PERCEIVED BARRIERS TO FREIGHT MOBILITY IN CANADA

MOVEMENT OF GOODS IN CANADA: A STATE-OF-THE-ART REVIEW AND A GROUNDED THEORY INVESTIGATION OF PERCEIVED BARRIERS

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Master of Science

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Title: Movement of Goods in Canada: A State-Of-The-Art Review and A Grounded Theory Investigation of Perceived Barriers

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Lay Abstract

This twofold work first presents a state-of-the-art review of the roots and context for hinderances to the movement of freight, and secondly, investigates the key barriers to freight mobility in Canada as perceived by Canadian stakeholders. The review provides a holistic approach to understanding the interconnected nature of mobility, spatial structure, congestion, supply chains, and the economy on generating, demanding, and hindering freight movements.

The investigation develops a novel theory grounded in the experiences of stakeholders in Canada. Emergent are categories which frame the barriers to freight mobility as high infrastructure utilization, diminishing reliability, rapidly growing regions, ineffective or absent policy support, and insufficient data collection and sharing. These categories are theorized to be influenced by cost, political risk, implement-ability, and maintainability considerations. The concepts are to collect and analyze data to inform stakeholder evaluations of policy interventions, with government funding to support knowledge generation, policy actions, and capacity investments.

Abstract

This twofold work first presents a state-of-the-art review of the roots and context for freight mobility barriers, and secondly investigates the key barriers to freight mobility in Canada from the perspective of stakeholders. The review provides a holistic approach to understanding the interconnected nature of mobility, spatial structure, congestion, supply chains, and the economy on generating, demanding, and hindering freight movements.

The investigation develops a novel theory grounded in the experiences of stakeholders following the Strauss/Corbin extended Grounded Theory approach of symbolic interactionism. From interviews with 28 industry and government stakeholders, a total of 50 themes emerged as barriers. These barriers were grouped into four categories which frame the issue of freight mobility as being impacted by high infrastructure utilization, cost impacts of diminishing distribution reliability, rapidly growing regions and ineffective or absent policy support, and lacking a robust data collection, analysis, and sharing framework.

The categories were considered in the frame of addressing goods movement barriers and were argued to be influenced by factors of cost, political risk, implement-ability, and maintainability. A framework was developed by integrating the emergent categories and factors, identifying four high-level interventions: data and knowledge mobilization; public-private collaborative freight evaluations; government funding and political support; and, capacity alterations: improvements and expansions. Overall, the key concepts of the emergent theory are to collect and analyze data to inform public-private stakeholder evaluations of policy interventions, with government funding to support both knowledge generation efforts, policy actions and capacity investments. There is a significant need to expand data collection and information sharing to enable firms and government to address physical and policy barriers which impede the effective goods movements, including infrastructure and land use planning. The theory is generally consistent with barriers identified internationally.

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-Sean

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List of Abbreviations

3PL – Third-Party Logistics Provider
4PL – Fourth-Party Logistics Provider
AV – Autonomous Vehicles
CAV – Connected Autonomous Vehicles
CMA – Census Metropolitan Area
FTL – Full Truckload
GT – Grounded Theory
HOT – High Occupancy Toll Lane
HOV – High Occupancy Vehicle Lane
ICT – Information and Communications Technology
ITS – Intelligent Transportation System
LTL – Less than Truckload
NIMBY – Not in My Backyard
PV – Personal Vehicles
TEU – Twenty-Foot Equivalent Unit

Declaration of Academic Achievement

This work is submitted in partial fulfillment of the requirements for the degree Master of Science.

Key parts of this work have been prepared in the form of a journal article that has been submitted for publication consideration to an international peer-reviewed journal*. The first author, Mr. Sean Sears, is the primary author of the work and is directly responsible for completing the analysis and the physical writing of the article. The associated authors (Drs. Moataz Mohamed, Mark Ferguson, Saiedeh Razavi, and Antonio Paez) have contributed in various supervisory aspects providing guidance, technical assistance, and editorializing. Furthermore, this work is constructed from a series of interviews conducted by the McMaster Institute for Transportation and Logistics (MITL) under the project *Metropolitan Traffic Congestion in Canada: Measures, Causes, Implications, and Policies* (Grant#: 435-2013-1120, MREB#: 2017 029 / 1839), of which Mr. Sears was associated with as a Research Assistant and as the Student Investigator on the project at its inception and participated in the research design. The interviews were conducted by Drs. Ferguson and Mohamed, and transcribed by MITL staff, including Mr. Sears.

All outputs are the work of Mr. Sears.

*NOTE: Pieces of this work, either in part or whole, have been submitted to *Transportation Research Part A: Policy and Practice* for review under the title: "Perceived Barriers to The Movement of Goods in Canada: A Grounded Theory Investigation." Sentences, paragraphs, tables, and figures from Chapter 1 and 7 may be reproduced within this Thesis or the submitted journal article in either part or whole.

Chapter 1. Introduction

Delays in transportation are a well-known issue in Canada, the United States, and across the globe. As motorists or transit users, experiences of delays are predominately rooted in roadway congestion, bottlenecks, construction works, accidents, or the weather. As consumers of goods, these delays are experienced indirectly. The availability of goods in stores and online retailers is impacted by the aforementioned issues, as well as border delays, the ease of delivering, the number of deliveries made in a shift, the availability of drivers, handoffs between modes, handoffs within modes, processing capacity at freight and postal terminals, delays across different modes and in different countries/regions, and a litany of other factors. The prices paid for these goods, to varying degrees of elasticity, are affected by the ease and duration of their transportation. Similarly, the time waited to receive e-commerce deliveries is the result of how quickly a complex chain of movements and handoffs can be made. Hinderances to freight mobility have immediate and daily, though not always visible, impacts of the lives of Canadians.

In fact, the impact that supply-chain delays and congestion have are immense. Without the complex interplay of commercial movements, store shelves would run empty, energy and fuel supplies would be inaccessible to most, and the basis on which life in Canada, the United States, and much of the world is predicated upon – quick and easy access to goods – would cease. Physically expansive countries with disjointed regional economies need transportation systems that operate fluidly and which able are to manage major shocks to the system, including infrastructure failures, major weather events (e.g., floods, heavy precipitation, avalanches, etc.), traffic incidents (e.g., vehicle crashes, derailments), and other events. The COVID-19 pandemic has emphasized the foundational importance of freight movements more than ever highlighting the myriad of ways in which supply chains can be interrupted and how much these movements are taken for granted in day-to-day life (CBC News, 2020). Supply-chain disruptions have been briefly experienced during various infrastructural failures in Canada including the partial closures of the Burlington-Skyway (CBC News, 2014) and Champlain bridges (Muschi, 2013), the failure of the Trans-Canada Highway Nipigon Bridge (Prokopchuk, 2018); and the Autoroute 19 Concorde Boulevard collapse (Mitchell et al., 2011).

As urban populations continue to grow, the efficiency of logistics networks between and within economic centres has become increasingly relevant. Within metropolitan regions, there is a concern that available space to expand infrastructure and accommodate residential and industrial development has been exhausted. Commercial movements are critical to attract industrial investments, which in turn generate jobs and tax revenue (Lan et al., 2017). This is poignantly true of roads, which are generally the only viable infrastructure for the last mile of supply-chains in cities (Bjørgen et al., 2019a; Marcucci et al., 2017b). Freight transportation is essential to the economic prosperity of metropolitan regions (Kiba-Janiak, 2017).

1.1. Objectives

There are two major objectives to this thesis. First, is to provide a state-of-the-art review of the aspects relating to and influencing the movement of freight. The review aims to provide a holistic approach to understanding the interconnected nature of mobility, spatial structure and land use, policy, congestion, supply chains, and the economy on generating, demanding, and hindering freight movements.

The second objective of this study is to investigate the perceptions of stakeholders concerning the barriers to the movement of goods in Canada. Despite significant contributions to the literature from the United States, European Union Members, and other global regions, it is unclear to what extent their findings translate to the Canadian case. Particularly, there is an insufficient understanding of the Canadian perspective on freight congestion, despite Canada's position as a partner in one of the major trading blocks in the world (Bookbinder and Fox, 1998; Bradbury, 2002; Brooks, 2001, 1994) and the level of traffic congestion in its major metropolitan regions. To address this gap in the literature, 28 stakeholders' interviews are analyzed by means of the Strauss/Corbin extended approach of symbolic interactionism, known as Grounded Theory ("GT").

This approach allows us to address the subjective understandings of the barriers to goods movement in Canada as perceived by the interview participants. Based on this investigation, the thesis aims to produce an explanatory theory integrating emergent categories with a series of theoretical factors and propositions. The emergent theory aims to offer insights to understand the perceived barriers to the freight system, as well to detail a framework on the desired infrastructure, operating, and policy outcomes and propositions to improve freight mobility in Canada.

1.2. Structure of Thesis

Given the objectives, this thesis is structured in two major parts: a state-of-the-art review, chapters 2 through 6; and, a novel grounded theory analysis, chapter 7.

First, a major review of the academic and government literature is undertaken to present an overarching understanding of the freight congestion and mobility. This begins with an overview of economic-spatial interactionism, walking through the basics of mobility, spatial structure, global trade, economic development, and the role of information technologies in transportation. This is followed a review of the transportation topology, modalism, specific transport modes, and supporting infrastructures. This leads into a detailed discussion of the logistics process, its integration into supply and value chains, the supporting physical distribution infrastructure, as well as topical discussions of urban logistics sprawl and last-mile movements. These discussions are then expanded with a specific focus on urban transportation and logistics issues focusing on distribution, urban intensification, planning, land uses, and conflict management. Followed by a generalized discussion about the constraining factors of infrastructure development, and a very brief overview of the Canadian urban regulatory context. The first part of the thesis concludes with a discussion on congestion in Canada, how to define congestion, and what the causes, sources, and impacts of congestion are. The aim is to provide a substantive base of information to act as context for the results of the GT process.

The second part of the thesis is focused on the undertaking of a novel grounded theory analysis. This methodological approach is applied to a set of interviews conducted by the McMaster Institute of Transportation and Logistics, which the author was associated with. The analysis of these interviews provides the foundational basis for this part of the thesis. There is a detailed review of the Grounded Theory methodology, including its drawbacks, as well as detailing the interview protocols followed and how the interview data was collected. This is followed by a discussion of the coding and analysis process. The results of the analysis are presented in depth, including relevant example quotations from the interviews. The analytical results are followed by a discussion of the emergent theory, the derived implications, and the theoretical propositions to address the identified barriers. The thesis is then brought to an end in a short conclusion.

1.3. Methods

The review portion of this thesis follows an ad-hoc assessment of academic literature, textbooks, government reporting, and industry / advocacy published works, predominately through a multi-phase backward snowballing approach (Wohlin, 2014). The method is not intended to be a systematic and comprehensive review but is reflective of the major issues. Some aspects are focused on providing a base of information, which helps to understand the results and discussion in the second part of the thesis. While other aspects represent the current literature and important facets to the discussion of freight mobility and barriers to goods movement. It is relevant to note that the grounded theory analysis, chapter 7, was completed before the major review of the literature, as not to introduce significant biases; this is discussed in more detail in section 7.1.

The research methodology for the second part of the thesis, chapter 7, follows the Strauss/Corbin extended Grounded Theory ("GT") approach of symbolic interactionism. This approach allows for the addressal of subjective participant perceptions in regard to barriers and events impacting freight performance in Canada. Specifically, how participants uniquely perceive and operate within their environment rather than a prescribed understanding derived from quantitative metrics (Wagner et al., 2010). GT is a powerful method for exploring and developing an understanding of freight congestion, it impacts, and potential redressals induced from the perspective of 28 Canadian stakeholders. While GT is recognized as an emerging method in logistics and supply-chain management fields (Kaufmann and Denk, 2011; Mello and Flint, 2009; Randall and Mello, 2012), uptake remains limited due to its interpretative nature and practical considerations.

Chapter 2. Mobility, Spatial Structure, and the Economy

Transportation is inherently geographic in nature as it is the means and methods by which physical space is traversed. These movements are hindered by the frictions of that space, including distance, physiography, time, and administrative boundaries (Black, 2003). Every movement has an associated cost which is influenced by the nature of the entity (e.g., movement of passengers versus freight), the distance between an origin and destination (e.g., the relative accessibility of a port city versus an inland city), the mode, and the technology utilized. The value of transportation is in the satisfaction of derived demands; the movement of a required resource from a supply location to a demand location, thus satisfying the demand for mobility (Hayter and Patchell, 2016).

Transportation allows for the mitigation of geographical constraints. It represents the backbone of the global economy as it links people, places, and resources (Hayter and Patchell, 2016). Transportation has four requisite components: the modes of conveyance (e.g., planes, trains, and automobiles), the infrastructures which support the modes of conveyance, network connections between locations, and flows (Black, 2003; Knowles et al., 2008). The importance of transportation is increasing as the demand for mobility continues to grow. The unit costs of transportation (i.e., the cost to move a single item, typically a box or container) have and continue to decrease as infrastructure continues to grow globally (Rodrigue, 2020). While transportation underlies the economy, infrastructure is the critical enabler of transport as it allows for the unequal spatial dispersion of resources and labour to be overcome.

2.1. Mobility

Mobility represents the ease with which movements and transportation-related economic activities can take place. It is constrained by the availability of infrastructure, the availability of a relevant modal vehicle (e.g., personal car, locomotive, aircraft, etc.), and the cost of moving between an origin and destination for any given trip (Black, 2003). Since transportation infrastructure is not a homogenously provided asset, there are variations at the local, regional, national, and global levels of the availability and scale of transportation mobility, producing differentials in available opportunities (Knowles et al., 2008). From an economic perspective, these variations lead to comparative and absolute advantages; from a pragmatic perspective, these affect the modes, frequencies, and distances goods and people are able to travel (Hayter and Patchell, 2016). Mobility and accessibility directly impact socio-economic opportunities, access to labour markets, and access to global trade markets (e.g., the relative accessibility of oil from Alberta compared to US shale production). The less accessible a good or location, whether in real or relative terms, the more expensive it becomes, limiting the competitiveness of that product or location (Alonso, 1964; Weber, 1929).

Transportation mobility within urban regions is constrained by a number of factors, including the complexity of the physical land use environment (i.e., the convergence and accessibility impacts land use planning and design imparts on the physical/built environment), the volume and scale of user types interacting, including pedestrian, active, public transit, private automobiles, institutional/ regulatory vehicles, and freight vehicles, that are interacting across a single shared infrastructure: roads (Aljohani and Thompson, 2016; de Carvalho et al., 2019; Holl and Mariotti, 2018; Isaksson et al., 2017; Mrazovic et al., 2017; Pettersson et al., 2018). More often than not, these activities compete for space. Whether it be physical space to build port terminals, roadways, or parks; street-space, including lanes for bicycles, extra-wide sidewalks, and parking; or, on the roads themselves during peak travel periods, wherein each additional vehicle disadvantages the others by further congesting the network (Legacy et al., 2017; Lindholm and Behrends, 2012; McLeod et al., 2019; Sakai et al., 2019; Taylor, 2006). All land uses generate, induce, and attract different types and volumes of movements, with residential lands producing commuter and discretionary/recreational trips, commercial lands producing professional movements or demanding goods from suppliers, and industrial lands, especially terminals, producing the heaviest volumes of freight movements (Rodrigue, 2020).

2.2. Transport Efficiency and Integration

The efficiency of transportation networks is generally related to the ability to maintain a designed level of flow, while meeting speed performance expectations, and its resilience to disruptions (Black, 2003; MITL, 2018a). North American highway networks are efficient in the scale of movement they enable but are easily disrupted by collisions and other events (FHWA, 2020a, 2019). Similarly, North American rail networks are extremely efficient at moving freight but can easily be disrupted by track blockages or down-network delays/congestion, such as the Chicago Interchange (Comtois, 2016; Hwang and Ouyang, 2014; Macharis et al., 2014). Resilience is considered both in terms of a network's ability to circumnavigate trouble points (prototypically through alternative routing), but also to resist the development of potential delays and impacts in the first place (Comtois, 2016; Rodrigue, 2020). Further considerations of network efficiency relate to their ability to integrate and operate with other networks – a key function of modern, global supply-chains. While there are considerations of how individual networks evolved overtime in their routing as a response to economic development and demand for mobility, the two key aspects of network interdependency focus on interoperability and resiliency (Black, 2003).

First, the transfer of goods between modes is a well-recognized congestion point in multi-modal supply-chains, as the forces of freight atomization and massification clash with the challenge of dealing with enormous volumes at only a handful of terminals (Clott and Hartman, 2016; Jiang et al., 2017; Rodrigue, 2020; Zografos and Regan, 2004). While this is less of an issue for air movements given the physical volume/weight constraints, conveyance transfer is a major operational challenge for marine and rail modalities (Caramuta et al., 2018; Gharehgozli et al., 2017; Ha et al., 2019; Sarhadi et al., 2017). In a general perspective, the challenge of transferability is further cemented as transfer points (typically terminals or ports) act as major network hubs and are the few interfacing locations between the separate networks (Black, 2003).

Second, returning to the idea of resiliency, developments in networks can impact the functionality or demand upon other networks – the Canadian rail blockades in early 2020 had the dual effect of increasing demand on trucking stock while also diminishing the capacity for marine terminals to operate as their on-dock storage becomes overburdened (Tunney, 2020). Cross network resiliency is typically bolstered by the complementary development of networks wherein between major regions, multiple modal options are available and should the capacity of one mode diminish, other modes can often absorb some of the demand, though at varying expenses and impacts (e.g., the corridor between Montreal and Toronto is a busy trucking corridor, but is also serviced by rail, marine, and air services) (Resor et al., 2004; Rodrigue, 2020).

Broadly speaking, networks also face a base set of common challenges; namely, capacity and reliability, in addition to the issues of transferability and interoperability already discussed (G. Chen et al., 2017; FHWA, 2019, 2005; Kopytov and Abramov, 2013). Capacitive constraints are a fundamental element of the transportation experience: any given mode can only move so much of any given entity due to vessel size, infrastructure size, terminal size, and innumerable other technological and physical factors (Black, 2003). Further, networks can only handle so much traffic before they become bogged down and begin to experience space-time divergences, i.e., congestion delays (ECMT, 2007; Knowles, 2006).

Reliability and resiliency go hand-in-hand, but reliability focuses on the time-cost aspect of a movement. For a given distance, on a specified mode, there is an expected travel time at an expected cost. When movements become unreliable because they have experienced capacity issues, delays, or other forms of congestion, the reliability equation alters, and the movement becomes more expensive (as a cost function of time). Reliability is a major concern of the road network, especially in Canada's metropolitan regions, and more generally on a global scale (Bradbury, 2002; Srivatsa Srinivas and Gajanand, 2017; Transport Canada, 2018; UTTF, 2012). Time reliability is also a concern of air movements, which have on-time arrival expectations of about 15 minutes, while rail movements are on-time within about 60 minutes, and marine movements have about 24 hours of flexibility in their on-time travel expectations (MITL, 2018a). Outside of these travel-time expectations, the delay impacts can scale severely causing a feedback loop of delays within and across networks, as the expected capacity is no longer readily available (Jiang et al., 2017).

2.3. Intersections of Spatial Economic Factors

Transportation facilitates economic development. Though the validity of such a statement in every situation is debatable, the construction of infrastructure is commonly seen as an indicator of economic development and progress (see aspects of the Belt and Road initiative, the US Interstate program, and even public transit deployments at local and regional levels). The higher the circuity, intensity, and density of a network, the greater the economic and social mobility opportunities, creating multiplier effects (Hayter and Patchell, 2016). Low infrastructure availability – either in terms of physical existence, or in terms of relative reliability – creates higher transportation costs and creates supply-chain uncertainty. This then leads to negative multiplier effects, which may incite governments or third parties to invest in infrastructure (e.g., should travel-time delay become so severe, a road may be widened)(Black, 2003; Rodrigue, 2020).

While transportation reflects the intensity of economic development, it also has explicit impacts on the spatial organization of labour, consumption, and production (Edwards, 2017). Physiography constrains the layout of networks, which therein alters the geography. The presence of roads has a physical impact on the spatial organization of a region; it explicitly defines that spatiality, which impacts where entities (i.e., firms or residences) locate (Black, 2003; Hayter and Patchell, 2016). Since the cost of infrastructure is so substantial, once created it is very slow to change as a function of inertial effects, and thereby produces localization economies through the accessibility it generates (Rodrigue, 2020). This reflexive relation then extends as activities interact with and create a level of demand on the transportation networks at varying scales (local, regional, global). Transportation responds to the needs of economic activities (e.g. global or local sourcing of inputs, or the distribution of outputs) but also impacts where and how facilities locate (Albino et al., 2015; Cui et al., 2015; Hayter and Patchell, 2016; Monios et al., 2018). For example, the sprawl of warehousing and logistics facilities are requiring new intermodal facilities to be built, as core-based infrastructure in urban regions becomes overburdened (Jakubicek and Woudsma, 2011a; Sakai et al., 2019).

The relationship between transportation, trade, and economic development has become more expansive as economies have increasingly derived value from spatial relationships. The caveat of the trade and barter of physical goods remains the basis of the global, regional, and local economies – it is the commodification of resources, labour, and capital that has resulted in increased material flows (Dicken, 2007; Fujita et al., 1999). The nature of the global economy has not necessarily shifted, but the distance at which goods can be shipped and procured has. Transportation mobility is particularly important for materials economies (i.e., physical distribution) and the availability of labour (Hayter and Patchell, 2016).

There are three basic geographic considerations relevant to transportation systems: location, complementarity, and scale (Black, 2003). These tie in nicely with the basic principles of spatial-economic interactionism: complementarity, transferability-accessibility, and intervening opportunity (Hayter and Patchell, 2016). Every entity has a spatial location with unique characteristics and a demand or supply of a particular entity. More broadly speaking, locations are the physical manifestations of economic and transportation intersections and tend to arise in valuable locations (Hayter and Patchell, 2016). Typically, the more accessible a location is, the more valuable it is (Alonso, 1964; Von Thunen et al., 1966). Highly valuable locations tend to be the sites of agglomeration economies, often as a result of low-cost access to resources / manufacturing inputs, or lower production/ labour costs (Rodrigue, 2020; Wood and Parr, 2005). These enable regional specialization and economic globalization more generally, in tandem with regional concentrations and dispersions of economic activities (Hayter and Patchell, 2016).

Across locations there are variations in the availability of goods or labour and demand; complementarity exists when the supply in one place is matched by the demand for it elsewhere (e.g., the mining and export of Potash in Western Canada). Scale focuses on the local, regional, or global geography of the interaction. Transferability is focused on the cost aspect. Notably, exchanges will not take place if the cost of transferability is higher than the value of the entity in question (Wood and Parr, 2005). Without a minimum efficient scale of movement, enabled through economies of scope, scale, and the spatial divisions of labour, exchanges cannot profitably take place and therefore, baring interventions, will not take place (Hayter and Patchell, 2016). Intervening opportunities are the ability to source, or satisfy demand of, an entity from a closer location. As the relative cost increases, locations experience a distance decay effect as the interactions between further places tends to decrease as the cost increases (Weber, 1929).

Global trade liberalization, affected by the GATT/WTO since its inception shortly after the Second World War, increased global manufacturing competition, production specialization, and the trade of goods in which countries, or regions, had comparative or absolute economic advantages (Hayter and Patchell, 2016). The trade of surplus goods allowed for importing countries to focus efforts on their respective comparative advantages, resulting in an interdependency between trading partners with low costs and relatively high profits. On average, everyone benefits when each partner focuses on their strengths and trades for their relatively weaknesses (e.g., the export of Canadian softwood). Globalized markets allow for product diversity and availability, that a nationalized market on its own would be unlikely to maintain (Hayter and Patchell, 2016). The difficultly, tariffs and free trade agreements notwithstanding, arises in the variations of mobility between countries and regions. Since there are variations in infrastructure availability at every spatial level, there is an uneven degree of mobility between markets (Saldanha et al., 2015). The greater the available level of mobility, the greater a catalyst for economic development it is perceived to be (Edwards, 2017). Transportation overcomes the discontinuity of spatial distribution and provides economic and social cohesion.

2.4. It's All About Location – Intersection of Accessibility and Trade

Activities are located by virtue of the concepts of site, the characteristics of a physical location, and situation, the surroundings and relationship of a location to other locations. These sites and situations are considered by three factors: accessibility, proximity, and connectivity (Hayter and Patchell, 2016). Accessibility refers to the ready availability of a market and the ability of that market to be reached. Market and hinterland accessibility have been common themes of research across various fields of geographic study, with famous theorists including: Christaller (1933), Von Thünen (1826), Lösch (1954), Burgess (Park et al., 1925), Hoyt (1939), Harris and Ulman (1945), and Isard (1956). The level of accessibility is typically related to network circuity and the relative importance of a location (Black, 2003). Proximity refers to the ready availability of resources and labour. Proximity to infrastructure and other similar land uses / economic activities will often incite agglomeration and density economies (Hayter and Patchell, 2016; Wood and Parr, 2005). Proximity to a city provides access to a major labour market, while close proximity to a resource provides ready access to material inputs. Connectivity is focused on the interoperability with which people and goods can be conveyed. Many of the world's current most 'important' cities are major port cities and are heavily accessible by road, rail, and air, which enable convergence effects through economic and social density (Rodrigue, 2020). The multi-modal nature of these sites gives rise to their importance by means of the ability to integrate with inland modes.

As a function of market forces, advances in transportation and communications technologies gave rise to economic globalization which intensified the impacts of agglomeration, localization, and specialization economies. In the basic premise of neoclassical location theory, via Alfred Weber (1929), firm situation is a maximum-minimization cost function of transportation relating to materials, labour, and markets/agglomerated economies considered at the micro, meso, and macro scales. And while theoretical arguments of location theory have expanded to include behavioural, institutional, and competitive aspects, the base premise remains that transportation accessibility and cost are critical site-location factors; in addition to the cost of labour and the operating environment more generally (Alonso, 1964; Dear and Flusty, 1998; Fujita et al., 1999; Fujita and Ogawa, 1982; Krugman, 1991; Lowry, 1964). Specifically, these site location factors are a process of substitution, wherein the cost of one factor is greater for one site (e.g. resource availability), but other factors may be substantially less costly (e.g., labour cost) (Hayter and Patchell, 2016). Though, considerations are restricted by the specific operational requirements of a particular economic sector (i.e., the location requirements of manufacturing activities are decidedly different than of quaternary activities).

Global economic organization reflects, at least in part, the cumulative connectivity of locations and their individual regional connectivity; as places become more connected, their value rises which reinforces agglomeration and localization/density economies (Hayter and Patchell, 2016). The greater the connectivity of a location, the greater the economic, network, and spatial effects are. Accessibility is the capacity to support the demand for mobility; it enables market areas, increases distribution efficiency, and expands the scale and scope of available labour (Black, 2003; Edwards, 2017). While transportation has enabled suburbanization and other spatial patterns of dispersion, economic activities are highly focused on the economic benefits which can be derived from concentrating and clustering (i.e., agglomeration and densification)(Hayter and Patchell, 2016; Rodrigue, 2020). Specifically, through economies of scale, scope, agglomeration, co-location, and density, firms are able to substantially reduce their per unit cost of movement (Rodrigue, 2020). Economies of scale and scope see the vehicle size of modes increase and the ability to convey different goods in tandem (Hayter and Patchell, 2016). Agglomeration and co-location take advantages of the physical reduction of space between activities to save on costs and derive efficiency, e.g., sorting facilities at airports removes the need to take cargo to a secondary facility, and instead can be directly loaded onto vehicles for local/regional delivery (Kumar et al., 2017; Wood and Parr, 2005). While urbanization / density focuses on the efficiency of large labour and consumer market areas in concentrated areas, which can be serviced with fewer facilities than spatially disparate locations.

In economic accessibility, there is the ongoing search for value derivation through cost-efficiencies, process streamlining, and the reduction of physical and operational barriers (Holguín-Veras et al., 2017a; Ivanov et al., 2019; Onstein et al., 2019; Roßmann et al., 2018). It stands to reason, that for any level of accessibility, new infrastructure facilities will influence the setting of new and current activities to varying levels of impact along a theoretical logistic curve, as well be a catalyst for further development through multiplier effects.

2.5. Information Technology and Mobility

Transportation is inherently reliant upon the exchange of information to determine who, what, where, when, how, and if a movement is to occur. In freight, there is a need to match the supply and demand requirements of various firms; a process which is notoriously difficult to achieve in practice, leading to various challenges throughout distribution networks, namely incongruities in capacity – whether in terms of production or consumption (Hesse and Rodrigue, 2004; Mishra et al., 2014; Onstein et al., 2019; Perboli et al., 2017; Thaller et al., 2017; Vaezi and Verma, 2018). Improved communications have been the lifeblood of the ever evolving and improving transportation system, as evidenced by the co-construction of railroads and telegraph lines, and have enabled the global system of trade to which markets have become accustomed (Audirac, 2005; Black, 2003; Holguín-Veras et al., 2017a; Mathauer and Hofmann, 2019; Melander et al., 2019). The modern impacts of the intersection of ICT and transportation can be seen in the dispersion of major conglomerates focusing their research and development in one region while outsourcing manufacturing to third parties, often through offshoring

(Hayter and Patchell, 2016). These large firms then manage the information that derives the value and supply-chains to produce, distribute, and sell their products (Rodrigue et al., 2017). As well, the rise in e-commerce since the late 1990’s is reliant upon the ability of producers and consumers to communicate with each other, as well for that information to be integrated with a distribution system which can complete transactions through movement and delivery of demanded products (Audirac, 2005; Carotenuto et al., 2018; Comi et al., 2018; Hayter and Patchell, 2016; He et al., 2019; Taniguchi et al., 2016; World Economic Forum, 2018). As we continue to live with and consider the broader impacts of emerging transportation (e.g., AV’s) and communication technologies, it is important to recognize that these innovations have significant socio-economic impacts.

Technology allows for more intensive and efficient interactions between individuals, businesses, and institutions through the removal of physical and temporal barriers (i.e., it dramatically alters the space-time prism of potential time/travel paths). The role technology plays can be viewed through its impacts on generating movements, substituting movements (e.g., downloading an e-book instead of purchasing a physical copy), and trip modifications (e.g., affecting route choice)(Black, 2003; Hayter and Patchell, 2016; Rodrigue, 2020; Suarez-Villa, 2003). Arguably the most impactful result of ICT’s is the ability to coordinate, track, and manage assets in near and relatively near time. This has predominately been employed as a cost-reduction and efficiency-improvement toolset in the consideration of physical freight distribution and warehousing / fulfillment, through the on-demand and just-in-time management systems (Hayter and Patchell, 2016).

E-commerce has shifted the retail paradigm over the past twenty years in connection with the evolution of ICT and a consumer society increasingly comfortable with digitization and an increasingly abstract fiat currency (Ardito et al., 2019; Audirac, 2005; Mathauer and Hofmann, 2019; Suarez-Villa, 2003). The critical aspect of e-commerce is how it changes the distribution across the last mile. While in traditional retailing, the customer would assume the disaggregate last mile (i.e., travel to a store and ferry the purchased item home), now it is incumbent upon the retailer to deliver to a consumer’s location (Rodrigue et al., 2017; Taniguchi et al., 2016; Xiao et al., 2017). This has incited the development of logistics fulfilment facilities and varied new concomitant processes to handle the diversity of products (Bean and Joubert, 2018; Jakubicek and Woudsma, 2011a; Jeevan et al., 2017; Monios et al., 2018; Williams, 2015). Of course, there is the tremendous consumer benefits of being exposed to the ability to purchase virtually anything from just about anywhere, the impacts on physical distribution capacity have been immense. While traditional retail operated through the economies of agglomeration and localization practices (e.g., shopping malls), e-commerce is a disaggregate process requiring an enormous volume of vehicles to satisfy demand (Aljohani and Thompson, 2016; Cardenas et al., 2017; Hayter and Patchell, 2016; Taniguchi et al., 2016; Williams, 2015; Woudsma et al., 2016). E-commerce is driving changes in the distribution of goods and is changing the nature of logistics movements.

Chapter 3. Modes and Transport Infrastructure

The growth of transportation and economic development are heavily intertwined with social, political, and commercial demands for mobility. As technological achievements grew, cities developed from a radial-agricultural design, to the less organic and rigid designs of the first and second industrial revolutions (Hodge and Gordon, 2013). These were heavily based on transportation accessibility, land use separations, and economic rent (Levy, 2015; Rodrigue, 2020). Infrastructure is not built and developed in a vacuum but rather it is inherited from historical patterns of development. Modern-day infrastructure tends to follow those patterns, especially at the local (e.g., the street patterns) and regional (e.g., highway routes) scales (Hodge and Gordon, 2013; Levy, 2015). As a result of development and changing conditions (political, physical, and elsewise), investments and expansions are continually made to infrastructure. In North America, the separation of primary/secondary manufacturing activities from residential and commercial activities, with agricultural along the periphery of cities, became the effective standard (Broaddus and Cervero, 2019; Hodge and Gordon, 2013). The modified gridiron layout became the de facto layout for streets in new cities (e.g., San Francisco, New York, Toronto, etc.), laying the foundation of what would become an entrenched preference towards automobilism (Broaddus and Cervero, 2019; Hodge and Gordon, 2013; Levy, 2015).

While some cities have seen success with their public transit systems (e.g. Toronto), the vast majority of movements are completed by private vehicles on either public (i.e., roads), private (i.e., railways), or mixed-ownership infrastructure (i.e., ports, airports) (Rodrigue, 2020). Figure 3-1 provides an overview of Canada's major transportation infrastructure including the national highway system and Trans-Canada highway, the major railway lines and various major terminals (intermodal and bulk), the National Airport System, and the major port authorities. Figure 3-2 provides the same overview except with a finer geographic focus on Metro Vancouver, Calgary, Edmonton, the Greater Toronto Hamilton Area ("GTHA"), Ottawa-Gatineau, Greater Montreal, the largest metropolitan areas in Canada, west-to-east respectively.

With little surprise, transportation is constrained by the physical environment; namely, topography, hydrology, and meteorology / climatology. While today's modern transportation systems work in and across virtually all but the most extreme weather conditions and climate, historical infrastructure and network linkages were severely encumbered by physical impediments (Hodge and Gordon, 2013). Paved roads, railways, canals, tunnels, and bridges have allowed for the traversal of nearly all terrains, whilst improvements in modal powerplants (e.g., locomotives, jet engines) and innumerable other technical innovations have allowed for improved vehicle speed, range, and capacity (Rodrigue, 2020). Resulting in the general shrinking of the amount of time required to travel a distance leading to an uneven but global 'space-time convergence' (Ma and Kang, 2011; Miller, 2004).

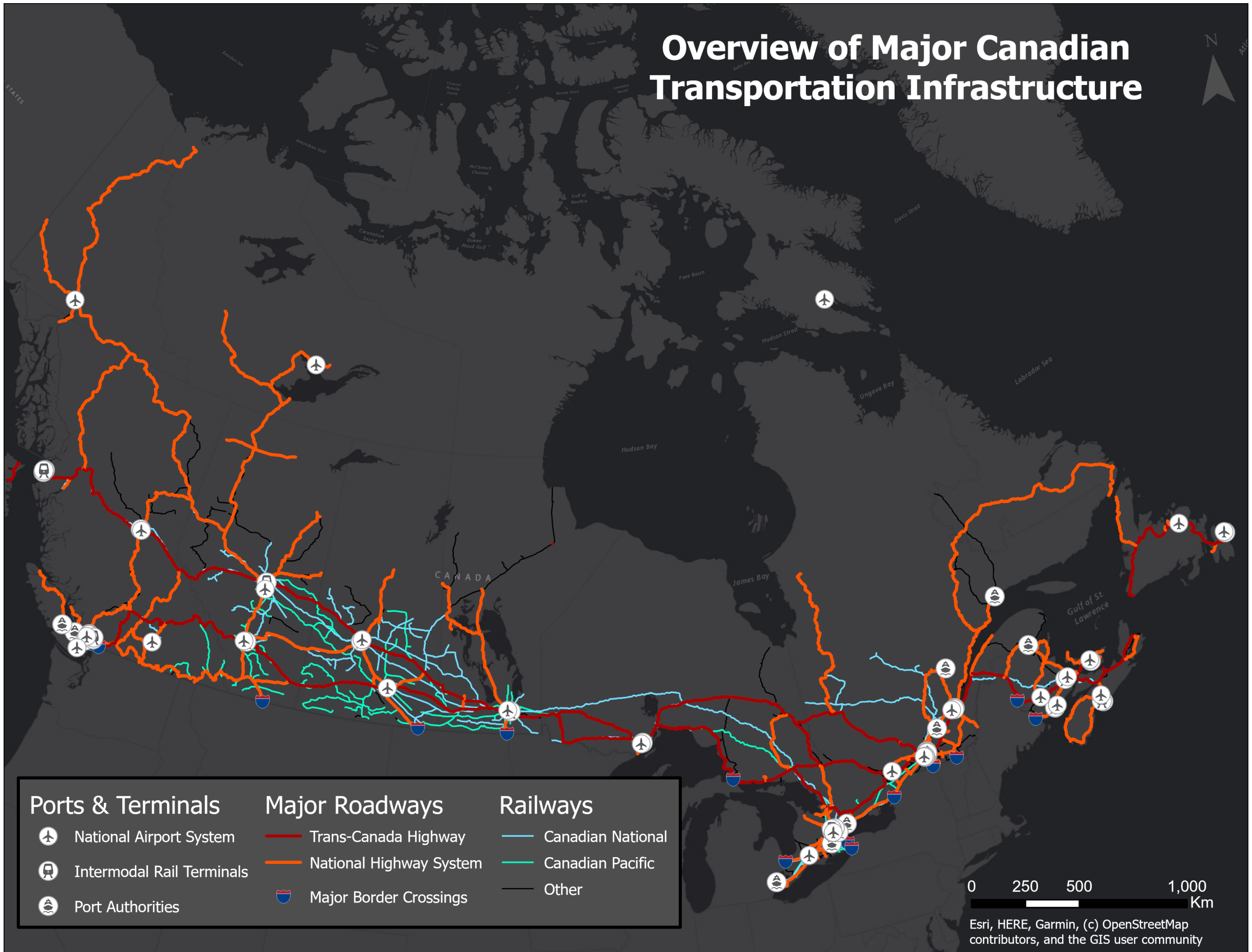

Figure 3-1: Distribution of Canada's Major Road, Rail, Marine, and Air Infrastructure. Data Source: DMTI, 2018.

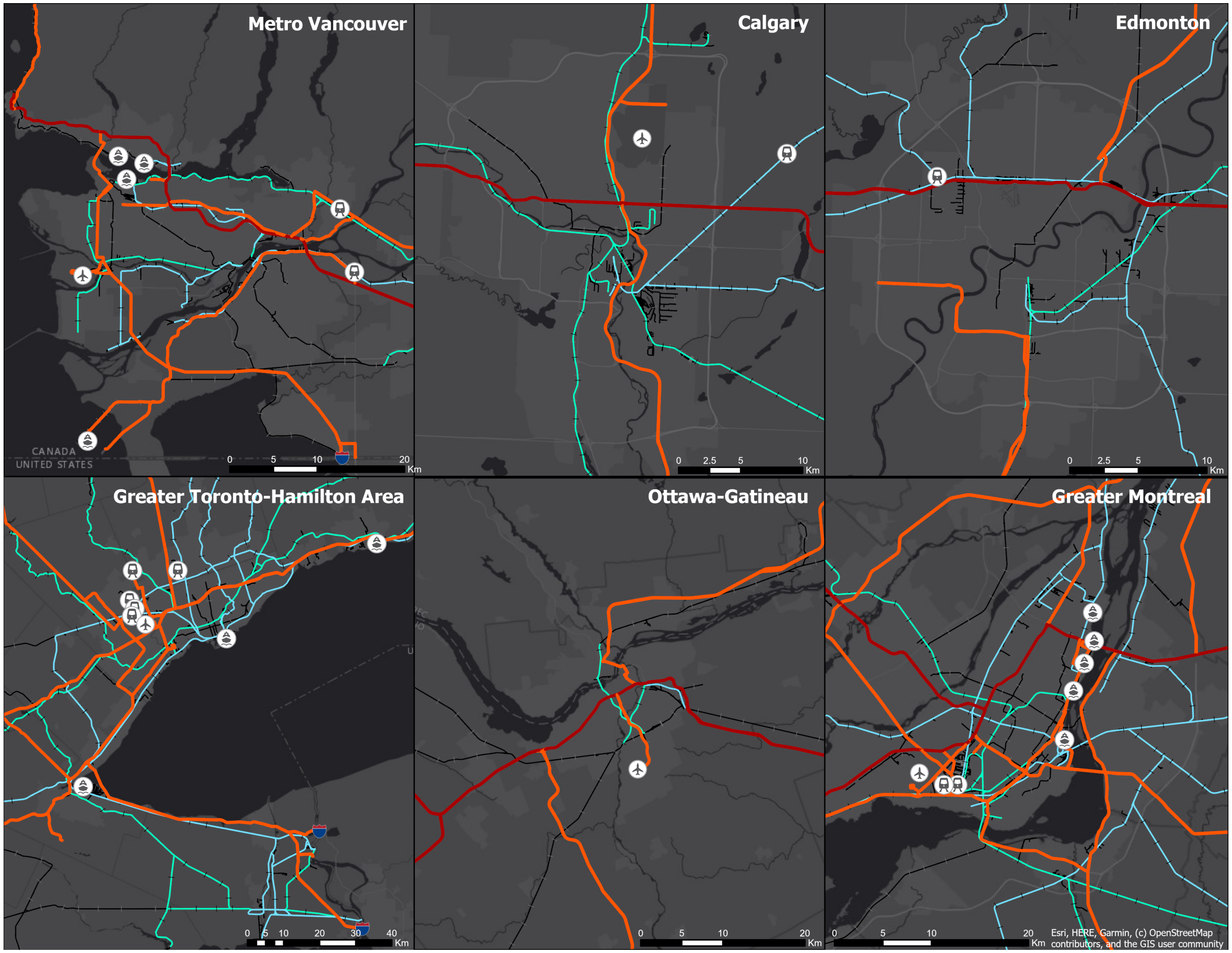

Figure 3-2: Distribution of Canada's Major Transportation Infrastructure by Metropolitan Areas - See Figure 1 for Legend. Data Source: DMTI, 2018.

Physical geography is the underlying framework which dictates how and where transportation infrastructure can be built, the types of vehicles that are able to traverse the terrain, and the speed and ease with which those movements can be made. Montreal and Vancouver are hindered by multiple physical geographic limitations and are both heavily reliant upon bridges, forcing traffic to slow, merge, and then diverge again as they pass these isthmuses. Physical geography also constrains outward development (i.e., sprawl) in these regions, forcing increased density (Filion et al., 2010; Woudsma and Jakubicek, 2019). Though densification and intensification have been recent themes of the urban planning paradigm, with Vancouver being particularly famous for its approach to mixed-use planning and architectural design, high densities increase the strain on transportation networks (Arnott, 2013; Levy, 2015; Ros-McDonnell et al., 2018a; White and Punter, 2017).

3.1. Topology Basics

The basic elements of networks are nodes (locations), links (routes), flows (volume of movement), and hubs which operate on an accessibility spectrum between centripetal and centrifugal designs (which is to say they either tend to locational advantages or they tend to not provide specific situational advantages) and on a connectivity spectrum between fully and minimally connected, through direct or indirect routing (Black, 2003; Ortúzar and Willumsen, 2011). Local roadways are typically contrived as fully connected, point-to-point networks wherein a user can easily traverse from their home to a neighbourhood shop across a variety of different route combinations. Hub-and-spoke models reduce the number of connections by routing all movements through a hub and a set of specific linkages. This enables economies of scale in serviceability and processing capacity, as well as potential economies of scope in the shared use of infrastructure (e.g., port processing and transshipping capacity, resulting in lower per-unit costs) (Hayter and Patchell, 2016). The operation of international flights is a prime example of hub-and-spoke networks, though highway systems, especially the national highway system in Canada or the Interstate system in the USA can be interpreted as hub-and-spoke operations. The network topology of each mode influences the types of barriers and issues that may arise during operation; these are discussed in more detail in the following sub-sections.

3.2. Modalism

Until about the 1960's mono-modalism was the de facto method for moving goods. Each modal operator had a financial incentive to maximize the cost advantages of their service – not unlike in today's market – and was disincentivized by the complexity of transferring goods between modes (Rodrigue, 2020). Intermodalism slowly became more prominent as the integration of marine to inland terminals improved and rapidly increased in prominence after the introduction of standardized containers and specialized equipment that could easily handle these containers – as opposed to old-fashioned, back breaking stevedoring work (Black, 2003; Cullinane and Khanna, 1999; Hayter and Patchell, 2016;

Jeevan et al., 2017). These improvements dramatically improved the time and cost efficiency to unload marine vessels, and coupled with innovations in rail and trucking, the burden of transferring goods between modes diminished significantly (Clott and Hartman, 2016; Hoel et al., 2012; Reis et al., 2013).

As transfer costs have fallen, the ability to take advantage of the economies of scale rail and other massified modes offer, has increased, decreasing the overall cost of movements. Of course, there are distance breakpoints, about 800 - 1,000km for road and rail, at which savings outweigh time-costs (Hayter and Patchell, 2016; Rodrigue, 2020). In North America extensive use of long-distance trucking and long-distance rail are used as a function of physical and administrative geographies, time, manoeuvrability, and infrastructure availability (Hayter and Patchell, 2016; Prata and Arsenio, 2017; Sarhadi et al., 2017). Generally for cargoes in North America, trucks are used for shorter distances, rail for longer distances, marine for very long distances / intercontinental, and air cargo is almost exclusively reserved for high priority or high cost items (Hayter and Patchell, 2016; Rodrigue, 2020).

Functionally there are three aspects to intermodalism, as have been discussed throughout this text: inter, multi, and trans modalism. There is also the concept of synchro-modalism, but that is focused on modal parallelism and selection based on time/cost-availability for a specific time window (Agbo et al., 2017; Ambra et al., 2019; Perboli et al., 2017). Intermodalism represents the usage of multiple modes to deliver goods to a destination, wherein each leg of the journey is separately charged and contracted through the specific operator (Agamez-Arias and Moyano-Fuentes, 2017; Bektaş and Crainic, 2007; Steadieseifi et al., 2014). Intermodalism has become the colloquialism for containerized freight movements involving multiple modes. Multimodal is effectively the same, except that the entirety of the movement, from origin to destination, is covered by a single rate and contract (Bektaş and Crainic, 2007; Rodrigue, 2020; Steadieseifi et al., 2014). This evolution has been heavily supported through ICT developments to enable the flow of relevant information between supply-chain partners (Ardito et al., 2019; Harris et al., 2015; Ivanov et al., 2019; Onstein et al., 2019).

Typically, in multimodal movements the cargos are not broken down from their unit load (e.g., container) and are transferred to the next mode without being converted to a different unit type (e.g., after sea containers are transferred into intermodal rail containers, these containers can be pulled directly off of the train and onto waiting trucks, without the need to unload the container) (Bektaş and Crainic, 2007). Trans-modal, the transfer of goods between the same mode, operations are modernly most relevant to trucking through the concept of cross-docking, wherein trucks are unpacked and distributed to other trucks (Danielis et al., 2010; Fikar et al., 2018; Reis et al., 2013). Transshipment is also relevant to some aspects of the North American rail network, vis-à-vis the Chicago rail interchange, and in air hub-and-spoke network structures (Clott and Hartman, 2016; Feng et al., 2015).

3.3. Containerization

The adoption of the standardized container in the freight shipping of non-bulk goods was the impetus for the explosive growth of intermodal movements. The cost and time savings of using a standardized set of containers, regardless of the type of cargo carried, dramatically improved the feasibility of multimodal movements (Guerrero and Rodrigue, 2014; Rodrigue, 2020; Steenken et al., 2004). Containers are just that: steel or aluminum boxes of fixed lengths (20', 40', etc.) and heights (8 ½', 9 ½', etc.) with specifically designed grab/hook points allowing a variety of equipment to handle and process them with as little cost, time, and labour as possible (Bektaş and Crainic, 2007). Oceangoing containers are typically of the 20' and 40' lengths while in North America we typically use longer and taller containers, specifically the 53' trailer, which is the mainstay size of heavy-class trucks (Bektaş and Crainic, 2007; Resor et al., 2004). Similar to railcars, there are a variety of container types with specific functional purposes including the standard container, tank containers, reefer containers, and other specialized designs. With few exceptions, civilian aircrafts are not intended to carry shipping containers due to their gross weight and size, and instead carry cargos in lightweight boxes which fit in either the belly or main cabin of modern passenger and freighter aircrafts (Feng et al., 2015; Rezaei et al., 2017; Wu, 2008). Which, similarly, improves the turnaround time and generally efficiency of air terminals over floor loading cargos.

3.4. Terminals

Terminals are the facilities where goods converge in the distribution network, representing the points of interchange and transference within and across the modal systems, enabling uni-, inter-, and multi-modalism. Terminal facilities are located based on their centrality to economic activities and accessibility to regional transport flows (i.e., marine, rail, air, and road) (Black, 2003; Hayter and Patchell, 2016). The largest intermodal terminal facilities are typically marine ports and inland rail facilities, which then feed out to regional and local trucking facilities to carry goods across the last mile (Hayter and Patchell, 2016; Woudsma and Jakubicek, 2019). Terminals handle enormous volumes of goods and require high levels of managerial organization to operate efficiently.

By definition, terminals are simply facilities at which transport begins, ends, or otherwise handles goods (e.g., transshipping). Each type of terminal focuses on the movement of specific types of cargo, at certain scales, and for and between specific modes. The time cargo waits at a port or yard is typically referred to as the dwell time and is impacted by a variety of operational (e.g., crane availability), managerial, and regulatory factors (e.g., customs). Terminals are equipped with specialized equipment, storage, and processing capabilities and facilities to accommodate transshipment. A major port will have separate terminals focusing on bulk and intermodal goods with different capacities to unload the vessel and transfer the cargo either to a yard for storage, or onto trucks and railcars for.

Terminals are major sources of delay in physical distribution networks. Unavoidably, it takes a long time to unload 16,000+ TEU's off of a container ship and redistribute those flows to the correct connecting mode or storage (e.g., a standard truck holds about 2.6 TEU's) (Caramuta et al., 2018; Muñuzuri et al., 2020). Still, containers and standardized equipment have dramatically decreased the time and effort required to unload/load vessels and vehicles, decreasing the cost required to transship cargos (Bektaş and Crainic, 2007). Processing times, and labour costs, have been further decreased through the implementation of electronic tracking and other ICT processes, diminishing the friction of terminals (Carlan et al., 2016; Hayter and Patchell, 2016; Rodrigue, 2020). This allows for not only lower cost movements, but also an increase in the volume of cargoes that can be moved through a facility, improving the efficiency of every mode and flow that interacts with the terminal (i.e., asset utilization). Regardless, terminals represent major pain points in the distribution of goods, in terms of cost and time.

3.5. Roads and Trucking

Mass automobility has been the defining characteristic of the North American socio-economic cultural experiment since the end of the second World War. Road infrastructure has since expanded tremendously, with the development of the US Interstate System, the Trans-Canada Highway, as well as Canada's National Highway System, a major component of which are the provincial highways in Ontario and Quebec. These roads and highways provide linkages between cities and support modern urbanity, as well as suburbanization. The provision of road infrastructure is unique compared to other modes, as it is generally built and maintained by the government, as opposed to private enterprise (Black, 2003). In conjunction with the improvements in automobiles and the continuous expansion of the roadways, virtually anything and everything is at some point driven and delivered by a truck of some type (MITL, 2018a).

The government subsidization of roadways encourages their use, especially for personal travel, and has the effect of decreasing the relative cost of truck transportation in comparison to other modes; as owners and operators of vehicles do not directly provide or maintain the infrastructure, it is not a direct cost (Hayter and Patchell, 2016; Hodge and Gordon, 2013). As per all government expenditures, such costs are paid for through the collection of taxes, fuel surcharges, debt, and the collection of tolls – though these are now less prominent in Canada with the notable exception of a few privately held routes (e.g., Highway 407). The construction of road infrastructure, especially highways and bridges, is expensive (in the range of millions per kilometre) but provides the highest level of service and the greatest level of flexibility in both construction and operation (Rodrigue, 2020). Road networks are generally considered to be fully connected network structures allowing for a variety of routes between any given origin-destination pair.

Given the infrastructure is without direct cost, the barriers to entry of the trucking industry, as well as personal vehicle ownership, are low compared to any of the other modes. This has led to a large number of operators in the trucking market, though increasingly driver shortages are becoming a major barrier for firms (Costello and Suarez, 2015; Min and Lambert, 2002). This is compounded by an already highly competitive market, as a result of the volume of operators and drivers demanding higher compensation – especially those which have to deal with high stress / urban routes (Keller, 2002; Mittal et al., 2018). Congestion is of course a major consequence of the level of demand placed on roadways and can be viewed as either a failure of government to adequately supply road capacity and alternative infrastructures (i.e., public transit), or a tragedy of the commons type event, wherein a free resource is being overused due to its lack of cost (Abdulhai, 2013; Hayter and Patchell, 2016; Holguín-Veras, 2011; Holguín-Veras et al., 2018a). Congestion is discussed more directly in Chapter 6.

3.6. Rail

The advent and adoption of James Watt's steam engine, followed by the Corliss engine, are often marked as the epitomising technological developments of the industrial revolution, providing the spiritual and physical basis for modern vehicular locomotion (Cortada, 2020; Heblich et al., 2018). Railways played a key role in the development of modern-day Canada, connecting the Provinces of Ontario and Quebec with British Columbia and the resources of the west coast (Hodge and Gordon, 2013). Railways, with fast, scheduled, and reliable service, proved revolutionary in the physical distribution of goods and inland logistics.

Railroads are expansive and hugely capital-intensive enterprises which operate along dedicated right-of-way's (i.e., low-friction steel tracks) between terminals (Carlson and Nolan, 2009; Lovegrove and Morrison, 2019). These lines provide an extremely high degree of operational efficiency but land rights for lines are prohibitively expensive to acquire in today's urban regions, if not impossible given public opposition and the built environment (Behrends, 2017; Hörl et al., 2016; Judyta, 2016; Legacy, 2016). In addition, track, locomotive, car, and terminal/yard maintenance costs are typically in the billions of dollars for Canadian Class 1 carriers (Transport Canada, 2018). Rail corridors are often only a handful of metres wide, but the supporting terminals, yards, and other facilities require relatively large areas of land to operate and integrate with either roads, ports, and/or more recently airport facilities (Rodrigue, 2020). Train length and velocity along routes within rail networks are strictly controlled for operational performance and safety considerations, especially for the movement of dangerous cargos (MITL, 2018a).

Railways are amongst the most efficient means to convey goods, especially bulk cargos/commodities, inland requiring substantially lower fuel and labour costs than trucking (Janic, 2008; Resor et al., 2004; Rodrigue, 2020). As with other massified modes, the load and unloading of containers and cargos at terminals represents one of the largest costs of the overall movement (Wiegmans and Behdani, 2018). Movements in excess of 1,000km are generally on par with or cheaper than truck movements, though the longer the distance and the longer the train length, the greater the savings potential (Ambra et al., 2019; Behrends, 2012; G. Chen et al., 2017). Intermodal rail is used extensively to move import containers from the Port of Vancouver to the major distribution centres in Toronto, for this reason (Transport Canada, 2018). Rail is able to haul a variety of product types in boxcars, hoppers, tankers, flatbeds, double-stack cars, which carry two stacked containers, and a variety of other specialized cars. Though, each car type requires specific and often specialized infrastructure at the terminals to facilitate loading and unloading.

3.7. Marine

Marine movements represent the global foundation of modern trade, carrying the vast majority of goods across oceans and maritime routes generally. Ports are the enablers of this activity. These facilities are transshipment and intermodal terminals, enabling the shift of bulk, breakbulk, and containerized cargos from vessels to vessels, trucks, and/or rail cars (Gharehgozli et al., 2017; Ha et al., 2019; Rodrigue, 2020). In addition to facilitating the transfer of freight flows, ports provide temporary storage (e.g., holding containers on dock) as well as warehousing and longer-term commodity storage. As containerization became increasingly relevant to global trade, new ports and new terminals at ports were developed to service the fleet of ever-growing container ships – the largest of which can now carry north of 22000 TEU's – an enormous volume (Cullinane and Khanna, 1999; Prokopowicz and Berg-Andreassen, 2016). Servicing container ships requires expensive quay/gantry cranes, substantial on-dock storage, and a high degree of organizational management; which has been assisted by the extensive deployment of ICTs in container shipping (Carlan et al., 2017; Kaveshgar and Huynh, 2015; Shin et al., 2018). Port performance is considered in terms of TEU and tonne throughputs, as well as average dwell times, gate wait times, truck and rail turn times, and storage on dock (MITL, 2018a).

Given the economic importance ports have played historically (e.g., the founding of Montreal, Halifax, and virtually every globally relevant modern city), and the economic importance they continue to play today, ports represent major centres of economic activity enabling significant agglomeration, localisation, and density economies (Hayter and Patchell, 2016; Hodge and Gordon, 2013). The connection ports maintain to service their inland market areas is as important as their access to sea routes. Ports in city centres (e.g., Montreal) are hindered by 100+ years of local development, constraining the ability to grow and manage road/rail-based congestion issues (Monios et al., 2018). As ship sizes have grown tremendously, many ports are unable to support the post-Panamax and very large/ultra-large class vessels that have become the workhorses of globalization, forcing a concentration of global marine movements through only a few handfuls of ports globally. (Prokopowicz and Berg-Andreassen, 2016; Rodrigue, 2020). Port infrastructure has become heavily intensified and concentrated in those geographies which can support them.

3.8. Air

Commercial aircrafts represent the fastest and most expensive means by which we are currently able to move both people and goods. While large aircrafts require specialized infrastructure (e.g., gangways and specific runway lengths), smaller aircrafts (including helicopters) are considerably more maneuverable and able to deliver to remote or otherwise inaccessible locations (Forsyth, 2007). Many of Canada's northern communities and entirely reliant upon seasonal air services to deliver goods and foodstuffs (Galloway, 2014). Due to the cost of air movements, only high-value items (e.g., electronics, high-end fashions, specialized machinery, pharmaceuticals, etc.) or high urgency items (e.g., perishables, next-day parcel, mail delivery) utilize this mode (Sales, 2013). Air movements make up about 2-3% of cargo-tons carried, but those cargos represent approximately 40% of total value of goods moved (Rodrigue, 2020; Sales, 2013). Commercial aviation operates through a hierarchical hub-and-spoke network structure wherein there are a series of global hubs which connect into national hubs, feeding into smaller regional, or local airports. Though cost-effective, air transportation is susceptible to disruptions and cascading delays (Campanelli et al., 2016; Vaaben and Larsen, 2015).

Airports are by and far among some of the largest, single-area transportation infrastructures built, consuming hundreds of hectares of land. These hubs provide passenger terminals, freight handling, processing, and sortation facilities, parking, as well as maintenance and a variety of other operational facilities. Of course, the critical infrastructural element is the runway. The longer and more numerous runways are at an airport, the higher the capacity and throughput of the port is (MITL, 2018a). Depending on the destination of cargo, different types of air carriers are used to complete movements. Domestic cargos are typically moved via private cargo freighters who specialize in freight movements, while international cargos are more commonly moved through the storage holds of passenger jets (Kupfer et al., 2017). For unique or complex movements there are air cargo integrators and other specialized operators (Rodrigue, 2020). Cargos can move rapidly through the air transport system, especially priority mail and parcels carried on freighters and delivered to in-terminal sortation facilities, though unloading cargo from passenger jets can still be a time-consuming process.

3.9. Vehicle Electrification and Autonomy

Though neither electric nor autonomous vehicles are explicitly a focus of this research, the concept of enabling future technologies does emerge in the results. Given the role in which transportation plays in contributing to emissions (greenhouse gases, pollutants, noise, and otherwise) the electrification of freight vehicles, across all modes, presents a major opportunity to decarbonize the sector (Transport Canada, 2018). Policies to enable as such have been the focus of some Provincial governments in the 2010's including Ontario, British Columbia, and Quebec to mixed rates of success (MITL, 2018b). The major barriers to electric adoption can generally be summarized as risk aversion, concerns regarding operational feasibility, and especially for commercial vehicles, the cost of acquisition and potential cost of maintenance (MITL, 2018b; Pelletier et al., 2014). The business and industrial communities rely on business cases and business rules approaches to operational and capital decision-making; without valid and compelling prospectuses these initiatives fail to find footing in the communities with the greatest ability to incite fleet changes.

Autonomy

In regard to vehicle automation, momentous developments have been in advancing the technology, evolving from cruise control to full driving automation / level 5 vehicles being actively tested in various jurisdictions globally. In the context of freight operations, labour availability has been a major hinderance to road-based transport for decades and autonomous vehicles have been prophesied to stymie those impacts (Boysen et al., 2018; Cohen and Cavoli, 2019; Tang and Veelenturf, 2019; Ziemke, 2018). The reality is likely that until trucks are able to complete dock-to-dock runs without human intervention, it is unlikely that vehicle automation will 'solve' the driver shortages any time soon.

Rather, autonomous trucks may be utilized along specific corridors to complete line-haul movements along relatively simple to navigate highways, then at a hub a driver could take over and complete the challenging aspect of weaving a 60'+ truck through a city. The role of the automation being to reduce driver strain and hours on non-challenging terrain, and to improve fuel efficiency. Such an implementation of autonomous trucks would act as a complement to human labour with the possibility of, eventually, driving down the cost to move freight by truck. Given the realistic complexity of operating medium and heavy-duty vehicles, including safety checks, moving axles, and maintenance, it is unlikely that trucks will be driving without humans in the cabs for a long-time (e.g., considering flight automation, there are still pilots on every commercial jet movement).

Drones

The same can likely be said of drones and delivery robots, which at current face a torrent of regulatory and practical hurdles, not the least of which including simply being vandalized or tipped over by passing humans (Florida, 2017). The prospect for autonomous drones is likely to be similar of that for autonomous trucks; they will operate between major hubs effectively completing milk runs, instead of delivering to front doors and other last miles, at least for the foreseeable future. Drones will also likely experience substantial community backlash in the context of NIMBY-ism. Given the noise complaints surrounding existing infrastructure hubs, safety concerns regarding commercial vehicles, and the prospective visual amenity impacts of fleets of drones roaming the skies (to say nothing of the potential avian impacts vis-à-vis bird strikes), there is a great deal of scepticism on the part of the author as to the full commercial ability of the technology to revolutionize urban logistics and freight congestion more generally.

Chapter 4. Supply Chains & Logistics

Logistics is a set of operations through which planning, implementing, and controlling the flow of goods and information between an origin and destination, are managed to make goods available at specific locations. The objective of logistics is to provide value through organizing and carrying out the movement of goods across production, location, and time constraints within a supply-chain (Kain and Verma, 2018). At every stage of the supply-chain value-added activities are undertaken (i.e., the product or commodity is processed in some fashion), which are linked with the physical distribution (Hayter and Patchell, 2016; Strange and Zucchella, 2017). Inherent is the need to move goods across from the locations of inputs, intermediate processes, to final markets, and across the last mile to (Hayter and Patchell, 2016). As well as the rapid backflow of information to suppliers about the volume of goods demanded and in what time frame.

The terms 'supply-chain management' and 'logistics' are often used interchangeably. Though, it is important to distinguish that logistics is the integration of physical distribution, materials management and handling, warehousing, and packaging, while SCM tightly integrates logistics with the competitive business aspects of sales, marketing, finance, and strategic planning (Kain and Verma, 2018). SCM focuses on the integration and specialization of the value-chain, mitigating time, and maximizing space-time convergences in the name of cost minimization (Rodrigue, 2020) . All of which has been enabled through the ICT advancements of the past forty years, relying heavily on fast and effective communication and information transfers (Hayter and Patchell, 2016; Roßmann et al., 2018). Understanding the cost to move passengers is relatively straightforward, unfortunately, freight carriers are not transparent with costs. Freight charges and transport costs are typically considered confidential, as firms attempt to maximize their profits and the equations used by firms to understand their costs to operate varying widely in complexity (e.g., understanding the per kilometre cost of tire wear across a fleet versus a simple cost of ownership function based on summing annual costs) (Behrens and Picard, 2011; Holguín-Veras et al., 2018a, 2011; Rodrigue, 2020). Though a general sense of the cost of distribution functions is assessed through the total portion of GDP logistics activities account for, while the performance is assessed through the World Bank Logistic Performance Index - Canada ranks 20th (2018).

4.1. Logistics

Modern logistics are a functional product of driving organizational cost efficiency, technological advances in physical transportation, and significant ICT advances since the 1980's (e.g., just-in-time/flow control, automation, fuel optimization, dynamic routing, supply-chain visibility, consumer shipment tracking, blockchain ledgers, etc.) (Ardito et al., 2019; Calatayud et al., 2017; Clott and Hartman, 2016; Ivanov et al., 2019; Kain and Verma, 2018; Muñuzuri et al., 2020; Zijm et al., 2015). Logistics is the framework upon which globalization was enabled and is sustained. Through the sheer volume of different commodities, each with their own respective supply-chains for each component piece of the good, adds dramatically to the complexity of the decisions to be made concerning an array of issues including the location and availability of suppliers, the transport modes available and to be used, where the goods or commodities may be stored, and the sequencing of movements from production facilities to warehousing/distribution, and then out to market (Hayter and Patchell, 2016; Rodrigue, 2020). Often, production requires the connection of various supply-chains to build value, requiring the further management of goods which must be shipped by different means – the differences between bulk, containerized, and high-value goods for instance. Logistics enables the improved efficiency of movements through optimizing mode selection, terminal usage, route planning, and dynamic, integrated scheduling. Logistics allows firm to manage their production flows in greater detail, with greater time specificity, and across global value-chains.

In logistics, there is a prodigious focus on cost, reliability, and serviceability. While the basic tenant of physical distribution remains - delivering on-time and intact - the pressure to deliver within a highly defined time slot has increased (Allen et al., 2018; Comi et al., 2018; Paddeu et al., 2018; Wygonik and Goodchild, 2018). Just-in-time production has led to the deployment of just-in-time labour, where if shipments are delayed, manufacturing plants may be left at a standstill and labour time goes underutilized – with similar effects experienced at retail stores (Green et al., 2014; Inman et al., 2011). The need to deliver reliably on-time has become a major operational focus of every mode, with the highest emphasis on road and air movements; though, there has also been increasing pressure on intermodal rail and port terminal serviceability (Handfield et al., 2007; Iyer et al., 2004; Zimmer, 2002). The tolerance for delays is low, with some shippers going as far as implementing fines for late deliveries; either to offset the JIT operational setbacks or as a deterrent (Danese et al., 2012; Handfield et al., 2007; Lim and Tan, 2018).

'Reverse Logistics' operates in the reverse of a consumer-oriented supply-chain, going from decentralized collections points (i.e., households and businesses), to transfer stations, then to distribution centres, and then into component pieces to be reused in production activities; effectively mirroring the first, middle, and last-mile of supply-chains (Hayter and Patchell, 2016).

4.2. Supply Chain Management

The enabling factor of SCM is the ability for firms to manage their cost levels through holding minimal levels of inventory as supplier integration / communication and data sharing are such that the supply produced is close to the product demand (Harris et al., 2015; Inman et al., 2011; Ivanov et al., 2019). The shift from inventory-based to replenishment-based logistics was a powerful motivator for manufacturing firms, especially automotive plants, to alter their production processes (Green et al., 2014; Inman et al., 2011). It allows for lower inventory carrying costs as firms are able to plan capacity requirements and have supply arrive in the factories "just-in-time" for them to be used; rather than heavily stockpiling products well before they are needed (Handfield et al., 2007; Hayter and Patchell, 2016; Iyer et al., 2004; Zimmer, 2002). This sharing of data helps to sync supply and demand, allowing flows from suppliers to be increasingly frequent, yet in smaller overall loads. Demand is famously difficult to predict though and consumer and business spending is typically cyclical in nature, adding to the challenge of adequately managing flows (Comi et al., 2018; Ortúzar and Willumsen, 2011). The rapid communication of information decreases delays in the ramping up or down of production, reducing the volume of inventory firms hold.

4.3. Freight Facilities

Freight operations are designed around physical infrastructure which produce, store, or distribute goods. Across these functions, we can define five main types of freight facilities: manufacturing, storage, terminals, distribution, and parcel (Rodrigue, 2020). These facilities, and the functions they undertake, broadly represent the value-chain of logistics. At each step activities occur where added value is generated through fabrication, transshipping/transloading, packaging and labelling, quality control, order picking, etcetera (Clott and Hartman, 2016; Handfield et al., 2007; Strange and Zucchella, 2017). There are a variety of facility types which enable and facilitate particular functions across the various steps in supply-chains, each uniquely suited to handle particular goods or modes. As a result of this coordination and increased communication, there has been a substantial shift in how goods are warehoused. Freight facilities are being consolidated into massive distribution centres which hold what may have been kept in multiple warehouses previously, and are able to manage the shipping of goods (Aljohani and Thompson, 2016; Gonzalez-Feliu and Salanova, 2012; Morganti et al., 2014; Williams, 2015).

Manufacturing

Since the focus of this work is on distribution, it is sufficient to say that manufacturing facilities are a critical element; these are the factories in which goods are produced and they require an input supply and an output demand. Fabrication/manufacturing facilities both derive transportation demand in order to function and induce transportation demand as the outputs need to be moved to the next functional step in the value chain (Black, 2003; Gilbert et al., 1992; Knowles et al., 2008; Onstein et al., 2019).

Bulk & Intermodal Terminals

Terminals are critical nodes in globalized supply chains reliant upon offshore manufacturing and enabling global commodity flows. In terms of cargos, container terminals allow for the transshipment of containerized goods off of container vessels or railcars and onto either container-enabled railcars or truck beds, to make their way to distribution centres (Bektaş and Crainic, 2007; Rodrigue, 2020). Given the volume of containers carried by vessels and the complexity of operators involved, retrieving containers from marine ports and inland ports, typically endures days of dwell time (MITL, 2018a). Terminals are highly reliant upon supporting transportation modes to clear the containers on-dock or in-yard to maintain operations; that is, they are dependent upon their ability to continually load/unload vessels effectively and efficiently. Significant focus has been put on improving the throughput of intermodal hubs, particularly through automation, gate scheduling, and optimally designed yard/dock layouts (Dkhil et al., 2013; Dotoli et al., 2013; Gharehgozli et al., 2017; Mazouz et al., 2017). The major Canadian ports, airports, and intermodal rail yards were highlighted in Figure 3-1 and Figure 3-2.

Distribution & Fulfillment Centres

Distribution centres ('DC') are the major congregation areas where goods are consolidated, deconsolidated, sorted for loading, changed container or load unit type (40', 53', 60' containers, palletized or floor-loaded) and are heavily integrated into the supply chain (Bektaş and Crainic, 2007; Danielis et al., 2010; Onstein et al., 2019). DC's centralize and manage the irregular nature of production and consumption cycles and manage the flow and fulfillment of orders. DCs are focused on throughput, so while short-term storage, cross-docking, packaging and labelling are inherent functions of the facility, the intent is to optimize economies of scale by having goods move to the DCs in the most economical manner possible (highly consolidated), and then unpack and distribute goods as demanded for a determined service area to minimize logistical costs (Bektaş and Crainic, 2007; Hoel et al., 2012; Rodrigue, 2020; Taliaferro and Guenette, 2016). Depending on the nature of the supply-chain, DCs offer various configurations, value-added functions, and operational technologies (e.g., automated sorting, robot retrieval, high-stack storage, randomized layouts, etc.) (González-Reséndiz et al., 2018; Taliaferro and Guenette, 2016; Tang and Veelenturf, 2019). Perishable foodstuffs typically move by reefers (climate-controlled containers) and are processed through cold storage facilities, while cross-dock facilities are used for consolidating less-than-truckload into full-truckload flows (and vice-versa), and retail-focused DCs and fulfilment centres are often extensively automated (Bektaş and Crainic, 2007; Moutaoukil et al., 2015; Oliveira et al., 2017; Pal and Kant, 2019; Taliaferro and Guenette, 2016).

Cross-docking is particularly relevant to time sensitive movements, such as e-commerce, wherein goods are coming off of trucks or aircrafts, and sorted into vehicles for rapid delivery (Van Belle et al., 2012). The main element of cross docking is the ability to consolidate/deconsolidate flows, such as bundling product shipments from multiple suppliers into a single full truckload quickly and with minimal turnaround time (measured in hours), to a receiving point (store, factory, distributor, etc.), rather than sending multiple partially filled trucks (Bektaş and Crainic, 2007; Boysen, 2010; Rodrigue, 2020). The effect is that these facilities act as sortation facilities which are able to manage the synchronization of multiple suppliers and receivers flows at the level of truckloads.

Fulfilment centres and postage/parcel facilities are facilities which have been designed specifically for the movement of parcels. The dramatic rise in e-commerce over the past twenty-years has substantially altered the types of parcels that can be shipped, the speed and ease with which those purchases can be made, and the high delivery expectations of consumers has shifted how sortation and fulfillment centres are designed (Taliaferro and Guenette, 2016). Notably, fulfillment centres have become enormous warehouse which extensively use robotics and automation to increase the operational efficiency of the facilities (Mathauer and Hofmann, 2019; Taliaferro and Guenette, 2016; Tang and Veelenturf, 2019). These facilities maintain high levels of inventory such that they can quickly satisfy the consumer demand of a local, or regional, market in a matter of days or hours (Rodrigue, 2020). Due to the enormity of e-commerce traffic, these facilities have very high levels of throughput and both receive and generate large volume of truck and parcel delivery vehicle movement (Carotenuto et al., 2018; Jaller et al., 2015; Ros-McDonnell et al., 2018a; Taylor, 2006). Smaller urban logistics depots also exist to perform a similar function of large fulfilment centres but at a smaller and more focused scale for high density consumer markets using small vans and micro mobility where applicable (e.g., NYC and Toronto bicycle delivery programs) (Fikar et al., 2018; Rudolph and Gruber, 2017). Where additional line movements are required, such as shifting goods from one DC to another, airports are extensively used as sortation facilities wherein aircrafts can be unloaded, sorted, and immediately loaded onto the delivery vehicles, instead of travelling to an intermediary transload facility (Budd and Mayer, 2017; Kupfer et al., 2017).

4.4. Logistics Clustering and Sprawl

Agglomeration and localization economies are major drivers of value in supply-chains and specifically physical distribution (Hayter and Patchell, 2016). Access to markets is the underlying and driving process for the siting of distribution facilities, and this is especially true of last-mile facilities. Logistics facilities are tightly integrated with the local transportation networks and are typically sited near the major gateway terminals for regions/countries (Rodrigue, 2020). A consequence of the concentration of some supply-chain activities into one major distribution facility, is the volume of physical space these large facilities require (Woudsma and Jakubicek, 2019). As the square footage requirements of facilities increases, the importance of land rent and regulatory barriers become increasingly relevant to the facility siting equation. As a combined result of the increasing land prices in urban regions, especially in Vancouver, Toronto, and Montreal (coupled with a physical lack of space in some instances), these facilities are increasingly locating in suburban and rural/exurban areas (Aljohani and Thompson, 2016; Sakai et al., 2019; Taniguchi et al., 2016; Woudsma and Jakubicek, 2019). The impact of this sprawl is the requirement of expanding or extending network infrastructure (e.g., the extension of the 427 to the new intermodal terminal in Southern Ontario) and a significant increase in the volume of heavy-class truck traffic – which can be considered a nuisance by local residents (Dablanc et al., 2013; Nathanail et al., 2017; Williams, 2015).

Chapter 5. Urban Transportation and Logistics

Home to clusters of economic activity, cities are intricate socio-spatial structures supported by varieties of complex infrastructure. The productivity of cities is reliant upon the efficient movement of individuals. The movement of goods through urban areas is a common and growing problem for cities globally as the interactions between increasing populations and increasing demands for both the production and consumption of goods, continues to rise (ECMT, 2007; TTI, 2019; UTTF, 2012). The continued growth of private automobiles, encouraged through auto-centric land use planning and subsidized roads, has led to gruelling congestion. Regional highways, arterial, and local roadways have all become congested during peak daytime travel periods (McPhee et al., 2015; Rodrigue, 2020; Taylor, 2006). Every city is unique in its prescription of physical infrastructure, the supply-chain flows it generates or supports, and its socio-economic culture. Cities are both regions of production and consumption, and there is the constant challenge of land availability and to whom that land should be allocated to (Jakubicek and Woudsma, 2011b; Judyta, 2016; Marsden and Snell, 2009). The purpose of urban transportation networks is to support and enable the accessibility and mobility demands of activities, however varied and diverse they may be.

5.1. The Last Mile: Distribution and E-Commerce

Last mile movements in the physical distribution of goods are just that: carrying a good over the final leg of a journey to reach the customer. The last-mile-to-market from a distribution facility represents the most complicated aspect of the logistics system by virtue of the extent of deconsolidation and the variety customers involved (Allen et al., 2018; Kedia et al., 2017; Marujo et al., 2018; Nathnail et al., 2016; Perboli and Rosano, 2019; Xiao et al., 2017). The last mile is impacted by both the efficiency of supply-chain components and the efficiency of public infrastructures, including sufficient road and parking capacity, as well as regulatory impacts (e.g., time-of-day restrictions) (Bean and Joubert, 2018; Eren Akyol and De Koster, 2018).

Urban freight activities are the outcome of the unique movement decisions of economic activities. Distribution patterns heavily revolve around consumer-based goods demand. Retail, grocery, restaurants, and parcels/mail are the largest generators of urban freight traffic (Jaller et al., 2015; Toilier et al., 2018; Yuan, 2018). Though, e-commerce has become an increasingly relevant aspect of the retail marketplace and is changing the distributional demand in urban areas through the growth of parcel movements (Allen et al., 2018; De Marco et al., 2018; He et al., 2019; Taliaferro and Guenette, 2016). Since parcel movements go to the home of recipients, it is a heavily fragmented movement which necessitates large fleets of small vehicles, typically vans, to deliver within the fast time frame which consumers have come to expect (typically less than two-days). Though e-commerce retailing involves just about any type of product imaginable, the average value of these movements is low, because of the fragmented nature, and as such the physical impact of e-commerce on road congestion is disproportionate to the retail value (Budd and Ison, 2017; Budd and Mayer, 2017; Transport Canada, 2018; Xiao et al., 2017). While convenient for consumers, delivering e-commerce parcels is a challenge. In addition to the issues of congestion and parking, a major hinderance is failed deliveries. These deliveries either need to be reattempted or taken to local postal outlets where the recipient must then complete the last mile; which, duplicates the volume of trips for that good. Community locker boxes, automated pickups, flexible delivery, and the ability to inform drivers of delivery preference (i.e., to leave parcels at the door or a side gate) are innovative and technologically reliant approaches to mitigate and reduce failed delivery attempts.

5.2. Congestion at the Curbside

Congestion is the single most prevalent transportation issue for urban regions. Cities are physical constrained in the space they have for the provision of infrastructure. As there is competition between modes, every additional vehicle, transit vehicle, cyclist, and freight vehicle compete for the limited amount of road space available (Akgün et al., 2019; Dablanc, 2011; Kiba-Janiak, 2017; Nourinejad et al., 2014). Similarly, only so much curbside space can be dedicated to parking; a major problem for delivery vehicles (Cherrett et al., 2012; Figliozzi and Tipagornwong, 2017; Marcucci et al., 2015; Ros-McDonnell et al., 2018b). Parking fines are very much considered a cost of doing business in the logistics industry as the easiest option for drivers is to either illegally stop or double-park their vehicle to make a drop, rather than cruising and looking for a legal space to stop (Amer and Chow, 2017; Nourinejad and Roorda, 2017). The impact on local vehicle traffic is so substantial that the City of Toronto has implemented high fines and immediate towing practices for vehicles blocking thoroughfares during peak travel times (2019). Curbside management in many cities has become a contested and intensely debated urban planning issue in the Americas and Europe, especially as cyclist and pedestrian safety issues have become exacerbated in recent years (Arnott et al., 2015; Q. Chen et al., 2017; Toilier et al., 2018). The primary issue as it relates to urban logistics is delivery friction which congestion imposes on movements; travel-times are becoming increasingly variable, delivering on-time is more difficult, fleets must increase to meet the demand, and the road supply is restricted.

5.3. The Impacts of Urban Spatial Structure

The modern urban planning paradigm in Canada's major metropolitan regions has been a theme of land use intensification, especially as housing and land shortages are becomingly increasingly prevalent and contributing to a rent affordability crisis. This unaffordability pushes people, and firms, further away from markets, increasing the time and volume of commuting and delivery trips. Instigating and compounding logistics sprawl as well as congestion in peripheral areas servicing terminals (Sakai et al., 2019; Woudsma and Jakubicek, 2019). While high residential densities, combined with ready access to commercial and employment lands (especially in the tertiary and quaternary sectors) are beneficial to the provision of housing, high land densities result in difficulties for freight distribution. Most prevalent are road congestion and parking availability, as roadways are shared public resources, which result in significantly increased operational costs as asset utilization falls, labour time increases, and deliveries have to be spread out to an increasing number of vehicles to ensure that entire trip turns can be completed on-time. An unfortunate and paradoxical result is that road congestion tends to induce further congestion, as more vehicles are deployed to overcome the delays.

Due to economies of agglomeration and localization, employment, freight generating, and freight distribution activities tend to cluster (Behrens and Picard, 2011; Jaller et al., 2015; Kumar et al., 2017). While this trend has been supported by hundreds of years of land use management and a variety of land use and siting theories have been developed, we can generally identify four major types of regions within urban areas, which have different levels of demand upon the urban logistic system: High density residential and employment; employment/industrial; residential; suburban/peripheral (Rodrigue, 2020). High density residential and employment (e.g., modern city cores / downtown's), require the most intense logistic services and are the most challenging to service. High employment density / employment lands are typically much of the logistical activity is based. Low-density residential and commercial focus on commercial and to-the-home parcel deliveries. Suburban regions experience fewer issues related to delivery because of the lower density, though it can be challenging to reach these areas due to regional congestion. The long and short is that outside of a Goldilocks's zone of perfect density, supply, and demand, the costs and challenges of delivering goods across the last mile to consumers and businesses increases.

5.4. The Role of the Community

Transportation is historically planned from a rational paradigm perspective, which is a pleasant way of saying civil engineers focus on quantitative aspects through a systematic, reproducible approach of a highly defined problem. The rational paradigm is what built the highways of the 1940's, 1950's, and 1960's including the United States *Interstate* system, the 400-Series in Ontario, and the Trans-Canada Highway. Which coincides with the era of Jane Jacob's famous study *The Death and Life of Great American Cities* and her opposition to the Lower Manhattan Expressway (and eventual opposition to the *Spadina Expressway* in Toronto). Jacob's seminal work eventually helped sparked a revolution in the world of planning, ushering in the era of new-modernist design (i.e., walkable mixed-use neighbourhoods with traditional-neighbourhoods and transit-oriented designs) and is oft credited as being the framework upon which the *Vancouverism* planning perspective is based. The socio-institutional framing of transportation has changed as the expectations of citizens has changed; similar to seventy years ago in Manhattan, new infrastructure cannot be bulldozed through existing communities under the banner of being for the public interest. The challenge is to collaboratively plan urban regions, and rural regions as well, with relevant stakeholders to build better communities with greater citizen input on projects.

The underlying challenge is in understanding the perspectives of users, decision-makers, third/related parties, and taxpayers, then developing and deploying a plan that balances the goals and objectives of each group. Participatory planning and collaborative planning approaches are complex, interwoven perspectives that focus on, at minimum, understanding public interest and opinion on projects (Hodge and Gordon, 2013). Higher level participatory paradigms shift the focus from public commenting on proposed planning actions, often which were likely to be adopted regardless of public input, to a community development focus (Legacy et al., 2017; Levy, 2015; Natarajan, 2017). Shifting the dynamic to the community having involvement in the specifics of how the community develops, rather than a series of officials developing a master plan with the aim of acting in the benefit of the collective public interest. For the little appetite there is for transit construction and expansion, there is substantially less interest in expanding highways and rail lines so that industries can more easily move their goods (Judyta, 2016; Legacy, 2016). The physical environmental implications of constructing new infrastructure aside (which is undeniably substantial), issues of visual dis-amenity (i.e., to the exception of perhaps enthusiasts, roads, railways, and other grey-type infrastructure, are arguably ugly), noise and light pollution, greenhouse gas emissions and VOC pollutants, costs to taxpayers, and land acquisition are all major hinderances to the development of infrastructure, in urban regions (Hodge and Gordon, 2013; Judyta, 2016).

5.5. Policymaking and Regulations

Within metropolitan regions, roadway movements are generally the only viable mode to facilitate the first/last mile of supply-chains (Bjørgen et al., 2019; dell'Olio et al., 2017; Marcucci et al., 2017). Despite the general dislike of commercial vehicles, these movements are critical to enabling industry, attracting industrial investments and job creation, and generating tax revenues (Alvarez et al., 2018; Fancello et al., 2017; Pronello et al., 2017). As city populations continue to grow, the efficiency of logistic networks between and within economic centres are becoming increasingly relevant to policymakers as available space to expand infrastructure and accommodate residential development runs out. Policymakers have paid relatively little attention to the challenges facing the movement of goods in metropolitan regions, focusing instead on passenger movements (Lebeau et al., 2018; Marujo et al., 2018; McLeod et al., 2019; Simoni & Claudel, 2018). The increasing interactions between commercial and passenger vehicles, as a result of burgeoning demand on the road networks, are leading to safety concerns, social stressors, increased emissions, and anti-industry sentiments as authorities struggle to develop cohesive and impactful policy interventions (Kelle et al., 2019; Mrazovic et al., 2017; Nordtømme et al., 2015; Talebian et al., 2018). As congestion impacts increase, there is concern that regions which do not adequately address issues may experience a decrease in business investment as industries relocate to the edges of markets where transportation networks are subject to less demand and operate more reliably (Chen et al., 2017; Gingerich & Maoh, 2019). It is imperative for governments to ensure the smooth movement of passenger and freight traffic to promote quality of life and to enable economic activity (Cleophas et al., 2019; Eren & De Koster, 2018; Fancello et al., 2017; Rashidi & Cullinane, 2019).

Urban regions invariably experiences different issues as the nature of the economy is unique in every city and the dissimilarity of industries present alters the demand of the freight network (Gatta et al., 2019; Marcucci & Gatta, 2016, 2017; Marcucci, Gatta, & Macharis, 2017) resulting in operational constraints and idiosyncrasies. Despite freight transportation activities being essential to the economic prosperity of metropolitan regions (Anderson et al., 2005; Ballantyne et al., 2013; Kiba-Janiak, 2017), there is a limited understanding of the complex interactions occurring across supply-chains facilitating the movement of goods (McLeod et al., 2019; Mullen & Marsden, 2015; Sakai et al., 2019). Policymaker, planner, and researcher understandings of congestion issues have historically focused on the movement of people, with less attention paid to the movement of goods and freight demand behaviour (Ballantyne & Lindholm, 2014; Bjørgen et al., 2019; Gatta, Marcucci, & Le Pira, 2017; Marcucci, Gatta, Marciani, & Cossu, 2017; Sánchez-Díaz, 2017; Verlinde & Macharis, 2016)

Local policymakers are in a difficult position though as they must develop strategic plans which achieve municipal and political objectives, foster economic growth, mitigate negative externalities, balance stakeholder demands, and balance a budget (Anderson et al., 2005; Bjerkan et al., 2014; Holguín-Veras et al., 2017b; Marcucci et al., 2015; Marcucci and Gatta, 2016; Nordtømme et al., 2015). The actions of municipalities can create potentially adverse impacts on supply-chains and outside regions, as transportation problems transcend political boundaries (Jakubicek and Woudsma, 2011c; McLeod et al., 2019). A lack of policymaker understanding of the challenges facing freight operations and the interactions amongst land use, infrastructure, and movements, compounds the difficulty to develop reasonable, mutually beneficial policies (Ballantyne et al., 2013; Ballantyne and Lindholm, 2014; Lindholm, 2010). Holguín-Veras et al. (2017b) note that as a result of the complexity of the freight environment, policymakers are at risk of implementing ineffective policies that not only reflect poorly on the capacity of government to solve problems, but risks introducing unintended consequences into an already tumultuous operating environment. The challenges facing policymakers are complicated by the volume of stakeholder interactions and the reality that policies which benefit one stakeholder can be detrimental to another (Browne and Allen, 1999; Gatta and Marcucci, 2016a).

Rigorous policy impact assessments are not always the standard when regulatory measures are implemented by local authorities (Lindholm, 2010; Marcucci et al., 2015), though imperative; predicting prospective reactions to policy across all stakeholders, is not a simple task (Gatta and Marcucci, 2016b; Holguín-Veras et al., 2017b). Consequently, policies have typically failed to adequately address either freight or passenger congestion issues have typically failed to produce the intended social purpose, while increasing the cost and difficulty of operations for stakeholders (Figliozzi and Tipagornwong, 2017). As such, it is imperative that local land use authorities address issues by communicating and cooperating with stakeholders through existing and innovative decision-making processes (Fancello et al., 2017; Marsden and Reardon, 2017; Mullen and Marsden, 2015).

5.5.1. Canadian Regulatory Context

Canada is a mixed market economy with the participation of private organizations in the role of shippers, receivers, and transport operators, with strong oversight from multiple regulatory layers including economic interventionist policies and the extensive provision of public infrastructure. Roadways, with few exceptions, are publicly owned, while rail infrastructure is privately owned by the rail operators. Air and marine ports are typically operated by semi-private non-profit firms on lands leased from the government. Canada is viewed as a world leader in the use of public-private partnerships to fund public and semi-public infrastructure (Stanley and Hensher, 2019). The 2017 creation of the Canada Infrastructure Bank as an example of the Federal government reaching out to private capital to fund works, though the historical approach has often been an ad hoc framework varying by the government of the day (Stanley and Hensher, 2019).

The freight environment in Canada is regulated by three layers of government oversight and control at the federal, provincial, municipal levels (including local and regional municipalities) and are interwoven through the various layers of public-private and arms-length organizations, regional planning agencies, and private interests. The Federal environment focuses on international and inter-provincial movements, regulating all modes and border-crossings but has limited responsibility in the direct provision of infrastructure, though is viewed as a major funding partner (Ferguson et al., 2018). The purview of the Provinces is across all modes, intra-provincially, with a focus on road movements. Provinces are responsible for the provision of road infrastructure, particularly highways and regional transit services. Municipalities are focused on local land use, transportation planning, roads, and on-the-ground management (Ferguson et al., 2018). Similar to the United States and Western Europe, Canada underwent an extensive period of deregulation in the transportation sector (Iacobucci et al., 2006); the history of Canadian transportation policy is extensively detailed by Doern et al. (2019).

The Federal regulatory environment focuses on international and inter-provincial movements regulating all modes and border-crossings but has limited responsibility in the direct provision of infrastructure (MITL, 2018a). Though, the Federal government is often viewed as a major capital funding partner for infrastructure and other innovative or pilot projects. The provision and operation of freight-supportive infrastructure is interwoven across the various layers of governments, public-private and arms-length organizations, regional planning agencies, and private interests. The Canadian freight environment does not have a national freight-management or data reporting strategy, as seen in the United States or the European Union, and there are varying degrees of interest in addressing freight issues across the national, provincial, and municipal levels and inter-departmentally (MITL, 2018a; Plumptre et al., 2017). Though, the Federal government does maintain a National Policy Framework for Strategic Gateways and Corridors which is focused on funding infrastructure and other initiatives that support or enhance international trade (Transport Canada, 2014). This was further strengthened the Canada's Transportation 2030: A Strategic Plan for the Future of Transportation in Canada which included further funding for trade corridors, as regulatory frameworks to support future technologies (Plumptre et al., 2017).

The purview of the Provinces is similarly across all modes, moving intra-provincially, but the primary focus is the regulation of commercial and passenger movements on roadways. The Provinces are responsible for the provision of major road infrastructure, particularly highways and regional transit services. British Columbia's transport system supports the framework of Western Canada's economy and facilities extensive trade with the Asia-Pacific region. B.C.'s Pacific Gateway Transportation Strategy (2012) and BC on the Move (2015) specifically aim to increase the capacity of the transportation network through investments. Quebec is providing investments to increase the capacity of non-road modes and is promoting the expansion of intermodal infrastructure (2018). Ontario is generally recognized as the Canadian leader in understanding and planning for freight movements and has historically considered the movement of goods in its long-term planning (Metrolinx, 2017a; Ontario Ministry of Transportation, 2004). To that point, the Province is currently in the process of finalizing its 2051 GGH Transportation Plan, which is explicitly addressing the impacts of e-commerce, changing logistical demand networks, automation, intermodal terminal accessibility, integrating transportation and land use development, and the optimization of existing road infrastructure (Metrolinx, 2017b). Ontario published a set of Freight Supportive Guidelines aimed at assisting municipalities coordinate their land use and transportation plans (Ontario Ministry of Transportation, 2016).

Municipalities are focused on local land use and transportation planning, the provision of local roads, transit services, and an on-the-ground management of cities and regions (MITL, 2018a). There is a great deal of disparity in interest in addressing freight issues in transportation and land use planning. The Regional Municipality of Peel is considered to be the state-of-the-art for municipal level addressal of freight (Plumptre et al., 2017). Though, Peel Region is home to the highest density of transportation infrastructure in Canada and has a strong economic imperative to work collaboratively with its tax base. Although some government layers, have or are in the process of implementing strategies to address freight congestion, goods movement will remain a challenge in Canada (Metrolinx, 2016).

Chapter 6. Congestion and the Canadian Case

Traffic congestion actively impacts the quality of life of millions of Canadians, creating substantial delays for passenger and commercial traffic alike while costing national and regional economies billions of dollars annually (Arnold, 2014; Metrolinx, 2016; Region of Peel, 2017; TransLink, 2017; Transport Canada, 2006; TRBOT, 2017; TTI, 2019; UTTF, 2012). There is little mystery as to why road traffic congestion is a major focal points of the discussion on general and freight mobility in Canada – it is being viewed as strangling the economy while driving the up the cost to move both people and goods (Canadian Chamber of Commerce, 2017; Transport Canada, 2018; UTTF, 2012). Road traffic impacts the ability to make unencumbered trips and for trucks to complete first, middle, and last mile movements throughout urban and rural regions. Another aspect of Canadian congestion is rail and port congestion which, while less visible than road congestion, is a recognized and significant challenge (Transport Canada, 2018).

Road congestion is intensive in Canada's major cities, especially compared to cities in the United States, such as Los Angeles, New York City, Chicago, Washington-Baltimore, Boston-Providence, Dallas-Fort Worth, Miami, Philadelphia, Miami, and Atlanta. The City of Toronto experiences more hours of congestion than New York City, which is approximately 3 million people larger (INRIX, 2020). While the City of Vancouver experiences similar levels of congestion to Los Angeles, which is approximately six times as large in terms of population and similar population densities, as well as more congestion that New York City (TomTom, 2020). The City of Toronto is ranked by INRIX as being the 20th most congested city in the world in terms of impact – defined by INRIX as being based on the impact congestion has on a city derived from city's population, commuting behavior and individual congestion delay – Montreal ranks 34th, Calgary 60th, Ottawa 68th, Edmonton 80th, Winnipeg 96th, Vancouver at 99th, and Halifax at 128th, Table 6-1 (INRIX, 2020). A 2015 report notes that 57% of average total delay in the City of Toronto takes place on arterials, though peak morning and evening times see the majority of delay attributed to, on average, highways (MITL, 2015). TomTom's data finds Vancouver at 40th, Toronto 80th, Montreal 138th, Ottawa 139th, Halifax 213th, Winnipeg 247th, Calgary 338th, and Edmonton 359th globally out of a list of 416 evaluated cities for 2019 (2020). Road traffic congestion is undeniably an issue in Canada's major cities.

Vancouver is well-known for congestion on its road and rail networks servicing the Port of Metro Vancouver (Mongelluzzo, 2019; TransLink, 2017). Montreal is similarly considered for its road and bridge congestion, especially in relation to servicing the Port of Montreal (Bruemmer, 2018; Spurr, 2014). The Greater Toronto Hamilton Area, the largest metropolitan region in Canada by population and physical expanse, is well known for crippling daily road traffic congestion on its major highways (e.g., QEW, 400, 401, 403, 404, 410, 427, and DVP), and substantial volumes of heavy commercial traffic servicing multiple rail terminals and international airports (Abdulhai, 2013; City of Toronto, 2015; Metrolinx, 2008; Region of Peel, 2017). Figures 6-1 and 6-2 provide an overview of the trip volumes through Southern Ontario on Provincial roadways and a visualization of congestion by normalizing average traffic speeds (during the AM peak) by the posted limit of the affiliated road, respectively.

Though road traffic congestion is a heavily urban concept, small rural towns experience congestion in surprisingly similar ways to large cities and conurbations. Notably, the perception of congestion varies by region – the levels of congestion we might normally expect in cities like Toronto or Montreal, Table 6-1, are unfathomable in more rural or less heavily urban-intensified regions; yet, both could be considered to be congested at times. What specifically defines a 'congested' environment or roadway similarly varies by person, time, day, city, region, and country – we know when we are in congestion, but there is not a universally accepted definition or metric wherein we can precisely say at which point networks become congested (ECMT, 2007). The measurement of congestion – whether by a travel-time index, hours lost, congestion level – are all proximate measures; that is, they do not explain why the networks are being demanded beyond a manageable level. How we define congestion and from what lens we approach it with changes both the perceived causes and solutions, but fundamentally the focus is on how we would prefer our transportation networks to operate in relation to how they are currently functioning (ECMT, 2007; MITL, 2015).

Table 6-1: Hours Lost in Congestion

City, Province	*Hours Lost in Congestion (peak Hours)*[1]	*Congestion Level*[2]	*Population*[3]	*Population Density*[3] *(Sq. Km.)*
***Toronto**, Ontario*	164	33%	5,429,524	3,028.2
***Montreal**, Quebec*	145	29%	3,519,595	2,719.9
***Halifax**, Nova Scotia*	119	25%	316,701	1,349.3
***Ottawa**, Ontario*	107	29%	989,567	1,900.0
***Vancouver**, British Columbia*	102	39%	2,264,823	2,637.8
***Winnipeg**, Manitoba*	94	22%	711,925	2,069.6
***Edmonton**, Alberta*	89	16%	1,062,643	1,855.5
***Calgary**, Alberta*	88	18%	1,237,656	2,111.8

Data Sources: [1](INRIX, 2020); [2](TomTom, 2020); [3](Statistics Canada, 2016)

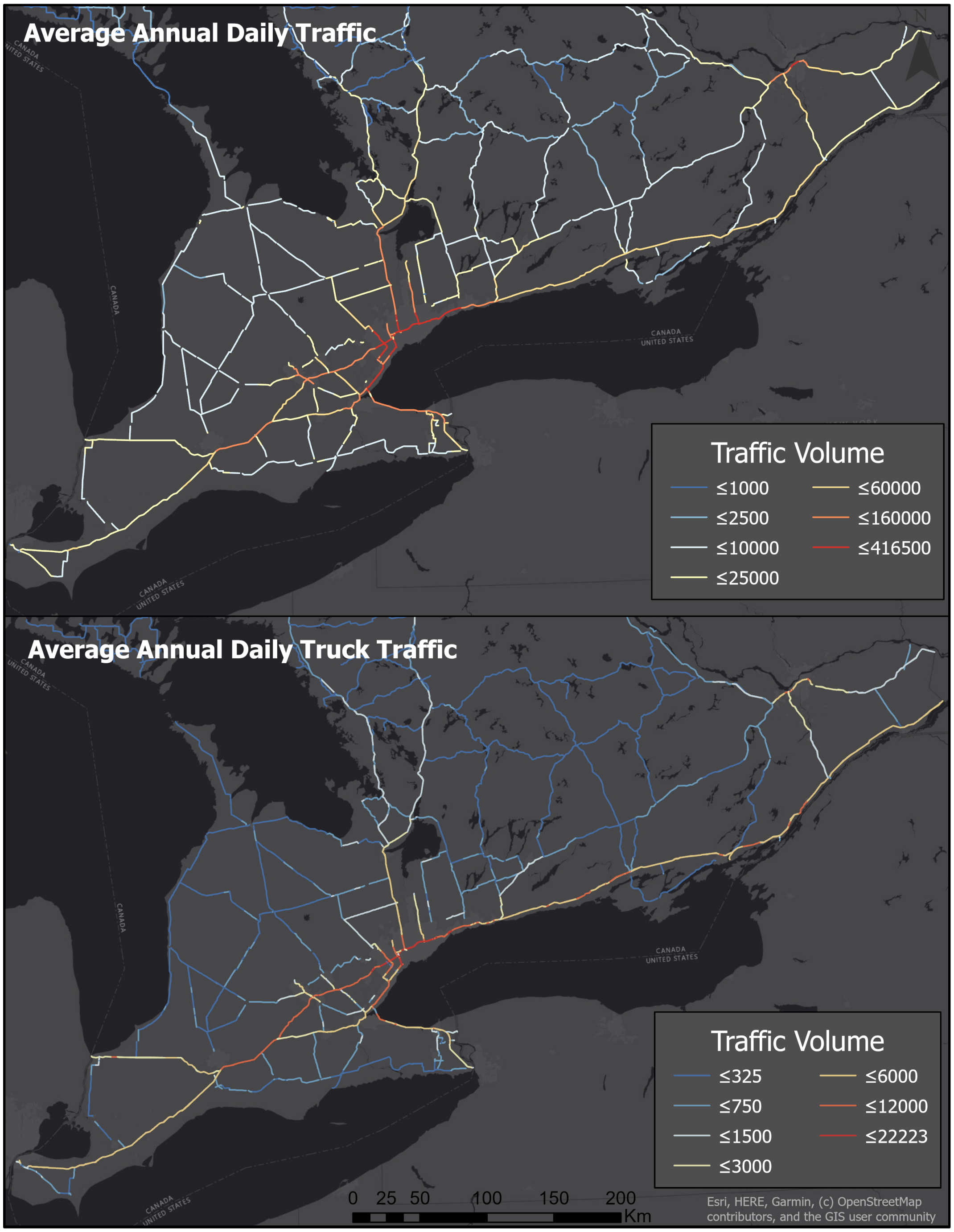

Figure 6-1: Trip volumes (AADT & AADTT) through Southern Ontario on Provincial roadways in 2016. Data Source: (Ontario Ministry of Transportation, 2019a)

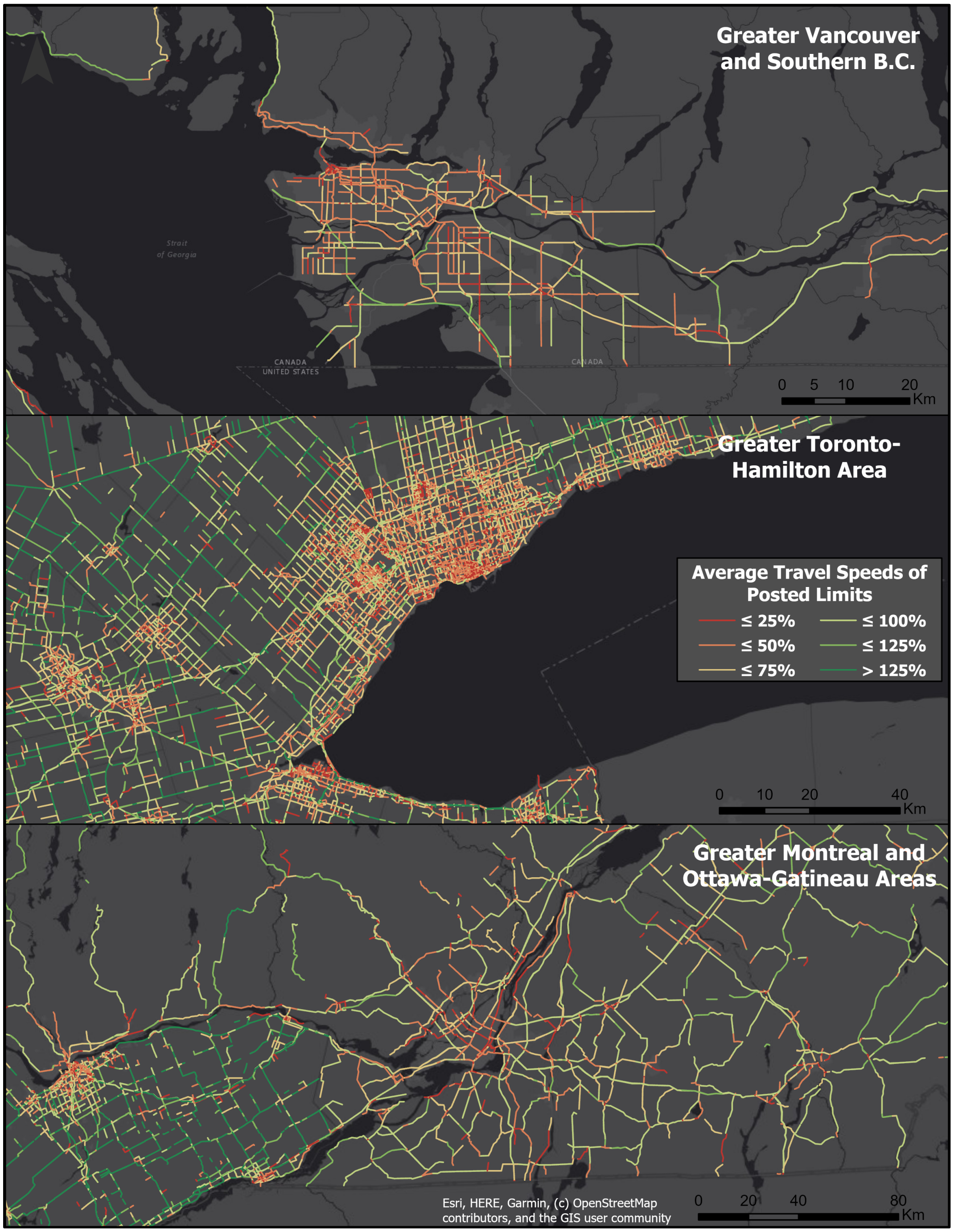

Figure 6-2: Average AM Travel Speeds of Posted Limits in Major Metropolitan Regions Across Canada. Data Source: (Ontario Ministry of Transportation, 2020)

6.1. Defining Congestion

Congestion is both a physical and relative phenomenon. Vehicles, and every additional vehicle, consume physical space which hinders the movement of other vehicles at an increasing rate as infrastructure approaches its capacity. Congestion is relative, as discussed in the Chapter preface, in how it performs as per the expectations of a user; most notably/commonly on roadways. Travel demand varies by time, day, season, and is influenced by everything from recreational events to the weather. Even capacity is in flux as weather, vehicular incidents (crashes, derailments, breakdowns, etc.), construction work, and the behaviour of motorists (speed differentials, or lane changing behaviours), are noted as impacting the relative capacity of infrastructure (ECMT, 2007). In the most general of senses, congestion restricts a user's ability to reach destinations in a satisfactory amount of time – relative to both the expectations and previous experiences of the user – as a result of less-than-ideal travel speeds (ECMT, 2007; FHWA, 2005).

If we consider a capacity-based definition of congestion, in which the demand for mobility exceeds the built capacity of the available infrastructure at or along a particular route/link, the focus is on the infrastructure and not why travel demand is overwhelming the capacity. The solutions are then invariably focused on increasing the capacity – as has been done for decades now – to reduce bottlenecking. In some cases, such expansions of physical capacity are well-warranted and needed – e.g., the 401-expansion announced through Cambridge, Ontario, or the expansion of the 410 from Brampton – while in many other cases, expanding capacity has been shown to induce demand and ultimately fail to address the underlying congestion. Further, there are regions where infrastructure has been expanded to its maximum capacity in urban areas as the cost to procuring land for a highway lane expansion, a rail line track, or additional airport runways or warehousing facilities has become prohibitively expensive or simply unfeasible due to the built environment – e.g., widening the Gardiner Expressway through downtown Toronto would be virtually impossible to complete. Similar issues of capacity exist for public transit systems. Local buses can impede and are impeded by road traffic, regional buses are caught in the same highway congestion as passenger vehicles (even with HOV and HOT lanes), heavy-rail is restricted by the availability/cost of land to expand the rail lines, and the construction of above ground light-rail systems has become a lighting-rod for politicians due to both expense and the complications of planning/construction.

The primary issue with capacity-focused definitions of congestion is that they ignore aspects of travel demand and behaviour. People do not behave according to fluid dynamics, and while vehicle braking breaking can cause 'waves' in traffic and wider roads can certainly accommodate more vehicles, travel demand is a multidimensional and complicated interrelation of a variety of factors, in which people are making active decisions about where to go, along which routes, and at what times – not following the path of least resistance. Demand, among other considerations (e.g., Chapter 5.3), is a function of where people live, work, and partake in leisure/recreation activities (e.g., sports, shopping, cafes, bars/clubs). Moreover, infrastructure can be argued to be congested before it reaches/exceeds its designed capacity and is reflexive to every additional vehicle – congestion is both caused and impacted by the volume of traffic circulating (FHWA, 2005). On urban roadways, specifically arterials and local streets, traffic flows are also interrupted by signalized intersections – which is used to produce 'green waves' or to purposely slow traffic (e.g., ramp metering) – not to mention the impacts of curbside activities and other road users, such as pedestrians, cyclists, and public transit.

Another consideration of capacity-focused definitions of congestion is the question of cost and marginal impacts. As pointed out by the ECMT (2007), "the cost of reducing congestion to [tolerable] levels may be much greater than the costs imposed by congestion itself" which is similarly voiced by VCEC (2006) in that "congestion could be defined as being excessive when the marginal costs to society of congestion exceed the marginal costs of efforts to reduce congestion." Expanding infrastructure is an infamously expensive undertaking, and it does beg the question of asking, how much congestion is costing the Canadian, provincial, regional, and local economies. Transport Canada's 2006 study on the costs of passenger-travel peak-period congestion, note that with drivers reduced to 50% of the speed limit, the cost is roughly $4.3 billion (2002 Canadian Dollars), accounting for both recurrent and non-recurrent congestion, based off of a buffer analysis index – roads operating at 50% of the posted speed limit in 2006 during the average AM peak travel period are drawn in orange in Figure 6-2 (2006). Nearly two billion of which is in Toronto and roughly one billion in each Montreal and Vancouver. Metrolinx's 2008 cost of congestion report, which actively considered the business-related costs of congestion including freight movements, pegged the total cost of congestion to the GTHA at $6 billion (2008). A 2009 study by the FHWA estimated that the annual cost of congestion to the economy of the United States was roughly $115 billion – and clearly indicated that highway expansion was not leading to the reduction of congestion in urban regions (UTTF, 2012). The 2019 Urban Mobility Report from TTI found that in 2017 the national cost of congestion cost is $166 billion and is expected to grow to $237 billion (2017 USD) by 2025 (TTI, 2019). It is abundantly clear that the impacts and dollar-costs of congestion are growing.

A flip on understanding the costs of congestion, as was discussed in Chapters 2.4, 4.3.1, and 5.3, is the economic perspective that congestion is not inherently bad – if the roads are being crowded, there is some sort of net-gain that is being achieved. Often, many of the activities that people seek to undertake can only be fulfilled in busy urban areas as individuals derive benefits from proximity and cities derive immense benefits from agglomeration, Chapter 2-2.4. Congestion is the sign of an economically prosperous region that is drawing in people and employment, rather than an indicator of abject failure of transport infrastructure and land use policy – though, there are likely situations in which both are true.

6.2. General Causes and Sources of Congestion

Broadly speaking there are three categories to which the causes of congestion can be considered: micro, macro, and stochastic. Micro-level factors are focused on specific infrastructure and traffic composition, macro-level factors are focused on the patterns of activity and demand, and stochastic factors are the random variables which are focused on things like the weather. The demand for transportation has been broadly discussed across this thesis, especially chapters 2 and 5, but the major factors that generally influence or generate demand for access and mobility are: socioeconomic growth (Muñiz and Garcia-López, 2019; Nuzzolo et al., 2016); urban population growth (Sanz et al., 2018; Sapena and Ruiz, 2019); automobile dependency and parking (Moya-Gómez and García-Palomares, 2017; Townsend and Ellis-Young, 2018); land use planning (Bjørgen et al., 2019b; Filion et al., 2010; McLeod et al., 2019; Sciara, 2017); travel patterns (Broaddus and Cervero, 2019; Wygonik and Goodchild, 2018; Zhang et al., 2019); public transit (Cochrane et al., 2017; Legacy et al., 2017; Reddy et al., 2016; Rodrigue, 2020); and, urban freight / city logistics (Amer and Chow, 2017; Cardenas et al., 2017; Comi et al., 2018; Woudsma and Jakubicek, 2019). Further categorization works to identify recurrent and non-current/random congestion events, as well as congestion triggers and drivers (ECMT, 2007).

As Figure 6-3 highlights, these factors influence one another and generate a feedback loop. Activity patterns are influenced by land use, demographics, and other high-level factors which lead to the generation of trips; travel behaviour is a consideration of travel times, along which route, by what mode(s); travel demand pattern considers the times at which varying levels of mobility is demanded, the origins and destinations of those associated movements. These first three factors are considered to be macro-level 'drivers' of congestion, while the next two factors

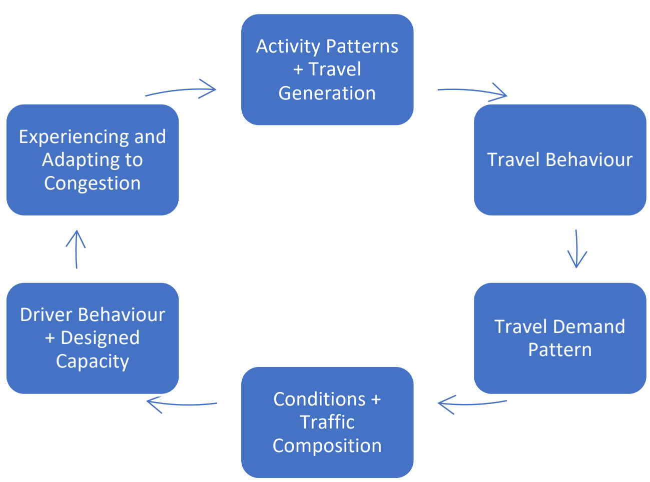

Figure 6-3: Factors Influencing Congestion. Adapted from: (Bovy and Hoogendoorn, 2000), (ECMT, 2007).

are considered to be micro-level 'triggers' of congestion. Conditions are influences relating to the weather, the quality of the infrastructure, lighting, physiography and other physical circumstances which can impact the immediate ability or ease to operate a vehicle. Driver behaviour – the mix of different driver types, trip purposes, operating behaviours, and vehicle size/types – is combined with the infrastructure design to affect the travel speeds, in/egress patterns, lane switching and other behaviours which can lead to traffic slowing, bunching, or being otherwise impaired. As network usage exceeds the operational capacity of the link, conditions deteriorate performance, or behaviour leads to negative impacts, congestion builds and propagates, immediately influencing travel behaviours and slowly influencing travel demand and activity patterns.

Recurrent congestion is the result of 'normal' levels of daily demand leading to slowed performance on a relatively consistent and repeating basis (FHWA, 2020b; MITL, 2015). Road utilization typically follows the daily flow of passenger movements, where traffic peaks during the morning rush, ebbs during the mid-day, and then between early afternoon and mid-evening there are very high volumes of movement (Black, 2003; Levy, 2015; Ortúzar and Willumsen, 2011). In the United States, this pattern is expanded to find that daily traffic congestion in large urban regions experience increasing volumes of congestion from Monday to Friday, with considerably lower volumes on the weekends (TTI, 2019). This pattern of hourly traffic flows is highlighted by Figure 6-4, presenting data from the Transportation Tomorrow Survey for the volume of trips starting by time of day – clear peak are identified the morning and mid-late afternoon. Congestion is also most prevalent in the afternoons and into the evenings, where based on Figure 6-4 and data from the TTI the majority of trips are clearly taking place, increasing the demand on the networks (TTI, 2019).

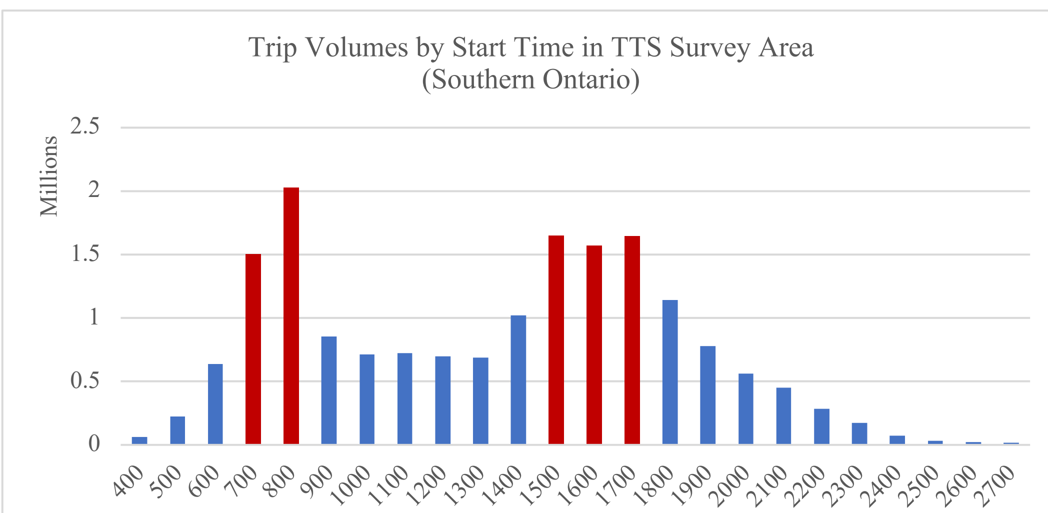

Figure 6-4: Trip Start Time, Highlighting Peak Travel Periods. Time begins at 4am and continues to 3am of the next day. Data Source: (DMG, 2016)

The default assumption of the cause of reoccurring congestion is that demand is outstripping the capacity, at some defined level of service (e.g., reliability index, buffer index, etc.). Though frequently true, it is difficult to define at what point roads become congested – as discussed in the previous section – and a part of the reason for that is the dynamic nature of capacity (Brent and Gross, 2018; Torrisi et al., 2017). Recurrent congestion is not reliably predictable, and a lot of effort has gone into investigating travel time reliability and buffer indices as ways to communicate the expected level of service a link or route will provide on average (FHWA, 2019, 2005). As roadways, and other transport infrastructure, approach their designed carrying capacity, traffic flows become increasingly unstable – some days there will be heavy congestion and phantom jams, while on others flows will run smoothly (Hoogendoorn and Bovy, 2001).

In a basic assessment of how traffic behaves on an uninterrupted network (e.g., a highway), drivers a) select their speed and distance from the vehicles around them, b) as the volume of vehicles increases, drivers slow to maintain a level of distance, c) at some point of saturation, the network enters a critical-state phase in which driver behaviours (aggressive acceleration, rapid breaking, lane changes, non-constant speeds, tailgating) have the most intensive impact on speeds and throughput volumes, d) eventually, traffic speed and throughput will come to a near halt until enough vehicles are able to exit the network or fewer vehicles enter (Black, 2003; ECMT, 2007; Ortúzar and Willumsen, 2011). At what point traffic actually becomes 'congested' is a function of the intensity of demand and the number/intensity of micro-triggers caused by driver behaviour. The relationship is less deterministic – i.e., roadways are congested at 90% of designed volume – and more probabilistic – i.e., roadway are more likely to experience congestion events about 90% of designed volume – as flows can be maintained above designed capacity, but congestion events can also occur at well-below the designed capacity (ECMT, 2007).

On an interrupted network – local, arterial, and regional streets – how traffic behaves, let alone defining the capacity of a link, is considerably more complicated, see 5.1 through 5.3. Urban roads are impacted by bike lanes, on-street parking, vehicle parking manoeuvres, curb cuts, public transit, public transit stops, turning vehicles, pedestrian crossings, legally/illegally stopped vehicles, and a litany of other factors. Traffic lights, stop signs, and other forced-yield mechanisms, represent the most obvious creators of 'congestion' on local roads. The timing of traffic lights is well known for its ability to facilitate or restrict the continuous movement of vehicles along a route; green waves are particularly helpful for heavy vehicles which require large volumes of energy to accelerate and brake. Local urban roads are specifically difficult to model and assess given the complexity and volume of inter-relating physical, social, economic, and mode-choice factors.

Non-recurrent congestion is associated with stochastic or large events and represents about half of experienced congestion-cost events on roadways in Canada

(FHWA, 2020c; Transport Canada, 2006; UTTF, 2012). The FHWA identifies vehicle incidents, work zones, weather, and special events to represent 25%, 10%, 15%, and 5% of all occurring road congestion, respectively (2020c). Inclement weather, crashes, vehicle incidents, and other network aberrations are well reflected in the literature as contributing to non-recurrent congestion events (Holguín-Veras et al., 2018b). What defines a non-recurrent event also varies by the infrastructure involved. At an urban level, roadway movements by delivery vehicles, garbage trucks, public transit, and other frequently stopping vehicles, can have negative impacts on the network flow; while a stopped vehicle on the side of a highway may have little to no effect on the traffic flow.

While reoccurring congestion can be a painful experience for those involved, non-recurrent events have a tendency to lead to the most severe congestion issues. Vehicle incidents can rapidly reduce road capacity through blocked lanes or vehicles slowing to see what is happening and fatal crashes can lead to road segments being closed for investigations. Weather impacts can be incredibly varied causing minimal slowdowns caused by light rain or snow, near shutdowns can be caused by heavy fogs, snow, or winds, and any changes to the physical condition of the infrastructure can increase the risk of, or precipitate, incidents. Extreme weather events and natural disasters can lead to congestion events through increasing the demand for mobility (e.g., evacuating from an incoming hurricane or forest fire) and/or by reducing infrastructure capacity through failures (e.g., sinkholes, collapses), temporary blockages (e.g., fallen trees/power lines, flooding, icing, avalanches), and other unlikely and/or infrequent events. The difficultly to manage non-recurrent congestion events varies as some events are more likely than others, and some are easier to mitigate – better designed roads are less likely to result in incidents and well-maintained infrastructure is less likely to fail.

6.2.1. Freight and Goods Movement / Delivery

Perceptions of the impact freight vehicles have on traffic flows and overall congestion is often overinflated due to their highly visible nature, the amount of physical space the vehicles require, and their slower acceleration (ECMT, 2007; Rodrigue, 2020; Williams, 2015). However, many commercial movements are made in smaller trucks, vans, and even passenger vehicles, which are significantly less visible (Holguín-Veras et al., 2011; Jaller et al., 2015; Rodrigue, 2020). Heavy truck movements represent about 5% of total traffic on average on a given day, though there will be substantial spatial variations in intensity, Figure 6-1. In the United States, trucks account for 7% of the traffic volumes, but are experiencing about 11% of the congestion (TTI, 2019). The specific intensity of freight trucks in Southern Ontario is highlighted in Figure 6-5, where the heaviest concentration of vehicles is focused around the Greater-Toronto Hamilton Area, and the highest concentration is specifically found in Peel Region – home to Pearson International Airport and multiple intermodal rail terminals. A major issue with the data informing Figure 6-5, is the information is collected through highway intercepts and as a result heavily underrepresents local freight movements – making the tracking of city logistics flows and issues especially difficult. Such local level data is either not collected or not made readily available through open data or academic data portals. The impact of trucks is mostly related to their size and speed: they are intimidating and motorists can be uncomfortable driving in proximity; and, they are slow to accelerate, take a long time to slow down, and are slow to overtake other trucks, in effect creating slow moving, rolling bottlenecks (ECMT, 2007).

Last-mile deliveries, as discussed in 5.1 and 5.2, is an issue of increased traffic volumes as a result of changing consumer demands (i.e., e-commerce, to-the-door, and rapid/next-day delivery). Time-constraints on deliveries, mixed with congestion, necessitate a larger number of vehicles to deliver the same volume of parcels; while missed deliveries and return increase the total number of trips which must be made for a single parcel delivery (Aljohani and Thompson, 2016; Woudsma and Jakubicek, 2019). Outside of contributing to overall traffic volumes, delivery vehicles create localized bottlenecks while stopped, especially in situations where they have illegally stopped, blocked lanes, or in other circumstances which cause either visual distractions or physical blockages to the flow of traffic (Amer and Chow, 2017; Ros-McDonnell et al., 2018a; Visser et al., 2014).

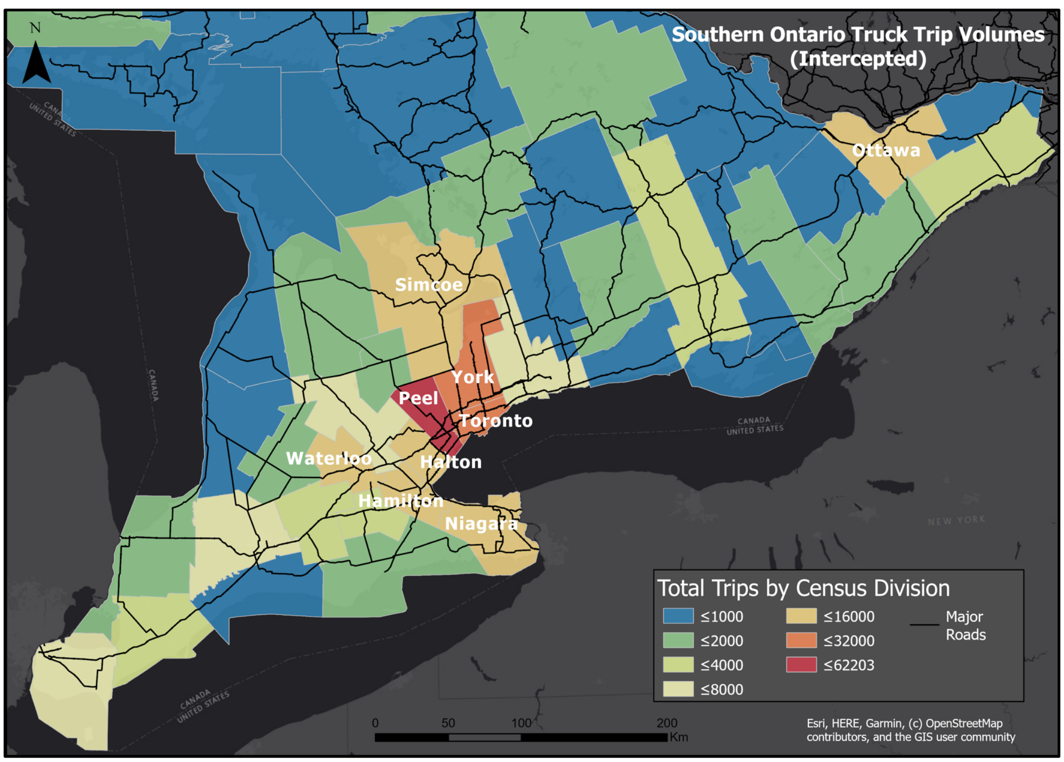

Figure 6-5: Estimated Truck Volumes by Census Division in Southern Ontario. Data estimated from Highway Intercepts - Under estimates local movements. Data Source: (Ontario Ministry of Transportation, 2019b)

6.3. Air, Marine, and Rail Congestion

Ports, railways, and airports all experience congestion problems in various different manifestations as discussed throughout Chapter 3 and 4 (Jacquillat and Odoni, 2018; MITL, 2018a; Nathnail et al., 2016). For these modes it is the opposite of road congestion, in that there is relatively little congestion experienced during travel to a destination, but at the origin and destination delays are often experienced in the loading and unloading of the vessels (Jaller et al., 2015; Kaveshgar and Huynh, 2015; Rodrigue, 2020; Wu, 2008). The congestion experienced at freight terminals is unsurprising given a consideration of numbers; through the massification of freight, Chapter 3.2.1, the volume of goods being loaded on to vessels has increased and the longer and more difficult it becomes to unload those units and transfer them to another mode (Dotoli et al., 2013; Feng et al., 2015; Gharehgozli et al., 2017; Ha et al., 2019; Jiang et al., 2017). For example, Canadian intermodal trains are able to move the equivalent of 280 long-haul truck movements at a time – units which will need to be loaded onto trucks upon arriving at the destination terminal (MITL, 2018a). While rail and marine terminals track truck-times through their gates and are able to lift containers in a relatively fast and efficient process, it is the volume and pairing of trucks that need to come through the terminal which represent the largest bottleneck in rail operations (Feng et al., 2015; Mazouz et al., 2017).

6.4. Impacts of Congestion

While at this point it may feel redundant to discuss as the impacts of congestion have been directly and indirectly examined throughout this text, the fundamental impacts can be broadly interpreted as time-loss and cost. However, there is a great deal of discussion about how to assess congestion, especially as the methodologies employed tend to impact the extent of policy responses (Ellison et al., 2017; Marsden and Snell, 2009; Stathopoulos et al., 2012). The specific measures used to identify and assess congestion are similarly impactful as each measure has built-in assumptions which can be tweaked to reflect different results (MITL, 2018a). Further, a traffic-management focused approach will highlight the physical dimensions of congestion (i.e., infrastructure), whilst more holistic approaches will take into consideration dimensions of land use and social costs (ECMT, 2007). As numerous assessments of the costs or impacts of congestion in Canada have highlighted, building such a holistic assessment is difficult (Canada Transportation Act Review Panel, 2016; Metrolinx, 2008; Transport Canada, 2006; UTTF, 2012).

Beyond what has already been stated throughout the text, it is not the goal of this thesis to produce an assessment of the impacts of congestion borne out of literature. Rather, this work seeks to understand the impacts of freight congestion and identify the barriers to freight mobility from the perspective of stakeholders, which is discussed in Chapter 7.

Chapter 7. Grounded Theory in Investigating the Perceived Barriers to the Movement of Goods in Canada*

Despite this wealth of research, there is still a limited understanding of the complex interactions across supply-chains (McLeod et al., 2019; Mullen and Marsden, 2015; Sakai et al., 2019). A vast majority of the studies in freight congestion utilizes quantitative metrics to model and forecast transportation movements. This approach is well understood and has been applied extensively (Alho & de Abreu e Silva, 2014; Cardenas et al., 2017; Rezaei et al., 2017; Solakivi et al., 2018). However, regional idiosyncrasies (Gatta et al., 2019; Marcucci et al., 2017a; Marcucci and Gatta, 2017, 2016), the role of various modes of transportation, and the multiplicity of stakeholders with diverse and sometimes conflicting views (Kaufmann and Denk, 2011; Mello and Flint, 2009), present challenges to developing an understanding of freight generation and consumption patterns, as has been discussed over the previous five chapters (Cherrett et al., 2012; Dablanc et al., 2013; McLeod et al., 2019; Onstein et al., 2019; Perboli et al., 2018; Sánchez-Díaz, 2017; Woudsma et al., 2016). Consequently, identifying barriers and their solutions is a complicated process, and one that is rarely amenable to the use of isolated quantitative metrics.

In this chapter, a grounded theory ('GT') approach aims to provide a perspective on the perceptions of issues that affect freight mobility by stakeholders across modes in urban regions. GT is recognized as an emerging method in the logistics and supply chain management field (Kaufmann and Denk, 2011; Mello and Flint, 2009; Randall and Mello, 2012), though its uptake remains limited due to its interpretative nature, practical considerations, and the amount of time/money/effort required for the data collection and analysis. As a result, to the extent of our [my] knowledge, this is the first work which employs a rigorous and extensive grounded theory approach to understanding metropolitan freight congestion issues and identifying barriers to the movement of goods in Canada; and, is one of few examples internationally. The focus of this work is on understanding freight barriers that stakeholders experience, as opposed to having stakeholders assess whether existing issues/barriers identified in other jurisdictions are relevant to their context. The emphasis is on generating an emergent theory and identifying themes which at the end of the process will be compared to recognized barriers internationally.

This chapter follows the flow of the submitted research paper, see footnote, and begins with a review of the grounded theory methodology including the interview protocol, data collection, stakeholder identification, coding, and analysis process. The results of the coding are then presented, followed by a discussion.

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* Note: The majority of Chapter 7 is material that has been submitted to a peer-reviewed journal and is reproduced here in either part or full, as noted in the declaration of academic achievement.

7.1. Methodological Approach

Quantitative approaches have a well-deserved place in the repertoire of methodological traditions in transportation and logistics. On the other hand, they are ill-suited to exploratory areas of research where we "*seek the answer to the question 'why'*" (Clifton and Handy, 2001). Qualitative research is now, after years of experience, well regarded in travel behavior research (Clifton and Handy, 2001), but its uptake is still limited in freight transportation (Holguín-Veras et al., 2017b).

The above is beginning to change. Mello and Flint (2009), among others, argue that logistics research can be well served by interpretative methodologies. GT is a powerful inductive method for exploring complex environments and developing statements on how stakeholders interpret reality (Eisenhardt and Graebner, 2007; Glaser and Strauss, 1967; Wagner et al., 2010). The focus of GT is the emergence of theories constructed through a systematic, iterative process of comparing, coding, and analyzing (Corbin and Strauss, 2008; Glaser, 1992; Manuj and Pohlen, 2012). The approach aims at the reconstruction of social patterns and their underlying constitutive structures; in effect developing a theory that is grounded in the experiences of the stakeholders and advances through the interaction and interpretation of the data (Chun Tie et al., 2019; John W. Creswell, 2009; Wagner et al., 2010). A key element of the process is constant comparison and analysis of the data in which categories and attributes can be organized and reorganized in various ways; GT purposely allows for a degree of ambiguity to aid theory generation (Glaser & Strauss, 1967). This process allows for a theory grounded in the experiences of the contributing stakeholders to emerge without a priori frameworks (Bryant et al., 2019; Charmaz, 2014; John W. Creswell, 2009). GT affords investigative phenomenological freedom since the method is not constricted by predetermined concepts (Mello and Flint, 2009; Näslund, 2002).

Previous research has helped to lay the foundations for quality GT-based research in logistics (Halldórsson and Aastrup, 2003; Kaufmann and Denk, 2011). Manuj and Pohlen (2012) outline eight steps to consider. Given the linear nature of a research report, these are presented linearly, even if the research itself is of necessity iterative (p. 791).

The first step in GT research is to ***identify a phenomenon*** in need of explanation, as is the case of the complex interactions between stakeholders in freight movement, and their perspectives with respect to congestion in freight movement. A balanced literature review is a key element for this. Although an effort should be made to minimize biases from influencing data interpretation (Glaser & Strauss, 1967), Manuj and Pohlen (2012) note that the researchers should not begin "devoid of any knowledge" but rather have an understanding of the context (Charmaz, 2014; Goulding, 2005). In the second step, it is important to establish the *appropriateness* of the approach: does the research establish the need for GT over other approaches, and are the features of the approach selected discussed? Selecting the *context for research* is the third step; this involves defining the scope of the field to be investigated. The fourth step is to select the *sources of data*; how were participants selected? Are they knowledgeable and relevant for the scope of the project? Was theoretical saturation achieved? This is followed in the fifth step by the development of an *interview protocol*; does the interview protocol allow the researcher to explore ideas as they emerge? Are questions phrased to avoid introducing bias due to preconceived theories and concepts? *Data collection and coding* constitute the sixth step of the process; does the study describe the methods to collect data? Are the tools used to support the analysis described (e.g., software?). Does the study describe the coding process, including possibly how it evolved? Once data have been collected and coded, the seventh step is to *diagram concepts, integrate memos, and develop theory*.

It is worthwhile to mention at this point that the eighth step, when the research is evaluated, continues through the peer-review stage. In the present case, the author was the main coder, and their work was closely reviewed by their supervisors, who challenged earlier interpretations, how concepts were linked, and the relative relevance of different categories of knowledge, among other things. The research went through several iterations with active participation of multiple researchers until a consensus was reached on the emergent theory. During the peer-review stage, experts not involved in the research provide feedback on the research. Useful criteria to assess the research include the following (Manuj and Pohlen, 2012, Table II): Does the work establish its credibility? Does it provide a theoretical framework? Was member checking, or some other technique, used to confirm that the analysis is consistent with the data? How does the theory increase our understanding of the phenomenon? Does the research establish its relevance and usefulness?

As described by Tie et al. (2019), memos represent analytical notes regarding the theoretical connections between the categories, which is used to support and document the development of codes, categories, and the integration of the final theory. Memoing is used throughout the analysis process in addition to the use of diagramming. The coding and analysis process of this research was supported using NVivo, which allows for extensive memoing and incident descriptions, as well as supporting diagramming tools, whilst being linked to the original transcripts.

Following Lincoln & Guba (1985) and Wagner et al. (2010), five criteria are considered in the evaluation of qualitative research: credibility, transferability, dependability, confirmability, and applicability. First, given the criticism that in traditional survey designs statistical rigor has been expanded at the expense of practical relevance, the search for applicability is a driving factor for qualitative research; it aims to be understandable and useful practitioners and stakeholders (Wagner et al., 2010). This is addressed by providing an understanding of the complex freight environment. Confirmability is addressed through the volume of data collection and multiple researchers completing the coding and coding review process, outlining similar results between researchers. The Strauss/Corbin methodological application provides procedures for coding, resulting in more dependable results than the Glaser/Strauss approach (Wagner et al., 2010). Unless results are dependable, there is no potential validity (Mentzer and Flint, 1997). For the issue of congestion and freight barriers, the applicability of test-retest approaches is limited due to the "problem of time" and the freight environment is inherently subject to substantive changes (Easton, 1995; Halinen and Törnroos, 2005). Dependability is one of the main weaknesses of GT in comparison to purely quantitative techniques (Mentzer and Flint, 1997). In addition to multi-researcher review, the literature review is the last element considered to minimize biases from influencing data interpretation (Glaser & Strauss, 1967). In regard to transferability, the depth of sampling is theoretically sensitive and includes sufficient data to satisfy category development saturation. While temporal and financial restrictions factored into the ability to achieve theoretical saturation, due to theoretical sampling, telephone interviews were carried out after the in-person interviews to satisfy category saturation and refinement. A total of 28 in-depth, expert interviews were ultimately conducted. Lastly, in regard to credibility, the intent is to ascertain a theory that stakeholders understand; the theory should be relevant to the participants as it is grounded in their experience (Wagner et al., 2010)

Identifying Stakeholders

The involvement of stakeholders in assessing and developing policy is important for ensuring successful deployments and positive receptions (Awasthi et al., 2016; Lindholm and Browne, 2013; Macharis and Milan, 2015; Nordtømme et al., 2015). As such, it is critical to identify who the relevant stakeholders are. Lindholm (2014) notes that numerous authors have identified pertinent stakeholders in freight transportation, though there are variations across the literature. Most authors appear to generally agree on authorities, receivers, shippers, and transport operators as the key groupings of freight stakeholders (Ballantyne et al., 2013; Bjørgen et al., 2019; Hans Quak, 2011; Macharis & Milan, 2015; Russo & Comi, 2011; Stathopoulos et al., 2012). Receivers and customers have been considered jointly and independently, as have shippers and receivers (Ballantyne et al., 2013; Bjerkan et al., 2014). While other authors have included indirect stakeholders such as advocacy groups or infrastructure managers (Lebeau et al., 2018). In this study we do not discriminate amongst stakeholders in the emergent theory, though we identified the key stakeholders to be carriers/transport operators, shippers/receivers, authorities/regulators, industry advocates, experts/observers, and infrastructural hubs/freight terminals.

Carriers and transport providers are responsible for the physical movement of the transport operations taking place. By virtue of carrying out the movements, carriers play the critical role in freight transport and are increasingly seen as being a relevant voice to urban policy development (Lindholm, 2014; Marcucci et al., 2015; Vieira et al., 2015). Shippers are the organizations that produce and send goods; often their role is limited to their operating location and the ordering of services from carriers. (Crainic et al., 2018; Lindholm, 2014). Receivers are typically offices, demand oriented consumer-facing firms, e.g., retailers or restaurants, or the end-customer, and are the demanders/ commissioners of freight and receive the goods produced by shippers (Bjerkan et al., 2014; Bjørgen et al., 2019; Crainic et al., 2018; Stathopoulos et al., 2012). Regulators are the governmental authorities responsible for the overall policy environment, including laws and enforcement, and the provision of public infrastructure.

Regulators set the policies, incentives, and taxes than may be beneficial or prohibitive towards freight operations within and beyond their jurisdictional authority. Regulators also manage the externalities associated with industrial outputs (Visser & Hassall, 2010). Industry advocates are the associations that represent different special interests and lobby government for policy changes. Experts and Observers are individuals or organizations which study, report, or otherwise assess the performance and operational environment of freight movements and are either affiliated with public institutions (e.g., universities, colleges, thinktanks, etc.), or private consultancy firms. Infrastructural hubs/freight termainls are private or semi-private organizations with public and private stakeholders overseeing management and operation. These entities provide and maintain key pieces of major infrastructure including ports, airports, bridges, et cetera (Crainic et al., 2018). In this research, though stakeholder groups are identified, the focus is to develop a generalized theory and not to develop specific theories to each categorization.

Interview Protocol and Data Collection

Data for the project were collected through semi-structured in-depth interviews. To ensure a diverse range of perspectives, organizations of various sizes and industry segments were invited to participate, including the following stakeholders: carriers/transport operators, shippers/receivers, and authorities/regulators, industry advocates, experts/observers, and infrastructural hubs / freight terminals (Ballantyne et al., 2013; Bjerkan et al., 2014; Bjørgen et al., 2019a; Lebeau et al., 2018; Macharis and Milan, 2015; Quak, 2011; Russo and Comi, 2011; Stathopoulos et al., 2012). A stratified participant selection process was used that started with the development of a long list of candidates for interviewing. Recruitment was based on email and/or telephone contact. Purposive sampling led to a group of participants that included directors, managers, owners, consultants, and other executives in their respective organizations, who could speak authoritatively about issues of freight congestion (see Table 7-1). Each participant individually represented their organization, except for respondents from regulatory agencies who represented either the agency or a working group. Prior to the interview, a detailed information package was sent to participants that included consent forms, inquiry statements, and a subject information sheet. Interviews lasted 75 minutes, were digitally recorded (audio), and transcribed for coding and analysis. A total of 28 stakeholders participated, and interviews were conducted in Spring/Summer 2017. The variations in group size do not impact the category development process.

The interview guide consisted of 14 open-ended inquiry statements organized into six groups (available in Appendix A). The first group of three statements pertained to the impact of congestion, generally and road-specific, and the geographic nature of goods movement bottlenecks. The second group of four statements related to operational management, in particular data collection and measurement processes. The third group of two statements focused on the causes of congestion. The fourth group of two statements concentrated on future impacts of congestion by stakeholder and/or their geographic region. The fifth group of two statements pertained to transportation policies at various levels and whether policies should focus on supply or demand management. The final theme concluded with an open discussion of any topics the participant felt were important to discuss. As interviews progressed, follow up questions were employed to increase the depth of understanding.

It is worthwhile to note, as a result of using the GT approach, respondents were never directly asked what they identified as barriers, yet barriers emerged organically as the focus of their concerns throughout the interviews.

Coding and Analysis

The analysis followed the approach advocated by Glaser and Strauss (1967) and followed the evolved procedural coding methods outlined by Strauss and Corbin (1998). Overall, the process is a reflexive interaction between coding and comparative analysis and inductive theory emergence (Patton, 2002; Wagner et al., 2010). The coding process began after the first interview with 'open-coding,' wherein the data was fragmented and each pertinent line of the transcript received a representative and unique code (Strauss and Corbin, 1990). Open coding generated 2,650 codes, which are refined by significance, frequency, or similarity. This resulted in categories and sub-categories through the specification of attributes/themes (Charmaz, 2014). Categories were then integrated through axial codes, a method to restore the relationships between independent categories (Bryant et al., 2019; Charmaz, 2014; John W. Creswell, 2009; Strauss & Corbin, 1990). As more interviews were completed, the coding process was repeated, and codes were constantly compared and contrasted, resulting in new interpretations, categories, or otherwise aiding to saturate existing categories (Chun Tie et al., 2019). Coding concluded with the linking of developed categories in theoretical codification which outlined the emergent theory. This process of selective coding connected the categories and produced a set of theoretical propositions (Randall and Mello, 2012). Theoretical coding integrated and synthesized the derived categories and relationships to form a theory emergent from the data; an integrated framework which aims to explain the phenomena (Chun Tie et al., 2019; Mello and Flint, 2009).

The analysis of this research was supported using NVivo, which allows for extensive memo-ing and descriptions whilst being linked to the original transcripts.

Table 7-1: Participants by Stakeholder Classification, Region, and Mode(s)

Stakeholder Classification	Industry Advocates	Carriers / Transport Operators	Infrastructural Hubs	Experts / Observers	Authorities / Regulators	Shippers / Receivers
Number of Respondents	4	7	4	4	7	2
Primary Modes Represented	Multi-Modal & Road	Air, Rail, & Road	Air & Marine	Air, Marine, & Road	Air, Multi-Modal, Rail, & Road	Multi-Modal & Road
Primary Provinces Represented	B.C., Ontario, Quebec	B.C., Ontario, Quebec	B.C., Ontario	Ontario	B.C., Federal, Ontario	Ontario

7.2. Results

Through the interviews, participants raised an extensive range of themes that caused issue, hindered, or otherwise impacted their organization and/or mode/focus of operation. These themes are broadly represented by four emergent categories, which focus on infrastructure demand, impediments to physical distribution, planning and regulatory barriers, and issues relating to information and data, as listed in Table 7-2.

Within the four categories are nine subcategories providing a grouped structure for the 50 themes that emerged from the coding process. The ordering of these themes and categories does not implicate an order of importance. It is relevant to note that the analysis results in a generalized theory across all stakeholders; future analysis could focus on comparing perceptions by mode to the generalized theory.

The following subsections aim to very briefly describe and add context to each of the categories and subcategories, as well as providing select, anonymized participant quotes to highlight some of the categorical themes. Appendix B presents a long form version of the results which includes a substantial volume of interview quotes.

7.2.1. Infrastructure Demand Outstripping Supply

There is a clear and definite perception of congestion across Canadian. The major population centres represent the worst areas, but peripherical and rural areas are noted for different types of capacity-related issues as well. While the focus is dominantly placed on the roadways – by virtue of the scale and scope of road-based congestion compared to issues experienced by other modes – there is a great deal of concern about the capacity and quality of the infrastructure networks, roads and otherwise, to handle the growth being precipitated by e-commerce and other pressures.

> *"I think it's the demand of freight, whether its goods movement by air, by ground, by ocean, whatever mode, it's moving by ground at some point, and I think the growth in industry, infrastructure hasn't kept up with the growth." – Carrier / Transport Operator*

> *"It seems as though we've driven significant new activity through infrastructure that just hasn't changed a great deal over the years, and you need to do nothing other than just looking at the condition of some of those routes to see that it's been left for a long, long time." – Carrier / Transport Operator*

<u>*High Network Demand*</u>

Freight vehicles are recognized as being highly visible contributors to road congestion as a result of their operational characteristics. While postal and e-commerce delivery vehicles are also recognized for the pressure they are adding to the road networks, there is a strong recognition that freight vehicles are not the primary drivers of road congestion, but rather single-occupant passenger vehicles are the dominant road users and contributors to peak congestion periods.

> *"Traffic congestion is getting worse. Goods movement might be one of the contributors, but we feel that the biggest contributor to traffic congestion is single occupant vehicles. Freight is not a big contributor as far as road congestion is concerned." – Authority / Regulator*

<u>*Low Capacity*</u>

Though there is strong enthusiasm for expanding and building new road infrastructures to accommodate growing populations and easing capacity constraints, there is concern of further inducing demand onto the roadways. While expansions are viewed as necessary especially dedicated highway accesses to ports, terminals, and distribution facilities, there is an emphasis on improving the physical quality of infrastructure, especially in Quebec, and to optimize roadway efficiency through various measures, as well as altering the physical design of intersections heavily trafficked by large freight vehicles, and other road designs.

> *"One of the biggest barriers to congestion is the design of the roads. The roads work fine as long as they work in a straight line. When you go from 3 lanes to 2 lanes to 4 lanes …it is not ideal." – Infrastructural Hub*

> *"It's the economic growth in the area, the population growth in the area, and I think planning really lags economic growth, and we're 10 years behind on our road networks and infrastructure. I think the other thing is the underinvesting in passenger train services, intercity passenger train services or bus services, and really having an efficient passenger movement network in the country." – Carrier / Transport Operator*

There is begrudging recognition that capacity expansions alone are likely to redress congestion issues and future solutions may need to consider demand management techniques in heavily congested regions to rationalize road demand. Though, tolls are perceived as disproportionately penalizing commercial movements, given limited feasible alternatives to the last mile. While there is a strong resistance to tolling in general, tolls on new roads are more palatable than on existing capacity. Transit investments meanwhile are viewed as a key tool in improving capacity, as any reduction in SOVs helps to mitigate the impacts of continuous population and vehicle-use growth.

> *"People can take transit; there's no real transit for commercial movements. And so, any shift that you can get to have the population is a big boon because it clears up some of that capacity for goods movement; where there's not a lot of choices." – Expert / Observer*

> *"From a business standpoint, if there is a solution to congestion that adds to our costs, you'd be reluctant to say, "yeah that's a good idea." But, particularly in Ontario, I don't think there's any other way to lessen the congestion." – Carrier / Transport Operator*

7.2.2. Physical Distribution Headwinds Impeding Commerce

The efficient movement of goods is recognized as being directly impacted by the added costs of, and efficiency hinderances encountered while, operating in congested road environments.

> *"It really is about reliability, especially when you get into just-in-time delivery. I want to know it's going to take that amount of time to deliver. If I can't count on that, then potentially my plant shuts down and it's costing me $20k every half hour." – Expert / Observer*

High Congestion Costs and Impacts on Fluidity

The impacts of chronic road congestion are recognized as higher operating costs for carriers and shippers, as delays are significantly reducing the efficiency of drivers. There is recognition that firms are responding with surcharges for certain regions, routes, and times. While lengthened travel times are problematic, it is the increasing unreliability of on-time delivery performance that is perceived as impacting asset utility the most, especially as it is difficult to plan for.

> *"When you get into metropolitan areas like the greater Toronto or greater Montreal GMA, GTA, or greater Vancouver, the time it takes to get to your final destination and the variability of that delivery is getting worse and worse." – Shipper / Receiver*

> *"The challenges of road traffic require us to have more trucks. We have to have more drivers because we're spending more time in delays than moving efficiently. It creates issues around product quality in sensitive items. It means greater carbon emissions because of course we're idling more, and no matter what we do we're going to idle more." – Carrier / Transport Operator*

> *"When you get a rate to deliver to the GTA, you're going to pay more than if you were going elsewhere. Same miles but it takes them longer. It impacts our bottom line as well as the carriers' ability to turn the asset and make money." – Shipper / Receiver*

Table 7-2: Conceptual Ordering of Grounded Theory Coding Process

Categories	Subcategories	Properties / Themes
Infrastructure Demand Outstripping Supply		
	High Network Demand	All Movements Contributing to Congestion E-Commerce Adding Pressure to the Logistics Networks Experiencing Congestion Issues Outside and Within Urban Areas Passenger / Single-Occupant Vehicles are Dominating Roadways
	Low Capacity	Expanded Infrastructure Inducing Demand Needing Investments to Address Capacity Issues Needing to Optimize Efficiency of Existing Infrastructure Infrastructure Quality Impacting Load Performance Road and Intersection Designs Inhibiting Vehicle Flow Efficiency Lacking Sufficient Transit Investments to Benefit Freight Needing to Assess the Role of Tolling & Demand Management to Affect Usage
Physical Distribution Headwinds Impeding Commerce		
	High Congestion Costs	Experiencing Chronic Congestion Congestion Negatively Impacting Asset Utilization and Load Utility Firms are Implementing Surcharges to Offset Congestion Delay Costs Lacking Modal Alternatives for Last-Miles
	High Impacts on Fluidity	Impacts Varying by Commodity and Supply-Chain Complexity Negatively Impacting Ability to Deliver Goods On-Time Decreasing Travel Time and Reliability Performance Road Congestion Negatively Impacting all Stakeholders and Supply-Chains Increasingly Difficult to Plan for Impacts Needing to Minimize Impacts of Non-Cyclical Congestion Events Modal Transfers are Major Bottlenecking Events Road Congestion Negatively Impacting Intermodal Efficiency
Urgent Regulatory Encumbrances		
	High Growth & Reflexivity	Congestion is a Result of Economic Prosperity (Growth Spurs Congestion) Poor Freight Mobility is Detrimental to the Economy Ease of Transportation is Major Consideration of Investment Analyses Congestion Impacting Government Investment Decisions Land Unaffordability is Inciting Logistics Sprawl
	Low / Freight Insensitive Land Use Planning	Conflicts between Land Uses Creating Issues NIMBY-ism Is Negatively Impacting Freight Planning Passenger Movements are Prioritized Over Freight Movements Need Harmonized Land Use and Transportation Policies Lack of Short-Term Commercial Parking (Complete Streets)
	High Need for Collaborative Policy Development	Needing to Enable Future Technologies Needing to Support Multi-Modal Movements Needing to Enable Off-Peak Deliveries Policies Increasing the Difficulty for Industry to Respond to Congestion Discontinuous Government Policies Impacting Operational Performance Requiring Regionally Unique Policy Approaches Lacking Industry Representation in Policy Development
Information & Data Management Complexities		
	Enhanced Data Collection	Needing Defined and Consistent Data Collection Methods Data Cost Inhibiting Collection and Analysis Conflicting Views of Data Relevancy Between Industry and Government Needing Real-Time Utilization of Roads, Highways, Parking, V:C Ratios Needing Detailed Origin-Destination Commodity Flow Data Supply-Chain Fluidity Analysis Benefiting Firm Modality
	Low / Lacking Information Management	Needing Measures to Support Operational Decision Making Needing Better Communication of Government Measurement Efforts Lacking Data Sharing Between and Within Government and Industry Needing Government Operated / Funded Road Measurement Programs

The cumulative impacts of travel-time variability manifest negatively across all supply-chains which interact with the road network, though those impacts are considered to vary by commodity and the degree of integration – especially those dependent upon cross-border movements. Inter-modal facilities – predominantly ports and inland rail terminals – are recognized as some of the most impactful areas to service due to the volumes of traffic generated, and the recursive impacts of missed queue times, delayed vehicles, and other factors negatively impacting reliability.

> *"One of the key bottlenecks within the multi-modal supply chain is the hand-off… There's lots of interdependency in terms of… sharing information, which is one of them, but it's having your capacity properly aligned… to move the goods through smoothly, that's the interdependency." – Authority / Regulator*

> *"We participate in fast lanes and all those things that allow us to keep product flow from being impeded. When there are innovations, we're going to take advantage of it because we don't want to be stuck sitting at a border, waiting 7-8-9-10 hours" – Shipper / Receiver*

7.2.3. Urgent Regulatory Encumbrances

Congested regions are prosperous regions, though excessive congestion is, expectedly, perceived as being detrimental. As land uses come into competition through residential and logistics sprawl, there is a clear concern of freight activities being deprioritised and ill-considered across political interests. There is enthusiasm for industry to been actively involved in the development of balanced policy approaches to mitigation strategies and economic development.

> *"Governments are only in for short terms, nobody is thinking for a 10-15-year horizon necessarily, and a goods movement strategy needs to look at the year now, but also 10-15 years out." – Shipper / Receiver*

<u>High Growth and Reflexive Operations</u>

While prosperous regions are beneficial to firms, with plentiful market and labor accessibility, ease of transportation is a major consideration of where firms choose to operate. Poorly accessible or prohibitively expensive land is recognized as pushing logistics facilities further away from markets – generating more and lengthier vehicle trips. Poor attractiveness impacts regions' ability to maintain industry and may harm local economies; some governments are recognized as actively working with industry to maintain local investment. There is recognition that until it is politically expedient to invest in congestion reduction solutions, governments are limited in the interventions they are able to implement.

> *"The reality is, as density increases, it's also not just going to increase the people movement but it's going to increase goods movement because all of those people need goods, so it just exacerbates itself." – Shipper / Receiver*

> *"Logistics Sprawl is happening very quickly in [Toronto] relative to other cities. Distribution centers are getting larger and they need to move to where land is available. With that movement, they're experiencing increased travel distances and times." – Expert / Observer*

> *"Transportation is probably # 1 or # 2 in terms of an investment decision by a company, they should look at the tax environment first, and then what's the transportation system like to get our goods to market? It's hugely important." – Carrier / Transport Operator*

<u>Freight Insensitive Land Use Planning</u>

Firms are attempting to navigate a political environment in which land use policies and urban-planning theories are perceived to be stacked in favor of passenger flows and residential uses with little consideration, or outright condemnation, of commercial or industrial employment lands and transportation. There is a strongly perceived lack of political weight given to the role of freight, especially as conflicts between physical freight facilities are perceived to be intensifying.

> *"And not only politicians, people involved with planning and development. Some have no idea why we need trucks, why we think about supply chains, or why we need the railways to the ports. It's the core of the economy, but they're not aware of that." - Industry Advocate*

> *"It's when we have to educate people in planning, people on circulation, people on urban side saying: yes, it is good for pedestrian, for bicycle, we have to share the road, but think for goods; a city without trucks to deliver goods will be a nightmare." – Industry Advocate*

> *"If you got it, chances are it came from a truck, and the only thing not delivered on a truck is a baby. As we move towards urbanization and as governments are encouraging density, it's only going to get worse; it's not going to get better." – Shipper / Receiver*

Industrial facilities are recognized as challenging to be planned for but there is a strong need for them to be integrated in to harmonized land use and transportation plans, with formal separations and setbacks for facilities and corridors from residential and sensitive land uses. Last miles of deliveries are challenging as a result of insufficient loading or parking space, and though there is a recognition of the emergence of complete street paradigms, it is perceived that freight considerations have been excluded from the discussion at the planning level.

> *"We have to find a way to work with the private and public sector together to reach some common objective to ensure that we support our freight industry and we improve the capacity and competitiveness of our sector." – Industry Advocate*

<u>*High Need for Collaborative Policy Development and Interventions*</u>

There is a need for industry and stakeholders to collaboratively develop policies to address both current and future issues relating to congestion, temporal and modal shifts, and implementing future technologies. There is a clear perception that industry wishes to be a part of policy development, especially as regulations can increase operational complexity, but are not being represented in those discussions. While it is well recognized that individual administrative regions have a need to implement policies tailored to their political and built environment, variable freight policies between abutting jurisdictions are considered challenging to manage and work with.

> *"There is a disconnect for the drive and the desire to have goods movement to happen in off-peak hours and to allow for flow of people, but then regulatory script doesn't allow that in many areas." – Carrier / Transport Operator*

> *"I think the challenge with government is the coordination between levels. Each level on its own,* they're *great to deal with, but then when you try to thread through all of them, they may not all have the same interests and objectives in mind." – Shipper / Receiver*

There was a recognition of the rapidly evolving technological environment in which autonomous vehicles, advanced ITS/R-ITS, and real-time logistics management will be the new normal – governments are perceived as the key to enabling and encouraging the Canadian development of these future technologies.

> *"For government, it is important to work on the frame to support the technological shift in the freight industry and to be prepared for what will happen. It's not when* autonomous *vehicles will be on the road, it's right now. What we see coming with AV's and all the ideas about AI, it is really important that the governments have a frame about what we want to do on our networks." – Industry Advocate*

7.2.4. Information & Data Management Complexities

Data collection, analysis, and information sharing are recognized as being of use for, and by, industry and government. Better information is well-regarded as a means to improve decision making structures, to expand the understanding of where investments are needed, if and where modal shifts could be accommodated, and improving the fluidity of local and global supply chains. The cost of data collection, as well as privacy concerns regarding sensitive industry data, are recognized as dominant barriers to a freight-specific data and information apparatus in Canada.

> *"What is difficult is sharing the information between government and industry, and I think that's one of the issues and where we have to work because of the changes with technology. It's not easy to see in five years, but at the same time it's going fast" – Industry Advocate*

Enhanced Data Collection

While there is enthusiasm for increasing the scale and scope of data collection at all government levels, there is a recognized need for a standardized data methodology to be adopted. Incumbent is the need to define what is relevant for governments to fund the collection of and whether that data is of use, or should be of use, to industry-partners. While most firms felt they generally had the information they needed to operate, though find government data of interest, governments and advocates are seeking for expanded data collection and inter-organizational sharing frameworks. The primary barrier to high-specificity data collection is, unsurprisingly, considered to be cost.

> *"Would like a commodity flow survey across Canada, so that we have a better sense of what goods are going from where to where. We have the CVS, but it's focused on long haul. What we're missing is the movement of goods within urban areas." – Expert / Observer*

> *"We measure each segment, the marine portion, the dwell time at the port terminal, and the rail, or truck transit time to the destination. [We're] trying to understand how the various [modes] are performing individually as well as collectively." - Authority / Regulator*

Low / Lacking Information Management

There is a perceived need for governments to improve their sharing frameworks with the private sector – data needs to be shared, or at least communicated, with organizations who can operationalize the information. Similarly, there is a perceived need for industry to improve its willingness to share data with government. Improved knowledge sharing between industry and government may lead to the deployment of well-conceived policy and lead to well-informed infrastructure investment decisions. Specifically, governments should be using data-based indicators and performance metrics to trigger policy interventions and prioritizations.

> *"For government, what is really important is real time information. Capacity of infrastructure is not well documented and the use of the road at the municipal level. If we want more efficient planning, the government has to have this kind information." – Industry Advocate*

> *"Measures are great; then becomes what comes out of the measure? Is there something actionable that can help address the measure? It's one thing to say, this road is blocked, that's helpful, but what do you do to solve this? That's what's key" – Shipper / Receiver*

7.3. Discussion

The results highlight the interconnected nature of the multi-modal supply chains we rely on across Canada, and the complex dependencies of these systems of which are impacted by a variety operational, political, and regulatory constraints.

A total of 50 themes, which can be read as a list of barriers to or considerations of effective goods movement, emerged from the analysis across nine subcategories and four categories. These categories broadly frame the issues of goods movements as relating to high infrastructure utilization (*Infrastructure Demand Outstripping Supply*), the cost impacts of diminishing reliability of distribution (*Physical Distribution Headwinds Impeding Commerce*), rapidly growing regions and ineffective or absent policy support (*Urgent Regulatory Encumbrances*), and a lack of a robust data collection, analysis, and information sharing framework (*Information and Data Management Complexities*).

These results broadly represent a generalized theory across the considered modes and stakeholders of what the perceived barriers are to the movements of goods in Canada. This theory contributes to the Canadian urban understanding and literature on goods movements and congestion across the four major categories; its generalisability at the international scale is discussed later on in this section.

Despite the well documented challenges faced by port and terminal facilities (Calatayud et al., 2017; Crainic et al., 2018), the emergent focus of the theory is unambiguously framed around road movements and road traffic congestion. Road congestion is perceived to be increasing operating costs, increasing the volume of vehicle assets required to complete workloads, and diminishing the reliability of travel times, forcing the deployment of large delivery-time windows, further decreasing asset utilization efficiencies and increasing operational costs. Within the intermodal context, the focus remains on roadways as traffic congestion is recognized as inhibiting the accessibility of terminal facilities and while issues of yard optimization and retrieval systems are emergent, the challenge remains at the handoff between modes – specifically onto the roads.

It is recognized that economic and population growth is pushing the capacity limits of existing infrastructure to the brink (INRIX, 2020; Sweet et al., 2015), but there is strong resistance to the implementation of system-wide travel demand management policies; despite the recognition that tolls may be the only feasible approach to reduce roadway movements and encourage a passenger modal shift. Though, it is perceived that a shift is only possible if there are sufficient public transit capacity and accessibility to make transit a temporally and economically pragmatic choice for commuters. Capacity improvements, specifically focusing on roadway expansions and to a lesser extent rail main lines through/into urban regions, is a recognized need. Despite advocacy for expanding or otherwise optimizing the road network, as it is perceived as a possibility to mitigate some congestion (Jakubicek and Woudsma, 2011c; McKinnon, 2016; Sakai et al., 2019), there is concern it will likely induce demand, negating any appreciable improvements. Regardless, there is a perceptible need for capacity improvements, optimizations, and management along the most congested and/or utilized routes. Regarding optimization, roadways need to be designed in consideration of freight vehicles, operations, and demand flows; intersection designs, loading zones, and improving direct highway accessibility of intermodal terminals are perceived as key considerations for improvement (Fancello et al., 2017; Holguín-Veras et al., 2018b; Mrazovic et al., 2017; Nourinejad and Roorda, 2017; Pinto et al., 2019; Wood and Regehr, 2017).

Localized interactions between freight/industrial and residential/sensitive land uses is perceived as a burgeoning issue as regional growth is pushing residential sprawl and gentrification towards industrial areas which used to either be distant, or at least relatively secluded. Logistics facilities generate large volumes of noise and traffic and are not amenable to residential land uses (Dablanc et al., 2013; Waheed et al., 2018; Williams, 2015). Yet, developments are encroaching ever closer to freight facilities, lands, and corridors and are perceived as being given political precedence in planning decisions, despite the historical situation and employment/tax advantages of these facilities. The phrase "*trucks don't vote*" is a common refrain reflecting the lack of perceived political immediacy given to freight, highlighting the lack of collaborative industry-stakeholder policy development and the recognition of policies that are actively restricting the industry's ability to respond to congestion and implement innovative technologies or approaches. While the difficulties of trying to balance economic-social priorities in urban cores are recognized as politically and regulatorily challenging, there is strong enthusiasm to actively involve and integrate freight processes, interactions, and facilities into transportation and land use planning paradigms, to consider and manage the needs of logistics activities, vis-à-vis curbside management, corridor setbacks, truck routes, intersection geometry, terminal access, and off-peak movements (Alho and de Abreu e Silva, 2014; Aljohani and Thompson, 2016; Ballantyne and Lindholm, 2014; Cardenas et al., 2017; Marcucci et al., 2015; Nourinejad and Roorda, 2017; Pronello et al., 2017; Sarhadi et al., 2017).

Technology is driving an immense growth in information systems, and data-based operational and managerial decision making, supporting enhanced and more efficient goods movement (Ivanov et al., 2019; Tang and Veelenturf, 2019; Winkelhaus and Grosse, 2019). As industry is attempting to utilize technological approaches to improve performance and mitigate congestion impacts, there is a strong perception that governments should be, and are, assisting in enabling the regulatory environment for those technologies to succeed (Ardito et al., 2019; Boysen et al., 2018; Flamini et al., 2018; Ivanov et al., 2019; Mathauer and Hofmann, 2019; Oliveira et al., 2017).

The role of technology is increasingly relevant to governments whom need to understand and develop policies to balance innovations with social costs (Crainic et al., 2015; Kusumakar et al., 2018; Taniguchi et al., 2016). Given the plethora of automated and intelligent solutions available, governments should be the largest utilizers of advanced technologies to collect and compile data that is operationally useful, but expensive/impractical for private organizations to collect (Gatta and Marcucci, 2016b; Pani and Sahu, 2019; Rathore et al., 2018; Taniguchi et al., 2016). There is a strong recognition for the need of government to expand and improve data collection and analysis efforts to support policymaking and industry. There is a recognized lack of access to industry-level data, as well as a lack of municipal /provincial data collection efforts. Lacking knowledge-based policy actions, there is concern that investments, especially in transit and road infrastructure, are overly influenced by political considerations rather than strategic business-case assessments. There is enthusiasm for collaborative collection, analysis, and shared knowledge-outputs for the mutual benefit of all stakeholders, industry and government.

7.3.1. Implications and Propositions

Overall, the process for addressing barriers to goods movement could be argued as being based around *cost*, *political risk*, *implement-ability*, and *maintainability*. These considerations are linked to the four categories and 50 themes that emerged from the analysis and guide the response and decision-making processes in regard to addressing the barriers to goods movement (Table 3).

The *cost* of building, maintaining, or otherwise altering physical infrastructure – roads, terminals, etcetera – is well-known to be expensive, especially in urban regions, as well as the cost of implementing and maintaining policies, and data collection and analysis structures (Judyta, 2016; MITL, 2018a; Olio et al., 2017). *Political risk*, or political difficulty, is also a well-known issue with lawmakers having difficulty supporting or taking concrete actions which may be perceived negatively by their constituents or oppose efforts which do not *directly* benefit their specific administrative region (Lindholm and Behrends, 2012; Mullen and Marsden, 2015; Nordtømme et al., 2015; Tadić et al., 2018). *Implementation* of policies and actions, or more specifically the barriers to implementation, is another well-understood issue across the urban logistics and urban planning literature (Lebeau et al., 2018; Nordtømme et al., 2015; Rubini and Lucia, 2018). Maintainability, or the ability to ensure the continuity of an action or policy to ensure its effectiveness, is also a recognized consideration (Cherrett et al., 2012; MITL, 2018a). These considerations are discussed in relation to the four emergent categories in Table 7-3.

The findings offer an opportunity to guide improvement efforts in a structured manner that is grounded in the experiences of stakeholders. A comprehensive framework was developed to provide that guide and identifies four major intervening stages, referred to as theoretical propositions, Figure 7-1, which integrates the perspectives of carriers/transport providers, shippers/receivers, infrastructural hubs, experts/observers, industry advocates, and regulators/authorities. The propositions are, in no particular order: *Data and Knowledge Mobilization*; *Public-Private Collaborative Freight Evaluations*; *Government Funding and Political Support*; and, *Capacity Alterations: Improvements and Expansions*. The integrated theoretical framework is produced by integrating the four emergent categories, the 50 themes, and the proposed interventions, reflecting the relationships and expected influences of the interventions to the identified barriers (Chun Tie et al., 2019; Mello and Flint, 2009). The framework is structured by four interactive and interdependent stages which collectively address all of the emergent themes from the analysis results.

Table 7-3: Theoretical Matrix of Factors Influencing Canadian Movement of Goods

	Infrastructure Demand Outstripping Supply	**Physical Distribution Headwinds Impeding Commerce**	**Urgent Regulatory Encumbrances**	**Information & Data Management Complexities**
Cost	Extreme high cost to build, expand, or alter infrastructure in urban regions	Incurring high costs to manage and mitigate operational and flow performance	Variable implementation; high derision of policies which increase costs to stakeholders	Data collection and analysis programs are expensive to operate and maintain
Political Risk	Little political appetite to build/fund highways, railroads, and public transit	Freight is an economic necessity but is not viewed as a primary concern by voters	Need to balance the social demands and concerns of constituents with the demands of the industry	Funding data research for the industry may be negatively perceived by citizens; social issues are a priority
Implement -ability	Construction works are extremely disruptive to traffic flows; worsens issues before improving	Willingness to implement novel approaches to goods mobility; business case approach	Blind and ill-conceived policies are detrimental to operations and status; need collaborative discussions	Definition of collection framework, methodology, storage, confidentially, and physical recorders/trackers
Maintain-ability	Infrastructure needs to be maintained to a high degree to ensure the level of service and load factors	Capital is freely mobile; industry will relocate to amenable regions if unable to sustainably operate	Need to review policy actions to determine if achieving the desired outcome; if not revise.	Long-term commitment required to ensure validity and consistency of measurement outputs

Data & Knowledge Mobilization

With the identified barriers being focused on roadways, land uses, and local-regional level policy development, there is a clear impetus for provincial and municipal governments to be the leaders in road-based data collection. Intergovernmental data groups and/or frameworks need to improve in order to increase the availability of in-house government data, to reduce analysis duplication, and to improve the communication of collected/available data with other government groups and industry-partners. A nationally adopted data dictionary and collection methodology is required to improve the interoperability of government data, which industry may or may not adopt. The collection and sharing of commercially sensitive data should either be encouraged through trusted government partners, or through the creation of third-party organizations. There is a clear need to reduce the cost of collecting and analyzing data and shift the focus to operationalize information to support government investment and policy decisions, as well as industry operations.

Public-Private Collaborative Freight Evaluations

Land use, transportation, and economic planning issue figure highly throughout the emergent barriers. There is a need to improve the education of municipal planners, politicians, and the public of the economic and commercial requirements, and necessity, of freight/industrial facilities within and surrounding urban areas. Government policy analyses need to consider and account for the needs of freight operations – transportation, accessibility, land use separations – within, and between, their administrative boundaries in urban planning strategies and regulations. Industry stakeholders need to be given the ability to provide active input into policy and regulation development – rather than passively responding to it – in order to promote collaborative, good-faith assessments to find meaningful compromises and balanced solutions to the needs of industry and residential/sensitive land uses. Developing balanced strategies to address transportation and land use issues is a challenging undertaking through extensive communication and consultation, especially considering the perceived disdain towards freight movements, but is the best approach.

Government Funding & Political Support

Frameworks and policy actions to address the barriers of goods movement need to be politically and financially supported at the municipal, regional, provincial, and federal levels. Without political support for projects or policies funding ceases, strategies change, data collection halts, and action plans are abandoned – dedicated administrative resources, including personnel, is necessary to ensure the continuity of freight frameworks and policy interventions. Government support is essential to enabling data collection, policy collaborations, and expanding infrastructure. Federally funded and provincially led data collection frameworks are perceived as being ideal.

Capacity Alterations: Improvements & Expansions

Unavoidably, there is a need to expand road, mainline rail, and port/terminal infrastructure capacity. While these expansions can be indicator-based or reliant upon reaching pre-determined levels of daily traffic, average daily reductions in travel speeds, or transit ridership, there are areas that will benefit from road/lane expansions. Governments need to utilize measurement programs to empirically identify the most problematic routes/areas for cyclical and non-recurrent congestion issues and implement expansions or redesigns to mitigate impacts. Direct highway access to intermodal facilities needs to be improved. The implementation of tolling is unpopular but may be a meaningful opportunity to rationalize roadway demand, especially if only used to fund new publicly owned roads. Where capacity cannot be expanded, other policies will need to be explored.

Overall, the key concepts of the proposed framework are to collect and analyze data to inform public-private stakeholder evaluations of policy interventions, with government funding to support both knowledge generation efforts, policy actions and capacity investments. Although this framework accounts for the emergent themes from the analysis, it is important to recognize that additional factors may inform the perception of barriers to goods movement in Canada and due to the temporal nature of population, economic activity, and policy, perceptions and factors are bound to shift over time. Further research should include validating the theory against stakeholder categories, determining if and where deviations from the model exist when evaluated at a non-generalized level.

7.3.2. The Literature & International Comparisons – Is the Canadian Situation Unique?

While a distinctly Canadian perspective has been sought and presented in this research, it is relevant to consider if the barriers and emergent theory identified are relevant/similar to generally recognized findings in other major regions. A brief analysis considers four major government supported reports – two from the European Union, one from Victoria, Australia, and one from the United States – as well as a major two-part journal article, which completed an international scan of urban freight management issues. The major conclusions/findings and key considerations of these literature are report in Table 7-4. The selected literature are viewed as in-depth major works and are considered as being broadly representative of their region's major barriers. As emerged from this original research, there is a dominant focus on roads in the selected literature. Further, Table 7-5 aims to provide a direct comparison between the emergent results from the grounded theory analysis and a summated reading of the barriers and/or issues to be addressed from the literature.

Through the simple comparative analysis between the emergent themes and categories, a great deal of similarity is realized with the selected literature. Across regions there is a consistent focus on the expansion of physical road capacity, the optimisation of road designs, the expansion of public transit, and the need to consider travel demand management systems, especially as enabled through ICT/ITS, to manage and mitigate the impacts of congestion. Similarly, high volumes of traffic are recognized as negatively impacting the effectiveness of movements and there is a need to specifically address highly congested routes/bottlenecks, as well as consider modal or temporal shifts through freight demand management. Issues relating to the high cost congestion is imparting on movements and the unreliability of travel times also arises across the review. The neglect, or lack of consideration, of freight logistics activities in urban land use and transportation planning is an issue specifically highlighted in the European context, though less prominent in the American and international-scan contexts. Land use issues are more generally recognized across the regions as needing to be addressed in some fashion, including parking/curbside management policies, consolidation centres, and a need for integrating freight into planning processes. The need for government funding and political support is perceived to be implicit in the identified barriers across the selected literature.

A major theme that does not emerge is the need for industry-government collaboration on policy development. While there are policies and strategies presented, there is no emergence of an express need for continuous dialogue between government and industry to assess and evaluate the on-going practices to manage congestion issues. Along that vein, data collection and analysis, or the need for more data, do not appear as major issues within the American and international-scan contexts, but is a relevant issue within the Australian and European contexts.

Across the analysis, there is generally a high level of similarity between the generalized emergent theory and associated themes/barriers and the findings/key considerations in the selected literature. Of particular interest is given the 10-year difference between the oldest selected report, and the 5-year difference from the 2013 report, from when the participant interviews were conducted, there are not major differences in the types of issues being identified – whether from a lack of action, surges in growth, or a failure to learn from international best practices is a question for debate. Additionally, where we expect to see fundamental variations and differences between major regions is within the cultural and political approaches taken, or not, to address and remedy the identified barriers and issues to efficient goods movements. Though perhaps unsurprising, we have found that the Canadian freight landscape, at a generalized scale across modes and stakeholders, is perceived to experiencing issues consistent with other major global regions.

These findings are in line with the results of other investigatory endeavours. Work by the European Commission outlines the need for cities to implement a more comprehensive and systematic approach to address their fragmented understanding of stakeholders and address the needs of urban freight, as highlighted by the European Commission's A Call to Action on Urban Logistics; which identifies, a lack of strategy, coordination, and data as major barriers. (Vieira et al., 2015) found that respondents from different sectors identified the following categories of freight distribution issues: regulatory, logistical, collaboration, environmental, and risks. (Stathopoulos, Valeri, & Marcucci, 2012) worked to identify the main issues affecting freight distribution according to stakeholders in case studies and surveys in Rome. The stakeholder analysis found that policies with the least cost and the lowest requirement for behavioural change were preferred, while policies requiring multi-stakeholder collaboration are less well received. (Allen et al., 2010) have shown that dialogue was improved between the different stakeholder groups and resulted in more efficient operations in freight transport. Modern logistics and consumer demand are changing the urban landscape and policymakers have begun to pay attention (Goodchild & Toy, 2018; L. K. de Oliveira et al., 2017; Perboli &

Rosano, 2019; Perboli et al., 2018; Rodrigue et al., 2017; Woudsma et al., 2016). Table 7-5 provides a direct juxtaposition of the emergent barriers from the research with some of the key barriers / areas of focus which were identified in the literature. These literature-based barriers are viewed as being broadly reflective the considerations discussed throughout chapters 2 through 6.

The emergent framework for addressing barriers to goods movement as defined through the data by cost, political risk, implementation, and maintainability. These four factors are linked to the emergent categories and themes from the of the interview data. These factors guide the identification, ability, and sustainability of remediations to the barriers of goods movements. The findings offer an opportunity to improve goods movements in a structured manner, grounded in the experiences of stakeholders whom operate in the freight environment. The framework is supported by four interactive and interdependent stages which may address all of the themes and concerns discussed throughout the analysis.

Table 7-4: Internationally Recognized Congestion Impacts / Barriers to Movement

Major Conclusions / Areas of Focus	Key Considerations
Europe – Managing Urban Traffic Congestion (ECMT, 2007)	
Much can be done to reduce the worst traffic congestion	Manage Congestion on Main Roads Manage highly trafficked roadways to preserve system performance Generate multiple impacts on urban regions
Effective land use planning are essential for delivering high quality access in congested urban areas	Increased Travel Times / Slower Speeds Impose Costs Ensuring land use planning is coordinated with congestion management Users want reliable door-to-door trips that are free of stress Appropriate levels of public transport service are essential for delivering high quality access in congested urban areas
Targeting travel time variability and the most extreme congestion incidents can deliver rapid, tangible, and cost-effective improvements	Improving Traffic Operations Deliver predictable travel times Build New Infrastructure Modifying Existing Infrastructure
Transport authorities need to employ a combination of access, parking, and road pricing measures to lock in the benefits from operational and infrastructure measures aimed at mitigating traffic congestion	Implementing Mobility management Unmanaged access to highly trafficked urban roads is coming to an end Parking Management Pricing Policies
Europe - Call to Action on Urban Logistics (European Commission, 2013)	
Causes inefficiencies in logistics operations	Costs of First and Last mile are too high High costs are barrier to growth of home delivery Needing improved load factors Needing Access to loading/unloading zones
Urban logistics is heavily neglected in city and transport planning	Lack of focus and strategy on urban logistics Few cities with clearly identified official responsible for logistics Urban Logistics is not properly integrated into urban transport and economic development strategies
Need to manage urban logistic demand	Needing good land use planning Needing widespread service and delivery plans Shifting to off-peak deliveries Bundling outgoing shipments Business Trends leading to significant changes in behaviour and expectations (E-commerce, personalized delivery, B-to-C) Lack of coordination of urban logistics actors
Lack of Data and Information	Lack of information and understanding of freight flows

	Need for increased transparency and information for all actors along the e-commerce value chain Needing data to improve operational efficiency Needing data to plan for the long term Lack of easily available information available to operators about policies, regulations, and services ICT could provide clear information about routes, restrictions, parking, and administrative procedures Information needs to be interoperable across the supply chain
Improved vehicles and fuels	High Environmental Impacts, Road damage Urban Logistics well suited for alternative fuels
Shift Modes - Needing better mode and vehicle selection	Dominated by Road Transport Freight pattern analysis can identify flows which could be efficiently moved by bike, boat, or rail City authorities not providing right framework conditions for technically proven solutions to be viable
Improve Efficiency	Deliveries delayed by road congestion Inadequate loading/unloading facilities
Australia – Making the Right Choices: Options for Managing Congestion (VCEC, 2006)	
Making the Right Choices: Options for Managing Traffic Congestion	Travel demand modification policies Incident management Road Use charging Parking pricing and supply restrictions Access regulations Car Purchase and ownership taxes, Fuel taxes
Options that address both supply and demand will be needed	There is not a single solution Road Capacity enhancement, Road Infrastructure Expansion Increasing peak capacity Road Space Reallocation Public Transport Enhancement Provision of alternative transport modes and associated development of intermodal logistics centres
More information is needed	Utilize Information and communication technologies Option identification is crucial Recognize and respond to interdependencies Rigorous project evaluation is needed Take advantage of incentives
Government Can take the Lead	Planning and zoning policies Vehicle capacities and standards Strategic Urban Planning Aspects Need for clarity and simplicity of regulations
United States – Effective Practices for Congestion Management (AASHTO, 2008)	
Adding Capacity / Physical Improvements	New Roads and Roadway Widening New Toll Roads and Managed Lanes (HOV, HOT), Truck-Only Lanes Bottleneck Relief Intersection Improvements, Street Connectivity Intermodal Access Roads Access Management
Using existing Capacity more efficiency / operational improvements	Traffic Signal Timing and Coordination Changeable Lane Assignments, Ramp Metering Congestion Pricing Road Screening / Clearance Programs for Commercial Vehicles Loading Zone Management Port Operations Border Crossing Improvements Incident Management, Work Zone Management, Road Weather Management, Integrated Corridor / Active Traffic Management
Reducing demand for vehicle-travel	Land Use management Road Pricing Freight Demand Management Nonmotorized Improvements Transit Enhancements Commuter Choice / Workplace Travel Demand Management
Reducing congestion on transit vehicles	Transit Capacity Expansion Peak-Period Pricing

International Scan - State of the Art and Practice of Urban Freight Management Parts I & II (Holguín-Veras et al., 2018b, 2018a)	
Infrastructure Management	Major Improvements - Ring Roads, New and upgraded infrastructure, intermodal terminals, freight clusters Minor Improvements - Climbing Lanes, Removal of Geometric Constraints, Ramps for handcarts / forklifts
Parking/Loading Areas Management	On-Street Parking and Loading - Freight parking and loading zones, loading and parking restrictions, peak-hour clearways, reservations Off-Street Parking and Loading - Enhanced building codes, timeshare of parking space, upgrade parking areas and loading docks, staging areas, truck parking outside of metropolitan areas
Vehicle-Related Strategies	Emission standards, low noise delivery programs
Traffic Management	Access/Vehicle-Related Restriction - Vehicle size and weight restrictions, truck routes, engine related restrictions, low emission zones, load factor restrictions Time Access Restrictions - Daytime delivery restrictions, daytime delivery bans, nighttime delivery bans Traffic Control / Lane Management - Restricted multi-use lanes, exclusive truck lanes, traffic control
Financial Approaches	Pricing - Road pricing, parking pricing Incentives - Recognition programs, certification programs, operational incentives of low emission vehicles Taxation
Logistical Management	Urban Consolidation Centres Intelligent Transportation Systems - Real-Time information systems, vertical height detection systems, dynamic routing Last Mile Delivery Practices - Driver training programs, anti-idling programs, pick-up/delivery to alternate locations
Demand and Land Use Management	Freight Demand Management - Voluntary off-hour delivery program, staggered work hours program, time slotting of pick-ups at large traffic generators, receiver-led delivery consolidation program, changes in destination of deliveries, mode shift programs Land Use Policy - Relocation of large traffic generators, integrating freight into land use planning process

Table 7-5: Comparison to Aggregated Literature-Based Barriers

Literature Categories	Literature Themes
Adding Capacity / Physical Improvements	New Roads and Roadway Widening, Road Capacity enhancement, Road Infrastructure Expansion
	New Toll Roads and Managed Lanes (HOV, HOT), Truck-Only Lanes
	Bottleneck Relief
	Increasing peak capacity
	Intersection Improvements, Street Connectivity
	Intermodal Access Roads
	Transit Capacity Expansion, Transit Enhancements
Using existing Capacity more efficiency / operational improvements	Traffic Signal Timing and Coordination
	Changeable Lane Assignments, Ramp Metering
	Congestion Pricing, Peak-Period Pricing
	Road Screening / Clearance Programs for Commercial Vehicles
	Freight Demand Management
	Loading Zone Management
	Curbside Management
Congestion Impacts & Causes	Border Delays
	Border Crossing Improvements
	Incident Management
	Infrastructure Failures
	Costs of First and Last mile are too high
	Road Traffic Congestion Costs
	High costs are barrier to growth of home delivery
	Business Trends leading to significant changes in behaviour and expectations
	E-Commerce Impacts
Supply-Chain Management	Lack of coordination of urban logistics actors
	Provision of alternative transport modes and associated development of intermodal logistics centres
	Intermodalism & Modal Shifts
	Modal Handoff
	Driver Availability
Government Policies	Impacts of Policymaking
	Investment Impacts
	Goods Movement Policies
	Accommodations for Future Technologies
	Lack of focus and strategy on urban logistics
Land Use Planning	Infrastructure and Intelligent Planning
	Urban Logistics is not properly integrated into urban transport and economic development strategies
	Land Affordability & Availability
	Land Use management
Data Collection & Information	Lack of information and understanding of freight flows
	Need for increased transparency and information
	Needing data to improve operational efficiency
	Needing data to plan for the long term
	Key Performance Measures
	Lack of easily available information available to operators about policies, regulations, and services
	Information needs to be interoperable across the supply chain

Categories	Themes
Infrastructure Demand Outstripping Supply	All Movements Contributing to Congestion
	E-Commerce Adding Pressure to the Logistics Networks
	Experiencing Congestion Issues Outside and Within Urban Areas
	Passenger / Single-Occupant Vehicles are Dominating Roadways
	Expanded Infrastructure Inducing Demand
	Needing Investments to Address Capacity Issues
	Needing to Optimize Efficiency of Existing Infrastructure
	Infrastructure Quality Impacting Load Performance
	Road and Intersection Designs Inhibiting Vehicle Flow Efficiency
	Lacking Sufficient Transit Investments to Benefit Freight
	Needing to Assess the Role of Tolling & Demand Management to Affect Usage
Physical Distribution Headwinds Impeding Commerce	Experiencing Chronic Congestion
	Congestion Negatively Impacting Asset Utilization and Load Utility
	Firms are Implementing Surcharges to Offset Congestion Delay Costs
	Lacking Modal Alternatives for Last-Miles
	Impacts Varying by Commodity and Supply-Chain Complexity
	Negatively Impacting Ability to Deliver Goods On-Time
	Decreasing Travel Time and Reliability Performance
	Road Congestion Negatively Impacting all Stakeholders and Supply-Chains
	Increasingly Difficult to Plan for Impacts
	Needing to Minimize Impacts of Non-Cyclical Congestion Events
	Modal Transfers are Major Bottlenecking Events
	Road Congestion Negatively Impacting Intermodal Efficiency
Urgent Regulatory Encum-brances	Congestion is a Result of Economic Prosperity (Growth Spurs Congestion)
	Poor Freight Mobility is Detrimental to the Economy
	Ease of Transportation is Major Consideration of Investment Analyses
	Congestion Impacting Government Investment Decisions
	Land Unaffordability is Inciting Logistics Sprawl
	Conflicts between Land Uses Creating Issues
	NIMBY-ism Is Negatively Impacting Freight Planning
	Passenger Movements are Prioritized Over Freight Movements
	Need Harmonized Land Use and Transportation Policies
	Lack of Short-Term Commercial Parking (Complete Streets)
	Needing to Enable Future Technologies
	Needing to Support Multi-Modal Movements
	Needing to Enable Off-Peak Deliveries
	Policies Increasing the Difficulty for Industry to Respond to Congestion
	Discontinuous Government Policies Impacting Operational Performance
	Requiring Regionally Unique Policy Approaches
	Lacking Industry Representation in Policy Development
Information & Data Management Complexities	Needing Defined and Consistent Data Collection Methods
	Data Cost Inhibiting Collection and Analysis
	Conflicting Views of Data Relevancy Between Industry and Government
	Needing Real-Time Utilization of Roads, Highways, Parking, V:C Ratios
	Needing Detailed Origin-Destination Commodity Flow Data
	Supply-Chain Fluidity Analysis Benefiting Firm Modality
	Needing Measures to Support Operational Decision Making
	Needing Better Communication of Government Measurement Efforts
	Lacking Data Sharing Between and Within Government and Industry
	Needing Government Operated / Funded Road Measurement Programs

Adapted from: ***(Holguín-Veras et al., 2018b, 2018a),*** **(ECMT, 2007), (European Commission, 2013), (AASHTO, 2008).**

Chapter 8. Conclusions

This thesis was broadly presented as two major parts. First, a large review of current academic and government literature was undertaken to develop a state-of-the-art understanding of the physical distribution aspects and challenges facing freight mobility, logistics, and supply chain management, with a general focus on Canada. This review represents chapters 2 through 6. The second part, chapter 7, focused on developing a current understanding of the multidisciplinary nature of the barriers to freight mobility as perceived by industry and government stakeholders in Canada. This original research utilized a series of interviews that were conducted by the McMaster Institute for Transportation and Logistics in 2017 and were the formative base of a grounded theory analysis. This analysis lead to an emergent theory grounded in the experiences of the stakeholders, and the development of a series of proposed interventions to address barriers, which took into considerations relevant concerns that emerged from the analysis. The original research from chapter 7 has been submitted as a journal article for review in an internationally recognized journal – Transportation Research Part A.

For the first part of the thesis, a broad and wide-ranging review was undertaken to discuss the varied factors which influence, demand, or otherwise impact the need and effective movement of goods. The review began with a discussion of the impacts of mobility, spatial structure, and the economy more generally. Followed by a transition into the different transport modes and their relevant supporting infrastructures, and how they relate back to spatial structure and the economy, as enablers of both. The review continues into a detailed discussion of supply chain management and logistics, with a heavy focus on the operational patterns and processes entailed as well as the requisite infrastructures, as well as brief comments on the issues experienced through each element of the chain. Naturally, the discussion flowed into urban transportation and urban/city logistics. The review of urban spatial structure focused on the impacts of changing consumer behaviours, the role of communities and policymaking, and related back to the discussions of spatial structure and mobility, as well as bridging the discussion between curbside/urban conflicts and broader congestion issues. The review concludes with a discussion focused on road congestion in Canada, highlighting the levels of congestion in the major metropolitan regions, and comparing to examples in the United States. The discussion continues by considering the ways in which congestion can be defined, how that alters policy perceptions and responses to congestion, and what are identifiably the sources and causes of congestion at both an on-the-ground and abstract level. The congestion discussion very briefly addresses non-road modes, but as highlighted in earlier chapters and very much so in chapter 7, the congestion issues and barriers to freight mobility are heavily focused on the roadways, and the points at which other modes interact and transfer onto the roadways, in Canada.

Admittedly, this review became more extensive than intended but is representative of the state-of-the-art of the academic and government-based literature for many aspects relating to and influencing the movement of freight. The review also provides an excellent base to transition to the identification of freight mobility barriers in Canada.

For the second part of the thesis, the focus was to investigate stakeholder's perspectives about freight congestion and the barriers to freight mobility in Canada's major metropolitan regions. Interviews with 28 Canadian stakeholders from different sectors were analyzed using Strauss/Corbin extended approach of symbolic interactionism with the objective of producing an explanatory theory to identify barriers to freight in Canada. By integrating emergent categories with a structured framework of theoretical propositions, the results are able to offer insight to understand the perceived barriers to goods movement in the Canadian landscape, as well as to detail a framework of interventions to improve freight mobility. The chapter began with a detailing of the methodological approach, including a detailed review of the literature of how to review GT works. Followed by a review of the interview protocol, data collection, and coding/analysis processes. The results of the analysis were presented by the major emergent categories and sub-categories, with selected quotations from the stakeholder interviews. The overall results were discussed, with a focus on the implications and proposed interventions to address the barriers identified in the results. The chapter concludes after a brief comparison of the results to internationally identified and recognized barriers, which identified a great deal of similarly between Canadian stakeholder identified barriers through the GT approach, and those identified by other means in academic and government literature.

8.1. Research Contribution

The perspective of individual stakeholders in identifying barriers to goods movement and developing policies to address freight mobility issues is an active and well-researched field but the Canadian perspective is not significantly and perceptibly accounted for, ultimately leading to the undertaking of the interview project by the McMaster Institute for Transportation and Logistics, this thesis work, and the associated paper produced from the work. This research represents a unique and useful contribution to the freight literature in Canada and internationally.

To the extent of our knowledge, the submitted paper – reflected in this thesis as Chapter 7 – is the first paper which employs a rigorous and extensive grounded theory approach to understanding metropolitan freight congestion in Canada. As well, being one of few examples internationally to explore the issue with such depth and breadth using a rigorous GT methodology. We attribute this as a result of the degree of effort required to undertake the interview/data collection and analysis processes, in combination with restrictions regarding GT's interpretative nature (Kaufmann and Denk, 2011; Mello and Flint, 2009; Randall and Mello, 2012).

In total, 50 themes emerged as barriers to the movement of goods, which were grouped into nine subcategories, and four overarching categories which broadly frame the issues of goods movements as relating to high infrastructure utilization (*Infrastructure Demand Outstripping Supply*), the cost impacts of diminishing reliability of distribution (*Physical Distribution Headwinds Impeding Commerce*), rapidly growing regions and ineffective or absent policy support (*Urgent Regulatory Encumbrances*), and a lack of a robust data collection, analysis, and information sharing framework (*Information and Data Management Complexities*). These four categories were considered in the frame of addressing goods movement barriers and were argued to be influenced by factors of *cost*, *political risk*, *implement-ability*, and *maintainability*. A comprehensive framework was developed to provide that guide and identifies four high-level theoretical propositions / interventions, which integrated the perspectives of stakeholders. The propositions presented are: *Data and Knowledge Mobilization*; *Public-Private Collaborative Freight Evaluations*; *Government Funding and Political Support*; and, *Capacity Alterations: Improvements and Expansions*. The theory and identified barriers were found to be consistent with barriers identified through major report in the European Union, Australia, and the United States.

Overall, the key concepts of the proposed framework are to collect and analyze data to inform public-private stakeholder evaluations of policy interventions, with government funding to support both knowledge generation efforts, policy actions and capacity investments. The findings highlight that there is a great deal of desire from stakeholders to improve the efficiency of freight movements and the associated planning environments. There is a significant need to expand data collection and information sharing to enable firms and government to address physical and policy barriers which impede the effective movement of goods, including infrastructure and land use planning.

8.2. Limitations and Recommendations for Future Work

It is important to recognize that additional factors may inform the perception of barriers to goods movement in Canada and due to the temporal nature of population, economic activity, and policy, perceptions are bound to shift over time. Additionally, while having 28 long form interviews presents an incredibly rich opportunity for grounded theory research, stakeholders who were exclude by way of unavailability, lack of interest, or for other reasons, may have perceptibly different viewpoints that were not accounted for. It is important to remember that this work aims to present a sampling of the viewpoints, rather than as a census, and as such there are fundamental limitations. Given these limitations, future research should include validating the general theory against stakeholder categorisations and modes, determining if and where deviations from the theory exist when evaluated at higher levels of specificity and how those variations may inform specific infrastructure implementations or policy interventions. Specifically, new works should aim to question the validity of the theory through new analysis of different stakeholder groups, and through the utilization of other survey methodologies.

8.3. Considerations of Pandemics and Catastrophic Events

In consideration of the global pandemic resulting from the outbreak of the novel coronavirus, it is relevant to acknowledge the impacts of extreme events on the fluidity of supply-chains. Catastrophic events, especially those of global scale, have the potential to disrupt, destroy, or otherwise disable every aspect of logistics and supply-chain systems. As this thesis has detailed, the focus for most firms and governments is on day-to-day congestion, administrative bottlenecks, infrastructure management and delays that we typically count in hours or days; these are hinderances which affect cost-performance. During catastrophes, delays of goods might be measured in days, weeks, and months – life threatening amounts of time. The narrative in these situations shifts dramatically and cannot be understood from a normative point of view. Crises are difficult to accurately plan for by their very nature, but disaster mitigation and crisis management is an active field of study across a variety of planes of research. It is not, nor was not, a goal or consideration of this research, to assess or otherwise investigate the perceived impacts of breakdowns in supply chains as a result of global bio-infectious or other catastrophic events. Though it is acknowledged that the SARS-CoV-2 pandemic has fundamentally changed how our global economy will work in the future, and those impacts will need to be assessed in future research and we move through this challenging time in our collective history as a global people.

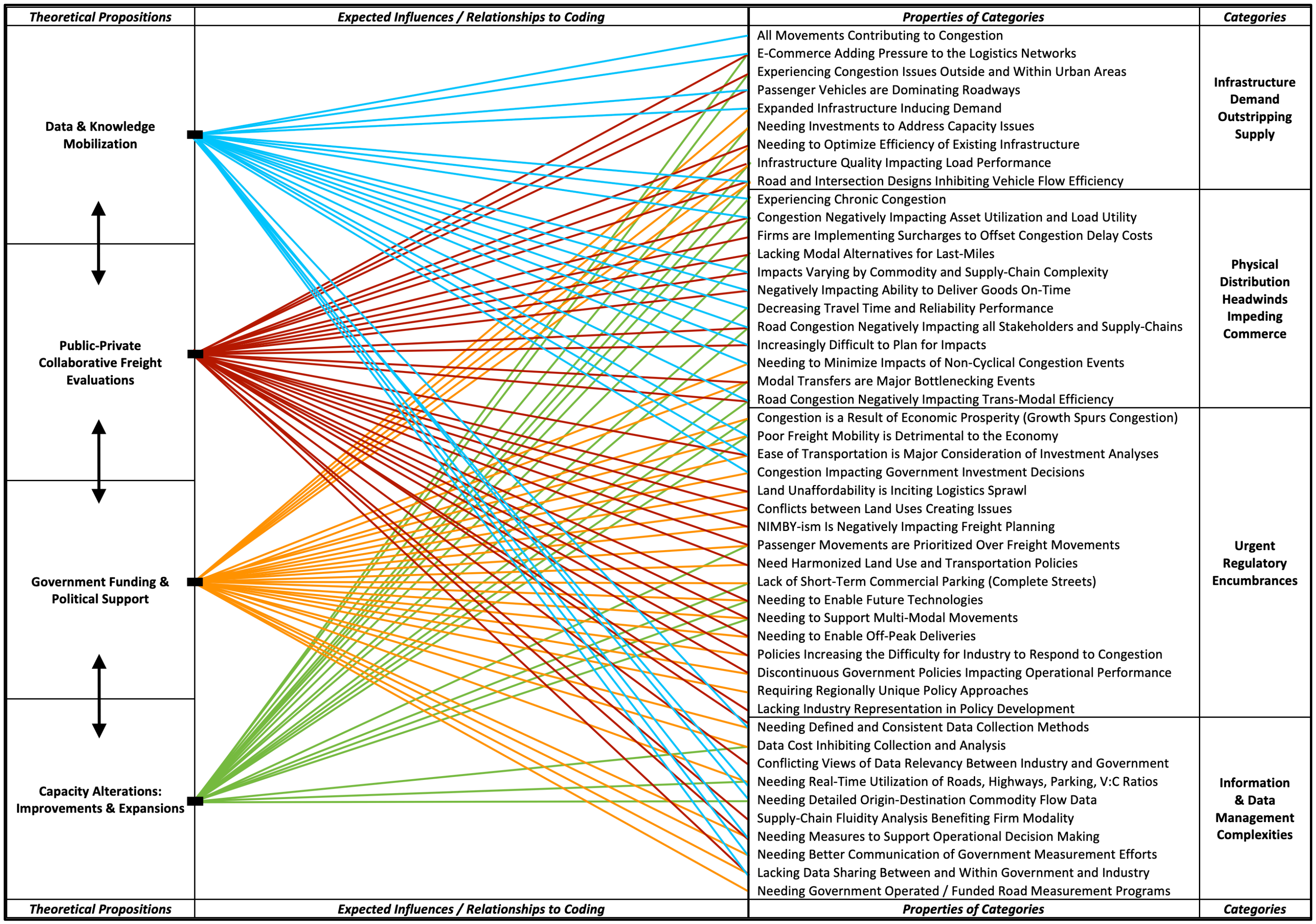

Figure 8-1: Integrated Theoretical Framework of the Grounded Theory; Explores the Relationships Between Categories, Theoretical Propositions, and Dimensionality, Adapted from: (Mohamed and Ferguson, 2017)

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Appendix A: Interview Script and Questions

This thesis uses interview data from a research study undertaken by MITL titled *Metropolitan Freight Congestion in Canada: Measures, Causes, Implications, and Policies*, which received ethics approval from the McMaster University Research Ethics Board, project number 2017 029. The following is the ethics-approved script used by Dr. Ferguson and Dr. Mohamed in conducting the participant interviews.

1. Introduction

Good Morning/Afternoon and thank you for taking the time to participate in this research. As a reminder you have the right to withdraw from the interview at any stage and for any reason. Feel free to pause the interview at any time if you need a break or to use the restroom. The interview is based upon six main themes that are important to the overall research topic. The questions below are posed in a generic manner intended for a diverse set of stakeholders. Thus, it may be important for you to adapt certain questions for the circumstances of your organization. For example, if you represent an industry association, you might answer the questions in terms of your opinions on member circumstances. If you represent government, you might answer based on feedback from firms with which you interact. We will start the digital recording when you are ready and begin our interview.

2. Subject Information Sheet

Have you had a chance to look over the information package? *If YES, we will proceed to the interview questions. If NO, a summary will be provided, and printed sheets will be handed over to the participant.*

3. General
   a. Can you outline some of the important bottlenecks (road-based and otherwise) that hamper the movement of goods in your organization? (or other organizations of which you are aware). Where or what are the greatest pain points within the supply chain?
   b. How is your organization, or others of which you are aware, affected by road traffic congestion?
   c. To what extent are freight bottlenecks inherently "metropolitan" in character versus "non-metropolitan"? When you consider bottlenecks in your supply chain what is the geographic scope of your thoughts? For example, are you thinking about multiple metropolitan areas?

4. Measurement
   a. Does your organization actively measure freight performance for one or more modes? If so, are there certain key philosophies or approaches that relate to freight performance measurement in your organization that you can share?
   b. In your view, what factors are most important for your organization to measure (e.g. fluidity, reliability, efficiency, safety, environmental impacts,

border, infrastructure or others?) Do you assess freight performance through measures/factors that are composite in nature (i.e. not tied to a specific mode?)

c. What elements would you want government (municipally, provincially, federally) to be monitoring/measuring or NOT measuring? If new reporting on freight congestion was introduced, what key measures would have to be included for it to be effective for you or your industry? What would be the role of the private sector?

d. Without access to high-quality data, measurement of freight congestion and a proper understanding of related issues, is impossible. Can you comment on issues that you see as important to the sharing, collection and use of data in this context, taking into account the many stakeholder organizations involved?

5. Causes
   a. What do you think are the underlying reasons for the general problem of metropolitan traffic/freight congestion? Do you see the freight/goods movement sector as a significant contributor?
   b. Is part of the issue a failure by government to properly measure the phenomenon or to measure the wrong things?

6. Implications
   a. Does freight congestion affect the investment decisions of your organization? Does it impact the investment climate in your metropolitan region or other key geographies for your organization? Can it affect future prosperity in certain metropolitan regions that handle the problem poorly?
   b. What do you think are the implications of a "business-as-usual" approach in your metropolitan region or other key geography?

7. Policies
   a. What policy measures, if any, ought to be implemented by either municipal, provincial or federal governments to address freight bottlenecks including traffic congestion problems? Are there potential policies that concern you?
   b. Should freight bottlenecks be addressed through the supply side (e.g. improved infrastructure) or through the demand side (e.g. road/congestion pricing) or both?

8. Other
   a. Are there any other comments that you would like to make based on aspects that you think are important that we have not covered sufficiently?

Thank you for participating in this study; your involvement in this research is very important. We look forward to sharing results with you and other stakeholders.

Appendix B: Extended Results

The following subsections aim to describe and add context to each of the categories and subcategories, as well as providing select, anonymized participant quotes to highlight some of the categorical themes. This appendix presents a long form version of the results which includes a substantial volume of interview quotes.

8.3.1. Infrastructure Demand Outstripping Supply

There is a clear and definite perception of congestion across Canadian. The major population centres represent the worst areas, but peripherical and rural areas are noted for different types of capacity-related issues as well. While the focus is dominantly placed on the roadways – by virtue of the scale and scope of road-based congestion compared to issues experienced by other modes – there is a great deal of concern about the capacity and quality of the infrastructure networks, roads and otherwise, to handle the growth being precipitated by e-commerce and other pressures.

> *"I think it's the demand of freight, whether its goods movement by air, by ground, by ocean, whatever mode, it's moving by ground at some point, and I think the growth in industry, infrastructure hasn't kept up with the growth." – Carrier / Transport Operator*

> *"It seems as though we've driven significant new activity through infrastructure that just hasn't changed a great deal over the years, and you need to do nothing other than just looking at the condition of some of those routes to see that it's been left for a long, long time." – Carrier / Transport Operator*

> *"If everybody was in a low occupancy vehicle and every single person drove one car to one place – that would be a lot of congestion." – Infrastructural Hub*

> *"It's true with passengers as well – they haven't kept pace with the growth of passenger movements in Toronto, and so the people are driving to work, so you've got more congestion." – Industry Expert*

<u>High Network Demand</u>

Freight vehicles are recognized as being highly visible contributors to road congestion as a result of their operational characteristics. While postal and e-commerce delivery vehicles are also recognized for the pressure they are adding to the road networks, there is a strong recognition that freight vehicles are not the primary drivers of road congestion, but rather single-occupant passenger vehicles are the dominant road users and contributors to peak congestion periods.

> *"Traffic congestion is getting worse. Goods movement might be one of the contributors, but we feel that the biggest contributor to traffic congestion is single occupant vehicles. Freight is not a big contributor as far as road congestion is concerned." – Authority / Regulator*

“The growth of couriers and small package deliveries it’s changing the nature of deliveries in the metropolitan areas, so I think that’s a big part of the congestion problem in terms of freight. – Industry Expert

“The percentage of online shopping of overall retail, is still a small percentage… so there’s a long way to grow, and all of that is going to cause more congestion on the roads because ultimately somebody is delivering something to somebody’s house.” - Carrier / Transport Operator

Low Capacity

Though there is strong enthusiasm for expanding and building new road infrastructures to accommodate growing populations and easing capacity constraints, there is concern of further inducing demand onto the roadways. While expansions are viewed as necessary especially dedicated highway accesses to ports, terminals, and distribution facilities, there is an emphasis on improving the physical quality of infrastructure, especially in Quebec, and to optimize roadway efficiency through various measures, as well as altering the physical design of intersections heavily trafficked by large freight vehicles, and other road designs.

“One of the biggest barriers to congestion is the design of the roads. The roads work fine as long as they work in a straight line. When you go from 3 lanes to 2 lanes to 4 lanes …it is not ideal.” – Infrastructural Hub

“It’s the economic growth in the area, the population growth in the area, and I think planning really lags economic growth, and we’re 10 years behind on our road networks and infrastructure. I think the other thing is the underinvesting in passenger train services, intercity passenger train services or bus services, and really having an efficient passenger movement network in the country.” – Carrier / Transport Operator

“It’s amazing that when you see the QEW between Hamilton and Fort Erie shut down, its chaos because there’s no redundancy there. It just boggles my mind that that highway has shut down so many times in the last few years…” – Shipper / Receiver

“… the volumes have gotten very high throughout the entire region… now there’s just as much peak hour traffic and the delay and uncertainty and difficulties getting across a region within a day. And so, the increased growth and pressures on the 400 series highway in particular are pretty extreme” - Authority / Regulator

We don’t have a lot of land to build more facilities so how do we improve the efficiency of what it is that we have? - Infrastructural Hub

“With all the things that we are able to do… we still can’t build roads. They take forever to build a road. The congestion and the cost to the consumers is huge, and yet we still cannot build and maintain roads.” – Infrastructural Hub

> *"…complete street – some of our arterial roads – they have bus rapid transit services on them, so there is a conflict from various other modes - and we also have an objective of promoting sustainable modes, so we want to promote sustainability in the region so we want to increase our sustainability in transit share, modal share to 50%, so definitely the goods movement and multimodality between the various modes is a challenge, so that's why we are thinking that if we can work with various partners – both public sector partners as well as private sector partners and addressing this particular part - it will be very nice about the traffic congestion". – Authority / Regulator*

> *"…trying to ensure that the congestion cost is taken into account as well as we want to make sure that they're able to relatively operate smoothly. We want to be competitive – so we are not only comparing ourselves with other regions in Canada, but we are also globally competing with New York, Chicago, and LA, so we want to ensure that we are globally competitive and we want to make sure that these industries are locating and Peel and we continue to attract that." – Authority / Regulator*

> *I think one of the biggest barriers to congestion is the design of the roads. The roads work fine as long as they work in a straight line. When you go from 3 lanes to 2 lanes to 4 lanes …it is not ideal. – Infrastructural Hub*

> *"We are looking at the geometric features of the entire road system, and we want to make sure that our road system is there and engineering a spatial map will ensure that he doesn't have to go through that individual process to ensure that the road system will be in place. They may still have to do some exercise for the local connections to our major arterial system, but most part we want to make sure that it is an easier process." – Authority / Regulator*

There is begrudging recognition that capacity expansions alone are likely to redress congestion issues and future solutions may need to consider demand management techniques in heavily congested regions to rationalize road demand. Though, tolls are perceived as disproportionately penalizing commercial movements, given limited feasible alternatives to the last mile. While there is a strong resistance to tolling in general, tolls on new roads are more palatable than on existing capacity. Transit investments meanwhile are viewed as a key tool in improving capacity, as any reduction in SOVs helps to mitigate the impacts of continuous population and vehicle-use growth.

> *"People can take transit; there's no real transit for commercial movements. And so, any shift that you can get to have the population is a big boon because it clears up some of that capacity for goods movement; where there's not a lot of choices." – Expert / Observer*

> *"I think people movement is another part of the problem. There needs to come a point when the solutions maybe aren't necessarily all focused-on freight movement, because everyone looks at a truck and they hate it but maybe there needs to be more LRT or subways or maybe there needs to be less of a pushback against*

Uber. All of those are nifty ways to move people, and get people out of their cars, and let's face it they all want to be in their car and drive in their car and in some ways, I don't blame people." - Shipper / Receiver

"From a business standpoint, if there is a solution to congestion that adds to our costs, you'd be reluctant to say, "yeah that's a good idea." But, particularly in Ontario, I don't think there's any other way to lessen the congestion." – Carrier / Transport Operator

"If you force people to pay a toll on a highway, chances are with human nature, they're probably going to try to find another way. So, you may solve the problem by freeing up a bit of capacity on the 401, but you may create another problem elsewhere – you may cause all of your arterial highways around the 401 to be completely jammed, and that's not what you want to do." – Shipper / Receiver

"On the supply side we are not that sure about the congestion pricing about the tolls because right now we feel that Highway 407 is underutilized, and businesses have told us that they operate on a very thin margin and if the congestion pricing is introduced, they might not be able to function that well and they might relocate. So we are really sensitive about congestion pricing – I don't think it's one thing that we need in this area as far as the businesses are concerned otherwise it will be a disincentive for the businesses to relocate to somewhere else. And 407 is a perfect example where businesses are not using it as much as they should be using it" – Authority / Regulator

"We also know that the transit alone would not be able to solve the traffic congestion issues of passenger movement. So, it has to be a good mix of personal vehicles, transit, as well as the goods movement, so we are focusing on intermodal and as well as the multimodal transit issue, which also includes the active transportation." – Authority / Regulator

8.3.2. Physical Distribution Headwinds Impeding Commerce

The efficient movement of goods is recognized as being directly impacted by the added costs of, and efficiency hinderances encountered while, operating in congested road environments.

"It really is about reliability, especially when you get into just-in-time delivery. I want to know it's going to take that amount of time to deliver. If I can't count on that, then potentially my plant shuts down and it's costing me $20k every half hour." – Expert / Observer

"It's going to either result in I have to add a whole bunch more lead time, or its going to mean that there are costly delays and either there will be empty shelves, or a lot of money spent on trucks and equipment sitting around waiting to move." – Shipper / Receiver

"I think the most important thing about the supply chain is predictability, and congestion is unpredictable – it is predictable to some extent, you know there's always going to be some congestion in the region, so you can make some allowances for that, but equally it can be unpredictable" – Expert / Observer

"The borders can always be, from a congestion point of view, a big bottleneck." – Industry Advocate

High Congestion Costs and Impacts on Fluidity

The impacts of chronic road congestion are recognized as higher operating costs for carriers and shippers, as delays are significantly reducing the efficiency of drivers. There is recognition that firms are responding with surcharges for certain regions, routes, and times. While lengthened travel times are problematic, it is the increasing unreliability of on-time delivery performance that is perceived as impacting asset utility the most, especially as it is difficult to plan for.

"When you get into metropolitan areas like the greater Toronto or greater Montreal GMA, GTA, or greater Vancouver, the time it takes to get to your final destination and the variability of that delivery is getting worse and worse." – Shipper / Receiver

"The challenges of road traffic require us to have more trucks. We have to have more drivers because we're spending more time in delays than moving efficiently. It creates issues around product quality in sensitive items. It means greater carbon emissions because of course we're idling more, and no matter what we do we're going to idle more." – Carrier / Transport Operator

"When you get a rate to deliver to the GTA, you're going to pay more than if you were going elsewhere. Same miles but it takes them longer. It impacts our bottom line as well as the carriers' ability to turn the asset and make money." – Shipper / Receiver

"A lot of carriers going downtown will build in a surcharge. It might not necessarily be a line item, but it will be tucked into the price." – Industry Advocate

"Yeah, a lot of congestion … and some parts of the roads in Montreal, [congestion] can double the time required to move from one point to another; so, it's a disaster." – Industry Advocate

"And when you hit the roadblocks, everything goes haywire so then you need to be able to find other ways to move the goods around, and again, layers cost a lot." – Expert / Observer

"*When there are accidents, police tend to close highways that don't need to be closed. It's a major issue that [has been] brought to the [police], but of course they say… "we're doing* what's *right." I understand the safety part, but there's the public* *issue too… I think that really has to be looked at, revisited and a practical answer made." – Carrier / Transport Operator*

The cumulative impacts of travel-time variability manifest negatively across all supply-chains which interact with the road network, though those impacts are considered to vary by commodity and the degree of integration – especially those dependent upon cross-border movements. Inter-modal facilities – predominantly ports and inland rail terminals – are recognized as some of the most impactful areas to service due to the volumes of traffic generated, and the recursive impacts of missed queue times, delayed vehicles, and other factors negatively impacting reliability.

"One of the key bottlenecks within the multi-modal supply chain is the hand-off… There's lots of interdependency in terms of… sharing information, which is one of them, but it's having your capacity properly aligned… to move the goods through smoothly, that's the interdependency." – Authority / Regulator

"The marine seaports being that key transfer point are often a point where you get congestion, and bottlenecks. ..., but it also includes other kinds of important intermodal or multi-transfer points such as the big intermodal railyards" – Authority / Regulator

"We participate in fast lanes and all those things that allow us to keep product flow from being impeded. When there are innovations, we're going to take advantage of it because we don't want to be stuck sitting at a border, waiting 7-8-9-10 hours" – Shipper / Receiver

"It's so time sensitive that the customers are waiting for the traffic when it arrives, so when it comes to congestion and trucking, particularly on roads, it's a big issue, particularly with our customers in the morning because most of them are located in Toronto" - Carrier / Transport Operator

8.3.3. Urgent Regulatory Encumbrances

Congested regions are prosperous regions, though excessive congestion is, expectedly, perceived as being detrimental. As land uses come into competition through residential and logistics sprawl, there is a clear concern of freight activities being deprioritised and ill-considered across political interests. There is enthusiasm for industry to been actively involved in the development of balanced policy approaches to mitigation strategies and economic development.

Traffic congestion bottlenecks that you get in large urban areas [are] probably never going to go away – Expert / Observer

"Governments are only in for short terms, nobody is thinking for a 10-15-year horizon necessarily, and a goods movement strategy needs to look at the year now, but also 10-15 years out." – Shipper / Receiver

"[Businesses] don't want to sit on the table and discuss about issues that can be solved that are 15 years down the road – [they] want some issues to be settled now" – Authority / Regulator

High Growth and Reflexive Operations

While prosperous regions are beneficial to firms, with plentiful market and labor accessibility, ease of transportation is a major consideration of where firms choose to operate. Poorly accessible or prohibitively expensive land is recognized as pushing logistics facilities further away from markets – generating more and lengthier vehicle trips. Poor attractiveness impacts regions' ability to maintain industry and may harm local economies; some governments are recognized as actively working with industry to maintain local investment. There is recognition that until it is politically expedient to invest in congestion reduction solutions, governments are limited in the interventions they are able to implement.

"The reality is, as density increases, it's also not just going to increase the people movement but it's going to increase goods movement because all of those people need goods, so it just exacerbates itself." – Shipper / Receiver

"Logistics Sprawl is happening very quickly in [Toronto] relative to other cities. Distribution centers are getting larger and they need to move to where land is available. With that movement, they're experiencing increased travel distances and times." – Expert / Observer

"Transportation is probably # 1 or # 2 in terms of an investment decision by a company, they should look at the tax environment first, and then what's the transportation system like to get our goods to market? It's hugely important." – Carrier / Transport Operator

"There's a huge number of advantages to living in a congested urban area, but there are disadvantages: it's a little bit more expensive to make your deliveries, and it's more expensive to get into and out of the urban area." – Expert / Observer

"It's in the thriving metropolitan areas, so congestion is a reflection of prosperous location, that maybe hasn't also kept pace with expansion or increased capacity" – Authority / Regulator

Freight Insensitive Land Use Planning

Firms are attempting to navigate a political environment in which land use policies and urban-planning theories are perceived to be stacked in favor of passenger flows and residential uses with little consideration, or outright condemnation, of commercial or industrial employment lands and transportation. There is a strongly perceived lack of political weight given to the role of freight, especially as conflicts between physical freight facilities are perceived to be intensifying.

"And not only politicians, people involved with planning and development. Some have no idea why we need trucks, why we think about supply chains, or why we need the railways to the ports. It's the core of the economy, but they're not aware of that." - Industry Advocate

"It's when we have to educate people in planning, people on circulation, people on urban side saying: yes, it is good for pedestrian, for bicycle, we have to share the road, but think for goods; a city without trucks to deliver goods will be a nightmare." – Industry Advocate

"If you got it, chances are it came from a truck, and the only thing not delivered on a truck is a baby. As we move towards urbanization and as governments are encouraging density, it's only going to get worse; it's not going to get better." – Shipper / Receiver

"We want to make sure that the freight activity is concentrated in a particular area which is closest to arterial road or a highway and is not negatively impacting other residents and neighbourhoods. So those are the type of activities that the municipalities can undertake" – Authority / Regulator

Industrial facilities are recognized as challenging to be planned for but there is a strong need for them to be integrated in to harmonized land use and transportation plans, with formal separations and setbacks for facilities and corridors from residential and sensitive land uses. Last miles of deliveries are challenging as a result of insufficient loading or parking space, and though there is a recognition of the emergence of complete street paradigms, it is perceived that freight considerations have been excluded from the discussion at the planning level.

"We have to find a way to work with the private and public sector together to reach some common objective to ensure that we support our freight industry and we improve the capacity and competitiveness of our sector." – Industry Advocate

"[The] whole concept of truck traffic and economic congestion from that commercial standpoint, I think gets lost in cities amongst the conversation of pedestrian and individual constituent traffic" – Carrier / Transport Operator

"The implication is the continued challenge of trying to balance the roles of important transportation hubs versus local opposition – the disruption it can cause and just competing interests for land" – Authority / Regulator

"It's the sensitivity around the trucks and the sensitivity around the goods movement traffic from the public. We do receive complaints and suggestions from the public as well as from the elected officers about the negative impacts of truck traffic, and I do agree, and we do agree that there's some negative impacts on quality of life and personally we are quite concerned about that as well." – Authority / Regulator

<u>*High Need for Collaborative Policy Development and Interventions*</u>

There is a need for industry and stakeholders to collaboratively develop policies to address both current and future issues relating to congestion, temporal and modal shifts, and implementing future technologies. There is a clear perception that industry wishes to be a part of policy development, especially as regulations can increase operational complexity, but are not being represented in those discussions. While it is well recognized that individual administrative regions have a need to implement policies tailored to their political and built environment, variable freight policies between abutting jurisdictions are considered challenging to manage and work with.

> *"I think the challenge with government is the coordination between levels. Each level on its own,* they're *great to deal with, but then when you try to thread through all of them, they may not all have the same interests and objectives in mind." – Shipper / Receiver*

> *"There are little incremental things like that that make a big difference to business, but sometimes we're so focused on the urban areas, we're not necessarily thinking about some of the other areas that could create some tremendous efficiencies" – Carrier / Transport Operator*

> *"There is a disconnect for the drive and the desire to have goods movement to happen in off-peak hours and to allow for flow of people, but then regulatory script doesn't allow that in many areas." – Carrier / Transport Operator*

> *"I think opening up the night, you're in essence creating the redundancy that you need. And I think that's probably one of the single biggest levers that we take advantage of to solve the problem, and I think somehow if you could coordinate with all the municipalities, you would have a real powerful lever to pull in the absence of capital for building new roads and other means." – Carrier / Transport Operator*

> *"…Drivers are not in plentiful supply, [and] if you are not using them as productively as possible, you may not have alternative drivers that can then take over and finish that load." – Expert / Observer*

> *"The availability of good drivers is a dwindling pool for us to tap into and we're all trying to find ways to make the driving functioning profession, that attracts people. That's a very real concern… we're all very much distracted by that." – Carrier / Transport Operator*

There was a recognition of the rapidly evolving technological environment in which autonomous vehicles, advanced ITS/R-ITS, and real-time logistics management will be the new normal – governments are perceived as the key to enabling and encouraging the Canadian development of these future technologies.

> *"For government, it is important to work on the frame to support the technological shift in the freight industry and to be prepared for what will happen.*

> *It's not when* autonomous *vehicles will be on the road, it's right now. What we see coming with AV's and all the ideas about AI, it is really important that the governments have a frame about what we want to do on our networks." – Industry Advocate*

8.3.4. *Information & Data Management Complexities*

Data collection, analysis, and information sharing are recognized as being of use for, and by, industry and government. Better information is well-regarded as a means to improve decision making structures, to expand the understanding of where investments are needed, if and where modal shifts could be accommodated, and improving the fluidity of local and global supply chains. The cost of data collection, as well as privacy concerns regarding sensitive industry data, are recognized as dominant barriers to a freight-specific data and information apparatus in Canada.

> *"What is difficult is sharing the information between government and industry, and I think that's one of the issues and where we have to work because of the changes with technology. It's not easy to see in five years, but at the same time it's going fast" – Industry Advocate*

> *"Carriers are complaining because there are so many construction sites and the information is simply not there, the detour, what will be the alternative? It's not there, and if something happens… they do not know until they have their nose in the accident." – Industry Advocate*

> *"we have a good handle on performance measures, but again, some of the performance measures are quite independent and as well as dependent on many other aspects, but definitely performance measures are quite important to us. For example, travel time, number of turns and goods moved, economic value of goods moving - these are some of the performance measures that we have used in our reporting and we really want to make sure that we are delivering and its very closely monitored by our senior management" – Authority / Regulator*

> *"I think we are able to collect as many measures as we can, but if we can collectively conduct and OD survey – origin and destination survey – or if we can collectively provide a travel time - reliable travel time within off peak period, as well as the value of goods moving– those are the reliable measures that we can work together." – Authority / Regulator*

> *"I think the data – it would be nice to have data from the private sector. But as a government organization – we would not like to get the data ourselves, but we would definitely like the universities to have the data which is in arm's length from the government" – Authority / Regulator*

Enhanced Data Collection

While there is enthusiasm for increasing the scale and scope of data collection at all government levels, there is a recognized need for a standardized data methodology to be adopted. Incumbent is the need to define what is relevant for governments to fund the collection of and whether that data is of use, or should be of use, to industry-partners. While most firms felt they generally had the information they needed to operate, though find government data of interest, governments and advocates are seeking for expanded data collection and inter-organizational sharing frameworks. The primary barrier to high-specificity data collection is, unsurprisingly, considered to be cost.

> *"Would like a commodity flow survey across Canada, so that we have a better sense of what goods are going from where to where. We have the CVS, but it's focused on long haul. What we're missing is the movement of goods within urban areas." – Expert / Observer*

> *"We measure each segment, the marine portion, the dwell time at the port terminal, and the rail, or truck transit time to the destination. [We're] trying to understand how the various [modes] are performing individually as well as collectively." - Authority / Regulator*

> *"We want to be big on employing new technologies… which includes not only on the data side like permanent count stations, the GPS and many other things, but also the autonomous vehicles. We really want to make sure that we are there, and how can these technological innovations help us for increasing the goods movement efficiency and safety." – Authority / Regulator*

<u>Low / Lacking Information Management</u>

There is a perceived need for governments to improve their sharing frameworks with the private sector – data needs to be shared, or at least communicated, with organizations who can operationalize the information. Similarly, there is a perceived need for industry to improve its willingness to share data with government. Improved knowledge sharing between industry and government may lead to the deployment of well-conceived policy and lead to well-informed infrastructure investment decisions. Specifically, governments should be using data-based indicators and performance metrics to trigger policy interventions and prioritizations.

> *"For government, what is really important is real time information. Capacity of infrastructure is not well documented and the use of the road at the municipal level. If we want more efficient planning, the government has to have this kind information." – Industry Advocate*

> *"Measures are great; then becomes what comes out of the measure? Is there something actionable that can help address the measure? It's one thing to say, this road is blocked, that's helpful, but what do you do to solve this? That's what's key" – Shipper / Receiver*

"We see them as very important partners in our supply chain. I've always seen a lot of willingness to participate, but even more to share measures. If you look at PMV and the stats that they measure on port congestion that they put out constantly which is great for us, it helps us to understand where our partner struggles are." - Shipper / Receiver

"Most of the time we focus on the number of trucks going through [redacted], or the number of vehicles moving, but also through our commercial vehicle survey, we want to know what type of commodities are flowing. So that's how we want to make sure that at least we know the value of goods at the higher level, but definitely this is something that we don't have any control from the government side. So whatever information we are able to collect through commercial vehicle survey, which is the partnership with MTO, we are able to get that information. But definitely we are able to get information on number of trucks moving, and that's where we get concern if the trucking activity or the other activity is going down, and what we are concerned more is the travel time, so we want to make sure the trucks are travelling the shortest distance on our road, and connecting to major highways" – Authority / Regulator

"I think for us coordination is big and collaboration is big, and we've been fortunately able to have a very good collaboration and coordination with all levels of government and private sector. We know that we alone cannot solve goods movement problem; as a geographical location, all the jurisdictions, they need to work together. If everyone is not working together, I don't think you will be able to attack the goods movement issue or problem, but if everyone works together as a team, you will be able to certainly achieve marvelous results. So, coordination and collaboration are definitely key" – Authority / Regulator

Appendix C: The Grounded Theory Coding Process

The coding process for the evolved approach to grounded theory is roughly structured around four major stages: Data Collection, Open Coding, Axial Coding, and Theoretical Integration. Figure 9-1, adapted from Roman et al. (2017), provides a diagrammatic representation of this process – though it is presented in a roughly linear fashion, the process is interactive, cyclical, and in a state of constant change until a saturation point is reached. Across the three major variants of grounded theory – traditional, evolved, constructivist – there are variations in the terminology as well as the ontological and epistemological frameworks of thought and approach, but the overall processes are relatively similar.

Data Collection

The process begins with the data collection and theoretical sampling to identify who are the relevant stakeholders to the project as well as determining what the relevant questions are. The initial literature review and knowledge from prior projects is used to establish an initial framework of questions. The participant selection process was discussed in Chapter 7.

After the first interview the structure of the questions, including the questions themselves, may change and alter to incorporate feedback received and follow up questions asked. The remaining interviews continue to follow the open-ended structure discussed in Chapter 7, with the researchers able to ask follow up questions and additionally queries throughout the process. The intent is to build a discussion.

Open Coding

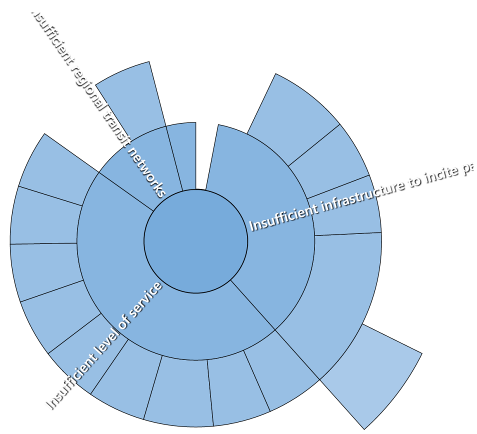
Open coding represents the second major stage of the GT process. There are two main steps: line coding and focused coding.

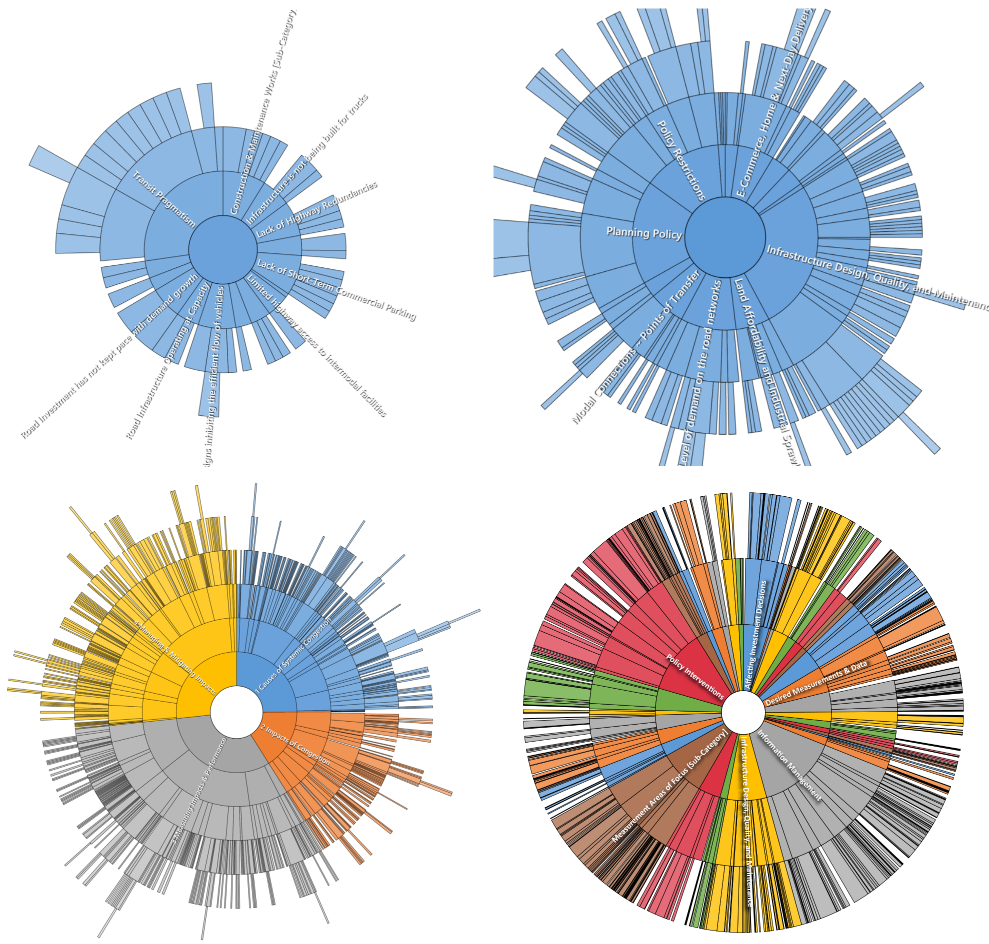
Line-by-line coding is undertaken of the transcripts whereby lines, phrases, sentences of varying length are attached a code which attempts to summarize the line using representative language. These codes represent the data at its most basic component form – 31,717 line codes were written in this analysis. Line codes are reviewed for similarity and duplication, and in total 2 650 unique codes were developed which were referenced 10 823 times. For example, consider the following quote:

> *"So given it's intermodal facility, trucks are constantly picking up or dropping off containers and our view is that given the road infrastructure around, there is truck congestion associated with that and ideally we would like to see the [redacted] expanded which would improve the truck fluidity out of the yard and increase the overall truck capacity so you can get more trucks through per day."*

This phrase could be coded as “Trucks constantly accessing intermodal facilities,” “Intermodal facilities impacting local road congestion,” “Wanting road infrastructure expanded to support intermodal facilities,” “Highway expansions improving intermodal fluidity,” “Improving truck fluidity increasing capacity of intermodal daily capacity.” Another author may have slightly different When coding, a focus is utilizing on verbs and adverbs (e.g., ‘increasing,’ ‘causing,’ ‘impacting,’ ‘reducing,’ etc.).

The second stage of open coding is the development of themes, sub-categories, and categories. Developing successively more abstract ideas through comparing codes with codes, codes with categories, and categories with categories, in order to identify commonalities and differences though a process of constant comparison to incite category development through continual upward abstraction. This constant comparison means that the categories are almost always in flux, until the category becomes saturated - meaning that new data (i.e., interviews) are not changing the coding structure. Depth of categories and the volume of information used to build each category varies. These sunburst diagrams visualize the depth and degree of generalization that went into building some of the themes and sub-categories within a category. Figures Appendix C 1 through 6.





Figures Appendix C 1 – 6: Iterations of the Focused Coding Process

<u>*Axial Coding*</u>

The third major stage of the analysis is axial coding. Categories are integrated through this process as a method to restore the relationships between the independent developed categories. Axial coding effectively occurs concomitantly with the later stages of open coding. Accomplished through using a coding paradigm to question the meaning and similarity of the categories. The coding paradigm facilitates the identification of the relationship between structure and process and the linking of categories and subcategories. In this case, we use Glaser's Six C's - Concepts, Causes, Contexts, Contingencies, Consequences, and Conditions. These are thinking techniques which prescribe the how the researcher questions and interacts with the data.

Open and axial coding are heavily supported through the use of memo-ing and diagramming to help visualize and remember the identified relationships between codes, themes, and categories. Memos are simply notes which identify or discuss the six C's. Figure Appendix C 7 highlights the generation of some of the interconnections between themes and is a diagrammatical representation of the process in action. In this research, the memos and diagrams were developed and stored in NVivo Software.

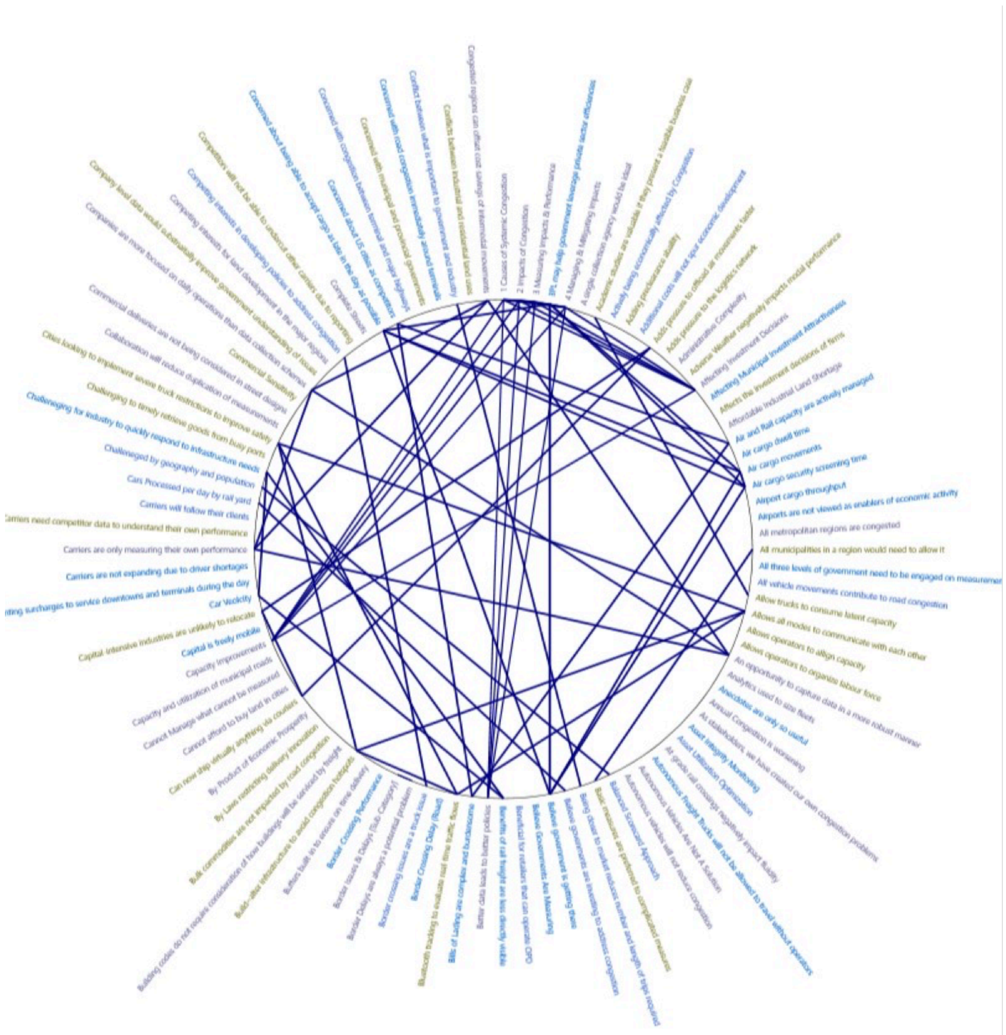


Figure Appendix C 7: An In-Process Diagram of the Interrelating Process

Selective Coding / Theoretical Integration

The fourth major stage of the analysis process is theoretical integration. This process selects a 'core' category and relates all of the categories and themes to it - in this analysis, we identified 4 core categories which represent the overall theory. I refer to these core categories as propositions as they are presented as areas which require action and intervention. This structure is built by systematically interrelating the developed categories by declaring relationships between the categories and themes with the selected core category. Since this is a flexible and iterative process of constant comparison, these core categories can change over the analysis as new data is read into the analysis and worked through the coding process.

As a part of the theoretical integration, the building of a theoretical matrix of categorical influences is built to assess micro and/or macro level issues which affect the developed categories - these factors are emergent / induced from the data. This is table 7-3 in the main text. Figures Appendix C 8 and 9 present a high level categorial view of some of the results from an iteration of the axial coding process and the final interrelation between the core categories (i.e., theoretical propositions) and the main themes.

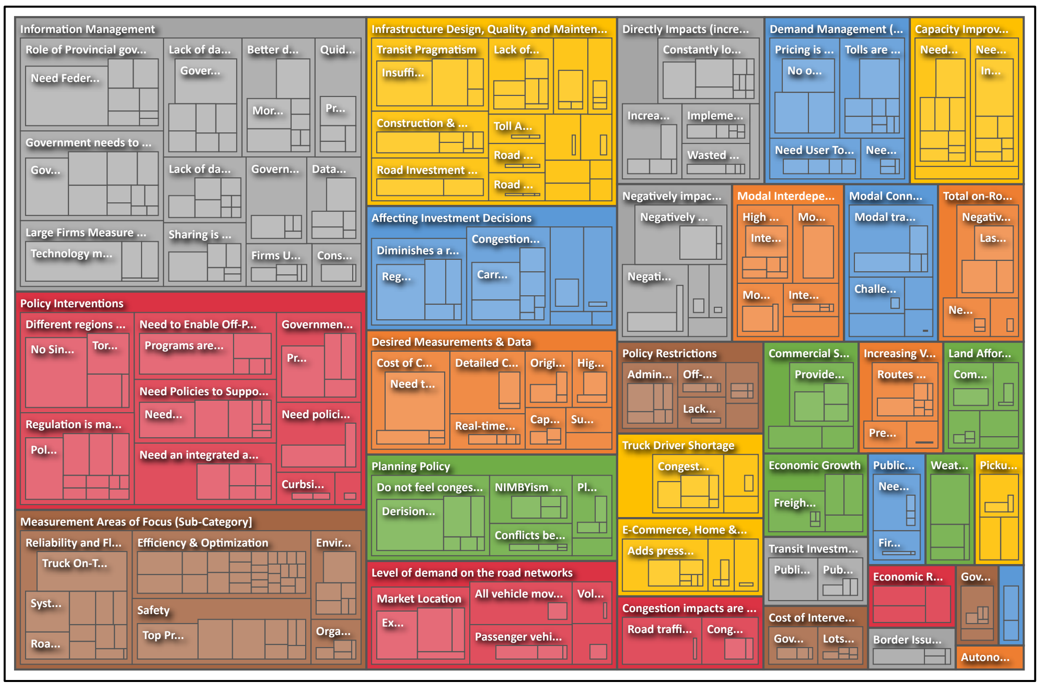


Figure Appendix C 8: An Iteration of the Axial Coding

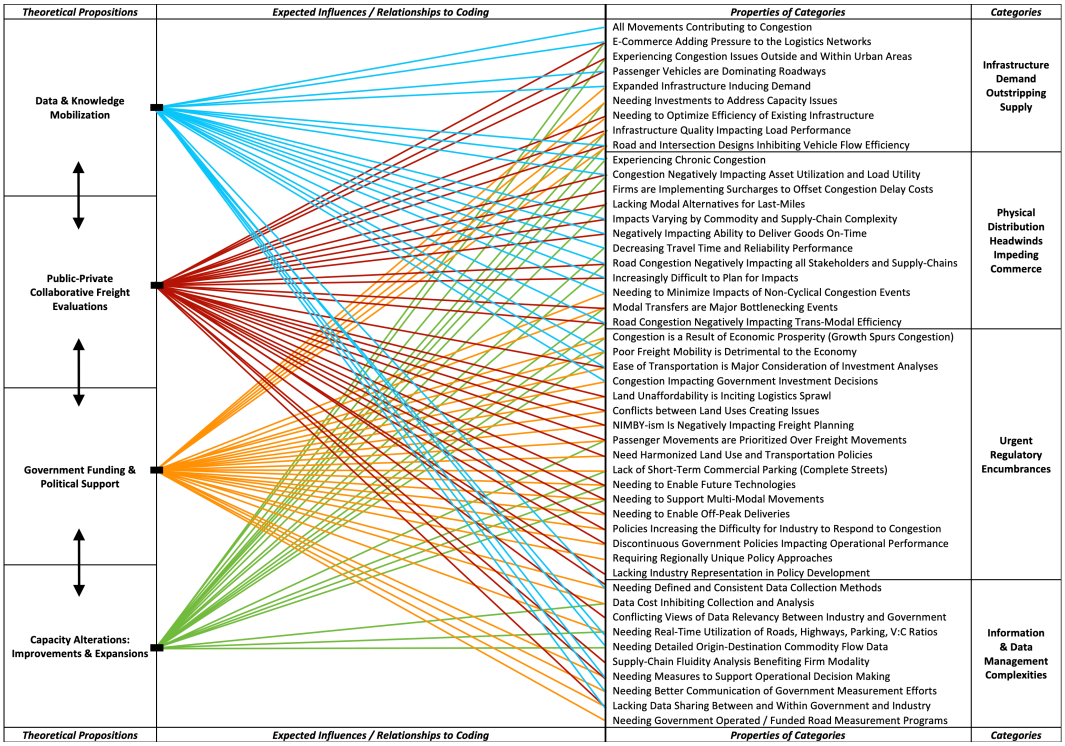


Figure Appendix C 9: Final Integrated Framework, from Chapter 7

Additional Resources

This appendix has provided a brief overview of the grounded theory process employed in this research but further and more technical information may be required for those researching or undertaking their own GT analysis. A word of caution, this is a deeply time-expensive process.

Depending on the approach and type of grounded theory analysis undertaken, including variations in the coding paradigm utilized there are a number of helpful resources and journal articles available. Of particular interest to current and future scholars may include: (Timmermans and Tavory, 2012), (Bryant et al., 2019), (Bryant and Charmaz, 2012), (Böhm et al., 2004), (Flick et al., 2014), (Charmaz, 2008), (Hernandez, 2009), (Roman et al., 2017), (John W. Creswell, 2009), and (Rieger, 2019).