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Urban Rapid Rail Transit and Gentrification in Canadian Urban Centres - A Survival Analysis Approach

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Abstract. Despite the existing knowledge that urban rapid rail transit has a multitude of effects on surrounding areas, and despite some attempts to understand the links between transit and gentrification, there has yet to be a systematic study of if, and how, proximity to transit plays a role in transforming neighborhoods. This research addresses the topic by assessing the relationship between the implementation of urban rapid rail transit and gentrification using an application of the statistical technique survival analysis. It specifically tests whether proximity to rail transit is related to the phenomenon of gentrification in Census Tracts (CTs) in Canada's three largest cities. It is found that proximity to rail transit, as well as proximity 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.

Keywords. Gentrification, urban transit, rapid rail transit, survival analysis, urban development, neighborhood change.

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INTRODUCTION

Transit is widely recognized to have effects beyond increasing accessibility. These effects, however, are not fully understood. The relationship between good accessibility to transit and the gentrification of surrounding neighborhoods, for instance, has recently been brought up in planning literature, but surprisingly little research examines this relationship explicitly. Attempts to investigate the link have suffered from two principal weaknesses. First, previous research has used definitions of gentrification that are not consistent with the extensive literature on the subject. Second, previous literature has not adequately accounted for the fact that gentrification is not an instantaneous phenomenon, but one that takes place over long periods of time.

The present research addresses the question, how does the implementation of transit networks, and more specifically urban rapid rail transit, affect the onset of gentrification in Canadian metropolitan areas over time. This study differs from publications in this burgeoning field by: adopting a definition of gentrification that is consistent with the majority of the literature; and explicitly incorporating time (until gentrification, as well as time exposed to transit) through the use of the statistical technique, Survival Analysis. This approach is used to test the relationship between proximity to urban rapid rail transit and gentrification in the three largest Canadian cities.

The metropolitan areas of Toronto, Montreal, and Vancouver have evolved in a variety of cultural, economic and geographical contexts resulting in markedly different patterns of development. Nevertheless, they are evaluated in this study using a consistent method of analysis in order to provide comparable results and gain insight into potential urban rail transit and gentrification linkages.

The questions addressed, and the results found, in this paper are important in providing guidance to researchers and planners as they seek to provide equitable and accessible transit. The methodology and outcomes of this research will function as tools to evaluate the potential for negative effects that can occur as a result of infrastructure investment.

The paper starts with a review of the existing literature, followed by a description of the cities analyzed, and the data and methodology used to establish which census tracts (CTs) are susceptible to gentrification and which have gentrified. Survival Analysis, is then introduced and described and finally, results from model estimation and a discussion of those results are presented.

LITERATURE REVIEW

Three aspects of the gentrification literature are important to understand the context of the research presented in this paper. First, a basic overview of the general themes of gentrification is needed to provide context. Second, a description of how gentrification is typically conceived of and operationalized is given. Third, more detail on the transit-gentrification literature is provided in order to identify existing weaknesses in this field of research.

Gentrification: A Large Literature

There have been hundreds of papers written on the topic of gentrification since the term was first defined by British Sociologist, Ruth Glass in the early 1960s (Glass, 1964). While the term has been applied to many different contexts it has been associated with central city, urban neighbourhoods and typically involves two core elements. The first element is the notion that a gentrifying neighbourhood is one that was previously poor, or 'working class.' The second is that the social status of the neighbourhood, (i.e., income, education and percentage of residents in professional occupations,) is increasing faster within the neighbourhood than the city as a whole, this is associated with changes in the housing market (i.e., rising rents and house values).

The literature seeking to describe the phenomenon of gentrification can be characterized by its theoretical approach and the particular analytical methods used. While various theoretical classifications could be used, one common distinction is that made between 'supply-side' and 'demand-side' perspectives. Supply-side proponents believe that gentrification is driven by policies intended to revitalize ultimately drawing 'gentrifiers' into neighborhoods (Slater, 2006). Demand-

side proponents, on the other hand, believe that gentrification is caused by changes in societal preferences – whereas residents previously sought to flee the city for the suburbs, gentrification results from the increased desirability of central-city neighbourhoods (Ley, 1986).

With respect to the analytical methods adopted the literature can also be categorized as either qualitative or quantitative. Quantitative or empirical analyses of the process of gentrification have tended to use census statistics to define and explain gentrification (Pollack, Bluestone and Billingham, 2010), whereas qualitative approaches focus primarily on interviews and observations (Rose, 2004; Newman and Wyly, 2005).

Throughout the literature, from both the supply- and demand-side perspectives, the link between accessibility to transit and gentrification has been mentioned (Filion, 1991; Atkinson and Bridge, 2005; Skaburskis and Mok, 2006; Walks and Maaranen, 2008). Despite this relatively common statement there has been surprisingly little research to have looked at this question specifically. The research that does broach this topic, further elaborated upon below, seems to have overwhelmingly taken a quantitative approach. Before describing this literature in more detail, it is first necessary to look at how gentrification has been operationalized in the quantitative literature on the topic.

Identifying Gentrification

In reviewing the literature it is clear that a concensus has developed amongst the quantitative studies about how to identify gentrification. First, quantitative analyses of gentrification use neighborhoods as the unit of analysis, and census tracts are generally used as a proxy for neighborhoods (Kahn, 2007; Freeman, 2005; Walks and Maaranen, 2008; Pollack, Bluestone and Billingham, 2011). Second, as suggested by the description of gentrification outlined in the previous section, there are two important criteria of gentrification.

The first criterion for gentrification is that in order for a neighborhood to undergo gentrification, it must be considered a ‘working class’ neigborhood at the beginning of the period of

analysis - in other words, to be included in the analysis of gentrifcation, a neighborhood needs to first be 'gentrifiable' (Freeman, 2005; Walks and Maaranen, 2008). While different authors have operationalized this in different ways, typically, neighborhoods are considered to be gentrifiable if the average, or median, income of the census tract is below the average of the Census Metropolitan Area (CMA) within which it is found (Freeman, 2005). Other indicators of social status are also sometimes used – for example Walks and Maaranen (2008) employ not only income in their classification of 'working class' neighbourhoods, but also other variables, including levels of educational attainment. The second part of recognising gentrification entails observing changes in 'status' of the neighbourhood in question. Gentrification is defined as a process whereby the middle and upper classes move into 'gentrifiable' neighbourhoods.

While the identification of census tracts 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 - , some characteristics of the housing stock, such as housing values or rents are also considered, since these are important indicators of the gentrification of neighborhoods. Analysis of gentrification is typically carried out by measuring whether all of the relevant indicators (see section on Data for more details) improve at a rate faster than for the CMA as a whole (Freeman, 2005). Critical to this then is the notion that gentrification is a relative process, gauged against changes in the CMA being analysed, and is identified by the use of several indicators jointly.

Transit and Gentrification

With this background established, it is now possible to discuss the literature that explicitly tests the link between transit and gentrification. It is worth noting that a significant number of studies have focused on the relationship between transit and housing values, a common indicator used in studies of gentrification (Hess and Almeida, 2007; Atkinson-Palombo, 2010; Cervero,

Bernick and Gilbert, 1994). Despite these studies and observations in the gentrification literature, the relationship of transit and gentrification has remained largely overlooked. The three studies that come the closest to explaining this link are described below.

In a study of Northeastern Chicago, Lin equated higher housing values near transit stations to the presence of gentrification (Lin, 2002). Although, as mentioned above, increased housing values is an important indicator of gentrification, housing costs alone are generally considered in conjunction with other indicators to identify gentrification.

A second study to examine the relationship of transit and gentrification found that neighborhoods in 12 urban centres that had transit implemented between the years 1990 and 2000 also showed gentrification (Pollack, Bluestone and Billingham, 2010). Indicators typically associated with gentrification are used in their analysis, however these indicators are not considered jointly and no attempt is made to identify neighborhoods that would be considered gentrifiable. The study period for this paper was only ten years, and did not take into account how long transit had been present for (Pollack, Bluestone and Billingham, 2010).

The final of these three papers examining the transit-gentrification linkage, is by Matthew Kahn (2007). The methodology and results of this paper leave many unanswered questions. The author, using regression analysis, estimates the impact of rail transit on income and the proportion of college graduates living in an area (Kahn, 2007). As with Lin's (2002) paper, Kahn (2007) omitted a number of widely cited indicators of gentrification including professional occupations (Filion, 1991; Walks and Maaranen, 2008). Moreover, the indicators included in the study (income, proportion of college graduates), are considered independently of one another. Unlike the two papers described earlier, Kahn (2007) assesses his study areas over a longer period of time, and also accounts for the length of time that census tracts are exposed to transit. Ultimately the author concluded that while some walk-and-ride stations did seem to bring about gentrification, park-and-ride stations did not (Kahn, 2007).

By not acknowledging the dynamic nature of gentrification, current literature is inconsistent in both descriptions and definitions. For a study's methodology to be consistent with the existing literature, the gentrifiability of an area must first be assessed. There must also be adequate justification given for the inclusion of indicators, and they must be assessed jointly in a given area to establish the presence of gentrification.

There are notable methodological omissions that appear in the key references on transit and gentrification. The first is the lack of analysis to establish whether or not the neighborhoods included are actually susceptible to gentrification, or 'gentrifiable.' Second, none of the transit-gentrification studies identify gentrification using multiple variables jointly. Two of the three reference papers fail to adequately take into account the temporal nature of the process of gentrification, an aspect that should be central to the methodologies used. Additionally, evaluating the effect of transit presence as instantaneous limits the scope of the analysis, such that long-term effects of transit infrastructure may not be captured.

Building upon the work described above, the research presented here uses a systematic approach to identify gentrifiability and gentrification, while at the same time explicitly examining the impact on gentrification of the proximity to transit stations as networks are implemented. This research explicitly accounts for the dynamic nature of the phenomenon by employing an innovative application of survival analysis to test the significance of proximity to rail transit, which may change over time as networks are expanded, to the onset of gentrification.

STUDY AREAS – MONTREAL, TORONTO AND VANCOUVER

The study areas included in this research are the CMAs of Montreal, Toronto and Vancouver; the three largest urban centers in Canada (see Figure 1 below). Toronto is the largest Canadian city with a total CMA population of 5.1 million residents in 2006 (Statistics Canada, 2006). Its rapid rail transit system, the Toronto Subway, opened its first stations in 1954 and in 2006

had a total of 69 stations extending 70 kilometers through the City of Toronto (Toronto Transit Commision, 2012).

Montreal, located in the province of Quebec, is the next largest Canadian city with a CMA population of 3.5 million (Statistics Canada, 2006). The Montreal Metro inaugurated its first stations 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. Only on-island CTs were analyzed for Montreal as the water barrier of the St Lawrence River was expected to eliminate any relationship between the onset of gentrification and the presence of transit. Additionally, the off-island metro stations were excluded because of the dates of inauguration (the three newest stations to the north opened in 2007) and drastically altered census tract boundaries, surrounding the stations to the south of Montreal, in Longeuil.

The third (and third largest) city is Metro Vancouver and, as of 2006, it had a significantly smaller CMA population of 2 million (Statistics Canada, 2006). Vancouver's Skytrain opened its first stations in 1986 for the Vancouver World Exposition. The system has since expanded, and in 2006 had 32 operational stations along 68.7 kilometers of track. It provides service to the city of Vancouver as well as four adjacent municipalities which are all a part of Metro Vancouver (Metro Vancouver, n.d.). An additional line has since opened, but the stations came into operation after the end of the study period.

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. Walks and Maaranen analyzed only the City of Vancouver proper, but that geography excludes the majority of transit stations and was therefore deemed inappropriate for the scope of this study.

Three conditions were used to establish the study area boundaries: first, any CTs separated from the Skytrain by water were eliminated. Second, population density had to be in the 90^{th} percentile to be considered a part of the 'urban' area, as gentrification has previously been defined

as a phenomenon observable in urban neighborhoods (Ley, 1986; Freeman, 2005). The census tracts 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 low population density.

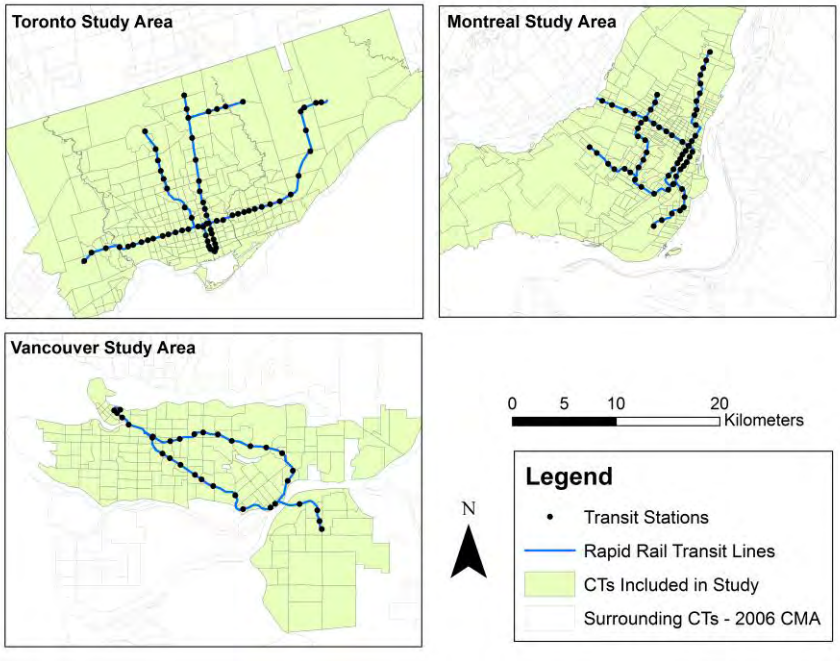

FIGURE 1: Study areas

DATA USED

To establish whether the process of gentrification is occurring, empirical studies use census data to distinguish changes in the makeup of neighborhoods (Filion, 1991; Freeman, 2005; Walks and Maaranen 2008). Specific indicators of gentrification used in the past to measure the process include demographic statistics such as: population; household, family and individual income; college or university education levels; persons employed in professional occupations; household structure (referring to the number of children in a household); and racial and ethnic composition (particularly 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; distance from CBD; distance from other

urban amenities, including parks as well as commercial districts (List compiled from; Filion, 1991; Freeman, 2005; Walks and Maaranen, 2008; Pollack, Buestone and Billingham, 2011).

Data used in the study originated from Statistics Canada and was aggregated to the CT level. Census tracts are small geographical areas delineated by Statistics Canada that have an approximate population of 2,500 to 8,000 residents and that are supposed to remain relatively stable over time (Statistics Canada, 2007). Despite this supposed stability, one challenge was rendering the census tract boundaries comparable across census years. The most common change in census tracts over time is for them to split into smaller census. In this study the authors decided to aggregate adjacent CTs that had undergone changes in order to make the 2006 census tract boundary file comparable to that of the first year in each of the study periods. Although the results of the analysis are less fine-grained, they are more accurate than if we were to normalize the boundaries to later years.

Study periods for the cities vary 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. The case of Toronto is more complicated as comparable data at the CT level was not available for 1951, the desired year since the subway opened in 1954. The literature on gentrification in Toronto identifies it as a process that was not really observed until the 1970s and 1980s (Walks and Maaranen, 2008), 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 includes census years 1961, 1971, 1981, 1986, 1991, 1996, 2001 and 2006.

In addition to census statistics, other data was collected in an effort to test, statistically, the relationship between aspects of the urban environment and gentrification. This data included the

distances from the centroids of each census tract to the nearest transit station for every year from the time that the first stations were opened. Past studies have explored the idea that gentrification is related to the distance from the Central Business District (CBD) (Lin, 2002; Kahn, 2007; Filion, 1991). To incorporate this idea, the distance was also measured from the centroids of census tracts to the centroid of the CBD, as defined by the delineations offered on each of the CMA government websites. Another condition 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). Age of housing stock was defined by the proportion of housing that was constructed before 1946; this was drawn from past emphasis put on pre-WWII inner-cities (Walks and Maaranen, 2008).

The distance was also measured from the centroid of each census tract to the nearest large park (defined as any park equal to or exceeding 50 000 square metres) or major body of water (lake, river or ocean). Many authors refer to the urban amenities that draw gentrifiers to the central city neighbourhoods. Often urban amenities refer to commercial districts, or areas of consumption that cater to middle and upper income residents (Smith and Williams, 1986). Since these urban attributes are impossible to accurately track over time they were excluded from this analysis, but both parks and proximity to water, viewed as urban amenities (Helms, 2003) which enhance the value of a location were included to test their statistical relevance to gentrification. The final variable that was added was the distance from the centroid of each census tract to the centroid of the nearest CT that had experienced gentrification. This has not previously been considered in the literature, but was suggested as a potentially important variable when preliminary results of this research were discussed.

METHODOLOGY

The following two subsections explain the methodology: the identification of gentrification and the survival analysis.

Identifying Gentrification

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

To establish whether a CT was gentrifiable the average family income of a census tract, and the number of degrees per capita were assessed, both of which needed to be lower than the CMA average for a given census year. 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 living in a census tract,
- percentage of owner-occupied dwellings,
- average family income
- and number of degrees per capita.

For a CT to be considered to be gentrifying, all of the aforementioned indicators had to have experienced a change greater than the change experienced in those indicators for the CMA, as well as being considered gentrifiable in the first census year of the census period (i.e. to have gentrified in 1971, it must be considered gentrifiable in 1961, the preceding census year in the dataset). Indicators used to establish gentrification were limited to those that were available for census years throughout the study period. Table 1 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 gentrified.

TABLE 1: Gentrifiable and Gentrifying 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

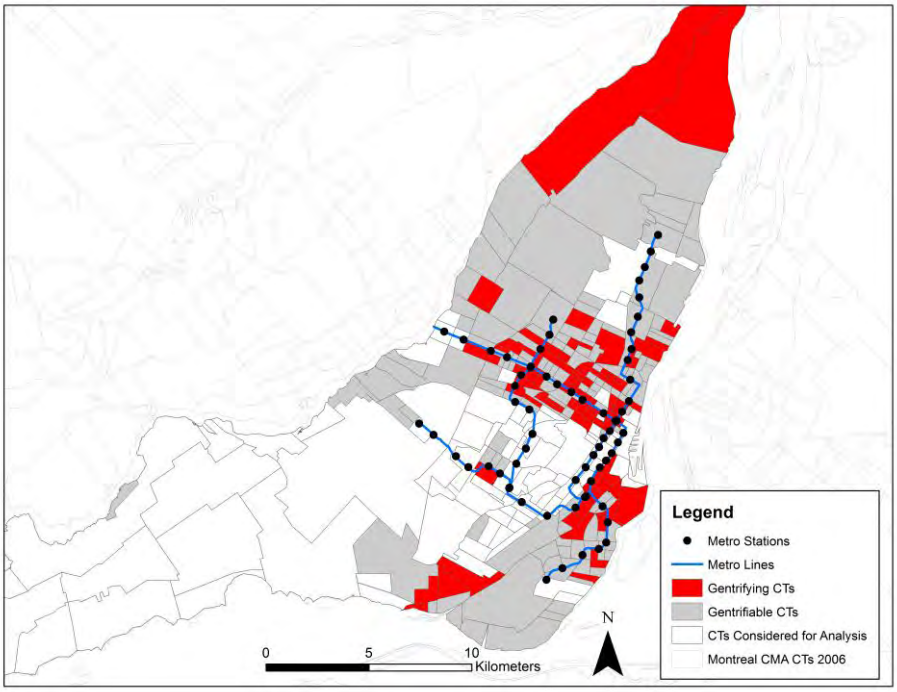

FIGURE 2: Gentrifiable and gentrifying tracts in Montreal (1961-2006)

Figure 2, above, shows the results of the gentrification analysis for Montreal. It is worth noting that the southernmost metro-line running North-West to South-East has very few gentrifiable CTs around it. Overall there appears to be an association between the onset of gentrification and the

presence of metro stations. Although there are some outlying tracts that appear to have experienced the demographic changes defining gentrification, there is a noticeable pattern of the effect in areas accessible to the metro.

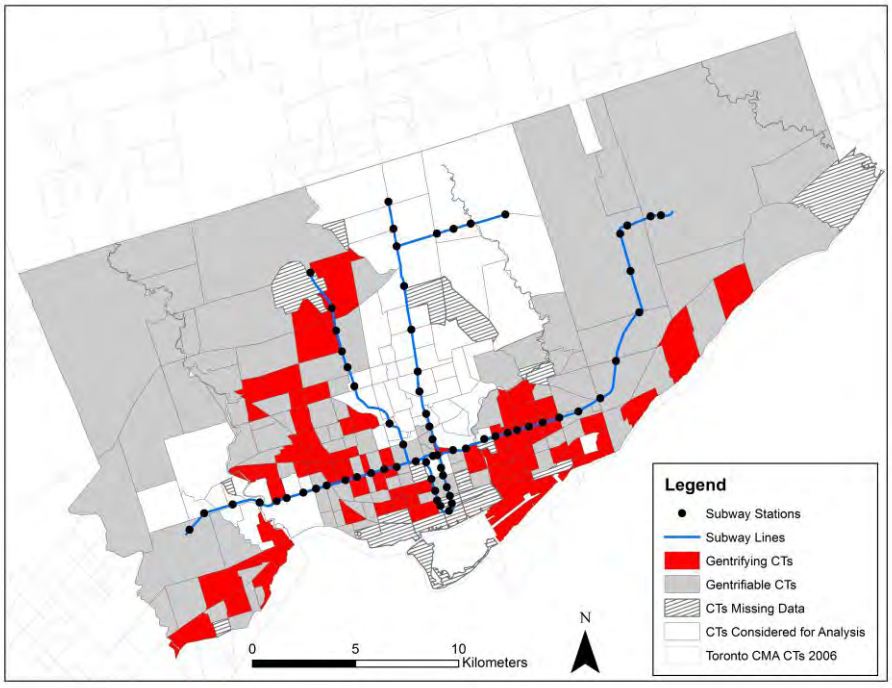

FIGURE 3: Gentrifiable and gentrifying tracts in Toronto (1961-2006)

The gentrification in Toronto shadows the Toronto Subway system in a similar, if not more striking, way than the process visible in Montreal. As seen in Figure 3 above, the gentrification occurring in Toronto is focused along two axes, one running North South along the westernmost branch of the Yonge-University-Spadina line, and one running East-West along the Bloor-Danforth line. Many of the most commonly cited gentrifying areas of Toronto are captured in this analysis (Slater, 2004; Hackworth and Rekers, 2005; Murdie and Texeira, 2011).

As the smallest area included for analysis, Vancouver had only 143 CTs included in the analysis (see Table 1 for details). Figure 4, below, depicts the gentrifiable and gentrifying tracts in Vancouver. The CTs that had undergone some form of gentrification in Vancouver are significantly

sparser than in the other two CMAs and shows notably less of a pattern in terms of their overall dispersal through the CMA.

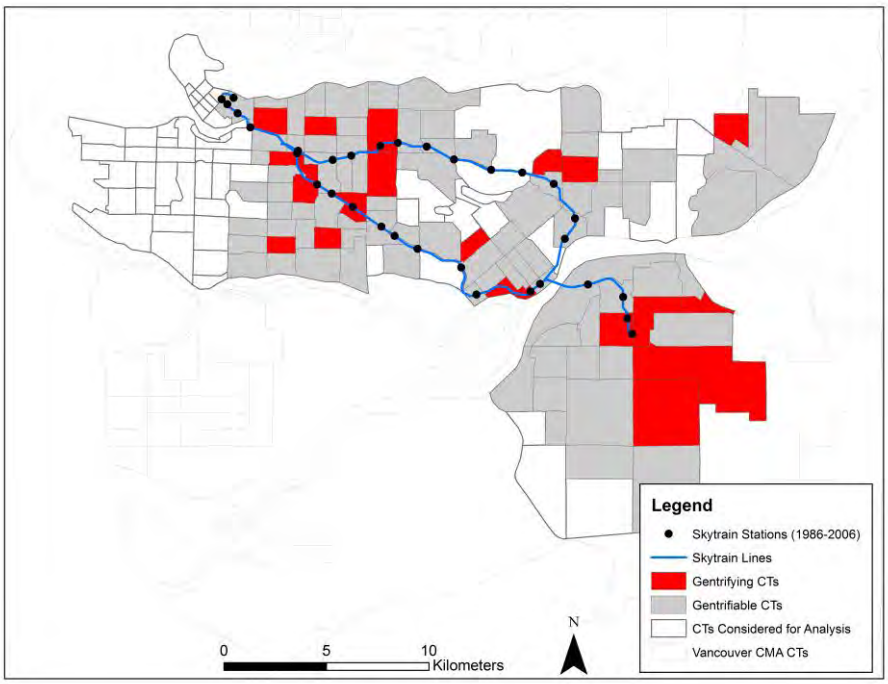

FIGURE 4: Gentrifiable and gentrifying tracts in Vancouver (1981-2006)

Survival Analysis

This section describes the statistical methods and results used in this study. The approach outlined analyzed the relationship between the presence of rapid rail transit and gentrification in Canadian urban centers. The statistical technique is one that was used in an earlier paper by the authors, presented at the 91st annual meeting of the TRB (Author B and Author A, 2011). As in the previous paper, the dependent variable in this analysis is binary since CTs will either have experienced gentrification or not, as such a limited dependent variable statistical method needed to be used (Kennedy, 2003; Maddala, 1983). Since this research project integrates multiple different urban centers the analysis was complex and needed to be adapted to be suitable for all cases included.

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, Karlaftis and Mannering, 2003). Survival Analysis is defined as "a collection of statistical procedures for data analysis for which the outcome variable of interest is time until an event occurs" known as the survival time (Kleinbaum and Klein, 2005). This type of analysis is particularly useful when working with variables whose effects vary over time, called time-dependent variables. For various applications of survival analyses see the text written by Kleinbaum and Klein (Kleinbaum and Klein, 2005).

In the model presented in this paper the 'event' in question is gentrification and the 'treatment' variable would be considered the presence of rapid rail transit close to the census tract. Thus, the results of the model give the survival time of census tracts until they gentrify based on the presence of transit over time as well as a few other variables defined below.

As was discovered in a preceding paper (Author B and Author A, 2011), the presence of transit was more difficult to integrate than predicted. Preliminary analyses showed that there does not appear to be a linear relationship between gentrification and the independent variable of proximity to transit. As a result, a gravity function was used to capture the effect of distance from transit to an individual CT. The gravity measure is calculated for each census tract for each year of the study as a function of 'cdist' as shown in Equation 1 below (for more details on the calculation of gravity measures see de Dios Ortúzar and Willumsen, 2001). Different betas were used for each city after testing to see which had the most statistically significant influence on the model.

$$\text{expo} = cdist^{\alpha} * e^{\beta * cdist} \qquad \text{Eqn. (1)}$$

The variable of proximity to transit, or 'exposure' as the gravity measure is called is a time dependent variable meaning that the variable changes over time. The distance to transit stations, 'cdist', may change every time new transit stations are added to the transit network. Before being

included in the statistical analysis, the variable is normalized to one to facilitate comparability of coefficients across cities.

THE SURVIVAL MODEL RESULTS

Introduction to Estimating Survival Models

Following the example of the preceding paper which included only preliminary analysis for Montreal, the Extended-Cox (EC) model was selected for this statistical analysis (Author B and Author A, 2011). The EC model is a semi-parametric model and therefore less restrictive in terms of the assumptions the model makes about the form and distribution of the outcome: survival time. 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 2 below) are the baseline hazard function, $h_0(t)exp$, and the exponential function which represents the independent variables in the model.

$$h(t, \boldsymbol{X}(t)) = h_0(t)exp\left[\sum_{i=1}^{p1} \beta_i X_i + \sum_{j=1}^{p2} \delta_j X_j(t)\right] \qquad \text{Eqn. 2}$$

In this equation, X_j is the time-dependent variable, 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

In this section the results of the survival analysis for each of the cities is described. Variables of interest were explored based on evidence found in the literature. These included the

proportion of pre-1946 housing, the exposure measure, distance to the nearest park, distance to the nearest major body of water (lake, ocean or river) distance to nearest gentrifying, or previously gentrifying CT, and the 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 seemed to be maximized at a different distance from the transit stations for each urban center.

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

TABLE 2: Toronto Extended-Cox Model Survival Analysis Results

Variables	Coefficient	Std Err	z	P>z
Exposure	1.910	0.7893	2.42	0.016
Proportion of Pre-1946 Dwellings	1.374	0.4677	2.94	0.003
Proximity to Nearest Gentrifying CTs	-0.119	0.0310	-3.83	0.000
Exposure*Time	-0.0968	0.0050	-2.79	0.005
Diagnostics				
Initial Log Likelihood	-339.987			
Final Log Likelihood	-322.147			
Observations	979			
Subjects	163			
Failures	71			

The model describing the gentrification in Toronto is summarized in Table 2. Exposure was statistically significant with a positive coefficient meaning that as the exposure measure increases the likelihood of a CT gentrifying also increases. 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 us an

odds multiplier of just over 5, indicating that if a Subway station is built 550 meters away from a census tract which previously had no access to transit, that census tract would be 5 times more likely to gentrify as a result.

The proportion of housing built before 1946 was also statistically significant, which reinforces findings by other analyses 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.' This variable proved to be statistically significant, with a negative coefficient indicating that as the distance to the nearest already gentrifying or gentrified CT increases the likelihood of gentrification decreases.

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.

TABLE 3: Montreal Extended-Cox Model Survival Analysis Results

Variables	Coefficient	Std Err	z	P>z
Exposure	1.276	0.642	1.99	0.047
Exposure*Distance to CBD	-1.444	0.664	-2.18	0.030
Proximity to Nearest Gentrifying CT	-0.133	0.057	-2.32	0.020
(Exposure*Distance to CBD)*Ln of Time	0.335	0.199	1.68	0.092
Diagnostics				
Initial Log Likelihood	-439.790			
Final Log Likelihood	-422.301			
Observations	1453			
Subjects	220			
Failures	86			

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% (see Table 3 above). The interacted

variable of exposure and distance to the CBD was also interacted with the natural log of time, and was significant at 10%. The positive coefficient of Exposure tells us that as exposure increases, the likelihood of a CT gentrifying increases. The model shows that metro stations located further from the central business district have less of an influence on gentrification according to the interacted variable of exposure and distance to CBD. The same may be said for the variable of Proximity to Nearest Gentrifying CT.

Lastly the model indicates that, over time, the distance that a metro station is located away from the CBD becomes less important, and that even metro stations located further away from the CBD would increase the likelihood of gentrification in surrounding Census Tracts. This would mean that as time goes on, census tracts located close to metro stations far from the CBD are increasingly likely to undergo gentrification. 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. Although this result contrasts with the hypothesis which led us to include this variable; that the waterfront would be a type of 'urban amenity' with recreational facilities and vistas, it does make sense in the context of Vancouver. First, it has been noted in the literature that much of the gentrification in that city, especially in the West end, took place in the 1970s, such that by the beginning of the study period much of the city was no longer considered to be gentrifiable. Many of these gentrified areas are located along the water, in areas where boardwalks and public parks and beaches feature prominently in the neighbourhood. Of the 'gentrifiable' census tracts considered for analysis in this paper, almost the entire shoreline is used for industrial uses, removing the 'amenity' that the waterfront may otherwise offer to nearby residents. Nevertheless,

this model should not be interpreted as a stand-alone explanation of gentrification in Vancouver, but indicates that in the case of Vancouver, more investigation is needed.

The difference in Vancouver in the relationship between transit and gentrification, or the lack thereof, is consistent with recent findings on the city of Vancouver, which 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). Due to all of these factors, it is understandable that the results should differ significantly from those of the other cities.

Despite the attention paid to the importance of urban amenity in the literature, and the attempts of the authors to describe this relationship with the statistical model, using urban parks and proximity to water, ultimately these indicators were no more helpful in describing the process of gentrification in Canadian urban centers.

DISCUSSION AND CONCLUSION

The difference in results from the three cities is not all together unexpected considering their varying contexts.

Vancouver, the city which diverges most from any noticeable trend is the one with the youngest transit system, therefore the shortest study period. Despite the results of the model in Vancouver, there is still an identifiable pattern in the analysis of Toronto and Montreal, as well as a statistically significant relationship between transit and the onset of gentrification. The importance of the addition of the variable Proximity to Gentrifying CTs must not be underestimated. With the addition of this variable the model shows that while proximity to gentrifying CTs is important, the presence of rapid rail transit remains statistically significant.

Though this paper provides an important foundation for future studies, there are still many questions about the relationship between transit and gentrification and what other urban elements

may be contributing to this process. It will be interesting to watch, as new censuses become available, how the trend 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.

Finally, being able to firmly conclude that rail transit has a significant impact on gentrification in two of the cities, the study should be used to inform planners and researchers about the many effects of the implementation of transit, and how best to mitigate the negative effects of gentrification and displacement, which may occur as a result of increased accessibility to transit. This study should be seen as an innovative and applicable starting point for research looking into transformations experienced in part or in whole as a result of urban transit coming into operation.

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