The Value of Access to Rapid Transit Among Affluent Households: Evidence from the City of Vancouver, Canada

Bogdan Kapatsila[1], Katrina Villeneuve[2], Emily Grisé[3], Feng Qiu[4]

[1]School of Urban and Regional Planning, University of Alberta, kapatsil@ualberta.ca
[2]School of Urban and Regional Planning, University of Alberta, kat.villeneuve@ualberta.ca
[3]School of Urban and Regional Planning, University of Alberta, egrise@ualberta.ca
[4]Department of Resource Economics and Environmental Sociology, University of Alberta, fq@ualberta.ca

ABSTRACT

Public transportation investment provides many potential benefits; however, without supporting policies, these investments may produce unintended consequences, such as displacement. To date, much attention on this matter has focused on light rail, while the effects of bus rapid transit (BRT) have been less explored. We used a spatial regression to model the residential movement of high-income households in the City of Vancouver, Canada, to better understand how transit and non-transit effects near BRT and rail rapid transit (RRT) infrastructure influenced housing choices of affluent households between 2012 and 2016. High-income movers were found to be drawn more to census tracts within 1,600 m of all RRT lines and one BRT line, whereas transit proximity variables were found to be trivial predictors of residential decisions for high-income movers in the suburban model. Additionally, we saw no significant difference in the average number of high-income movers in census tracts within 1,600 m of all RRT lines and the BRT Line, after controlling for relevant demographic, natural, and built environment characteristics of each Census Tract. This suggests that both modes were similarly appealing to affluent urban households. This finding suggests that BRT can be equally as effective as light rail for transit-oriented development; however, it also indicates that the City of Vancouver should employ policy measures allowing for equitable access to housing near all forms of rapid transit.

1. Introduction

Investing in public transportation provides many potential benefits, however, without proper supporting policies, transit infrastructure may contribute to unintended consequences that could negatively affect vulnerable populations (Garrett & Taylor, 1999; Zuk et al., 2018). For example, high-income households that demand access to public transit and can pay higher real estate prices may induce property values to increase around transit-oriented developments (TODs), potentially excluding existing low-income residents from their communities and access to needed transportation services (Dawkins & Moeckel, 2016).

To address transit-related inequities, the effects of transit investment have to be assessed reliably. As such, there is growing interest in comparing neighbourhood socioeconomic change in the vicinity of different modes of transit. However, little work has been done in the Canadian context thus far. In this research, we used spatial regression modelling to explore the residential movement of high-income households in the City of Vancouver to better understand how transit and non-transit effects in the vicinity of bus rapid transit (BRT) and rail rapid transit (RRT)

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influenced their housing choices within the region between 2012 and 2016. The BRT and LRT lines considered in this study are presented in Figure 1.

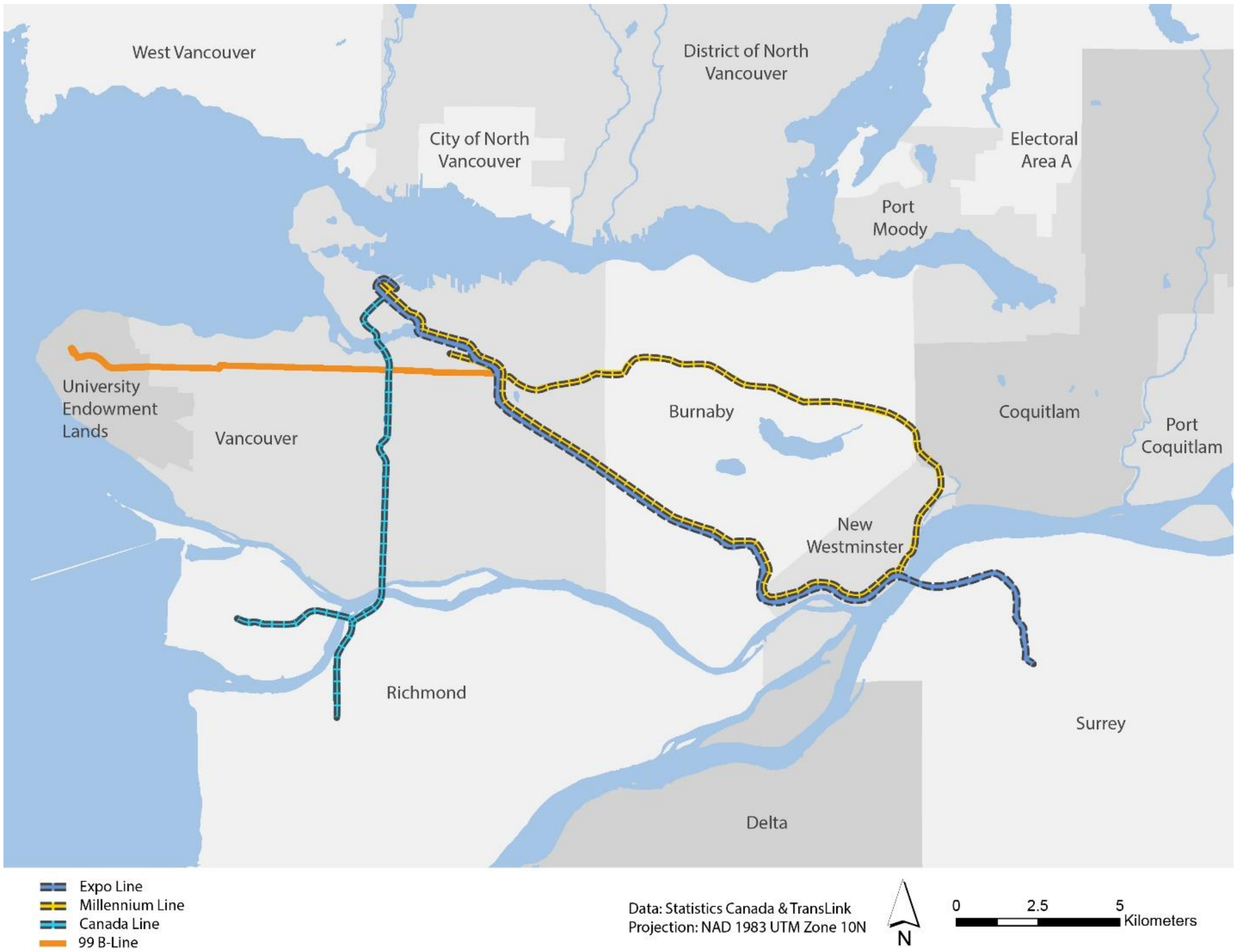

Figure 1: Study lines of TransLink's rapid transit network

2. Methods & Data

Information for this study came from multiple sources. Sociodemographic data, as well as population density and the number of dwellings in need of major repairs, were sourced from the Statistics Canada 2016 Census of Population at the census tract (CT) level. Residential mobility data for different income groups were procured from Statistics Canada as a custom table that reflected the number of households in occupied private dwellings that moved into a given CT between 2012 and 2016. High-income households were defined following the Metro Vancouver Regional Affordable Housing Strategy (*Regional Affordable Housing Strategy*, 2016), where affluent movers were considered to be those earning at least $100,000 per year (Statistics Canada, 2017). The spatial distribution of high-income movers in the City of Vancouver is presented in Figure 2.

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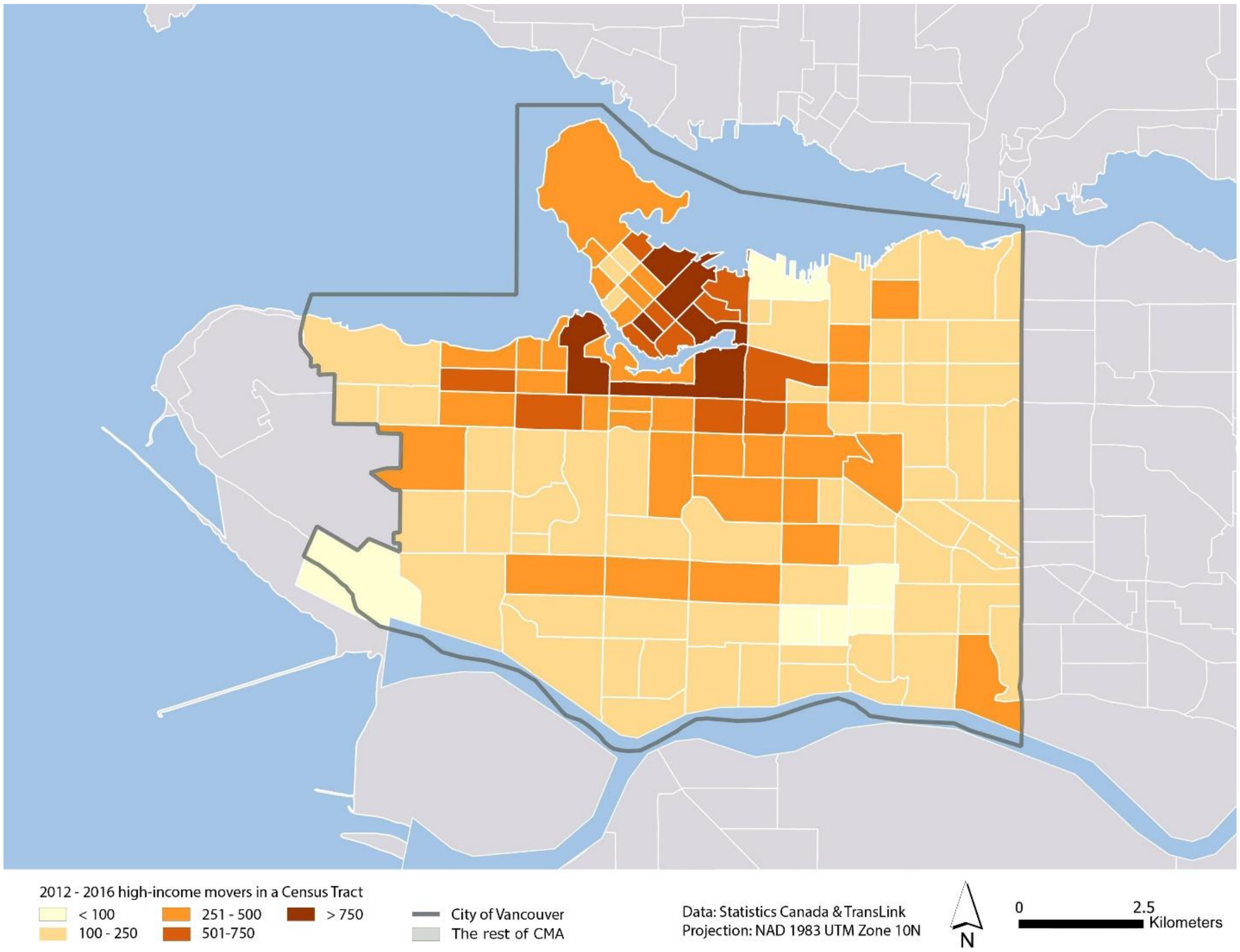

Figure 2: Number of high-income movers per CT in the City of Vancouver

Dissemination block proximity measures to childcare, primary schools, neighbourhood parks, and grocery stores were derived from the Statistics Canada Proximity Measures Database (Statistics Canada, 2020) and aggregated to the CT level using CTs area as a weighting factor. We used information on the number of housing units completed from 2012 to 2016 to control for the supply side of new housing available in a CT. This data arrived from the Canada Mortgage and Housing Corporation Starts and Completions Survey (CMHC, n.d.) that we normalized using a Z-score. The measure of walkability was obtained from Walk Score (n.d.).

CTs that border water bodies were identified using GIS and informed the creation of the binary variable for the model. Areas that are next to the Fraser River were excluded from this measure due to the preponderance of industrial areas and thus low desirability for their residential use. Similar dummy coding was used to record if a CT centroid was within 1,600 meters (1 mile) of the rapid transit line stops studied in this paper, as this buffer was commonly used in other studies assessing the impact of transit infrastructure (e.g. in Bardaka et al. (2018)).

We used ordinary least squares (OLS) regression as the first step in our analysis and moved to the spatial regression models based on the results of subsequent statistical tests. The use of spatial regression models was motivated by the intention to account for spatial spillover effects that occur among neighbouring CTs, given that they are not isolated from each other and a factor that disrupted one area had a high chance to affect its surroundings similarly. Not accounting for this spatial dependence and using a simple OLS regression would lead to biased estimates or invalid statistical inference (Anselin, 2002).

To support our assumption of spatial dependence, we calculated a global Moran's I for the number of high-income movers per CT, which presumes spatial randomness under the null hypothesis. It came out negative and insignificant, indicating the absence of autocorrelation in the dependent variable for the urban core of the region. We also conducted the Lagrange Multiplier (LM) tests that, unlike Moran's I statistic, compare the OLS and spatial regression specifications (Anselin, 1988). Unidirectional LM tests were calculated using the OLS estimates under the assumption that the spatial error was absent (i.e. the spatial autoregressive coefficient was zero), while the robust version of LM tests took into account the spatial weights matrix and was not affected by the spatial error. Following the results of the robust LM test, where the spatial-error coefficient was significant and the highest (7.95 compared to 6.95 for spatial-lag specification considered as an alternative), we proceeded with spatial error model (SEM) specification for the analysis.
Modelling and statistical tests for this study were executed in R statistical software with the use of spdep (R. S. Bivand & Wong, 2018) and spatialreg (R. Bivand et al., 2013) packages. As indicated above, the SEM specification was used for the final model. It takes into consideration the spatial dependence in the disturbances, adjusting for that correlation between the factors not included in the model (like household preferences). This correlation across CTs due to their location is captured by the spatial weights matrix. It is specified as:

$$y = \alpha\iota_n + X\beta + u$$

$$u = \lambda Wu + \varepsilon,$$

where α is the constant, ι_n is a vector of ones, X is a vector of explanatory variables, and u is the disturbance term with its autoregressive structure. This term consists of the λ which measures the spatial dependence in the disturbances among the neighbours defined by the 8-nearest neighbour matrix W, while ε stands for the normally distributed error term.
When evaluating the final model, the spatial dependence parameter was significant and SEM specification proved to be successful in correcting for the spatial dependencies. Likewise, an insignificant Moran's I on the residuals of the SEM regression indicated the absence of remaining autocorrelation in the error term.

3. Results

The results of the final OLS and spatial error models are presented in Table 1. Although we report the results of OLS regression, interpretation is only provided for the spatial error model, as its estimates are more accurate and account for the dependencies identified in the data.
The spatial-error model for the context of the City of Vancouver found that high-income movers were more attracted to CTs within 1,600 m of SkyTrain lines and 99 B-Line. In particular, we can be 99% confident that, on average, proximity to Canada Line and 99 B-Line increased the number of affluent households by 138 and 110 respectively, while access to Millennium Line expanded that number by 94, at a 95% confidence interval, all else equal. This finding follows the intuition, as it is apparent that affluent Vancouverites with a preference for an urban style of living and available amenities chose locations with easy access to any form of rapid transit. Given their high value of time and constant traffic congestion levels in Vancouver (TomTom, n.d.), it is reasonable to assume that many of them commute using public transit. Moreover, similar impacts of transit infrastructure were observed in other North American transit-rich cities like Portland, OR (Dong, 2016).
It is also apparent that well-off Vancouverites exhibit a high preference for environmental amenities like neighbourhood parks and access to water. This is the trend found in existing research, where access to water bodies was shown to be viewed as an amenity that increased the value of neighbourhoods (Muller, 2009), while the same was true for the presence of neighbourhood parks (Conway et al., 2010).

Variables	OLS	SEM
λ (Spatial dependence term)	-	-0.46 (0.23)*
Demographics		
% 65 and over	-5.33 (5.53)	-6.18 (4.89)
Median income	2.54 (1.62)	3.28 (1.44)**
% High education	4.53 (2.63)*	3.17 (2.01)
Employment rate	4.89 (3.83)	4.92 (3.21)
Neighbourhood characteristics		
Population density	-8.39 (4.37)*	-7.24 (3.81)*
Walk score	1.17 (2.64)	1.66 (2.33)
Adjacent to water	161.96 (57.71)***	182.58 (48.69)***
Proximity to child care	-149.13 (233.73)	-290.93 (191.24)
Proximity to primary education	-20.50 (90.92)	0.60 (82.42)
Proximity to neighbourhood parks	364.04 (269.93)	440.57 (248.01)*
Proximity to grocery stores	34.39 (124.17)	4.50 (109.39)
% in need of major repairs	-28.84 (8.36)***	-29.88 (7.18)***
Number of housing completions	-14.74 (11.97)	-16.01 (9.82)
Proximity to transit		
Within 1,600 m of Millennium Line	110.02 (46.22)**	93.88 (37.32)**
Within 1,600 m of Canada Line	114.04 (46.22)**	137.57 (34.19)***
Within 1,600 m of 99 B-Line	110.00 (54.33)**	122.00 (44.65)***
Constant	-364.81 (343.347)	-353.43 (300.41)
R^2: Multiple/Adj./ Pseudo	0.6/ 0.54 / 0.6	- / - / 0.6
AIC	1596.7	1596.0
N	118	

Notes: The weights are based on a K-8 nearest neighbour matrix; ***, **, and * indicate significance at 1 %, 5 %, and 10 % levels, respectively.

Table 1: Coefficient Estimates from OLS and Spatial Regression Models

Other neighbourhood characteristics were found to have a negative impact on the number of high-income movers. CTs with a higher share of dwellings in need of major repairs drew in fewer affluent households, which was along the lines with existing studies, where the higher quality of built environment had been found to enhance the value of the real estate (Kain & Quigley, 1970). Though to a smaller degree, population density growth decreased the appeal of a CT to high-income movers — something that was found to be true in cities with comparable high-density neighbourhoods like New York City (Deboosere et al., 2019).

Finally, median household income was the only socio-demographic variable with a statistically significant estimate. It followed the common logic of income sorting in residential locations (Bayer & McMillan, 2012), suggesting that, on average, affluent households chose to live in the parts of Vancouver that housed residents in the comparable income bin.
Overall, the SEM model results for Vancouver suggest that access to transit and environmental amenities increased the appeal of CTs in the City of Vancouver, while other neighbourhood features like the poor quality of the housing stock and higher population density had a negative impact on the number of high-income movers.

4. Discussion & Conclusion

This study presented evidence that rapid transit lines were viewed as an amenity among high-income households in the City of Vancouver. We saw no significant difference in the average number of high-income movers in CTs within 1,600 m of SkyTrain lines and 99 B-Line, suggesting that the premium the rapid transit constitutes for affluent households in Vancouver is mode-agnostic. This suggests that BRT can be an equally effective tool for transit-oriented development as RRT, bringing more fiscal revenues through property taxes and fees. However, with the influx of wealthy families, low-income households may be slowly pushed out of these communities, potentially causing serious social problems (Stone & Wu, 2014). It is therefore important for the City of Vancouver to consider policy measures that allow for equitable access to housing close to rapid transit for households of different incomes (Brown, 2016).
It is also important to point out that despite the dedicated attempt to control for numerous demographic and neighbourhood characteristics of the studied CTs, as well as the use of complex specifications, the final models were only moderately successful at capturing the variation in the dataset, as indicated through the R2. While some of that can be explained by the lack of necessary data, as not everything that we aspired to include in the final models was available for research. For example, the records of educational outcomes released by the British Columbia Ministry of Education had numerous gaps because of the need to suppress numbers to protect privacy in schools with low student populations. At the same time, we believe that this research exemplifies the inherent difficulty of quantitatively explaining residential movement patterns in an amenity-rich environment like the City of Vancouver, where policies and decisions made locally cause ripple effects across the region. It is evident, that metropolitan regions should pay more attention to the coordination of planning efforts to ensure the effective distribution of public resources and equitable access to amenities like housing near transit.

This study also lays out the groundwork for future research. We plan on expanding the models to the whole region and by using a longitudinal panel data model design to quantify the change of high-income movers in Vancouver CMA over time as new rapid transit lines were introduced and old ones discontinued. We also intend to examine the factors that influence housing choices of other income bins to understand if rapid transit infrastructure is also viewed as an amenity by households that earn less than $100,000 annually.

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