PEMBINA institute

Using Data to Reduce Urban Freight Emissions

Recommendations for data-driven climate solutions in Canada

Mark Stout

Saeed Kaddoura

June 2021

PEMBINA institute

Using Data to Reduce Urban Freight Emissions

Recommendations for data-driven climate solutions in Canada

Mark Stout

Saeed Kaddoura

June 2021

Contributors: Maddy Ewing

Recommended citation: Stout, Mark and Saeed Kaddoura. *Using Data to Reduce Urban Freight Emissions: Recommendations for data-driven climate solutions in Canada*. The Pembina Institute, 2021.

The Pembina Institute
219 19 Street NW
Calgary, AB
Canada T2N 2H9
Phone: 403-269-3344

Additional copies of this publication may be downloaded from the Pembina Institute website, www.pembina.org.

About the Pembina Institute

The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We employ multi-faceted and highly collaborative approaches to change. Producing credible, evidence-based research and analysis, we consult directly with organizations to design and implement clean energy solutions, and convene diverse sets of stakeholders to identify and move toward common solutions.

pembina.org

twitter.com/pembina facebook.com/pembina.institute

Donate to the Pembina Institute

Together, we can lead Canada's transition to clean energy. Your gift to the Pembina Institute directly supports environmental education and innovative research that advances understanding and action on critical energy and environmental issues.

pembina.org/donate

This report was prepared for Transport Canada.

Using Data to Reduce Urban Freight Emissions

Recommendations for data-driven climate solutions in Canada

Table of Contents

List of Figures

List of Tables

Executive summary

In this era of big data, we have the ability to collect more information than ever before. In cities, telecommunication companies harness data on the movement of people and vehicles in an effort to understand the evolving mobility demands and needs of both city residents and freight. While there are important considerations in the collection of data like protecting people's privacy, deepening this knowledge and understanding around mobility and transportation in urban areas is a good thing. For cities to be economically competitive, move forward on climate action, and meet the increasing demands to move people and goods, they must leverage available data to inform and strengthen policy-making.

Through our work and engagement with policy practitioners and planners, better data collection on urban freight has been identified as an urgent need, especially when considering the rise in freight emissions and recent changes to e-commerce activity in Canada. Not only has demand sharply increased but the way deliveries move through our cities has also changed — going directly to our doorstep.

In this study, the Pembina Institute has set out to better understand what drives urban freight trips — especially in the business-to-consumer (B2C) segment — and what information and data is currently being collected or should be collected to inform future planning and policy-making efforts.

This research has made it clear that there are multiple ways Canada can improve its collection and use of data toward stronger and more efficient urban freight systems. We recommend the federal government do the following:

- **Strengthen data governance framework and co-ordination**: Establish an overarching national data governance framework and co-ordinate actors in the freight ecosystem, such as private business and industry, academic institutions and civil society organizations, to facilitate data sharing.
- **Establish new national data collection initiatives:** Canada should look to adopt best practices from other countries on national data collection. National carrier companies could play a leading role in aggregating information on urban freight trip generation, similar to the data collected by the U.S. Postal Service, in order to understand broad trends.

- **Explore new legislation, including mandating data-sharing**: Data-sharing models used elsewhere can serve as an example as to how legislation could support data collection of urban freight activity. In the Netherlands, for instance, newly adopted legislation requires transport companies of a certain size to submit their precise truck routing data to the national statistics agency.
- **Establish data partnerships with logistics operators:** The federal government should consider further research or projects on urban freight data sourced directly from logistics operators or help establish partnerships between those operators and other levels of government.
- **Leverage real-time data from telecom operators**: Data from telecommunication operators, or telematics, is another area that warrants further investigation as a detailed source of urban freight data.
- **Enhance municipal/regional household travel surveys:** Expanding these surveys to include questions on e-commerce and home delivery frequency can be a cost-effective approach to better understand urban freight trends and how to plan for it accordingly.

1. Introduction

Canadians are buying online more than ever. Between 2016 and 2020, e-commerce sales made by Canadians grew by more than 350%, as shown in Figure 1. As urbanization, online shopping, and the demand for same-day and next-day home deliveries increases, it is expected that more freight vehicles will be on urban streets contributing to emissions, traffic congestion, noise, air pollution, and greater conflicts between road users at the curbside. Canada's 2021 National Inventory Report shows that since 1990, freight transport emissions have increased by 154%, making freight the second-highest emitting subsector in Canada next to oil sands, with an emissions growth rate far in excess of passenger transport.[1]

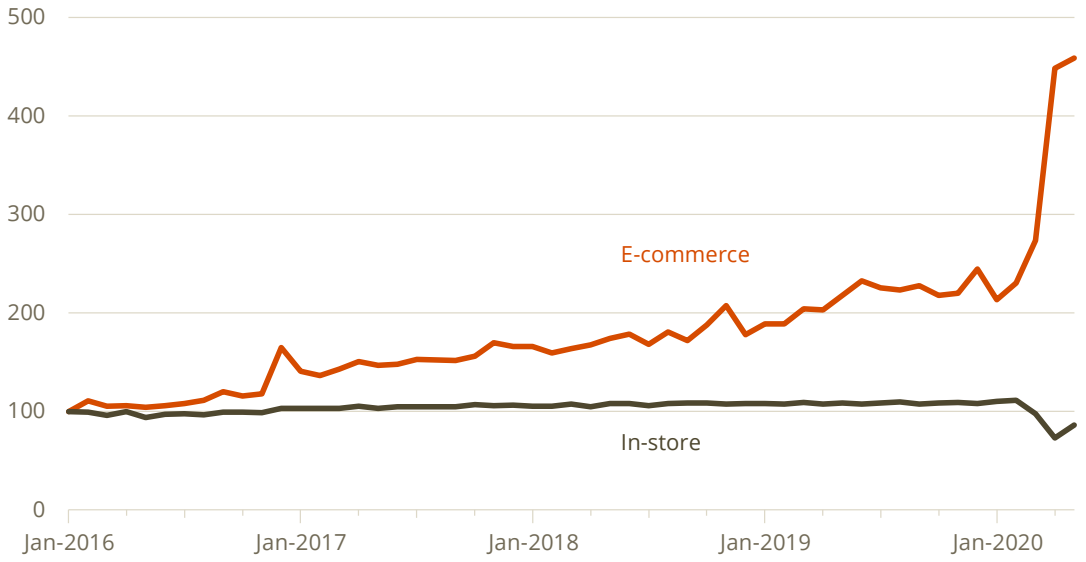

Figure 1: Growth of e-commerce sales in Canada

indexed; Jan. 2016=100

Data source: Statistics Canada[2]

But what do we know in Canadian cities about the volume of purchases, the number of individual doorstep deliveries, the vehicle kilometres travelled by trucks to deliver parcels and packages, the most common truck routes used, impacts of trucks on

[1] Environment and Climate Change Canada, *National Inventory Report 1990-2019: Greenhouse Gas Sources and Sinks in Canada* (2021), Table A10-2, Annex 10. https://unfccc.int/documents/271493

[2] Aston, Jason et al., *Retail e-commerce and COVID-19: How online shopping opened doors while many were closing* (July 24, 2020). https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00064-eng.htm

different neighbourhoods, or the carbon emissions produced by these trips? There is limited publicly available data in terms of estimating truck trip demand and routing to help municipal and regional policy-makers and planners respond and adapt to changing urban delivery patterns. While some governmental entities and agencies in Canada undertake comprehensive traffic surveys that provide a snapshot of the goods movement sector (e.g., origin-destination travel flows, trip lengths, commodity types), most of these data collection efforts do not track urban intra-municipal/regional freight movements and only offer a high-level national or provincial picture of goods movement activities. More granular data is needed to equip policy-makers and decision-makers with timely information and insights to better understand what is happening in our local and regional roads and to adapt and respond to the public health, economic, and environmental impacts from an evolving goods movement system.

Using new, real-time data will inform daily government and business workflows, build a culture of more evidence-based decision-making, and in this case, help to reduce the carbon emissions of transportation and freight in Canadian cities, especially with the trend of increased e-commerce activity and trucks on our streets.

2. Objectives and methodology

The research objectives for this study were to:

- Understand the key indicators of urban freight activity.
- Identify and consolidate existing data sources that can inform future research into urban freight in Canadian cities.
- Identify data and knowledge gaps that create barriers to well-informed urban freight and goods movement policy and planning efforts.
- Identify key learnings and recommendations to improve understanding of urban freight activities.

To inform our research, we undertook a literature review of urban B2C last-mile trip generation to homes, and carried out surveys with three municipalities — Toronto, Edmonton, and Vancouver — to understand the urban freight datasets that inform their planning work and those that may be useful in future. Additionally, in April 2021, we hosted a virtual workshop, *Using data to decarbonize urban freight in Canadian cities*, which included breakout sessions for discussion on the urban freight data gaps and top priorities in Canadian cities, potential sources and collection methods of urban freight data, and partnerships for local or regional urban freight laboratories.

3. Taking stock of freight data

Several organizations are involved in the governance and collection of freight data in Canada. The federal government plays the biggest role through Transport Canada's work on national freight commodity and financial statistics. Provinces and territories collect different data and have various freight data initiatives. Even the cities and regions of Canada collect a small amount of freight data in different ways. Clearly, there is room in Canada to advance a more co-ordinated urban freight data collection effort to develop a better understanding of the movement of freight in cities.

The federal government of Canada has several freight datasets on commodities and financial performance of the freight industry — of course national in scope. These datasets are the result of several mandatory, countrywide surveys that Statistics Canada conducts on behalf of Transport Canada. By nature of a countrywide survey with mandatory participation, these initiatives are costly and time-consuming to operate.

In this study, the Pembina Institute performed a review of freight-related datasets from these data collection agencies and surveyed Edmonton, Vancouver, and Toronto to identify publicly available datasets on urban freight, as well as household and personal characteristic data in Canada (and some sources from the United States). The findings of our data catalogue are summarized in Table 1. This is not intended to be a complete and comprehensive listing and should be considered as a starting point to take stock of what data exists today and the gaps that should be filled.

In Table 2, gaps and priority urban freight data are highlighted and summarized, reflecting the key findings of our survey of three municipalities. In summary, the three cities surveyed by Pembina Institute stated that they have next to no data on urban freight and wish to begin collecting much more to understand the existing situation and the associated emissions. Common areas of interest to increase data collection include: travel demand, such as volumes of packages; emissions associated with different types of travel and travel patterns; curbside use; and modes of transport and vehicles.

Table 1: Relevant urban freight datasets in Canada

Level	Department/agency	Dataset
National	Transport Canada	Freight Trucking Statistics
	Transport Canada	Trucking Commodity Origin and Destination Survey
	Transport Canada	Annual For-Hire Trucking Survey
	Innovation, Science and Economic Development Canada	Canadian Internet Use Survey
	Transport Canada	Rail Commodity Origin and Destination
Provincial	Ministry of Transportation	Commercial Vehicle Survey, Ontario
Municipal / Regional	City of Vancouver	City of Vancouver Annual Transportation Survey
	Many local and Ontario government agencies	Transportation Tomorrow Survey (Toronto and Hamilton area)
	City of Edmonton	Edmonton and Region Household Travel Survey
	City of Edmonton / Alberta Transportation	Edmonton Commodity Flow

Table 2: Aggregated summary of municipal survey findings

Themes	Data gaps / summary of priority data to obtain
Travel demand	• More extensive truck volume data across the city • Data on origin–destination patterns of urban freight • Volume by vehicle type to estimate urban freight VKT and GHG emissions • Distances travelled for urban freight • Volumes of packages delivered • Number of trips by commodity type / industry
Curbside use	• Data on pick-ups / drop-offs of urban freight at the curbside • Locations and durations of stopping and loading / unloading
Modes of transport and vehicles	• Significant blind spot in data on sharing economy freight (food delivery services and Amazon and other courier services) • Breakdown of freight vehicle types operating in the city, including cars, bicycles, cargo bikes, and other micromobility devices which often carry meal deliveries • Mileage and fuel consumption • Proportion of zero-emission vehicles by vehicle type • Proportion of fleet vehicles to owner–operator vehicles

4. Indicators of urban freight trips

As mentioned, the growth of e-commerce and doorstep deliveries is changing the profile of urban freight activity. Freight trips do not end solely at commercial destinations anymore; they also end at Canadian households. As a result, traditional indicators of urban freight activity like land use and employee numbers that captured the urban freight activities of the past (when most shopping occurred in bricks-and-mortar buildings and not online) are now not enough to capture the full spectrum of freight trips that are occurring on our highways and local streets. These traditional indicators are well-documented by the Institute of Transportation Engineers and publications of the Transportation Research Board (TRB).[3]

These indicators are used for various purposes, a common one of which, when coupled with historical trip generation data, is to estimate trip generation and the estimated traffic impacts of new developments. Indicators of trip generation are also used to quantify travel demand more broadly and to estimate sizing of infrastructure like street widths, accommodation of cycling facility type, and intersection traffic signal timing plans, among other uses.

To adapt to the shifts in the urban freight landscape, new academic research in the United States is emerging that studies business-to-consumer (B2C) freight activity using household travel surveys. While similar studies in Canada are lacking, these U.S. studies offer insights.

Several studies in the United States have used datasets such as the U.S. National Household Travel Survey and the U.S. Postal Service Household Diary Study to establish the relationships between household and personal characteristic data and the number

[3] Transportation Research Board, *Freight Trip Generation and Land Use*, (2012). http://www.trb.org/Publications/Blurbs/168397.aspx

of home deliveries received.[4,5,6] Common indicators that have a statistically significant correlation with freight activity include level of education, household income, gender, and employment. The key takeaway is that these indicators can enable practitioners to predict the number of deliveries to home and therefore provide additional insights and knowledge to future planning efforts. It is important to note that some indicators have a stronger correlation with the tendency to generate e-commerce deliveries, as shown in Table 3. This is useful information to be able to model the e-commerce freight deliveries of any urban area with more readily and publicly available data like household income and level of education.

The information in Table 3 below, sourced from the cited studies, provides an understanding of the indicators of urban freight trip demand in residential areas, with internet use, education level, self-employment status and household income being the strongest correlating factors. However, the information is derived from various methodologies using different assumptions, complicating a simple comparison of the studies' outputs. For example, when it comes to examining the statistical relationship between urban freight trips and education level, one study defined education level as having at least a bachelor's degree or not whereas another study analyzed this at a more granular level (five categories of educational attainment). Household income was also categorized in a variety of ways.

[4] Xiaokun Wang and Yiwei Zhou, "Deliveries to residential units: A rising form of freight transportation in the U.S.", *Transportation Research Part C: Emerging Technologies*, 58, Part A (2015). http://dx.doi.org/10.1016/j.trc.2015.07.004

[5] Tayo Fabusuyi et al., "Estimating small area demand for online package delivery", *Journal of Transport Geography*, 88, (2020), 102864. https://doi.org/10.1016/j.jtrangeo.2020.102864

[6] Monique Stinson, Annesha Enam, Amy Moore, Joshua Auld, "Citywide Impacts of E-Commerce: Does Parcel Delivery Travel Outweigh Household Shopping Travel Reductions?" in *SCC '19: Proceedings of the 2nd ACM/EIGSCC Symposium on Smart Cities and Communities, Portland, Oregon, US September 10-12, 2019* (2019) article no. 10. https://doi.org/10.1145/3357492.3358633

Table 3: Indicators of urban freight trip generation in residential areas

Indicators with tendencies to generate urban freight trips in residential areas			
Internet use frequency	✓✓	Gender	✓
Education level	✓✓	Race	✓
Self-employment	✓✓	Age of consumer	✓
Household income	✓✓	Occupation	✓
		Housing density	—
		Rural area	—
		Number of vehicles	?

Legend

✓✓ stronger correlation — weaker correlation

✓ moderate correlation ? unclear (dataset and model dependent)

Unlocking new insights with household data

In two studies, these indicators of urban freight trip generation listed above in Table 3 have been applied to specific urban settings and tested for accuracy.

In a study by Fabusuyi et al., the indicators in Table 3 are included in a model to estimate the number of home deliveries in the Miami-Dade County area of Florida. The model used only publicly available datasets including the U.S. National Household Travel Survey and outputs of the Southeast Florida Regional Planning Model to extract the strongest indicators of tendency to receive online deliveries and then used those indicators to estimate the total number of deliveries across many micro analysis zones as small as 0.0015 square miles (also showing the spatial variation of deliveries). This total number for Miami-Dade County was then compared to the sum for the same geography from the National Household Travel Survey. The results of the model are 5.93 million deliveries total, summed from the individual zones estimated, which correlates well with the results from the National Household Travel Survey for the same area (5.56 million deliveries). This study develops an important model for delivery estimation and shows how this type of modelling could be applied in cities — using only publicly

available data in the U.S. — to forecast, model, and understand the B2C urban freight traffic, and lead to interventions to manage the demand and resulting carbon emissions.

Second, in the Wang and Zhou study, the researchers applied the indicators of Table 3 in a model of the Capital District (Albany area) of New York State. This study estimated freight trips generated by residential units and businesses, as shown in Figure 2. A key conclusion of the study is that residential households generate the same order of magnitude of freight trips as businesses. In other words, freight trip generation by households cannot be overlooked in urban transport policy and planning.

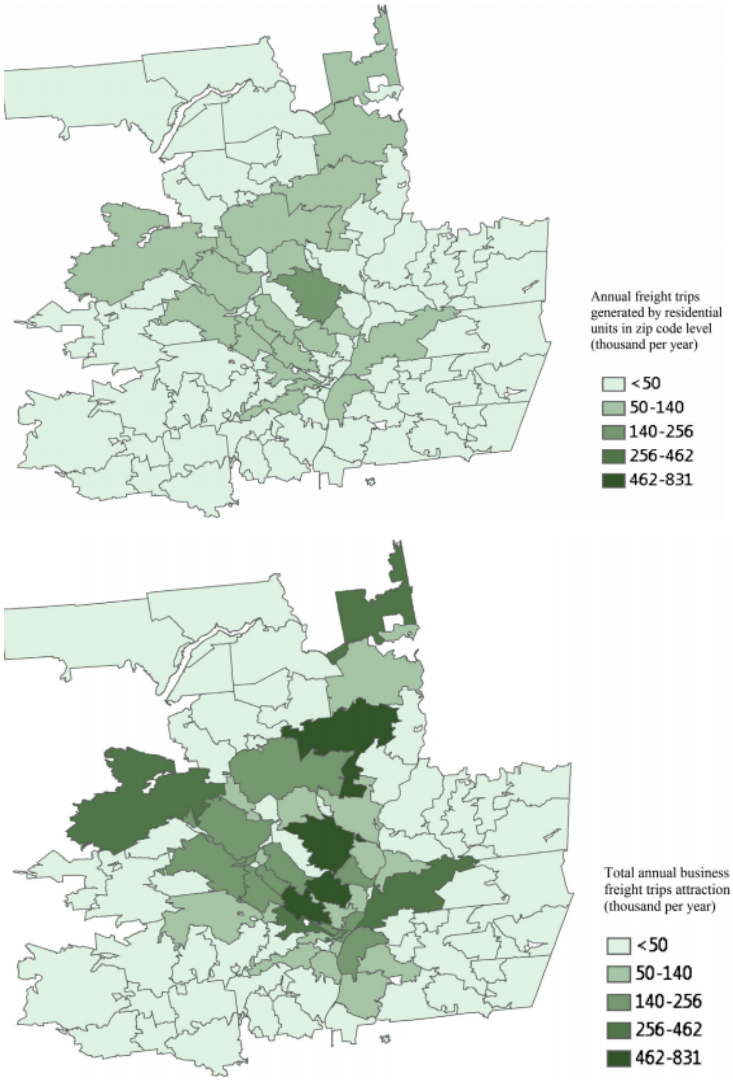

Figure 2: Comparison of urban freight trip generation by residential units (top) and businesses (bottom) in the Capital District area of New York State

Source: Wang and Zhou[7]

[7] "Deliveries to residential units."

Similar analysis could also be applied to Canadian cities using publicly available Statistics Canada and / or municipal census data such as education level, household size, age, gender, race, home ownership status, housing unit density, and population density. This would allow an estimate of freight trip demand to residential areas and facilitate analysis of alternative means to reduce the carbon emissions of urban freight.

5. Recommendations

With freight transport emissions growing and urban delivery activities changing in Canada, the imperative for Canada to implement transformative and data-driven solutions is also growing. There are opportunities for the federal government to strengthen the co-ordination and data governance framework with relevant actors, strengthen our data collection efforts, and leverage technological advances in collecting real-time datasets to better understand the rapidly evolving trends and impacts of urban freight in Canadian cities. As next steps, we recommend the following actions.

1. Strengthen data governance framework and co-ordination

Bolstering our collective understanding of urban freight and being able to effectively plan for the future requires co-ordinating a multitude of actors in the urban freight ecosystem. There is a role for the federal government to establish an overarching national data governance framework and co-ordinate actors in the freight ecosystem such as private business and industry, academic institutions and civil society organizations to facilitate data sharing. Similar to physical infrastructure, we need to think about building national data infrastructure. There are many datasets in the private domain that could be used for public and private benefit, like actual delivery vehicle routing information in urban areas. For access and to maximize benefits, these datasets require some form of neutral platform for information exchange, possibly even connected to vehicle transport management systems, that ensures privacy and data integrity.[8]

Data sharing agreements could be used to further the governance framework and co-ordination between entities. These agreements could cover such elements as included datasets, purpose of sharing the data, any requirements on the end use of the data and any analysis, data storage security, data disposal requirements, etc.

2. Establish new national data collection initiatives

A dataset used frequently in the U.S. to understand and quantify e-commerce urban freight activity is the annual United States Postal Service's Household Diary Study. In a

[8] Alliance for Logistics Innovation through Collaboration in Europe, *A framework and process for the development of a roadmap towards zero emissions logistics 2050,* (2019). http://www.etp-logistics.eu/wp-content/uploads/2019/12/Alice-Zero-Emissions-Logistics-2050-Roadmap-WEB.pdf

similar vein, Canada Post and other carrier companies could play a leading role in aggregating data on urban freight trip generation to homes and businesses in Canadian cities and regions, in order to understand broad trends.

The U.S. Postal Service's annual survey includes questions on packages sent and received and is cited frequently in the academic literature on estimating residential area urban freight trip demand for traffic or parking modeling or other purposes.[9,10] Table 4 shows sample questions and their rationale from the U.S. Household Diary Study.

Table 4: Sample questions and rationale from the U.S. Household Diary Study

Sample question	Question rationale
Contents of package	Understanding the key segments *e.g. clothing is number one in the 2019 survey, in volume received*
Sender type *e.g. department store, grocery store, online sales site, etc.*	Gathering the key sender types in the market
Ordering method *e.g. online via Amazon, online other website, by phone, etc.*	Understanding the means of ordering
Class of mail *e.g. ground delivery, expedited, etc.*	Grasping the demand for fast delivery *e.g. next-day, two-day*

It is acknowledged that Transport Canada would not simply request Canada Post to conduct an annual, large, and expensive survey. However, the idea is worth consideration based on, first, the observation of what other countries are doing; and second, by the fact that it is used frequently in academic research to further the understanding of urban freight delivery and supportive infrastructure needs (for example to guide curbside loading supply and demand management in higher density areas). Canada's cities and regions, and indeed the country, would benefit from such an initiative.

[9] Quanquan Chen, Alison Conway, Jialei Cheng, "Parking for residential delivery in New York City: Regulations and behavior", *Transport Policy*, 54 (2017), 53-60. http://dx.doi.org/10.1016/j.tranpol.2016.12.005

[10] Pierre Escand, Quanquan Chen, Alison Conway, "Parking Conditions for Residential Delivery in New York City: A Case Study Analysis", *Transportation Research Record: Journal of the Transportation Research Board,* 2672, 9, (2018), 204-215. https://doi.org/10.1177/0361198118783161

3. Explore new legislation, including mandating data-sharing

Canada should look to urban freight data models from other countries to understand the opportunity new legislation and national co-ordination could provide. Inter-governmental efforts in the Netherlands offer a good example of actions to reduce urban freight emissions to create healthy and sustainable cities.

The Dutch national government is working with 30 to 40 of its cities to implement a federal "Roadmap for introducing a zero-emission zone for city logistics (ZECL), for local authorities" by 2025. As a part of this initiative, the national government is providing multiple resources to assist municipalities with planning and implementation such as:[11]

- Funds for developing plans to achieve ZECL zones
- Co-ordinated expert advice
- Information sharing with other cities
- Advice on engaging local elected officials

A key enabling component to this planning work is newly adopted national-level legislation that requires transport companies of a certain size to submit their precise truck routing data to the national statistics agency.[12] To protect data privacy, the data can be accessed and analyzed under strict agreement only at the agency offices. This work provides a good example of what Canada and its cities could do.

4. Establish data partnerships with logistics operators

Logistics operators also have urban freight data that could be shared further. One research paper published in 2019 in the U.S. cited data from UPS in modelling, but papers with these data appear to be limited in number.[13] Data sharing opportunities among logistics operators, including retailers and delivery app companies, were mentioned during the virtual workshop of this study. The federal government should consider further research or projects on urban freight data sourced directly from logistics operators and help establish partnerships between those operators and other levels of government.

[11] Transport Decarbonization Alliance, *Zero-emission zones: don't wait to start with freight!,* (2020). http://www.rupprecht-consult.eu/uploads/tx_rupprecht/ZEZ-F_How-to-Guide_low.pdf

[12] Ron van Duin, Technical University of Delft, personal communication, April 12 and 14, 2021.

[13] "Citywide Impacts of E-Commerce."

5. Leverage real-time data from telecom operators

Data from telecommunication operators, or telematics, is another area that warrants further investigation as a detailed source of urban freight data. The federal government should consider providing funding for information sharing, data collection efforts, and partnerships with telecom operators and fleet operators.

As more real-time data are collected by telecom operators, this source will become increasingly important, as French scholar Laetitia Dablanc mentioned in her presentation during the urban freight data workshop hosted by Pembina Institute in March 2021.[14]

In correspondence with the Pembina Institute, Canada-based vehicle analytics provider Geotab revealed that it is able and interested in exploring its urban freight mobility data further to understand the origins, destinations, and routing of trips in time and space — segmented by various commercial vehicle types. This could be examined further, for example, in one city and could be used for multiple ends: understanding trip lengths and possibility of mode shift to lower-emitting modes like cyclelogistics, typical routing and best opportunities for charging stations for urban freight vehicles, heatmaps of delivery stops and opportunities for curbside loading zone pricing and management, etc. It is recommended that Transport Canada consider such an initiative and support further research on the topic.

6. Enhance municipal/regional household travel surveys

From the literature, one of the most used datasets in the U.S. to understand and quantify e-commerce urban freight activity is the U.S. National Household Travel Survey. This survey, however, is large, comprehensive, and expensive to conduct, and an equivalent survey does not exist in Canada.

Based on feedback from the March 2020 virtual workshop, this type of large survey is unlikely to be the future of urban freight data collection due to the costs involved. Further, most large Canadian cities or regions already conduct regular surveys to collect information on household travel patterns. Expanding the survey to include questions on e-commerce and home delivery frequency can be a cost-effective approach to better understand urban freight trends and how to plan for them. For instance, the U.S.

[14] Laetitia Dablanc, "Urban freight data and decarbonization, some elements from Paris and France," presented at *Using Data to Decarbonize Urban Freight in Canadian Cities*, March 24, 2021. https://www.pembina.org/docs/event/2021-03-28-urbanfreight-laetitiadablanc.pdf

National Household Travel Survey 2017 asked: "In the past 30 days, how many times did you purchase something online and have it delivered?"[15]

Adding similar content to existing surveys would generate a regular data series on urban freight trip activity and patterns. Cities or regions would be able to apply their data to modelling to estimate the quantity and spatial distribution of urban freight activity. They would then be able to begin to take action to reduce the carbon impact of urban freight, knowing the quantity and characteristics of it. For example, knowing the estimated number of urban freight trips or deliveries per neighbourhood per day, the municipality could develop programming in central urban areas to encourage a transition to cyclelogistics or small shorter-range zero-emission-vehicle vans to service the freight demand. The data collected could even be used in business case development for delivery operators.

[15] U.S. Department of Transportation, Federal Highway Administration, *Summary of Travel Trends 2017 National Household Travel Survey*, (2018). https://nhts.ornl.gov/assets/2017_nhts_summary_travel_trends.pdf