

The Effects of Urban Rapid Rail Transit on Gentrification in Canadian Urban Centres

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Executive Summary

Throughout the second half of the 20th century theories attempting to explain the phenomenon of gentrification have been pervasive among studies of the changing social structures of urban centres in Europe and North America. Gentrification is defined as a process whereby higher income households move into what were previously working class neighbourhoods, resulting in either direct or indirect displacement of working class households, and ultimately transforming the social character of the neighbourhood. There has been contentious debate over the definition of gentrification, but through its evolution and adaptation to new contexts it has remained a popular topic among scholars in urban planning. Among the studies and papers published, there are many that show that the process is not only driven by individual actors', but it is also a process deeply affected by government interests and objectives and therefore by public investments.

The consequences of the process are still debated; some hail the process as a boost for everyone, (e.g. Duany, 2001), while others assert that gentrification limits accessibility to urban space for lower-income, working-class households, often with already reduced options in terms of housing, and ultimately contributes to creating increasingly socially polarized urban spaces (Marcuse, 1986; Newman and Wyly, 2006).

Keeping a necessarily critical perspective in mind, this study identifies the onset of gentrification in Canadian cities and links this process to an element of urban infrastructure essential to cities; transit. The objective of this research is not only to see what the effects of the implementation of transit are on gentrification when it is initially implemented, but also to look at the impacts of transit over time on the gentrification of surrounding neighbourhoods.

In the gentrification literature there are a number of articles that make mention of the influential role of accessibility, and transit, on the process of gentrification. The relationship between neighbourhood changes and the implementation and upgrading of transit infrastructure, has, as of yet, not been clearly established. Though transit has long been recognized as having important connections to changes in land-use in the areas surrounding it, there have been few studies that attempt to explore, explicitly, the connections between the implementation of rail transit infrastructure and the process of gentrification in the surrounding metropolitan area. Additionally the few studies that do exist that explicitly address the relationship between transit and gentrification do not adhere to the conventional definition of gentrification according to the literature. The hypothesis of this project is that the implementation of rapid rail transit contributes to the gentrification of surrounding neighbourhoods and may result in the displacement of lower-income households, who would have the greatest marginal benefit from access to transit. This study presents data and analysis in order to assess the hypothesis using a number of indicators of gentrification and covering a study period long enough to capture the effects of major urban rapid rail transit as it has been implemented and upgraded in Canadian cities in the 20th century. This study will specifically address the effects of rail transit infrastructure on gentrification in Montreal, Toronto and Vancouver.

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1.0 Literature Review

The following section will provide a review of the literature pertaining to gentrification and transportation and how these two aspects of urban development and change have been linked by academics in past research. The literature review is divided into three distinct parts, first defining gentrification while the second will provide insight into how the process of gentrification has been studied and measured in the past, specifically in North America and Canada. The last section will show how the effects of transportation have been taken into account in the study of gentrification.

The use of the term, gentrification, and the main academic debates described in the scholarship on the subject will be traced from its origin in the mid-twentieth century. This first portion of the literature review will also cover how the term was adopted in North-America, briefly touching on the debate regarding the theoretical explanations of how, and why, gentrification occurs. It is important to keep in mind that this research evolved out of a critique of how urban space was being managed and appropriated, and by whom, in the city. I will briefly elaborate on how gentrification fits into this context.

Following this introduction of the term, the second part of the literature review will focus on how gentrification has been studied empirically in the past, and in particular what indicators have been used to quantify the process. Though long recognised as being important elements to the process of gentrification in the literature, mass transit and accessibility have been the focus of very few published studies explicitly relating them to gentrification. The final section of the literature review will provide details regarding four studies that have sought to explicitly examine the links between urban rail transit and gentrification.

1.1 Definitions and Origins

Gentrification, thought of not long ago as a uniquely European and North American phenomenon is now thoroughly entrenched in the changing nature of cities around the world (Smith, 2002; Lees, 2011). The process of gentrification is defined as an urban neighbourhood that experiences increases in house price and educational attainment, and which would previously have been described as low-income (Chapple, 2009). The fact that neighbourhoods affected by gentrification are previously low-income, or have suffered disinvestment, is integral to the definition of the process (Hammel and Wyly, 1996; Meligrana and Skaburskis, 2005; Walks and Maaranen, 2008).

The evolution of gentrification in urban settings is closely linked with processes of industrialization and de-industrialization and concerted efforts to revitalise and rebuild cities suffering from dramatic economic shifts through the twentieth century, and now into the twenty first century (Smith, 2002). Some of these major shifts in terms of the economic foci of cities is often talked about in terms of ‘restructuring,’ which has explicit outcomes and impacts on low-income populations, many of whom were previously employed by disappearing industry in North American towns and cities (Newman and Wyly, 2006).

The term ‘gentrification’ was first used in the 1960s by Ruth Glass, an urban sociologist who focused on issues of equity in the city, looking specifically at recent immigrants’ access to housing (Baker, 2004). During the post-war era of continued suburbanization and urban reconstruction, Glass observed a phenomenon of middle and upper class households moving into the inner-city, changing the aesthetics of neighbourhoods by transforming rooming houses, which sheltered some of the most marginalized populations, and transforming them into “elegant, expensive residences” (Glass, 1964: pp.xviii). The consequences were fewer multi-unit

dwellings and higher property values, both contributing to the displacement of residents whose housing needs were already compromised (Glass, 1964). She called this phenomenon ‘gentrification’ invoking the class divisions highly present in British society. Glass (1964) described this process as an unstoppable and fast moving process from which no part of London was entirely safe.

Since Glass’ definition of gentrification was published, many social and urban theorists have adopted the term and adjusted it to fit new contexts and settings, both spatially and temporally. Consistent with Glass’s observations some authors state that the process began in an identifiable way in the 1950s (Hackworth and Smith, 2000), while others contend that gentrification did not really emerge until the 1970s (Hammel and Wyly, 1996). Building on Glass’ earlier observations, a later study of London referred to gentrification as being simultaneously a “physical, social and cultural process” (Hamnett and Williams, 1980: pp.471) that not only includes the renovation of houses, as Glass mentioned, but emphasizes a particular middle class ‘lifestyle’ and selective tastes (Hamnett and Williams, 1980).

In addition to the conventional terminology, this field of inquiry has been expanded by several authors to encompass different forms of neighbourhood change where it has been argued that the definition of gentrification is too narrow (Van Criekingen and Decroly, 2003; Walks and Maaranen, 2008; Owens, 2012). These authors explicitly defined the need for different types of upgrading to be assessed and argue that not necessarily all of the changes captured by traditional gentrification analysis should be considered in the same category (Owens, 2012).

In the 1970s the process of gentrification was observed and documented in North America for the first time, and a new focus emerged in the research; analysing the effects of urban policy and concerted revitalisation efforts on the advent of gentrification. Public

investments of resources to create new amenities and to brand neighbourhoods with new images and associated lifestyles have been found to contribute in many cases to gentrification. Take, for example, the various cases of ethnic place marketing in Toronto (Hackworth and Rekers, 2005).

Urban policies aimed at reinvigorating and spurring investment in what were considered depressed neighbourhoods have done so under a number of banners. These have included such themes as environmentalism and liveability through increasing the quality of architecture, density and amenities of an area (Lees, 2000), justifications that still, though at times unintentionally, lead to gentrification. Transportation investments have also played a key role in forming revitalisation plans for urban neighbourhoods following these objectives. Transit Oriented Development (TOD) is one popular method of reinvestment in order to create denser, more livable neighbourhoods, with a focus on the availability and proximity of transit (Calthorpe, 1993). It is also a process which is increasingly being criticized for not being inclusive enough and for blatantly promoting gentrification (Dominie, 2012).

The negative effects of some urban policies promoting revitalisation, TOD, and reinvestment have been cited in studies across North America as contributing to the process of gentrification (Hackworth and Smith, 2000; Lees, 2000; Rose, 2004; Newman and Wyly, 2006; Wyly and Hammel, 2007). Succinctly put, these policies are often aimed at the “creative use of market forces to rebuild low-income inner-city neighbourhoods,” but may easily result in increased marginalization of the existing residents (Wyly and Hammel, 2007: pp. 1215).

The implementation of urban policies, which guide development in the ways mentioned above, also reflect a shift in the role of governments with respect to urbanisation and the development of urban centres, shifting their part from one of management to a more entrepreneurial role. Government has been seen as more of a “consummate agent of – rather than

a regulator of – the market” (Smith, 2002: pp.428). Gentrification is one of the ways in which this form of governance of the city manifests itself in the evolution of urban space and urban settlement patterns.

1.2 Gentrification Debates

“For one can hardly look at the world today without perceiving that, at the hands of capital, the last two decades have witnessed an emergent restructuring of geographical space more dramatic than any before.”

- Neil Smith (1990, pp.IX)

The effects of capital and of capitalism on space continue to be immense, and gentrification research is one analytical lens through which this process may be studied. The study of gentrification originally emerged as a critique of capitalism’s effects on urban centres, as the continued and expanded commodification of housing and urban space (Hamnett and Williams, 1986; Slater, 2006), and particularly how, under capitalism, the housing needs of already marginalized populations were being further exploited.

The economic restructuring referred to in the previous section has come with a dramatic change in the way that cities are governed, and changes in the objectives of urban governments. Most significantly, there has been a shift in the governance of urban space and policies from one that was primarily managerial, to more entrepreneurial priorities (Harvey, 1989). This contrast is important because, where urban governments of the past acted as more stringent regulators, regional governance since de-industrialisation has focused not on how to maintain their working class base, but on how to attract more tertiary and high-service employment and employers. This is one facet, of many, of the urban sphere that affect gentrification and how it progresses, largely through policy focused on redevelopment projects aimed at revitalising neighbourhoods that

experienced disinvestment in the 20th century. Institutions including the Housing and Urban Development department of the US (HUD) have openly stated that gentrification is a positive process and one that allows specific opportunities for ‘integration’ of groups in the aim of creating mixed-income neighbourhoods, a strategy taken up almost exclusively in depressed areas to introduce higher income earners in the hopes of improving the target neighbourhood (Newman and Wyly, 2006).

By studying gentrification, as a process of change and evolution occurring within cities as a result of shifting priorities, in part of urban governance, this domain is also addressing the effects of capitalism on how the city is structured. This fact is not always explicitly stated in contemporary research, although it continues to frame the debates perpetuated by experts in the field such as Neil Smith, David Harvey and Peter Marcuse.

Over 1,000 articles on gentrification have been published since 1964 (Atkinson & Bridge, 2005). The process of change in a neighbourhood, which Glass first identified, has been denoted by many terms, the connotations of which play an important role in the angle and theoretical framework of the research conducted both historically and more contemporarily. From revitalisation, regeneration and renaissance (Ley, 1986; Freeman, 2005; Slater, 2006) to neighbourhood change and even colonisation (Atkinson & Bridge, 2005) the evolution in the terms used with reference to the process show important differentiation in the attitudes and opinions of researchers to the process. Though some academics have argued in the past that the term ‘gentrification’ is not suitable for use in the North American context because of the culturally specific connotation of the term ‘gentry’ it continues to be the dominant word in the literature allowing for rich debates globally (London & Palen, 1984).

In a call for a return to the critical perspective with which the term was originally coined, Slater listed the ways in which the process of gentrification has become more openly accepted, and even encouraged, by experts, a view echoed by other authors (Slater, 2006; Newman and Wyly, 2006). His stance is supported by many fellow academics who agree that the study of gentrification requires a consistently critical perspective from researchers, a stance that has waned in recent years (Shaw, 2008; Watt, 2008; Wacquant, 2008). It has been stated that the perspectives of those residents who do not benefit from this process, and consequently those who would be most critical, are under-represented in the research and popular media coverage of the ongoing gentrification of cities (Shaw, 2008). Though the topic has been subject to much debate and investigation, the continued importance of the study of gentrification is defended by authors in the 21st century who note the fluctuating global economy along with changing urban policy in North American cities as reasons why it is still essential that gentrification be studied and understood in a modern context (Wyly and Hammel, 2005). Lees has also recently noted the need for a broadened scope of the study of gentrification as the process has only recently moved from the Global North to the Global South (Lees, 2011).

Neil Smith, in his comprehensive book on gentrification in the United States, cites it as a process linked to the urban policies being enforced, instituting social change and transforming the city increasingly into a place for “services, recreation and consumption” exclusive to those who can afford it (Smith, 1996: pp.8). Building on Glass’ original definition of gentrification as an abuse of marginalized populations by a population with more financial means, Smith asserts that gentrification is a concerted effort to transform cities through class conflicts (Smith, 1996).

Two of the most cited authors in the gentrification literature, David Ley and Neil Smith, differ in what they have identified as the central causes of gentrification. David Ley’s work is

synthesized as presenting gentrification as a process which is occurring as “a spatial manifestation of... new cultural values” (Lees, 2000:396), arguing that the origins of gentrification are consumption-based. Alternatively, Smith adopts a more fundamentally Marxist theoretical framework, stating that gentrification is created by opposing class interests (Smith & LeFaivre, 1984). Smith argues that gentrification has come about due to the flight of capital from the inner-cities to the suburbs resulting in a ‘rent-gap’ in many inner-city neighbourhoods (Smith, 1986:32). In Smith’s own words, the ‘rent gap’ is the difference “between the actual ground rent capitalized from the present (depressed) land use and the potential rent that could be capitalized from the ‘highest and best’ use... given the central location” (Smith, 1986:23). The perspective that gentrification is an intentional process, driven by the interests of property owners and speculators, is echoed in Slater’s call for a return to the critical perspective in which the study of the phenomenon first emerged (Slater, 2006). He emphasizes that where the focus of gentrification research before the 1980s was highly critical, it has since evolved, and in some cases even embraces the changes that are brought about by gentrification. In order to effectively challenge the process and its adverse effects Slater states a need for a return to those critical roots (Slater, 2006). Wyly and Hammel contribute to this debate, writing that gentrification does not just result from opposing class interests, but is driven by urban policy, state investment and the distribution of resources within urban centres (Wyly and Hammel, 2005).

In a comprehensive literature review Loretta Lees writes that the differences between researchers’ conclusions regarding gentrification may be more methodological than theoretical, citing the lack of comparable studies as a shortcoming in the field of research (Lees, 2000). Another article states that the differences between authors’ conclusions are based on ideology, and on how data is used, rather than on empirical evidence (Freeman, 2009). Lees concludes that

the study of gentrification needs to be continued as the agents of gentrification have changed and study results from the past no longer necessarily apply (Lees, 2000). As one of the few authors who writes about the benefits of gentrification for neighbourhoods, Freeman agrees that research should continue, stating that more empirical evidence of gentrification, its causes and its effects are needed before conclusions are drawn about the net consequences of the process (2008).

1.3 Indicators of Gentrification

The methods and indicators used to establish the presence of gentrification vary quite significantly, but there are some basic ‘rules’ that are generally followed. This section elaborates further on indicators selected in the past and why they were chosen.

Previous research has attempted to describe the process of gentrification through a variety of means. Studies have focused on changes in the housing market (Ley, 1986; Filion, 1991; Lin, 2003; Freeman, 2005; Heidkamp and Lucas, 2006; Kahn, 2007; Walks and Maaranen, 2008; Pollack et al, 2010), and demographic shifts in neighbourhoods (Hamnett and Williams, 1980; Meligrana and Skaburskis, 2005). Studies have also mentioned the importance of the physical changes made to gentrifying neighbourhoods, characteristics only observable through on-site surveys (Hammel and Wyly, 1996). Several of these studies employ various indicators together, or create social, or gentrification, indicators that include a variety of the variables mentioned above (Ley, 1986; Hammel and Wyly, 1996; Walks and Maaranen, 2008).

According to Hammel and Wyly’s paper on methodology for the study of gentrification in cities, “studies [of gentrification] typically draw on census data to identify neighbourhoods experiencing changes in hypothesized indicators of gentrification: income, occupation, education, housing value and rent. Analyzed separately however, these indicators often fail to distinguish gentrification from other forms of neighbourhood change.” (Hammel and Wyly,

1996: 249). The joint analysis of indicators is, therefore, essential to establishing whether the process being observed is gentrification, or other forms of demographic change.

Another factor that plays an important role is increased value placed on the proximity to the central business district for both work and urban amenities as a result of growth in the service sector (CBD) (Meligrana and Skaburskis, 2005). Some work has included proximity to the CBD as a necessary criterion for a census tract to be included in the analysis of gentrification at all (Ley, 1986; Beauregard, 1986; Filion, 1991; Lin, 2002; Kahn, 2007). In addition to the recognition of the importance of the proximity to opportunities to the onset of gentrification, there are also the widely documented effects of centrality on property value. Filion defines gentrification as occurring in areas that are close to the CBD, that contain older, architecturally interesting housing and that are close to “physical amenities” (Filion, 1991: pp. 553). There is consensus among some researchers that amenities such as proximity to water and urban parks may contribute to the onset of gentrification (Helms, 2003; Lin, 2003; Heidkamp and Lucas, 2006; Ley and Dobson, 2008).

Kolko defines the three principal explanations of gentrification as being divided depending on whether the authors focus on housing location, characteristics of the housing stock or demographic changes, noting that very few studies integrate all of these perspectives into their analysis (2007). The effects of proximity to wealthier, or middle class areas, have also been associated with the process of gentrification, and in more contemporary research a relationship has been established between the ‘spillover effect’ from previously gentrified neighbourhoods, or higher income neighbourhoods, contributing to neighbourhood change in adjacent areas (Hamnett and Williams, 1980; Kolko 2007).

According to the research of Walks and Maaranen, the vast body of literature describing gentrification has attempted to define the process by describing three main demographic and economic changes: changes in tenure status of housing (from rental to owner-occupied), changes in property and land values, and ‘upgrading’ in the social class, or character, of a neighbourhood from working class to middle and upper class (Walks and Maaranen, 2008).

Though authors have long debated what causes gentrification and which indicators are necessary to include in an analysis of gentrification, there are some main themes that are agreed upon and have more often been used in analyses of the process.

1.4 Established Methodological Practices

Based on the literature reviewed up to this point it is evident that, although there are a diversity of studies published on the topic of gentrification, there are some attributes that are necessary to the study of gentrification to remain loyal to the established methodologies of past studies. In addition to literature on gentrification there is a significant amount of supporting literature that addresses the topic of transit’s impact on surrounding neighbourhoods, which include increased land and housing values.

First it must be established which geographical areas of the study area included in the research may be considered gentrifiable (ie working class or low-income) at the beginning of the study period (Hammel and Wyly, 1996; Meligrana and Skaburskis, 2005; Walks and Maaranen, 2008). Second, that the variables identified as relevant and indicative of gentrification must be measured jointly, and not independently, of one another (Hammel and Wyly, 1996). Finally, although many of the authors mentioned in the previous section use continuous variable techniques for modelling the relationship between property values and transit (Bajic, 1983; Cervero 2003, Debrezion, 2007; Hess and Almeida, 2007; Cervero and Deok Kang, 2009;

Duncan, 2011) the study of the onset of gentrification is considered in this project as the point in time at which an area is observed to have undergone gentrification, based on the relevant and available indicators. As such the occurrence of the onset of gentrification should be considered an event, where the outcome is a binary variable; 0 if the onset of gentrification has not been observed or 1 if it has. An event-analysis approach is therefore more appropriate than the continuous techniques used to establish the relationship between transit and, for instance, housing values. Survival Analysis, the event analysis approach employed in this study, is an example of what is an appropriate method, based on how gentrification is being analyzed in this study.

1.5 Gentrification in Canadian Cities

Examples of gentrification are visible in every large urban centre in Canada. The more widely cited studies primarily include research from Montreal, Toronto and Vancouver (Rose, 1984; Ley, 1986, 1994; Filion, 1991; Meligrana and Skaburskis, 2005; Slater, 2005; Walks and Maaranen, 2008). In their review of gentrification in Montreal, Toronto and Vancouver, Walks and Maaranen come to the conclusion that gentrification has occurred in 18% of central city census tracts of all three cities from the 1960s to 2000 (Walks & Maaranen, 2008:64). In an earlier assessment of gentrification in Canada authors found that between 5% and 12% of all CMA CTs were affected by gentrification, with that number increasing to 25% when only inner-city CTs were included (Meligrana and Skaburskis, 2005). Despite these general statistics, the cases of gentrification differ significantly among different metropolitan areas.

Gentrification in Montreal

The context of Montreal's gentrification is unique among the three Canadian cities included in this study in a number of ways. One notable distinction is the rent-control mechanisms specific to the city, which may have curbed on the onset of gentrification to some degree (Rose, 2004). Despite this, there has been a significant amount of gentrification documented in Montreal through the conversion of older industrial buildings into lofts and condominiums, especially along segments of the Lachine Canal, a previously industrial area (Van Crieking and Decroly, 2003). Additionally, where in some urban contexts major redevelopment projects propelled gentrification, infill condominiums played an important role in transforming Montreal neighbourhoods under a banner of promoting 'social mix' (Rose, 2004).

Gentrification in Toronto

A number of studies on gentrification and on the distribution of income have emerged out of Toronto in the past two decades. A recent paper assessed the accessibility of Toronto's transit system and came to the conclusion that it does a relatively good job of providing transit and access to opportunities to Toronto's marginalized populations (Foth, et al, 2012). The advent of gentrification in that city is still of great concern as there appears to be increasing spatial polarization of the population based on income (Hulchanski, 2007). There has also been a significant amount of research conducted on the way that culture and cultural marketing plays a role in gentrification as there are a number of distinct neighbourhoods, which use specific cultural identities to brand themselves and to spur investment in business and development (Murdie and Teixeira, 2011; Hackworth and Rekers, 2005). A focus has emerged on some particular neighbourhoods of interest in Toronto where the process of gentrification is occurring very rapidly, or in a unique way. One notable neighbourhood is Parkdale, a neighbourhood,

which was severely affected by the construction of the Gardiner Expressway along Lake Ontario in the 1960s (Slater, 2004). Slater uses a case study of Parkdale to show the importance of intentional gentrification by municipal bodies through the use of urban policies, a dynamic that has become particularly evident in the 21st century (Slater, 2005). Following the construction of this highway, the neighbourhood experienced serious disinvestment and transitioned from a desirable, middle and upper-class neighbourhood, to one predominantly filled with rooming houses, housing cooperatives and social housing (Filion, 1991). In 1991 25% of the city's adult group homes were in Parkdale, where only 2% of the Census Metropolitan Area's population resides (Filion, 1991). This was largely a result of the 'deinstitutionalization' of local psychiatric institutions, including the Queen Street Centre for Addiction and Mental Health, which subsequently pushed a huge number of ex-patients into the surrounding neighbourhood: Parkdale (Slater, 2004). In the past ten years this area has started to undergo a dramatic transformation as the value of housing all over Toronto has skyrocketed, a change that has been noted by researchers such as Walks and Maaranen (2008) and Slater (2004).

Gentrification in Vancouver

Vancouver is currently host to an increasingly heated struggle over gentrification, where new businesses have been opening up in one of Canada's poorest postal codes (Canadian Broadcasting Corporation, 2012). According to an analysis of the city from 1961 to 2001 Vancouver is the Canadian city that has had the highest proportion of its housing stock affected by gentrification (Walks and Maaranen, 2008). Like Toronto it has experienced an unprecedented leap in property values in the past 15 years, and author Mowatt has noted dramatic shifts in terms of social demographics (2010). The most highly contended space, the Downtown Eastside, has received national attention because of the density of poverty, and the

strength and persistence of the resistance to forces of gentrification in the area (Canadian Broadcasting Corporation, 2012). The Downtown Eastside consists of a relatively small area to the East of Vancouver's Central Business District and is a unique centre of facilities and services for drug addiction, with some of Canada's poorest and most vulnerable populations (Smith, H.A., 2003). Despite attempts by developers in the 1960s to redevelop the area, it has persisted as one of the poorest neighbourhoods in Canada (Smith, H.A., 2003). As the city around it has experienced exploding condominium construction, the neighbourhood has changed also, and become a place riddled with a new kind of conflict, between people defending the need for a focal point of services, increased affordable housing and resources for the existing populations in need, and those who support and want to speed up the transition of the Downtown. In 2012 Vancouver received national news for attacks on various small businesses by a group calling themselves the Anti-Gentrification Front (Hopper, 2013, May 16th).

Another oft cited part of Vancouver that has undergone gentrification in the past is the neighbourhood of Kitsilano, mentioned in previous studies as a 'classic' case of gentrification whereby a working class neighbourhood has been completely transformed into a middle or upper class neighbourhood, in close proximity to highly valued urban amenities, such as parks and beaches (Ley and Dobson, 2008). Ley and Dobson point to the importance of the political boundary that bisected Vancouver on a north south axis, separating the acceptable western from the 'wrong side of the tracks' to the East, an area where gentrification has been observed more recently (Ley and Dobson, 2008).

1.6 Effects of Gentrification: Revitalisation and/or Displacement?

Whether the net effect of gentrification is good or bad has been widely contested in the literature. Some authors cite gentrification as a positive process which balances out social

inequalities and provides an increased tax-base for central municipalities (Vigdor, 2001; Freeman, 2005; Duany, as cited in Newman & Wyly, 2006). The overwhelming majority of studies list negative consequences of the process of gentrification, which range from destroying social networks (Newman and Wyly, 2006) to conflict between existing residents and gentrifiers moving into the area (Kolko, 2007) to the outright displacement of residents from their neighbourhoods (Marcuse, 1986; Hackworth and Smith, 2000; Hefferman, 2006; Lucas and Heidkamp, 2006). The unfortunate evidence of the process - that it does adversely affect urban populations, particularly those with a lower socio-economic status - is difficult to demonstrate in empirical studies, and requires a stable and rigorous study of gentrification in cities (Newman and Wyly, 2006). As social polarization continued in the late 1970s and 1980s, such research began to be undertaken to measure the plight of those adversely affected by gentrification, and this goal continues to motivate research (London & Palen, 1984). Research regarding displacement began in the 1970s and 1980s (London & Palen, 1984), and remains one of the main foci of gentrification research as the most obvious negative consequence which is evoked by the definition of gentrification. Low-income residents being forced to move out of their neighbourhoods is a known process termed 'displacement' (Walks and Maaranen, 2008).

Displacement is defined as the forced movement of households for reasons associated with the conditions of the dwelling or the neighbourhood within which the dwelling is located, which are beyond the residents' control (Freeman, 2005). Marcuse affirms in his paper that gentrification results in increased demand in central urban areas resulting in displacement of low-income households from their neighbourhoods (Marcuse, 1986). A widely cited expert in the field, Marcuse also lists exclusionary displacement, as a consequence of gentrification; the exclusion of people from a neighbourhood which would previously have been accessible to

them, but no longer is due to the effects of gentrification (Marcuse, 1986). Displacement is difficult to quantify since it requires having data about residents both before and after they have moved. In a comprehensive study which measured both direct and indirect displacement it was found that displacement was an effect of gentrification (Newman & Wyly, 2006). Residents of previously working-class, but subsequently gentrified neighbourhoods were found to be adversely affected by the process of gentrification, as they were pushed into a housing market more competitively shaped by accessibility to jobs and services, affordability and commuting costs (Newman & Wyly, 2006).

Though displacement is of central concern when discussing gentrification, it is a very difficult process to quantify. In the case of this research, investigating displacement in a Canadian context, and with reference to the implementation of transit, was of interest, but the data is simply not available to conduct such studies. As described by Newman and Wyly (2006), the data necessary to conduct research on displacement is difficult to come by (it would ideally include individual-level data), and best accompanied by qualitative evidence, for instance, from interviews. As such the further analysis required to assess the amount of displacement that has occurred was not included in this project.

1.7 Transit and Land Values

Widely cited in the literature are some of the earliest attempts to describe the relationship between transit and land value through monocentric econometric models (Alonso, 1960, 1964; Mills, 1967; Muth, 1969). These initial models attempted to describe the relationship between people's location choice and their commuting costs (LeRoy and Sonstelie, 1983). Where these first models assumed that everyone was using the same mode of transportation to reach their work, and that everyone worked in the CBD, in the early 80s the model was extended to account

for changes in transportation modes and costs (LeRoy and Sonstelie, 1983). LeRoy and Sonstelie were attempting to account for a partial-reversal in settlement patterns, where some wealthier households were returning to the city centre, a process that they referred to as 're-gentrification' (1983), which later formed the basis for one of the first studies explicitly done on transit and gentrification (see description of Lin's 2002 paper in the following section).

Over the decades much research has been conducted on the relationship between land values and the presence of different forms of transit (Bajic, 1983; Cervero et al, 1994; Ryan, 1999; Adair et al, 2000; Cervero 2003; Debrezion, 2007; Hess and Almeida, 2007; Cervero and Deok Kang, 2009; Immergluck, 2009; Atkinson-Palombo, 2010; Duncan, 2011). Other studies, such as Cervero et al, (1994) have looked at the relationship of transit and land-use with the goal of increasing transit ridership, and the viability of funding new transit systems, by maximizing on vacant land in response to market demands for housing closer to transit, and in response to rising land values. The potential for development around transit is an important outcome of the results of many studies suggesting the effectiveness of 'value-capture' of increased property values around transit stations to better fund transit (Smith and Ghiring, 2006). Many of the studies around transit and land values are explicitly looking at how the real estate market is affected by proximity to transit (Bajic, 1983; Cervero 2003; Smith and Ghiring, 2006; Debrezion, 2007; Hess and Almeida, 2007). Results vary regarding the relationship between transit and land value; some studies showing only marginal increases, while others show negative relationships between housing prices and transit stations (particularly park and ride see Baum-Snow, 2005; Kahn, 2007).

In Toronto, through the use of a hedonic pricing model it was found that the implementation of the Subway system increased housing values around transit stations (Bajic,

1983). Although studies on transit and land value do not uniformly observe increased property values related to proximity to transit, in a review of the literature on the topic, Ryan concludes that studies that accurately capture accessibility to transit also tend to capture property value increases (Ryan, 1999).

1.8 Transit and Gentrification

Keeping in mind the established methodological practices presented earlier in section 1.4, this section describes the most important references that have tried to describe, explicitly, the relationship between gentrification and transit. It outlines what each article has contributed to the domain of research, some of their shortcomings and what this study has to contribute.

As was mentioned previously, public investment of resources into specific neighbourhoods, along with public policies on housing and urban planning, have important effects on gentrification (Newman and Wyly, 2006; Wyly and Hammel, 2005). Among publicly provided services, the provision of urban mass transit plays an essential role in attempting to maintain and improve equitable accessibility in urban centres (Manaugh and El-Geneidy, 2010). The transportation and land use literature is based around the fact that transit, and transportation infrastructure, has effects other than just the movements of people. It also affects the surrounding area, in terms of use, density and property values (Badoe and Miller, 2000; Cervero et al, 1994). Moreover, accessibility more generally has been noted as an important factor which makes a neighbourhood more susceptible to the onset of gentrification (Lin, 2002; Kahn, 2007; Walks and Maaranen, 2008; Pollack et al, 2010).

The link between neighbourhood renewal and gentrification as a result of transit infrastructure has been alluded to and recorded by multiple previous researchers (Beauregard, 1986; Lin, 2002; Chapple, 2009; Filion, 1991; Wyly and Hammel, 2005; Kahn, 2007; Pollack et

al, 2010; Dominie, 2012). Pollack et al. affirm that transit can be a catalyst for neighbourhood renewal, and that such improvements to neighbourhood accessibility could potentially ‘price out’ current residents because of rising property values (Pollack et al, 2010). These results are reflected by a similar study conducted in Los Angeles (Dominie, 2012). The question of rising property values due to the implementation of mass transit infrastructure has been addressed in literature on Transit Oriented Development (TOD), where Cervero et al acknowledged the development of new demands around this form of urban development (Cervero et al, 1994). Despite the connections between improved accessibility, higher property values, and gentrification, there have only been four studies conducted and published, to date, that address these issues explicitly (Lin, 2002; Kahn, 2007; Pollack et al, 2010; Dominie, 2012).

The earliest of the four studies was conducted by Jeffrey Lin who did a study of North-Western Chicago that looked at a limited number of variables and their changes in three phases: 1975-1980, 1980-1985 and 1985-1991 (Lin, 2002). This study of Chicago was influenced by earlier research which focused on the influence of transportation on processes of land and real estate selection of households as modelled by a bid-rent curve (Lin, 2002). The Alonso, Muth and Mills models of residential location choice assume that all households commute by the same means (Lin, 2002; Skaburskis and Moos, 2008). These models also make the assumption that all households within the same income brackets will have the same marginal utility for proximity to the CBD (Lin, 2002). LeRoy and Sonstelie (1983) introduced the effect of changing transportation technology providing different results for household location based on changed commuting costs (Lin, 2002). By the 1970s, cars had become relatively accessible to most socio-demographic classes, resulting in increased competition for properties in the suburbs. Citing congestion as a possible impetus for the movement of more affluent households back to the city,

Lin hypothesizes that “transit serves as a magnet for gentrification” (Lin, 2002: 176). Using the three periods mentioned earlier, he additionally looks at the importance of distance to the CBD, and distance from the shore of Lake Michigan to see if there is a wave-like effect of gentrification spreading away from those two areas. Using independent variables of residential zoning densities, as well as the straight-line distances to the CBD, Lake Michigan and transit stations, annual changes in land values were regressed for each of the three periods indicated above (Lin, 2002). Based on his findings, Lin came to the conclusion that over the 15 year study period transit had influenced gentrification during two of the three periods, with large, negative and statistically significant coefficients relating changes in housing values to proximity to transit (Lin, 2002). These values indicate that as distance to transit increases, the housing values decrease. The variables of proximity to Lake Michigan and distance from the CBD also proved to be statistically significant, with negative coefficients resulting from the analysis (Lin, 2002).

The results of this study are limited. The author acknowledges that gentrification is usually measured with a variety of indicators, yet he only takes into account the changes in land values (Lin, 2002). There are two other important points to note about the Chicago case study. First, that transit was present during the whole study period - there was no comparison made between property values before and after transit implementation. Second, at no point is there mention of the status of the neighbourhoods at the beginning of the study period. As per the generally accepted definition of gentrification, a neighbourhood should be defined as ‘working-class’ or ‘gentrifiable’ in order to undergo this process of change (Hammel and Wyly, 1996; Meligrana and Skaburskis, 2005; Walks and Maaranen, 2008). The susceptibility to the onset of gentrification has often been demonstrated in other studies by establishing whether or not the

average income and education levels, among other variables, are below those of the average of the surrounding metropolitan area (Kolko, 2007; Walks and Maaranen, 2008).

A second study explicitly studying the statistical effects of transportation investments made between 1970 and 2000 on gentrification was published in 2007 (Kahn, 2007). Whereas Lin was attempting to establish to what degree transit influenced the rate of growth of land values, Kahn attempts to measure the effects of the public investment made to build transit on surrounding real estate prices by statistically measuring the changes before and after transit has been implemented. In doing so he states that he is contributing to a body of real-estate literature focused on the desirability of living near transit in 'new-urban' communities (Kahn, 2007). Inspired by an earlier study on the effects of the implementation of rail-transit (Baum-Snow & Kahn, 2005), Kahn decided to further investigate the effects of transit on surrounding areas. The paper evaluates the effects of transit in 14 cities across the United States. Using property values and education levels as independent indicators of gentrification in census tracts which were previously further from transit and were 'treated' during the study period with new transit stations, Kahn estimates gentrification (Kahn, 2007). Three models structure Kahn's statistical analysis of the effects of transit implementation on the surrounding neighbourhoods (Kahn, 2007). He uses a regression analysis to estimate the changes in housing prices at 4 points in the study period; 1970, 1980, 1990 and 2000. The independent variables included in the initial models are proximity to walk and ride stations, proximity to park and ride stations and proximity to any transit station interacted with the median household income. All of the variables of distance to transit stations are binary; 1 if a census tract is within one mile of transit, and 0 if it is more than one mile from a transit station. This regression showed mixed results across the study

sample, with walk and ride stations having a positive effect on housing prices, and park and ride stations affecting housing prices negatively (Kahn, 2007).

In the second set of regressions analysis, both changes in housing values and changes in the number of college graduates within surrounding census tracts are estimated, but in separate regressions. The independent variables included in the regression models are: the variable of the presence of transit within a one mile distance, distance to walk and ride stations, and a measure of the distance to transit station interacted with the income if the income is above the median of the metropolitan area in 1970 (Kahn, 2007). Lastly Kahn compares the results from his ordinary least squares (OLS) regressions with those of an instrumental variable (IV) approach.

Although the variable of distance interacted with income partially introduces the idea of a census tract being 'gentrifiable' it does not acknowledge that tracts may enter into the sample (become gentrifiable) at later dates in the study period. Furthermore the two variables used to demonstrate the presence of gentrification are measured independently, there is no evidence that the trends observed for each are necessarily happening in the same census tracts. Despite these shortcomings, the paper does attempt to quantify the difference in the effect of the number of years that transit is within close proximity to the census tract. The results of Kahn's study were inconclusive, and varied according to the models (either OLS or IV) being used, ultimately demonstrating that although gentrification does occur near some stations typified as 'walk-and-ride' stations, it does not appear to occur near 'park-and-ride' transit stations.

The third paper written on the topic of gentrification and transportation was published by authors Pollack, Bluestone and Billingham (2010). In a 12-city study, they set out to study the social equity of accessibility to transit before and after the implementation of major transit infrastructure between 1990 and 2000 in the United States in Transit Rich Neighbourhoods

(TRNs) (Pollack et al, 2010). They were motivated by the growing number of people using transit, and the way that living in TRNs has become more desirable (see also Cervero et al, 1994) to wealthier residents who typically own more cars (Pollack et al, 2010). This study assesses both light and heavy rail transit, and includes far more demographic indicators of gentrification, including; population, race, household income, gross rent, mobility status (whether residents have moved in the last 5 years), transit ridership, housing value, and number of cars per household (Pollack et al, 2010). The variables were collected and analysed at the census block group level (Pollack et al, 2010). Census block groups represent multiple census tracts which were agglomerated to create a proxy for 'transit-rich neighbourhoods' surrounding each transit station. The block-group had to have at least 50% of their area fall within a ½ mile of a transit station to be considered in the analysis. Although the variables included should give a comprehensive view of gentrification according to the literature (see Fillion, 1991; Freeman, 2005; Walks and Maaranen, 2008) the study period covers only ten years. Moreover, the analysis used does not take into account the effects of time exposed to transit and would not differentiate, for example, between the effects of transit stations which came into operation in 1991 and the effects of transit stations which came into operation in 1997 on their surrounding areas. Similarly to Kahn's methods, the analysis in this paper does not ensure that the trends occurring in the different variables in TRNs are happening in the same census tract blocks, which would be necessary as changes in the variables are assessed across the aggregate group of TRNs. Moreover, they do not address the idea of gentrifiability in their analysis.

The study's goal differs slightly from the other two in that it attempts to quantify gentrification due to transit, but also focuses on displacement which occurs as a result of gentrification (Pollack et al, 2010). The displacement of low-income residents from

neighbourhoods in proximity to transit creates the potential for a doubly negative situation where those who would benefit most from transit no longer have access to it, and new residents are less likely to use transit because of their higher levels of automobile ownership associated with higher incomes (Pollack et al, 2010; Dominie, 2012). The success of transit investments are thus in peril since automobile ownership is the most important determinant of choice of mode (Pucher and Renne as cited in Pollack et al, 2010). The study showed that undesirable patterns of neighbourhood change can occur as a result of transit investment, but are not inevitable (Pollack et al, 2010). The authors emphasize the importance of studying the correlation between neighbourhood change and the implementation of transit infrastructure because of the symbiotic relationship that exists between successful transit and diverse neighbourhoods, in terms of race, education and income (Pollack et al, 2010).

Following the methodology established by Pollack et al, a fourth study was conducted in Los Angeles relating TOD-promoting policies to gentrification (Dominie, 2012). The case of Los Angeles at this juncture in its public transit investments was unique. Known as one of the most notoriously auto-oriented and sprawling centres of North America, Los Angeles still has an important bus transit system, which has an active lobby group, the Bus Riders Union, self-proclaimed as the “largest grassroots mass transit advocacy organization [in the USA]” (The Labour/Community Strategy Centre, n.d.).

Dominie looked at gentrification surrounding transit stations of rail and bus rapid transit, which detracted funding from the bus system (Dominie, 2012). This study was limited in the number of variables utilized to establish gentrification, and also, like the Pollack et al study, assessed only census tracts located within a certain distance of transit stations. The context of the study differed from the three articles previously reviewed in this section in that it was framed

more explicitly as a critique of some of the discourses of sustainability and environmental development that often form the marketing basis, and the political justification of TOD and rail transit development (Dominie, 2012). Although this study does attempt to quantify gentrification around transit stations, its focus is more explicitly the environmental effects of gentrifying neighbourhoods, which, based on past evidence, demonstrate higher levels of car-ownership and lower levels of transit use (Pollack et al, 2010; Dominie, 2012). The study concluded that areas around transit, for the most part, were more likely to gentrify and, worryingly, saw greater increases in car-owning residents than the surrounding counties, and experienced resultant losses in transit ridership (Dominie, 2012).

Table 1, below, summarizes the methodological approaches of some key references, listing things that may be drawn upon for this research, in addition to things the authors neglected to incorporate.

Table 1: Methods of Most Relevant Reviewed Studies of Gentrification

Authors	Definition of Gentrification	Susceptibility to Gentrification	Indicators of Gentrification	Multiple Indicators Measured Jointly	Length of Study Period	Transit Included
Lin, 2002	"Middle-class resettlement of the inner city" (pp.175)	Not addressed	Land values	No	15 years	Yes
Kahn, 2007	Not defined	Not addressed	Property values College degrees	No	30 years	Yes
Walks and Maaranen, 2008	"the rehabilitation of both working-class neighbourhoods and previously downgraded "larger Victorian houses" originally built by and for the middle class" (pp. 3)	Addressed	Average income LQ for university degrees* LQ for tertiary workers* Proportion of rented dwellings Average rents Average housing values	Yes	60 years	No
Pollack, Bluestone and Billingham, 2010	"Neighborhood change process characterized by increasing property values and incomes." (pp. 5)	Not addressed	Population growth Housing units Racial and ethnic composition Household income Housing costs Public transit use	No	10 years	Yes

*LQ refers to the Location Quotient, ie the proportion of the variable in question visible in the area, compared with the reference area (CMA)

In reviewing these studies it is evident that there is much room for improvement as none of them assess gentrification across whole census metropolitan areas, over a long period and with comprehensive definitions and analyses. Nor do they include appropriate statistical techniques for establishing the relationship between transit and gentrification. Most of the transit-gentrification studies fail to offer a definition of 'gentrifiable' tracts, observing gentrification in their results in areas that are potentially not susceptible to gentrification due to the pre-existing conditions of the neighbourhoods. The upward changes observed in a neighbourhood that is not 'gentrifiable' would be considered forms of neighbourhood upgrading (Van Criekingen and Decroly, 2003; Walks and Maaranen, 2008; Owens, 2012), an expansion of this field of research that is out of the scope of the project described here. An explicit definition of the term 'gentrification', which should be the basis of any study of the process, is also conspicuously absent from both Kahn's and Lin's studies, respectively. With the exception of Lin's assessment of Chicago, the papers do not map those areas that should be monitored or where gentrification is already underway.

Though each of the three studies on the effects of transit on gentrification contributes something to the field of transportation land-use planning and gentrification literature, none of them contain all of the elements of a holistic study of the effects of transit on gentrification.

The research topic - the relationship between proximity and exposure to transit and the onset of gentrification - addressed in this thesis will contribute to the vast amount of work on gentrification, and the relatively new sub-discipline of its interactions with urban transit. It will contribute to this growing field of research in a number of important ways, filling gaps that currently exist in the literature and facilitating the future measurement and monitoring of the phenomenon of gentrification. The ways in which this study differentiates itself from past

studies, and contributes to this burgeoning field of research are many. First, gentrification in this study will be clearly defined according to author Kolko as a process leading to the “upgrading of urban neighbourhoods, especially neighbourhoods starting from low average income, low housing values, or high poverty rates” (as cited in Pollack et al, 2010). In order to measure this phenomenon of upgrading from ‘working-class’ neighbourhoods, census tracts that are susceptible to gentrification will be established, a step which Lin (2002), Kahn (2007), Pollack et al (2010) and Dominie (2012) all neglected to clearly address. Next the study period will be at a scale large enough that long-term effects of transit will be noted. The study periods will begin with the census year immediately prior to the inauguration of the first transit station for each system and will end in 2006 (see Table 2 below for a list of the study periods). This is an important addition to be made to this field of study as past research has only assessed gentrification near transit over the course of 10 to 30 years (Kahn, 2007; Pollack et al, 2010). In addition, the indicators used to establish gentrification (detailed in the following section on methodology) include a comprehensive list pertaining to income, education, occupation, and housing costs.

This study will also assess transit systems in their entirety, not singling out stations for analysis, thus giving a more holistic view of gentrification across cities than studies which only measured the influence of a select number of stations as is seen in the studies by Pollack et al. (2010), Kahn (2007) and Dominie (2012). This approach will also be useful in identifying what other patterns or characteristics of the urban form may be contributing to gentrification, in other words, why some stations may catalyze gentrification, while others do not. The statistical method which has been selected for this research project will allow for a comprehensive analysis of the

effects of transit on the onset of gentrification over time, as an event-analysis, while at the same time ensuring that the studies of the three Canadian cities will be comparable.

2.0 Methodology

The following chapter details the methodology, first by offering the context of the research questions and objectives, followed by a description of the study areas included in this project, and the data used. The last two sections of this chapter detail how gentrification was identified and the statistical analysis used to assess its relationship to exposure to urban rapid rail transit.

2.1 Research Questions

The research question for this study is: What is the statistical evidence for the relationship between urban rapid rail transit infrastructure and the onset of gentrification in the three largest Canadian cities as their respective urban rapid rail transit systems were implemented in the 20th and 21st centuries. The research objective takes into account both the initial effects of transit implementation, but also because of the long time-frame used, assesses the changes surrounding transit in the years after it is implemented. This question will be approached through multiple stages of analysis. First, census tracts which are susceptible to gentrification will be identified, using as indicators average household income and the number of university degrees per person in a census tract. If at any point a census tract becomes 'gentrifiable' it will be entered into the study sample for the rest of the study period. Second, the onset of gentrification will be established through a simple analysis of the data, both demographic and housing variables, in order to compare changes observed in census tracts with changes observed in the surrounding metropolitan area as a whole. The final step of the analysis is a statistical model to measure the

significance of the presence of transit, over time, on the onset of gentrification in the gentrifiable CTs identified in the analysis.

In addition to analysing the relationship between transit and gentrification, the importance of other factors will also be assessed in the statistical analysis, including the distance from the Central Business District (CBD), the presence of urban amenities, the proportion of older architecture, and the effect of the proximity to other previously gentrifying CTs. The latter variable has not been assessed before, although a similar variable was integrated into Kolko's analysis (2007) as the spill over effect of adjacent neighbourhoods with higher incomes.

Table 2 below lists the year each respective transit system was first inaugurated, as well as the total study period for each city (from the census prior to the inauguration of the first transit station to 2006).

Table 2: Study Periods for each City

City	Montreal	Toronto	Vancouver
Type of Transit	Heavy Rail	Heavy Rail (Subway)	Light Rail (SkyTrain)
Year first station	1966	1954	1986
Study Period	1961-2006	1961-2006 ¹	1981-2006

(Information compiled from: Bromley and May, 1973; Clairoux, 2001; Wales, 2008; TTC, 2012)

This study will be the first to establish the importance of transit, statistically or otherwise, to the process of the onset of gentrification in Canadian cities, though the impacts of transit on gentrification in Canada have been noted by authors in the past (Walks and Maaranen, 2008).

¹ Census data for Toronto was not comparable for 1951, the census year prior to the opening of the Subway in 1954, as there was data used in the analysis that was not collected for that year. According to the literature (Walks and Maaranen, 2008) gentrification was not observed until the 1960s and 1970s. Based on this information, the necessary omission of 1951 was considered acceptable and the analysis was conducted using the time period of 1961 to 2006.

2.2 Study Areas

Gentrification in Canadian cities has been studied extensively (Ley, 1986; Van Criekingen & Decroly, 2003; Slater, 2004; Walks & Maaranen, 2008), but the impacts of the cities respective transit systems have never been taken into account during these studies. This section gives a brief introduction to the cities and their respective transportation systems. This study assesses the impacts of the implementation of urban rapid rail transit on gentrification on Canada's three largest Census Metropolitan Areas (CMA); Montreal, Toronto and Vancouver.

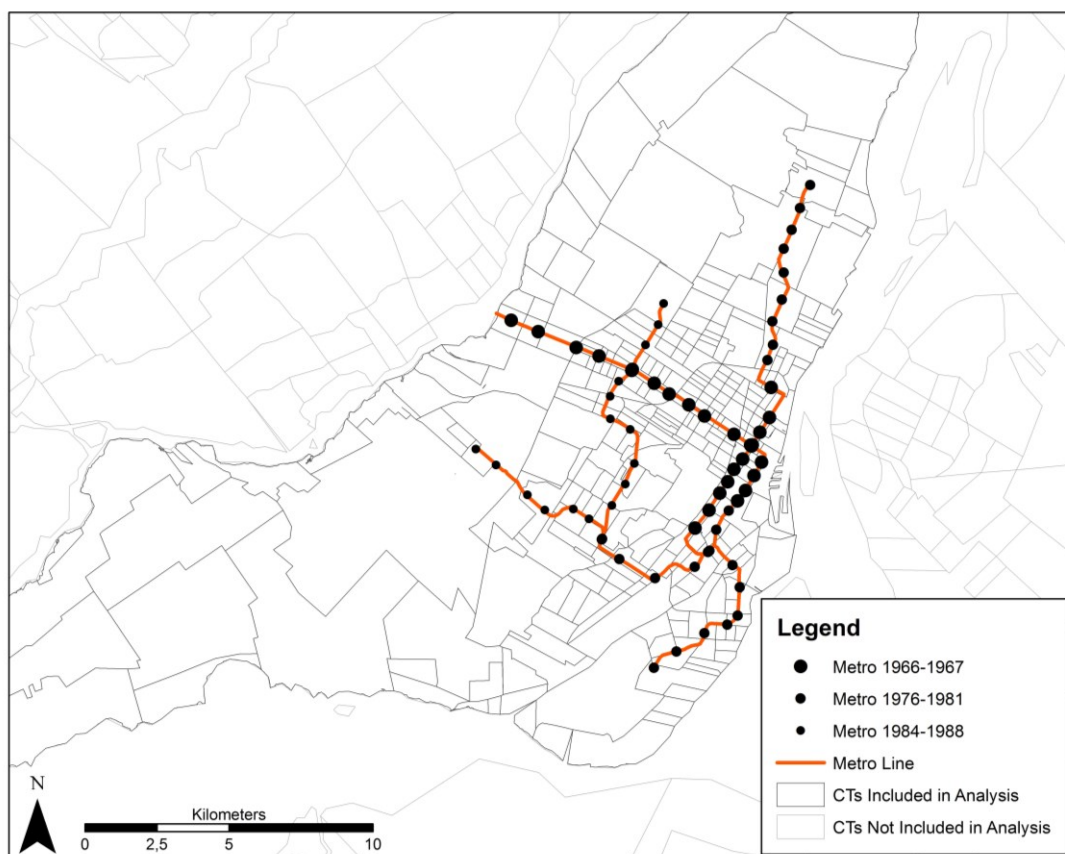
Montreal

Montreal is the second largest CMA in Canada, with a population of 3.6 million in 2006 (Statistics Canada, 2007). The evolution of the Montreal Metro, a subterranean heavy rapid transit system, happened over the course of more than 50 years (STM, 2009c).

As early as 1910 plans for an underground rail system were being presented to city hall from various private organizations (STM, 2009a), but it was not until 1961 that the plans for the existing Metro system were first unveiled (STM, 2009b). Inauguration of the first stations in 1966 occurred to provide transportation for the Expo 1967, the World's Fair that was held in Montreal that year (Clairoux, 2001). Since the study period goes from 1961 to 2006, the stations that opened after this date, to the North West of the island of Montreal, on the island of Laval, were excluded from the analysis. Additionally the stations to the south of the island of Montreal, in Longueuil, and on the Isle St Helene, were excluded from the analysis for two reasons. The Isle Sainte Helene is a parc, not a residential, nor an urban space, therefore it would not be susceptible to gentrification. The metro station of Longueuil was excluded because the census tract boundaries changed so much over the years that the area could not be made comparable.

Figure 1 below shows the 68 stations on the island of Montreal built between 1966 and 1988 that were included in this research project.

Figure 1: Montreal and Metro Stations by Year Built



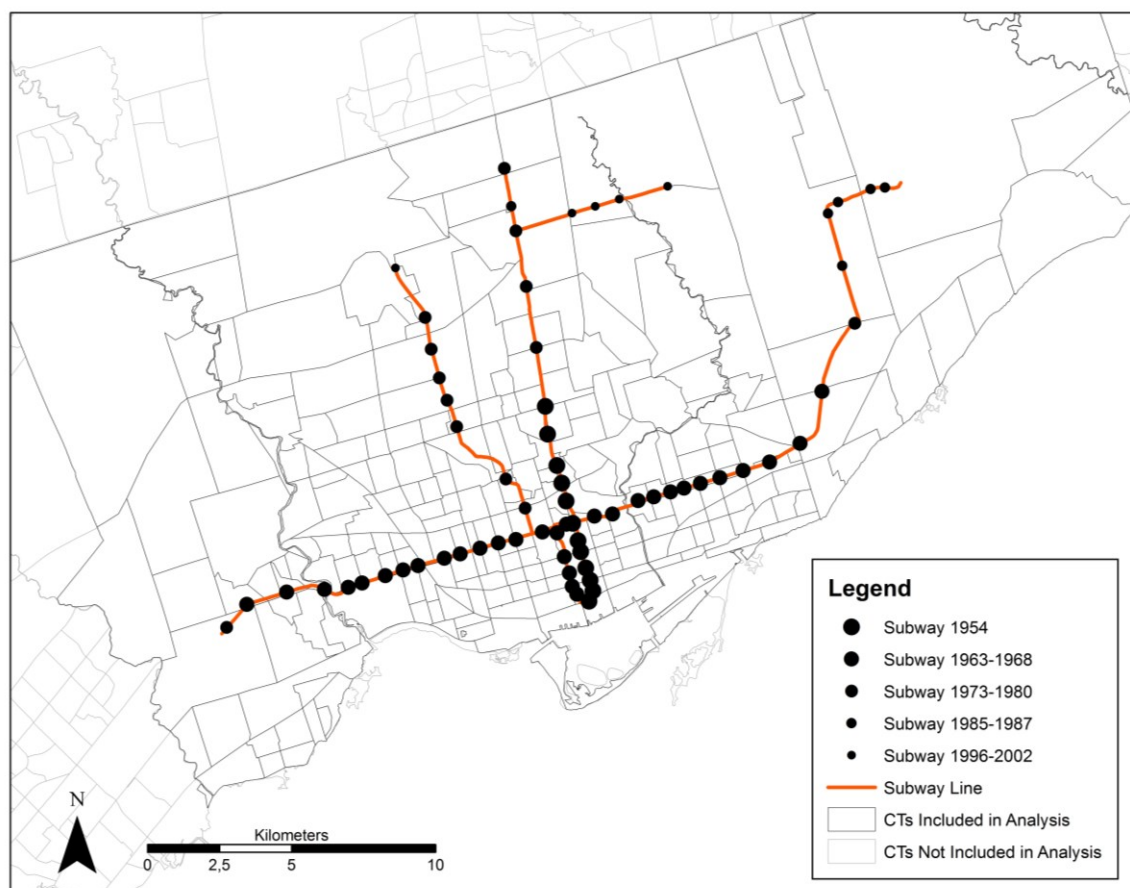
Sources: Statistics Canada, 2001

Toronto

As the largest CMA in Canada, Toronto also hosts the oldest Canadian urban rail system. Operated by the Toronto Transit Commission (TTC) a transportation authority created in 1921 to consolidate transportation governance in the rapidly growing city (Toronto Transit Commission, 2013a). Under the TTC, a rapid transit department was created in 1944 to plan for the projected growth in traffic post-WWII (Osbaldeston, 2008). In 1946 the plans for the Toronto subway (see Figure 2 below) were approved and construction proceeded with the system's first stations being

inaugurated in 1954 (Osbaldeston, 2008). Unlike Montreal's Metro, whose cars run on rubber wheels, the Toronto Subway is an underground rail system. The most recent part of the Subway system, the Sheppard line, extends East from Yonge Street along Sheppard and was opened in 2003 resulting in a system (in 2006) that consisted of 69 stations that extended along 68 kilometres (Toronto Transit Commission, 2012b). The area included in the analysis is all of the census tracts in the City of Toronto, which completely encompasses the subway lines and where comparable Census Tract Identifier's were available for the duration of the study period (1961-2006).

Figure 2: Toronto and Subway Stations by Year Built



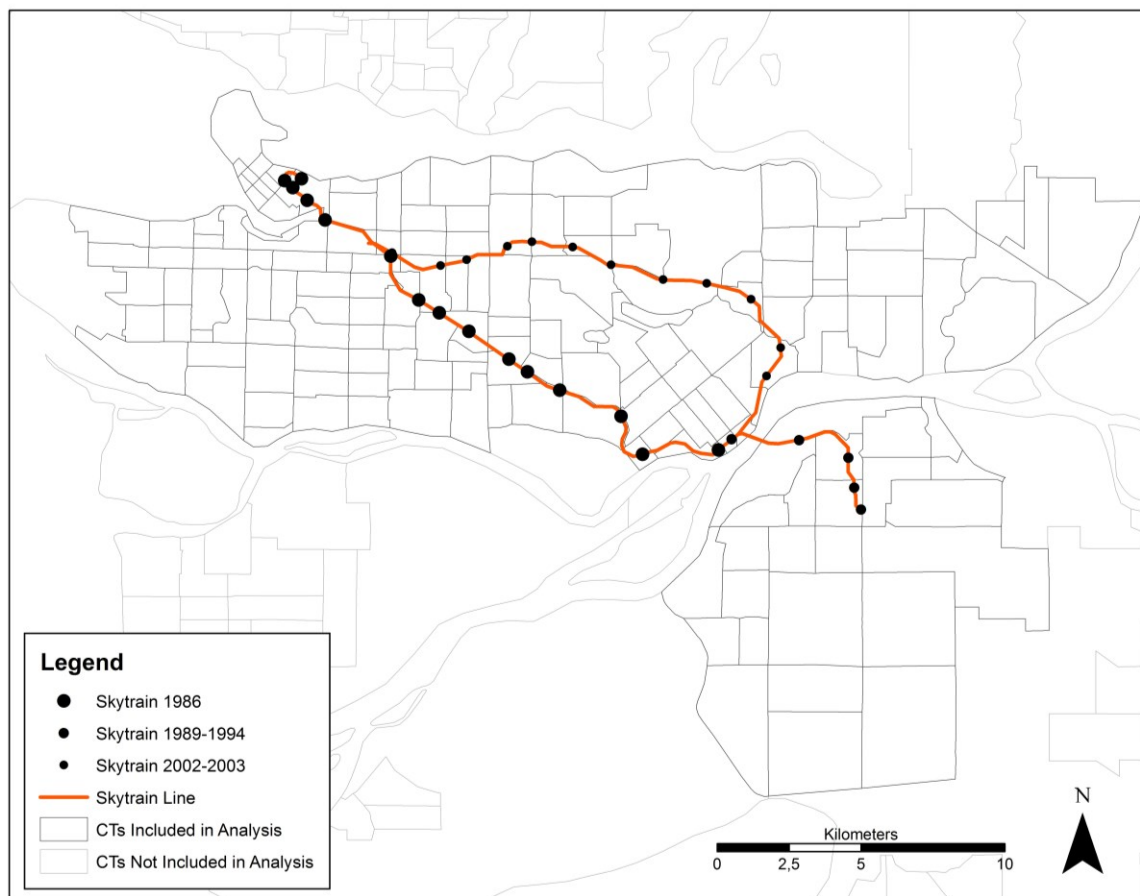
Sources: Statistics Canada, 2006; CanMap Rail, 2010

Vancouver

Of the three cities included in this study Vancouver (seen below in Figure 3) is the smallest CMA and contains the youngest transit system, with the first stations of the SkyTrain system having opened in 1986 for the World Exposition. The Skytrain is operated by Translink, the transportation planning authority formed under the Greater Vancouver Regional District's jurisdiction (now known as Metro Vancouver) (Wales, 2008). The SkyTrain is an elevated light rail rapid transit system, which in 2006 consisted of 33 stations along 49.5 kilometres of track making it, in 2008, the longest automated rapid transit system in the world (Wales, 2008). The SkyTrain serves not only the City of Vancouver, but also three adjacent municipalities – Burnaby, New Westminster and Surrey - all of which are a part of Metro Vancouver (Wales, 2008).

A new line, extending south from the CBD, was opened in time for the 2010 Vancouver Winter Olympics, but was excluded from this analysis since it came into operation after 2006. Defining the boundaries of the analysis in Vancouver was more complicated than in the other two cities. In initial analyses gentrification was observed in some fringe CTs, which had very low population density and high proportions of agricultural-based work in 1981 (the start of the study period). In order to exclude these CTs from the analysis, since what was being observed was more urbanization than gentrification, different population density thresholds were tested. The 10th percentile population density was judged to best exclude largely rural CTs, while maintaining the urban CTs in the analysis. Census tracts were also excluded from the analysis if they were separated from the SkyTrain by water, or by other CTs with low population densities. The CTs included in the analysis are visible in Figure 3, below.

Figure 3: Vancouver and Skytrain Stations by Year Built



Sources: Statistics Canada, 2006; CanMap Rail, 2010

The following section will describe the methodological approach that was used in order to address the hypothesis and research question starting with a description of the data used. Recall that the research question of the proposed project is to establish whether transit has a statistically significant effect on the onset of gentrification in Canadian cities. The hypothesis is that the likelihood of gentrification occurring within a census tract will increase the longer a census tract is exposed to a nearby transit station. All stations for each transit system will be

included in the analysis, with the exception of any stations that came into operation only during or after 2006, the end-year of the study period.

2.3 Data

In order to identify gentrification, the spatial resolution of the ‘neighbourhood’ has most often been used in studies in the gentrification literature. As this term has boundaries that are difficult to delineate and is more abstract than concrete or political, a proxy of the census tract (CT) will be used, in accordance with the most common methods of analysing gentrification (Hammel and Wyly, 1996; Freeman, 2005; Heidkamp and Lucas, 2006; Kahn, 2007; Kolko, 2007; Walks and Maaranen, 2008; Pollack, Bluestone and Billingham, 2011). A census tract is defined as a geographic area found within a CMA which is relatively small and stable and usually contains a population of approximately 2,500 to 8,000 residents (Statistics Canada, 2009).

The digital census boundary files that graphically illustrate the limits of census tracts were available from different sources, including Statistics Canada, as well as the Computing in the Humanities and Social Sciences (CHASS) database at the University of Toronto’s Faculty of Arts and Science. It was also necessary to georeference some of the older maps (1961 for Toronto and 1961 for Vancouver) in order to establish comparable census tract identifiers. Cross sectional data at the census tract level was used and is available through Statistics Canada and the University of Toronto’s CHASS. The indicators retrieved from Statistics Canada included average household income, average gross rent, educational attainment (number of degrees per capita), the proportions of rented versus owner-occupied dwellings, as well as the proportion of ‘professional’ occupations (defined as managerial positions, or positions requiring a university degree or higher). These were chosen based on indicators used in other studies (see Freeman,

2005; Walks and Maaranen, 2008; Pollack et al, 2010), taking into account the availability of variables for the full time period and across the three cities included in this study.

In order to ensure that all the census data collected were comparable, the spatial areas of the census tracts had to be rendered comparable. The changes that occur in census tract boundaries are summarised in Figure 4 below (Cote, n.d.). The first change listed, ‘Many to One,’ is a less common type of change where multiple census tracts are agglomerated over time. The most commonly occurring change over time is the second change noted in the figure: the ‘One to Many’ change. This occurs when one census tract is split into a number of smaller census tracts often due to population growth. The third type of change is the ‘Many to Many’ change in which the census tract boundaries of multiple adjacent tracts are adjusted over time.

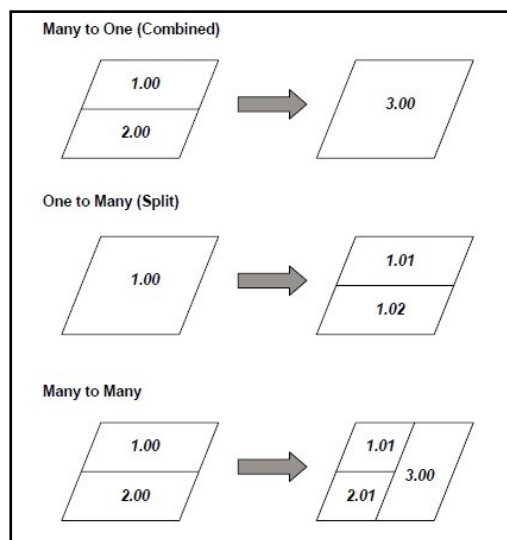


Figure 4: Census Tract Changes

These changes may sometimes be quite small, but in any cases where there is a significant redistribution of territory, and therefore population, some action on the part of the researcher is required. In the past this has often been done by using a later year as a base year and attempting to divide up the data as accurately as possible by weighting the averages of the

different variables according to spatial area (Walks and Maaranen, 2008; Pollack et al, 2010). Though this technique allows the results to be somewhat more comparable, it requires making assumptions about the geographic consistency of changes occurring throughout years and thus obviously introduces a level of error into the analysis. The consequences of altered data have been considered a necessary part of any analysis spanning a period of time which saw changes to the census tract boundaries (Walks and Maaranen, 2008).

In this study we began by first establishing the magnitude and extent of changes that have been observed in each of the study areas over the given period of time by overlaying the maps from the beginning of the respective study periods until 2006. Once a list had been compiled of all the changes which have taken place, the normalization of the boundary files and data spreadsheets began.

Data was aggregated from any adjacent census tracts which have experienced changes as in the 'many to one' example in Figure 4. All of these data adjustments were done in GIS once changes had been identified and census tracts had been labelled in excel with new 'final' census tract identification (ID) numbers, which are unique for each final census tract. Tracts that were joined were identified with the same identification number and subsequently dissolved by their new ID number. Census tracts were removed that were mostly, or entirely, park space or institutional space, such as hospitals or universities. In these CTs the data was often inadequate or inconsistent (for instance household income available for one census period but not the next, or data given, but missing the number of households in the CT). Once the boundary files and demographic data sets have been adjusted to take into account any census tract changes from the beginning to the end of the study period, the analysis begins.

2.4 Identification of Gentrification

As was mentioned previously, the identification of the onset of gentrification requires several steps. In Walks and Maaranen's study of Montreal, Toronto and Vancouver, the census tracts included in their analysis of gentrification needed to conform to certain constraints including the criteria of being below the average levels of educational attainment and individual income levels at the beginning of the study period (Walks and Maaranen, 2008; Pollack et al, 2010). Following previously established methodologies, identification of gentrifiable CTs was done through a preliminary analysis which identified census tracts with below average levels of education (university degrees per capita) and below average household incomes at the beginning of each respective study period. This analysis was repeated for each census year so that if a census tract becomes 'gentrifiable' later than the starting point of the study period it was still included in the analysis from that point in time. Any census tracts included were analysed for the remainder of the period from the point at which they are first deemed gentrifiable.

In order to measure the onset of gentrification in the gentrifiable CTs preliminary tests included the variable of 'household structure' (number of children in a household), but this variable did not seem to give consistent results across the different cities and so was excluded from the analysis. Ultimately the study includes percent changes over time of the following variables: average household income, average gross rent, number of degrees per capita and the proportions of rented versus owner-occupied dwellings. The changes observed in the gentrifiable census tracts were measured against the changes over the same period for the CMA within which the CTs are found. If the changes observed in a CT were greater than the average change experienced by the CMA as a whole for all of the listed variables, then the census tract was considered to have undergone gentrification over that period.

For the study area of Vancouver the gentrification analysis was done from 1961 to 2006 to get a better idea of the gentrification that had happened in that city, but only the 1981 to 2006 time period was included in the statistical analysis.

Once the results of the gentrification analysis were collected, the results were represented on a map in GIS. The patterns of gentrification with regards to transportation were compared from city to city across Canada to see how this process has differed or what common patterns may be identified among the three major Canadian cities included in the analysis.

2.5 Statistical Analysis

The majority of the articles reviewed that employed quantitative, and specifically statistical models, in the study of gentrification used regression analysis (Ley, 1986; Filion, 1991; Helms, 2003; Freeman, 2005; Newman and Wyly, 2006; Kahn, 2007; Kolko, 2007; Chapple, 2009; Freeman, 2009). Many of these models are created to test the relationship, or existence of a relationship between gentrification and other phenomena, such as displacement (Freeman, 2005, 2009; Newman and Wyly, 2006).

In cases such as the studies of Lin (2003) and Kahn (2007), the continuous variable regression models used are possible only because of the fact that they are assessing only one aspect of gentrification at a time. As explained above, it is more appropriate to consider the onset of gentrification as an event, and not as a continuous variable, and that the observation of changes in multiple variables over one time period need to be observed together for said 'event' to have occurred. As was mentioned earlier, in order for an area to undergo gentrification it must first be observed to be gentrifiable, and must subsequently experience changes in a number of established indicators of gentrification at the same time. The observation of the onset of gentrification according to these criteria can be observed at a point in time. The dependent

variable in both of the aforementioned studies are not only individual indicators of gentrification; housing prices in Lin's study of Chicago, and housing prices and percentage of college graduates, respectively, in Kahn's multi-city study, but they are modelled as continuous dependent variables. In order to address this methodological oversight, the study presented here employs a type of event analysis: Survival Analysis. Survival Analysis has the additional benefit of integrating time-dependent variables into the analysis, (Kleinbaum and Klein, 2005) an important aspect of the variable of proximity to transit, as time goes on and as new stations may be implemented in a system.

2.6 Introduction to Survival Analysis

Described as an analytical method which assesses the time until an event occurs Kleinbaum and Klein state that this procedure may be applied to any research question where the outcome is time until "any designated event of interest that may happen to an individual" (2005:pp.4). Though primarily used in the field of bio-statistics, for example to assess time until death, or the spread of disease (Kleinbaum and Klein, 2005), this technique has also been integrated into the fields of transportation research and planning (Washington, et al, 2003). The most common examples of use in the field of transportation research are in estimating the time until an accident occurs, or the likelihood of an accident occurring based on different factors (Washington, et al, 2003; Ahmed, et al 2012; Jovanis et al, 2012), though the technique has also been used to establish the time until acquisition of a license, or of a car (Bohnet and Gertz, 2010).

In addition to application in the fields of bio-statistics and transportation planning, the use of survival analysis may be seen in the context of studies of urban environments, where it has been applied to research questions such as the effects of processes of urbanisation on risk of

AIDS among women (Greif et al, 2011) and the psychological effects of urbanisation in terms of the likelihood of the onset of depression (Sundquist et al, 2004).

Ultimately the dependent variable in this study is the onset of gentrification at a given point in time, an outcome that is a binary variable, which calls for the use of a limited dependent variable method, such as the technique further elaborated below. The variable, ‘effect of transportation on gentrification over time’, is what is called a time dependent variable due to the important role that time plays in the effect of the variable, and how the variable – proximity to transit – may have a changing effect on the dependent variable over time.

To statistically analyze the likelihood of a census tract gentrifying over time with reference to the census tract’s exposure to a transit station, a number of statistical methods could be employed. The idea of using a simple linear regression was briefly entertained, but because the data is discrete (gentrifying or not) rather than continuous, this analytical method would not make sense (probabilities of the onset of gentrification of greater than 1 or less than 0 could potentially be outcomes). Walks and Maaranen described many forms of gentrification and upgrading and specified tracts considered ‘fully gentrified,’ (Walks and Maaranen, 2008). This study differs in its objectives as the idea is to test the effect of transit, and other urban amenities on the *onset* of gentrification, and does not attempt to show when the process is ‘complete.’ A type of more simplistic discrete variable model, such as a logit model, was another possibility, but this type of model does not easily incorporate the effect of time which is an essential component of assessing the long-term effects of transit on gentrification. As a result, an event, or survival analysis approach was adopted.

Of the different hazard models available the Extended-Cox hazard model, a semi-parametric model, was used in this analysis. In Survival Analysis, the outcome of the model

depends on whether the hazard function, or the survivor function, is being used. Whereas the hazard function gives the potential rate, at a given point in time, that an individual in the sample will experience the event, the survivor function describes the probability that an individual will experience the event after a certain point in time (Kleinbaum and Klein, 2005: 13). The Extended-Cox hazard function presented in Equation 1 is composed of two main parts, the first part is the baseline hazard function ($h_0(t)\exp$) that accounts for the potential (over time) that an event will occur at an instantaneous point in time, given that it has not occurred up until that point (Kleinbaum and Klein, 2005). As such, the outcome of the hazard function is a rate (since it is the potential over time) and not a probability and is also sometimes referred to as the ‘conditional failure rate,’ due to the fact that it is dependent on the event (failure) not having occurred up until that point (Kleinbaum and Klein, 2005).

Equation 1: Extended-Cox Hazard Model

$$h(t, X(t)) = h_0(t) \exp \left[\sum_i^p \beta_i X_i + \sum_i^p \delta_i X_i g_i(t) \right]$$

The second part of the EC hazard function is the exponential function, which integrates the independent variables into the analysis. The Cox Proportional Hazard model requires that the hazard ratio be constant over time, which is why the Extended Cox model was selected for this analysis, where the hazard, or failure rate, is expected to increase as time exposed to transit increases (Kleinbaum and Klein, 2005). In the EC model (Equation 1) both time independent and time dependent variables are included in the right side of the model, the time-dependent variables are indicated by the presence of (t). There are two types of variables whose values differ across time. The first are time-varying covariates, in other words variables that may be used to explain the dependent variable, but which change over time (eg the distance to the

nearest transit station as a transit system is expanded). The concept of the second type of variable affected by time is slightly more abstract. Time dependent variables, as they are called by Kleinbaum and Klein (2005), refer to variables whose values, or effects on the dependent variable, may change over time. In the model described in this project the variable of exposure is both time-varying and time dependent, as it changes as the transit system expands (time-varying), but is also expected to have an increased impact on the probability of nearby census tracts gentrifying over time (time dependent).

Despite the fact that the effect of the time-dependent variable is changing over time, there is only one coefficient provided to account for changes in this variable, represented by small delta (δ). In the left-hand side of the Equation, the bold **X** represents the combined effects of the time independent (X) and time-dependent ($X(t)$) variables (Kleinbaum and Klein, 2005). The results of this analysis are easily understood as the parameters are estimated using maximum likelihood techniques (Kleinbaum and Klein, 2005). Therefore the coefficients may be interpreted in the same manner as with other discrete dependent variable statistical models.

The most obvious ‘treatment’ variable to include in this analysis is the distance from an operational metro station. However, exploratory GIS analysis revealed that the relationship between distance from a metro to the centroid of each census tract and the gentrification of that tract is non-linear. Buffers were created at 400, 600 and 800 metres from the metro stations and the strongest relationship was visible not in the innermost-ring, as was expected, but in the intermediate buffer. It appeared that the relationship was non-linear: gentrifying census tract centroids were often close to stations, but less likely to be immediately adjacent. As a result, a gravity function was used to capture the effect of distance from transit to an individual CT. This conclusion, though counter to our original hypothesis, corroborates with past studies that have

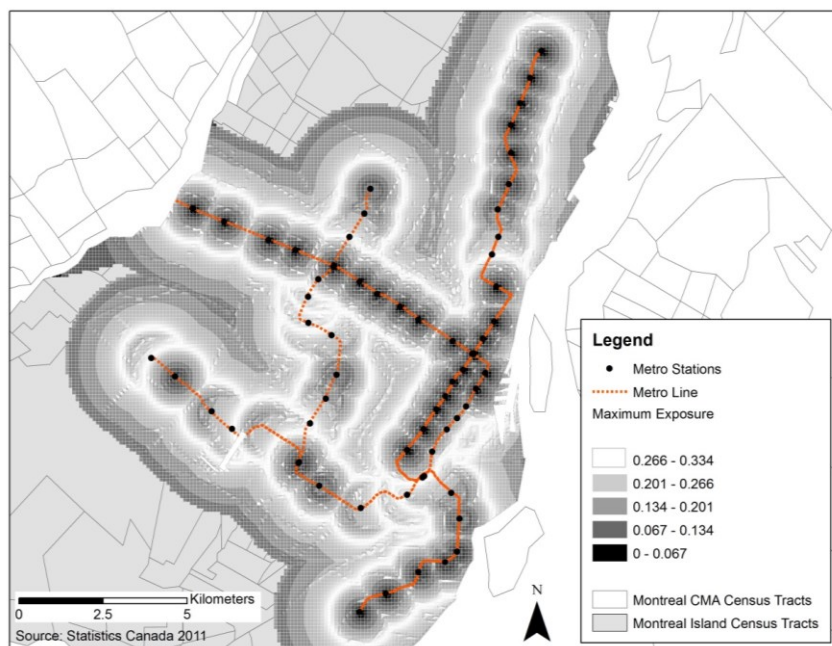
identified transit stations as poverty magnets (Baum-Snow and Kahn, 2005). As such it was found that the distance from a transit station cannot simply be represented in the survival analysis as the distance itself. The adoption of a gravity measure, presented in Equation 2 below, was the best way identified to represent ‘Exposure’ to transit. The formulation of this gravity measure is based on a measure from de Dios Ortuzar and Willumsen (2001).

Equation 2: Exposure Gravity Measure

$$expo = cdist^{\alpha} * e^{\beta * cdist}$$

The alpha and beta in the above equation are parameters of the Exposure function, alpha (α) being positive and beta (β) negative. These parameters result in a gravity function that at first increases, and then decreases as distance to a transit station increases. Figure 5 shows an example of a graphical representation of the gravity measure around transit stations of the Montreal Metro system. The white ‘ridge’ or ring around each metro station represents the maximum of the gravity measure (where Exposure to transit has the greatest effect) for any given station.

Figure 5: Gravity Measure of Exposure to the Metro



With the use of this gravity measure the Survival Analysis hazard function estimated how the potential rate of the onset of gentrification varies as a function of the proximity to transit (Exposure) as time goes on while controlling for other confounding variables such as distance to the CBD and the distance to other, previously gentrified CTs. In the Survival Analysis model, only time and exposure to the metro were included in preliminary analyses to determine the dependent variable, ‘time until the occurrence of gentrification’. Subsequently, other variables were introduced including distance from previously gentrifying CTs, distance from CBD, distance to nearest large parks, proportion of pre-1946 housing, as well as distance to major water bodies controlling for as many of the variables mentioned in the literature as possible. This allowed for a richer discussion and more robust results of the relationship between the onset of gentrification and the broader urban environment.

Based on the results of the statistical test as well as the visual representation of the results of gentrification mapped with the transit systems, conclusions and recommendations are outlined

in the last chapter. Areas for further research are also listed along with contributions to the knowledge of policy makers and transportation planners. Though the following article provides important information it in no way answer all of the questions that exist around this subject and there remain many interesting avenues of research to explore with regards to the relationship between transit and gentrification in cities.

The methodological contributions of the manuscript that follows are notable, as we attempted to address as many of the problems and inconsistencies evident in the gentrification transportation literature. In addition to identifying census tracts that are gentrifiable and have experienced the onset of gentrification, this study maps those areas, providing useful and legible guides to some of the areas most notably affected by this process in Canada. It then employs an appropriate statistical model to analyze the impact of the implementation of transit on the onset of gentrification in the three Canadian cities included in the study.

3.0 Introduction to Manuscripts: Contributions by Authors

What follows is a co-authored paper that builds on the extensive field of gentrification research introduced in the literature review. This paper utilizes the methods and data previously described and provides some further insight into how gentrification is occurring in Canadian cities and what elements of the urban environment are spurring the onset of this process. The paper provides the basis for a new way to study gentrification as well as results showing some of the elements that most strongly affect the process. In the final chapter some conclusions are drawn and the result of the paper is synthesized. This paper comprises part of a larger and ongoing research project looking at the effects of the implementation of urban transit on demographic changes in surrounding neighbourhoods, with a particular focus on gentrification.

In the following article, currently under review at the Journal of Urban Studies, the identification of gentrification was programmed in Python to ensure consistency and to avoid errors. This portion of the analysis was done by Zachary Patterson, second author on the paper, while I was responsible for the literature review and context, writing up the results, incorporating new variables into the statistical analysis and running the models to find the best fit. Preliminary results of this research for the city of Montreal were presented at the Transportation Research Board's 91st annual meeting in Washington, DC, in January of 2011. Subsequently the methodology was modified and the study expanded to include Toronto in the analysis. That portion of the project was presented at ACFAS, the Association Francophone pour le Savoir, in May, 2012. The article was subsequently presented at the annual meeting of the American Association of Geographers in Los Angeles, California in April, 2013.

This article appears as it was resubmitted to the Journal of Urban Studies in July of 2013.

4.0 Urban Rapid Rail Transit and Gentrification In Canadian Urban Centres – A survival analysis approach

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Keywords: gentrification, urban transit, survival analysis, neighborhood change

4.1 Abstract

Despite the existing knowledge that urban rapid rail transit has many effects on surrounding areas, and despite some attempts to understand the links between transit and gentrification, there remain methodological gaps in the research. This study addresses the relationship between the implementation of urban rapid rail transit and gentrification, which is conceived of as an event. As such, an event analysis approach using Survival Analysis is adopted as the statistical analytical tool. It tests whether proximity to rail transit is related to the onset of gentrification in Census Tracts in Canada's largest cities. It is found that proximity to rail transit, and to other gentrifying census tracts, have a statistically significant effect on gentrification in two of the three cities analyzed. By providing a methodological framework for the empirical analysis of the impact of urban rail transit on gentrification, this paper is a reference for both researchers and transportation planners.

4.2 Introduction

Transit is widely recognized to have effects beyond increasing accessibility; however these effects, including a possible relationship with the onset of gentrification, are not fully understood. Though this link has been mentioned in the gentrification literature, there is surprisingly little research that examines the relationship explicitly. The studies that do exist on transit and gentrification have used definitions of gentrification that differ from those most commonly used in the broader literature. One of the implications of this is that the statistical methods employed in those studies are not consistent with the commonly used definitions. We argue, that based on the most common methods of defining gentrification in the literature, gentrification ought to be thought of as an event. As a result, we use Survival Analysis, a

statistical procedure for analyzing data whose outcome variable is “time until an event occurs,” to test the relationship between proximity to urban rapid rail transit, and the onset of gentrification in Canada’s three largest cities.

The questions addressed, and the results presented, in this paper are important in providing guidance to researchers and planners as they seek to provide equitable and accessible transit, taking into consideration the various implications that the construction of urban rail transit could have on surrounding communities.

The paper starts with a review of the existing literature, followed by a description of the cities analyzed, as well as the data and methodology used to establish which census tracts (CTs) have undergone gentrification. The statistical approach, Survival Analysis, is described in detail and the results of the estimated models are explained. Finally, we compare our results with prior research, summarize the contribution this paper represents and offer suggestions for future research.

4.3 Literature Review

Defining Gentrification

While the term, gentrification, has been applied to many different contexts, it is generally acknowledged that for a neighbourhood to have undergone gentrification, it must first be considered “gentrifiable”; it must have been poor, or “working class” prior to there being a marked change in socio-economic status (Hammel and Wyly, 1996; Freeman, 2005) . For an area considered gentrifiable to gentrify, its social status (typically measured through income, education and percentage of residents in professional occupations (Ley, 1986; Filion, 1991; Freeman, 2005; Heidkamp and Lucas, 2006) needs to be observed to increase faster than that of

the city. At the same time, rents and house values should also be observed to increase faster than the city as a whole (Hammel and Wyly, 1996; Lin, 2002; Kahn, 2007).

Some authors describe the process as one bringing positive change to previously marginalized neighbourhoods (Freeman, 2005; Vigdor, 2001). Despite these views, the overwhelming majority of the literature describes adverse effects (Smith and Williams, 1986; Rose, 2004; Slater, 2004; Newman and Wyly, 2006; Kolko, 2007; Walks and Maaranen, 2008; Lin, 2002; Pollack et al, 2010). Negative effects identified range from increases in rents, to conflict within neighbourhoods, to displacement of existing residents (Kolko, 2007; Slater, 2004).

There is still some debate as to how this process should be analyzed. Using Principal Component Analysis (PCA), Walks and Maaranen identify not only gentrification, but a variety of forms of 'upgrading' (2008). Owens (2012) also uses PCA, but argues that some types of neighbourhood change and socio-economic ascent are not related to gentrification. She states that the research on the topic has been too limited in scope and calls for an expanded terminology (Owens, 2012). While studies have employed a variety of methods and terminologies to study neighbourhood change, that gentrification is typically characterized by an improvement in socio-economic status in previously disadvantaged neighborhoods, is undisputed.

Throughout the gentrification literature, the relationship between accessibility to transit and gentrification has been observed (e.g. Filion, 1991; Atkinson and Bridge, 2005; Skaburskis and Mok, 2006; Walks and Maaranen, 2008). Despite this common acknowledgment there has been little research to have looked at this question specifically. Before describing this literature

in detail, it is first necessary to look at how the identification of gentrification has been operationalized.

Identifying Gentrification

In studies of gentrification, the basic unit of analysis is the neighborhood, and census tracts (CTs) are generally used as a proxy for neighborhoods (Hammel and Wyly, 1996; Freeman, 2005; Heidkamp and Lucas, 2006; Kahn, 2007; Kolko, 2007; Walks and Maaranen, 2008; Pollack, Bluestone and Billingham, 2011). Moreover, the use of CTs as proxies has been shown to be effective in most instances (Hammel and Wyly, 1996).

For a CT to be susceptible to gentrification it must be considered ‘working class’ at the beginning of the period of analysis. In other words, to be included in the analysis of gentrification, a neighborhood needs to first be “gentrifiable” (Hammel and Wyly, 1996; Freeman, 2005; Walks and Maaranen, 2008). Neighborhoods may be considered to be gentrifiable if the average (or median) income of the CT is below the average of the metropolitan area within which it is found (Hammel and Wyly, 1996; Freeman, 2005). Other indicators of social status have also been integrated in this definition (see Walks and Maaranen, 2008).

While the identification of CTs considered to be gentrifiable is relatively straightforward, empirically distinguishing gentrification in an area is more complex. In addition to characteristics of the residents themselves, including higher levels of educational attainment, higher incomes, and an increasing number of professionals, characteristics of the housing stock (i.e. housing values or rents) are also considered, since these are important indicators of the gentrification of neighborhoods (Ley, 1986; Filion, 1991; Lin, 2002; Freeman, 2005; Heidkamp and Lucas, 2006; Kahn, 2007; Walks and Maaranen, 2008; Pollack et al, 2010). Analysis of gentrification is done by measuring whether all of the indicators improve in a given CT at a rate

faster than the average rate of the urban region (Freeman, 2005; Owens, 2012). Critical to this is the notion that gentrification is a relative process, gauged against changes in the region being analysed. Also essential is the fact that gentrification is identified by the use of several indicators jointly, meaning that the values of *all* of the indicators need to increase faster than in the region as a whole – not just one variable – to be considered as having undergone gentrification (Hammel and Wyly, 1996).

Transit and Gentrification

Many studies have focused on the relationship between transit and land value, a common indicator used in studies of gentrification (Bajic, 1983; Ryan, 1999; Cervero 2003, Debrezion, 2007; Hess and Almeida, 2007; Immergluck, 2009; Atkinson-Palombo, 2010; Duncan, 2011). Among these studies, regression analysis is the most common method used to estimate the effect of proximity to transit on land values while controlling for other explanatory factors.

An early study of Toronto's Subway found that property values increased with increased access to the network (Bajic, 1983). In their study of the impacts of light-rail transit on property value, Hess and Almeida (2007) found a marginal appreciation of value related to proximity to transit. Others (e.g. Cervero et al, 1994) have found that as a new market for Transit Oriented Development (TOD) has emerged, proximity to transit has become an important incentive for development, around transit stations (Cervero et al, 1994). Despite these studies, and the aforementioned observations of links between transit and gentrification in the gentrification literature, analysis of this relationship has remained largely overlooked with only a few studies addressing this topic directly.

In a study of Northeastern Chicago, Lin (2002) analyzed the link between housing values and proximity to transit stations and equated higher housing values to the presence of

gentrification. Lin estimates regressions of the change in house values by block for three periods between 1975 and 1990. He observed increased housing values along transit lines for two of the three periods examined, and a pattern of the “spreading” of higher prices away from the shore of Lake Michigan.

The study of Pollack et al. (2010) analyzes the demographic progression of 42 “Transit Rich Neighborhoods” (TRNs) in 12 Metropolitan Statistical Areas (MSAs) in the US that had rail stations built between the 1990 and 2000 US censuses. The authors compare the change in a number of demographic factors (race, income, car ownership, etc.) between TRNs and the MSA as a whole. They conclude that TRNs more often saw a rise in income, housing values, rent and car ownership greater than in their surrounding MSAs. For example 26 of the TRNs saw income rise faster than in the MSA as a whole, while in 16 TRNs, the income grew faster across the MSA (Pollack et al, 2010: Table 2).

The last of the papers to examine the transit gentrification linkage, is by Kahn (2007). He equates increasing home prices and increasing education with gentrification. Two different sets of regressions are estimated. For each of the 14 MSAs included in the study, cross-sectional models of housing values and share of college graduates (as separate models) are estimated. It is found that being within a mile of transit stations has had both negative and positive effects on housing values and the proportion of college graduates, depending upon the city. The second set of regressions looks at the change in house values and proportion of graduates (in separate regressions) for all MSAs together between 1970 and 2000. In these regressions, he finds that for house prices, each additional year that a tract is within a mile of a walk-and-ride station, house price increases, whereas park-and-ride stations have the opposite effect. Both types of stations are found to contribute to an increase in graduates.

Taken as a whole, the three studies that explicitly look at the link between transit and gentrification do not follow conventions in the literature about the definition of gentrification. In particular, none of the three explicitly considers the question of gentrifiability of neighborhoods in their analyses. Moreover, they only use one variable at a time (and not several jointly) to identify gentrification. Kahn, (2007) looks at two indicators in separate regressions, while Lin (2002) only includes one indicator of gentrification in his analysis. Pollack et al (2010) include a variety of indicators, but they do not address them jointly, looking rather, at the aggregate trends across their study areas. That gentrification is not defined in a manner consistent with the broader gentrification literature is a problem in itself, but also has implications about the appropriateness of the methods used to analyze the effect of transit on gentrification. This is particularly relevant to the Kahn and Lin articles that endeavor to estimate the effect of proximity to transit on their indicators of gentrification. Since both of them consider only one indicator in their regressions, and since these indicators are continuous, they can use continuous dependent variable statistical techniques (i.e. OLS). Since the more common definition of gentrification requires a CT to have been “gentrifiable,” and to have had several indicators *all* improve more than the metropolitan region as a whole in the same period, gentrification shouldn’t be described as a continuous variable. Instead, the process of gentrification is more appropriately thought of as an event – characterized as a variable that takes a value of 1 if a CT is observed to have undergone gentrification, and a value of 0 if it has not. This suggests that continuous dependent variable techniques are not appropriate in this context.

The research presented here builds on the transit and gentrification literature by first using conventional definitions of gentrification, and second by using a more suitable statistical technique in the context of gentrification as an event, i.e. Survival Analysis.

4.4 Study Areas – Montreal, Toronto and Vancouver

The study areas for this research are the Census Metropolitan Areas (CMAs) of Montreal, Toronto and Vancouver in Canada. Toronto is the largest with a total CMA population of 5.1 million residents in 2006 (Statistics Canada, 2006). The Toronto Subway first opened in 1954 and in 2006 had 69 stations extending 70 kilometers through the City of Toronto (Toronto Transit Commission, 2012). The limits of the City of Toronto in 2001 were used to bound the area of analysis as they encompass the entirety of the Subway system, and the CT identifiers for the area were available from 1961 to 2006.

Montreal, Quebec, is the next largest Canadian city with a CMA population of 3.6 million (Statistics Canada, 2006). The Montreal Metro was inaugurated in 1966 (Clairoux, 2001). As of 2006 it consisted of 68 stations on the island of Montreal which were built and opened in 11 increments between 1966 and 1988. Off island metro stations were excluded because they opened after the end of the study period (to the North), and because CT boundaries consistent over time were unavailable for the study period (to the South).

The third city is Vancouver that as of 2006 had a CMA population of 2 million (Statistics Canada, 2006). Vancouver's SkyTrain opened its first stations in 1986 for the Vancouver World Exposition. By 2006 it had 32 stations along 68.7 kilometers of track. It provides service to the city of Vancouver as well as four adjacent municipalities, all part of Metro Vancouver, the CMA (Metro Vancouver, n.d.). An additional line has opened since 2006, but as the study period ended in 2006, that line is not addressed in this study.

Defining the boundaries of the study for Vancouver was more challenging than for the other cities since there was no obvious delineation that encompassed the whole SkyTrain system. As such, three conditions were used to establish the study area boundaries: any CTs separated

from the SkyTrain by water were eliminated, and CTs with population densities lower than the 10th percentile were not considered in the analysis.

In initial analyses of Vancouver, when all CTs were included in the analysis, several outlying CTs appeared as having undergone gentrification. These CTs had high percentages of agricultural employment and had low population densities. It was clear that what was being observed was not gentrification, but rather urbanization. Since gentrification is typically characterized as taking place in “urban” areas (see e.g. Ley, 1986; Freeman, 2005), it was deemed necessary to restrict the analysis to “urban” CTs. Various population density thresholds were tested to do this. The lowest threshold that most effectively included urban areas, while excluding predominantly agricultural and other non-urban CTs on the fringe of the city was the 10th percentile population density.

Finally, CTs were also excluded if they were not a part of the contiguous area of ‘urban’ CTs, that is, if they were separated from the SkyTrain by areas with less than the 10th percentile population density.

4.5 Data Used

To establish whether the process of gentrification is occurring, empirical studies use census data to distinguish changes in neighbourhoods, or CTs (Hammel and Wyly, 1996; Freeman, 2005; Heidkamp and Lucas, 2006; Kahn, 2007; Kolko, 2007; Walks and Maaranen, 2008; Pollack, Bluestone and Billingham, 2011). Indicators of gentrification used in the past to measure the process include demographic statistics: population; household, family and individual income; college or university education levels; persons employed in professional occupations; household structure (number of children in a household); and racial and ethnic composition, particularly in studies conducted in the USA. Indicators related to housing and location are also

taken into account, typically as statistics on the number of housing units, housing tenure and age of the housing stock; housing costs, both the value of homes and costs of rent (List compiled from; Filion, 1991; Hammel and Wyly, 1996; Freeman, 2005; Walks and Maaranen, 2008; Pollack et al, 2011).

As such, census data aggregated to the CT level was collected from Statistics Canada and CT boundaries were normalized to the first year in each of the study periods. Study periods for the cities varied depending on when their respective transit systems first came into operation. For Montreal the first year of census data used is 1961, five years before the first stations opened. In Vancouver the study period only begins in 1981 as the SkyTrain was first inaugurated in 1986. Comparable census statistics were not available for Toronto for 1951 (the census before the subway opened in 1954), and as such the study period for Toronto is the same as Montreal: 1961-2006. Missing data in 1966 and 1976 led them to be excluded from the analysis for both Montreal and Toronto so the full data set for those cities includes census years 1961, 1971, 1981, 1986, 1991, 1996, 2001 and 2006.

In addition to census statistics, other data were used as control variables in the Survival Models of gentrification. These control variables were chosen based on those that have been identified in previous literature as being associated with gentrification. They included the straight line distance from the centroids of each CT to the nearest transit station for every year from the time that the first stations were opened. Although network distance would also have been a useful measurement, Hess and Almeida found that the perceived proximity to transit, as measured by the straight line distance, had a greater effect on property values of surrounding neighbourhoods, one important indicator of gentrification (Hess and Almeida, 2007). Past studies have explored the idea that gentrification is related to the distance from the CBD (Filion, 1991;

Lin, 2002; Kahn, 2007; Walks and Maaranen, 2008). As such, distance from CT centroids to the centroid of the CBD was used as an additional control variable. Distance to the CBD is included in this (and previous) analyses of gentrification primarily because it serves as a proxy for proximity to tertiary employment (Walks and Maaranen, 2008). It would be interesting to explicitly include measures of accessibility to employment, but employment data by CT was not available at this scale for the full study period. Another characteristic of gentrifying neighborhoods mentioned in the literature is the presence of older housing stock with the architectural character desired by “gentrifiers” (Filion, 1991; Walks and Maaranen, 2008; Ley 1986). To control for this, the census variable “proportion of pre-1946 housing” in each CT was used.

Many authors refer to the urban amenities that draw gentrifiers to the desirable neighbourhoods (Smith and Williams, 1986; Lin, 2002; Helms, 2003; Heidkamp and Lucas, 2006; Ley and Dobson, 2008; Walks and Maaranen, 2008). Often, urban amenities refer to commercial districts that cater to middle and upper income residents (Smith and Williams, 1986). Since these urban attributes were impossible to accurately track over the period of time required for this study they were excluded from this analysis, but both parks and proximity to water, viewed as urban amenities (Helms, 2003; Lin, 2002; Heidkamp and Lucas, 2006; Ley and Dobson, 2008) were also included as control variables.

In order to integrate these variables in the analysis the distance was measured from the centroid of each CT to the nearest large park (defined by the authors as any park equal to or exceeding 50,000 square metres) or major body of water (lake, river or ocean). Though the size of the park may seem arbitrary, some minimum boundary was necessary to ensure that the parks included in the study were of a certain importance in the urban fabric and therefore more likely

to represent a recognised amenity such as Montreal's Mont-Royal or Vancouver's Stanley Park. The final variable that was included was the distance from the centroid of each CT to the centroid of the nearest CT that had experienced gentrification. This variable was chosen to represent one of the determinants of gentrification highlighted by Kolko; the spillover effect of proximity to higher income neighbourhoods (Kolko, 2007).

Another type of variable that would ideally have been included in the analysis would identify municipal policies or investments associated with the construction of the transit infrastructure that may have influenced the onset of gentrification. Obtaining such information is extraordinarily difficult, and as a result, is not incorporated into the analysis, but is left as an important avenue to improve this approach in further research.

4.6 Methodology

Identifying Gentrification

In order to conduct a statistical analysis of the effect of urban rail transit on gentrification, it is necessary to identify CTs that could be considered gentrifiable and those that have actually undergone gentrification over the study period.

To establish whether a CT was gentrifiable average family income of a census tract and number of university degrees per capita were assessed, both of which needed to be lower than the CMA average. If this was the case for a CT, then the CT in question was included in the sample for the statistical analysis. The full list of indicators used in the identification of the onset of gentrification is below;

- average monthly rent,
- proportion of people in professional occupations,
- percentage of owner occupied dwellings,

- average family income;
- and number of degrees per capita.

For a CT to be considered to have undergone gentrification, *all* of these indicators had to have experienced an improvement in that CT greater than the average change experienced in those indicators for the CMA in the same year. Additionally, the CT needed to be considered gentrifiable in the preceding census year in the dataset (i.e. to have undergone gentrification in 1971, it must be considered gentrifiable in 1961). Indicators used to establish gentrification were limited to those that were available for census years throughout the study period. Table 3 below summarizes how many CTs were included for each CMA, how many of those were considered gentrifiable according to our criteria, and how many ultimately underwent gentrification.

Table 3: Gentrifiable and Gentrifying Census Tracts for all Cities

City	CTs Included in Study	Gentrifiable CTs	Gentrifying CTs
Montreal	291	220	86
Toronto	248	165	71
Vancouver	143	101	19

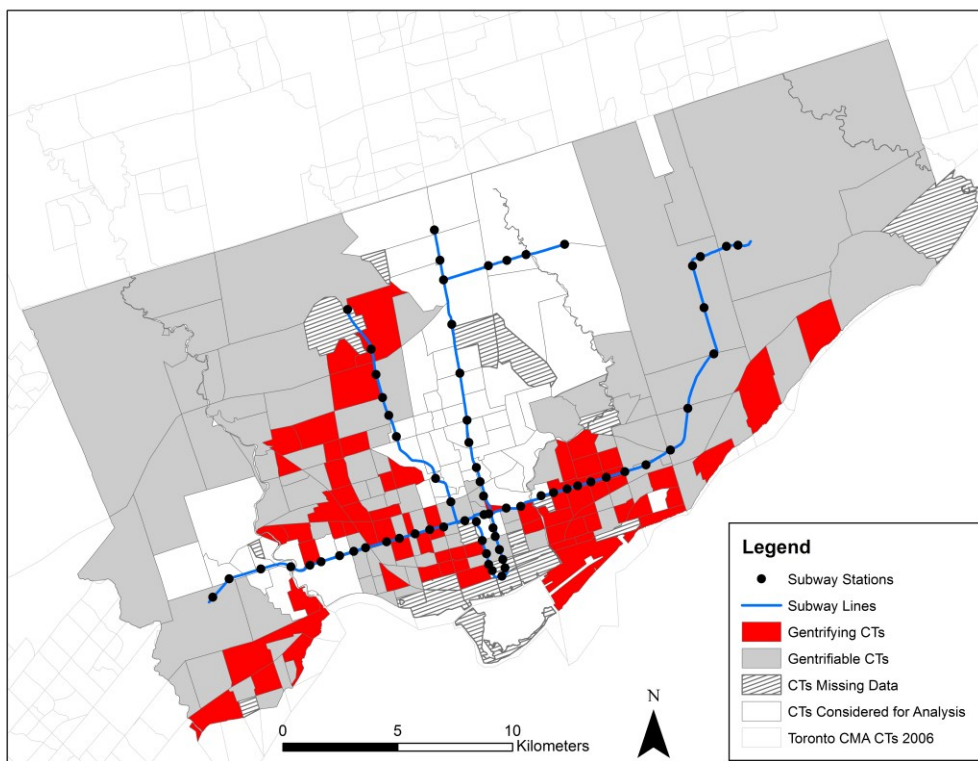


Figure 6: Gentrifiable and Gentrifying Census Tracts in Toronto (1961-2006)

Figure 6 highlights the census tracts that were considered gentrifiable at any point during the study period, as well as those that were observed to have gentrified in Toronto.

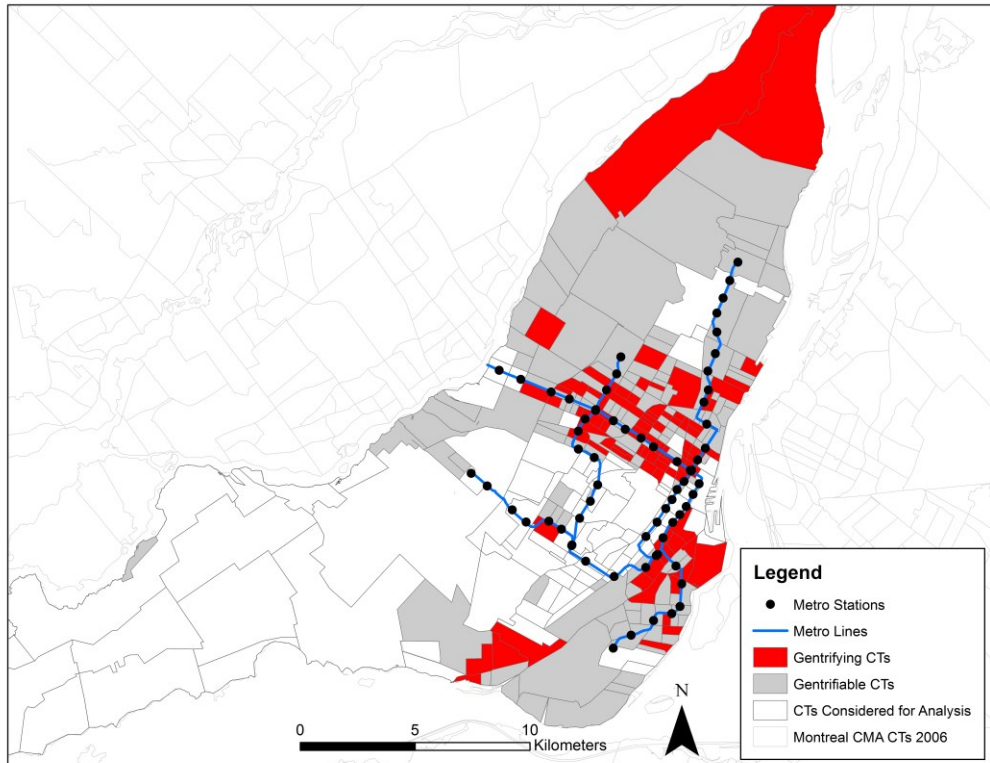


Figure 7: Gentrifiable and Gentrifying Census Tracts in Montreal (1961-2006)

Figure 7 shows the results of the gentrification analysis for Montreal.

Figure 8, below, depicts the gentrifiable and gentrifying tracts in Vancouver.

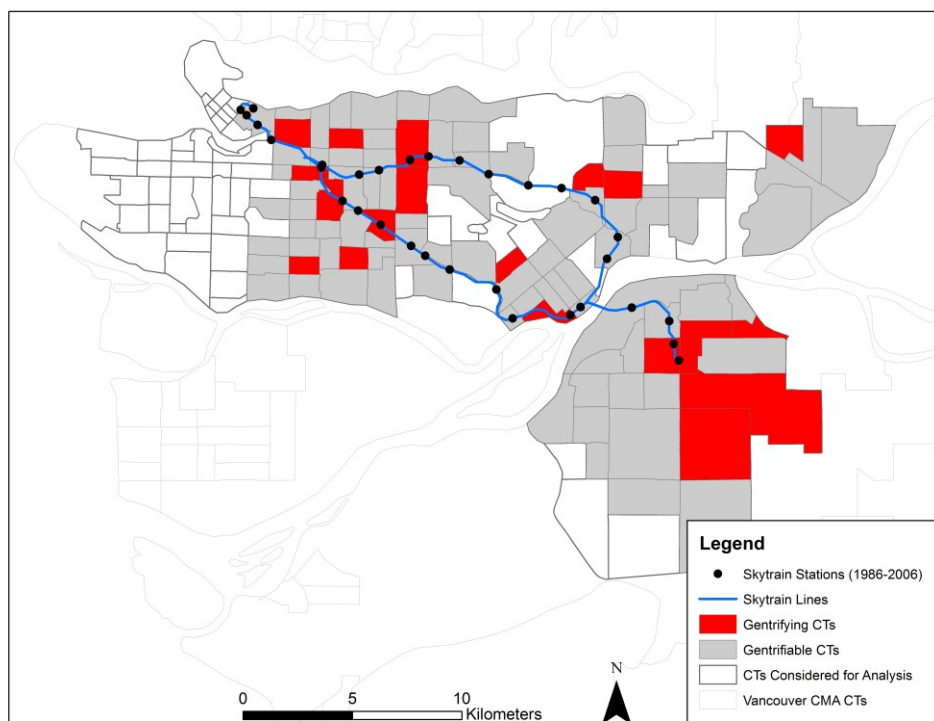


Figure 8: Gentrifiable and Gentrifying Census Tracts in Vancouver (1981-2006)

4.7 Survival Analysis

As explained in the literature review, gentrification is conventionally identified by the use of several variables jointly, that all need to increase at a rate faster than the surrounding region over a given period of time. If a particular CT (that is gentrifiable) experiences a relative (to the surrounding region) increase of all the relevant variables at the same time, it is considered to have undergone gentrification. As a result, gentrification is more appropriately thought of as an event, and should be analyzed as such. The most common statistical technique adapted to event analysis is Survival Analysis.

Primarily used in the field of bio-statistics, Survival Analysis has had limited use in transportation research, but it is still particularly relevant to the field (Washington et al, 2003). Survival Analysis is a collection of statistical procedures for analyzing data where the outcome

variable is time until an event occurs (Kleinbaum and Klein, 2005). The result of survival analysis is to make statistical inferences about how a given independent variable affects the probability of the event occurring at a given time. This type of analysis is particularly useful when working with variables whose effects vary over time, called time dependent variables (Kleinbaum and Klein, 2005).

Examples of applications of this type of analysis include time until death of patients with or without a certain type of treatment (Kleinbaum and Klein, 2005), or time until an accident occurs after a driver has obtained their license (Washington, et al, 2003). A related approach, “spatial hazard analysis,” where duration is substituted with distance as the outcome variable, has more commonly been applied in a planning context. Carruthers et al. (2009), for example, used the approach to analyze urban form and sprawl in American metropolitan areas.

In the model presented in this paper the ‘event’ is gentrification and the ‘treatment’ variable is proximity to stations of rapid rail transit. The population in question is all of the census tracts that are deemed gentrifiable in the previous census period. As such, a census tract enters the sample in the year that it becomes gentrifiable, and leaves when it either experiences gentrification, or when the study period ends, whichever occurs first. Census independent variables (e.g. % pre-1946 housing) change for each census and distance to transit stations was recalculated every time there were stations added to the system in question. The results of the model give the survival time of CTs until they gentrify based on the presence of transit over time as well as the control variables used in the models.

In initial analyses for this research, we found that there does not appear to be a simple linear relationship between gentrification and distance to transit. Instead, it appeared that the relationship was non-linear: gentrifying census tract centroids were often close to stations, but

less likely to be immediately adjacent. As a result, a gravity function was used to capture the effect of distance from transit to an individual CT. The measure used was calculated for each CT for each year of the study as a function of distance to the nearest station - 'cdist' in Equation 1 (for more details on the calculation of gravity measures see, for example, Ortúzar and Willumsen, 2001). Alpha and beta are parameters that adjust the height and location (along the horizontal – cdist - axis) of the maximum of the gravity function. Alpha is positive (with a value of 1 used for all cities) and beta negative, with the value changing for cities depending on what resulted in the highest value of the log likelihood function. The result is a gravity function that at first increases and then decreases along the horizontal axis.

Equation 3: Exposure Gravity Measure

$$\text{expo} = \text{cdist}^{\alpha} * e^{\beta * \text{cdist}}$$

We refer to this gravity measure of proximity to transit as 'exposure.' The distance to transit stations, 'cdist', was recalculated for each year that new transit stations were added to the transit network. Before being included in the statistical analysis, the variable was normalized to one to facilitate comparability of coefficients across cities.

4.8 The Survival Model Results

Introduction to Estimating Survival Models

The Extended-Cox (EC) model was selected for the statistical analysis in this study. The EC model is a semi-parametric model and therefore less restrictive in terms of the assumptions made about the form and distribution of the hazard function. The EC model also allows for the analysis of time dependent variables, which are present in this model. The two parts of the EC hazard function (see Equation 4) are the baseline hazard function, $h_0(t)exp$, and the exponential function, which incorporates the independent variables in the model.

Equation 4: Extended-Cox Hazards Model

$$h(t, \mathbf{X}(t)) = h_0(t) \exp \left[\sum_{i=1}^{p1} \beta_i X_i + \sum_{j=1}^{p2} \delta_j X_j(t) \right]$$

In this equation, X_i represents the time-independent variables and X_j represents the time dependent variables, denoted by the presence of (t) . The coefficients, beta and delta, are estimated using maximum likelihood techniques. The variables included in the models for each of the three cities are outlined in the next section with an interpretation of the results.

Survival Model Estimation Results

The following section describes model estimation results for the three cities. Many models were tested before arriving at these models, and many variables were also tested in each model. These included the proportion of pre-1946 housing, measured for each census year, the exposure measure, distance to the nearest park; distance to the nearest major body of water; distance to nearest previously gentrifying CT, and distance to the CBD. Different interactions between variables, and between the variables and time, were also tested. The gravity measure, “exposure,” was recalibrated for each city as the effect of transit was maximized at a different distance from the transit stations for each urban center.

While tempting to include census variables such as average income, number of degrees, etc. as independent variables, they cannot be used since they are used to define gentrification itself and as a result are endogenous. The following table presents summary statistics for the main (not interacted) variables used in model development and estimation.

Table 4: Summary Statistics

Toronto					
Variable	Observations	Mean	Std. Dev.	Min	Max
Distance to CBD	979	7.933	4.623	0.870	23.457
Proportion of pre-1946 Dwellings	979	0.468	0.344	0.004	1.000
Distance to Nearest Gentrifying Tract	979	6.707	7.233	0.414	20.866
Distance to nearest park	979	0.578	0.379	0.000	1.683
Distance to water	979	4.531	3.027	0.314	14.434
Exposure measure	979	0.289	0.360	0.000	1.000
Montreal					
Variable	Observations	Mean	Std. Dev.	Min	Max
Distance to CBD	1450	5.672	3.146	0.784	23.679
Proportion of pre-1946 Dwellings	1450	0.546	0.304	0.000	1.000
Distance to Nearest Gentrifying Tract	1450	6.596	7.716	0.155	23.477
Distance to nearest park	1450	0.958	0.560	0.000	2.367
Distance to water	1450	2.163	1.653	0.019	5.424
Exposure measure	1450	0.598	0.330	0.000	1.000
Vancouver					
Variable	Observations	Mean	Std. Dev.	Min	Max
Distance to CBD	645	13.074	7.095	0.562	28.444
Proportion of pre-1946 Dwellings	645	0.146	0.149	0.000	0.895
Distance to Nearest Gentrifying Tract	645	6.438	6.010	0.529	20.000
Distance to nearest park	645	0.470	0.360	0.000	1.520
Distance to water	645	2.252	1.293	0.257	7.353
Exposure measure	645	0.442	0.386	0.000	1.000

Following are the results for the three cities and a brief description of each. The number of subjects is the number of gentrifiable CTs, included in the analysis, and the number of failures is the number of census tracts that were observed to have experienced gentrification at some point during the study period.

Table 5: Extended-Cox Model Survival Analysis Results for Toronto and Montreal

Toronto Results				
Variables	Coefficient	Std Err	z	P>z
Exposure	1.91	0.79	2.42	0.016
Proportion of Pre-1946 Dwellings	1.37	0.47	2.94	0.003
Proximity to Nearest Gentrifying CTs	-0.12	0.03	-3.83	0.000
Exposure*Time	-0.10	0.01	-2.79	0.005
Descriptive Statistics				
Initial Log Likelihood	-339.99			
Final Log Likelihood	-322.15			
Observations	979			
Subjects	163			
Failures	71			
Montreal Results				
Variables	Coefficient	Std Err	z	P>z
Exposure	1.28	0.64	1.99	0.047
Exposure*Distance to CBD	-1.44	0.66	-2.18	0.030
Proximity to Nearest Gentrifying CT	-0.13	0.06	-2.32	0.020
(Exposure*Distance to CBD)*Ln of Time	0.34	0.20	1.68	0.092
Descriptive Statistics				
Initial Log Likelihood	-439.79			
Final Log Likelihood	-422.30			
Observations	1453			
Subjects	220			
Failures	86			

The model describing gentrification in Toronto is presented in Table 5. Since the Extended Cox model is fitted using maximum likelihood estimation, the appropriate goodness of fit statistic is the likelihood ratio (LR) test (Blossfeld et al. 2007). This tests the hypothesis that, jointly, the variables in the model have no influence on survival time. The LR statistics is χ^2 distributed with degrees of freedom equal to the number of coefficients estimated. The LR statistic for this model is 35.68 rejecting the null hypothesis of no influence at almost any level significance (STATA reports a p-value of 0.0). With respect to model coefficients, exposure was statistically significant with a positive coefficient meaning that as the exposure measure increases there is an associated increase in the likelihood of a CT gentrifying. It is important to

understand the meaning of the Exposure measure. In the case of Toronto, the maximum of the Exposure measure, one, is found at a distance of 550 meters from a metro station. In order to get the odds multiplier for the variable in this model, we raise e to the power of the coefficient for Exposure from the model. This gives an odds multiplier of just over 5, indicating that according to the model, if a Subway station is built 550 meters away from a CT which previously had no access to transit, that census tract would be 4 times more likely to gentrify as a result.

The proportion of housing built before 1946 was also statistically significant, which reinforces findings by others that consider the importance of housing stock (Walks and Maaranen, 2008). Another variable (Proximity to Nearest Gentrifying CT) is included to answer the question of whether the effect of gentrification is one that ‘spreads.’ The coefficient of this variable indicates that as the distance to the nearest already gentrifying or gentrified CT increases, the likelihood of gentrification decreases.

The elasticities (estimated at the mean) of each of these main variables are: exposure, 0.55; proportion of pre-1946 dwellings, 0.64 and proximity to nearest gentrifying tracts -0.79. These imply that a one percent increase in the exposure measure results in a 0.55% increase in the hazard ratio, while the same proportional increase in pre-1946 dwellings results in a 0.64% increase, whereas a 1% increase in distance to the nearest gentrifying tract results in a 0.79% decrease in the hazard ratio. These elasticities are all in the same order of magnitude with the exposure measure being smaller than the others.

The negative coefficient of the last variable included, an interaction of Exposure with time, indicates that the effect of Exposure on gentrification is greatest soon after transit is implemented and then decreases as time goes on. This result is important in that it should be used to guide policy. In order to best respond, policy should be implemented in conjunction with

transit to mitigate the very strong effect transit has, even initially, although the impact of the implementation of a transit station may determine the evolution of its surrounding neighbourhoods for a much longer time period.

As was the case for Toronto, in the results of the Montreal model the LR test rejects the hypothesis of no influence of the variables in the model with $p < 0.001$ with a value of 34.98 and 4 degrees of freedom. The variables included in the model for Montreal were the Exposure measure, the interaction between Exposure and the Distance to CBD, and the Proximity to Nearest Gentrifying CT, all of which were found to be significant at or below 5%. An interaction between exposure, distance and the natural logarithm of time was found to be significant at 10%. The positive coefficient of Exposure tells us that a higher exposure value is correlated with a higher likelihood of a CT gentrifying. As distance to the nearest gentrifying CT decreases, the likelihood of a CT gentrifying increases. The elasticities (estimated at the mean) of these main variables are: exposure, 0.76 and proximity to nearest gentrifying tracts -0.88. These imply that a one percent increase in the exposure measure results in a 0.76% increase in the hazard ratio, whereas a 1% increase in distance to the nearest gentrifying tract results in a 0.88% decrease in the hazard ratio. These elasticities are in the same order of magnitude as in Toronto, and as with Toronto, the exposure measure has a smaller elasticity than distance to the nearest gentrifying tract.

The interacted variable of exposure and distance to the CBD implies that metro stations located further from the CBD initially have less of an effect on gentrification, but as time goes on the distance from the CBD becomes less important, and gentrification is more likely to occur. This appears to be capturing the spreading of gentrification away from the city's center over time.

In the case of Vancouver, despite many different models being tested, only one of the variables, distance from water, proved to be statistically significant to the onset of gentrification with a positive coefficient indicating that as distance to water increases, the likelihood of gentrification increases. As the model was not informative, results from the model are not shown here. This may seem surprising to readers familiar with Vancouver since many of the city's famously gentrified neighborhoods (e.g. Kitsilano and the West End) are found close to the water. At the same time it needs to be highlighted that by 1981 (the first year of the study period), these neighborhoods are recognized to have already gentrified (Walks and Maaranen, 2008), thus explaining why they were not identified as gentrifiable, and therefore not in our analysis.

The lack of correlation between transit and gentrification in Vancouver is consistent with recent findings that demonstrate that poverty is actually spreading along the SkyTrain lines, rather than gentrification as seems to be the case in other cities, such as Toronto (Ley and Lynch, 2012).

To summarize our results, it is worth contrasting them with those of others who have examined the question of transit and gentrification. The results of the three studies described in detail in the literature review demonstrated that transit has had varying effects with regards to gentrification; in some neighbourhoods it seemed related to the process and in others not (Lin, 2002; Kahn, 2007; Pollack et al, 2010). We find that in Montreal and Toronto there is a positive relationship between transit exposure and gentrification, whereas in Vancouver there does not seem to be any effect of exposure to transit. As with Kahn (2007) and Pollock et al. (2010) we find variability in the relationship between transit and gentrification by city. Unlike in Kahn's multi-city study where a negative relationship between transit and housing values was observed

in some cases (2007), we find no evidence of transit having a negative impact on gentrification in any of the cities examined.

4.9 Discussion and Conclusions

This paper contributes to literature on gentrification and transit by identifying the process in a manner that is consistent with the broader gentrification literature and applying an appropriate and innovative statistical technique to test its relationship to transit in the three largest Canadian cities. As such, and according to the definition of the onset of gentrification as an event, it is argued that an event analysis approach, such as Survival Analysis, is a more appropriate method than what has been used in past studies.

Our results show statistically significant and positive relationships between exposure to urban rail transit stations and the likelihood that CTs undergo gentrification in Toronto and Montreal, although not in Vancouver. These results are similar to previous research that has found mixed results in terms of the relationship between transit and gentrification, although unlike previous studies, we find no evidence of a negative relationship between the two.

While the approach employed in this paper is more appropriate than methods used in previous studies, the models could certainly be improved. In particular, more precise information on accessibility to tertiary employment, information on commercial districts, and perhaps most importantly, municipal policies and investments associated with the development of the urban environment as these rail systems developed would be informative. The inclusion of these variables in the future would help to better understand the process of gentrification, and tease out the effect that transit plays. It will also be interesting to watch, as new censuses become available, how gentrification evolves over time in different urban centers as well as expanding the studies to encompass smaller, regionally important urban centers and other forms of transit

such as Bus Rapid Transit. The integration of the aforementioned variables and the expanded scope of studies represent important avenues for future research on the topic.

The study of gentrification remains an important and relevant topic in research on the changes occurring in cities worldwide, as it has been observed to have adverse effects, especially to marginal communities. Public investments, such as transit infrastructure, could be contributing to neighborhood change and therefore the implications of these investments, including those of public transportation, need to be well understood in order to mitigate any harmful effects.

This study contributes, in an innovative and applicable way, to the burgeoning field of research pertaining to the effects of transit on the process of gentrification. The research presented here could be used to inform planners and researchers about the many effects of the implementation of transit, which may occur as a result of increased accessibility to transit in order to mitigate the negative effects of gentrification and displacement.

5.0 Study Weaknesses

Although the manuscript presented here makes some important contributions to the literature on gentrification and its causes, there are still many questions left unanswered. This study would have greatly benefitted from a more thorough review of documents on the topics of urban policy, specifically those aimed at either revitalizing neighbourhoods, or at curbing the effects of gentrification and maintaining levels of rental and affordable housing. The studies that have looked explicitly at this topic have found that the impacts made by municipal policies are very significant (Newman and Wyly, 2006). This type of research would surely help to explain the differences in the onset of gentrification between the Canadian cities included in this research. It would have been particularly informative to integrate a discussion of the policies

that were implemented alongside the transportation process that lead to the construction of the cities respective transit systems.

In addition, some more qualitative analysis would be extremely helpful in understanding the consequences of gentrification for the people living the experience of it, both those adversely affected by the process as well as ‘gentrifiers’. Rose (2004) assessed the impacts of the social-mix discourse in a gentrifying neighbourhood in Montreal through interviews with owners of new condos in the area. Her results revealed some unsettling attitudes that go a long way to explain how the policies designed with this end in mind can have detrimental effects for segments of the population.

In terms of the statistical analysis included in this project the variables included could always be expanded. One of the greatest shortcomings that the model faced is the exclusion of a holistic measurement of ‘urban amenity,’ a recurring theme in the gentrification literature, and one that typically refers to the presence of middle or upper class areas of consumption. Ley refers to the impetus that the ‘culture of consumption’ has on gentrification and defining what neighbourhoods are considered cool as residents use consumption to define their personal style (Ley, 1986). The variable of centres of consumption, or shopping areas, was excluded from this analysis for the simple reason that this information is impossible to gather over such a time period for all three Canadian cities.

Another variable that was unavailable was distance to major centres of employment (other than the CBD). As cities continue to become ever more polycentric (Bertaud, 2004) it would be good if the distance could be measured to other centres of employment, but unfortunately this information is prohibitively expensive and furthermore, consistent and comparable statistics are only available from 1986 onwards.

6.0 Future Research

In light of the aforementioned themes missing from the article presented here I have many suggestions for future research on the topic of the interaction between transit and gentrification. The introduction of survival analysis to this type of research should be further explored, especially in terms of identifying gentrification as an event in the urban environment, and in order to better understand the onset of the phenomenon with regards to other aspects of the urban environment. This includes not only expanding the variables included in the survival model, but also broadening the research methods. In order to integrate the evolution of centres of consumption over time it may actually be useful to look more closely at a smaller spatial scale in order to be able to map changes over time. In addition, it would be helpful to integrate information from a wider variety of methodologies to make the discussion more holistic in terms of its description of not only some of the causes, and indicators, of gentrification, but also the results specific to the areas being studied.

Where data is available, it would also be very interesting to see whether displacement results from the implementation of transit, not only from processes of gentrification, but also potentially from the construction of transit infrastructure itself.

Future studies could also broaden the scope of research to encompass other cities, on other continents, as Lees has recently noted the lack of research on gentrification in the Global South (Lees, 2011). It would also be interesting to look at the relationship between different forms of transit and gentrification, such as Bus Rapid Transit systems.

7.0 Conclusions

As cities continue to move through cycles of development, and as the process of industrialization, de-industrialization and the phenomenon associated with post-industrial

developments continue, the study of how cities change is essential. As was mentioned in the introduction to this thesis, the fact that capital, and economic interests, mold the city is undeniable but the ways in which cities change occur in a plethora of ways. The field of study of gentrification is one lens of analysis of these changes that may be used in order to better understand them. It provides a theoretical framework for analysis, based on much research in the 20th and 21st centuries.

The study of gentrification warrants continued attention as cities evolve and change and as struggles over urban space, and access to opportunities, in urban settings continue. The resistance against gentrification has received growing attention since the 1970s, but analyses of the process often lack some fundamentals, either in defining what is meant by gentrification, or in identifying where the process may occur. In addition, the impacts of specific investments and changes to the urban form, an important one of which is transit infrastructure, remain relatively limited.

The article presented here contributes to the few existing published studies on this topic and provides a unique methodological basis for future research. As was demonstrated by the results of the manuscript, in the majority of cases transit is seen to have contributed to the process of gentrification, along with other attributes of neighbourhoods including the distance from each respective Central Business District. In Toronto and Montreal higher exposure to transit is found to be correlated with the likelihood of undergoing gentrification. In Montreal a notable relationship was observed between transit and gentrification, with metro stations located further away from the city centre, or CBD, had less of an influence on the process than those located more centrally. Over time however, the statistical model (see results in Table 5) shows

that the distance from CBD decreases in importance, and gentrification becomes more likely to occur further out from the centre.

There continues to be a great need to evaluate the effects of transit infrastructure investments on the surrounding areas. Both to ensure that those who would have the greatest marginal benefit from transit are able to live nearby and to access it, and to increase the accessibility and equity of urban centres more generally.

This study provides some important insight and new ideas about the causes and progression of gentrification in Canadian cities, there are many avenues still open for investigation. Though there remains much to be done, this study marks an essential addition to the field of gentrification research, demonstrating an aspect of the implementation of transit not previously explored in this context. With the knowledge that transit, in many cases, spurs gentrification, those implementing policy in large urban centres should be able to better mitigate the potential negative effects of infrastructure investments on populations vulnerable to the adverse effects of gentrification. Policy interventions should be made in conjunction with the planning and construction of transit systems themselves, to prevent speculation of land around transit, and in response to the model results that showed that the greatest effects of the implementation of transit were felt soon after its implementation. This provides information that can in turn ensure that those people who garner the greatest marginal benefit from transit are able to live in the surrounding neighbourhoods and access it easily.

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