

CANADA'S PUBLIC TRANSIT INFRASTRUCTURE: A REVIEW

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Introduction

Many developed economies have incorporated to some extent the principles of Keynesian economics; that is, the practice of investing public funds during an economic downturn in order to increase aggregate demand or total spending in the economy. Canada invested heavily in physical infrastructure following the 2008 financial downturn. Such investments should both increase short term aggregate demand and enhance longer term economic efficiency via innovation. For example, investment in bolstering rural broadband connectivity was viewed as not only putting “shovels in the ground” in the short term, but also enabling longer term digital innovations. In Canada, infrastructure investments have continued with almost \$180 billion in resources committed in the 2017 “Investing in Canada Plan”.

A significant portion of this plan was aimed at transportation, both public transit and national trade corridors. As Winston (2013) asserts, an efficient and extensive transportation system improves the standard of living in society by reducing the cost of nearly everything in the economy.¹ With urban travel in particular, investment in public transit helps create a more efficient arrangement of people and activities and creates benefits for society from innovations enabled by what is referred to as agglomeration economies.² At the same time however, it is critical to have statistical data on which to direct such investments. As Iacobacci (2017) asserts, there is also a need for public transit investment to undertake a proper business case to ensure a net benefit to citizens by accounting for all considerations.³

Recognizing the benefits from investments in infrastructure as well as the need to have data on which to direct funding, Infrastructure Canada and Statistics Canada conducted a survey on the state of the nation's core infrastructure. The aim of the survey was to provide information on the stock, condition and asset management strategies of core public infrastructure assets. It consisted of a questionnaire on asset management as well as modules specific to asset classes such as roads, bridges and tunnels, wastewater treatment facilities and public transit. After a review of the survey instrument, this paper provides a review of urban transit infrastructure in Canada focussing on the inventory, age and condition of rolling stock assets including buses, streetcars and subways as well as management practices.

Canada's Core Public Infrastructure Survey

In order to “build the cities of the future”, the Investing in Canada plan targeted five main infrastructure priorities including Public transit as well as Trade and transportation.⁴ With respect to the former, the plan asserted that Canadian cities have been growing steadily but investment in public transit has not kept pace, resulting in more traffic congestion and longer commutes.⁵ The resulting gridlock has serious financial as well as environment impacts.⁶ To improve and expand public transit systems, funding was provided through the Public Transit Infrastructure Fund to support rehabilitation of public transit systems; planning of future system improvements and expansions; enhanced asset management; and system optimization and modernization. Funding under the program was allocated to municipalities based on transit ridership.

¹54th Annual Meetings of the *Canadian Transportation Research Forum*, May 26 to 29, at Vancouver, British Columbia.

To better understand investment needs, Infrastructure Canada sponsored Canada's Core Public Infrastructure (CCPI) survey to gather data on the inventory, condition, performance and management strategies of public infrastructure assets owned by government. The target population consisted of Municipal, Regional, First Nation and Provincial/Territorial jurisdictions that owned infrastructure. Jurisdictions were stratified by population and a survey was sent to 2,111 jurisdictions in July 2017 to establish a 2016 benchmark.⁷ The instrument consisted of a core questionnaire on Asset management along with modules on specific asset classes including Roads, bridges and tunnels, Potable water, Wastewater & storm water, Public transit, Solid waste, Culture, sports and recreation, and Social housing.

In essence, the CCPI constitutes a catalogue of Canada's core infrastructure and its condition as of December 31, 2016. Statistics Canada issued a series of *Daily* releases to present this new information, including Public transit assets in November of 2018, and a final release featuring Asset management practices.⁸ The remainder of this paper will focus mainly on Public transit rolling stock assets as well as aspects of their asset management plans. In 2016, 144 government organizations - mainly municipalities - across Canada owned public transit assets, including at least one transit bus.⁹ Public transit assets were classified into two main types. The first, Rolling stock, is buses and railcars while the second, Fixed assets, includes transit shelters, passenger terminals, parking facilities, exclusive rights-of-ways and maintenance facilities. We begin by providing an overview of jurisdictions owning at least one public transit bus.

Canadian Jurisdictions with Public Transit Assets

The 144 jurisdictions in Canada owning at least one public transit bus is a heterogeneous group, ranging from small jurisdictions with 1 or 2 buses to Canada's largest urban areas, which operate extensive transit services with hundreds of buses as well as streetcars, light rail transit (LRT), subways or commuter rail (Table 1). Almost all jurisdictions reported owning or leasing at least one diesel bus, the traditional workhorse of public transit. As expected, the mean number reported for each asset class of rolling stock, particularly buses, is sensitive to the higher values from a relatively small number of larger jurisdictions. For instance, while the mean number of diesel buses owned or leased was 80, the median was just 9. In other words, half the jurisdictions with diesel buses reported having fewer than 9 such vehicles while the other half reported having more.

Only a small number of jurisdictions reported having rail rolling stock assets. Of course, these same jurisdictions also have a large number of transit buses. We hypothesize that the transit asset management practices employed by the larger jurisdictions is likely to be quite different from that employed by those with a smaller number of vehicles. That is, jurisdictions with a larger number of rolling stock assets will, all else being equal, employ a more systematic and formal asset management strategy. In order to help examine variation in reported data by size of fleet, we created a typology of four classes based on asset ownership numbers and categories:

1. Large Rail jurisdictions are those 7 that reported some type of rail rolling stock;
2. Large Bus jurisdictions are those 18 that reported 100 or more total buses;
3. Medium Bus includes 46 jurisdictions reporting from 10 to 99 total buses; and
4. Small Bus is comprised of the 72 jurisdictions that reported less than 10 total buses.

Table 1 Number of jurisdictions by class of transit asset, as of December 31, 2016

Asset Class	Number	Min	Max	Mean	Median	Sum
Total Buses						
Diesel	126	1	1,268	80	9	11,767
Bio-diesel	8	5	1,728	341	43	3,224
Hybrid	29	4	121	54	54	1,679
Other buses	25	1	229	25	3	582
Natural gas	6	1	691	57	10	326
Electric	3	4	262	91	8	274
Other Rolling Stock						
Subway railcars	3	286	842	685	828	2,056
Commuter railcars	3	5	771	270	33	1,124
Specialized Transit	65	1	97	15	3	1,004
Light railcars	3	6	198	100	95	299
Streetcars	1	247	247	247	247	247
Ferries	2	3	5	4	4	8

Note: Jurisdictions having at least one public transit bus

Source: Canada's Core Public Infrastructure Survey, 2016

Public Transit Assets: Stock, Age and Condition

As of the end of 2016, the 144 jurisdictions reported having a total of 17,852 buses of various types as well close to 5,000 other types of rolling stock including railcars, specialized transit vehicles (para transpo, dial a ride), streetcars and ferries (Table 1). About two-thirds of transit buses in Canada were diesel, followed by bio-diesel and hybrid with other buses, natural gas and electric accounting for the rest. With more and relatively larger jurisdictions owning at least one transit bus, Ontario accounted for over third (38.8%) of total buses and almost one half (47.3%) of diesel buses. British Columbia (B.C.) accounts for almost all (95.6%) of the electric buses as well as most (80%) of other buses powered by battery or fuel cells and 70% of the natural gas powered buses.

The 3,726 railcars used for urban transit consisted of Heavy or Subway railcars and Commuter railcars operated in Canada's three largest urban areas as well as Light railcars operated almost entirely in Alberta with a small number in Ontario. All Streetcars in Canada are operated by one jurisdiction in Ontario. The ferries are operated on each respective coast, in Halifax and Vancouver. Finally, these 144 jurisdictions with bus rolling stock assets reported having 26,391 transit shelters, 13,039 bicycle racks and shelters, 723 passenger stations and terminals, 350 maintenance and storage facilities, 311 park and ride parking lots, 186 passenger drop-off facilities, and 207 exclusive rights-of-ways. The pluralities of all these fixed public transit assets are in Ontario, reflecting the number and size of the province's transit operators.

One indication of the condition for any physical asset, particularly a vehicle, is the age or year of purchase (Table 2). Most transit buses in Canada were purchased after 1999 with some variation by type and province. For example, 85% of buses powered by natural gas and 95% of those powered by other means such as battery or fuel cells have been purchased since 2009. Provincially, Ontario with the most and some of the largest operators, more or less mimics the Canadian trends for year of purchase. Quebec and Saskatchewan each have more than half of their respective bus fleets purchased after 2009 while, conversely, Manitoba and New Brunswick have relatively older fleets, with roughly 20% and 30% purchased before 1999 respectively.

Table 2 Public transit rolling stock assets by year of purchase, December 2016

Asset Class	2016	2010 to 2015	2000 to 2009	1970 to 1999
Total Buses				
Diesel	3.0 %	40.2%	49.6%	7.2%
Bio-diesel	1.5 %	33.1%	58.5%	6.9%
Hybrid	15.0 %	21.6%	63.3%	0.0%
Other buses	19.0 %	75.8%	5.1%	0.0%
Natural gas	37.4%	47.2%	15.3%	0.0%
Electric	0.0%	4.4%	95.6%	0.0%
Other Rolling Stock				
Subway railcars	6.6%	26.5%	18.0%	48.9%
Specialized Transit	9.7%	77.3%	12.7%	0.4%
Commuter railcars	10.9%	24.1%	32.1%	32.8%
Light railcars	0.0%	29.1%	32.8%	38.1%
Streetcars	12.1%	0.0%	0.0%	87.9%
Ferries	12.5%	37.5%	12.5%	37.5%

Note: Jurisdictions having at least one public transit bus

Source: Canada's Core Public Infrastructure Survey, 2016

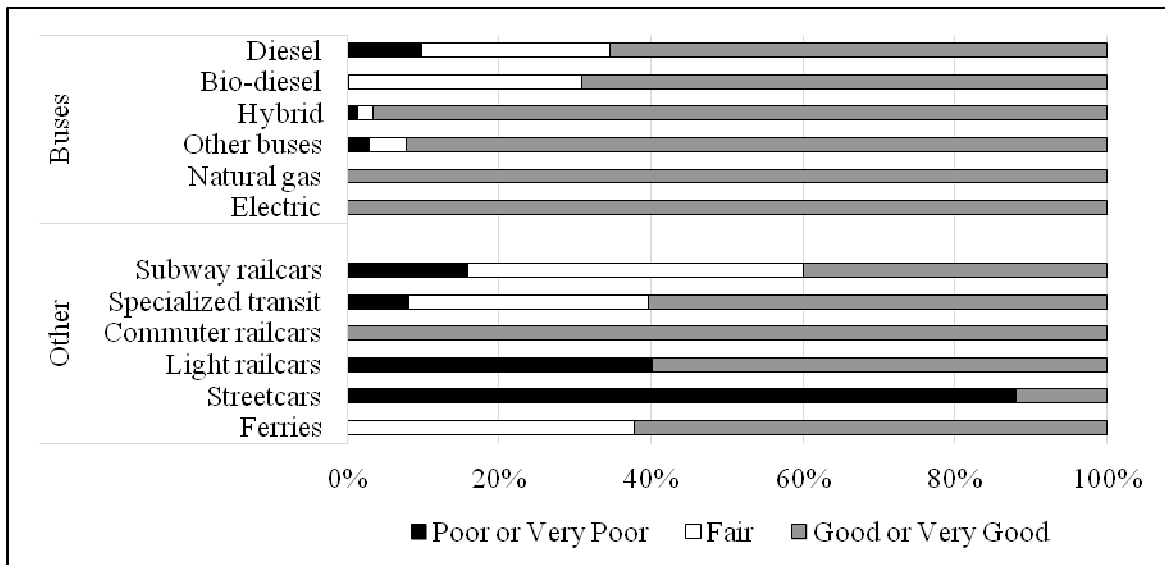
In general, American transit systems expect their buses to have an economic life of 12 years, or roughly 400,000 kilometres.¹⁰ While the lifespan of a bus will be different in Canada, this will depend on subsidy programs (i.e. operating vs. capital) as well as climatic and local operating conditions. On balance, railway rolling stock tends to have a longer self-life. In Canada, almost one half (45.8%) all railway rolling stock including streetcars was purchased between 1970 and 1999. Indeed, about one half (48.9%) of subway railcars and 88% of all streetcars and were purchased before 2000. As expected, the fixed transit assets represent a more heterogenic grouping with more variation by year of purchase (data not shown). For instance, while more than three-quarters (76%) of Transit maintenance and storage facilities were built before 2000, over two-thirds (70%) of Bicycle racks and shelters were purchased after 2010.

Jurisdictions with transit assets were asked to classify the overall physical condition of their assets according to a five point scale ranging from Very poor (i.e. near or beyond expected service life), Poor (i.e. approaching end of service life), Fair (i.e. asset requires attention), Good (i.e. the asset is adequate) to Very good (i.e. well fit for services, new or rehabilitated). Combining the two top categories and the two bottom categories, Figure 2 illustrates the condition of Canada's public transit rolling stock. Less than 10% of Canada's diesel bus fleet is considered to be in Poor or Very Poor condition with just over one fifth (22%) considered as Fair. Most other type of buses appear to be in good condition. With other rolling stock however, we note that the vast majority of streetcars are reported to be in Poor or Very Poor condition as are two of every five Light railcars.

Provincially, almost half (45%) of Manitoba's buses are reported as Poor or Very Poor as are almost one-third (32.5%) of New Brunswick's. Remember that the stock of buses by year of purchase was found to be relatively older in these two provinces. Conversely, with a relatively newer fleet of buses, transit agencies in Quebec classified more than 80% of such assets as Good or Very Good. Also, we note that almost one in five (18.3%) of total buses in Ontario for which the overall condition was reported as "unknown". On the rail side, again most streetcars and many light railcars are considered to be in Poor to

Very Poor condition; all of the streetcars are operated by one transit agency in Ontario¹¹ while the majority light railcars are operated in Alberta by two municipal agencies.

Figure 1 Condition of public transit rolling stock assets, December 2016



Note: Jurisdictions having at least one public transit bus

Source: Canada's Core Public Infrastructure Survey, 2016

Public Transit Assets: Management

Canadians have made significant investments in transit assets and, as with any capital asset, it is critical to ensure they are maintained in order to derive a reasonable rate of return. An indication of how jurisdictions approach this matter is whether or not they have a formal management plan. The CCPI survey asked each jurisdiction if their organization had such a plan for its transit assets (Table 3). For those jurisdictions that answered yes, they were then asked how often it was updated. And for those jurisdictions without, they were then asked when their organization was intending on implementing such a plan.

Table 3 Jurisdictions and a formal asset management plan, December 2016

	Yes	No
Does your organization have a public transit management plan?	60	84
<i>If Yes - How often updated / If No - Is there an Implementation Plan</i>		
Every year / In one year	36.3 %	17.3%
Two to four years	36.1 %	31.1%
Five years or more	27.7 %	13.2%
No plans to implement	na	38.3%

Note: Jurisdictions having at least one public transit bus

Source: Canada's Core Public Infrastructure Survey, 2016

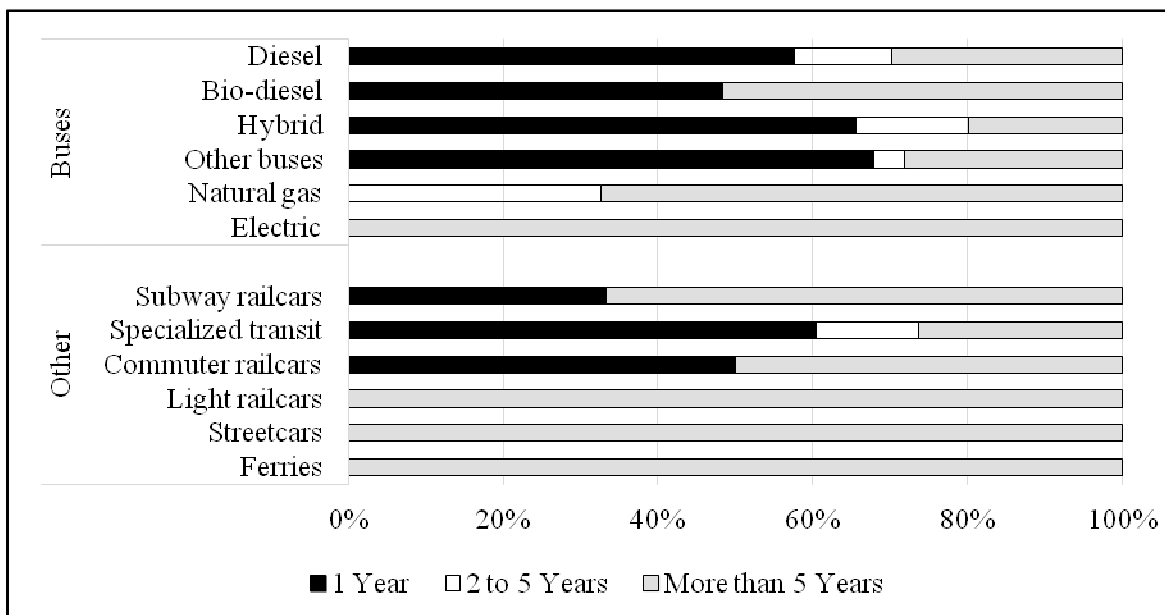
Less than one half of the jurisdictions reported having a formal asset management plan and, of those that did, just over one-third (36.3%) updated it annually. Those with larger fleet sizes were more likely to have a formal plan compared to those with fewer transit rolling stock assets (68% of Large Rail and Large Bus versus 36% of Small and Medium Bus). Of jurisdictions without an asset management plan, just under one-half (48.5%) were planning on implementing one within the next five years. However, more than

one-third (38.3%) without had no plans to implement such a plan over the next five years; a higher proportion (55.9%) of Small bus jurisdiction had no schedule for implementation.

Regardless of whether they had a formal plan, jurisdictions were asked about the condition assessment cycle, or period of time required to assess the type of public transit asset (Figure 2). About one half to two-thirds reported using a one year assessment cycle for bus rolling stock (48.4% bio-diesel, 57.7% diesel, 65.6% Hybrid and 67.9% Other buses). The assessment cycle was more than 5 years for two-thirds (67.3%) of the Electric and all of Natural Gas buses. With rail rolling stock, the assessment cycle was annual for some jurisdictions with Subway railcars (33.3%) and Commuter railcars (50.0%) but more than 5 years for all Light railcars and Streetcars. Again, some of these operators were in the midst of a transit rolling stock asset replacement plan.

Most jurisdictions indicated they used spreadsheets, paper records or off-the-shelf asset management software (data not shown). Only about one in every five jurisdictions (19.0%) indicated that they employed a custom asset management software, and Large Rail jurisdictions were more likely than Small Bus jurisdictions to report using such software (71.4% vs. 4.5%). The use of a Spreadsheet was the most commonly reported management information system used to manage transit assets. We note that more than one in ten (11.8%) jurisdictions owning public transit buses reported not using any asset management tools. The vast majority of jurisdictions that reported not using asset management tools and not having a formal asset management plan were either Medium Bus or Small Bus operations.

Figure 2 Condition assessment cycle for public transit rolling stock, 2016



*Note: Jurisdictions having at least one public transit bus
Source: Canada's Core Public Infrastructure Survey, 2016*

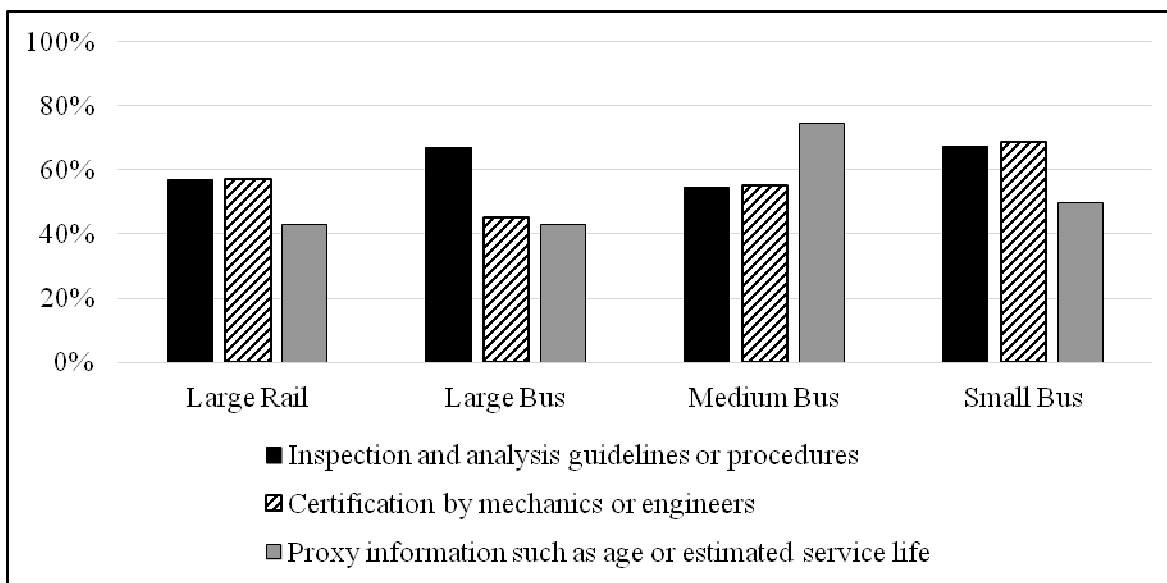
Again, regardless of a formal asset management plan, all jurisdictions with transit assets were asked to report on the method they used to assess the physical condition of their rolling stock assets. Jurisdictions could check one, two or all three of the following assessment methods:

1. ... based on a Detailed inspection and analysis guidelines or procedures;
2. ... based on an Internal or external certification by mechanics or mechanical engineers; and/or

3. ... based on using Proxy information such as age of the rolling stock or estimated service life.

Although jurisdictions could answer separately for each class of asset, we summarize the bus rolling stock assets by presenting only that assessment tool reported for the most numerous type of bus in each respective fleet; diesel buses in 85% of the cases (Figure 3).¹² The results reported on the assessment tool used for the most numerous type was somewhat unexpected. That is, about two thirds of Large Bus (67.0%) and Small Bus (67.5%) jurisdictions reported using tools based on a detailed Inspection and analysis guidelines or procedures, proportionately more than either Large Rail (57.1%) or Medium Bus (54.4%). For jurisdictions reporting a tool based on Internal or external certification by mechanics or mechanical engineers, the results were also mixed; more than two thirds (68.9%) of Small Bus jurisdictions reported this method. Of note was that the use of Proxy information such as age or estimated service life as the most common assessment tool for three-quarters (74.6%) Medium Bus jurisdictions.

Figure 3 Tool used to complete physical assessment of principal bus by size of fleet, 2016



Note: Jurisdictions having at least one public transit bus
Source: Canada's Core Public Infrastructure Survey, 2016

For the seven jurisdictions with rail rolling stock, we did not summarize by most frequent asset type but instead examined each independently. All three jurisdictions with Subway railcars as well as all three with Commuter railcars used an assessment based on detailed Inspection and analysis guidelines or procedures. Only one jurisdiction with Subway railcars used all three assessment tools as did one different jurisdiction for Commuter railcars. For jurisdictions with Light railcars, the two operating almost all such vehicles reported using an assessment method based on Proxy information such as age or estimated service life to complete the physical assessment. Finally, the jurisdiction with Streetcars used an assessment tool based on internal or external Certification by mechanics or mechanical engineers for assessing.

Summary

There has been much emphasis recently on the need to invest in public transit infrastructure, viewed as reducing both urban congestion and carbon emissions associated with urban travel. In 2017, Statistics Canada, in partnership with Infrastructure Canada, launched a first-ever catalogue of the state of the nation's infrastructure. The catalogue provides statistical information on the stock, condition, performance and management strategies of Canada's core public infrastructure assets. As mentioned at the outset, high-level results from the surveys of various asset classes, including roads, bridges and tunnels, wastewater

treatment facilities and public transit, were made available by Statistics Canada in a series of releases during 2018.

For jurisdictions owning at least one public transit bus, some results were as expected. For example, jurisdictions with larger transit fleets (bus and rail) were more likely to have a formal transit asset management plan. However, evidence to support our hypothesis that jurisdictions with larger fleets would always have a more systematic approach to asset management was mixed. For example, there was not a clear pattern for the type of condition assessment cycle time and for the assessment tool or method used to assess the condition of assets by size of fleet. As such, we suggest that subsequent research is needed to disentangle some of the determinants (e.g. size, province, asset type and jurisdiction) using logistic regression in order to explain the observed variations.

Acknowledgements

The authors would like to recognize the valuable comments and insights provided on this paper by Chris Johnston and Craig Kavanagh of Statistics Canada.

Endnotes

¹ Winston, C. (2013). On the performance of the U.S. transportation system: Caution ahead. *Journal of Economic Literature*, **51** (3), 773-824.

² Florida, R. (2003). Cities and the creative class. *City and Community*, **2** (1), 3-19. Florida asserts that firms tend to cluster in urban locales not only to capture inter-firm linkages and spillovers effects as well as to enable face-to-face encounters, but also to draw from concentrations of talented people deemed essential to spawn innovation and economic growth.

³ Iacobacci, M. (2017). Business cases for major public infrastructure projects in Canada. University of Calgary School of Public Policy *Research Paper*, **10** (28), 1-30. University of Calgary.

⁴ See, <http://www.infrastructure.gc.ca/plan/about-invest-a-propos-eng.html> (accessed 13/12/17).

⁵ The Canadian population grew by 5.0% from 2011 to 2016 but Census Metropolitan Areas (CMA) grew by 6.2%. In 2016, commuters spent an average 26.2 minutes travelling one way to their workplace, up from 25.4 in 2011. In Canada's three largest CMAs, the average one-way commute was at or above 30 minutes. Statistics Canada (2017). Journey to Work: Key results from the 2016 Census. *The Daily*: <https://www150.statcan.gc.ca/n1/daily-quotidien/171129/dq171129c-eng.htm> (Nov. 29, 2017).

⁶ For example, the Toronto Board of Trade estimated that delays on roads and highways from congestion costs as much as \$500 to \$650 million per year in higher prices for goods across Canada, see Toronto Region Board of Trade (2017) Movement of Goods Series Report # 3, November (<https://www.bot.com/PolicyAdvocacy/PolicyAdvocacy/Transportation.aspx>, accessed 28/01/19). And the Pembina Institute reports that emissions from on-road freight are set to eclipse passenger emissions around 2020 and there needs to be more attention paid to the environmental impact from urban freight congestion. See, Plumtree, B., Angen E. and Zimmerman, D. (2017) The State of Freight: Understanding greenhouse gas emissions from goods movement in Canada. Pembina Institute, June (<https://www.pembina.org/pub/state-of-freight>, accessed 28/01/19).

⁷ A census of urban municipalities and regional governments within the urban core and rural municipalities with at least 5,000 population was taken. A sample of rural municipalities with population between 1,000 and 4,999 was taken. Municipalities with population below 1,000 were excluded from the target population.

⁸ Statistics Canada (2018). Canada's Core Public Infrastructure Survey: Public transit assets, 2016. *The Daily*: November 27 <https://www150.statcan.gc.ca/n1/daily-quotidien/181127/dq181127c-eng.htm>.

⁹ In the November 27, 2018 Daily release, 315 jurisdictions were identified as owning public transit assets. In order to more precisely identify what is intuitively considered a public transit system, our analysis is based on those 144 jurisdictions that owned or leased, and hence operated, at least one transit bus.

¹⁰ Rail vehicles, such as subway cars and light rail cars, have much longer life spans than buses. For example, the original Bay Area Rapid Transit (BART) cars in the San Francisco area, built in 1968, are still in operation fifty years later. And the Toronto Transit Commission continues to use streetcars originally built in the 1970s. MacKechnie, D. How Long Do Buses and Other Transit Vehicles Last? (Accessed 05/02/19: <https://www.thoughtco.com/buses-and-other-transit-lifetime-2798844>)

¹¹ With respect to particular rolling stock, we note that some operators are in the midst of a planned replacement. With streetcars for example, the Toronto Transit Commission has a long term contract with Bombardier. According to the original delivery plan, 204 new streetcars were to be delivered by 2019. By the end of 2016, about 30 had been delivered and then another 59 by the end of 2017. See, Artuso, A. (2018), Aging TTC streetcar fleet feeling the cold, replacements slow to arrive. *Toronto Sun*, Jan. 3: <https://torontosun.com/news/local-news/aging-ttc-streetcar-fleet-feeling-the-cold-replacements-slow-to-arrive>, accessed 12/2/19).

¹² Of the 144 jurisdictions, there were only 21 that had a bus type other than diesel as the most frequent bus asset; several Bio-diesel in the Large Rail, Large Bus and Medium Bus jurisdictions and more Other types of buses for Small Bus jurisdictions.