-	
One-person hh	+	+	+	+	+	+	+	+	+	

In 'weak transit' and 'moderate transit' cities, density and age of buildings indicators are mostly as expected and the same as 'strong transit' cities, confirming that whatever frequent lines these city have are linked to the small older downtowns. However, the variation in direction for detached housing concentrations, rental tenure concentrations, and even no-car households (Houston) shows the more ambiguous relationship of frequent transit with traditional urban form attributes. In these cities, frequent routes can run through areas that were built around the car, and car-free (transit-dependent) households may not be served by frequent transit. As discussed, there are often too few frequent lines to make a true network, and outside of the downtown centre their alignment may have little support in terms of urban form. These variables are discussed individually below.

Legacy-based transit systems

In all cases, the frequent transit network is highly associated with older areas of the city. In most cases, age of residential buildings is a stronger predictor of FTN access than density. Because these results hold other built environment variables, such as density and detached housing, this adds confirmation to the assumption that transit networks are largely legacy-based in their location. Post-war transit network expansion has not kept up with auto-oriented urban growth. This is an important finding.

Density

In all cities except Edmonton, residential density increases the likelihood of transit access, even after accounting for the age of buildings and thus the likelihood of prewar buildings to have higher densities and be associated with legacy networks. This makes sense, and confirms previous findings in the literature on the relationship between density and transit ridership. The higher the density in an area, the more trip demand. This demand increases both numbers of potential transit riders as well as increasing traffic congestion for drivers. More transit riders can support frequent transit routes. Edmonton may have frequent routes in low-density areas. The map confirms that the Edmonton LRT does not run through the high-density, western side of the downtown, but does extend into suburban areas to the north and south of the downtown. This would explain the negative sign for density in these results.

Single-detached housing

In the majority of cities, FTN access decreases as the proportion of detached homes increase in an area. This is an expected and intuitive result, given that areas of detached homes also tend to be mono-residential and not mixed use. The exceptions are Toronto, Calgary, Edmonton, Minneapolis- St Paul, Houston, and Atlanta. Of these, only Toronto is in the "strong transit" cities category, with a robust transit system. The rest are "weak transit" cities, where mono-functional detached residential neighbourhoods are more of the norm, and so large sections of FTN lines inevitably run through these areas. The explanation for Toronto may be that the old 'streetcar suburbs' of Toronto include many detached houses, and the inner suburbs like Scarborough and Etobicoke have large areas of small, detached veteran's houses. Both these types of neighbourhoods are served by frequent transit, with the inner suburbs being covered by frequent bus routes along major 'big-block' arterials.

Rental housing concentrations

This variable measures local concentrations of rental tenure: in each Block Group or Dissemination Area, the percentage of non-vacant residential units that are rented as opposed to owned. Rental units can be in purpose-built rental buildings or rented from owners. High-rise rental buildings house large numbers of people, enough that groups of these buildings can form their own Block Group or Dissemination area, which would have 100% rental housing. Higher rental housing concentrations are associated with lower incomes and with lower car ownership rates (see Appendix C: correlations). These areas would be more supportive of frequent transit networks than other residential areas, and so one would expect to find a positive sign in this variable, because this category of city is defined by its relatively robust transit network. However, the results show the opposite: for all "strong transit" cities, an increase in percent of rental housing means a decrease in the likelihood of transit access, after other variables are accounted for. A possible reason for this unexpected outcome could be that suburban areas have larger developments of a uniform type and less mixing of housing types. A dissemination area or block group would be more likely to have all rental housing or all single-family detached.

It should be noted that the logistic regression rental tenure variable only measures the percent of rental tenure in the groups or areas, and so doesn't reflect overall tenure mix inside and outside of the FTN-shed. For this, the descriptive statistics are needed. They show that, in all "strong transit" cities, the percent of rental housing inside the FTN is considerably higher than outside it. For example, 44% of the occupied housing units in Toronto's FTN zone are rented, while only 16% of units outside this area are rented, with the rest being owned. This coincides with the maps, which show higher concentrations of rental housing in areas covered by the FTN than in areas not covered. Older cities have a greater diversity of housing types, while post-war suburban areas are often largely composed of single-detached houses.

On the one hand, individual Block Groups (average population 1,425) or Dissemination Areas (average population 635) with higher rental tenures are less likely to be in the FTN; on the other hand, the overall area served by the FTN has much higher rental tenure mix than areas not served. How can this discrepancy be explained? The most probable explanation is that rental housing inside the FTN is less likely to take the form of a large-scale purpose-built rental neighbourhood development, and more likely to be mixed in with owned housing units, perhaps as attached or mid-rise dwellings. This would mean that areas inside the FTN have more even shares of rental and owned housing. Outside the FTN, having an urban form with more detached houses, lower densities, and post-war development, rental housing would tend to be more often found in larger clusters, or not at all. This would explain the discrepancy.

See Appendix F for a Toronto case study, where large numbers of high-rise rental towers were built in the inner suburbs. This is an exception to the generally low-rise suburban areas of most North American cities.

Car ownership

As expected, households without vehicles are more likely to live in FTN zones (in all cities but Houston), even after controlling for income, density and other variables. This confirms the ability of frequent transit service to free households of the financial burden of owning and operating a private vehicle, and reflects a deliberate choice by car-free households to prefer areas with better transit service. The exception of Houston may show that in low-density, auto-oriented cities, where frequent transit networks do not offer effective mobility because of small coverage areas, households without vehicles face mobility challenges regardless of their location relative to frequent transit.

Racial and ethnic diversity

Within neighbourhoods (BGs and DAs), some cities have greater racial diversity inside the FTN[4], and others have greater diversity outside of it[5][6]. This could be explained by the relative mixity vs. segregation on a neighbourhood-by-neighbourhood scale. This may be a phenomenon dependent entirely on how the neighbourhood census boundaries are drawn, a good example of the "modifiable area unit problem" in mapping where results can change based on boundaries and scale. However, it is likely that some of this segregation is real. Observers who mapped census data have noted that some eastern seaboard cities are known for clear racial boundaries in downtowns where other cities tend to have a more of a "blur" between boundaries, with transitional areas being more mixed (Rankin, 2010; Fischer, 2011). The reality of neighbourhood segregation and the existence of "ethnic enclaves" are not unexpected.

However, comparing *overall* diversity inside and outside the Frequent Transit Network, all but three cities have a greater balance of ethnicities within walking distance to frequent transit. Only Los Angeles,

[4] New York, Toronto, Washington & Baltimore, Montreal, Ottawa, and Minneapolis-St Paul
[5] Philadelphia, San Francisco, Los Angeles, Boston, Miami, Calgary, Edmonton, Pittsburgh, Houston and Atlanta
[6] Chicago, Vancouver, and Seattle had no clear conclusion on intra-neighbourhood diversity, because the results differed for different races and ethnicities.

Miami and Atlanta are more balanced outside of the FTN; inside the FTN, Atlanta's population is 49% African-American, and both LA and Miami have majority Hispanic populations (58% in Los Angeles and 63% in Miami). New York, San Francisco, Chicago, Philadelphia, Houston, Washington and Baltimore have FTN zones with no one racial majority (over 50% of the population). The remaining cities have majority white populations both inside and outside the FTN zone, but in all of these cases the FTN zones are more diverse. This confirms Elijah Anderson's characterization of public transit as part of the public space that functions as a 'cosmopolitan canopy', where people of different races and ethnic backgrounds share space, if not conversation, with people different than themselves (Anderson, 2011).

The results also show a consistent relationship between the white homogeneity of an area and a decreased likelihood of access to transit, when other socioeconomic and built environment variables are held constant. Two reflections could be drawn from this observation. The first is the continued association of white privilege and exclusivity with automobility, and the concurrent racialization of public transit. The second is the thought of white suburban populations with a culture and expectation of automobility who are faced with affordability stress.

Household size

All cities showed an increased likelihood of transit access for areas with higher percentages of one-person households, all else being equal. This is not surprising, given that one-person households cannot share the cost of owning and operating a car with other household members, and so may be more reliant on public transportation for mobility. Also, housing units in suburban areas may be less suitable for single adults, as they would need a larger detached house with multiple bedrooms.

Research Summary

This research was designed to test for affordable accessibility in Canadian and American metropolitan regions. Multiple methods using data from the American Community Survey and Canadian Census in GIS and statistical software were able to triangulate an answer to this question. These included a spatial analysis that mapped frequent transit networks against neighbourhood-scale geo-referenced data to determine accessibility, descriptive statistics comparing the built environment and socioeconomic characteristics inside and outside of this FTN zone in each city, and a logistic regression model run for each city that queried the relationship of home value to transit access, holding other variables constant.

The twenty metropolitan areas were subdivided into two different typologies based on the results, with one transitional typology. Ten cities had robust frequent transit networks that covered a relatively large percentage of households. These ten cities were organized to show the degree of alignment between frequent transit networks and areas of affordable housing, ranging from good alignment to almost no connection; these were called 'strong transit' cities. Seven cities had limited frequent transit networks and majority areas of auto-oriented urban form. These were classified as 'weak transit' cities. They still demonstrated spatial polarization of housing prices, with some areas being more affordable than others, but their transit systems do not offer a realistic alternative to the car. The remaining three cities were 'moderate transit' cities, that fall somewhere between 'strong transit' and 'weak transit' cities.

The results showed FTN zones were generally associated with older areas of the city, as predicted. The characteristics of these mostly pre-war areas are higher densities, fewer detached homes, and a greater mix of rental and owned tenures. Unsurprisingly from a transportation perspective, these areas have lower car ownership rates and higher transit commuting rates. Socioeconomically, these areas have lower incomes, higher poverty rates, and mostly greater ethnic and racial diversity. Housing affordability, however, did not align with these trends as might have been expected. In all cities studied the probability of transit access did not improve as home values decreased across 4 quartiles, when other variables are accounted for. Even in cities with minimal degrees of misalignment between housing affordability and transit access, the probability of access at best stayed steady (Philadelphia) and in other cases rose (Toronto and New York) as home values rose. In general, as the degree of misalignment increased, the steepness of this difference in probability of access also increased. This demonstrates housing affordability stress in areas of frequent transit networks, with greater stress in cities where the misalignment between affordability and accessibility is more pronounced.

The research question was based on two possible counter-hypotheses. The first hypotheses posited that frequent transit systems are well aligned with affordable areas in metropolitan regions. This hypothesis assumes that frequent transit networks continue to serve the majority of lower-income populations. A counter-hypothesis is that frequent transit networks are not well aligned with housing affordability in metropolitan regions. The results show that although FTN networks still serve a substantial number of lower-income populations in many cities, housing affordability is no longer well aligned, in most cases, with these networks. There are indications, namely low incomes combined with high home values, that these FTN zones are producing housing affordability stress that could result in a combination of gentrification (and restrictively high household debt) and the suburbanization of poverty. For low-income households who don't already own or rent an affordable home in an FTN zone, and for those who must move, this poses an affordability paradox. These households must choose between affordable transportation and affordable housing. Areas of affordable housing come with the added cost of owning and operating a car in order to meet mobility requirements.

Frequent transit networks are mainly legacy systems and have not kept up with suburban growth and change, but instead remain mostly anchored to older areas of cities. There are some frequent routes that serve newer areas, but the service in suburbs is greatly inferior to that in older urban areas. No city had networks that could offer complete metro coverage, and almost half did not have 'networks' as much as a small collection of frequent routes, or none.

Each of the three different methods for empirical analysis of the built environment, transit access, and socioeconomics – namely, descriptive statistics, logistic regression, and spatial analysis through mapping – have revealed a different side of the story. The descriptive statistics confirmed the continued value of transit systems to lower-income households. The logistic regression, by holding built environment and socioeconomic variables constant, revealed a housing affordability issue in transit-accessible areas in most cities with strong transit systems. The maps show the existence and locations of the affordable, auto-dependent suburbs in many of the cities evaluated.

Chapter 4: Implications

Strategies for affordable access

The above research demonstrates a decreased likelihood of frequent transit service in areas of affordable home ownership in almost all of the cities studied. It confirms an affordability alignment issue, where some suburbs have become more affordable than older areas with good transit service. This points to the suburbanization of poverty, and poses a problem. If transit is aligned with more expensive housing options in North American cities, the mobility of households and the effectiveness of transit networks are threatened. This chapter describes what a suburban transformation to enable affordable accessibility might look like, from an auto-oriented urban form to a hybrid, networked realm of strategic intensification and transit service. It observes the characteristics of this space and proposes strategies for transit and land use that could apply to this particular urban form, in order to achieve a better alignment of affordable access.

Visions of networked intensification

This speculation is not the territory of this dissertation alone. Many researchers, designers and thinkers have wondered about the transformation of the mid-century suburb (City of Surrey, 2009; MOMA, 2011; BIG, 2010). The visions call for the intensification and urbanization and simultaneous greening of the suburbs through 'landscape infrastructure'. These designs echo those of utopian visionaries like Ebenezer Howard (Garden Cities), Frank Lloyd Wright (Broadacre City), and le Corbusier (Ville Radieuse) who were responding to the industrial city and whose ideas were influential in creating modern (mid-century) cities and suburbs. This time the focus is on the transformation of the inner suburb, rather than the creation of it through the automobile-enabled escape from the city. Some scholars see a 'post-car' transformation that responds to various influences that 'tip' the system of automobility into something different:

> This system of the 'post-car', commencing in some societies in the rich 'north', would consist of multiple, dense forms of movement including small, light, smart, probably hydrogen-based, de-privatized 'vehicles' electronically and physically integrated (seamlessly) with many other forms of mobility. In this post-car system there will be a mixed flow of slow-moving semi-public micro-cars, bikes, many hybrid vehicles, pedestrians and mass transit integrated into a mobility of physical *and* virtual access. Electronic tolls will regulate access, price and speed. Neighbourhoods will foster 'access by proximity' through denser living patterns and integrated land use. Systems will promote electronic coordination between motorized and non-motorized transport, and between those 'on the move' in many different ways. The cool way of travelling will not be to own to but access small, light mobile pods when required. (Urry, 2004, pp. 35-6)

What is common in these visions is the hybrid nature of the transformed space; not a city, or a suburb, but something of both that becomes something new. In a more prosaic version, regional land use and transportation plans call for the strategic intensification of parts of the extended, suburban realm (Long range plans, page 185), with a focus on nodes and corridors (Filion & Kramer, 2012; forthcoming). In many cases, the plans are to strategically intensify parts of the dispersed realm. The resulting hybrid realm, presumably, would be different in many ways than existing prewar downtowns because these new networks of centres and corridors will be *superimposed* over an auto-oriented dispersed realm, rather than replacing it. In this case, the challenge is whether or not this hybrid realm is functionally possible, given super-block structures, separated zoning, and a number of other suburban characteristics. This may be considered a new type of urban transformation, comparable to when previously concentrated transit-oriented downtowns were remade for the automobile. It would be a type of suburban (dispersed) form with urban (concentrated/centralized) characteristics. This new hybrid form would not be *centralized* as much as *networked*. The accessibility gradient would look not like one large centralized cone (the central city) or a flat uniform surface (the suburb), but rather a grid or network of peaks at nodes and along corridors.

> The outcome of such recentralization strategies in a primarily dispersed urban environment would take the form of islands of centralization in a sea of dispersion. There would be one large island, the downtown, and smaller ones dispersed throughout the metropolitan area – in the form of lower order centres. As such this configuration would do little to invigorate the centralized realm. But if interconnected by quality public transit and corridor-type development, centres could amount to a realm, which we name 'networked centralization', superimposed over the dispersed urban realm. Networked centralization would thus differ from traditional contiguous forms of centralized urbanization consisting of the downtown and adjacent inner city areas. The critical mass of residents and activities achieved by networked centralization would encourage further development within this realm, thus launching a virtuous growth cycle. The metropolitan-wide appeal of the networked centralization realm would grow with the expansion in the number and range of opportunities it offers across the metropolitan region, and thereby assume increasing importance within this hybrid – dispersed/networked centralized – urban form (Filion, Kramer, & Sands, 2013).

This transformation requires both land use intensification and growth management in combination with the expansion of frequent transit networks and cycling/walking infrastructure that can compete with the car. It is therefore dependent on some public sector investment as well as private development. The forces influencing these possibilities include a public reluctance to build more roads and other infrastructure to service greenfield development, as well as growing preferences for urban lifestyles in generations X and Y, who have accumulated less wealth than previous generations.

Historically, the auto-centric nature of transportation systems in North America, combined with transit's design around the commuter, has excluded a number of demographics, including women, home-makers, shift-workers, old people, and children. Due to demographic factors (aging populations) and changes in the nature of work and communication technology, the transportation needs of this society are continuing to transform. However, the underlying structural urban form over which these socioeconomic and demographic changing mobilities are happening remains largely bound by the 'spatial fix' of the era it was built in; for the suburbs, this means a particular landscape that has not been designed, originally, for public transit and its complementary modes like walking and cycling. Just as the pre-war city was adapted to the automobile, the post-war city will need to be reconfigured to meet new realities, needs and lifestyles. However, the nature of the underlying fabric and its inherent characteristics need to be recognized, so that the urban solutions are not simply copied and pasted onto a suburban context. Highways destroyed urban neighbourhoods when they were inserted in the 1960s and 70s because of a lack of sensitivity to the way these neighbourhoods worked. It is important that this mistake isn't repeated in reverse in the post-suburban context. The question of how this should be accomplished should be the subject for further theorization, design, demonstration projects, and public debate.

The lack of flexibility of suburban form is an issue. The ability of suburban form to respond to more transit-oriented intensification is debatable. The wideness of arterials combined with the super-block spacing offers potential for rapid transit grids, with intensified nodes and room for dedicated lanes. The width of roads inside the superblocks offer potential for layering on better bicycle and pedestrian infrastructure, although these alternative modes must be protected from speeding cars. The zoning in low-density residential areas often does not allow for intensification, and the 'spatial fix' of separated land uses may not be easily changed.

In many ways, the concentrated realm offers a built environment more suitable to transit service, and the historical link between transit systems and older areas of metropolitan regions remains strong today, especially in the industrial cities whose significant construction took place before the automobile became ubiquitous, cities like New York, Boston, Chicago, Philadelphia, Toronto, and Montreal. These older cores of metropolitan regions grew up with and were built around public transit systems. New York is perhaps the penultimate example; the construction of an extensive subway network allowed the extreme densities of Manhattan to be decanted to surrounding boroughs, whose own densities are also quite high. The subway network remains a competitive way to get around because of these high densities, offering rapid access to even far flung areas of the surrounding boroughs. If everyone drove, the congestions would cause glacial gridlock and make movement impossible.

The dispersed, post-war city often does not have the aspects of the built environment that complement transit ridership. Even where density thresholds are met, the pedestrian infrastructure and street network permeability are often missing (Filion, 2001). The superblock structure surrounding residential cul-de-sacs, the separation of uses and employment clusters surrounded by parking lots are generally not considered amenable for transit service. Where density exists in a post-war format, it often takes the modern shape of the 'tower in the park', le Corbusier's auto-centric ideal of high-rises surrounded by parkland and without the mixed use and streetscape urban fabric that animates downtowns. For this reason, and because it is easier to service existing lines than extend new ones, transit agencies have been caught in a sort of inertia with respect to matching service levels with densities and potential demand in newer areas. If transit can discover a new logic of public transportation for a suburban context, adaptation to the actual conditions in a changing suburbia becomes more likely.

Despite the perceived and actual unfriendliness of the suburbs to public transit, this 'dispersed realm' offers different aspects of the built environment that may be capable of transformation into a transit-oriented realm in a different way than downtowns. Unlike the narrow streets of the old city, where precious width is fought over by various modes and unable to support wider sidewalks, bike lanes, dedicated lanes for rapid transit, and automobile traffic simultaneously, the wider arterials of suburban areas have greater potential capacity. Even if they are currently congested, these arterials could support higher number of travelers if alternative modes, which take up less space per traveler, were layered on to the network. The superblock structure, with few opportunities for mid-block interruptions of flow, could actually make for faster travel times between stops. If the main intensification happens at the intersections of these super grids, the prized green space, larger parks and bigger backyards inside of the superblocks could also be preserved. Rather than burying the rapid transit underground in subways, surface rapid transit with dedicated lanes like bus rapid transit (BRT) or light rail transit (LRT) is more visible in the public eye; this visibility can help make the transit network more present and legible for potential riders, especially if the dedicated lanes allow rapid transit to move at speeds similar to cars. If the density and socioeconomics are present and favorable for transit, then regardless of the era of construction of the urban form or the particular organization of the street network, transit has potential.

In the imagining of these plans and potentialities for suburban transportation, there has not been an explicit discussion of socioeconomics, particularly geographies of affordability. Transportation and land use strategies specific to these geographies of affordable suburbanism are addressed in this chapter.

The culture of automobility and the stigma of transit

Another consideration is cultural. The suburbs are a built manifestation of the Fordist marriage between the car and the single-family home, and this powerful symbol of middle-class autonomy may continue to resonate and exert attraction even as the mid-century middle class becomes something altogether different. Attitudes about driving influence driving behaviour. Research shows that even though many people wish other people would drive less, they themselves enjoy driving and choose to drive even when they do not need to (Handy, Weston, & Mokhtarian, 2005; Mokhtarian, Salomon, & Redmond, 2001). Those who drive more tend to live in lower-density, suburban areas and have a pro-driving attitude, showing that travel behaviour, attitude, and the built environment are mutually reinforced (Bagley & Mokhtarian, 2002).

Public transit remains a public space of diversity, and it is possible that some potential riders could, at least initially, find this to be a challenge. Transit is still widely stigmatized in the North American context, and car-drivers, even those with money worries, may resist taking transit. In Toronto, modes of transportation have been politicized and cars have been tied to an inner suburban, modest home-owning population who voted against transit and to end 'the war on the car' along with a 'roll-back' neoliberal agenda. It is possible that the owners of these modest homes are determined to defend the system and culture of automobility, even as their role in this system (in the form of well-paid auto manufacturing jobs) is threatened. In many ways, the trends described by this research snapshot reflect structural issues of inequality, income polarization, and socio-environmental-spatial transformations[7], and market failures and structural global economic issues cannot be fully or solely addressed through the tools of urban planning.

However, there is some evidence that preferences and habits can change. Handy et al (2005) found that even though attitude explains travel behaviour in the present, changes in the built environment can

[7] For a more in-depth discussion of these structural issues, see Rosen & Walks, 2013; Walks, 2012; Walks, 2013, among others.

influence mode choice over time. These long-term elasticities show that if transit-supportive land use and transit supply are present, driving culture has the potential to transform, over time, into a more balanced modal split.

Equity in Planning Practice

Transportation Planning Practice

Transportation planning practice is the art and science of predicting the demand for transportation and planning transportation infrastructure to meet this projected demand. Transportation planning practice has begun to recognize the influence of the built environment on transportation demand, in response to the large body of research on this subject (see Appendix A). Despite being known to be influential, the relationships between transit demand and socioeconomic geographies like income and housing affordability have been under-researched. The standard transportation planning process may echo this devaluation of socioeconomics in its process. It has been hypothesized that this is possibly because transportation planning is a technically driven process and methods have not been developed to translate the idea of transportation disadvantage into the transportation planning process (Deka, 2004). As this research demonstrates, however, technical methods are quite capable of incorporating these considerations; instead, it may be that the language or justification for doing so has not been well developed or accepted.

Historically, some transit agencies emphasized the 'choice rider' and ran programs with the goal of converting current car commuters to public transit. Although a transit agency's assignment is also to serve non-car-owning populations, the use of the language of 'choice riders' vs. 'transit dependent' reveals which are preferred customers. The use of this language may be lessening. Economics are an important reason for transit ridership. Until transit networks offer access that is comparable to the car – both in terms of time and spatial coverage – it will not capture the bulk of middle class ridership (unless there is an extreme rise in fuel prices). Until then, transit agencies are as dependent on their core customers as the 'transit dependent' *are* dependent on transit. These populations will always be a vital part of the transit system, even if the system is able to improve service levels to the point of attracting riders with greater choice.

There may not be such a sharp line separating 'transit dependent' riders from 'choice riders' either, especially given the larger structural changes such as growing inequality and income polarization, the loss of manufacturing jobs, and the growth of the poorly paid service economy. Transit planning tends to be hesitant about mentioning the economic underpinnings of people's transportation choices, preferring to think of everyone as a potential transit rider and to establish taking transit as a normative choice. In this way, public transit is re-framed as an environmental issue, ignoring how public transit's most dedicated users are not environmentalists, but the poor. Transit planners may wish to avoid the economic motivations for taking public transit as a way of escaping the class stigmatism associated with transit, rather than embracing the core users as an important ridership constituency.

The methods of the transportation planning process, as currently practiced in North America, are interrogated below with reference to the question of how they incorporate socioeconomic influences on demand.

Choosing projects: Assessment tools

The first methods to interrogate are how transit projects are chosen in the first place. The first, cost-benefit analysis, commonly used to compare potential transit projects, can lack a spatial dimension and do not include distribution or ridership considerations (Murray & Davis, 2001). The second, impact assessments (such as environmental assessments) that are commonly required of projects before they are approved consider the distribution of inconvenience, e.g. construction noise, on specific populations and neighbourhoods. They do not necessarily consider the demand side or the equity benefits from extending service to lower-income neighbourhoods. Both of these methods could have the flexibility to incorporate these considerations, if those doing the assessments and analysis considered these issues important enough, and data was available to track the socioeconomic benefits and impacts.

Funding projects

The source and structure of funding for transit projects often influences which projects will be built, and where. Federal transit subsidies in America have not always been weighted to maximize ridership, although that may be changing with the FTA 'new starts' program. Instead, the focus is on the number of miles covered rather than the frequency or efficiency of those routes (Garrett & Taylor, 1999, pp. 16-17). The American federal government has different rules for funding capital costs of highways than transit projects. Highways are funded 80 to 90 percent federally, while approved transit projects are generally funded around 50 percent (Beimborn & Puentes, 2005). The rest of the funding for transit projects relies on local property, sales or income taxes that are often decided by referenda and compete with other public programs for funding. Cities compete against each other for transit funding, and each project needs a congressional sponsor to secure an earmark, as well as the demonstrated ability to operate and maintain their project into the future (Ibid). Transit projects need to be justified by measures of cost effectiveness, and the project needs to be compared to other alternatives and studied and reviewed extensively. Highways have a much more streamlined path to approval and funding, and much less justification is required.

In Canada, there is no dedicated funding for public transit at the federal level; instead, the federal and provincial governments contribute on an ad-hoc basis, without reference to a national transportation strategy. Given the long-term planning and large capital costs involved in building transit projects, there is a need for a consistent and reliable funding source for these types of projects.

Transportation demand modeling

One of the main tools used to determine which projects are recommended, both in terms of road infrastructure and transit service allocations, is the multimodal four-step transportation demand model. It is the current standard of practice in North America, taught in universities and used by transit agencies. This model incorporates socioeconomics into the prediction of mode choice and transportation demand. It takes current patterns of transportation behaviour from a survey of the population and constructs a model. This calibrated model is then used to forecast future demand, given growth trends. Unfortunately, this process first suppresses demand from lower-income households and only later, in the third step, assigns mode choice to households based on socioeconomics. This may have the effect of underestimating the potential demand for lower-cost modes of transportation (transit and active modes) of lower-income households.

The first step is trip generation, which uses socioeconomic and land use data to determine the number of trip origins and destinations in each small traffic analysis 'zone'. More trips are allocated to higher-income households than lower-income ones. In transport studies, it is generally held to be true that higher income people tend to make more trips and travel greater distances (Zacharias, 2005, p. 335; Handy, 2006). The reason for more mobility with increased income could be attributed to the fact that higher-income people may have more places to go, or that the cost of travel restricts lower-income people from traveling as much as they would otherwise (suppressed demand). A reliance on non-automobile forms of transportation in North America generally implies a time penalty, which means shorter distances are covered in the same amount of time and therefore fewer trips can be made (Clifton & Lucas, 2004). It is quite possible that both of these reasons account for the difference in travel demand by income. The second step distributes trips by matching origins with destinations. The third step assigns mode to each trip. This step acknowledges that income and other socioeconomic factors will influence the mode of travel. It assigns higher rates of public transit and walking trips to lower-income households, as the evidence shows. In some cases, no socioeconomic data is incorporated at all; in others, proxy variables for socioeconomics like vehicle ownership are used instead of income. For example, in the Greater Golden Horseshoe EMME model used in the Toronto region, the model is calibrated using data from the Transportation Tomorrow Survey, which has vehicle ownership but no income statistics. Finally, the fourth step assigns particular routes through the network for each trip.

The possible problem with the order of these steps is that the model first suppresses demand for travel by lower income households, and only after that assigns these trips to have higher transit rates. Hypothetically, if these lower-income households had good accessibility by public transit, trips would no longer be dependent on a car, and because of the reduced cost of travel by transit and the savings from not having a car, they would make more trips. If lower-income areas were well connected by transit, then the transit network would be gaining riders making trips that otherwise *wouldn't have happened.* It is unclear if the model is able to account for this possibility.

This hypothetical gain in transit ridership would not necessarily improve congestion in the metro area, because none of these trips were taken from the auto mode share. This may be why this suppressed demand is not estimated into the demand model. There may be good reason to release untapped travel demand for poorer households: trips mean more economic activity and opportunity, and access to the city. This released demand for transit would also mean higher ridership for transit agencies, and more fares to support operating costs.

The four-step demand model has been critiqued from other perspectives, particularly for not being capable of estimating the decrease in per capita trips by car due to the built environment characteristics of intensification, which allow shorter trips, as well as more trips by foot and bicycle as well as transit (Cervero, 2006). The four-step travel demand model, while fairly rigorous at guiding highway investment, "remain largely insensitive to changes in land use and transportation policy" (Bartholomew & Ewing, 2009, p. 13) and was "never meant to estimate the travel impacts of neighbourhood-level smart growth initiatives" (Cervero, 2006, p. 285).

Techniques for transportation demand models are possible to take into account the ridership bonus from transit-oriented development and other land use elasticity. This is sometimes addressed through post-estimation adjustment of the travel demand estimates. Transit agencies can go back and re-assign some of the trips in these areas to alternative modes, to reflect the synergy that results from these built environment characteristics being planning around alternative modes. This has become a well-accepted way of dealing with the shortcomings of the four-step demand model. Given the importance of socioeconomics to transit ridership, and the suppression of trip demand by lower income households before actually assigning mode in the four-step demand model, perhaps there is an opportunity for some post-estimation tweaking similar to what is done for the built environment inputs, using spatial socioeconomics. This would take into account the combined impacts of urban form with socioeconomics to adjust estimated demand for travel by transit in these areas. Plans and recommendations could be changed accordingly.

Another alternative is to use spatial analysis methods like the one in this research to determine how well transit systems are serving lower-income populations. Where transit agencies don't have the resources to do regular travel behavior surveys, the socioeconomic data from the American Community Survey will be available every year (bundling the previous five years into a statistically significant summary). These data are free and available at a disaggregated scale with a statistical validity that is impossible with privately run surveys. It also has variables that include residential built environment factors as well as household income, poverty levels, housing costs, and vehicle ownership. This data could be incorporated into route planning without too much complexity. This data, along with the tools to use it, is now more accessible than at any other time. For example, one can now store, map and analyze data from the entire US census on a personal computer. Large metropolitan regions like New York have established departments (Office of Policy and Strategic Planning) that analyze the multiple databases available to improve the efficiency and effectiveness of government services (Feuer, 2013). This use of 'big data' could also be applied to check the alignment of transit systems with various socioeconomic and built environment characteristics.

Researchers are working on new types of demand models that are much more complex, based on behaviour at the scale of the individual household or person. These are known as 'activity-based microsimulation models' (Roorda & Miller, 2006). This type of model requires incredibly detailed survey data on travel behavior, and so far is limited to university research centres as many transit agencies lack the time and resources to develop them. This type of modeling could improve the understanding of travel behaviour and help transportation planning to tailor services and modes to actual behaviour in a very specific way. The increasing availability of geo-spatial crowd-sourced data from cell phones and possibly automobile GPS systems could also be incorporated into better models, if privacy concerns can be addressed. While these are not yet embedded in practice, they are the next wave of adjustments to travel demand models.

Long range plans

Long term plans for regional metropolitan transportation and land use, looking ahead towards 20- or 30-year horizons, are standard practice in most large cities; in fact, a Long Range Transportation Plan, prepared by a Metropolitan Planning Organization, is required in the United States in order for a metropolitan region to receive federal transportation funding. While coordination between transportation and land use plans is difficult, given that land use decisions are under local municipal jurisdiction while major transportation investments rely on funding and approval from higher levels of government, the importance of coordinating land use with transportation infrastructure is mentioned in many of these plans[8]. There is a trend in these plans towards encouraging various aspects of 'smart growth', including transit-oriented intensification, mixed use and built form designed for multiple alternative modes of transportation. Of the strategies mentioned in plans, the focus is on multi-modal improvements and on focusing development around transit (See Appendix G).

Environmental justice is the third-most-cited reason for encouraging transit-oriented development and smart growth, after air quality and congestion. It is mentioned in 84% of the long range transportation plans surveyed, most likely because this consideration is required by law (*Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*, passed in 2005 and awaiting update). However, the mandatory mention of environmental justice usually refers to how the negative externalities of transportation projects are distributed, at the most comprehensive, and does not extend to considering socioeconomics when planning public transit improvements. The prevalence of transit-oriented development and smart growth strategies in these plans demonstrates that this approach is given an important role by planners in addressing issues of climate change, congestion, possible fuel shortages or higher fuel prices, and air quality. The connection between environmental justice and targeting improved multimodal service to low-income areas, however, is not made in any of these plans – the focus is on encouraging new development in older areas, rather than extending alternative transportation service to areas of higher demand. It would seem that the first strategy of intensification would be more difficult than the second, which would achieve a more immediate ridership bump without requiring lifestyle changes from the more wealthy residents of metro areas.

Adjusting route frequency and technology to ridership demand

Shorter term route planning tools are used by transit agencies to consistently adjust route frequencies based on ridership. Although they do not include socioeconomic data in their analysis, given the attention paid to ridership and matching supply tightly to demand, these planning exercises may actually have a greater response to socioeconomic need. These processes do not determine new route locations, but regularly (usually at least twice a year) assess the ridership on all routes by counting –

[8] Based on unpublished 2009 research by Pierre Filion and Anna Kramer that assessed the content of land use and transportation plans from Canadian and American metros with populations of over one million, and interviewed planners involved with the organizations who made these plans. See Appendix G for more details.

automatic passenger counters or even by people trained to count passengers and levels of crowding – and re-adjusting headways to not waste any fraction of service-hours unnecessarily (Dawson, 2012).

Because there are normally maximum headways applied to the entire network (half hour or hour headways, for example), the frequencies of routes with little demand cannot be cut beyond a certain point. Unfortunately, then, the service adjustment process tends to focus its tight service-to-need tailoring on popular and crowded routes, with an emphasis on squeezing maximum efficiencies out of available resources rather than being generous with service on crowded routes to allow for some passenger comfort and 'breathing room'. Reaching maximum crowding levels on busy routes is the goal, in order to save money on drivers and extra vehicles along these routes. The perverse result of this type of service review is to make the high-demand routes a more unpleasant and uncomfortable way to travel than lower-demand routes.

Vancouver's TransLink, the regional transportation planning agency, uses a fleet of smaller buses, called 'community shuttles', on routes that have less demand. This allows them to have higher frequencies on these routes than they could otherwise afford if they were running full-size buses[9]. This also allows them to run service on routes that would not otherwise have service at all. These smaller buses can also be used to phase in a new route. One example[10] is a route in Surrey, which has regionally affordable housing in an outlying community which is linked to Vancouver by a SkyTrain station in the Surrey Centre. The route was identified by transit planners as having the potential to support frequent service, but full-size buses that ran frequently on this route were only half full. Rather than cutting the frequency, the planners decided to run community shuttles (half-size buses) on the same schedule. They also advertised the route's frequency through direct mail flyers delivered to homes along the route. The smaller buses soon filled up and eventually were replaced with larger ones. This time they were full. This demonstrates that flexibility along with marketing to create awareness of route frequency can build up demand along potential routes.

Similarly, articulated buses are often used on heavily subscribed routes to add capacity without adding extra drivers. Where there is not enough road space to support a dedicated-lane BRT or LRT, but high demand for transit, these articulated buses, used frequently, can carry a large number of people. This is another way of tailoring service capacities while maintaining efficiencies, without causing crowding.

Land use planning practice

Research has demonstrated that plans and policies align with outcomes in Vancouver, Toronto and Calgary (Taylor & Burchfield, 2010). In Calgary, where land use plans have favored contiguous suburban-style development, the development outcomes have matched. Vancouver, where plans have encouraged residential transit-oriented intensification, has experienced the greatest intensification in recent years. This suggests that there is a strong link between plans and development outcomes, but it may not be one-directional. A review of the plans in all cities included in this research shows

[9] Having two types of vehicles in a fleet might also add complications, though. Labour costs should also be considered.

[10] This example was shared with the author by a transportation engineer at TransLink, while the author was working as a student transportation analyst there in 2010.

considerable presence of ‘smart growth’ and alternative transportation concepts (Appendix G). Interviews with planners revealed that this metropolitan-scale land use planning is entirely voluntary in the American context, where a greater priority is placed on local ‘home rule’, and that this may limit the application of these concepts. However, the presence of a metropolitan-scale coordinating body, together with federal programs that fund local-scale smart growth initiatives like complete streets, can encourage conversation on these ideas and introduce these concepts in areas where they are not part of the lexicon.

There is often a lack of housing type variety in post-war suburban form, where neighbourhoods tend to have a more uniform and homogenous built form, due in part to restrictive covenants and zoning bylaws that shape the types of housing that are allowed. Other researchers have pointed out the potential inflexibility of suburban form shaped by restrictive zoning (Lee & Leigh, 2007; Levine, 2006).

Splintered urbanism

Political boundaries often define the limits to where transit agencies operate, and these boundaries do not always match the growth patterns or the socioeconomic need in a region. Multiple transit agencies often serve one metropolitan region, and this poses a problem of coordination. This fragmentation of agency negatively impacts the ability to provide a seamless regional transportation service. It is often the suburban transit agencies and municipalities that have a more limited ability to provide transit service. Metropolitan-scale transit service, whether achieved through the cooperation between agencies, one unified transit agency, or a regional-level government, is necessary in order to respond to changing socioeconomic geographies on the metropolitan scale. However, in many cases, cities are seeing increasing fragmentation of services, politics and social geographies. This has been called ‘splintered urbanism’ (Graham & Marvin, 2001), and refers not only to infrastructural differentiation, but a general unevenness and disconnectedness between areas in the same regional metropolis. In the North American context, this can be related to socioeconomic polarization in cities (Walks, 2007; Hulchanski, 2010) and the general post-Fordist differentiation of suburbs combined with a neo-liberal disinvestment in public infrastructures and a populist rejection of taxes.

Transportation strategies

The most obvious transit strategy to improve affordable access is to extend the frequent transit network into the affordable suburban areas. Given the relatively low cost of LRT and BRT compared to subways, there is a possibility for expanding Frequent Transit Networks so as to ‘saturate’ areas of high demand and thus abate the gentrification effect. Using buses and Bus Rapid Transit to improve service frequencies takes advantage of the existing road network. An extension of the FTN goes a long way to solving the problem of affordable access. The nuances of this strategy, such as how it responds to suburban land use issues and what technologies of transit to use, are addressed below.

There are strategies to re-design transit service to serve suburban areas (Pucher, 2004). Polycentric systems link suburban nodes together rather than relying on the radial hub-and-spoke to the central city. Orienting development around these nodes and providing timed transfers could result in ridership gains. Transit systems that have already shifted to a polycentric route network performed better than most CBD-focused systems, with larger increases in ridership per capita, more passengers per vehicle, and lower operating costs per passenger mile in a comparison of 9 transit systems between 1983-1998 (Thompson & Matoff, 2003).

Bus Rapid Transit and Light Rail Transit

If a route has enough demand to support BRT or LRT, and enough road space for dedicated lanes, these technologies can offer several benefits over local bus routes that run in mixed traffic. BRT and LRT on dedicated lanes become a form of rapid transit, able to travel at faster speeds, especially if stops are spaced far enough apart. If demand for transit was established, BRT and LRT offer aspects that would be ideal for suburban arterials:

1. Width
   Unlike pre-war urban streets that can be narrow and where there is often legitimate conflict for space between modes of transportation, suburban arterials are wide and spacious, designed for high car volumes and speeds. This wider curb-to-curb distance has more flexibility for incorporating alternative modes. If some travelers change from cars to other modes, there is room to add dedicated lanes for transit and separated bike tracks for cyclists, at relatively little engineering cost compared to other options like widening streets.

2. Super-grids
   The fine, dense grids of pre-war urban form encourage local walking and offer alternative, quiet routes for cyclists. However, on higher-volume streets, this density of intersections slows down traffic considerably, with stop signs and stoplights but also at unmarked intersections as traffic crosses or turns. This intersection density makes achieving speed difficult for transit that runs in mixed traffic. Transit vehicles in mixed traffic are vulnerable to every possible delay, from cars that parallel park, to car traffic, to cyclists and pedestrians. Even dedicated-lane transit poses difficulties by preventing traffic from turning into side-streets. Post-war suburban form, however, is built around arterials that form a super-grid, typically one kilometer spacing, with fewer mid-block interruptions to traffic flow. While this makes mid-block pedestrian crossing difficult, it also has the potential to allow for BRT and LRT to travel rapidly between major intersections. Intensification at these intersections could make them into a linked series of nodes, and if these transit stops at major intersections are integrated well with alternative modes like walking and cycling, then a person can continue their local journey from these nodes.

3. Transit visibility and route legibility
   In dense urban centres with a fine street grid where larger streets are often retail destinations, the most convenient place to run frequent transit, given enough demand, is underground or elevated in the form of subways or elevated rail. While these technologies remove rapid transit from the difficult spatial conflicts of the ground-level streetscape, they also hide them from view and require enormous logistical and structural support at great cost. Along suburban arterials, there is sufficient space to run rapid transit ‘at grade’. Even after moderate to medium intensification, the densities in these areas are generally not sufficient to fill the capacity of subways or elevated rail, and thus it is difficult to justify the cost, unless the underground rapid transit is used for express cross-regional travel. Because LRT and BRT run at street level, they

have the benefit of being visible and obvious. Suburban arterials also follow clear, straight trajectories, allowing for route legibility. Together with frequent network branding through route colours or names, along with maps and real-time next-vehicle arrival times posted at stops, this can reduce traveler uncertainty, especially for those unfamiliar with how to use transit.

This visibility also works from the perspective of those inside the vehicle, who can look out the window to their surroundings while in transit. This, together with wireless access through cell phones, which is often inaccessible underground, can make for a more pleasant journey. Passenger who can see their surroundings are also less likely to get disoriented or miss their destination.

Although BRT and LRT are both dedicated-lane rapid-transit systems that are made more efficient by pre-paid boarding (boarding through all doors), they also offer different capacities and drawbacks. Bus rapid transit has higher capacity than local bus routes in mixed traffic, but not as much capacity as light rail transit. Bus rapid transit is less expensive to implement from a capital costs perspective, but requires more drivers per passenger volume. Operating cost then depends on ridership volumes, with LRT becoming more efficient for higher volumes and BRT for medium volumes. Bus rapid transit ideally requires the construction of separated lanes and in-line stations that offer pre-payment and bus-level boarding. In addition to all of these things, light rail requires tracks and overhead wires as well as a storage yard for trains, which add cost to construction. Bus rapid transit systems can be upgraded to light rail systems when ridership demands this transition. LRT is more permanent and may also offer a smoother ride; given its added expense and capacity, it is best justified by higher ridership volumes. For affordable suburban areas that are beginning to intensify and build ridership, BRT may offer the best option as a starting point. It has the advantage of being less expensive and permanent and so may be better suited to political situations where metropolitan regions are not ready to invest large amounts of money on an untested idea. As discussed in the next section, it also might induce less of a price increase in surrounding lands compared to LRT, and therefore preserve affordability.

Design and marketing transit networks

At present, transit agencies do virtually no marketing. In the case of transit, the purpose of marketing is not as much to sell a product as to make designing transit networks to be more convenient and increase awareness. There are a number of possibilities to do this. The first is to map and promote frequent transit networks. This will show people where they can go without having to resort to a schedule. Simple strategies like mailing information on a new route to homes in its catchment can also be effective. Other methods of accessing information on routes and schedules are posting maps at stops to show where a route goes and how it connects with other routes, and real-time GPS-based arrival times posted at stops. Providing real-time information at transit stops and stations has the potential to increase ridership (Litman, 2008). In addition, the quality of transit facilities at stations can also attract new riders (Brons, Givoni, & Reitveld, 2009).

Providing GTFS data to Google and other web developers can allow people to access apps on phones to plan routes and see schedules more conveniently. System-wide smart cards can make fare payment more convenient, and can also be used to pay for linked transportation modes like rented bicycles and cars. Branding frequent and rapid routes with their own colours or names, and simplifying routes to run intuitively along major arteries can also improve the visibility and legibility of the network.

Complementary infrastructures for walking and cycling

Cycling has been demonstrated as a mode that is ideal for trips under 5 kilometers (Pucher & Buehler, 2012). It has the benefit of being inexpensive with low barriers to entry; most people in North America already own a bicycle and know how to ride. In addition, habitual cycling for utilitarian purposes is a way of building in moderate exercise to people's routines. Moderate exercise of 30 minutes daily has been shown to improve health outcomes, preventing or mitigating a range of problems like cardiovascular disease, diabetes and obesity (Ibid). Cycling thus has a way of combating two related social inequities: health and mobility, whose opposites tend to be disproportionately distributed across low-income populations. In a suburban context, where frequent rapid transit would run along major arterials with stops at super-block intersections, bicycles would be a good way of completing the journey. Cycling infrastructure to facilitate this would include bike parking at transit stations, cycle tracks protected from traffic along dangerous streets, and possibly capacity to take bikes on transit vehicles (Ibid). This infrastructure is inexpensive compared to other types of transportation infrastructure, but is necessary to allow for safe cycling in these auto-oriented areas. Alternative routes along greenways like hydro corridors, rivers, or parallel to highways could also connect origins and destinations if they are integrated into the cycling network. Research has shown that where infrastructure exists to protect cyclists from cars, the numbers of cyclists are dramatically higher, with a greater gender balance (Ibid).

Similarly, walking is both healthy and free. Walking is ideal for trips under one kilometer, although it is possible to cover much larger distances by foot. Pedestrian infrastructure includes crosswalks, sidewalks, and painted lines on parking lots to alert cars to pedestrians. Intensification can improve the pedestrian experience by providing nearby destinations as well as visual interest. Station area design can also improve pedestrian and cyclist access.

Together, walking and cycling provide important local mobility and access to destinations. . In order to unlock the potential of this complementarity, urban design and infrastructure is needed to help to make walking and cycling safer and attractive. They are necessary to solve the 'last mile' problem, where frequent transit routes are present but residential locations are nearby but not immediately adjacent to these routes, especially in environments that create unintentional barriers to walking and cycling by being designed exclusively for cars. They are ideal modes to be combined with frequent transit for farther destinations. The cul-de-sac and traffic calming street designs within suburban residential superblocks are ideal for biking, as long as connections are made from cul-de-sacs to nearby streets to allow cyclist and pedestrian access.

The concept of 'complete streets' describes a road that facilitates transit, cycling and walking, in addition to travel by automobile (Laplante & McCann, 2008). In some cases, completing streets involves widening sidewalks, adding bike lanes and crosswalks, and installing bicycle parking and street benches. This kind of street redesign is a good opportunity to plant street trees for shade and aesthetics, making streets more attractive for pedestrians as well as offering environmental benefits.

Land use strategies

Affordable housing near frequent transit service would improve mobility choices for nearby lower-middle income suburban households, but this investment should strengthen rather than undermine the geographies of affordability. Research on the impacts of transit investment on land and home prices is reviewed, to answer the question: Is it possible to increase transit access without inducing gentrification? Strategies for affordable transit-oriented development are outlined.

Preserving existing affordable housing in FTN zones

Affordable housing can refer to both publicly funded and provided housing options as well as market-rate housing in the private sector[11]. It is difficult to build new affordable housing projects in transit-rich downtown areas for a number of reasons, including a general disinvestment in subsidized housing programs and the rising cost of land in these areas. Existing public housing projects run by institutions like Toronto Community Housing and the New York City Housing Authority often face large repair deficits, as structures age and the budget does not cover the costs of sufficient upkeep. This neglect can threaten the existence of these important stocks of existing affordable housing, in areas that often have long waiting lists and high demand for units. The federal and provincial or state governments could improve equity and re-balance the unequal impacts of the market economy by using a number of different tools to make affordable housing in transit-rich areas possible.

Preserving private rental housing can be achieved by requiring any units that are destroyed in the process of redevelopment to be replaced either as part of the new development or on a nearby site. Inclusionary zoning requires new housing developments to include a certain percentage of affordable units in the development. Tax breaks for investment into real estate trusts that specifically built market-rate affordable rental or owned homes could also stimulate construction, given the right economic circumstances. Government can also partner with non-profit housing developers to offset the cost of land near transit for affordable housing development. Some transit agencies consider leveraging transit access for the development of affordable housing in appropriate densities as part of their Land Value Capture strategies. These tools will need to be strengthened and adapted to be implemented effectively.

Affordable transit-oriented intensification

'Transit-oriented development' (TOD) is a strategy to intensify mixed-use development around transit stations, intersections where one line crosses another, or along transit corridors. These developments can include a range of housing types, like condos and townhouses, as well as shops and other amenities within walking distance. Although these units may be less expensive than a fully detached unit in the surrounding neighbourhood, they are nevertheless often not 'affordable' for transit-dependent populations.

These TODs may be attracting residents who already own cars and who move to the development for reasons other than transit access. A survey of households who moved to California TODs showed that

[11] Most housing is supported in some way by government programs like mortgage insurance.

only one-third reported access to transit as one of the top three reasons for choosing their location (Lund, 2006). In a study on how and to what extend TOD influences household expenditures on transportation in the San Francisco Bay area, there were small elasticities between TOD characteristics and transportation affordability, but some TOD characteristics also increase housing costs (Xin, 2011). Although in general, residential proximity to rapid transit increases the likelihood of residents to take transit, in areas where the TOD housing prices are expensive, ridership levels in these developments can actually be *lower* than in surrounding areas farther away from the station, for example in Long Beach TODs along the Blue Line in Los Angeles. “The Blue Line has a very high level of ridership (approximately 67,000 riders per day), largely because of its proximity to lower-income, transit-dependent populations. The surveyed residential TODs, however, are not low- or moderate- income housing and are thus less likely to be attracting transit-dependent residents (Lund, Willson, & Cervero, 2006, p. 253). This demonstrates the importance of affordable housing for transit-oriented development to be able to achieve its purpose of shifting mode through intensification around transit.

Reports on the combined burdens of housing and transportation costs on moderate income households focus policy recommendations on providing affordable housing in ‘location-efficient’ areas, near transit stations and job centres (Hickey et. al., 2012; Lipman, 2006).

One of the biggest barriers to adding higher-density affordable housing in both urban and suburban contexts is the protection of ‘stable neighbourhoods’ through zoning bylaws which forbid intensification in order to preserve the character of the area. These bylaws are often supported by neighbourhood groups representing existing residents, especially homeowners. These bylaws do not take into account the demand for housing from potential residents of the neighbourhoods. The demand for more entry-level housing combined with a limited supply drives up prices in these neighbourhoods. Even in areas where high-level policy and plans suggest intensification, along transit corridors or at transit nodes, these areas are not necessarily zoned ‘as-of-right’ to allow for intensification, so developers considering must request a zoning amendment, which involves public consultation. Neighbourhood homeowner associations are often more organized and proactive in protesting against such developments than are the potential new residents, and the result is that these zoning amendments are sometimes not approved.

Toronto’s ‘Avenue’ plan is a good example of this dynamic. The City of Toronto has identified transit corridors that they have designated as ‘Avenues’, along which they recommend mid-rise (6-8 stories) intensification. Because these avenues are not already zoned ‘as of right’ for midrise development, most developers who go through the trouble of applying for a zoning amendment will increase the density of the proposed building to high rise; since they are going through the expensive and time-intensive process, they might as well get a higher return on investment. Toronto is currently seeking to address this issue by proposing to zone all designated avenues for midrise, as of right, to make it easier for developers to build midrise while still adding a procedural barrier to high rise development.

Residents of the San Francisco Bay Area were asked to identify their preferred neighbourhood type, based on photos of different types of development (Cervero & Bosselman, 1998). Although the overall preference was for low-density neighbourhoods, the study showed that higher densities were chosen when amenities, like shops and community centres, were present. Communities can be made more supportive of transit and physical activity through the strategic location of amenities like schools and neighbourhood parks along transit corridors and in centres (Brownson & Boehmer, 2004).

Even if zoning is changed to allow intensification around transit, this does not guarantee development or affordability. New development itself is not usually more affordable, as the incentive for the developer is to sell to upscale markets that can bear a higher cost. This luxury incentive could be balanced by incentives or motivations to develop more affordable housing, like tax credits, density bonuses, favorable financing, or a mandate on the part of a non-profit or public sector developer.

Inherently affordable housing types

Housing prices have been found to decrease with proximity to multi-family residential units (Song & Knaap, 2004). Multi-family residential buildings, especially rental buildings as opposed to condos, can through their very structure and tenure function as inherently affordable. In this way, high-density market apartments can establish security of tenure for lower-income, renter populations (Shaw, 2005), as these types of units may be less attractive to higher-income households, for whom home ownership offers an opportunity for investment. Some types of housing are more gentrification-proof than others; multistory apartment buildings compared to row houses, for example (Walks & August, 2008; Ley & Dobson, 2008). In a discussion on the Bronx, the New York Times Magazine noted that compared to Brooklyn and Queens, "[the Bronx] became, by the late 19th century, a haven for immigrants attracted to (but unable to afford) Manhattan. The borough developed far fewer wealthy areas, and many neighbourhoods became devoted to less-gentrifiable housing units", and remains less prone to high housing prices, despite being a subway ride away from Manhattan (Davidson, 2012). The inclusion of high-density rental housing is one strategy for maintaining affordability around transit. Because density increases are often zoned around new transit stations, this strategy could be an important part of new transit development. Of course the role of affordable housing is not the complete answer; as income polarization continues, progressive income redistribution through income taxes and/or better incomes in service jobs will continue to play an important role in equity and access.

The strategy for intensification of affordable housing aligned with frequent transit nodes and corridors in suburban areas recognizes the importance of access to transit as a way of minimizing the economic burdens on lower-income households and allowing greater mobility and freedom for the members of these households. These developments could include a mix of housing types and price points, with some being more inherently affordable than others. The addition of higher-density mixed use along arterials that have introduced transit and at intersections of major frequent transit routes would have the benefit of expanding the types and tenures of housing available in what is otherwise a fairly homogenous urban form with large areas of detached residential housing. The addition of transit along arterials in neighbourhoods like these that are already affordable will have the benefit of drawing on ridership from these low-density suburban neighbourhoods in addition to potential transit riders in newly intensified developments.

A concern with redeveloping along arterials is the poor local air quality along streets with heavy traffic, and the unpleasant and dangerous impact of living directly adjacent to fast-moving traffic. One possibility to mitigate this is to place mid-rise or high-rise development away from the arterials themselves, using the existing commercial corridor as a buffer. This would involve zoning for higher-density residential on streets adjacent to arterials, rather than on the arterials themselves. These new residential developments would still be within walking distance of the frequent transit.

Incentives for developers to build this kind of housing could involve the municipal government buying and bundling land along corridors and at nodes of future transit routes, and selling this land to developers in exchange for a commitment to build the desired forms, uses and tenures. In areas where land prices are low and there is little interest from the private market, the municipality could partner with non-profit developers to build affordable housing. Developments that meet the desired criteria for an area could be fast-tracked to minimize procedural barriers and uncertainty that can slow down or even prevent viable projects from going ahead. Other tools include form-based codes, where zoning is amended to specify maximum setbacks and minimum densities for new development, to prevent low-density, auto-oriented redevelopment along transit lines.

Residential self-selection

Residential development near transit produced an appreciable ridership increase in California (Cervero, 2007) . Part of this ridership increase was due to people who *choose* to live near transit – known in the literature as residential self-selection. Current transit users and those predisposed to use transit have been found to seek out transit-oriented developments (Arrington & Cervero, 2008). The presence of self-selection underscores the importance of providing housing choices so that households are able to choose for themselves, via the marketplace, locations that are well served by transit.

Personal preferences impact mode choice and residential locations. People who lived in a transit-oriented development were surveyed to find out their reasons for choosing to live there. The top three reasons given were the quality of the neighbourhood, lower housing cost, and access to transit (Lund, 2006).

In order to provide a range of options for people who would like to take transit, there needs to be an adequate supply of a range of housing types accessible by transit. A study comparing Boston and Atlanta found that Boston, with its balanced stock of housing options both in the denser, older core, as well as in newer communities, provided people with the ability to match their housing location to their lifestyle and mode choice. Atlanta, with its predominately low-density building stock, has a greater proportion of people who consider their current housing situation to be mismatched to their preferences (Levine, Inam, & Torng, 2005). In further analyzing the Atlanta survey responses, the findings suggest “an undersupply of compact, walkable, and transit-friendly neighbourhood types relative to current demand” (Levine & Frank, 2007, p. 255).

Filion et al (2006) found that Toronto does not generate as much walking and public transit patronage benefit from high residential density as it could, due to the fact that many high rise apartment buildings are located far from frequent transit service. Inversely, many areas served by subway are medium or even low-density, because these ‘stable neighbourhoods’ are protected by zoning restrictions. This could be considered ‘wasted transit’, or at least under-used. This underscores the need to build high density residential development adjacent to existing or planned frequent transit, or to concurrently phase in new development with transit service increases, and possibly to revisit the concept of stable neighbourhoods to allow some flexibility.

Transit-induced gentrification (land value uplift)

A final concern in measuring affordability is what kind of an impact extending transit service would have on housing costs. Transit can have an uplift effect on housing prices; this reflects the value that is added by improved accessibility. Little attention has been paid to the affordability of housing around public transit, and most of the research has seen higher prices as a bonus in support of transit development, rather than from the perspective of the prospective or current income-challenged resident. However, examining this research can help estimate the potential changes in home prices with the addition of various types of transit investment.

The presence of public transit does not have a consistently predictable effect on nearby housing prices; it has been seen to have different effects depending on the area and the type of transit. Suburban areas with commuter rail service have higher house prices than similar areas without rail service (Voith, 1991). From a variety of before-and-after transit studies, there is evidence to suggest that in more affluent neighbourhoods, the addition of light rail or subway generally depresses or does not impact the cost of single family homes, but homes in less affluent areas and multi-family units near transit experience a significant price premium in the range of anywhere from four to thirty percent (Wardrip, 2011). However, it has also been observed that after rapid rail transit links an area to the rest of the network, there is an influx of lower-income households to the area as they take advantage of the transit access (Glaeser, Kahn, & Rappaport, 2008), despite an increase in housing costs. Lower-income households will choose to pay higher housing costs in exchange for transit access. These findings confirm the value of transit for lower-income households.

The addition of rapid transit to an area increases the value of the area in part because of the increase in density that often accompanies transit investment. “The existence of higher order transit frequently provides an argument to support increased density in planning permissions, the density in itself being a major contributor to the value of a subject property” (Metrolinx, 2009). A review of value impact research, shown below, attempts to control for the uplift associated with increased density allowed in order to isolate the effects of transit on land values, independent of zoning changes. The methodology is described in the following quote:

Technology	Bus	BRT	LRT At Grade	LRT: Grade Separated	Subway	GO Rail
Stations Impact Area (m)	100	400	500	600	800	800
Premium %						
Residential	1%- 2%	2%-4%	10%-25%	15%-30%	20%-50%	20%-50%
Office	1%- 2%	2%-4%	10%-50%	15%-50%	20%-50%	20%-50%
Industrial	0%- 1%	0%- 2%	1%- 2%	1%- 2%	5%- 5%	5%- 5%
Source: Metrolinx 2009: Yonge North Subway Extension Benefits Case Analysis						

Table 8: Impacts of transportation type on land value

> In order to provide a reasonable basis for this calculation, and as with the other land value analysis projects, MKI [Metropolitan Knowledge International] developed a matrix of potential land value uplift percentages based on value impact research from other North American urban centres as shown in [the table above]. The ranges provided in the table are based on a compilation of research findings relating to land value uplift assessment around transit stations and corridors in various countries, including Canada, the United States and the United Kingdom. The research also showed that there is a large variance in land value impacts as the studies struggled to isolate the impacts of transit investment specifically amid the complex multitude of factors that determine land value. The ranges presented [in this table] represent the mid-range of land value impacts found in the reference material and shows the level of premium in land value that can be expected for properties around the transit stations and for properties located along the right of way of the transit line. (Metrolinx, 2009, p. 34)

The estimated land value premiums, based on North American research, for various transit technologies shows that residential land value prices around light rail are expected to rise by 10-25 percent, compared to only 2-4 percent for bus rapid transit (Crombie, et al., 2012; Metrolinx, 2009). Commercial land with access to light rail can be more expensive, from 23 percent more in a typical California parcel to 120 percent if it is part of a business park cluster (Cervero & Duncan, 2002). It should be noted that land value uplift can vary depending on other factors, including the economic climate for development.

The possibility that housing prices may reflect transit accessibility should not deter extending service to areas with high potential ridership. If the first quartile of housing values in the fourteen American cities under study - $211,900 and below – is taken to represent an affordable home cost, it is assumed that transit access will add 10% value to the price of that home, and then the added cost is $21,190 for transit access. Assuming that a monthly pass ($1,200 per year) would replace a vehicle ($7,746 per year), it would take just under three years to recoup the extra cost of transit access. Even with two monthly transit passes to replace the one vehicle, the extra value would be paid off in three years and three months. Obviously, this calculus will be different in different cities, depending on the actual price uplift, parking costs (which are not included in the AAA estimate for car ownership), the accessibility offered by the transit system, and the local cost of transit. Whether or not a household has children and the age of these children would also impact the decision. The presence of frequent transit might also signal a higher-density, more urbanized area which could allow for more nearby amenities (parks, grocery stores, schools, libraries, restaurants, bars, community centres, places of worship, etc.) within walking or cycling distance, which could reduce transportation costs even more.

These economics have a greater impact on lower-income households, who may be willing to exchange a preference for a home in a low-density area with a car for a lower-cost, less auto-dependent urban situation. When housing prices are higher (say, $524,000), then a 10% value uplift for transit access would add $52,400 to the cost of a house and take much longer (6 years and 9 months) to recover in terms of transportation savings. Households may not be able to afford this up-front cost, even if it is a beneficial trade-off in the long run. For households that can afford this higher home value, the transportation savings may not be as relevant. These calculations show that transit remains considerably less expensive than driving a private vehicle, and that these savings are much more likely to be relevant to areas of housing affordability and lower incomes. Home owners in areas of affordable housing could benefit from uplift in housing values through added transit accessibility, and home buyers moving in could re-coup the extra cost of housing through savings in transportation.

Many land use and transportation plans have goals for transit-oriented development, but not as many include plans for affordable housing. There is a tendency for newer housing to be more expensive, and only gradually over time to ‘cycle down’ the income spectrum as it ages. Depending on the type and location of housing stock, older housing can also be subject to re-investment, like brownstones or Victorian row houses. Given the nuances in the various types of uplift in housing prices with transit investment, some strategies for maintaining affordability present themselves.

The research shows that using BRT could also preserve residential affordability by limiting the land value uplift around transportation investments.

> Bus Rapid Transit technology is less effective than the subway in stimulating land value uplift. In addition to slower service, a BRT system is usually viewed as less permanent and is not viewed as equally desirable from a development perspective. For this reason, research on uplift associated with BRT (albeit much less extensive than for subways) has typically found much lower land value uplift associated with these projects, and identifies a smaller impact area for stops/stations. (Metrolinx, 2009)

The Metrolinx study indicates that BRT has a significantly lower uplift effect on residential housing prices of 2-4% compared with 10-30% for LRT and 20-50% for a subway station area. This is based on case studies in the North American context, where elements of BRT have been introduced in various cities but where a complete BRT rapid transit system is arguably not yet present, so these numbers should be considered tentative. However, they point to an undervaluing of buses compared with rail in the North American context. This undervaluing may be related to the stigma of bus transit and the lack of a complete BRT system as a demonstration project, along with the perception that BRT is less permanent than rail. North American cities could take advantage of this undervaluing of BRT and its ability to keep land values steady in planning transportation projects. BRT could be a strategic tool for connecting areas of affordable, high-density without incurring significant price increases that could subject the area to pressure for higher-end, less affordable development. Since BRT is also less expensive to implement and is the lowest-capacity version of rapid transit, it may be more appropriate for extending to affordable post-suburban areas. Part of the issue of transit-induced gentrification around LRT may be that LRT has been used as an economic development strategy, with the explicit goal of land value uplift.

To a certain extent, some uplift in home costs around transit is to be expected. If frequent transit is extended in a significant way in multiple lines at the same time, this would go a long way to mitigating transit-induced gentrification by equalizing transit access. There are certainly benefits of keeping housing with transit access in the affordable range for lower-income households. This benefit accrues to those households themselves, who value transit access; to the transit agency, with an increase in ridership; and to the metropolitan region as a whole, in that public infrastructure is used efficiently to provide automobile-alternative access. Metrics to capture this benefit in the assessment of potential transit projects could be developed and incorporated into the decision-making process.

Coordinating transportation and land use

Alignment of frequent transit networks with housing affordability requires metropolitan regions to coordinate land use and transportation. This coordination continues to be challenging, mostly because land use planning is ultimately in the hands of local municipal governments. Transit planning is often conducted by transit agencies that do not have influence over land use decisions, and so they must plan transit in reaction to land use development.

As discussed above, American long range transportation plans are highly responsive to federal requirements, because they depend on federal dollars to fund any proposed projects. Federal funding has shifted away from new highway and road projects, requiring more and more qualifications – air quality, environmental justice, growth forecasts – to be taken into consideration in these plans. It is clear that MPOs are being asked to consider land use in their transportation planning process, despite the fact that that land use is a local institution. This conflict has been addressed in other research. In their description of California MPOs, Goldman and Deakin (2000) write that ‘the available evidence is that partnerships are not an easy matter when the various partners’ goals are in conflict. Experience with transportation and air quality planning suggests that legislatively mandated relationships are an insufficient basis for mutual respect and cooperation, and conflict may continue to simmer rather than be resolved’ (p70). In a paper on how metropolitan planning organizations incorporate land use issues in regional transportation planning, Wolf and Fenwick (2003) note that ‘the separate institutional environments in which land use and transportation issues are addressed do not permit extensive integration…land use planning and zoning are closely held powers of local jurisdictions. The principle land use policies in metropolitan areas are determined by these localities’ (p 123). In their series of interviews with MPO level planners, these researchers found that ‘although reluctance among MPOs to address these [land use] issues is easing, the study found that most local land-use agencies are not interested in working with MPOs’ (p124).

It is clear that bringing transit accessibility to affordable post-suburban areas will require intent and motivation on the part of all levels of transportation and land use planners, as well as acceptance by the neighbourhoods in question. It may be possible to extend transit and plan for intensification in areas that are already more affordable, if it is clear that the goal is to maintain this affordability while adding accessibility. Lower-income neighbourhoods may be more receptive to public transit improvements.

There are challenges associated with extending frequent transportation networks into the post-suburban context, such as designing systems and technologies appropriate to large arterials and superblock structure as well as separated land uses. Bus rapid transit (BRT) or light rail transit (LRT) could potentially be overlaid along arterials, along with complimentary cycling and pedestrian infrastructures. Land use could focus on intensification along these corridors and at intersection 'nodes', zoning for mixed use and using a variety of location-efficient development incentives. 'Inherently affordable' housing types would allow for residential self-selection by people who value transit access. The initial use of BRT could minimize land value uplift in affordable suburbs. The result would be a hybrid city, a networked intensification of nodes and corridors offering frequent rapid transit overlaid on an otherwise dispersed urban form.

In order for this transformation to be unlocked, transportation planning would need to take the geographies of affordability into account, and land use planning would need to respond to demand from future, potential residents as well as current ones. Both land use and transportation planning would need to be coordinated at a regional metropolitan scale.

Conclusion

This dissertation has drawn attention to accessibility in the post-suburban metropolis, as North American cities transition from the dual nature of pre-WWII cities and midcentury suburbs to something else. Midcentury suburbanism was fueled by the Fordist manufacturing- and consumption-based economy with a strong middle class and large-scale government investment in the infrastructures of automobility. Since then, neoliberalism has caused a withdrawing of government investment, just as globalization has resulted in a post-manufacturing, service-based economy. Income inequality has grown and the middle class is facing economic challenges that are being temporarily solved through taking on debt. The suburbs are ageing just as there is a re-investment in urban living. Plans call for intensification and transit-oriented development and for an urban form that has the 'D variables' – density, mixed use (diversity), fine street grids (design), etc.). The question that this research raises is one of affordability. As the combined cost of housing and transportation grows, is there an alignment between housing affordability and transit access?

The results of the research reveal isolated suburbansisms, areas of lower-cost home ownership that are not connected by frequent transit. Lower-income households in each region often face a choice between affordable housing and affordable transportation. The likelihood of access to frequent transit declines as house prices decrease, with all else equal. This is especially clear with owned homes; consistently, the more affordable home ownership opportunities are not served by frequent public transit routes. The maps comparing housing to transit confirm this result, showing that frequent transit networks have often not been extended to clusters of affordable homes in inner suburbs or outer centres. Half of the cities studied do not have effective transit networks, and are primarily composed of suburban form. Of the remaining cities with robust transit networks, most show some degree of misalignment between frequent transit networks and affordable home ownership opportunities. The extent of this misalignment is related to the greater likelihood of inaccessibility to transit for affordable homes. Affordable rental units are scattered in clusters throughout regions and show less of a distinct pattern. Rental housing is to a large extent the only affordable option within walking distance of frequent transit networks. The long term affordability of rental housing is not guaranteed, nor is security of tenure in a society where the dominant culture has been one of home ownership. There are indications of possible gentrification in pre-war urban areas. Transit network coverage is often limited by jurisdictional boundaries within metropolitan regions.

These findings present the challenge of the affordable suburb underserved by transit. Although there are literatures and case studies that look at transit access inequity, such as social exclusion, spatial mismatch, environmental justice, social urbanism in South American cities and the Los Angeles Bus Riders' Union, none address this North American affordability paradox directly. Although there has been speculation about possible suburban transformation, the question of equity of access and affordability is not yet a substantial part of this conversation. If equity is defined as the goal of equalizing access by various modes of transportation for people, then people of all incomes and abilities would have better access to opportunity.

Limitations and further research

There are certainly limitations to this research that could be improved with further research. This project does not capture the *process* of socio-spatial transformation, which is an important one to understand. Taking a longitudinal approach rather than a snapshot would improve our understanding of the processes of suburban transformation, of transit-induced gentrification, and of downtown gentrification. Follow-up work could include a repeat of this analysis in five or ten years, and even a similar analysis using previous data from five or ten year increments looking back.

This project also doesn't get a complete picture of low-cost rental housing in relation to transit access, due to less data points for rental costs in these cities. However, this analysis could be done to focus on rent. When rent was included in the model and run for a few cities, it tells an interesting story (Appendix D). It would be helpful to expand this rent-focused analysis to all the cities, given the importance of rental housing for lower-income households.

Case studies on specific cities could help rectify some of the data limitations, particularly the lack of destinations in the accessibility metric. Although destinations are not available in the Census or Community Survey, they can be found in various other datasets individual to cities, such as the Transportation Tomorrow Survey in Toronto.

As transit is extended into suburban areas, it would be excellent to track some case studies and see how housing costs are impacted over time. As well, it would be good to expand the research using agent-based data to better understand and establish the relationships between income and alternative modes of transportation, given different Socioeconomic and urban form geographies. Our understanding of travel behavior and potential ridership would also no doubt benefit from qualitative fieldwork and public consultation, focusing on the isolated suburbanisms identified by this research. What do people living there want and need? What are their transportation and land use preferences and budget constraints?

In a larger sense, it would be interesting to test the question of housing cost in relation to 'smart growth' policies. Do policies of intensification combined with urban growth boundaries or greenbelts drive the cost of housing up by limiting supply, or is density a result of high land prices and demand in downtown areas? What is the role of larger global market forces on higher housing costs in cities?

This last question leads to a further area of inquiry, that of global city gentrification and the expulsion of urban populations into urban hinterlands, and how that impacts transportation sustainability as well as equity.

For the moment, these larger questions will remain unanswered (in this thesis, anyway) and this research incomplete. However, I trust that more research on this topic of affordability mismatch and the auto-oriented marginalization of poverty will follow. It is my hope that this research will contribute a helpful baseline measurement upon which more complete studies can be built.

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Appendix A

Literature review on the influence of the built environment on transit ridership

Transit and the built environment: The “D” variables

The relationship between the built environment and public transit has been well researched. There are excellent descriptions and explorations of the specific relationships between characteristics of the built environment and demand for transit ridership, and this has greatly contributed to an understanding of how density, mixed use, street grid networks, and pedestrian infrastructure really contribute to a more accessible environment by allowing multiple modes of transportation[12]. This research has also demonstrated the inverse, how design around the automobile produces lower densities, separates uses, and makes travel difficult for non-automobile modes of transportation, although traveling by car becomes easier.

The aspects of the built environment that support transit use were originally described as density, diversity, and design – the alliteration causing them to be referred to as the ‘three D’s’ (Cervero & Kockelman, 1997). Later, the ideas of distance to transit and destination accessibility were added (Ewing & Cervero, 2001; Ewing & Cervero, 2010; Ewing, et al., 2011). In some cases, a sixth ‘D’, demand management, is added. These aspects of the built environment were measured for their impacts on travel behavior. The results found that these qualities, where they exist in the urban fabric, produce demand for more trips by ‘alternative’ means like walking, cycling and public transit, and fewer by car. These variables change the accessibility of destinations by mode, making them easier to access by alternative modes.

Density

One of the most fundamental qualities of the built environment that impacts travel mode choice is density, both of origins (residential density) and destinations (employment and other attractions). Density is intrinsically interlinked with other ‘D’ variables. Broadly speaking, the higher the density, the greater local demand for trips, and the more likely there is to be congestion if all trips are taken by car. The higher the density, the less space there is for parking and roads. This makes modes that take up less space per traveler, like walking, cycling, and transit, more efficient. The higher the density, the closer

[12] Parts of the following literature review were developed by the author while working as a student transportation analyst in the policy planning division of TransLink, Vancouver’s regional transportation agency, in 2010.

origins and destinations are to each other, making trip distances shorter. This allows slower modes of transportation to become competitive.

Density is a measure of the *intensity* of the use of land. Density can be measured in a variety of ways, such as people per hectare (residential density), jobs per hectare, people and jobs per hectare, or floor space ratio (FSR, also known as floor area ratio, or FAR). Floor space ratio measures the amount of built floor space compared to the area of the lot. Density can be measured in gross or net terms; gross density is inclusive of all land uses in the calculation for a given area, whereas a net density usually refers to one particular land use (such as residential) and excludes roads, rights-of-way and green space. The higher the density, the more people, jobs, or built floor space there is per unit area. Higher densities generally support greater levels of transit service, as there are more potential riders in the same amount of space.

Density has the potential to draw origins and destinations closer together when the appropriate land use mix exists, resulting in shorter average trip lengths. Ewing and Cervero (2001) find that trip lengths are primarily a function of the built environment. Trip length factors into calculations of total distances travelled (vehicle kilometres travelled) and total time spent in travel (vehicle hours travelled). Of course, if alternative transportation modes are not available, increasing density will also increase congestion, slowing travel times even as distances decrease. This demonstrates compatibility between density and alternative modes, which take up less space per passenger than cars do, and which can therefore lessen congestion effects in dense areas. In fact, efficient transit service relies on density (Chen, Gong, & Paaswell, 2008). Lower densities and the separation of uses make the private automobile the practical mode of transportation (Filion, Bunting, & Warriner, 1999). All else being equal, "higher densities worked in favor of transit ridership and against drive-alone automobile traffic" (Cervero, 2002).

An international comparison of urban density and transit usage found that US cities exhibit the most extreme dependence on the automobile, followed by Canadian and Australian cities, with European and Asian cities being much more transit-oriented with greater levels of walking, cycling, and transit. These patterns are not strongly related to differences in wealth between cities, but do vary in a clear and systematic way with land use patterns, particularly density (Kenworthy & Laube, 1999).

Table 9: Comparison of Urban Density and Transit Mode Share in Various International Cities

Selected Cities	Urban density (persons/ha)	Journey to work trips by Transit (% of workers)	Journey to work trips by Walking and Cycling (% of workers)
American Cities	14.2	9%	4.6%
Australian Cities	12.3	14.5%	5.1%
Canadian Cities	28.3	19.7%	6.2%
European Cities	49.9	38.8%	18.4%
Asian Cities	157.4	48.7%	19.4%

Source: Kenworthy and Laube, 1999

Although the complexity of urban environments makes it difficult to establish causality by isolating variables like density and mode share, a review of the literature indicates a fairly robust consensus that density is correlated with larger non-auto mode shares and higher transit ridership. The opposite also holds – low density environments must rely primarily on the automobile for transportation because they are too spread out to serve effectively by transit. This has led researchers to suggest that the most effective *land use* strategy for increasing transit ridership is to increase development densities close to transit (Arrington & Cervero, 2008).

It has long been recognized that there are thresholds of population density – both residential and employment – that help determine the appropriate level of transit service. In 1977, two engineers published a detailed technical treatise on this relationship (Pushkarev & Zupan, 1977). This landmark book asks the question, "What density of transit service can be supported by what density of urban development?" The researchers take many variables into account when considering this question, including concentrations of non-residential land uses as well as household size, income, car ownership levels, and labor force participation rates; from the supply side, capital and operating costs for different service types are calculated. Here are some of their recommendations for frequency in relation to density (density thresholds have been converted to people/square kilometer):

Table 10: Service levels and density (Pushkarev & Zupan)

Headways (and span of service)	**Density threshold** (average dwelling unit density over tributary area)	**Residential density** (at 2.5 people per dwelling unit)
10 minutes	3,700 units/km^2	9,250 people/km^2
30 minutes (over 20 hours)	1,700 units/km^2	4,250 people/km^2
60 minutes (over 20 hours)	1,000 units/km^2	2,500 people/km^2

They also break down densities by type of service:

Service frequency & technology	**Minimum dwelling unit density in service catchment**	**Residential density** (at 2.5 people per dwelling unit)
Frequent local bus	3,700 units/km^2	9,250 people/km^2
Light rail (5 min headways)	2,200 units/km^2	5,500 people/km^2
Rapid transit (5 min headways)	3,000 units/km^2	7,500 people/km^2

The profile of American cities has changed since this analysis – most notably, the polycentric nature of today's metropolitan regions compares to the stronger pull of the central city in 1977, with higher rates of car ownership today – so it is worth noting that density thresholds for service frequency may have increased since this analysis. It should also be noted that density thresholds are not generally used to determine service levels by transit agencies; there are often minimum service levels and a minimum percent of the urbanized area required to be covered that apply regardless of density. The higher densities necessary to reach certain levels of ridership and justify frequency and improved service type, on the one hand, and the need to cover much most of the newer, lower-density areas with infrequent routes, on the other, both contribute to low ridership levels in many cities (see Walker, 2012 for a summary of the debate on ridership vs. coverage).

A more recent piece of research on this subject (Messenger & Ewing, 1996) used a regression model to determine the relationship of density to service frequency, while taking other variables into account. Transit mode share by place of residence proved primarily dependent on automobile ownership and secondarily on jobs-housing balance and bus service frequency. Automobile ownership, in turn, proved dependent on household income, overall density, and transit access to downtown. Thus, three types of variables— socio-demographic, land use, and transit service—were found to affect bus use through a web of interrelationships. Likewise, bus mode share by place of work proved dependent on the cost of parking, transit access to downtown, and overall density, again through a web of interrelationships. Overall density is a significant determinant of bus mode share although its effect is largely indirect (through automobile ownership and parking charges). The relationship between density and mode share, when reduced to mathematical equations, allows the densities required to support different levels of transit service and productivity to be estimated. The relationship between required density and bus service frequency is particularly interesting. An increase in service frequency boosts the bus mode share but also increases the number of bus trips that must be generated to achieve any productivity standard (because more runs are made at higher frequencies).

Table 11: Service levels and density (Messenger & Ewing)

Headways (over a 16-hour span of service)	**Density spectrum** (average dwelling unit density over tributary area)	**Residential density** (at 2.5 people per dwelling unit)
15 minutes	2,700 – 4,800 units/km2	6,750 – 12,000 people/km2

Comparing this to Pushkarev & Zupan's research, it can be confirmed that when car ownership and income levels are updated, the density per hectare required for frequent transit service is higher in 1996 than in 1977. One factor that may contribute to this is the decline in average household size over the 20 year period, resulting in a higher residential dwelling density to yield the same population density. Both studies acknowledge that factors other than density affect these frequency service levels; Messenger & Ewing actually build in these other factors into their model. "If other variables in the preceding equation assume values significantly above or below the sample averages, the overall density required to achieve the same transit productivity changes accordingly. Areas with below average incomes, for example, require lower overall densities than areas with above average incomes.” We can have some confidence in these results, since both studies also test their models against data from real cities.

There are many urbanized areas in large American and Canadian cities that fall below these densities. There may be other reasons for sending transit service through lower-density areas, such as making important connections in the network or serving employment or commercial centres. These numbers are actually fairly generous in giving service, as frequent service has the capacity to cover much higher densities than this. It is the intersection of these minimum densities with socioeconomic attributes such as low income, low car ownership levels, and affordable housing that is the focus of the research. As discussed above, the combination of socioeconomics favourable to transit ridership with density will result in higher potential ridership than in wealthier, more auto-dependent areas of similar densities.

Diversity

Mixed land use means having a complementary and context-appropriate combination of shops, services, housing types, offices, and employment opportunities within the same area that allow people to meet most of their daily needs nearby. Mixed use can include: a) vertical mixing within a building, such as with commercial on the ground floor and residential above; b) horizontal mixing, as with a commercial building located adjacent to a residential building; or, c) a mix of uses within a wider area. Local mixed use at transit nodes and along transit corridors encourages trip chaining. These trip chins combine more than one destination into one extended trip (for example, by going to the hardware store and the grocery store on the way home from work, rather than making a separate trip for each of these destinations (Frank, Bradley, Kavage, Chapman, & Lawton, 2008). Land use mix and accessibility are relevant to travel behaviour (Badoe & Miller, 2000). Local diversified land use at origins and destinations is associated with reduced driving (Jun, 2008; Cervero, 2002). Chen et al (2008) found that increasing land use diversity creates a potential reduction in travel distance by increasing one’s access to activities and services.

In a study of Portland, Jun (2008) found that mixed land use zoning at place of residence decreased the likelihood of driving alone, while the more exclusively residential a neighbourhood was, the more likely a trip choice would be by car. Similarly, the results of another study show that “mixing land uses tends to discourage the generation of auto trips and facilitate the use of transit and non-motorized modes” (Cao, Mokhtarian, & Handy, 2009, p. 555). Retail located within a one-mile (1.6 km) radius of a person’s residence made it more likely that they would walk to the store rather than drive (Cervero & Duncan, 2003, p. 1481).

The mix of uses at employment destinations allows for the ability to run errands during work breaks (trip chaining), eliminating the need for a separate trip (Frank et al, 2008). Diversified land use is associated with fewer choices to drive (Jun, 2008; Cervero, 2002) The mix of uses does not necessarily have to be local, however, as long as they are well connected: “Good regional accessibility [by transit] was found to cut down on household vehicular travel to a far greater extent than did localized density or mixed use” (Badoe & Miller, 2000). On a regional scale, improving the proximity of jobs to housing reduces travel (Cervero & Duncan, 2002).

Diversity in terms of land use can also be applied to housing types. By separating types of use as well as types of housing through zoning regulations, suburban areas "are actively preventing a spontaneous mixing of population" (Giuliano, The weakening transportation-land use connection, 1995, p. 12). This results in a uniformity of demographic profiles in an area. By having a mixed, diverse housing stock with a variety of housing types, tenures, and price points, a community can attract a broader cross-section of people and be better able to support transit.

Design

Design describes the amenities available in the public realm. In combination with the "D's" already discussed - the arrangement of land uses and facilities with sufficient levels of density and diversity – it involves attractive and visually interesting buildings, streetscapes, and public amenities.

A large role of design is to enhance 'walkability', as walking trips are the beginning and end of most transit trips. In researching how urban design affects human perception and behavior, researchers have identified and identified a number of qualities that contribute (Ewing, Handy, Brownson, Clemente, & Winston, 2006):

- **Imageability** - The quality of a place that makes it distinct, recognizable, and memorable.
- **Legibility** – The visual cues that allow pedestrians and motorists alike to navigate the environment with ease.
- **Enclosure** - The degree to which streets and other public spaces are visually defined by buildings, walls, trees, and other elements.
- **Human Scale** – The size, texture, and articulation of physical elements that match the size and proportions of humans.
- **Transparency -** The degree to which people can see or perceive what lies beyond the edge of a street or other public space.
- **Linkage** - The continuity of the form between buildings and streets, specifically the sidewalks and crosswalks that lead you from one place to another.
- **Complexity** - The condition and cleanliness of a place.
- **Coherence** – A complimentary set of visual elements (e.g. building sizes and styles).
- **Tidiness** – The extent to which nothing looks damaged or is in need of repair.

Public amenities, trees and green space can also contribute to aesthetics, a sense of place and a pedestrian-friendly environment. People will walk longer distances in areas of greater density and with better urban design (Canepa, 2007). Whether walking to transit or walking the entire length of a trip, having more to look at can make the journey a more interesting experience. A well-designed pedestrian environment as one that will entice people to get out of their car to experience the character of a neighbourhood (Chen, Gong, & Paaswell, 2008). People are more likely to walk to transit in areas that have shops, sidewalks, and trees (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003). These design attributes are more than just superficial; for example, street network linkage and legibility are necessary for successful navigation by alternative modes of transportation like walking, cycling and transit.

The street network or street grid is an important aspect of urban form. Street connectivity is a measure of how well the streets connect places. Fine street grid patterns allow for flexible travel patterns and cost-efficient transit service, through offering more routes between origins and destinations. Since the 1970s, many communities have been built with larger block sizes and less internal connectivity (such as cul-de-sacs, T-intersections and dead ends) than traditional grid city forms. Larger block sizes have higher traffic volumes along arterial roads, whereas a finer grid pattern allows traffic to disperse more evenly throughout the network. A finer grid network with more intersections allows for more route choices, more opportunity for ground floor retail and a more even distribution of vehicle traffic (Handy, 1996). In measuring an area's walkability, a street connectivity of greater than 30 intersections per square kilometre has been defined as pedestrian-friendly (Frank, et al., 2009). As all transit trips start and end as a pedestrian trip, walkability at trip origins and destinations has an important influence on transit use. Connectivity can also be provided with pedestrian and bicycle paths; for example, a suburb with cul-de-sacs can still provide connectivity to transit by creating a path to connect the cul-de-sac to a nearby road with transit service. In a meta-analysis of travel and the built environment, Ewing and Cervero (2010, p265) conclude that "bus and train use are equally related to proximity to transit and street network design variables".

Pedestrian infrastructure goes beyond street grid, however. Rodriguez and Joo (2004) found that the presence of sidewalks on route to transit will increase the odds of using transit. Adding a crosswalk to a road segment was correlated with a 57% increase in pedestrians on that segment (Rodriguez, Brisson, & Estupinan, 2009). "An integrated and continuous pedestrian and bicycle network that connects points of origin with popular destinations should be in place before we can observe major modal changes" (Loukaitou-Sideris, 2004, p. 24). Areas that are dark and not well-lit at night, or environments where traffic is a safety threat, reduce the likelihood of people walking (Ibid). The feeling of safety is improved with the presence of buildings and their occupants (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003), or what Jane Jacobs called 'eyes on the street'.

Distance to transit

Proximity of origins and destinations to transit is also associated with increased transit use. In Washington DC, for every 300 meters farther away from a subway station, transit mode share of commuters working in offices declined by 12% and residential mode share declined by 7%. A 2003 San Francisco study found that employees working at offices within 800 meters of rapid transit stations had a 19% transit mode share, compared to just 5% region-wide. The residential transit mode share was even higher: approximately 27% of those who lived within 800 meters of a station took transit compared to only 7% in a larger four-kilometer catchment area beyond this initial proximity (TCRP, 2007).

Generally, current planning practice recommends a 400 to 800 meter radius as the pedestrian catchment for transit service (Canepa, 2007). For local stop transit service, a 400 meter pedestrian catchment area is often used, representing a 5 minute walking distance. For rapid transit, people are willing to walk farther and an 800 meter pedestrian catchment area to transit is generally used, representing a 10-minute walking distance. However, an Australian study examined walking patterns across five transit stations in the vicinity of Perth, a city of approximately 1.3 million. The study found that 55% of people walking to these stations came from points originating more than one kilometer away (Ker & Ginn, 2003). Canepa (2007) demonstrates that people may be willing to walk longer distances to reach transit, in areas of higher density and urban design standards. However, other factors such as topography or climate may also affect how far people are willing to walk to reach transit.

Along with distance to transit, the *frequency* of transit service also impacts mode choice. The availability of frequent transit service is necessary for supporting any transit-oriented land use strategy. Matching transit supply with demand is one of the primary objectives of transit agencies; transit-oriented communities are places that have enough demand to support frequent transit service. The frequency and span of service, in turn, shape demand and ridership in a positive feedback loop. A generally accepted threshold level of service for transit-oriented developments is frequencies of 15 minutes or better during most of the day (Dittmar & Ohland, 2004). The reliability of transit service is also an important transit supply factor that affects people's willingness to take transit. Transit riders have been found to be more sensitive to unpredictable delay than predictable waiting times indicating the importance of service reliability (TCRP, 2007).

In some cases, the *type* of transit service influences ridership levels. For example, people have been found to walk farther to access rail compared to bus transit (Besser & Dannenberg, 2005). Some people find rail systems simpler to understand and easier to use (more immediately legible) than conventional bus systems. However, bus rapid transit has the potential to address this gap by running along dedicated lanes and providing many of the features of rail-based systems (Currie, 2005).

Destination accessibility

The demand for mobility is derived from the need to connect origins with destinations. Similar to distance to transit, destination accessibility refers to how many opportunities can be accessed by transit – also known as regional accessibility. As the transit network increasingly links together concentrations of people with job and commercial centres, educational opportunities, and cultural facilities, transit use increases (Arrington & Cervero, 2008). Regional accessibility is in part a function of the *cost* of a trip which in turn is a function of the money, time, and distance involved in making that trip; the greater the cost to travel to a destination, the less "accessible" that destination is. Accessibility is different for every mode of transportation (Maat, van Wee, & Stead, 2005); for example, a destination may be more easily accessible by car than by transit; or may be accessible most conveniently by walking.

Polycentric regions, such as Metro Vancouver, concentrate growth to improve regional accessibility by clustering origins and destinations in centres. Localized density is most effective for reducing auto use when these areas are well connected to other parts of the region – and a region can be made 'mixed use' by providing a variety of functions (residential, commercial, industrial, and educational) along transit lines (Badoe & Miller, 2000). On a regional scale, improving the proximity of jobs to housing reduces travel (Cervero & Duncan, 2006). It is challenging to match jobs and housing within each neighbourhood, because many people no longer live, work, and play in the same neighbourhood. This is why it is so important that key regional land use destinations are connected by transit (Badoe & Miller, 2000).

In an analysis of Portland's MAX rapid transit system, Jun (2008) found that locating employment near a rapid transit station increased ridership and decreased auto trips. When employment clusters are oriented to rapid transit networks, ridership increases (Frank & Pivo, 1994; Chen, Gong, & Paaswell, 2008). Research shows that higher density, large employment clusters with low levels of parking and a mix of uses adjacent to rapid transit greatly influences transit use (Badoe & Miller, 2000). This holds true for central business districts as well as suburban employment centres. Density, convenient access to a transit station, and reduced parking requirements at employment centres have the greatest impact on ridership levels (Lund, Willson, & Cervero, 2006). The strong, clear relationship between employment density and mode choice found in the literature supports the effectiveness of employment clusters for improving metropolitan transit mode share. Regions that generate the highest commuter ridership have a high percentage of regional jobs accessible by frequent transit (Arrington & Cervero, 2008). Employment density was found to be the most strategic kind of density to locate near rapid transit, generating definite ridership gains from commuting trips.

In a region with a growing population and economy, growth can be accommodated in a number of different ways. The way that growth is accommodated determines to a large extent whether it is transit-supportive. In a review of the connections between transportation infrastructure and land use, Handy (2005) concludes that new highway capacity will often attract low-density development, whereas growth around rapid transit infrastructure will have a smaller urban footprint. The shape and form of the growth in either case will be adapted to the type of mobility that is most readily available. Thus, the type of transportation infrastructure investments in a region may help shape the location choices that incoming residents and business make. Land use decisions in turn impact the demand for the type and amount of transportation infrastructure investment.

In an analysis of urban form and travel in Portland, Jun (2008) found that the farther away from the central city that someone lived or worked, the greater the chances of their driving to get around. Similarly, "population centrality" (i.e. how compact a regional population is assembled) increases the chances that a worker walks to work (Bento, Cropper, Mobarak, & Vinha, 2005). Regional urban growth boundaries alone cannot improve regional accessibility (Song Y. , 2005). Instead, density must be strategically deployed in centres and along rapid transit corridors in order to strengthen the use of regional transit (Cervero & Duncan, 2003; Filion, 2009).

Demand management

Two key aspects of transportation demand management (TDM) that influence individual behaviour and travel patterns are trip costs and parking. The relative cost for a trip varies by mode and can impact the attractiveness of one mode compared to another. The direct cost of a trip includes both the financial cost and the time spent taking the trip. Indirect or external costs include congestion and air pollution. Decreasing the availability of road space and parking also has the effect of increasing density, and in this way demand management is related to the built environment.

Because of improved fuel efficiencies, the average financial cost (adjusted for inflation) of one kilometer of car travel in the United States fell by almost 50% between 1980 and 1993. During the same time period, the average cost of transit fares rose by 47% (Cervero, 1998). In the UK, higher transport costs cause people to consume goods locally and use alternative modes of transportation (Giuliano & Dargay, 2006). In an international comparison of cities, Kenworthy and Laube (1999) found that the cost per kilometer of auto travel is related to the degree of automobile dependence in cities. Asian and European cities were found to have the highest auto costs per kilometer and were the least auto-dependent, and American cities were found to have the lowest auto costs per kilometer and were the most auto-dependent. Despite this, transit is still an order of magnitude less expensive than owning and operating a vehicle in most cases (see Section C for a comparison of costs), and walking and cycling are practically free.

In research on major transportation corridors between a suburban shopping district and a city centre, Casello (2007) finds that increasing the cost of driving at the same time as making alternative modes more speed-competitive results in mode shift from automobiles to transit. A positive feedback loop is then created where higher ridership supports even better levels of transit service, which in turn attract even more riders. Road tolls and congestion charges are forms of demand management that impose a higher cost on car trips. Singapore is well known for a responsive road pricing system, where the cost of driving different routes varies by time of day and congestion levels. The result is a disincentive for drivers to use roads at the busiest times and in areas of higher demand.

Research has found that mode choice decisions also depend on variables such as parking cost and supply (Jun, 2008). Chatman (2008) found that significant mode shift cannot be achieved where there is high road volume capacities and plentiful free parking. Increasing the cost of parking, reducing the amount of free parking, and limiting the amount of total parking supply increases the cost of using a car and reduces its convenience relative to using transit. Parking lots also take up considerable space, and result in a less pedestrian-oriented area (Filion, McSpurren, & Huether, 2000). Office workers surveyed at suburban employment centres found that the amount of space occupied by surface parking and the lack of pedestrian infrastructure made them inhospitable environments for walking and explained the low number of pedestrians in these centres (Ibid). Researchers used satellite photographs of a 'typical Midwestern county' to discover that there were 6.3 parking spaces per family, not including street parking, driveways or garages (Davis, Pijanowski, Robinson, & Engel, 2010). Together, these findings demonstrate the land consumption impacts associated with the amount of space devoted to parking in auto-oriented communities. Cars generally occupy more space than other modes of transportation, requiring not only road space but also parking at both the trip origin and destination. Roadway and parking requirements contribute to a "design template for auto-oriented development" (Levine et al, 2005:317). Areas with fewer parking spots and with paid parking can manage the demand for car trips. For example, San Francisco is experimenting with a parking meter system where the cost of parking varies with demand, and drivers can check smart phones to see where spots are available and how much they cost.

These TDM measures help to capture some of the costs of the negative externalities produced by the automobile, especially when the funds generated are put towards alternative transportation infrastructures with positive externalities. However, the cost of driving is an equity issue in areas that are both affordable and auto-dependent. Without transportation alternatives, TDM measures like road tolls, gas taxes, and parking fees can be regressive, having a disproportionate impact on people with limited means.

Appendix B

Multicollinearity Test

VARIANCE INFLATION FACTOR –

The variance inflation factor measures how much the variance of coefficients are inflated by multicollinearity. Because it is impossible to measure VIF using a logistic regression model, I ran a OLS regression using transit commuting rates as the dependent variable and all the same variables as in the logistic model as the independent variables. The results are shown below, with a VIF measurement for each variable along with 1/VIF (the tolerance). How should these numbers be interpreted?

A generally used rule of thumb is that a VIF of over 10 (or tolerance under .1) is evidence of a multicollinearity problem (William, 2012; Golder & Golder, 2013). Other sources suggest a more conservative 5 as the indicator of multicollinearity (William, 2012; Fattah, 2011). Still others say they are concerned if the VIF is higher than 2.5, but that if it meets the following criteria it is not a concern (Allison, 2012):

- The high VIFs are on control variables, and the variables of interest have low VIFs
- The variables with high VIFs are indicator (dummy) variables that represent a categorical variable with three or more categories (true for housing cost and income)

When testing for multicollinearity, I highlight VIFs of over 5. All VIFs are under 10, and most are under 5. The variable of greatest interest is home value, which are all under 5 despite being in the form of categorical variable (quartiles). The VIF that is most commonly over 5 is the fourth quartile of income, and because this variable meets both the 'control variable' and 'categorical variable with three or more categories' exceptions, these slightly higher VIFs do not reasonably challenge the integrity of the conclusions. The second most common variable with a VIF over 5 is the rental variable, which measures the percent of rental housing in an area. Because this does not directly represent housing cost, and is a control variable, it also can be dismissed, although the interpretation of the 'rental' odds ratios for the cities with these higher VIFs are not relied on to carry the results.

Atlanta		
Variable	VIF	1/VIF
Qincome		
2	2.39	0.418981
3	4.08	0.244966
4	**6.37**	**0.156985**
Qvalue		

2	1.88	0.53161
3	2.63	0.379686
4	3.56	0.280682
age	1.49	0.672076
density	1.49	0.672644
detached	**5.53**	**0.18094**
rental	**6.74**	**0.148378**
noCar	1.84	0.543054
white	2.29	0.436469
single	2.16	0.463387
Mean VIF	3.27	

BOSTON		
Variable	VIF	1/VIF
Qincome		
2	2.16	0.463878
3	3.04	0.328865
4	4.54	0.220154
Qvalue		
2	1.66	0.602665
3	1.84	0.544791
4	2.39	0.418282
age	1.31	0.761787
density	2.21	0.4524
detached	**5.74**	**0.174323**
rental	5.8	0.172451
noCar	2.52	0.397322
white	1.98	0.505826
single	1.89	0.527748
Mean VIF	2.85	

Calgary		
Variable	VIF	1/VIF

Qincome		
2	2.28	0.437869
3	4.09	0.244382
4	**6.21**	**0.160901**
Qvalue		
2	1.91	0.522909
3	2.24	0.447384
4	2.72	0.368135
pre46	1.27	0.787185
density	1.31	0.762
detached	4.65	0.215042
rental	3.99	0.250851
white	1.25	0.800687
single	4.16	0.240212
Mean VIF	3.01	

Chicago		
Variable	VIF	1/VIF
Qincome		
2	2.02	0.493996
3	2.93	0.341634
4	4.86	0.20563
Qvalue		
2	1.88	0.531848
3	2.26	0.442561
4	3.14	0.318563
age	1.58	0.634836
density	2.04	0.490299
detached	3.72	0.268563
rental	4.08	0.244877
noCar	2.28	0.438291
white	2.45	0.407901
single	1.91	0.52275
Mean VIF	2.7	

Edmonton			
Variable		VIF	1/VIF
Qincome			
	2	2.47	0.405025
	3	4.27	0.234042
	4	**7.24**	**0.138186**
Qvalue			
	2	1.8	0.556515
	3	2.06	0.485069
	4	2.81	0.355718
pre46		1.29	0.772477
density		1.27	0.790075
detached		4.49	0.222894
rental		4.24	0.235595
white		1.15	0.870426
single		3.44	0.290745
Mean VIF		3.04	

Houston			
Variable		VIF	1/VIF
Qincome			
	2	2	0.500231
	3	3.39	0.294597
	4	**6.05**	**0.165259**
Qvalue			
	2	1.93	0.517835
	3	2.78	0.359933
	4	3.54	0.282687
age		1.75	0.571179
density		1.39	0.717751
detached		4.57	0.218984
rental		**5.57**	**0.179396**
noCar		1.66	0.601239
white		2.5	0.399246
single		1.72	0.580804

Mean VIF	2.99

Los Angeles		
Variable	VIF	1/VIF
Qincome		
2	1.9	0.52667
3	2.72	0.367922
4	4.47	0.223749
Qvalue		
2	1.6	0.625071
3	1.88	0.531634
4	2.59	0.385367
age	1.51	0.663819
density	1.92	0.521339
detached	3.85	0.259452
rental	4.18	0.238984
noCar	1.73	0.576856
white	2.52	0.396381
single	1.9	0.526022
Mean VIF	2.52	

Miami		
Variable	VIF	1/VIF
Qincome		
2	2.14	0.467701
3	3.07	0.325498
4	**5.55**	**0.18023**
Qvalue		
2	1.9	0.527568
3	2.12	0.472462
4	3.29	0.303801
age	1.77	0.563392
density	1.57	0.635426
detached	3.86	0.258773
rental	3.12	0.32084

noCar	1.82	0.547975
white	2.56	0.389959
single	2.1	0.477028
Mean VIF	2.68	

Minneapolis-St Paul

Variable	VIF	1/VIF
Qincome		
2	2.39	0.419031
3	4.14	0.241585
4	**6.77**	**0.147704**
Qvalue		
2	1.89	0.528239
3	2.37	0.422422
4	3.23	0.309413
age	2.22	0.450882
density	1.91	0.524096
detached	4.77	0.209524
rental	5.32	0.187882
noCar	2.23	0.448814
white	2.06	0.486053
single	2.73	0.366606
Mean VIF	3.23	

Montreal

Variable	VIF	1/VIF
Qincome		
2	2.02	0.494815
3	3.52	0.284475
4	**6.06**	**0.165016**
Qvalue		
2	1.63	0.612084
3	1.81	0.553954

4	2.03	0.493673
pre46	1.37	0.727298
density	1.8	0.555526
detached	4.43	0.225483
rental	**6.52**	**0.153418**
white	1.71	0.584434
single	3.79	0.263865
Mean VIF	3.06	

New York		
Variable	VIF	1/VIF
Qincome		
2	1.94	0.516102
3	2.73	0.366721
4	3.82	0.261458
Qvalue		
2	1.59	0.629851
3	1.71	0.585961
4	2.14	0.468181
age	1.27	0.787066
density	2.55	0.392252
detached	4.58	0.218207
rental	4.98	0.200603
noCar	4.36	0.22921
white	2.06	0.486608
single	1.7	0.588512
Mean VIF	2.72	

Ottawa		
Variable	VIF	1/VIF
Qincome		

2	2.53	0.395058
3	4.54	0.220497
4	**6.52**	**0.15336**
Qvalue		
2	1.79	0.559931
3	2.33	0.429469
4	2.8	0.356545
pre46	1.4	0.713868
density	1.37	0.729606
detached	3.16	0.316913
rental	4.75	0.210732
white	1.59	0.627438
single	3.34	0.299335
Mean VIF	3.01	

Philadelphia		
Variable	VIF	1/VIF
Qincome		
2	2.79	0.358958
3	4.23	0.23643
4	**6.56**	**0.152534**
Qvalue		
2	3.08	0.325172
3	4.46	0.224328
4	5.8	0.172558
age	1.62	0.61841
density	2.29	0.437277
detached	3.27	0.305373
rental	2.48	0.403604
noCar	3.1	0.322725
white	2.62	0.381833
single	1.84	0.542405
Mean VIF	3.39	

Pittsburgh

Variable		VIF	1/VIF
Qincome			
	2	2.29	0.435805
	3	3.35	0.298336
	4	**5.86**	**0.17066**
Qvalue			
	2	2	0.499628
	3	2.79	0.357896
	4	4.1	0.244029
age		2.11	0.474296
density		1.78	0.56223
detached		4.45	0.224636
rental		5	0.200069
noCar		2.61	0.382719
white		1.69	0.592355
single		2.31	0.432778
Mean VIF		3.1	

San Francisco			
Variable		VIF	1/VIF
Qincome			
	2	1.92	0.52213
	3	2.66	0.376177
	4	4.04	0.247763
Qvalue			
	2	1.74	0.575195
	3	2.14	0.467306
	4	2.94	0.339568
age		1.53	0.654693
density		2.3	0.434243
detached		3.54	0.282793
rental		3.4	0.294483
noCar		2.16	0.463251
white		1.91	0.523404
single		2.25	0.444207
Mean VIF		2.5	

Seattle		
Variable	VIF	1/VIF
Qincome		
2	2.07	0.482903
3	3.01	0.331941
4	4.73	0.211335
Qvalue		
2	1.59	0.63007
3	1.84	0.54408
4	2.5	0.400246
age	1.53	0.653094
density	1.61	0.620819
detached	6	0.166724
rental	**5.45**	**0.183391**
noCar	1.98	0.505084
white	1.36	0.734445
single	2.69	0.371058
Mean VIF	2.8	

Toronto		
Variable	VIF	1/VIF
Qincome		
2	2.08	0.480734
3	3.05	0.328278
4	4	0.250203
Qvalue		
2	1.56	0.642634
3	1.76	0.567271
4	2.09	0.478464
pre46	1.33	0.752989
density	1.33	0.749277
detached	2.97	0.337101
rental	3.16	0.316627
white	1.72	0.579798
single	2.68	0.37253

Mean VIF	2.31

Vancouver

Variable		VIF	1/VIF
Qincome			
	2	1.96	0.509954
	3	2.65	0.376662
	4	3.98	0.251049
Qvalue			
	2	1.75	0.572541
	3	2.07	0.483788
	4	2.35	0.425865
pre46		1.25	0.800671
density		1.58	0.631672
detached		3.55	0.281811
rental		2.58	0.387746
white		1.96	0.509271
single		4	0.249867
Mean VIF		2.47	

Washington-Baltimore

Variable		VIF	1/VIF
Qincome			
	2	2.49	0.402182
	3	4.15	0.241181
	4	**6.05**	**0.165293**
Qvalue			
	2	2.38	0.420116
	3	3.15	0.317571
	4	3.96	0.252259
age		1.58	0.63333
density		2.06	0.48616

detached	3.43	0.29114
rental	3.23	0.30947
noCar	2.46	0.407039
white	1.55	0.647201
single	1.9	0.525627
Mean VIF	2.95	

And just for curiosity's sake, here are the results for the US and Canada (all cities together):

AMERICAN CITIES

regress transit i.Qincome i.Qvalue age density detached rental noCar white single [w=pop]

Source	SS	df	MS			
				Number of obs	=	46063
				F(13, 46049)	=	6943.82
Model	94725.19	13	7286.553	Prob > F	=	0
Residual	48321.92	46049	1.049359	R-squared	=	0.6622
				Adj R-squared	=	0.6621
Total	143047.1	46062	3.105534	Root MSE	=	1.0244

transit	Coef.	Std.Err.	t	P>t	[95%	Conf.Interval]
Qincome						
2	0.144	0.015	9.400	0.000	0.114	0.174
3	0.170	0.018	9.350	0.000	0.134	0.205
4	0.225	0.023	9.920	0.000	0.180	0.269
Qvalue						
2	0.202	0.014	14.340	0.000	0.175	0.230
3	0.423	0.015	28.240	0.000	0.394	0.452
4	0.556	0.017	31.960	0.000	0.522	0.590
age	0.182	0.003	57.900	0.000	0.176	0.188
density	0.034	0.001	48.660	0.000	0.033	0.035
detached	-0.142	0.002	-57.130	0.000	-0.147	-0.137
rental	-0.116	0.003	-35.260	0.000	-0.123	-0.110
noCar	0.487	0.005	106.910	0.000	0.478	0.496
white	-0.061	0.002	-31.480	0.000	-0.065	-0.057
single	-0.083	0.004	-19.560	0.000	-0.091	-0.075
_cons	0.905	0.034	26.390	0.000	0.838	0.972

vif.

Variable	VIF	1/VIF
Qincome		
2	1.95	0.511613
3	2.81	0.356216
4	4.36	0.229348
Qvalue		
2	1.67	0.599208
3	1.9	0.52685
4	2.46	0.405831
age	1.24	0.805331
density	2.23	0.448174
detached	3.19	0.31299
rental	3.55	0.281887
noCar	2.97	0.336466
white	1.78	0.561192
single	1.68	0.593641
Mean VIF	2.45	

CANADIAN CITIES

regress transit i.Qincome i.Qvalue pre46 density detached rental white single [w=pop]

Source	SS	df	MS	Number of obs	=	17499
				F(12, 17486)	=	1251.05
Model	15876.93	12	1323.078	Prob > F	=	0
Residual	18492.72	17486	1.057573	R-squared	=	0.4619
				Adj R-squared	=	0.4616
Total	34369.65	17498	1.964205	Root MSE	=	1.0284

transit	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Qincome						
2	-0.23819	0.025324	-9.41	0	-0.28782	-0.18855

3	-0.36516	0.030806	-11.85	0	-0.42554	-0.30477
4	-0.36949	0.037374	-9.89	0	-0.44275	-0.29623
Qvalue						
2	0.245515	0.022545	10.89	0	0.201325	0.289705
3	0.341187	0.023382	14.59	0	0.295357	0.387017
4	0.242896	0.025398	9.56	0	0.193113	0.292679
pre46	0.18039	0.004607	39.15	0	0.171359	0.18942
density	0.02944	0.001199	24.56	0	0.027091	0.03179
detached	-0.06039	0.003898	-15.49	0	-0.06803	-0.05275
rental	0.098208	0.005227	18.79	0	0.087962	0.108455
white	-0.10329	0.003858	-26.77	0	-0.11086	-0.09573
single	0.036335	0.008817	4.12	0	0.019054	0.053617
_cons	2.333323	0.042267	55.2	0	2.250475	2.416171

Variable	VIF	1/VIF
Qincome		
2	1.97	0.508525
3	2.98	0.335209
4	4.42	0.225998
Qvalue		
2	1.57	0.63808
3	1.69	0.590119
4	1.95	0.513473
pre46	1.22	0.822869
density	1.37	0.730789
detached	3.28	0.304599
rental	3.63	0.275149
white	1.67	0.600523
single	3.24	0.308584
Mean VIF	2.42	

Appendix C

This appendix shows variable correlations and detailed FTN coverage statistics for each metropolitan region studied.

Variable correlations

This section shows the correlations between variables for each city. Correlations higher than .5 are shaded lightly to darkly (very high). High correlations show a strong relationship between variables. For example, the relationship between detached housing and rental housing is usually strongly negative – that is, detached houses are owner-occupied more than other types of housing.

Variable Key:

ftn	Access to the frequent transit network (Y/N)
Transit	Percent of commuters who take transit in the area
Density	Residential density (people/square kilometer) in the area
Detached	Percent of single-detached housing (housing type) in the area
Rental	Percent of rental housing (housing tenure) in the area
Age/Pre46	Median age of housing; percent of housing built before 1946
Single	Percent of single-person households in the area
Income	Median household income
Value	Median home value of owner-occupied dwellings
noCar	Percent of households without a vehicle

-> city = Atlanta

(obs=851)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.41	1.00							
density	0.31	0.30	1.00						
detached	-0.20	-0.27	-0.39	1.00					
rental	0.26	0.44	0.37	-0.82	1.00				
age	0.25	0.35	0.30	-0.03	0.19	1.00			
single	0.31	0.26	0.35	-0.56	0.50	0.33	1.00		
income	-0.13	-0.39	-0.13	0.43	-0.65	-0.17	-0.39	1.00	
value	0.04	-0.19	0.09	0.09	-0.30	0.05	-0.05	0.77	1.00
noCar	0.36	0.57	0.20	-0.37	0.54	0.33	0.36	-0.47	-0.25

-> city = Boston

(obs=2942)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.68	1.00							
density	0.54	0.53	1.00						
detached	-0.43	-0.42	-0.57	1.00					
rental	0.34	0.35	0.51	-0.88	1.00				
age	0.26	0.30	0.40	-0.38	0.37	1.00			
single	0.18	0.16	0.18	-0.51	0.47	0.15	1.00		
income	-0.05	-0.08	-0.25	0.59	-0.64	-0.20	-0.44	1.00	
value	0.26	0.24	0.05	0.19	-0.21	0.06	-0.12	0.64	1.00
noCar	0.46	0.49	0.59	-0.63	0.65	0.28	0.40	-0.45	-0.05

-> city = Calgary
(obs=1343)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.27	1.00						
income	-0.21	-0.37	1.00					
value	0.04	-0.15	0.57	1.00				
density	0.19	0.15	-0.25	-0.22	1.00			
detached	-0.29	-0.36	0.65	0.28	-0.33	1.00		
rental	0.33	0.39	-0.68	-0.19	0.32	-0.79	1.00	
pre46	0.21	0.04	-0.09	0.31	0.00	-0.17	0.26	1.00
single	0.35	0.27	-0.61	-0.11	0.26	-0.79	0.73	0.35

-> city = Chicago
(obs=4279)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.62	1.00							
density	0.62	0.49	1.00						
detached	-0.51	-0.44	-0.54	1.00					
rental	0.47	0.43	0.48	-0.78	1.00				
age	0.45	0.37	0.41	-0.18	0.34	1.00			
single	0.21	0.24	0.15	-0.49	0.39	0.03	1.00		

income	-0.25	-0.11	-0.23	0.42	-0.55	-0.27	-0.32	1.00	
value	0.07	0.15	0.08	0.06	-0.18	-0.04	-0.10	0.74	1.00
noCar	0.55	0.56	0.47	-0.56	0.64	0.34	0.38	-0.43	-0.13

-> city = Dallas

(obs=2256)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	.								
transit	.	1.00							
density	.	0.13	1.00						
detached	.	-0.13	-0.33	1.00					
rental	.	0.18	0.35	-0.84	1.00				
age	.	0.14	0.10	0.19	0.01	1.00			
single	.	0.11	-0.03	-0.47	0.42	0.07	1.00		
income	.	-0.19	-0.20	0.36	-0.53	-0.26	-0.27	1.00	
value	.	-0.11	-0.08	0.06	-0.21	-0.12	-0.02	0.77	1.00
noCar	.	0.37	0.10	-0.32	0.42	0.17	0.27	-0.35	-0.18

-> city = Edmonton

(obs=1229)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.35	1.00						
income	-0.31	-0.49	1.00					
value	-0.07	-0.28	0.61	1.00				
density	0.12	0.27	-0.24	-0.17	1.00			
detached	-0.26	-0.46	0.68	0.38	-0.40	1.00		
rental	0.32	0.53	-0.72	-0.29	0.36	-0.81	1.00	
pre46	0.28	0.23	-0.27	-0.07	0.01	-0.11	0.26	1.00
single	0.38	0.45	-0.72	-0.26	0.32	-0.72	0.75	0.33

-> city = Houston

(obs=1551)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								

transit	0.28	1.00							
density	0.16	0.13	1.00						
detached	-0.09	-0.15	-0.22	1.00					
rental	0.19	0.29	0.30	-0.79	1.00				
age	0.21	0.19	0.23	0.21	0.06	1.00			
single	0.21	0.22	0.04	-0.46	0.43	0.10	1.00		
income	-0.11	-0.24	-0.13	0.32	-0.54	-0.24	-0.22	1.00	
value	0.02	-0.12	0.01	0.03	-0.19	-0.11	0.06	0.77	1.00
noCar	0.23	0.46	0.12	-0.31	0.49	0.24	0.29	-0.41	-0.21

-> city = Los Angeles
(obs=7011)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.39	1.00							
density	0.35	0.50	1.00						
detached	-0.25	-0.30	-0.42	1.00					
rental	0.32	0.44	0.55	-0.75	1.00				
age	0.24	0.25	0.21	0.16	0.12	1.00			
single	0.08	-0.01	-0.04	-0.47	0.28	0.03	1.00		
income	-0.25	-0.38	-0.39	0.46	-0.61	-0.17	-0.16	1.00	
value	-0.07	-0.19	-0.19	0.20	-0.24	0.06	0.10	0.66	1.00
noCar	0.33	0.51	0.43	-0.39	0.51	0.20	0.19	-0.45	-0.24

-> city = Miami
(obs=952)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.26	1.00							
density	0.29	0.27	1.00						
detached	-0.10	-0.28	-0.36	1.00					
rental	0.29	0.46	0.45	-0.68	1.00				
age	0.29	0.22	0.17	0.30	0.04	1.00			
single	0.07	0.17	0.08	-0.53	0.34	0.00	1.00		
income	-0.20	-0.37	-0.38	0.44	-0.57	-0.16	-0.29	1.00	
value	-0.05	-0.28	-0.27	0.34	-0.35	0.01	-0.15	0.78	1.00
noCar	0.27	0.57	0.33	-0.40	0.54	0.19	0.31	-0.44	-0.34

-> city = Minneapolis
(obs=1654)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.41	1.00							
density	0.52	0.52	1.00						
detached	-0.16	-0.31	-0.29	1.00					
rental	0.28	0.42	0.42	-0.81	1.00				
age	0.49	0.38	0.52	0.11	0.16	1.00			
single	0.27	0.28	0.29	-0.62	0.57	0.21	1.00		
income	-0.25	-0.35	-0.36	0.56	-0.66	-0.26	-0.57	1.00	
value	-0.06	-0.15	-0.16	0.23	-0.21	-0.07	-0.24	0.68	1.00
noCar	0.33	0.51	0.43	-0.49	0.63	0.26	0.45	-0.56	-0.25

-> city = Montreal
(obs=5145)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.63	1.00						
income	-0.35	-0.45	1.00					
value	0.33	0.17	0.28	1.00				
density	0.56	0.58	-0.44	0.16	1.00			
detached	-0.59	-0.59	0.67	-0.16	-0.58	1.00		
rental	0.55	0.59	-0.75	0.11	0.61	-0.85	1.00	
pre46	0.47	0.40	-0.18	0.26	0.39	-0.41	0.40	1.00
single	0.49	0.50	-0.68	0.05	0.46	-0.76	0.80	0.43

-> city = New York
(obs=11691)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.78	1.00							
density	0.62	0.66	1.00						

detached	-0.64	-0.64	-0.59	1.00					
rental	0.53	0.56	0.56	-0.85	1.00				
age	0.37	0.40	0.31	-0.28	0.31	1.00			
single	0.20	0.21	0.26	-0.49	0.43	0.08	1.00		
income	-0.34	-0.26	-0.26	0.58	-0.62	-0.17	-0.33	1.00	
value	0.17	0.25	0.19	0.05	-0.07	0.15	-0.06	0.49	1.00
noCar	0.71	0.76	0.74	-0.74	0.74	0.35	0.40	-0.43	0.14

-> city = Ottawa

(obs=1343)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.31	1.00						
income	-0.17	-0.31	1.00					
value	0.25	-0.10	0.56	1.00				
density	0.23	0.28	-0.30	-0.10	1.00			
detached	-0.26	-0.38	0.69	0.33	-0.42	1.00		
rental	0.29	0.36	-0.73	-0.15	0.39	-0.71	1.00	
pre46	0.35	-0.01	-0.10	0.35	0.11	-0.17	0.33	1.00
single	0.36	0.27	-0.68	-0.14	0.40	-0.67	0.76	0.36

-> city = Philadelphia

(obs=3275)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.63	1.00							
density	0.60	0.55	1.00						
detached	-0.56	-0.52	-0.58	1.00					
rental	0.26	0.33	0.31	-0.65	1.00				
age	0.42	0.42	0.47	-0.39	0.25	1.00			
single	0.25	0.23	0.11	-0.49	0.47	0.21	1.00		
income	-0.42	-0.42	-0.44	0.66	-0.60	-0.39	-0.48	1.00	
value	-0.41	-0.41	-0.45	0.55	-0.34	-0.38	-0.23	0.76	1.00
noCar	0.60	0.67	0.57	-0.63	0.53	0.43	0.35	-0.60	-0.51

-> city = Pittsburgh

(obs=1235)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.48	1.00							
density	0.45	0.46	1.00						
detached	-0.35	-0.40	-0.42	1.00					
rental	0.31	0.40	0.45	-0.84	1.00				
age	0.27	0.31	0.46	-0.16	0.31	1.00			
single	0.24	0.26	0.24	-0.62	0.62	0.24	1.00		
income	-0.14	-0.27	-0.27	0.48	-0.62	-0.41	-0.55	1.00	
value	-0.03	-0.17	-0.14	0.17	-0.30	-0.41	-0.29	0.77	1.00
noCar	0.31	0.53	0.36	-0.55	0.62	0.37	0.45	-0.54	-0.40

-> city = San Francisco
(obs=3381)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.55	1.00							
density	0.51	0.58	1.00						
detached	-0.41	-0.44	-0.49	1.00					
rental	0.36	0.34	0.45	-0.77	1.00				
age	0.40	0.42	0.38	-0.02	0.14	1.00			
single	0.25	0.27	0.19	-0.58	0.51	0.18	1.00		
income	-0.20	-0.16	-0.25	0.44	-0.58	-0.06	-0.35	1.00	
value	0.01	0.08	0.01	0.19	-0.22	0.19	-0.06	0.66	1.00
noCar	0.45	0.53	0.59	-0.55	0.57	0.28	0.44	-0.39	-0.07

-> city = Seattle
(obs=2002)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.41	1.00							
density	0.43	0.46	1.00						
detached	-0.29	-0.29	-0.40	1.00					
rental	0.31	0.33	0.44	-0.84	1.00				
age	0.28	0.28	0.25	0.18	0.02	1.00			
single	0.34	0.35	0.37	-0.67	0.61	0.17	1.00		

income	-0.17	-0.14	-0.23	0.56	-0.63	-0.05	-0.51	1.00	
value	0.04	0.13	0.00	0.24	-0.25	0.15	-0.13	0.67	1.00
noCar	0.36	0.37	0.45	-0.52	0.57	0.13	0.58	-0.42	-0.12

-> city = Toronto
(obs=5713)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.59	1.00						
income	-0.31	-0.40	1.00					
value	0.05	-0.01	0.50	1.00				
density	0.24	0.35	-0.27	-0.15	1.00			
detached	-0.37	-0.50	0.59	0.27	-0.43	1.00		
rental	0.37	0.53	-0.58	-0.04	0.37	-0.66	1.00	
pre46	0.37	0.44	-0.07	0.24	0.10	-0.27	0.27	1.00
single	0.41	0.48	-0.49	0.00	0.32	-0.57	0.69	0.40

-> city =
Vancouver
(obs=2726)

	ftn	transit	income	value	density	detached	rental	pre46
ftn	1.00							
transit	0.48	1.00						
income	-0.35	-0.49	1.00					
value	0.00	-0.19	0.52	1.00				
density	0.32	0.38	-0.38	-0.25	1.00			
detached	-0.42	-0.54	0.68	0.45	-0.54	1.00		
rental	0.38	0.57	-0.62	-0.23	0.50	-0.71	1.00	
pre46	0.28	0.21	0.08	0.40	-0.01	-0.03	0.15	1.00
single	0.33	0.42	-0.55	-0.32	0.53	-0.70	0.67	0.11

-> city = Wash-Balt
(obs=2983)

	ftn	transit	density	detached	rental	age	single	income	value
ftn	1.00								
transit	0.50	1.00							
density	0.47	0.50	1.00						

detached	-0.41	-0.42	-0.57	1.00					
rental	0.32	0.42	0.45	-0.71	1.00				
age	0.45	0.36	0.42	-0.19	0.15	1.00			
single	0.31	0.26	0.29	-0.56	0.50	0.23	1.00		
income	-0.27	-0.26	-0.35	0.59	-0.59	-0.23	-0.44	1.00	
value	-0.15	-0.10	-0.22	0.44	-0.31	-0.16	-0.23	0.82	1.00
noCar	0.48	0.59	0.53	-0.57	0.59	0.38	0.40	-0.51	-0.35

Detailed FTN coverage statistics

For each city, the number and proportion of households with access to frequent transit are described, and breakdowns of FTN coverage by the first quartile (lowest quarter) of income, home value and rental value are cross-tabulated by density. Low density is less than 2,500 people per square kilometer; high density is more than 5,000 people per square kilometer, and medium density is between these numbers. Zero is the code for no access, and one is the code for access – those households that are within walking distance of frequent transit.

ATLANTA	Transit coverage			
FTNAccess	Population	Percent	Households	Percent
0	1,735,090	93.3	608,705	92.65
1	124,614	6.7	48,298	7.35
Total	1,859,704	100	657,003	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
107,760	85.44	1,851	38.25	10,606	69.4	95,303	89.91
18,366	14.56	2,988	61.75	4,677	30.6	10,701	10.09
126,126	100	4,839	100	15,283	100	106,004	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
62,208	94.75	116	60.73	2,661	71	59,431	96.27
3,446	5.25	75	39.27	1,066	29	2,305	3.73
65,654	100	191	100	3,727	100	61,736	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
53,974	83.13	544	18.63	6,931	76.7	46,499	87.79
10,951	16.87	2,376	81.37	2,106	23.3	6,469	12.21
64,925	100	2,920	100	9,037	100	52,968	100

BOSTON		Transit coverage			
FTNAccess		Population	Percent	Households	Percent
	0	3,273,966	84.43	1,233,080	83.81
	1	603,830	15.57	238,116	16.19
Total		3,877,796	100	1,471,196	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
268,206	79.96	86,950	61.47	68,435	87.66	112,821	97.32
67,236	20.04	54,492	38.53	9,637	12.34	3,107	2.68

335,442	100	141,442	100	78,072	100	115,928	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
189,210	98.27	17,418	87.37	26,312	97	145,480	99.98
3,337	1.73	2,517	12.63	785	3	35	0.02
192,547	100	19,935	100	27,097	100	145,515	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
128,008	83.87	30,876	61.67	31,384	88.36	65,748	98.09
24,610	16.13	19,194	38.33	4,136	11.64	1,280	1.91
152,618	100	50,070	100	35,520	100	67,028	100

CALGARY Transit coverage

FTNAccess	POPULATION	Percent	HOUSEHOLDS	Percent
0	660,763	72.05	242,255	67.76
1	256,365	27.95	115,270	32.24
Total	917,128	100	357,525	100

Coverage by income and density (households)

Q1income	Percent	high density	Percent	medium density	Percent	low density	Percent
43,385	44.37	12,650	30.96	22,150	57.4	8,585	46.85
54,385	55.63	28,205	69.04	16,440	42.6	9,740	53.15
97,770	100	40,855	100	38,590	100	18,325	100

Coverage by home value and density (households)

Q1owned	Percent	high density	Percent	medium density	Percent	low density	Percent
38,035	73.56	8,345	59.71	21,435	78.47	8,255	79.26
13,670	26.44	5,630	40.29	5,880	21.53	2,160	20.74
51,705	100	13,975	100	27,315	100	10,415	100

Coverage by rent and density (households)

Q1 Rental	Percent	high density	Percent	medium density	Percent	low density	Percent
14,830	41.05	4,255	23.75	6,630	59.33	3,945	56.08
21,295	58.95	13,660	76.25	4,545	40.67	3,090	43.92
36,125	100	17,915	100	11,175	100	7,035	100

CHICAGO Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	4,151,948	70.99	1,461,289	69.08
1	1,696,999	29.01	654,142	30.92
Total	5,848,947	100	2,115,431	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
217,377	47.28	32,277	14.85	63,708	58.43	121,392	91.01
242,436	52.72	185,111	85.15	45,328	41.57	11,997	8.99
459,813	100	217,388	100	109,036	100	133,389	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent

237,411	86.12	14,985	48.75	63,553	79	158,873	96.58
38,258	13.88	15,752	51.25	16,885	21	5,621	3.42
275,669	100	30,737	100	80,438	100	164,494	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
94,641	50.36	9,948	11.92	25,972	62.18	58,721	93.63
93,287	49.64	73,496	88.08	15,794	37.82	3,997	6.37
187,928	100	83,444	100	41,766	100	62,718	100

DALLAS	Transit coverage			
FTNAccess	Population	Percent	Households	Percent
0	3,453,791	100	1,200,240	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
265,193	100	49,849	100	77,846	100	137,498	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
119,089	100	2,549	100	30,662	100	85,878	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent

133,154	100	31,153	100	41,699	100	60,302	100

EDMONTON	Transit coverage				
FTNAccess		Freq.	Percent	Freq.	Percent
	0	662,049	78.94	252,310	75.09
	1	176,636	21.06	83,700	24.91
Total		838,685	100	336,010	100

Coverage by income and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
53,125	51.75	18,955	44.38	21,825	55.28	12,345	60.34
49,530	48.25	23,760	55.62	17,655	44.72	8,115	39.66
102,655	100	42,715	100	39,480	100	20,460	100

Coverage by home value and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
33,445	72.23	5,990	64.72	15,615	72.59	11,840	76.19
12,860	27.77	3,265	35.28	5,895	27.41	3,700	23.81
46,305	100	9,255	100	21,510	100	15,540	100

Coverage by rent and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
20,730	54.4	6,605	41.92	8,990	60.89	5,135	67.65
17,380	45.6	9,150	58.08	5,775	39.11	2,455	32.35
38,110	100	15,755	100	14,765	100	7,590	100

HOUSTON	Transit coverage			
FTNAccess	Population	Percent	Households	Percent
0	2,515,236	87.83	859,559	86.63
1	348,413	12.17	132,684	13.37
Total	2,863,649	100	992,243	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
157,188	74.2	19,029	70.58	40,306	70.22	97,853	76.76
54,653	25.8	7,930	29.42	17,092	29.78	29,631	23.24
211,841	100	26,959	100	57,398	100	127,484	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
75,286	83.94	2,504	80.03	12,882	74.73	59,900	86.41
14,405	16.06	625	19.97	4,357	25.27	9,423	13.59
89,691	100	3,129	100	17,239	100	69,323	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
73,335	73.46	9,307	70.6	20,682	70.87	43,346	75.43
26,498	26.54	3,876	29.4	8,501	29.13	14,121	24.57
99,833	100	13,183	100	29,183	100	57,467	100

LOS	Transit

ANGELES	coverage			
FTNAccess	Population	Percent	Households	Percent
0	9,130,286	77.3	2,935,522	78.09
1	2,681,028	22.7	823,480	21.91
Total	11,811,314	100	3,759,002	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
547,922	58.5	232,467	42.72	153,387	71.75	162,068	90.71
388,690	41.5	311,708	57.28	60,379	28.25	16,603	9.29
936,612	100	544,175	100	213,766	100	178,671	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
387,437	83.68	59,154	55.82	123,894	86.04	204,389	95.95
75,550	16.32	46,814	44.18	20,106	13.96	8,630	4.05
462,987	100	105,968	100	144,000	100	213,019	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
255,059	51.66	111,546	35.8	70,742	70.36	72,771	89.24
238,625	48.34	200,047	64.2	29,802	29.64	8,776	10.76
493,684	100	311,593	100	100,544	100	81,547	100

MIAMI	Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	1,604,719	80.62	560,795	80.41
1	385,727	19.38	136,639	19.59
Total	1,990,446	100	697,434	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
87,336	57.66	19,562	35.42	33,980	60.75	33,794	83.86
64,120	42.34	35,664	64.58	21,954	39.25	6,502	16.14
151,456	100	55,226	100	55,934	100	40,296	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
92,311	87.5	9,343	67.22	41,640	90.44	41,328	90.72
13,188	12.5	4,557	32.78	4,401	9.56	4,230	9.28
105,499	100	13,900	100	46,041	100	45,558	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
31,346	47.03	7,268	30.8	9,890	42.69	14,188	71.34
35,307	52.97	16,329	69.2	13,277	57.31	5,701	28.66
66,653	100	23,597	100	23,167	100	19,889	100

MINNEAPOLIS Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	1,774,771	78.79	691,453	77.29
1	477,769	21.21	203,184	22.71
Total	2,252,540	100	894,637	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
109,447	52.7	3,825	11.94	25,819	40.55	79,803	71.27
98,224	47.3	28,207	88.06	37,852	59.45	32,165	28.73
207,671	100	32,032	100	63,671	100	111,968	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
85,688	73.25	1,123	39.87	14,923	48.59	69,642	83.45
31,299	26.75	1,694	60.13	15,792	51.41	13,813	16.55
116,987	100	2,817	100	30,715	100	83,455	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
34,942	45.57	987	5.5	9,114	37.35	24,841	72.36
41,741	54.43	16,966	94.5	15,285	62.65	9,490	27.64
76,683	100	17,953	100	24,399	100	34,331	100

MONTREAL Transit coverage

FTNAccess	Freq.	Percent	Freq.	Percent

	0	1,890,798	58.98	746,465	54.87
	1	1,314,878	41.02	614,070	45.13
Total		3,205,676	100	1,360,535	100

Coverage by income and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
115,925	28.99	68,215	21.09	31,125	60.91	16,585	65.4
284,020	71.01	255,270	78.91	19,975	39.09	8,775	34.6
399,945	100	323,485	100	51,100	100	25,360	100

Coverage by home value and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
172,160	94.37	28,885	76.83	95,070	98.68	48,205	99.41
10,270	5.63	8,710	23.17	1,275	1.32	285	0.59
182,430	100	37,595	100	96,345	100	48,490	100

Coverage by rent and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
64,445	37.05	31,825	24.7	20,695	67.98	11,925	81.57
109,475	62.95	97,030	75.3	9,750	32.02	2,695	18.43
173,920	100	128,855	100	30,445	100	14,620	100

NEW YORK	Transit coverage			
FTNAccess	Population	Percent	Households	Percent
0	9,251,388	54.11	3,254,220	53.04
1	7,846,199	45.89	2,881,200	46.96

Total	17,097,587	100	6,135,420	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
419,057	26.15	169,676	12.82	105,019	83.13	144,362	94.72
1,183,497	73.85	1,154,143	87.18	21,314	16.87	8,040	5.28
1,602,554	100	1,323,819	100	126,333	100	152,402	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density
651,212	79.12	74,304	31.89	121,144	92.19	455,764
171,826	20.88	158,679	68.11	10,269	7.81	2,878
823,038	100	232,983	100	131,413	100	458,642

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
215,124	23.47	68,317	9.07	55,596	81.58	91,211	95.84
701,425	76.53	684,907	90.93	12,556	18.42	3,962	4.16
916,549	100	753,224	100	68,152	100	95,173	100

OTTAWA		Transit coverage			
FTNAccess		Freq.	Percent	Freq.	Percent
	0	499,731	56.05	187,595	52.14
	1	391,794	43.95	172,180	47.86
Total		891,525	100	359,775	100

Coverage by income and density (households)							
Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
39,615	36.37	19,460	28.13	12,625	46.58	7,530	59.64
69,295	63.63	49,720	71.87	14,480	53.42	5,095	40.36
108,910	100	69,180	100	27,105	100	12,625	100

Coverage by home value and density (households)							
Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
39,850	80.72	9,385	61.16	19,935	94.75	10,530	81.09
9,520	19.28	5,960	38.84	1,105	5.25	2,455	18.91
49,370	100	15,345	100	21,040	100	12,985	100

Coverage by rent and density (households)							
Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
20,380	54.33	8,815	42.54	7,540	67.78	4,025	71.05
17,130	45.67	11,905	57.46	3,585	32.22	1,640	28.95
37,510	100	20,720	100	11,125	100	5,665	100

PHILADELPHIA	Transit coverage			
FTNAccess	Population	Percent	Households	Percent
0	3,259,409	78.63	1,233,258	79.27
1	885,829	21.37	322,586	20.73
Total	4,145,238	100	1,555,844	100

Coverage by income and density (households)							
Q1	Percen	Q1 income,	Percen	Q1income,	Percen	Q1income,	Percen

income	t	High Density	t	medium density	t	low density	t
128,476	44.66	37,028	22.76	33,838	57.68	57,610	86.85
159,227	55.34	125,683	77.24	24,824	42.32	8,720	13.15
287,703	100	162,711	100	58,662	100	66,330	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
51,382	35.53	18,788	19.56	12,120	48.06	20,474	87.66
93,251	64.47	77,269	80.44	13,100	51.94	2,882	12.34
144,633	100	96,057	100	25,220	100	23,356	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
56,453	50.41	7,162	14.91	15,423	56.58	33,868	92.33
55,525	49.59	40,875	85.09	11,835	43.42	2,815	7.67
111,978	100	48,037	100	27,258	100	36,683	100

PITTSBURGH Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	1,215,261	85.23	518,163	84.5
1	210,540	14.77	95,075	15.5
Total	1,425,801	100	613,238	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent

99,583	73.51	6,465	47.59	25,702	57.94	67,416	86.96
35,889	26.49	7,120	52.41	18,657	42.06	10,112	13.04
135,472	100	13,585	100	44,359	100	77,528	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
54,497	81.44	2,646	65.56	14,770	69.6	37,081	89.01
12,420	18.56	1,390	34.44	6,450	30.4	4,580	10.99
66,917	100	4,036	100	21,220	100	41,661	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
48,289	85.54	1,642	44.45	8,625	72.71	38,022	92.97
8,162	14.46	2,052	55.55	3,237	27.29	2,873	7.03
56,451	100	3,694	100	11,862	100	40,895	100

SAN FRANCISCO Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	3,560,628	69.59	1,266,446	68.6
1	1,555,937	30.41	579,594	31.4
Total	5,116,565	100	1,846,040	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent

243,448	54.5	55,758	28.46	102,588	68.73	85,102	83.84
203,209	45.5	140,142	71.54	46,668	31.27	16,399	16.16
446,657	100	195,900	100	149,256	100	101,501	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
174,126	78.75	19,516	44.97	77,528	81.78	77,082	92.96
46,994	21.25	23,885	55.03	17,268	18.22	5,841	7.04
221,120	100	43,401	100	94,796	100	82,923	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
107,358	45.83	24,640	22.4	47,345	59.59	35,373	78.98
126,881	54.17	85,358	77.6	32,106	40.41	9,417	21.02
234,239	100	109,998	100	79,451	100	44,790	100

SEATTLE Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	2,166,321	84.11	845,972	81.42
1	409,235	15.89	193,056	18.58
Total	2,575,556	100	1,039,028	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
191,138	67.88	5,477	13.61	60,179	67.58	125,482	82.39

90,443	32.12	34,759	86.39	28,865	32.42	26,819	17.61
281,581	100	40,236	100	89,044	100	152,301	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent
127,253	88.96	693	41.92	20,285	77.23	106,275	92.31
15,792	11.04	960	58.08	5,982	22.77	8,850	7.69
143,045	100	1,653	100	26,267	100	115,125	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
81,111	64.51	3,272	15.26	21,873	60.09	55,966	82.45
44,617	35.49	18,176	84.74	14,527	39.91	11,914	17.55
125,728	100	21,448	100	36,400	100	67,880	100

TORONTO	Transit coverage			
FTNAccess	Freq.	Percent	Freq.	Percent
0	1,824,158	42.8	566,015	37.51
1	2,438,303	57.2	942,970	62.49
Total	4,262,461	100	1,508,985	100

Coverage by income and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
75,815	14.47	41,545	9.77	19,280	28.63	14,990	47.53
448,215	85.53	383,605	90.23	48,065	71.37	16,545	52.47

524,030	100	425,150	100	67,345	100	31,535	100

Coverage by home value and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
107,235	40.02	44,420	27.38	43,210	56.83	19,605	66.04
160,730	59.98	117,825	72.62	32,825	43.17	10,080	33.96
267,965	100	162,245	100	76,035	100	29,685	100

Coverage by rent and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
20,565	15.69	9,715	9.26	6,160	34.11	4,690	57.62
110,520	84.31	95,170	90.74	11,900	65.89	3,450	42.38
131,085	100	104,885	100	18,060	100	8,140	100

VANCOUVER Transit coverage

FTNAccess		Freq.	Percent	Freq.	Percent
	0	651,306	37.1	222,055	32.57
	1	1,104,185	62.9	459,670	67.43
Total		1,755,491	100	681,725	100

Coverage by income and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
29,365	12.95	15,730	8.84	9,180	29.68	4,455	24.97
197,375	87.05	162,240	91.16	21,750	70.32	13,385	75.03
226,740	100	177,970	100	30,930	100	17,840	100

Coverage by home value and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
43,745	34.81	11,125	17.57	21,185	54.36	11,435	48.88
81,925	65.19	52,180	82.43	17,785	45.64	11,960	51.12
125,670	100	63,305	100	38,970	100	23,395	100

Coverage by rent and density (households)

Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
15,505	21.22	7,195	13.54	6,545	47.67	1,765	28.51
57,550	78.78	45,940	86.46	7,185	52.33	4,425	71.49
73,055	100	53,135	100	13,730	100	6,190	100

WASHINGTON & BALTIMORE Transit coverage

FTNAccess	Population	Percent	Households	Percent
0	3,303,107	73.46	1,220,625	71.92
1	1,193,504	26.54	476,479	28.08
Total	4,496,611	100	1,697,104	100

Coverage by income and density (households)

Q1 income	Percent	Q1 income, High Density	Percent	Q1income, medium density	Percent	Q1income, low density	Percent
165,805	46.66	34,279	23.14	51,039	50.41	80,487	75.96
189,532	53.34	113,848	76.86	50,217	49.59	25,467	24.04
355,337	100	148,127	100	101,256	100	105,954	100

Coverage by home value and density (households)

Q1 home value	Percent	Q1 value, high density	Percent	Q1 value, medium density	Percent	Q1 value, low density	Percent

109,890	62.28	16,292	34.99	36,404	61.99	57,194	80.38
66,551	37.72	30,269	65.01	22,319	38.01	13,963	19.62
176,441	100	46,561	100	58,723	100	71,157	100

Coverage by rent and density (households)

Q1 rent	Percent	Q1rent, high density	Percent	Q1 rent, medium density	Percent	Q1 rent, low density	Percent
70,815	44.49	10,393	15.69	18,928	46.82	41,494	79.06
88,339	55.51	55,848	84.31	21,501	53.18	10,990	20.94
159,154	100	66,241	100	40,429	100	52,484	100

Appendix D

Including Rent

Boston and Philadelphia were tested for including rent in the logistic regression model, and the results are quite evocative. Including rent drops the total number of observations available, as many areas do not have rent statistics due to presumably low numbers of rental units, which is why rent was not included in the main analysis. However, including rent illuminates the role of rent in providing affordable access, and thus tells the other half of the story compared to home ownership.

In Philadelphia, the probability of access to transit is greater for areas with lower rents, whereas in Boston the opposite is true. These results are quite strong. It would be useful to run this rent-inclusive model for all cities, to determine the relative importance of lower-cost rents in providing affordable access. It would also be helpful to track rents over time in relation to transit to indicate gentrification.

PHILADELPHIA – INCLUDING RENT

Logistic regression		Number of obs	=	4573611			
		LR chi2(16)	=	2900452			
		Prob > chi2	=	0			
Log likelihood = -1256075.9		Pseudo R2	=	0.5359			
FTN		Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10		1.64	0.00	312.33	0.00	1.63	1.64
Qincome							
	2	1.20	0.01	36.55	0.00	1.19	1.21
	3	1.74	0.01	88.03	0.00	1.72	1.77
	4	2.32	0.02	96.92	0.00	2.28	2.36
Qvalue							
	2	0.84	0.00	-33.91	0.00	0.83	0.85
	3	0.99	0.01	-1.37	0.17	0.98	1.00
	4	1.17	0.01	21.40	0.00	1.15	1.19
Qrent							
	2	0.79	0.00	-49.05	0.00	0.79	0.80
	3	0.59	0.00	-109.43	0.00	0.58	0.59
	4	0.44	0.00	-141.34	0.00	0.44	0.45

age10	1.26	0.00	178.54	0.00	1.26	1.26
density1000	1.26	0.00	410.94	0.00	1.26	1.26
detached10	0.81	0.00	-212.89	0.00	0.80	0.81
noCar10	1.05	0.00	28.72	0.00	1.04	1.05
white10	0.98	0.00	-30.67	0.00	0.98	0.98
single10	1.22	0.00	146.97	0.00	1.22	1.22
_cons	0.02	0.00	-345.93	0.00	0.02	0.02

	Margin	Std. Err.	z	P>z [95%	Conf.	Interval]
constant	0.28	0.00	2084.33	0.00	0.28	0.28
Qrent						
1	0.31	0.00	906.16	0.00	0.31	0.31
2	0.29	0.00	1063.53	0.00	0.29	0.29
3	0.27	0.00	1027.81	0.00	0.27	0.27
4	0.24	0.00	756.77	0.00	0.24	0.24

BOSTON – INCLUDING RENT

Logistic regression	Number of obs	=	4354438			
	LR chi2(16)	=	2706101			
	Prob > chi2	=	0			
Log likelihood = -756355.61	Pseudo R2	=	0.6414			
FTN	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10	2.62	0.01	478.83	0.00	2.61	2.63
Qincome						
2	2.18	0.01	113.04	0.00	2.15	2.21
3	2.76	0.02	128.34	0.00	2.72	2.80
4	3.09	0.03	118.19	0.00	3.03	3.15
Qvalue						
2	2.80	0.02	120.73	0.00	2.75	2.85
3	4.13	0.03	171.66	0.00	4.06	4.19

4	9.97	0.09	257.53	0.00	9.80	10.15
Qrent						
2	1.08	0.01	9.10	0.00	1.06	1.09
3	1.97	0.02	85.96	0.00	1.94	2.00
4	3.71	0.03	162.71	0.00	3.65	3.77
age10	1.29	0.00	157.12	0.00	1.29	1.30
density1000	1.09	0.00	139.86	0.00	1.09	1.09
detached10	0.85	0.00	-126.65	0.00	0.84	0.85
noCar10	1.42	0.00	157.91	0.00	1.42	1.43
white10	0.86	0.00	-138.09	0.00	0.86	0.86
single10	1.29	0.00	128.77	0.00	1.28	1.29
_cons	0.00	0.00	-432.83	0.00	0.00	0.00

	Margin	Std. Err.	z	P>z [95%	Conf.	Interval]
constant	0.19	0.00	1751.68	0.00	0.19	0.19
Qrent						
1	0.15	0.00	518.28	0.00	0.15	0.15
2	0.16	0.00	641.29	0.00	0.16	0.16
3	0.19	0.00	856.85	0.00	0.19	0.19
4	0.22	0.00	926.39	0.00	0.22	0.22

Appendix E

Including Regional Rail

When testing to see how the inclusion of regional rail in the transit network impacts the results, two comparisons were added to the base Frequent Transit Network. The first was areas within a 5 kilometer radius of regional rail stations. This is the approximate radius within which most people drive to commuter rail stations (Vijayakumar, El-Geneidy, & Patterson, 2011). However, because this research is especially concerned with populations who don't have a car, a second comparison including areas that were within 1 kilometer (walking distance) of commuter rail stations was run. In both cases, these areas were added to the existing FTN and the logistic regression model was re-run.

Boston and Philadelphia were used to test the inclusion of regional rail. Both cities have commuter rail systems that extend the transit network into the suburbs, but the spatial socioeconomics of these two regions are quite different. Philadelphia's lower-cost housing is mostly located in the FTN zone, while Boston's is not. We could therefore expect that regional rail will increase coverage in both cities but improve equity in Boston while not necessarily improving equity in Philadelphia.

The results show that while regional rail extends the network coverage considerably, especially when using a driving distance radius, the likelihood of having coverage as income rises is exacerbated. The coverage provided within walking distance of regional rail is improved by an amount somewhere between that of the driving distance and the base case. In Philadelphia, the likelihood of access to the FTN is 26%, to the FTN and RR (5km) is 61% (more than doubling coverage, for those with vehicles), and to the FTN and RR (1km) is 34%. The same numbers in Boston are 17%, 67%, and 25%, respectively. It is clear that although regional rail significantly extends coverage for those with vehicles, it does not extend coverage nearly as much for those without. In Philadelphia, the likelihood of access for second-quartile home values remains considerably lower than for other home values even as regional rail is added, and the polarization of access for lower-income residents (less likely) compared with higher income (more likely) became more extreme as regional rail was taken into account. In Boston, the same observations could be made with regards to increasing polarization of access for low-income vs. high-income residents as regional rail is added, although driving distance (5km) access to regional rail was improved for 2nd quartile income residents (mid-low incomes). These results show that although commuter rail improves coverage, it does so mostly in an auto-dependent way. For these reasons, it seems justified not to include commuter rail in the main analysis, which limits transit accessibility to Frequent Transit Networks.

PHILADELPHIA – BASE CASE[13] (FTN ONLY)

Logistic regression		Number of obs	=	5699066.00			
		LR chi2(14)	=	3594986.30			
		Prob > chi2	=	0.00			
Log likelihood = -1463098.9		Pseudo R2	=	0.55			
FTN		Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10		1.57	0.00	311.45	0.00	1.56	1.57
Qincome							
	2	1.06	0.01	12.01	0.00	1.05	1.07
	3	1.20	0.01	30.83	0.00	1.19	1.21
	4	1.28	0.01	31.43	0.00	1.26	1.29
Qvalue							
	2	0.62	0.00	-98.80	0.00	0.62	0.63
	3	0.94	0.01	-9.80	0.00	0.93	0.96
	4	1.03	0.01	4.32	0.00	1.02	1.04
age10		1.30	0.00	228.27	0.00	1.30	1.30
density1000		1.23	0.00	396.48	0.00	1.23	1.23
detached10		0.76	0.00	-318.55	0.00	0.76	0.77
rental10		0.82	0.00	-230.53	0.00	0.82	0.82
noCar10		1.17	0.00	108.20	0.00	1.16	1.17
white10		0.97	0.00	-44.60	0.00	0.97	0.97
single10		1.26	0.00	192.15	0.00	1.26	1.27
_cons		0.04	0.00	-304.01	0.00	0.04	0.04
		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons		0.26	0.00	2254.01	0.00	0.26	0.26
Qincome							

[13] This base case is slightly different than the one in the main result section, due to a slightly different approach in dealing with missing values and in selecting urbanized areas.

1	0.25	0.00	880.25	0.00	0.25	0.25
2	0.26	0.00	1263.59	0.00	0.26	0.26
3	0.27	0.00	1074.52	0.00	0.26	0.27
4	0.27	0.00	674.42	0.00	0.27	0.27
Qvalue						
1	0.27	0.00	859.99	0.00	0.27	0.27
2	0.24	0.00	1214.56	0.00	0.24	0.24
3	0.27	0.00	1051.58	0.00	0.27	0.27
4	0.27	0.00	771.70	0.00	0.27	0.28

PHILADELPHIA – FTN PLUS REGIONAL RAIL STATIONS (5-KILOMETER RADIUS)

Logistic regression	Number of obs	=	5699066.00
	LR chi2(14)	=	2351775.23
	Prob > chi2	=	0.00
Log likelihood = -2626447	Pseudo R2	=	0.31

FTN_RR_5km	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10	1.77	0.00	304.15	0.00	1.77	1.78
Qincome						
2	1.26	0.01	43.74	0.00	1.25	1.28
3	1.52	0.01	70.88	0.00	1.50	1.54
4	1.83	0.01	89.79	0.00	1.81	1.86
Qvalue						
2	0.57	0.00	-104.33	0.00	0.56	0.57
3	1.07	0.01	10.85	0.00	1.05	1.08
4	1.71	0.01	84.27	0.00	1.69	1.73
age10	1.57	0.00	526.17	0.00	1.56	1.57
density1000	1.29	0.00	315.21	0.00	1.29	1.29
detached10	0.77	0.00	-415.05	0.00	0.77	0.78
rental10	0.87	0.00	-189.68	0.00	0.87	0.87
noCar10	0.89	0.00	-77.21	0.00	0.88	0.89
white10	1.13	0.00	202.57	0.00	1.13	1.13
single10	1.13	0.00	109.67	0.00	1.12	1.13

_cons	0.09	0.00	-248.19	0.00	0.09	0.09

	Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons	0.61	0.00	3724.65	0.00	0.61	0.61
Qincome						
1	0.55	0.00	701.44	0.00	0.55	0.55
2	0.59	0.00	1340.21	0.00	0.58	0.59
3	0.61	0.00	2007.11	0.00	0.61	0.61
4	0.64	0.00	1834.86	0.00	0.64	0.64
Qvalue						
1	0.60	0.00	740.51	0.00	0.60	0.60
2	0.51	0.00	1365.50	0.00	0.51	0.51
3	0.61	0.00	2116.94	0.00	0.61	0.61
4	0.68	0.00	2207.31	0.00	0.68	0.68

PHILADELPHIA – FTN PLUS REGIONAL RAIL STATIONS (1-KILOMETER RADIUS)

Logistic regression	Number of obs	=	5699066.00
	LR chi2(14)	=	3468124.91
	Prob > chi2	=	0.00
Log likelihood = -1912035.6	Pseudo R2	=	0.48

FTN_RR_1km	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10	1.69	0.00	345.18	0.00	1.68	1.69
Qincome						
2	1.15	0.01	28.67	0.00	1.14	1.16
3	1.30	0.01	46.34	0.00	1.28	1.31
4	1.41	0.01	50.06	0.00	1.40	1.43
Qvalue						
2	0.59	0.00	-112.03	0.00	0.58	0.59
3	0.83	0.00	-34.02	0.00	0.82	0.84

4	1.14	0.01	20.88	0.00	1.13	1.15
age10	1.64	0.00	494.18	0.00	1.64	1.64
density1000	1.20	0.00	333.14	0.00	1.20	1.20
detached10	0.81	0.00	-310.63	0.00	0.81	0.81
rental10	0.94	0.00	-83.14	0.00	0.94	0.94
noCar10	1.07	0.00	46.61	0.00	1.07	1.07
white10	1.08	0.00	122.67	0.00	1.08	1.08
single10	1.20	0.00	162.10	0.00	1.20	1.20
_cons	0.01	0.00	-455.94	0.00	0.01	0.01

	Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons	0.34	0.00	2519.00	0.00	0.34	0.34
Qincome						
1	0.32	0.00	787.61	0.00	0.32	0.32
2	0.33	0.00	1287.26	0.00	0.33	0.33
3	0.34	0.00	1326.97	0.00	0.34	0.35
4	0.35	0.00	890.45	0.00	0.35	0.35
Qvalue						
1	0.36	0.00	777.59	0.00	0.36	0.36
2	0.30	0.00	1268.91	0.00	0.30	0.30
3	0.34	0.00	1285.79	0.00	0.34	0.34
4	0.37	0.00	1050.91	0.00	0.37	0.37

BOSTON – BASE CASE[14] (FTN ONLY)

Logistic regression	Number of obs	=	5188838.00
	LR chi2(14)	=	3054661.50
	Prob > chi2	=	0.00
Log likelihood = -854042.44	Pseudo R2	=	0.64

FTN	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]

[14] This base case is slightly different than the one in the main result section, due to a slightly different approach in dealing with missing values and in selecting urbanized areas.

transit10		2.69	0.00	538.27	0.00	2.68	2.70
Qincome							
	2	2.61	0.02	146.14	0.00	2.57	2.64
	3	3.74	0.03	172.37	0.00	3.69	3.80
	4	4.33	0.04	155.45	0.00	4.25	4.41
Qvalue							
	2	2.21	0.02	105.20	0.00	2.18	2.25
	3	3.41	0.03	165.62	0.00	3.37	3.46
	4	10.84	0.09	298.51	0.00	10.67	11.01
age10		1.21	0.00	127.14	0.00	1.21	1.21
density1000		1.08	0.00	138.09	0.00	1.08	1.08
detached10		0.73	0.00	-219.20	0.00	0.72	0.73
rental10		0.90	0.00	-63.01	0.00	0.90	0.90
noCar10		1.52	0.00	206.54	0.00	1.52	1.53
white10		0.88	0.00	-120.28	0.00	0.88	0.88
single10		1.11	0.00	59.11	0.00	1.11	1.11
_cons		0.00	0.00	-277.06	0.00	0.00	0.00

		Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons		0.17	0.00	1806.91	0.00	0.17	0.17
Qincome							
	1	0.14	0.00	747.32	0.00	0.14	0.14
	2	0.18	0.00	955.70	0.00	0.18	0.18
	3	0.19	0.00	848.02	0.00	0.19	0.20
	4	0.20	0.00	632.47	0.00	0.20	0.20
Qvalue							
	1	0.12	0.00	498.58	0.00	0.12	0.12
	2	0.15	0.00	738.20	0.00	0.15	0.15
	3	0.17	0.00	900.60	0.00	0.17	0.17
	4	0.24	0.00	827.30	0.00	0.24	0.24

BOSTON – FTN PLUS REGIONAL RAIL STATIONS (5-KILOMETER RADIUS)

Logistic regression	Number of obs	=	5188838.00

	LR chi2(14)	=	2386652.47			
	Prob > chi2	=	0.00			
Log likelihood = -2107076.3	Pseudo R2	=	0.36			
FTN_RR_5km	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10	3.75	0.01	440.25	0.00	3.73	3.77
Qincome						
2	1.43	0.01	76.02	0.00	1.42	1.45
3	1.35	0.01	55.24	0.00	1.33	1.36
4	1.16	0.01	23.32	0.00	1.15	1.18
Qvalue						
2	2.95	0.01	293.80	0.00	2.93	2.97
3	5.30	0.02	397.74	0.00	5.25	5.34
4	7.21	0.04	405.55	0.00	7.14	7.28
age10	1.34	0.00	328.86	0.00	1.34	1.34
density1000	1.16	0.00	149.04	0.00	1.15	1.16
detached10	0.96	0.00	-45.83	0.00	0.96	0.96
rental10	0.84	0.00	-150.03	0.00	0.84	0.84
noCar10	0.96	0.00	-22.08	0.00	0.95	0.96
white10	0.59	0.00	-471.61	0.00	0.59	0.59
single10	1.27	0.00	184.99	0.00	1.27	1.27
_cons	4.27	0.06	105.50	0.00	4.16	4.39
	Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons	0.67	0.00	4137.60	0.00	0.67	0.67
Qincome						
1	0.64	0.00	1034.55	0.00	0.64	0.64
2	0.69	0.00	1812.39	0.00	0.69	0.69
3	0.68	0.00	2228.78	0.00	0.68	0.68
4	0.66	0.00	1694.59	0.00	0.66	0.66
Qvalue						

1	0.50	0.00	1276.55	0.00	0.50	0.50
2	0.65	0.00	1936.30	0.00	0.65	0.65
3	0.74	0.00	2257.50	0.00	0.74	0.74
4	0.78	0.00	2001.52	0.00	0.78	0.78

BOSTON – FTN PLUS REGIONAL RAIL STATIONS (1-KILOMETER RADIUS)

Logistic regression	Number of obs	=	5188838.00			
	LR chi2(14)	=	2749396.39			
	Prob > chi2	=	0.00			
Log likelihood = -1563766.4	Pseudo R2	=	0.47			
FTN_RR_1km	Odds Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
transit10	2.11	0.00	493.23	0.00	2.10	2.11
Qincome						
2	1.81	0.01	122.63	0.00	1.79	1.83
3	2.78	0.02	182.04	0.00	2.75	2.81
4	3.10	0.02	160.99	0.00	3.05	3.14
Qvalue						
2	1.70	0.01	112.45	0.00	1.69	1.72
3	1.71	0.01	106.83	0.00	1.70	1.73
4	4.01	0.02	251.63	0.00	3.97	4.05
age10	1.41	0.00	323.95	0.00	1.40	1.41
density1000	1.04	0.00	78.59	0.00	1.04	1.04
detached10	0.83	0.00	-178.33	0.00	0.83	0.83
rental10	0.99	0.00	-5.13	0.00	0.99	1.00
noCar10	1.28	0.00	154.22	0.00	1.28	1.28
white10	0.88	0.00	-161.81	0.00	0.88	0.88
single10	1.12	0.00	88.26	0.00	1.12	1.13
_cons	0.01	0.00	-309.57	0.00	0.01	0.01
	Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
_cons	0.25	0.00	1922.89	0.00	0.25	0.25

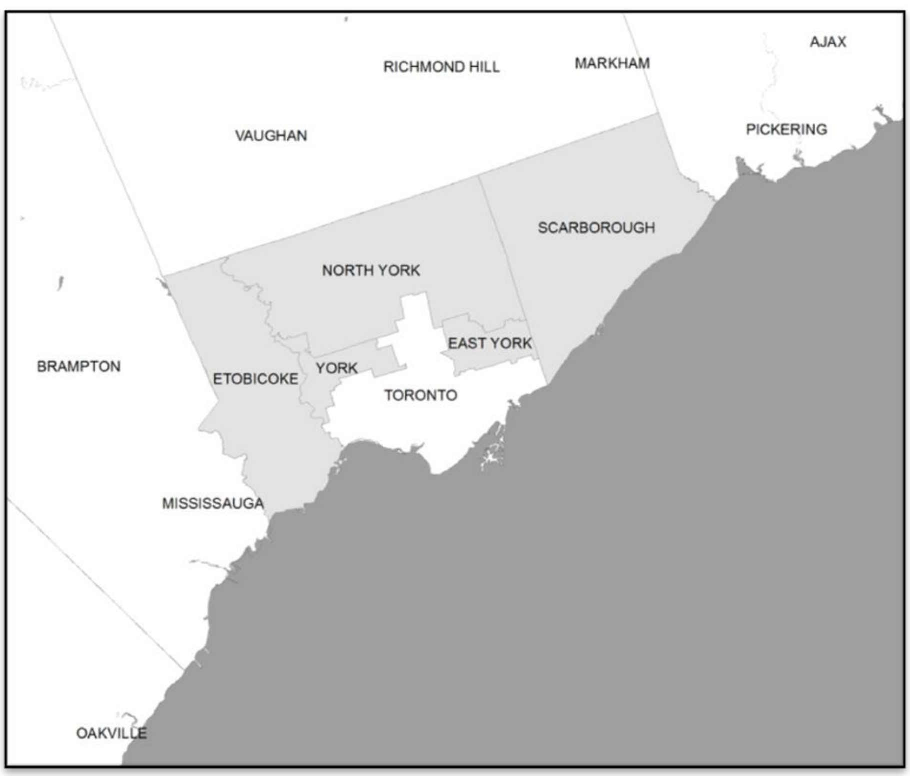
Qincome						
1	0.20	0.00	766.54	0.00	0.20	0.20
2	0.25	0.00	972.50	0.00	0.25	0.25
3	0.29	0.00	946.95	0.00	0.29	0.29
4	0.30	0.00	707.83	0.00	0.30	0.30
Qvalue						
1	0.20	0.00	671.14	0.00	0.20	0.20
2	0.24	0.00	895.24	0.00	0.24	0.24
3	0.24	0.00	904.91	0.00	0.24	0.24
4	0.33	0.00	874.37	0.00	0.33	0.33

Appendix F

Toronto Case Study

Unlike most North American cities, Toronto has many high-rise rental apartment buildings in the inner suburbs. These would generally be post-war modernist concrete structures, rather than the smaller rental buildings and rented units in mixed-typology older areas. Many of these high rise modernist rental towers would have been constructed post-war, in the 1960s and 70s heyday of modernist 'worker housing', built to satisfy demand for rental housing before more profitable condos replaced rental housing as a more profitable high-rise residential construction model in North America. Because they required large plots of land, these modernist rental apartments may have been built in suburban areas, where large parcels of land were less expensive to acquire.

These towers now serve as affordable rental housing stock for lower-income and immigrant populations. Although they are often spoken of as mono-functional and homogenous places, research on suburbs has shown that this broad category contains great social, economic, and demographic diversity. These diversities are visible in the inner suburbs of Toronto, those largely built between 1945 and 1980, which form an inner ring between the original city and the newer surrounding suburban municipalities (Figure 19) and which are the geographic focus of this paper. These include Scarborough, Etobicoke, York, East York, and North York.

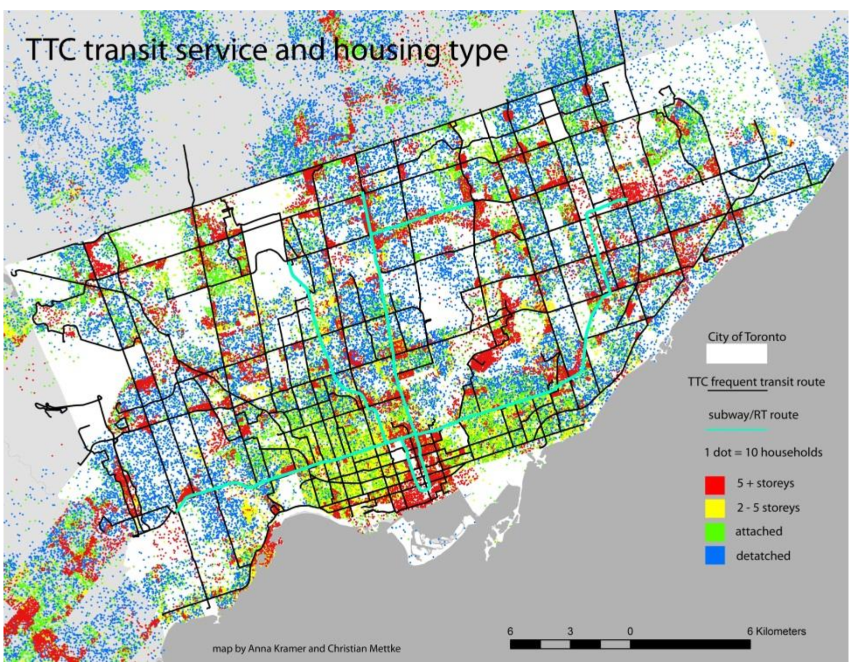


The inner suburbs (shaded) refer to the post-war suburbs amalgamated into the City of Toronto, which are Etobicoke, Scarborough, and the Yorks. Outer suburbs are the independent municipalities located outside of the City of Toronto.

Figure 19: Inner and outer suburbs in the Greater Toronto Area.

Functionally, suburbs are often defined as primarily residential areas of low density with high automobile dependency (Forsyth, 2012; Moos & Kramer, Atlas of Suburbanisms, 2012). However, these functional definitions are confounded in the inner suburbs of Toronto, where the built form is a mixture of detached single-family homes and high-rise rental apartment buildings (Boudreau, Hamel, Jouve, & Keil, 2006), giving it a higher density than comparable inner suburbs in American eastern industrial cities (Filion P. , McSpurren, Bunting, & Tse, 2004). These high-rises were built in response to demographic predictions of more single professionals; development was stimulated by a tax break for this type of REIT. These developments, built between the 1960s and early 1980s, took the form of high-rise concrete structures on large lots, often on suburban arterials and at major intersections (Figure 20), similar to the 'tower-in-the-park' model proposed by the modern architect and planner le Corbusier (E.R.A. Architects, 2009). There are nearly 2,000 post-war apartment towers in the greater Toronto area, representing 48% of the City of Toronto's rental housing stock and home to approximately one million people (Ibid). In Toronto's case, they are mostly owned and operated by private management companies, but in some cases are owned and operated by Toronto Community Housing Corporation. These buildings provide a large supply of relatively affordable rental housing in a city with a high demand for such. By 2006, 43% of low income families in Toronto rented a unit in a high-rise building, and nearly 40% of all the families in these buildings were poor (United Way, 2011). In Toronto, these buildings are located along major inner suburban arterials (see Figure below)Figure 20, and they do have frequent bus service, but it is quite possible that this transit service is an exception rather than the rule in North American cities.

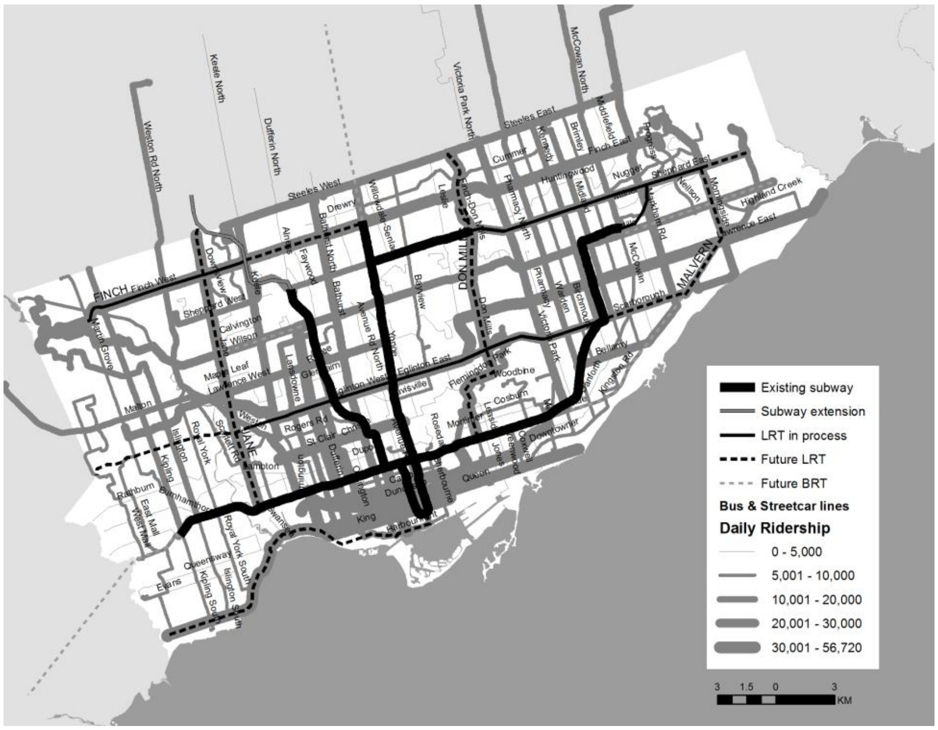
Figure 20: TTC Transit Service and Housing type.



(Housing data from the 2006 Census of Canada; transit data from TTC)

Given the city's structure, residents of high-rise towers rely more on transit, walking and cycling than other residents of the region; many of these neighbourhoods have higher-than-average rates of transit use, cycling and walking and lower-than-average car ownership (E.R.A. Architects, 2009). A map of Toronto Transit Commission ridership numbers shows that the transit ridership on the major bus routes in the inner suburbs rivals that of the busiest bus and streetcar lines downtown (Figure 21).

Figure 21: Map of recent ridership data



(Data courtesy of the TTC, counted between 2005 and 2011, depending on route)

These data shows high ridership on inner suburban bus routes, particularly on Eglinton and Finch streets travelling east-west and Jane, Keele, Dufferin, Victoria Park and Markham roads running north-south. This challenges the assumption that suburbs are auto-dependent and matches the pattern of socioeconomic polarization of poverty to the inner suburbs. Increasingly, suburban high-rise renters are low-income immigrants who list the "lack of adequate transit and convenient access to services, jobs and amenities" as most pressing (Smith & Ley, 2008, p. 701). Where this socio-spatial exclusion is mitigated through good access to public transport, schools, shops and community services, for example in the high-rise inner suburban Thorncliffe Park neighbourhood, the immigrant experience is more positive (Smith & Ley, 2008).

If the pattern of Toronto's inner suburban, post-war modernist high-rises is common to other "shift" cities in this research, minus the frequent bus service, then this would fit with the 'legacy' aspect of transit systems' association with older, pre-war areas of the city, and it would explain the unintuitive finding of negative likelihood of transit access as rental housing rates in a small area increase. If so, this is a concern for transit agencies and social equity, as these populations have greater demand for frequent transit than most suburban residential areas. As noted in by other researchers, these pockets of high density in an otherwise low-density milieu are 'wasted' opportunities from a transportation perspective unless there is an opportunity to integrate them into transit and pedestrian networks and mixed use areas (Filion, McSpurren, & Appleby, 2006).

Appendix G

Research done in 2009 by Pierre Filion and I was foundational for developing this dissertation. This 2009 research included a review of long range transportation and land use plans in over 50 metropolitan regions in Canada and the United States, to check for the presence of concepts of transit-oriented development, intensification and smart growth. Planners from each of these metropolitan regions were interviewed, by telephone or in writing, to ask about the importance of these ideas in their region's plans. Some of these findings, and quotes from various planners, are included in the dissertation where relevant. This appendix includes the questions asked the planners, as well as the presence of concepts in plans from the cities included in this dissertation.

Land use and transportation plans content analysis

	REASONS									CONCEPTS					
	Equity	Economic benefits	Save greenfields	Limits to available land	Infrastructure efficiency	Traffic congestion	Health	Air quality	Climate change	Growth around transit (TOD)	Mixed use	Higher densities	Pedestrian friendly	Multi-modal	
PHILADELPHIA		●	●		●	●		●		●	●	●		●	Greenworks Philadelphia
	●	●	●		●	●	●	●	●	●	●	●	●	●	Delaware Valley RPC Long Range Plan
NEW YORK			●	●	●	●		●	●	●	●	●		●	planNYC
	●	●			●	●	●	●	●	●	●		●	●	New York MTC Regional Transportation Plan
TORONTO		●	●		●	●		●		●	●	●	●	●	Places to Grow (Ontario)
	●	●	●	●		●	●	●	●	●	●	●	●	●	The Big Move (Metrolinx)
VANCOUVER		●	●		●			●	●	●	●	●	●	●	Metro Vancouver Regional Growth Strategy
		●	●		●	●		●	●	●	●	●	●	●	TransLink Transport 2040
WASHINGTON & BALTIMORE			●	●		●		●	●	●	●	●	●	●	The Comprehensive Plan for the National Capital
	●		●			●		●		●				●	National Capital Region Long Range Transportation Plan
		●	●	●				●		●	●	●	●	●	City of Baltimore Comprehensive Master Plan
	●		●			●		●	●	●	●	●	●	●	Baltimore Regional Transportation Outlook 2035
CHICAGO	●	●	●	●	●	●	●	●		●	●	●	●	●	Northeast Illinois RPC Regional Framework Plan
	●	●	●		●	●	●	●		●	●	●	●	●	CMAP 2030 Regional Transportation Plan
SAN FRANCISCO	●	●	●		●	●	●	●		●	●	●	●	●	San Francisco General Plan
	●	●				●		●	●	●		●	●	●	MTC Transportation 2035 for the San Francisco Bay Area
	●	●	●	●	●	●		●		●	●	●	●	●	San Jose General Plan
LOS ANGELES	●	●	●	●		●	●	●	●	●	●	●	●		Southern California Regional Transportation Plan 2008
	●	●	●	●	●	●	●	●	●	●	●		●	●	SCAG Regional Comprehsive Plan
MONTREAL	●	●	●	●	●		●	●	●	●	●	●		●	Communauté métropolitan de Montréal Cap Sur le Monde
	●	●			●		●	●	●	●		●	●	●	AMT Plan stratégique
BOSTON	●	●	●		●	●	●	●	●	●	●	●	●	●	Boston Future MAPC Regional Plan
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Boston Region MPO 'Journey to 2030'

	REASONS									CONCEPTS					
	Equity	Economic benefits	Save greenfields	Limits to available land	Infrastructure efficiency	Traffic congestion	Health	Air quality	Climate change	Growth around transit (TOD)	Mixed use	Higher densities	Pedestrian friendly	Multi-modal	
SEATTLE	•	•	•	•	•	•	•	•	•	•	•	•	•	•	Puget Sound Regional Council Vision 2040
		•	•	•	•		•	•	•	•	•	•	•	•	Puget Sound Regional Council Destination 2030
MIAMI			•	•	•	•				•	•	•	•	•	Miami-Dade Strategic Plan
	•	•	•			•		•	•	•		•	•	•	Miami-Dade Transportation Plan 2030
OTTAWA			•		•			•	•	•	•	•	•	•	City of Ottawa Official Plan
	•	•			•	•	•	•	•	•	•	•	•	•	Ottawa 2020 Transportation Master Plan
CALGARY			•		•			•	•	•	•	•	•	•	Calgary Regional Partnership Metropolitan Plan
	•	•			•	•		•		•	•	•	•	•	Calgary Transportation Plan 2005
EDMONTON		•	•		•			•	•	•	•	•		•	Captial Region Growth Plan: Growing Forward
MINNEAPOLIS - ST PAUL			•	•	•	•		•		•	•	•	•	•	Metropolitan Council Regional Development Framework
	•	•			•	•		•	•	•	•	•	•	•	Metropolitan Council 2030 Transportation Policy Plan
PITTSBURGH	•	•	•	•	•	•	•	•		•	•	•		•	SW Pennsylvania C. Transportation and Development Plan
HOUSTON			•	•	•			•						•	HGAC Comprehensive Planning Framework
	•	•	•	•	•	•	•	•	•	•	•	•	•	•	2035 Houston-Galveston Regional Transportation Plan
ATLANTA			•	•	•	•		•		•	•	•	•		ARC Regional Development Plan Policies
	•		•		•	•		•		•	•		•	•	Atlanta RC Regional Transportation Plan
DALLAS	•	•	•	•		•		•		•	•	•	•	•	City of Dallas Comprehensive Plan Vision
	•	•			•	•		•		•	•	•	•	•	North Central Texas CoG Mobility 2030

Interviews with planners

Questions asked of planners:

1. What is the impetus for metropolitan planning in your region? What are the organizations involved in planning at this scale? To what extent do you anticipate that the proposals of the regional plan will be implemented? Which aspects of the plan are most likely to be implemented? Which are least likely to be implemented? Why?

2. Do you see a convergence of land use and transportation planning in your region? Is this a recent planning trend?

3. In the context of your metropolitan region what would be the best achievable modal split? What change would this represent relative to the present situation? What would be the role of Transit Oriented Development (TOD) in achieving this change?

4. How would you define TOD in your metropolitan region? (Does it include mixed use, density, walkability, housing variety and affordability, jobs and housing match? Is it related to infill or Greenfield development?)

5. Is TOD a series of nodes/centers? If so, what is the role of the connecting corridor i.e. for quick transit between nodes, or as a focus for development in itself?

6. How important is TOD relative to other aspects of the regional plan?

7. How extensive are the proposed TOD's?
   On a scale of 1 to 10, ten being high, how would you rate the level of commitment to TOD in your metropolitan region? From which constituencies does most of the support come from?

8. What are the barriers to TOD in your region? How do you see TOD in the context of the growth trends in your region (growing population or not, rustbelt or sunbelt, east or west coast or Midwest) and in relation to the current economy?

9. What are the reasons and motivations for adding TOD to your plan? Do you see getting away from auto-oriented development as a priority? What are the drivers of change?

10. On a scale of 1 to 10, how likely do you think it is that these proposed TOD's will happen? What are the aspects of TOD that are most likely to materialize?

11. As a planner, do you think that TOD is an intelligent strategy for development in your region? Why or why not?

12. If you could plan for anything in your region, without budget and approval constraints, what would it be?

Response rates and mode of communication:

			NO REPLY/ DECLINE
Atlanta	METRO		
Austin		METRO	
Baltimore	CITY		
Birmingham		METRO	
Boston		METRO	
Buffalo		CITY	
Calgary	CITY		
Charlotte	METRO		
Chicago	METRO		
Cincinnati			
Cleveland		METRO	
Columbus		METRO	
Dallas	CITY	METRO	
Denver	METRO		
Detroit	METRO		
Edmonton	METRO		
Hartford			
Houston	METRO		
Indianapolis		METRO	
Jacksonville		METRO	
Kansas City			
Las Vegas		METRO	
Los Angeles-Riverside-San Bernadino	METRO		
Louisville			
Memphis			
Miami	METRO		
Milwaukee	METRO		
Minneapolis-St Paul	METRO		
Montréal		METRO	
Nashville	METRO		
New Orleans		METRO	
New York	CITY	METRO	
Oklahoma City		METRO	
Orlando	METRO		
Ottawa		CITY	
Philadelphia	METRO		
Phoenix	METRO, CITY		
Pittsburgh	METRO, CITY		
Portland	METRO	METRO	
Providence			
Raleigh			
Richmond		METRO	
Rochester			
Sacramento	METRO		
Salt Lake City	METRO	CITY	
San Antonio		METRO	
San Diego		METRO	
San Francisco-San José	METRO		
Seattle	METRO		
St Louis			
Tampa	METRO		
Toronto	METRO	PROVINCE	
Tucson			
Vancouver	METRO		
Virginia Beach	METRO, CITY		
Washington	METRO, CITY		

Content analysis of plans for concepts and reasons:

Insight from interviews

In interviews with planners about regional plans for intensification, NIMBY-ism is a strong force countering smart growth efforts. "Plunking down a station in an established area that has been well maintained as is fairly attractive, the likelihood of a TOD – even if you had the mechanisms in place, the zoning and the developer and the finance all lined up – doesn't bode well with the neighbourhood”. This planner went on to give the example of the Decatur station along the MARTA line in Atlanta, where developers who owned land near the station were taken to court by neighbourhood groups, who succeeded in having the area down-zoned to disallow commercial development. “If someone wants to develop their property as they see fit, that’s all fine and good, as long as it doesn’t happen immediately next door of course”, is how one Houston area planner put it. “The reluctance comes with neighbourhood associations. They are well versed in the benefits of higher intensity, mixed use walkable neighbourhoods, until someone says, ‘I want to put one near you’, and they’ll say, ‘we support that, but this is not the right place.’” (Nashville). Even in the relatively urban environs of Washington, DC, where density is not uncommon, it is “always going to be a hot button issue”.

This resistance to the urban can extend to transit, as well. In Orlando, the planners avoid naming future LRT station locations lest “someone sees a dot…next to their house”. A planner from the city of Baltimore paraphrased residents of an adjoining county neighbourhood as saying, “Don’t talk about density. Don’t talk about mixed use. And please don’t talk about bringing a subway line out here, because that brings in criminals from the city”. This emphasizes the stigmatization of public transit.

Based on these reports, one could be forgiven for thinking that TOD is impossibly unpopular, but planners also spoke of an increasing demand for transit and other alternatives to the automobile, as well as for alternative land uses that focus growth rather than spread it out. “The younger populations are not part of the car culture. They are not interested in owning a single family home. We are going to lose them to other areas unless we provide them with some alternative living and lifestyle choices” (City of Phoenix planner). Many planners took a ‘wait and see what emerges’ attitude towards the demand for this type of development. “It’s fairly new, it’s fairly strange, but when you start getting some examples on the ground, that’s when people start to say, ‘I want some of that too’” (Nashville). Many planners noted changing demographics and smaller household sizes as a factor in changing demand.

In Phoenix, a non-profit organization called the Urban Land Use Institute has hosted several public workshops to explore scenarios for growth. People were asked to put LEGOs symbolizing new housing and jobs where they would like to see them on the regional map. The first exercise was conducted before the 2008 recession, and the result was, in the words of a city planner, “sprawl as usual”. After the economic downturn, however, the same exercise was conducted, and the results were “starkly different from the first. People decided to focus [growth] on existing transportation corridors.” And although, in the works of one planner, “zoning in general is pretty unexciting to people”, many cities had or were in the process of engaging the public in some sort of dialogue about future scenarios for land use and transportation (including Charlotte, Orlando, Chicago, Vancouver, and Houston). Often, when faced with the choice of scenarios, people chose the one with better transit networks and higher, tighter land use intensities than normal. Of course, this could be equally due to a desire to preserve existing single family neighbourhoods without adding to congestion, as it could be due to environmental reasons. But whether the motivations come from preserving the environment or preserving highway space, alternatives are becoming part of the urban lexicon.

Metropolitan planning tends to be the scale at which federal and state pressure for smarter growth meets varying degrees of resistance at the local level. The fact that MPOs are treading on the territory of local jurisdictions when it comes to land use was not lost on the planners who were interviewed[15]. Planners emphasized the difficulty of planning for land use at the metropolitan level. “All power [for land use] is at the local government level” (Philadelphia MPO). “The commission is strictly advisory. [We have] recommended higher density, mixed use, since the 1960’s. There is still a trend towards lower density development” (Milwaukee). One regional planner described the process as “nebulous. Our regional plan provides policy guidance, [but] we have no legislative capacity to effect change. And the regional governments join on a voluntary basis” (Denver). Some metropolitan planners disassociated themselves from land use planning altogether. “We don’t do land use.” (Houston) “There is no concerted or high-level management of land use in the area”. “There is no formal power we have over land use” (Atlanta). “You have two entities, one dealing with transportation, and one dealing with land use…there has always been that disconnect” (Chicago). “We have very strong local home rule, and the cities, villages, and townships have jurisdiction over land use. Local municipalities and counties can control their own zoning, and we have no desire to upset that tradition”. Some planners even questioned the reality of metropolitan-scale planning, despite being planners at the metropolitan scale. “True metropolitan planning, unfortunately, doesn’t take place” (Charlotte MPO). It is clear that metropolitan planning is an inter-jurisdictional and inter-scalar issue.

The conversation between MPOs and local land use planning bodies, if initiated, becomes a process of negotiation. San Francisco has a policy that requires station area planning in support of transit-oriented development in every area that receives a new transit station. “As a region, we are investing billions of dollars in transit projects, so we have a policy that actually requires regions to do planning. There was a tremendous amount of resistance to the adoption of that policy, because it was seen as a regional agency meddling in local planning.” An Orlando transportation planner described this process in his region: “Seven or eight years ago, we were trying to add some land use planning into the transportation plans, but we were running into resistance from local land use planners. So we promised to adopt whatever they had in their land use plans, but we also tried an experiment with their participation to look at other land use concepts, to see how it would affect transportation planning. We came up with a smart growth concept with high density centres, and we estimated air quality, vehicle miles travelled, hours of travel, congestion levels, gallons of gasoline used: every single measure came out in favor of the experimental land use concept. The land use planners were excited about this. This time we contrasted the trend land use with the concentrated land use, and again the smart growth came out a hit against all the different measurements. This time the local land use planners were in favor of it and even started to modify their local land use plans. So our new plan definitely meshes land use and transportation. We recognized that trend, continuing with highways, transit would not be feasible. On the other hand, if you concentrated land use, you could serve those areas much more efficiently with transit.”

While acknowledging that local jurisdictions are the ones that implement land use, Sacramento said that the regional COG provides a “forum for discussing land use issues”. Seattle, despite not being the ones “directly implementing transportation projects or developing local land use plans, …establish long range vision plans that call for a radically different future outcome.” “We try to work with all the separate local governments”, a transportation planner working for the Los Angeles Council of Governments said, “we start by asking them what are their local growth plans, we collect all that and try to suggest pushing a little denser in some places. It’s basically a huge consensus building project. We don’t have the sticks to really make it happen so we try to bring out the carrots”. Because land use decisions remain firmly in the power of the local, it is important for metropolitan-scale planning capacity, where it exists, to work with local governments to coordinate land use and transportation.