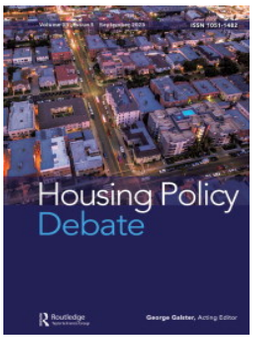

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Does Subsidized Housing Facilitate More Sustainable Commute Patterns? Insights From Canadian Metropolitan Areas

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ABSTRACT

Housing has become increasingly unaffordable, particularly in amenity-rich and transit-accessible areas. In this paper, we conduct an empirical analysis to investigate the relationship between living in subsidized housing and commuting patterns (mode and distance) in Toronto, Montreal, and Vancouver. We find that compared to otherwise similar individuals, those in subsidized dwellings have shorter and less auto-oriented commutes at statistically significant levels. The paper positions the discussion on subsidized housing in the broader context of the relationship between housing and sustainability, and within specific metropolitan geographies and histories of housing policies. In combination with prior research, the findings provide support for policies that promote investment in subsidized housing near transit as an affordability and sustainability strategy, particularly benefiting low-income renters.

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Housing; subsidized; subsidy; affordability; commuting; climate; sustainability

Cities face the dual crisis of housing affordability and climate change. For this reason, there have been increasing calls for governments to facilitate and/or subsidize the creation of more affordable housing in transit- and amenity-rich locations in cities. This, it is commonly argued, would help address housing affordability, as well as climate concerns, the latter by reducing carbon emissions via lower automobile use and shorter trip distances (Nieuwenhuijsen, 2020), referred to here as "more sustainable commutes." Building on an existing body of evidence and observations, we could infer a high likelihood that subsidized housing, when located near transit, contributes to more sustainable commutes (Grant et al., 2020; Walks, 2015). Yet this may not necessarily materialize in all cases.

For instance, dispersed employment opportunities may mean that individuals accessing subsidized housing near transit may still have less sustainable commute patterns given that they must travel from central areas to more far-flung employment locations. Although people generally can make trade-offs between location and commute decisions, the housing location becomes fixed for those in subsidized housing stock. Alternatively, the costs associated with building and maintaining subsidized housing may lead to its development in lower density

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contexts, which are often not well served by transit. These complexities make a case for an empirical analysis of the aggregate outcomes of the commuting patterns and their relationship to the location of subsidized housing. To date, there has been surprisingly little research that empirically and directly analyzes the relationships between subsidized housing and more sustainable commutes. In part, this is due to the inherent difficulty of obtaining, ideally, time series data that allows observation of changing commuting patterns in response to moving into, or out of, subsidized housing.

In lieu of the "ideal" data, we take advantage of a unique variable from the 2016 Canadian census that identifies people living in subsidized housing. We focus on Canada's three largest census metropolitan areas (CMAs) where there is well-developed public transit infrastructure and a relatively high proportion of subsidized housing: Toronto, Montreal, and Vancouver. We conduct our analysis by comparing commute modes and distance between renters living in subsidized housing versus renters in market housing using a multivariate statistical framework. Our analysis includes employed renters under the age of 65 who work outside of the home, as commute data is only available for the employed. About 30% of those living in subsidized housing are employed commuters. Further research is required to illuminate how subsidized housing may impact transportation patterns for the unemployed and those who are not actively seeking paid employment.

The hypothesis we test in this paper is whether employed commuters living in subsidized housing have shorter and less auto-oriented commutes than otherwise similar households living in market housing. The paper's main contribution is a first look at the relationship between housing subsidies and the commute through an empirical lens using individual-level data across entire metropolitan areas. Although much has been stated about the potential of subsidized housing to contribute to sustainability goals, the data used in the paper allow us to conduct an experimental analysis to provide a first test of how subsidized housing relates to commute patterns empirically. Importantly, the paper also makes a broader conceptual contribution to housing research by framing the analysis in the literature regarding linkages between subsidized housing and sustainability goals.

As is usual with panel data, we cannot infer causality directly. However, our multivariate analysis can shed light on whether commute mode and distance are "better" predicted by including information about housing subsidies than with other determinants of commute patterns alone. In other words, we can establish that there is an association between commute patterns and housing subsidies. Such an analysis, in conjunction with prior research, can point to the increased likelihood of subsidized housing contributing to more sustainable commute patterns. The plausible causal link behind this association is that if subsidized housing is in relatively more central locations with proximity to transit where housing costs are highest, it would facilitate access to these locations for households who would otherwise live farther from transit and therefore also have a higher probability of longer commutes and/or commuting by car.

Our findings support this argument by showing that those residing in subsidized housing have lower overall shelter costs and have shorter, less automobile-oriented commutes, as compared to their otherwise similar counterparts, at statistically significant levels. The magnitude of the difference is smaller in terms of commute distance than in terms of shelter costs and commute mode. We note that our results should not be interpreted to imply that subsidized housing is necessarily well served by transit. Indeed, the commuting challenges facing low-income earners have been well documented (Allen et al., 2022; Grant et al., 2020). Rather, our results show the relative differences between employed renters in subsidized versus market-based housing.

The remainder of the paper proceeds as follows. First, the paper illuminates the connections among subsidized housing, commuting and carbon emissions by synthesizing prior literature on housing, sustainability, and affordability in cities. Next, we discuss the specific context of subsidized housing and transit-induced gentrification in Canada's three largest metropolitan areas, which are the subject of our analysis. We note that, in Canada, *subsidized housing* is often used

interchangeably with terms such as social housing, public housing or rent geared to income (RGI) housing. In this paper, we use the term subsidized housing in reference primarily to the government-assisted provision of housing stock, whether fully subsidized or RGI. We provide further details on this definition in our methods section, followed by a discussion of the findings of our statistical analysis.

Housing, Commuting, and Sustainability

Housing has long been an important component of policies aimed at achieving greater sustainability. Research and policy have focused, for instance, on how housing can contribute to reductions in carbon emissions from construction, operations, building orientation and location, and greening (Government of Canada, 2022; Jaakkola & Amegah, 2014; Teixeira et al., 2022; Winston, 2022), and in addressing impacts from natural disasters, which are expected become more prevalent due to climate change (Davies et al., 2018; Lamb et al., 2022). Most germane to this paper are the ways in which housing and commuting patterns are connected by virtue of location. Housing location shapes ease of access to different transportation modes. Different transport modes and distances travelled, in turn, have a direct influence on carbon emissions, with public transit, bicycling and walking generally associated with lower emissions than driving (Akenji, 2021; Bernstien, 2021; Nieuwenhuijsen, 2020; Sheller, 2015).

Commute patterns, due to their relationships to the geographies of employment, housing costs, and transportation infrastructure, are thus an outcome of location decisions, as well as a host of demographic and household characteristics (Shearmur, 2006). Studies have generally conceptualized the commute as an outcome of trade-offs between housing and transportation costs, and/or as outcomes of structural constraints related to race, gender, household formation and other variables of social differentiation (Horner, 2004; Shearmur, 2006; Walks, 2015). Prior research has documented how the ability to locate near transportation infrastructure that facilitates shorter and less auto-oriented commutes is shaped by the cost of housing (Moos & Woodside, 2019), and that location and housing decisions of lower income earners are influenced by the availability of public transit (Dawkins et al., 2015). In addition, improved access to public transit tends to benefit low-income earners and otherwise marginalized populations most in several aspects of employment and social life (Canada Mortgage & Housing Corporation [CMHC], 2022; Sanchez et al., 2007), although in the US the car tends to be a better predictor of employment than transit (Blumenberg & Pierce, 2017), which—in some cases—is likely due to underdeveloped urban/suburban public transit systems.

Recent trends have seen housing costs rise in general; however, it is acute in the central, amenity-rich areas of large cities, especially in proximity to transit (CMHC, 2022; Quastel et al., 2012). This trend, referred to as a form of eco-gentrification, has been well documented (Grant et al., 2020; Lees, 2003; Quastel et al., 2012; Rayle, 2015; Rérat and Lees, 2011; Rice et al., 2020; Zuk et al., 2018). Relatedly, the experience of cities that have implemented transit-oriented development (TOD), a purposeful urban planning practice whereby planners encourage densification and development within walking distance to transit, has also shown that introducing TOD generally raises land values (CMHC, 2022). For instance, TOD is often financed by investors and land developers with the expectations of rising land values (CMHC, 2022; National Academies of Sciences, Engineering, and Medicine [NASEM], 2004). Without purposeful affordable housing provision, low-income and otherwise marginalized households are commonly displaced from or kept out of TODs, or face exclusion in less visible forms (Lynott et al., 2017; Rayle, 2015; Zhao & Gustafson, 2013).

Assessments of the combined cost of transportation and housing point to the importance of providing affordable housing near transit for lower income households in particular (CMHC, 2022; Reed, 2019; Zhao & Gustafson, 2013). Reconnecting America's Center for Transit-Oriented

Development (RACTOD, 2007) positions TOD as an "unprecedented opportunity" to provide more affordable housing near transit. They argue that there is a demand for housing close to public transit by individuals from across the income spectrum, leading to accelerated increases in housing prices and rents; this finding is consistent with the eco-gentrification literature (Kramer, 2018). RACTOD (2007) points to a now common realization in policy circles that cost of living is a factor in housing and transport decisions, both of which are shaped by location. Access to cheaper housing in suburban areas, they note, is often offset or more than offset by transportation costs, which are higher in auto-dependent neighborhoods. Their conclusions are also borne out by studies analyzing the spatial dimensions of transportation and housing costs (e.g., Capital Region District [CRD], 2020).

Overall, there is a growing consensus that environmental and social sustainability goals need to be considered together in housing strategies (Colantonio & Dixon, 2010; Cuthill, 2010; Dempsey et al., 2011; Shirazi et al., 2022; Winston, 2010). This, however, tends to be the exception rather than the norm (Angelo et al., 2022; Winston, 2022). Although reducing commute times and distances are important for reducing emissions, there is a deep disparity in how commutes are experienced. Individuals who are from low-income groups, immigrants, members of a visible minority group, or live in substandard housing are significantly more likely to experience "extreme commuting," especially in terms of commute duration, often spending over 60 minutes on one-way commutes (Allen et al., 2022). This is somewhat paradoxical given that low-income earners are more likely to commute shorter distances than the general population; differences in commute times associated with public transit versus the car, for instance, may play some role (Cui et al., 2019).[1] Yet, according to Walks (2015), "across all transport modes, social effective speeds are considerably lower for poor households, by roughly 35 per cent on average across all CMAs, in comparison with all households" among low-income transit users and drivers (p. 145).

There is growing recognition that disparities in commuting are linked, in part, to the growing promotion, and—in some cases—the active embrace, of compact urbanism to help curb carbon emissions to achieve climate change goals (Nieuwenhuijsen, 2020). As locations with greater transit accessibility and walkability have gained in popularity, costs of living in these locations have also tended to increase (Rigolon & Collins, 2023). Despite the ostensible goals of compact urbanism to reduce land consumption, trip distances and automobile reliance, the lack of protection for maintaining housing affordability has achieved the opposite in some cases. Scholars find that, in a context where government intervention in the housing market has declined substantially due to neoliberal restructuring, more amenity- and transit-rich locations in cities have become increasingly gentrified (Grant et al., 2020; Moos, Vinodrai, et al., 2018; Rigolon & Collins, 2023).

The implication of this phenomenon is that those who are most reliant on public transit—low-income, racialized, and systemically marginalized individuals and groups—face increased housing displacement and consequently longer commute times (Allen et al., 2022; Jones & Ley, 2016; Walks et al., 2021). As a result, housing options for lower-income individuals are increasingly restricted to auto-dependent areas. Thus, according to Walks (2015), the continued prevalence of driving among low-income people "is increasingly because they are concentrated in places where driving is the only viable option" (p. 148). This reinforces Kramer's (2018) argument that the reduced level of convenience, reliability and speed facing people who cannot afford to drive reinforces the dominance of the car within an unequal "mobility regime" (p. 2). Thus, because of a lack of cohesion between social and environmental planning, those who are most willing to use, or are reliant on, public transit are structurally motivated into car use over time, if they can afford it (Prayitno & Moos, 2022).

Various policy solutions exist to address eco-gentrification and the lack of available affordable housing, but most focus on market-based approaches aimed at stimulating housing supply (Wetzstein, 2022). The counterargument to these policies is that affordability issues are fundamentally a structural problem related to financialization and other forms of neoliberalization in housing and labor markets. It is often argued that market-based approaches alone are unlikely

to improve affordability, resulting in renewed emphasis on the need for subsidized housing and affordability requirements in transit-oriented housing developments (Been et al., 2019; Dawkins & Moeckel, 2016). Winston (2022) positions subsidized, affordable housing as an essential component of any climate plan, as low-income populations "experience multiple social and environmental deprivations" that enhance their probability of being the most severely impacted by the "risks associated with climate change while having the least resources to cope with them" (p. 192). The overall context set by the literature is that subsidized housing would provide an opportunity to address social and environmental policy goals by facilitating greater access among low-income earners to transit- and amenity-rich areas. The outcome depends, however, on several aspects specific to each metropolitan context. We consider these trends specifically in Montreal, Toronto, and Vancouver next.

Metropolitan Social Geographies and Transit-Induced Gentrification in Toronto, Montreal, and Vancouver

Like other North American cities, Toronto, Montreal, and Vancouver have experienced the growing suburbanization of poverty, with spatial concentrations of low-income residents increasingly located in less-accessible suburban neighborhoods (Ades et al., 2016; Allen et al., 2022; Grant et al., 2020). The suburbanization of poverty is largely driven by inner-city gentrification that has occurred over the past four decades (Couture & Handbury, 2020; Jones, 2023; Kramer, 2018; Ye & Vojnovic, 2020). This shift in the geographies of poverty in Toronto, Montreal, and Vancouver has been accompanied by increasing disparities between the lowest- and highest-income neighborhoods, resulting in rising racial and ethnic segregation and income polarization (Grant et al., 2020).

Increasing sociospatial polarization of Canadian cities links directly to public policy changes that have encouraged the financialization and commodification of housing. Evidence from Canada's largest cities has shown that the financialization of housing has had negative impacts on the rental housing sector, resulting in the increased conversion of rental units to condominiums, the loss of older rental units, and the growing concentration of rental building ownership by "financialized" large corporate landlords, and the neglect of existing rental units (August & Walks, 2018; Walks, 2014). In practical terms, this has meant that the housing options available to lower income populations are increasingly restricted to neighborhoods with high automobile dependency and limited or insufficient public transit access, as well as the few areas where subsidized housing remains in proximity to transit (Allen & Farber, 2019; August & Walks, 2018).

This phenomenon, what Allen and Farber (2019) refers to as "transport poverty," is not just geographically linked, but tied to a particular built form (high-rise towers), which is most apparent in dense, low-income, tower neighborhoods "located off of the main axes of transit supply … [or] … wherever low-income populations live in low-density suburban urban forms across the nation [Canada]" (p. 215). The correlation between transit poverty and high-rise towers is not surprising given that high-rise towers in the suburbs are increasingly becoming the only affordable option for low-income renters (August & Walks, 2018). However, it is important to note that many lower income earners continue to rely on transit despite service deficiencies because they cannot afford cars, and walking/cycling are much less feasible in low-density suburban settings (Prayitno & Moos, 2022; Walks, 2015).

There is a correlation between lower rents and limited transit access, as well as between higher rents and access to a greater diversity of modes of travel in Canadian metropolitan areas, as gentrification has become increasingly associated with specific transportation advantages (Kramer, 2018; Moos, Prayitno, et al., 2018). Kramer (2018), citing a vast literature on the connection between transit development and gentrification, describes transit-oriented gentrification (or eco-gentrification) as the rising land costs, higher rents and subsequent displacement that have accompanied transit investment and the movement toward car-light lifestyles, alongside the

promotion of creative, livable cities. This relationship between transit accessibility and rents points to how the financialization of housing is associated with the commodification of housing in particular locations within metropolitan regions, with access to public and active forms of transportation. Without the clear prioritization of equity within TOD, state-supported TOD planning has arguably been an important factor in contributing to growing spatial inequalities in the Canadian metropolitan context and points to the limits of market-based mechanisms in achieving social equity goals (Biggar & Friendly, 2022; Grant et al., 2020; Moore, 2013; Zuk et al., 2018).

Vancouver provides a clear case study of the need for equity prioritization in TOD planning and housing development (Jones, 2023). A 2015 study of Canada's largest cities found a positive relationship between urban rail transit stations and gentrification in Toronto and Montreal, but not Vancouver, where it appeared poverty was spreading along the SkyTrain line (Grube-Cavers & Patterson, 2015). This is because the corridor around the SkyTrain contained a sizable stock of affordable and large apartment units built using federal and provincial tax incentives between the 1950s and the early 1980s (Jones & Ley, 2016). Like Toronto and Montreal, aging postwar apartment buildings in Vancouver are an important source of affordable and large enough shelter for low-income families, including recent immigrants and refugees (Jones, 2023; Jones & Ley, 2016). However, this is beginning to change with what Jones and Ley (2016) describe as "state-endorsed transit-oriented condominium redevelopment" (p. 3). Jones and Ley (2016) argue that the implementation of TOD plans in Vancouver, alongside the subsequent replacement of crucial old-stock rental apartments with condominiums, has resulted in the "elevation of environmental sustainability over social sustainability," aggravating class and racial inequalities (p. 3).

It is important to note that Montreal is somewhat less divided than Toronto and Vancouver, partly because some of the displacement that traditionally accompanies gentrification has been avoided due to the substantial amount of subsidized housing in or near gentrifying neighborhoods (Grant et al., 2020, p. 120). The geography of subsidized housing in Montreal is a result of government policy to build public housing in smaller, more dispersed projects and "partly as the outcome of local housing activism to transform private rental buildings into housing cooperatives" (Grant et al., 2020, p. 120). Although the case of Montreal demonstrates how subsidized housing in transit-accessible locations has proven to be successful in minimizing displacement, the current rise in condominium development and the loss of aging subsidized and private rental units has meant that Montreal is becoming more similar to Toronto and Vancouver in terms of income inequality (Grant et al., 2020, p. 120). The impact of TOD plans that lack adequate protections for existing rental stock are deeply racialized and classed in all three cities. Certainly, Canadian evidence points to growing inequities over who has access to the more sustainable commuting options promoted under climate change plans, TOD, and compact urban policies. Whether subsidized housing facilitates more sustainable commute patterns, from an environmental perspective, remains partly a question of the specifics of subsidized housing, which we turn to next.

Contextualizing Subsidized Housing in the Toronto, Montreal, and Vancouver Metropolitan Regions

It is important to understand the context of subsidized housing provision and policy that shapes the geography of housing and thus commute patterns before embarking on a numerical analysis. In Canada, metropolitan regions are actively shaped by housing policies at the national and provincial level. Although there is some local variation, it is well established by scholars that investments and policies made by federal and provincial governments largely determine the direction of urban housing policy, particularly when it comes to the delivery of housing subsidies and its associated housing stock (Filion, 2001; Jones, 2023; Suttor, 2016). We provide a brief

overview and discussion of the broader Canadian context, followed by a discussion of provincial policies in Ontario, Quebec and British Columbia that inform housing policy and subsidies in the Toronto, Montreal, and Vancouver metropolitan regions, respectively.

Canada has a dualist rental housing system, meaning that access to subsidized housing is restricted primarily to individuals below an established income threshold. Despite the differentiation made between subsidized housing and market rental housing, publicly provided housing in Canada does not have the same history or narratives of stigmatization that have accompanied US public housing projects (Suttor, 2016, p. 70). Explanations for this difference rest partly on Canada's political environment, which has generally been more receptive to government social policy interventions. In addition, Canadian social housing policy historically promoted a dispersion strategy aimed at avoiding perceived issues of concentrated poverty observed in the US public housing context (Suttor, 2016, p. 70). This is not to say that stigmatization of lower-income areas does not occur in Canada—indeed, it has risen with the increasing sociopolarization of Canadian cities—but social housing and private rental housing markets were at least historically "little differentiated in the public mind" (Suttor, 2016, p. 71). Although subsidized housing in Canada continues to be relatively more dispersed than in the US, in the context of the three metropolitan areas studied here, subsidized housing is still relatively more centralized than the rental market in general.

Subsidized housing accounts for only 6% of Canada's housing stock, with nonmarket rental housing accounting for most units (Housing Services Corporation, 2014). Despite the relatively small proportion of housing stock, subsidized housing is an important source of affordable housing for low-income Canadians navigating an increasingly unaffordable housing market (Suttor, 2016, p. 7; Walks et al., 2021). Canada's investments in subsidized housing have largely followed global trends, with increases alongside the expansion of the welfare state, and decreases accompanying the austerity politics of the 1980s and 1990s.

Suttor's (2016) historical account of Canadian social housing policy delineates three eras of social housing policy (pp. 47–126), which are generally observed in all three metropolitan regions under study—of course, with some variations in part due to differences in provincial and urban policy context (Filion, 2001; Germain & Rose, 2000; Quastel et al., 2012). The first period is characterized by the dramatic expansion of annual production of social housing, beginning in the mid-1960s and sustained at high levels over the next three decades until the mid-1990s. During this period, social housing policy was relatively consistent across the country and led by the federal government. An important feature of this period was the transition away from traditional government-developed public housing to social housing produced and managed by community not-for-profits and co-ops. This policy shift has had a lasting impact, as most of the social housing in Canada's three most populated provinces and their largest metropolitan regions is not-for-profit or co-op style housing (Suttor, 2016, p. 76).

Suttor (2016) describes the second period as one of devolution and retrenchment, which saw the withdrawal of the federal government from new social housing production during the 1990s (p. 125). The responsibility for existing social housing stock was downloaded to provincial governments, leading to divergence in provincial social housing programs and policy approaches. In Canada, this devolution of social policies to the provincial level occurred nearly two decades later than in the United States, spurred by the economic recession of the early 1990s and a corresponding austerity agenda. The third period, beginning in the early 2000s and continuing today, can be characterized by modest federal and provincial government reengagement with affordable housing programs without a wholesale reversal of the retrenchment policies instituted in the 1990s (Suttor, 2016, p. 151). A wide variation between provincial social housing programs persists today, and we highlight key policy differences across provinces—and, therefore, in Canada's three largest cities—in our discussion below.

Across Canada, the retrenchment of senior levels of government from subsidized housing provision has led to the decline of building conditions, a reduction in subsidized housing stock and

a ballooning of waiting lists. This is particularly true in Ontario, where more people are currently on a waiting list than are housed in subsidized housing (Ministry of Housing, 2018). Most subsidized housing is tied to a physical unit; for instance, 93% of Ontario's existing supply of below-market rentals were built by not-for-profit organizations between the 1960s and 1996 (Ministry of Housing, 2018). In 2017, Ontario introduced legislation allowing portable subsidies that can be applied toward market-rate rents in nonsocial-housing units. However, the data used in this paper were collected by Statistics Canada prior to this policy change; thus, this paper focuses on subsidized housing tied to physical units and does not account for this newer portable subsidy program.

Both Quebec and British Columbia maintained provincial funding assistance programs for social housing after the withdrawal of the federal government in the 1990s (Suttor, 2016, p. 140). Quebec offers subsidized housing primarily through RGI housing and a rental supplement program. As in Ontario, rent supplements are primarily tied to specific units and are not portable. By contrast, British Columbia is often identified as one of the few provinces that have been able to maintain some level of social housing production after the federal government withdrawal in the 1990s. However, it has been argued that because most units that have been added are emergency short-term housing, the programs have not contributed to an increase in long-term subsidized housing stock (Lee, 2022). British Columbia has three main areas of subsidized housing provision, distributed as follows: emergency and temporary housing (approximately 30%); subsidized housing units for low-income residents (nearly 40%); and rental assistance in the private market (nearly 30%) (BC Housing, 2022; BC News, 2017). These high levels of rental assistance are due to the provincial Shelter Aid for Elderly Renters program, which offers rental supplements to seniors living in specific elderly community homes. This portable rental assistance program accounts for around 8% of households supported in the province; however, such individuals are excluded from our analysis, due to our focus on commuting and, therefore, on only employed renters that are under 65 years old.

Methods

With this context in mind, we turn to answering the question of whether working-age, employed individuals residing in subsidized housing have shorter commute distances and lower shares of automobile commutes as compared to otherwise similar renters in Canada's largest three metropolitan areas, drawing on data from the 2016 Canadian census. In 2016, Statistics Canada introduced a new question in the Census of Population questionnaire that asked renters to identify if they live in a subsidized dwelling. Statistics Canada (2017) defines subsidized housing as "referring to whether a renter household lives in a dwelling that is subsidized. Subsidized housing includes rent geared to income, social housing, public housing, government-assisted housing, non-profit housing, rent supplements and housing allowances." To our knowledge, there is no other analysis focused on this unique variable. Our analysis focuses on Canada's three largest urban regions (Toronto, Montreal, and Vancouver) defined by CMAs. A CMA is a spatial definition established by Statistics Canada based on commuter flows to and from a central city and therefore includes urban, suburban, and exurban communities. Because of our interest in commuting (i.e., the journey to work), we only include working-age, employed renters, therefore excluding those who are unemployed, as well as those more than 65 years old, to avoid complexities related to seniors' housing and the accompanying social housing policies targeted to this specific demographic.

Our hypothesis is that working-age, employed renters in subsidized housing will have shorter and less auto-oriented commuting patterns. This is based on several conditions specific to these metropolitan areas. First, although much of the subsidized housing stock in Canada's largest cities is commonly understood to be insufficiently served by transit in terms of frequency and

network coverage, much of this housing was developed during a period of urban expansion that emphasized locating public goods and services in relatively amenity- and transit-rich areas (Filion, 2001; Grant et al., 2020). Subsidized housing is thus arguably relatively more centralized compared to the overall rental market in these three metropolitan regions; this is also confirmed in our mapping and analysis of location quotients at the neighborhood level in Toronto, Montreal, and Vancouver (below).

Second, as noted, the variable capturing subsidized housing includes a wide range of location and nonlocation-based subsidies. As established in the preceding section, because the data are drawn from the 2016 census, the population under consideration (employed individuals who are 65 years of age or younger) would have accessed housing subsidies in the three metropolitan areas in the form of RGI or subsidized housing stock. This limits the possibility of bias in our analysis arising from the inclusion of subsidies that are not location based, such as portable rent subsidies. For example, portable subsidies permit more location flexibility, potentially leading to longer and more auto-oriented commutes; however, as noted above, prior research has explored the importance of transit access in lower income households' location decisions, indicating that dispersal may not be likely anyway (e.g., Dawkins et al., 2015).

We approach our statistical analysis in the spirit of strategic postpositivist approaches that utilize quantitative evidence to make a case for social and environmental policy (Wyly, 2009), rather than using models to establish causal relationships that hold true regardless of societal context. We build two logistic regression models to explore the relationship between subsidized housing and more sustainable commutes. Logistic regression models compare the probability of response variable outcomes as a function of several explanatory variables and are frequently used in these types of analyses (Sperandei, 2014). Regression coefficients show the probability of the response variable outcome with each explanatory variable. As is common with logistic regressions, we report the results in the form of odds ratios to facilitate interpretation. Odds ratios greater than 1 indicate a higher probability of longer or more auto-oriented commutes relative to the base category, whereas odds ratios below 1 indicate a lower probability. We calculate expected commuting patterns for those with and without subsidies based on marginal effects, holding other variables constant.

The first model is a binary logistic regression that compares the probability of an individual commuting by car as compared to public transit as a function of whether the individual lives in subsidized housing, and demographic and labor market characteristics well known to influence commuting (Horner, 2004; Shearmur, 2006; Walks, 2015). Specifically, the model includes explanatory variables for sex, immigration status, visible minority status, total income from all sources, household composition, the presence of children, and industry of work to account for many of the factors that could explain differences in commuting behavior among renters other than the housing subsidy. Although the Canadian census includes variables on other commuting modes as well, we restricted the comparison to commuting by car (as driver only) versus public transit, as the share of walking/cycling/other among individuals receiving housing subsidies in each metropolitan area was too small to produce robust model outcomes.

The second regression is an ordered logistic regression model that compares the probability of different commute distances as a function of whether the individual lives in subsidized housing, as well as accounting for demographic and labor market characteristics known to influence commuting (Walks, 2015). The demographic and labor market characteristics included in the ordered logistic regression model are the same as in the binary logistic regression. Both regressions include a CMA variable to hold constant place-specific differences. An ordered logistic regression had to be used (as opposed to a linear regression) as the publicly available census data only provide information on commuting distance in predetermined, discrete categories.

Findings

According to the 2016 data, Toronto had the highest proportion of tenants living in subsidized dwellings (14.6%), compared to Montreal (8.1%) and Vancouver (13.1%). Average shelter costs are lower for those in subsidized dwellings compared to nonsubsidized housing in all three cities: Toronto ($785 vs. $1,501), Montreal ($674 vs. $975) and Vancouver ($995 vs. $1,495). A linear regression with shelter costs as response variable and number of bedrooms, dwelling type, repair status, census metropolitan area, and subsidy as explanatory variables shows that shelter costs are $527 lower on average for those residing in subsidized dwellings compared to other renters ($p < .001$, model details not shown for brevity). These results indicate that costs are lower not only because of differences attributable to the dwelling characteristics. Subsidized housing could thus be expected to allow people to access housing that would otherwise exceed their budget constraints. Although potentially intuitive, it cannot be assumed that shelter costs would be lower for those in subsidized housing than for otherwise similar renters, as those without subsidies may locate in lower cost areas (at the cost of a longer commute), and/or market-based housing could be of different quality. In theory, lower shelter costs could also mean that subsidized households have relatively more budget available that could be allocated toward commuting, including car ownership. Because the residential location becomes fixed for those in subsidized housing, it may limit employment search and/or result in longer commutes. For instance, if employment is highly suburbanized and subsidized housing more centralized, the household may have a longer commute than if they were able to locate based on a trade-off between residential location and commuting decisions. For these reasons, the net effect of subsidized housing on aggregate commuting patterns cannot be directly inferred but must be empirically measured via a modelling exercise that controls for these differences.

Table 1 provides a summary of the variables included in the regression models, comparing renters in subsidized and nonsubsidized dwellings. These data confirm prior findings from the literature on the characteristics of people living in subsidized housing (Claveau, 2020). Those living in subsidized housing are more likely to be female, immigrants, and visible minorities as compared to renters in nonsubsidized housing. Those renters in subsidized housing are also more likely to be lone parents, couples without children or living alone, and living in the Toronto CMA. Differences across industries are less pronounced in magnitude but still different from zero at a statistically significant level ($p < .001$). Those living in subsidized housing are more likely to work in retail trade, administration and support in waste management, health care and social assistance and accommodation and food services, industries that are known to have high proportions of low-wage work.

Those living in subsidized housing are less likely to work in finance and insurance, or in the professional, scientific, and technical services industries. Not unexpectedly, there are also pronounced income differences, with renters in subsidized housing more likely in the lowest income quartile. From what is known about commuting from prior literature (e.g., Banister, 2018), and based on the characteristics of the metropolitan areas' social geographies described above, we would expect people living in subsidized dwellings to have shorter (in terms of distance) and less auto-oriented commutes than other renters. Using regression models allows us to control for these differences to determine whether there are differences in the commute (distance and mode) attributable to living in a subsidized dwelling. It is important to emphasize, though, that the empirical analysis on its own can only speak to an association, not causation.

It is also important to understand the underlying geography of subsidized housing across the three cities included in our analysis. Figures 1–3 show the relative concentration of subsidized housing across the Toronto, Montreal, and Vancouver CMAs, respectively. Using location quotients comparing the proportion of renters living in subsidized dwellings to the metropolitan average, we show where there are higher concentrations of subsidized dwellings across each of the three CMAs. Notably, there are lower concentrations in the central cities that have

Table 1. Comparing renters in subsidized and nonsubsidized dwellings in Canada's three largest metropolitan regions: percentage of employed renters under 65 years of age.

	Renters		
	Subsidized housing		
	No	Yes	*p* value
Socioeconomic characteristics			
Female	50	55	***
Immigrant	38	40	***
Visible minority	44	62	***
Household Income (CAD $)			
<15,000	23	33	***
15,000–31,999	21	21	
32,000–58,999	22	11	
>59,000	34	35	
Household			
Couple without children	22	9	***
Couple with children	28	26	
Lone parent	9	24	
Living alone	24	33	
Living with nonrelatives only	13	5	
Not in census family but with other relatives	4	3	
CMA			
Montreal	39	27	***
Toronto	41	53	
Vancouver	20	20	
Industry			
Agriculture, forestry, fishing and hunting	0	0	***
Mining, quarrying, and oil and gas extraction	0	0	
Utilities	0	0	
Construction	6	5	
Manufacturing	8	6	
Wholesale trade	4	3	
Retail trade	12	15	
Transportation and warehousing	5	6	
Information and cultural industries	4	3	
Finance and insurance	5	3	
Real estate and rental and leasing	2	2	
Professional, scientific, and technical services	10	5	
Admin and support, waste management	7	9	
Educational services	7	6	
Health care and social assistance	10	12	
Arts, entertainment, and recreation	3	3	
Accommodation and food services	10	14	
Other services (except public administration)	5	7	
Public administration	3	3	

Note. CMA = census metropolitan area. Numbers may not add to 100% due to rounding.
Source. Authors' calculations based on the 2016 Census Public Use Microdata File. Includes all individuals who are renters, employed, and under the age of 65.
*$p < .1$. **$p < .01$. ***$p < .001$.

undergone substantial gentrification over the past decades. The nature of census tract maps (where larger size of tracts corresponds with lower population densities) distorts the fact that there are many tracts with location quotients above 1.2 in the inner city and older suburbs. Areas in the outer suburbs with higher location quotients are areas also known to be better served by transit compared to other outlying areas. However, based on the geography alone, it is admittedly still unclear how the spatial distribution of subsidized dwellings (as compared to other renters) would materialize in differences in commuting patterns.

Table 2 shows the differences in commute distance and mode for all three metropolitan areas combined. Differences in commuting patterns between those in subsidized and those in nonsubsidized housing differ from zero at statistically significant levels (chi-squared tests). Differences in the magnitude of the commute distance appear small, although the

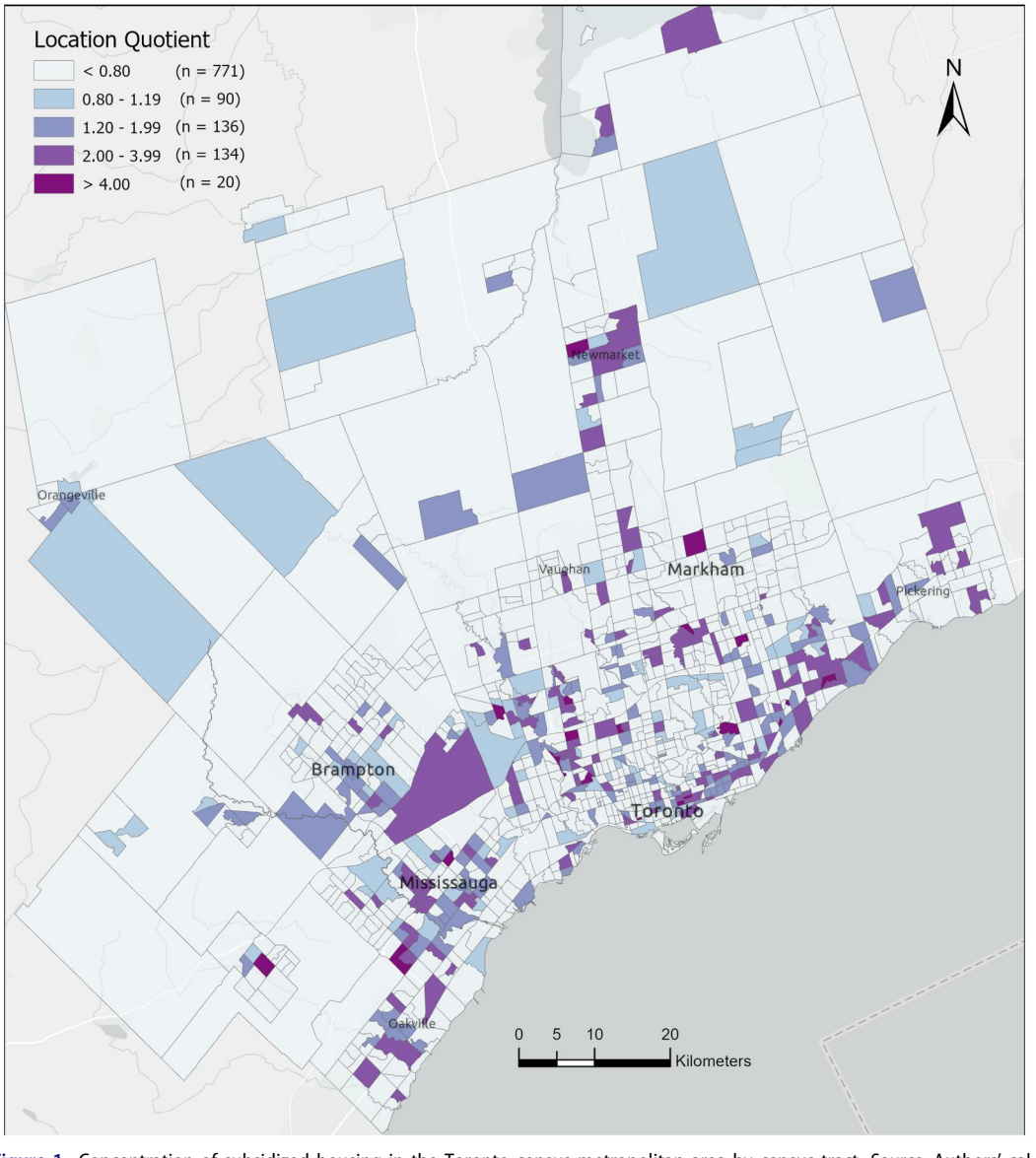

Figure 1. Concentration of subsidized housing in the Toronto census metropolitan area by census tract. *Source.* Authors' calculations based on the 2016 Statistics Canada Census Tract Data.

categorical nature of the data may mask some of the differences. Forty-three percent of those in nonsubsidized dwellings commute less than 5 km to work, as compared to 46% of those living in subsidized dwellings.

In terms of commute mode, the most apparent differences between renters in subsidized versus nonsubsidized dwellings are visible in the "car, truck, van as driver" and "public transit" categories. Forty-six percent of those in nonsubsidized housing commute by car, truck, or van as drivers, compared to 37% among those in subsidized dwellings. Thirty-five percent of those in nonsubsidized dwellings commute by public transit as compared to 44% of those residing in subsidized dwellings. There are few to no differences in the other commute mode categories between renters in subsidized versus nonsubsidized dwellings.

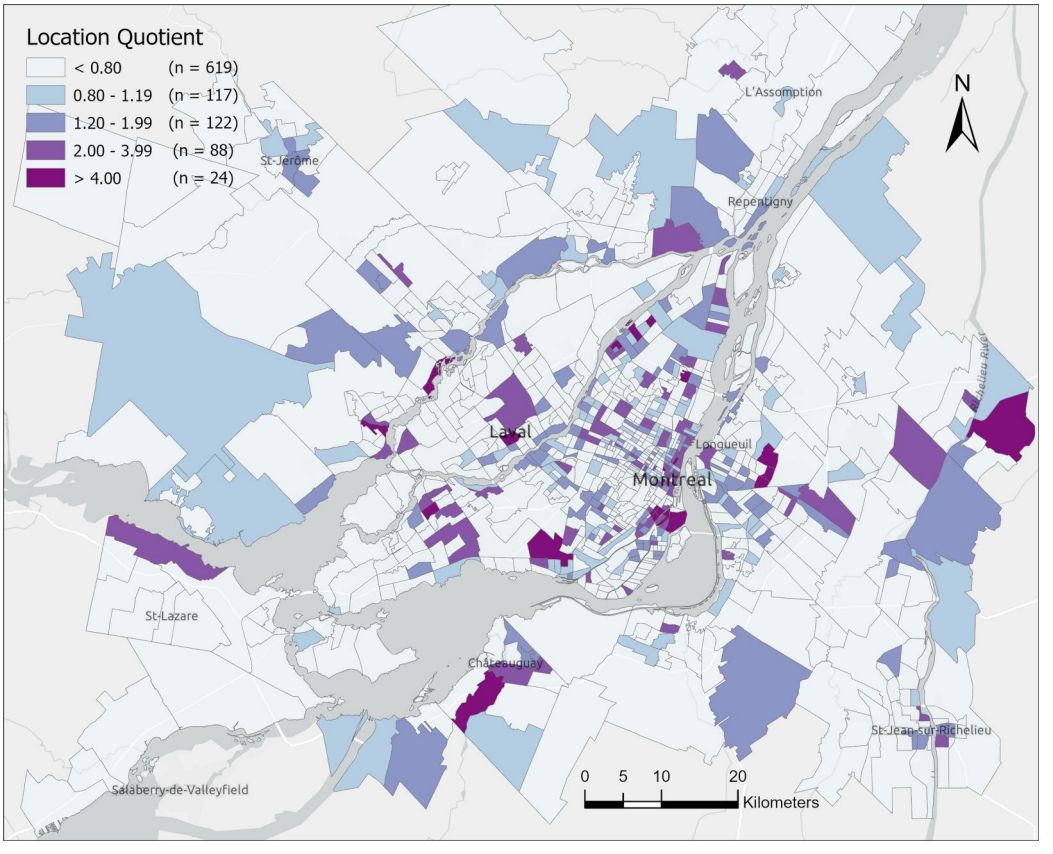

Figure 2. Concentration of subsidized housing in the Montreal census metropolitan area by census tract. *Source.* Authors' calculations based on the 2016 Statistics Canada Census Tract Data.

Model Results

We now turn to the regression model findings that test whether the observed differences in commute distance and mode are associated with residing in subsidized housing, as compared to other factors that have an impact upon commute distance and mode. The models also include variables for the census metropolitan areas to test whether any differences are attributable to differences in commuting patterns inherent to metropolitan specific characteristics, and we include interaction effects to test whether the relationship between subsidized housing and the commute differs by CMA. We also include interaction effects between income and subsidized housing. This allows us to see how the subsidy is associated with commute patterns at different income levels. Ideally, we would be able to compare the commute patterns between those eligible for but not living in subsidized housing with the commute patterns of those residing in subsidized housing. Although our data do not include a variable on eligibility, the interaction effects ensure we compare the relationship between subsidized housing and commuting for specific income brackets as a proxy for subsidy eligibility, because eligibility for subsidy programs in Toronto, Montreal and Vancouver is primarily determined by income.[2]

Table 3 shows the results from the ordered logistic regression with commute distance as the categorical response variable. The odds ratios indicate how the probability of a longer/shorter commute is influenced by each explanatory variable compared to the base. For instance, the coefficient (1.24) for "Male" indicates that males have higher odds of a longer commute as compared to females. As indicated by the odds ratio below 1, living in a subsidized dwelling is

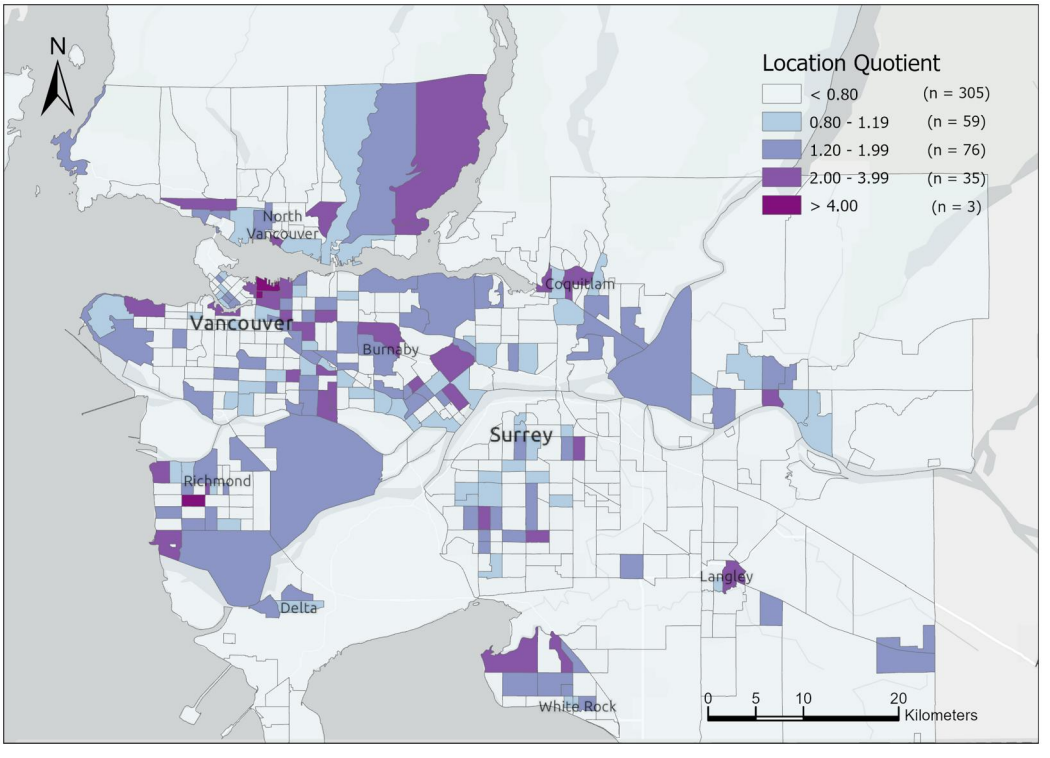

Figure 3. Concentration of subsidized housing in the Vancouver census metropolitan area by census tract. *Source.* Authors' calculations based on the 2016 Statistics Canada Census Tract Data.

Table 2. Commuting distance and mode for renters in subsidized and nonsubsidized dwellings in Canada's three largest metropolitan regions: percentage of employed renters under 65 years of age.

	Subsidized housing		
	No	Yes	*p* value
Commute distance			
Less than 5 km	43	46	**
5–9.9 km	26	27	
10–14.9 km	14	13	
15–19.9 km	7	6	
20–24.9 km	4	4	
25–29.9 km	2	2	
Greater or equal to 30 km	4	3	
Commute mode (all)			
Car, truck, van as driver	46	37	***
Car, truck, van as passenger	4	5	
Public transit	35	44	
Walked	10	10	
Bicycle	3	2	
Motorcycle, scooter o	0	0	
Other modes	1	1	
Commute mode (select)			
Car, truck, van as driver	56	45	***
Public transit	44	55	

Note. Numbers may not add to 100% due to rounding.
Source. Authors' calculations based on the 2016 Census Public Use Microdata File. Includes all individuals who are renters, employed, and under the age of 65.
*$p < .1$. **$p < .01$. ***$p < .001$.

Table 3. Ordered logistic regression results: Commute distance for employed renters under 65 years of age.

Variable	Odds ratio	*p* value
Male	1.24	***
Immigrant	0.94	*
Visible minority	1.14	***
Couple with children	1.15	***
Lone parent	1.16	***
Living alone	0.77	***
Living with nonrelatives only	0.77	***
Not in census family but with other relatives	1.06	
Subsidized housing	0.67	**
15,000–31,999	1.01	
32,000–58,999	1.30	***
>59,000	1.37	***
Subsidized * (15,000–31,999)	1.25	
Subsidized * (32,000–58,999)	0.96	
Subsidized * (>59,000)	1.43	
Toronto CMA	1.20	***
Vancouver CMA	0.97	
Subsidized * Toronto CMA	1.14	
Subsidized * Vancouver CMA	1.12	
Mining, quarrying, and oil and gas extraction	2.82	
Utilities	1.36	
Construction	1.19	
Manufacturing	0.88	
Wholesale trade	0.88	
Retail trade	0.46	***
Transportation and warehousing	1.07	
Information and cultural industries	0.47	***
Finance and insurance	0.58	**
Real estate and rental and leasing	0.46	***
Professional, scientific, and technical services	0.52	**
Admin and support, waste management	0.79	
Educational services	0.53	**
Health care and social assistance	0.55	**
Arts, entertainment, and recreation	0.47	***
Accommodation and food services	0.40	***
Other services (except public administration)	0.49	**
Public administration	0.70	
/cut1	−0.55	
/cut2	0.60	
/cut3	1.41	
/cut4	2.06	
/cut5	2.60	
/cut6	3.04	

Note. CMA = census metropolitan area. Number of obs. = 37,185 LR $chi^2(30)$ = 2239.82 Prob > chi^2 = 0.0000 Log likelihood = 0.0198.

Source. Authors' calculations based on the 2016 Census Public Use Microdata File. Includes all individuals who are renters, employed, and under the age of 65.

*$p < .1$. **$p < .01$. ***$p < .001$.

associated with lower odds of a longer commute as compared to renters living in market housing. This confirms that the findings from the descriptive analysis above still hold even when we account for other factors that influence the commute. The interaction effects show that the effect of the subsidy does not vary by income level or CMA.

The remainder of the results are mostly in line with expectations based on prior research. Commute distance tends to be shorter for immigrants. Visible minority status is associated with longer commute distances, perhaps a function of the social geography of Canada's metropolitan areas that see large clusters of ethnic concentrations in the suburbs where commute distances tend to be longer (as compared to the core). Higher income is associated with longer commute distances. In terms of household composition, those living alone or with nonrelatives tend to have shorter commutes. Those in Toronto tend to have longer commutes, as compared to

Montreal. There are also clear demarcations by industry. For example, working in accommodation and food services and retail trade industries, which are more represented among renters in subsidized dwellings, is associated with commutes of shorter distance. Interestingly, and consistent with the literature, the model also shows lower odds of a longer commute for those working in cultural industries, finance and insurance, arts, entertainment and recreation, and other industries often associated with eco-gentrification (Jones & Ley, 2016).

Table 4 shows the outcome from the logistic regression analysis that considers commute mode ("car, truck or van as driver" vs. "public transit") for employed, working-age renters as a function of the explanatory variables. Similarly, as with the ordered logistic regressions, coefficients are shown as odds ratios, interpreted as changes in the odds of one commute mode over another. The variable for subsidized housing shows an odds ratio above 1 at a statistically significant level. That is to say that those living in subsidized dwellings have higher odds to commute by public transit (vs. the car) as compared to renters who do not live in subsidized dwellings even after accounting for other explanatory variables that could explain the difference. The

Table 4. Logistic regression results: Commute mode for employed renters under 65 years of age.

Public transit (vs Car as driver)	Coefficient	*p* value
Male	0.54	***
Immigrant	1.38	***
Visible minority	1.42	***
Couple with children	0.60	***
Lone parent	0.56	***
Living alone	1.18	***
Living with nonrelatives only	1.73	***
Not in census family but with other relatives	1.33	***
Subsidized housing	1.46	*
15,000–31,999	0.92	*
32,000–58,999	0.66	***
>59,000	0.50	***
Subsidized * (15,000–31,999)	0.79	
Subsidized * (32,000–58,999)	0.79	
Subsidized * (>59,000)	0.98	
Toronto CMA	1.25	***
Vancouver CMA	0.86	***
Subsidized * Toronto CMA	1.01	
Subsidized * Vancouver CMA	0.92	
Mining, quarrying, and oil and gas extraction	1.27	
Utilities	2.14	*
Construction	0.80	
Manufacturing	1.39	
Wholesale trade	1.46	
Retail trade	2.30	**
Transportation and warehousing	0.90	
Information and cultural industries	4.14	***
Finance and insurance	5.47	***
Real estate and rental and leasing	1.72	*
Professional, scientific, and technical services	4.33	***
Admin and support, waste management	2.63	***
Educational services	2.57	***
Health care and social assistance	2.17	**
Arts, entertainment, and recreation	2.46	**
Accommodation and food services	3.25	***
Other services (except public administration)	2.21	**
Public administration	2.93	***
Constant	0.43	**

Note. CMA = census metropolitan area. Number of obs. = 35,556 LR $chi^2(30)$ = 4990.523 Prob > chi^2 = 0.0000 Log likelihood = 0.1040.

Source. Authors' calculations based on the 2016 Census Public Use Microdata File. Includes all individuals who are renters, employed, and under the age of 65.

*$p < .1$. **$p < .01$. ***$p < .001$.

Table 5. Predicted[a] and actual commute distance and mode (%).

	Predicted		Actual	
	Subsidized housing		Subsidized housing	
Commute distance	No	Yes	No	Yes
Less than 5 km	41	51	43	46
5–9.9 km	28	26	26	27
10–14.9 km	14	11	14	13
15–19.9 km	7	5	7	6
20–24.9 km	4	3	4	4
25–29.9 km	2	1	2	2
Greater or equal to 30 km	4	3	4	3
	Predicted		Actual	
	Subsidized housing		Subsidized housing	
Commute mode	No	Yes	No	Yes
Car, truck, van as driver	60	52	56	45
Public transit	40	48	44	55

[a]Calculated using marginal effects keeping other variables at their means. Calculations include all individuals who are renters, employed, and under the age of 65 in the Statistics Canada 2016 Census Public Use Microdata File.

interaction effects are not statistically significant, showing that the effect of the subsidy on commute mode also does not vary by income level or CMA.

In terms of other explanatory variables, females, immigrants, visible minorities, lower income earners and those without children present have higher odds of commuting by public transit. Renters in Toronto have higher odds of commuting by public transit, and those in Vancouver lower odds, as compared to Montreal. Some of the industries where higher proportions of renters in subsidized dwellings work, such as retail trade and accommodation and food services, show higher odds of public transit use. This is also true for industries such as information and cultural industries, finance and insurance, and professional, scientific, and technical services, again potentially arising from growing gentrification in transit-accessible areas found in prior research.

Table 5 shows the predicted commute distances and modes by housing subsidy, compared to the actual commute patterns. The predictions are calculated based on marginal effects, holding other variables in the regression models at their means. The predictions show a 10% difference among those commuting less than 5 km associated with living in subsidized housing. In terms of commute mode, the predictions show an 8% difference in public transit usage for living in subsidized housing. The models predict a higher share of commuters in subsidized housing with shorter and less auto-oriented commutes, when other explanatory variables are held constant at their means, showing the predicted effect of living in subsidized housing. Notably, the relationships between subsidized housing and commuting pattern found in the three specific CMAs also hold across Canada (not shown for brevity).

Conclusions

This paper contributes to understanding the relationship between living in subsidized housing and commute patterns. Prior research on TOD, combined housing and transport costs, and eco-gentrification note the land value uplift associated with development near transit. Low-income earners and otherwise marginalized populations are often displaced from or denied access to transit-accessible areas. Subsidized housing is often believed to be able to reduce this displacement. Our findings provide an exploratory empirical test that shows a statistically significant effect of living in subsidized housing on commuting patterns. We find living in subsidized housing to be associated with shorter and less auto-oriented commutes, holding constant other

factors that are known to impact the commute. Our findings provide another layer of evidence to existing studies that make a case for investment in subsidized housing as both urban housing affordability and climate policy (Nieuwenhuijsen, 2020; Walks, 2015).

It should be kept in mind that these are aggregate-level findings, which cannot account for whether subsidized housing projects were specifically and proactively sited near transit. In other words, greater reductions in the magnitude of commute distance and automobile use may be possible if subsidized housing is proactively incorporated into TOD, subsidized housing developments are expanded to keep pace with decentralizing employment, and transit systems are expanded to meet the needs of increasingly suburbanized transit-dependent populations. Although there is a common mantra for the need to coordinate land use and transportation planning, our work points more specifically to the need for coordinated *affordable* housing and *public* transportation planning.

Our analysis should be interpreted carefully and in a highly contextualized manner, not as an attempt to produce a universally generalizable causal relationship. Our analysis shows that, in the case of Canada's three largest metropolitan areas, subsidized dwellings appear to have been located in a manner that in aggregate lead to shorter and less auto-oriented commutes for employed, working-age renters compared to otherwise similar renters. Even though we cannot show causality analytically, the implications for policy are the same. In other words, our models can be interpreted to show that either living in subsidized housing induced relatively more sustainable commute patterns or that subsidized housing facilitates more sustainable commute patterns.

Thus, the generalizable conclusion beyond the specific case is that subsidized housing can facilitate shorter and more transit-oriented commutes *if* subsidized housing is provided in a manner that aligns its location with transit and amenity provision. In combination with prior research reviewed in this paper, and the specific characteristics of low-income earners who commonly rely on transit, the conclusion that building more affordable housing near transit would facilitate more sustainable commuting patterns appears entirely defensible. Of course, this also requires a reasonably well-established transit system that serves large parts of a metropolitan region. The findings should not be taken to mean that building subsidized housing "anywhere" will necessarily have the same effects as if built centrally—if, for instance, it is built in a much more dispersed metropolitan context with an ineffective or largely absent transit system—or that subsidized housing in Canada's largest metropolitan areas is adequately served by transit at this time.

The analysis in this paper is also important in that it sheds light on a relationship that has received little to no prior treatment in an empirical, quantitative manner: subsidized housing and more sustainable commutes. Additional research is required to help understand the specific dynamics that facilitate shorter distance and less car-centric commutes. Such research could explore the relationship between subsidized housing and specific public transit locations, the employment decisions of subsidized housing residents, and the circumstances of those in subsidized housing, including occupational status, access to other financial resources (e.g., family wealth) and income sources, access to vehicles, disability status, and—for immigrants—the length of time that they have resided in Canada. In other words, there may still be other factors specific to those living in subsidized dwellings that contribute to the differences in commute as compared to other renters. Further research is also required to consider how subsidized housing may compare to market-based housing in terms of other aspects of sustainability, such as LEED certification or net zero construction, and how results may vary among countries.

The specific analysis here does suggest that more sustainable commutes, associated with lower carbon emissions, are plausible in the context of the three largest Canadian metropolitan areas that—despite much intensification—also continue to see suburban expansion and where transit has largely not kept pace with metropolitan growth. In other words, larger gains may be possible if locating subsidized housing near transit was proactively incorporated into public policy. Investment in subsidized housing may very well act as a "two for one" policy, increasing

affordability and facilitating carbon emission reductions related to commuting. However, further research is also required on how subsidized and market housing would contribute to other aspects of sustainability and climate goals.

Notes

1. Although it has generally been established that commute distance increases with income (Banister, 2018; Cui et al., 2019), more recent research suggests growing complexity. Changing geographies of poverty occurring in North American cities may be increasing distance traveled for low-income commuters (Antipova, 2020; Blumenberg & Siddiq, 2023; Blumenberg & Wander, 2023; Islam & Saphores, 2022).
2. As a robustness test, we also conducted a regression analysis that predicts a household's probability of receiving subsidized housing (as a proxy for eligibility). This variable (probability of living in subsidized housing) was then used in the logistic regressions predicting commute distance and mode. The results are similar to the findings reported in the paper.

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