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Public transport and the built environment

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PUBLIC TRANSPORT AND THE BUILT ENVIRONMENT

Murtaza Haider and Ahmed El-Geneidy

Introduction

The economic, cultural, and social success of large and small cities, to an extent, depends upon the ease of mobility and accessibility to destinations. Modern metropolises are also known for their advanced transportation systems that enable accessibility and mobility. A glance at the populace and economically vibrant cities in Southeast Asia, Europe, and North America would reveal several common factors that contribute to their success. One of those factors is an efficient public transport system that provides comprehensive spatial coverage throughout the urban landscape. Densely populated cities like New York and Hong Kong cannot function without the elaborate public transport spatial networks that provide access to employment hubs during peak periods of travel.

Whereas comprehensive and efficient public transport systems have contributed to the economic and social success of cities across the globe, the presence of public transport-based mobility continues to be concentrated in a small number of large cities. In North America, despite the significant contribution of public transport-based mobility to enhancing economic and social outcomes in populous cities, public transport use is somewhat limited in mid- to small-sized cities. Meanwhile, the experience in mid- to small-sized European cities is different from the one in America such that commutes by public transport continue to account for a sizable proportion of all trips made.

Public transport use is more pronounced in cities of varying sizes in Europe but not as much in North America. Researchers have identified several reasons for the differences. The most cited difference between cities in Europe and North America is their respective built environments. European cities are known for their high-density, compact, mixed land uses, which researchers believe have enabled more extensive adoption of public transport. In comparison, except for larger and more populous cities, a limited number of North American cities, urban land use in North American cities is characterised by mid- to low-density, sprawling, and single-purpose land uses. Researchers point out that vintage matters for land use. The land use in European cities, most of which were predominantly built before the emergence of the private automobile or rail-based public transport, reflects the prevalent transport technology of their times. It has been argued that the maximum desirable commute throughout human history, irrespective of the transportation technology, has been 45 minutes (Garreau, 1991). This
implies that land use and the physical extent of the city from ancient Rome (when the mode of transportation was predominantly walking) to the modern mixed-mode transportation cities should be so that the desirable (average) commute times are less than 45 minutes.

It is argued that in addition to vintage, the scarcity of developable land is more pronounced in European cities than their North American counterparts, which made post-war development transpire at much higher densities in Europe. At the same time, comparatively higher gasoline taxes, parking charges, and other levies in Europe make mobility by private automobile significantly more expensive than it is in North America.

This chapter focuses, because of the availability of suitable data, on the relationship between the built environment and mobility by public transport in selected North American cities. The aim of this chapter is not to solely focus on how one can increase mobility by public transport in urban settings where travel by public transport has taken a backseat. Instead, this inquiry also focuses on the circumstances that make public transport not the preferred alternative for travellers, particularly because trips by public transport are, on average, much longer in duration than the comparable trips by private automobile, and with individuals assumed to be utility maximisers, the desire to optimise their utility often overshadows the desire to have the better societal outcomes that would come with public transport rather than car trips.

This chapter comprises two parts. First, the chapter undertakes a systematic literature review to determine how research in the past has addressed the relationship between the built environment and public transport. In the second part, the chapter focuses on empirical evidence, mostly in the form of spatially disaggregated demographic data, complemented with spatial measures of accessibility and travel behaviour to answer more nuanced questions. For instance, is public transport use in the newly built part of the traditionally public transport-dominated cities significantly higher than neighbourhoods of similar vintage in other cities not known for higher public transport use? The chapter concludes by identifying the enabling factors for better public transport outcomes and avenues for further exploration in the future.

What is known from the literature

A symbiotic relationship can be imagined between the built environment and public transport use. Public transport-supportive built form, the specifics of which are discussed later, can promote public transport use. Consequently, and over time, newly built higher-order public transport could influence the built environment in proximity of public transport stations. Hence, a bidirectional model of the built environment and public transport use emerges. The literature presented here, though not exhaustive, presents the essential themes that have come to define the prevalent “conventional wisdom” as it relates to how the built environment and public transport use are connected. Slightly divergent views from the literature are presented when empirical tests reveal weak or no association between the built environment and public transport use.

A cursory look at the academic and professional literature suggests that the contemporaneous correlation between proxies of the built environment and travel behaviour has been the most frequent output of studies exploring the determinants of public transport use. The built environment attributes, namely population or employment densities measured as persons or jobs per unit area at the neighbourhood, city, regional, or national level; housing density, intersection density, road-length or sidewalks per unit area, land use mix, and prevalence of non-residential land uses, such as retail, in the walking distance have served as proxies to describe built environment at varying spatial scales. Others have broadened the list by including public transport...
supply attributes, namely public transport service frequency and proximity to public transport stations, among others. Research has mostly documented that a compact built environment discourages travel by private automobile and encourages travel by public transport (Ewing & Cervero, 2017).

Cervero and Kockelman (1997) analyzed the travel mode choices for non-work trips for the residents in the San Francisco Bay Area and concluded that the built environment attributes, clustered as density, land-use diversity, and design (3Ds), are correlated with travel behaviour. They observed that high population and employment density, diversity in land uses, and urban design that favoured mobility by non-motorised modes were able to reduce trip generation rates and to increase travel by non-motorised modes. The strength of the relationships they uncovered was weak, as they concluded that the influence of the 3Ds on travel behaviour appeared to be modest at best, concluding travel behaviour might be influenced by compact and diverse built form that favours mobility by non-motorised modes.

The 3Ds highlighted as a bundled set of attributes have, either individually or collectively, dominated the discourse on the determinants of travel behaviour. Earlier, Newman and Kenworthy (1989) highlighted the need to reduce automobile dependence by focusing on factors that help reduce automobile and gasoline use. Compact urban form or density emerged as the central theme since then and was later reiterated in a series of subsequent publications that demonstrated lower automobile use in jurisdictions with higher population densities (Kenworthy & Laube, 1999).

Bivariate comparisons of population densities and automobile use were instrumental in framing policies on how to increase public transport ridership while reducing dependence on the private automobile. However, as was demonstrated by others (Handy et al., 2006), comparing a proxy of the built environment and one for travel behaviour in isolation ignores the other mitigating factors that influence the evolution of the built environment and associated human behaviour. Often, high-density cities are older than low-density cities, such that the higher-density neighbourhoods were primarily built earlier before the use of automobiles became ubiquitous. Controlling for the age of a place is likely to demonstrate the inherent limitations in bivariate correlations, which ignore the structural differences amongst jurisdictions. This vintage argument is considered again later.

Neighbourhood design attributes that influence connectivity are also associated with travel behaviour, especially the use of non-motorised modes. At the same time, the built environment attributes that promote walk or bicycle modes might be associated with lower public transport mode share, thus exposing the trade-off between non-motorised modes and public transport. A study from Beijing demonstrated that “[h]igher destination accessibility, a higher number of exclusive bicycle lanes, a mixed environment and greater connectivity between local streets tend to increase the use of the bicycle” (Zhao, 2014, p. 1019). Two additional findings were equally relevant. One was that residential density had “no significant effects on the use of a bicycle for commuting” (p. 1019). Second, an increase in the supply of public transport was associated with a “decrease rather than increase [in] bicycle commuting” (p. 1019). Zhao (2014) found that “drastic changes in the built environment are a major reason for the demise of ‘the kingdom of bicycles’ in China” (p. 1019). This implies that a very walkable built environment might not necessarily be equally supportive, or facilitating, of travel by public transport. In fact, at extremely high population densities, one sees diminishing returns to density for public transport as the mode of travel switches in favour of walking and cycling (Haider, 2019).

The correlation between the walkability of a place and greater use of public transport has been reported independently in different jurisdictions (Frank et al., 2006). However, such a line of inquiry often makes certain assumptions implicitly or explicitly and, at times, ignore factors
that may influence the statistical significance and magnitude of the association between attributes of the built environment and travel behaviour. Glazier et al. (2014), for instance, assume that the presence of walkable destinations and residential density could be achieved by modifying built form. The authors assume that, as an outcome of public policy interventions, modifying the built environment by changing its density or land use is doable. However, transforming existing land uses in the short term requires political and financial capital, changing demographics, and the resulting change in cultural preferences, all of which cannot be readily accomplished by recommending “for use by policy-makers, planners and public health officials”.

The other associated challenge is with self-selection, where those who are more likely to have opted for non-motorised modes of travel or public transport would self-select themselves in such locations that permit the desired travel behaviour Handy et al. (2006), Cervero and Duncan (2008), Cao et al. (2009), Mokhtarian and Cao (2008), Cao et al. (2006), Næss (2009). After accounting for self-selection, the strength of the relationship between built environment attributes and travel behaviour might be weaker than expected. When it comes to travel mode choice decisions, Cervero and Duncan (2008) show “that residential self-selection accounts for approximately 40 percent of the rail-commute decision” (p. 1) (see also Chapter 4).

The geography of intellectual curiosity

While reviewing research on the linkages between the built environment and public transport use, a small number of cities can be identified that have served as experimental laboratories. Influential research from the small number of cities has been instrumental in devising policies linking the built environment and public transport. A question emerges about the relevance of these studies for other cities with distinct demographics, topology, climate, and economy. A large number of highly influential studies, for instance, are based on data from Bay Area in San Francisco (Cervero & Landis, 1997); Portland, Oregon (Li et al., 2008; Dong & Zhu, 2015); New York (Chen et al., 2008); King County (Frank et al., 2006); and Beijing (Zhao, 2014).

Furthermore, few international comparisons of built environment-public transport use nexus could be found in the literature. Also, how sampled cities were selected and what was done to account for the order-of-magnitude difference between the sampled cities is not known. A comparative study of the built environment of 15 cities located in 12 countries found considerable differences in the built form (Adams et al., 2014). The authors found “a 38-fold difference in median residential densities, a 5-fold difference in median intersection densities and an 18-fold difference in median park densities” (p. 1). Hence the question that emerges is whether one can generalise findings from a relatively high or very high-density place, such as Hong Kong, to North Shore, New Zealand, which depicts much lower development densities.

At the same time, few if any studies consider the relationship between the built environment and public transport for European cities. The relative scarcity of research exploring the linkages between the built environment and public transport use from European cities needs some reflection. Perhaps similarities in the built environment among European cities, the similar vintage of their construction and development over the past few centuries, and much higher use of public transport throughout the European continent are the reasons such exploration was not needed. Also, the sociopolitical frameworks commonly found in Europe, for instance, acceptance of higher levels of taxation in return for higher levels of public services and social security safety nets, are inherently different from those prevalent in the United States and Canada. Hence, intercity comparisons of jurisdictions across the Atlantic would ignore not just the fact that most North American urban centres, unlike the European counterparts,
developed primarily in the past 100 years, but also that sociodemographic and economic frameworks across the continents differ considerably.

Old versus new cities

Comparative studies of the built environment and transportation often control for the systematic differences between and among cities. For instance, empirical analysis controls for household demographics, income levels, automobile ownership, price of gasoline, and the like. What is often not controlled for is vintage. The built environment, to a large extent, is a product of the prevalent transportation technology. Since human beings started living in formal settlements, the shape and size of the settlements have been influenced by transportation technology. The spatial extent of the mostly pedestrian communities in ancient Rome and Egypt was defined, to a large extent, but the distances covered comfortably by foot. As transportation technology improved first with domesticated animals and later with motorised transportation, the spatial extent and structure of communities changed considerably.

The built environment seen in the modern European metropolises with narrow streets, tree-lined boulevards, and low-rise multiresidential buildings supporting very high population densities was a reflection of the modes of transportation available when these places were first built and settled over the past few hundred years. In comparison, the North American metropolises were mostly developed when the private automobile and rail-based, higher-order public transport were readily available. The resulting built form in North America is thus a reflection of the automobility of its time.

Neighbourhood vintage influences the built environment, which in turn influences public transport use. For comparative research, one must, therefore, attempt to control for vintage. Comparing cities built mostly in the 19th century or before with those developed primarily in the 20th century must include explicit controls for vintage to tease out the nuanced relationship between the built environment and public transport. Even comparing areas of different vintage within the same cities must not ignore the timing of development. For instance, Dong and Zhu (2015), in a study of smart growth developments in Portland and Los Angeles, observed that older neighbourhoods, when compared with newer builds, tend to be more advanced on smart growth metrics.

The next section presents empirical (stylised) findings of the relationship between the built environment and public transport. The analysis is informed by the discussion presented in the literature review. Questions as to why public transport use is higher in some jurisdictions and not in others are addressed. The literature reviewed in this chapter demonstrates various benefits of higher public transport use. Still, at least in North America, public transport use pales in comparison with that of the private automobile. Of course, efficient and reliable public transport is a prerequisite for the mass adoption of public transport. In places where public transport service is unreliable, not efficient, or not comprehensive in its coverage, people will likely use other modes for mobility. However, in many large North American cities that are characterised by the public transport-supportive built environment, public transport use still lags travel by private automobile. The analysis presented here explores the barriers to higher public transport use by exploring some factors that have not attracted sufficient attention in the past.

Spatial analysis of the built environment – public transport linkages

The empirical analysis presented here is based mainly on Census-based data from Canada and the United States. A new database of the built environment and public transport proximity
indicators for almost 480,000 neighbourhoods across Canada is used to explore the relationship between the built environment and public transport use.

‘Public transport is better, but cars are faster’

Statistics Canada, Canada’s official statistical agency, for the first time in 2011 included a question about the duration of daily commutes in the National Household Survey (NHS) that replaced the long-form census. The respondents, employed individuals 15 years of age or older, were asked the following question: “How many minutes did it usually take this person to get from home to work?” The public-use microdata file was subsequently released in 2013, which prompted an op-ed in Canada’s national newspaper, the *Globe and Mail*. The op-ed revealed that commutes by public transport, irrespective of the local demographics, were significantly longer than commutes by the private automobile (Haider, 2013). On average, across Canada, public transport commutes were 81% longer in duration than those by car (Haider, 2013). Even for cities known for high public transport use, public transport fared poorly for travel time. The commute to work data, released as part of the NHS, showed that in a public transport-friendly city like Montréal, travel to work by car on average took 26.5 minutes. However, travel by public transport on average took 42 minutes. Thus, even in cities known for public transport use and infrastructure, commute by public transport was 58% longer.

The op-ed revealed nothing new to the transportation planning fraternity. However, for the public transport enthusiasts, and the broader public, public transport times being considerably slower was a revelation. Four days after the op-ed was published, the newspaper dedicated a section to publishing feedback from readers who had reacted with hundreds of messages and comments. The exercise revealed that many who advocate for public transport earnestly believed that public transport commutes were faster than those by the private automobile and that if urban workers were moved in large numbers from using cars to public transport, the system-wide travel times would improve. Nevertheless, Haider (2013) noted that

commute to work data challenges the notion that building more public transit will save travel time by shifting commuters from cars to public transit. How is it possible that transferring commuters from a faster mode of travel to a slower one will shorten travel times? Simple arithmetic and common sense suggest that system-wide travel times will instead be longer when more people commute by the slower mode, i.e., public transit.

(p. A13)

The more pertinent question to ask is even if public transport service is available and travel costs are not the deciding factor, why would one opt to commute by a slower mode to and from work? Urban commuters, especially those who are time poor, are likely to prefer the mode of travel that is faster. Hence, public transport does not have to be just cheaper or reliable; it must also offer travel times that are competitive with those by cars.

In 2016, the long-form census in Canada reconfirmed what was observed five years earlier in the NHS. Public transport commutes on average were significantly longer than by cars in Canada’s eight most populous Census Metropolitan Areas (CMAs), which are collectively home to 18 million people, about 50% of Canada’s population. Commutes by public transport were, for example, 70% longer in Calgary than by car (Figure 23.1). At the lower end, public transport commutes were 58% longer by public transport in Winnipeg. Despite public transport commutes being significantly longer than those by cars, Canada’s most populous urban regions...
reported high public transport use, with Toronto reporting a public transport mode split of 24.7%. Quebec City was at the lower end with 11.4% (Statistics Canada, 2019).

A similar relationship is observed for urban regions in the United States. Higher public transport use is associated with longer commute times. The three-dimensional association between population density (a proxy for the built environment), commute times, and public transport mode share is compared for the core-based statistical areas (CBSAs). A CBSA is essentially a conurbation developed around an urban centre with a minimum population of 10,000.

The 31 CBSAs are necessarily conurbations that stretch beyond state boundaries. The most populous CBSA with a population of 14.3 million is linked with New York City and includes areas in New Jersey and White Plain. The least populous in the dataset is San Rafael, CA, with a population of 259,358 individuals. The results are shown in the next two figures. Figure 23.2 provides evidence in support of the oft-cited observation about the built environment and public transport mode share that higher-density regions are associated with higher public transport mode share.

Figure 23.3 illustrates the argument being made here that higher public transport use is associated with longer average commute times. CBSAs with public transport mode share of greater than 10% are associated with average commute times of 30 minutes or more. The size of circles in Figure 23.3 depicts the population densities. What is interesting is that some high-density CBSAs, characterised by large circles, report lower public transport mode share of 5% or less and commute times of less than 30 minutes. On the other hand, one sees some high-density CBSAs associated with higher public transport mode share and consequently longer average commute times. Thus, one could infer from Figure 23.3 that population density does not automatically associate with higher public transport mode share. This observation has also been made in the literature, such that higher density is a prerequisite but not a sufficient condition for higher public transport use. However, the primary inference remains the same as was observed for the Canadian data; that is, higher public transport mode share correlates with longer commute times.

CBSAs are agglomerations of urban areas with significant diversity in demographics, where the most populous regions such as New York and Los Angeles have populations over 10 million, while smaller areas such as Gary, Indiana, have populations of 0.7 million. Similarly, the

![Figure 23.1](https://example.com/figure23.1) The difference in average commute times by public transport and car (percentage)
spatial footprint of these areas varies significantly, such that Washington-Arlington-Alexandria covers an area of 5,000 square miles, whereas Boston, Massachusetts, stretches over 1,160 square miles. One can argue that comparing CBSAs with such diversity in demographics and spatial extent could suffer from aggregation bias that may hide the nuanced local differences within and across CBSAs.
To address this limitation, a similar analysis performed at the census tract (C.T.) level for the New York region using data from the 2000 census is presented. Mainly, the 5,000-plus C.T.s constituting the New York region are divided into six discrete regions based on distance from downtown Manhattan. Figure 23.4, therefore, contains six panels, each representing a unique subset of C.T.s based on their distance from downtown Manhattan. The panel labelled nearest covers only those C.T.s that are nearest to downtown Manhattan and are situated within 10 km of the Central Business District (CBD). Other panels accordingly present data for C.T.s that are located at greater distances from downtown Manhattan. A breakdown of the C.T.s distances is presented in Table 23.1. The discrete slices of space allow an exploration of any change in the relationship based on the location of the C.T.s.

The $x$-axis for the six panels represents public transport mode share, whereas the $y$-axis represents the average commute time in minutes. Also, the markers are customised to categorise each C.T. into low- (diamond), medium- (triangle), or high-income (square) neighbourhoods.

Figure 23.4  Population density, household income, and public transport mode share in the New York region
The panel labelled nearest presents a scatter plot between public transport mode share and median commute times for C.T.s situated within 10 km of the Manhattan CBD. One sees a positive correlation between public transport mode share and median commute times. Even for the neighbourhoods that are closest to downtown Manhattan, which is served by fast-moving subways on dedicated rights-of-way, commute times on average are higher for the neighbourhoods with higher public transport use. The positive correlation persists for C.T.s that are depicted in panels labelled as nearer, medium near, medium far, or farther from the CBD. The correlation weakens for only those neighbourhoods that are located at least 70 km away from downtown Manhattan.

The shape of markers in the scatter plot, which accounts for the neighbourhood income level, reveals that low-income C.T.s (diamond) often report higher levels of public transport mode share and longer commute times. This is more evident for C.T.s located nearest or nearer to the CBD but not for remotely located suburban C.T.s.

A key finding from Figure 23.4 is that a higher level of public transport mode share is associated with longer commute time. The relationship holds for both a comparative analysis of spatially aggregated data for CBSAs and also the spatially disaggregate data at the neighbourhood level (C.T.) for the New York region. This exposes a key challenge for increasing public transport use in North America. Even in places where the built environment is conducive to higher-order public transport systems and places with ample supply of diverse public transport modes offering efficient public transport service, public transport commute times are longer. To compete with the private automobile, public transport must offer competitive travel times.

**Table 23.1 Distance thresholds for the six neighbourhood categories**

<table>
<thead>
<tr>
<th>Distance from Manhattan CBD (km)</th>
<th>mean</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest</td>
<td>6.59</td>
<td>0.28</td>
<td>10.04</td>
</tr>
<tr>
<td>Nearer</td>
<td>12.63</td>
<td>10.05</td>
<td>15.55</td>
</tr>
<tr>
<td>Medium near</td>
<td>18.70</td>
<td>15.57</td>
<td>22.40</td>
</tr>
<tr>
<td>Medium far</td>
<td>30.01</td>
<td>22.44</td>
<td>40.16</td>
</tr>
<tr>
<td>Farther</td>
<td>54.28</td>
<td>40.17</td>
<td>71.36</td>
</tr>
<tr>
<td>Farthest</td>
<td>97.35</td>
<td>71.79</td>
<td>179.80</td>
</tr>
</tbody>
</table>

**Does vintage matter?**

In the literature review section earlier, the relevance of vintage for the built environment and associated public transport use was discussed. Cities built before automobile use became ubiquitous were designed to facilitate mobility by non-motorised modes of travel. Specifically, such cities were known for higher population densities and mixed land uses, and the destinations were closely placed. Pre-auto era cities portrayed a compact urban form that was devoid of sprawl, which is characteristic of automobile-dependent communities.

In this section, the relationship between vintage, specifically the age of a neighbourhood, is compared with the associated built environment and its association with public transport use. Data from the 2016 Census in Canada is presented for two urban regions, Montréal and Calgary. Data for respective Census Metropolitan Areas is used, where a CMA consists of “one or more neighbouring municipalities situated around a core. A census metropolitan area must have a total population of at least 100,000 of which 50,000 or more live in the core”.

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A spatially disaggregate approach is adopted where Calgary and Montréal CMA s are analyzed at the census tract level. C.T.s are “small, relatively stable geographic areas that usually have a population between 2,500 and 8,000 persons. They are located in census metropolitan areas and in census agglomerations that had a core population of 50,000 or more in the previous census”. The purpose of this analysis is to compare population densities, a proxy for the built environment, and public transport mode share in similar vintage neighbourhoods. Montréal is known as a public transport city and famous for its European-styled urban design (Racine, 2019). On the other hand, Calgary reports a much lower population density and public transport use. Competitive analysis of public transport mode share across Canada often highlights the apparent fact that places like Montréal, because of their compact built form, have been able to achieve much higher public transport use than places like Calgary, whose built environment is categorised as sprawling.

Such intercity comparisons, as argued earlier, often ignore vintage. Calgary, unlike Montréal, is a newer city where a majority of the dwelling units enumerated in 2016 were constructed after 1980. In comparison, Montréal was settled much earlier in the 18th century and grew in space and population over the past 200 years. Using Calgary and Montréal as opposite poles of the built environment, the role, if any, that vintage may have played in their respective built environments and consequent public transport mode share is investigated.

However, instead of comparing the entire urban landscape in one metropolis with that in the other, the public transport mode share and built environment for respective neighbourhoods that are differentiated by age are compared. A C.T. is categorised as new if most of the dwellings in the C.T. were constructed after 1980. Similarly, a C.T. is categorised as old if most dwellings were built before 1981. Hence, the comparative analysis presented here contrasts population densities and public transport mode shares for older neighbourhoods in Montréal with older counterparts in Calgary and vice versa.

The results are presented in Table 23.2.

The Montréal CMA has a population of 4 million, with 1.73 million dwellings. Calgary, on the other hand, is a smaller urban region with a population of 1.4 million inhabitants and

<table>
<thead>
<tr>
<th>CMA</th>
<th>Dwellings in 2016</th>
<th>Built since 1981</th>
<th>New if at least 50% dwellings built since 1981 (%)</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Old neighbourhoods</td>
<td>New neighbourhoods</td>
</tr>
<tr>
<td>Montréal</td>
<td>1,727,215</td>
<td>731,225</td>
<td>42.3%</td>
<td>66.5</td>
</tr>
<tr>
<td>Calgary</td>
<td>519,775</td>
<td>328,880</td>
<td>63.3%</td>
<td>44.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CMA</th>
<th>Employed 15-plus (commuters)</th>
<th>Public transit mode split (%)</th>
<th>Public transit mode split (%)</th>
<th>Population density (persons/sq. km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Old neighbourhoods</td>
<td>New neighbourhoods</td>
<td>Old neighbourhoods New neighbourhoods</td>
</tr>
<tr>
<td>Montréal</td>
<td>1,883,920</td>
<td>30.2</td>
<td>13.9</td>
<td>7,125 New opponents 2,352</td>
</tr>
<tr>
<td>Calgary</td>
<td>684,260</td>
<td>16.6</td>
<td>12.8</td>
<td>2,777 New opponents 2,605</td>
</tr>
</tbody>
</table>

Table 23.2 A comparison of age differentiated neighbourhoods in Calgary and Montréal
The built environment

520,000 dwellings. Apart from the differences in size, the two cities are inherently different in the age of the constituting neighbourhoods, such that 63% of the dwellings in Calgary were constructed after 1980. In Montréal, post-1980 dwellings represented 42% of the dwellings. Whereas one in three neighbourhoods were predominantly built since 1981 in Montréal, 56% of the neighbourhoods were of post-1980 vintage in Calgary.

The public transport mode split in Montréal at 25% for commute trips is 72% higher than the one in Calgary. However, the difference in public transport mode splits when compared for the entire urban areas ignores the vintage of the constituting neighbourhoods. To address this limitation, public transport mode splits between Montréal and Calgary are compared by dissecting the cities into old and new neighbourhoods. As expected, parts of Montréal characterised as old neighbourhoods reported a much higher public transport mode split of 30.2% compared to older parts of Calgary with the corresponding statistic at 16.6%.

Unlike older neighbourhoods, a comparison of newer neighbourhoods between the two cities revealed that Montréal, with a 13.9% public transport mode split, was marginally better than 12.8% observed for Calgary. Interestingly, the significant difference in public transport mode splits observed for older neighbourhoods between the two cities almost disappears for newer neighbourhoods. A comparison of the means test revealed that the difference in mode splits for newer neighbourhoods was not statistically significant (p = 0.2870, Table 23.3). The difference in average public transport ridership for older parts of the two cities was statistically significant (p < 0.000).

To a large extent, the previously mentioned results can be explained by the differences and similarities in the built environment between the two cities. Working with population density as a proxy for the built environment, one sees a significant difference in population densities of old neighbourhoods in Montréal and Calgary. However, that difference disappears, in fact, reverses, for newer neighbourhoods. Consider that the average population density in the older neighbourhoods of Montréal was recorded at 7,100 persons per square kilometre compared to 2,777 persons per square kilometre for older neighbourhoods in Calgary. However, when neighbourhoods built predominantly after 1980 in Montréal are compared with similar-vintage neighbourhoods in Calgary, then, at 2,605 persons per square kilometre, newer neighbourhoods in Calgary reported higher density than their newer counterparts in Montréal.

These results present an interesting story. Public transport mode share is higher for a public transport-supportive built environment characterised by higher development densities, compact built form, and mixed land uses, to name a few. When differences in the built environment exist between cities, one also sees a difference in public transport mode shares. However, the differences in the built environment are more pronounced in parts of the cities built earlier. Recently developed neighbourhoods, even in public transport-friendly cities, have similar built environments like the ones found in newer neighbourhoods in cities not known for public transport use. As the difference in the built environments reduces or disappears over time, public transport

<table>
<thead>
<tr>
<th>Group</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. err.</th>
<th>Std. dev.</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montréal</td>
<td>306</td>
<td>13.8549</td>
<td>0.611841</td>
<td>10.70285</td>
<td>12.68152 15.08945</td>
</tr>
<tr>
<td>Calgary</td>
<td>141</td>
<td>12.84501</td>
<td>0.550887</td>
<td>6.541415</td>
<td>11.75588 13.93414</td>
</tr>
<tr>
<td>Combined</td>
<td>447</td>
<td>13.55728</td>
<td>0.453677</td>
<td>9.5918</td>
<td>12.66567 14.44889</td>
</tr>
<tr>
<td>Diff</td>
<td></td>
<td>1.040476</td>
<td>0.976152</td>
<td>-0.87796</td>
<td>2.958916</td>
</tr>
</tbody>
</table>
mode shares also become similar across jurisdictions. Regrettably, the trend one sees here is of less reliance on public transport in newly built parts of cities, irrespective of the public transport use prevalent in the well-established, older parts of the city.

A national database of public transport accessibility

Comparative analysis of the built environment and public transport use requires comparable data or metrics to explore the association between the built environment and public transport use. Developing such metrics is resource and time intensive. Comprehensive multijurisdictional studies of the built environment across countries or continents are few and often involve a handful of jurisdictions. The financial and resource constraints in data gathering and metric development are the reason built environment studies are confined to a select few cities in North America where there has been a tradition of collecting such datasets.

National-level public-sector agencies have the capacity and the resources to develop cross-country metrics for proximity, built environment, and public transport-supportive land uses. One such database is the recently released (April 2020) Proximity Measure Database (PMD) by Statistics Canada. In collaboration with the Canada Mortgage and Housing Corporation, Statistics Canada developed a nationwide database of 10 proximity/built environment-related metrics at the spatially disaggregated scale of dissemination blocks such that the database comprises half a million (mutually exclusive and almost exhaustive) observations. Statistics Canada defines the dissemination block (D.B.) as follows:

A dissemination block is an area bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which population and dwelling counts are disseminated. Dissemination blocks cover all the territory of Canada.

This extensive database makes it possible to answer questions about the relationship between the built environment and public transport at the national level. As pointed out earlier, most previous research has focused mainly on local urban markets, from which inferences were drawn for policymaking at the national, provincial, or regional levels that might not be relevant beyond the study areas. In the following paragraphs, a brief discussion of some of the relevant metrics from PMD is presented to determine the extent of public transport-supportive built environment at the national level and to compare relevant metrics amongst nine populous urban centres in Canada accounting for more than 50% of Canada’s population. Canada’s capital, Ottawa, spreads across two provinces, Ontario and Quebec, and therefore the metrics are presented separately for the two parts.

The journey-to-work data collected as part of the census in 2016 showed that public transport mode split for commutes is highest in the Toronto Census Metropolitan Area, followed by Montréal and Vancouver such that the three most populous urban regions report at least one in five work-related trips being made by public transport (Figure 23.5). The public transport mode share declines to a low of under 10% for Hamilton, a neighbouring CMA to Toronto and part of the Toronto commuter belt. The public transport mode splits differ across the urban regions in the same way their demographics differ. Toronto, Montréal, and Vancouver are more populous, and their respective built environments, proxied by population and employment densities, compactness of urban form, diversity in land uses, and the like are more likely to facilitate commuting by public transport.

Proximity to public transport infrastructure offering reliable and regular public transport service is a prerequisite for higher levels of public transport use. Often, proximity to public transport use is measured as the network or straight-line distance from trip origins to the nearest public transport station or stop. However, the public transport proximity measure developed by
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Statistics Canada not only accounts for spatial proximity to public transport infrastructure but also normalises proximity by the aggregate trip making activity in the morning peak period and public transport operating frequencies derived from the General Transit Fleet Specification. The measure is defined as follows:

Proximity to public transit measures the closeness of a dissemination block to any source of public transportation within a 1 km walking distance. This measure is derived from the number of all trips between 7:00 a.m. – 10:00 a.m. from a conglomeration of 95 General Transit Feed Specification (GTFS) data sources.

(Statistics Canada, 2020)

Figure 23.6 presents the distribution of proximity to public transport index. A quick comparison of Figures 23.5 and 23.6 reveals a lack of one-to-one correspondence between higher public transport proximity and higher public transport mode shares. Whereas Toronto CMA reported the highest public transport mode split, the highest proximity to public transport infrastructure is reported for Winnipeg, which reported a much lower public transport mode split. Similarly, whereas Edmonton and Calgary, the two most populous cities in Alberta, have ranked lower in public transport proximity, their corresponding public transport mode shares are higher than other regions that reported better proximity to public transport infrastructure. This suggests that whereas proximity to public transport matters, it is not a sufficient condition for higher public transport use.

Another point to realise is that not all public transport is created equal. Accessibility to higher-order public transport, either rail or bus, but having a dedicated right-of-way, could be an essential factor in determining the extent of public transport mode share. Consider that the highest public transport mode shares are reported for Toronto, Montréal, and Vancouver,
which are the three cities with rail-based public transport operating on dedicated rights-of-way. Montréal and Toronto are served by underground rail in their core municipalities, whereas Vancouver is served by surface rail operating on the dedicated right-of-way. Following these three cities in public transport mode share is Ottawa, which until recently operated one of the most successful bus rapid transit systems in North America, with an overall public transport mode split for commute trips of about 19%. Recently, Ottawa has replaced its bus rapid transit system with a rail-based system. Following Ottawa is Calgary, which also operates a well-subscribed surface rail system that serves part of the urban core (see also Chapter 13).

Figure 23.6 shows that Winnipeg reports the highest accessibility to public transport, but that it is not among the cities with higher public transport mode points to the fact that accessibility to any type of public transport is not sufficient. Instead, proximity to higher-order public transport that offers competitive or near competitive travel times to automobile is seen to have a higher payoff for public transport mode share.

Since the public transport mode share reported here is for work trips only, one would expect that higher accessibility to employment destinations should correlate with higher public transport use. Figure 23.7 offers corroborative evidence. Cities with higher accessibility to employment are also the ones with the highest public transport mode shares. However, this relationship does not hold for all cities, where Calgary and Winnipeg report higher accessibility to employment, yet higher-order public transport facilities in Ottawa are partly responsible for higher public transport mode split.

The numerous proxies for the built environment, including measures of compactness, diversity, and accessibility, may be collapsed into one aggregate measure to classify places. As mentioned earlier, Statistics Canada developed eight distinct metrics to capture proximity to destinations, including employment, public transport neighbourhood parts, educational facilities, grocery stores, and pharmacies. In addition, Statistics Canada combined these disaggregate metrics into one aggregate measure as an ordinal variable categorising each neighbourhood as being a high, low, or medium amenity-dense neighbourhood.6

Figure 23.8 presents the map for Vancouver, where each dissemination block has been coded as a high amenity (dense grey-coloured dots), medium amenity (dark grey), and low amenity

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Figure 23.6 Proximity to public transport infrastructure in large CMAs in Canada
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Figure 23.7 Proximity to employment in large CMAs in Canada

Figure 23.8 Ordinal depiction of neighbourhoods being of high (light-grey clustered), medium (dark grey), or low (scattered dots [grey]) amenity density
density (sparse grey-coloured dots). Of the vast area that makes up Vancouver, only a small segment of neighbourhoods is categorised as high-amenity (dense grey-coloured dots) neighbourhoods. Most neighbourhoods are categorised as medium (dark grey) or low (sparse grey-coloured dots) amenity density. If a public transport-friendly city like Vancouver could boast only a small minority of its neighbourhoods as high amenity density, what can one say of large and small towns whose built environment is not compact and public transport mode share is considerably small?

Another relevant question to pose is what segment of the population lives in high amenity density neighbourhoods. Since the Proximity Measures Database covers all dissemination blocks across Canada, one may try to answer this question by aggregating the population for dissemination blocks per their categorisation for amenity density. The results are presented in Figure 23.9.

Primarily, across Canada, fewer than 3% of Canadians live in areas that could be categorised as amenity-dense neighbourhoods. An overwhelming majority of Canadians making up more than 80% of the population reside in neighbourhoods that are categorised as lower amenity density. One can infer from these results the potential for public transport use across Canada. The current built environment of neighbourhoods across Canada such that more than 80% of the population resides in places where the built environment does not meet the prescribed standards for supporting reliable and efficient public transport. The fewer than 20% of Canadians who live in medium amenity density neighbourhoods are the ones who could be targeted for improvement in public transport mode share.

**Conclusions**

This chapter has explored the relationship between the built environment and public transport use.

The near-consensus in the reviewed literature is that higher density, diversity, and other urban design dimensions of the built environment are associated with higher use of public transport. However, no one factor is a sufficient determinant of higher public transport use. At the same time, built environment metrics are correlated with each other such that any association observed between a built environment metric and public transport use might ignore other indicators, not controlled for explicitly in the analysis, which may also be influential and yet
missing from the analysis. For instance, higher population density neighbourhoods share several other built environment traits, such as higher intersection or road densities, and demographic traits, such as smaller housing units and small-sized households. Thus, population density, if used as an indicator of the built environment in isolation, might reveal a more pronounced impact on public transport usage. In contrast, other supporting built environment attributes, not explicitly controlled following the analysis, may also be influential on the outcome and, when included in the analysis, might reduce the estimated impact of population density.

The empirical part of the chapter explores the question of why, even when public transport service is available, a large number of commuters, at times the majority, travel by non-public transport modes. This chapter identifies the average travel time differences between public transport and automobile as a reason for the lower use of public transport. Data from Canada’s most populous cities shows that even for cities where higher-order public transport operating on a dedicated right-of-way exists, average travel times by public transport are considerably longer than those by the private automobile.

The empirical analysis presented in the chapter shows that neighbourhood vintage is a critical determinant of the built environment that consequently influences public transport mode share. A comparison of public transport use in Montréal, Canada’s second-most-populous urban centre, also known for higher public transport mode split for commutes, and Calgary, which is not known as a public transport-oriented city, showed significant differences in their built environment and public transport use. Such comparisons, though, ignore the differences in vintage between the two cities. Future comparisons of cross-jurisdictional differences in built environment attributes and public transport use must also be informed by the differences in the vintage of neighbourhoods and cities.

Public policy recommendations emerging from research on the linkages between the built environment and public transport use often assume that the existing built environment characteristics, if not supportive of higher public transport use, could be modified. For instance, when researchers find higher densities to be correlated with higher public transport use, their findings imply that population densities be increased in low-density areas above the minimum threshold needed for operating frequent public transport service. Such recommendations are based on the assumption that the built environment of existing neighbourhoods could be modified. However, such interventions are costly for political and financial reasons. Hence, examples of changes in the built environment of existing neighbourhoods are quite rare. Hence, recommendations for a higher population density or compact built form to support mobility by public transport will be more useful for planned developments.

**Future research**

Research on this chapter was initiated before the onset of COVID-19. Since March 2020, restrictions on mobility and assembly have disrupted all forms of local, regional, and international travel. Even in the cities known for higher use of public transport, ridership has declined precipitously, especially during the COVID-19-mandated lockdowns. International travel, even in August 2020, is allowed only under exceptional circumstances. Whereas restrictions on urban mobility have been relaxed, and public transport agencies can operate service, public transport ridership in developed economies is only a fraction of its pre-pandemic levels (Verma, 2020).

A related response to COVID-19 has been a growing preference for suburban locations where larger homes are available at relatively lower prices than the urban core. If the increase in the preference for suburbs continues, even at a slower rate, suburban population growth will imply even a larger share of the population residing in public transport-deficient areas.
At the same time, travel to and from employment hubs in downtown, which are often served efficiently by public transport, has declined significantly because of COVID-19. Even though workers are now being allowed to return to their offices, the uptake is significantly less than anticipated, which further contributes to a decline in travel by public transport to destinations that have been served efficiently by public modes of transportation.

Future research exploring the relationship between the built environment and public transport must account for the aforementioned changes in the socioeconomic spheres resulting from the restrictions related to COVID-19. In addition to COVID-19, other technological innovations in transportation are also influencing the way people plan and execute urban travel. The expected arrival of fully autonomous vehicles in the future and the rise of ride-hailing apps and services – for example, Uber and Lyft – have already started to impact how people travel (Tirachini & del Río, 2019). Technology-driven innovations are influencing the relationship between the built environment and public transport. In the future, research in public transport must be mindful of the technological and intergenerational shifts in tastes, where millennials have shown diverging behaviours for home and automobile ownership compared to the generations that preceded them (Klein & Smart, 2017).

Previous research has often adopted cross-sectional approaches to study the relationship between the built environment and public transport. Future research, though, should focus on longitudinal analysis to improve the understanding of the dynamic relationship between the built environment and public transport. Furthermore, interjurisdictional comparisons of public transport use should account for the vintage of built form, which, to a large extent, is determined by the prevalent modes of transportation.

The relationship between the built environment and public transport is not stationary. It has evolved and manifested differently across divergent urban spaces. Changes in travel behaviour will be better understood with a broader research agenda to embrace the traditional and emerging determinants of travel behaviour and land use.

Notes
3 https://www150.statcan.gc.ca/n1/pub/92-195-x/2011001/geo/ct-sr/def-eng.htm
4 https://www150.statcan.gc.ca/n1/pub/17-26-0002/172600022020001-eng.htm
5 https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo014-eng.cfm
6 https://www150.statcan.gc.ca/n1/pub/17-26-0002/172600022020001-eng.htm

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