

**Caught in Traffic:  
Road Congestion in Metro Vancouver and its  
Impact on Commercial Goods Movement**

**by**

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## **Abstract**

Congestion is a costly burden for the trucking industry, supply chains, and society as a whole. Despite the significant adverse effects of these costs on consumer prices, productivity, human health, and the environment, congestion's impacts on the movement of commercial goods is an understudied topic in Metro Vancouver. To help fill this void, this study investigates the costs of congestion for commercial goods movement. Original estimates conclude that the costs for the region in 2013 are between \$400 million and \$2 billion.

In the short-term, this study recommends that local and regional governments establish a pilot program to encourage and facilitate night-time deliveries. To address the systemic long-term issues of road congestion, local, regional, and provincial governments should collaboratively implement time-of-day tolls on the region's tunnels and bridges. Ultimately, these options will lower the costs of congestion and increase the reliability, efficiency, and sustainability of goods movement in Metro Vancouver.

**Keywords:** Road congestion; Metro Vancouver; commercial goods movement; trucking industry; road pricing

## **Dedication**

To my incredible parents who have given me unconditional love and support. I am forever grateful for the clothes on my back, food in my stomach, and the educational opportunities you've provided. Life lessons of hard work, putting family first, humility, and balance gave me tools to successfully complete 20 years of schooling. You pushed me when I didn't want budge, picked me up when I was down, and continually challenge me to be a better person.

I also dedicate this work to my loving brothers who toughened my skin and kept me out of trouble (or provided me with uncompromising accomplices). This work is also dedicated to my two loving grandfathers. The sacrifices you've made for our family and your contribution to the Nova Scotia community provide me with a lifetime of inspiration.

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## List of Acronyms

BCTA	British Columbia Trucking Association
CAC	Critical Air Contaminants
CO <sub>2</sub> e	Carbon Dioxide Equivalent
GHG	Greenhouse Gases
GPS	Global Positioning System
GVGC	Greater Vancouver Gateway Council
HOT	High Occupancy Tolloed lanes
HOV	High Occupancy Vehicle
MRN	Major Road Network
NO <sub>x</sub>	Nitrogen Oxide
OBD	On-Board Diagnostics
PM <sub>2.5</sub>	Particulate Matter up to 2.5 micrometers in size
PM <sub>10</sub>	Particulate Matter up to 10 micrometers in size
SFU	Simon Fraser University
SO <sub>2</sub>	Sulfur Dioxide
TEU	Twenty-foot Equivalent Unit
UCC	Urban Consolidation Centres
VKT	Vehicle Kilometre Travelled
VOC	Volatile Organic Compounds
VOT	Value of Time

## Glossary

Goods Movement	A catch-all term for the transportation of commercial goods and services, and refers to all of the deliveries and services that utilize the Metro Vancouver transportation network. It includes trips or deliveries that have their origin or destination inside the Metro Vancouver region. This might include a container chassis moving between marine ports, a local bike shop transporting inventory between locations, or a plumber driving to a job site. Goods movement also encompasses road freight moving inside and outside of the Metro Vancouver region.
Non-Recurrent Congestion	Congestion due to unexpected events typically caused by chance human error, or inclement weather.
Pacific Gateway Strategy	A strategy initiated by the Government of British Columbia (BC) to create an integrated network of rail, road, and aviation infrastructure to better facilitate people and goods movement. Partners include: the Government of Canada, CN Rail, Canadian Pacific, the Government of British Columbia, Government of Saskatchewan, Government of Alberta, Prince Rupert Port Authority, Vancouver Airport Authority, and Port Metro Vancouver.
Recurrent Congestion	Congestion that is endemic to the transportation system and occurs on a regular basis at predictable times.
Road Congestion	When the number of vehicles using a road exceeds the design capacity, resulting in flows below what is considered reasonable (Weisbrod, 2003). Transport Canada uses three different thresholds for its definition of congestion: when traffic moves at 50, 60, and 70 percent below the posted speed limits (Transport Canada, 2006).

## **Executive Summary**

The trucking industry is an essential component of modern urbanization, goods movement, and the Canadian economy. By its very nature, urbanization puts great distances between where food and consumer goods are produced and where they are delivered and consumed. Over 90 percent of all consumer goods in BC are, at one point, transported by truck. With increasing trade with Asia-Pacific markets, the trucking sector plays an especially important role in Metro Vancouver. The port terminals in Metro Vancouver are the busiest in the country (Port Metro Vancouver, 2013) and serve as integrated hubs for goods movement for Western Canada and the United States.

Worsening road congestion poses a significant challenge for maintaining an efficient and reliable transportation network in Metro Vancouver. Based on trends of population growth and urbanization, vehicle ownership, and demand for goods and services, road infrastructure in the region is becoming increasingly congested during peak periods of the day. Congestion is, in large part, driven by a mismatch in pricing signals where road users (both passenger and commercial vehicles) pay significantly less than the full social costs of driving. As a result, road networks are both underpriced and overused. Higher consumer prices, poorer air quality, higher accident risk, and the release of climate-change causing greenhouse gases are a sample of some of the impacts from worsening traffic.

While the impacts of congestion on passenger vehicles are well-studied, the full impacts to the trucking industry and goods movement are less known. Data collection on trucking activity is sparse, and Metro Vancouver lacks a comprehensive strategy to address road congestion. To create a renewed dialogue, this study investigates the costs of congestion for commercial goods movement and constructs original congestion cost estimates. Such research has not been attempted on a regional scale in nearly two decades; my aim is to help elucidate the scope and magnitude of congestion for commercial goods movement in Metro Vancouver.

Conservative estimates from this study indicate the costs of congestion for port container trucks in 2013 are between \$26 and \$56 million, or roughly \$13,000 to \$30,000 per truck. If the ports operate at full capacity (currently port terminals operate at roughly

65 percent capacity) congestion costs for container trucks jump to \$41–92 million. Notwithstanding some methodological limitations, adjusting this model to include all commercial trucks in Metro Vancouver reveals a cost of between \$417 million and \$2 billion in 2013. These costs estimates are not comprehensive and only include the cost of time delays, GHG emissions, and air pollution attributable to congestion.

Without concerted government action, the systemic impacts and costs from road congestion will continue to hamper goods movement in the region, adversely affecting businesses, consumers, citizens, and the natural environment. A general consensus is emerging in the region that something needs to be done about road congestion to reduce these costs. However, the options available to improve the flow of commercial goods are often overshadowed by broader discussions of mobility, transportation, accessibility, and affordability. These high level issues are important to consider, as any viable policy response must fit within the bigger picture, but the considerations for commercial goods movement are different from other road users and have clear economic consequences for the region.

Designing and implementing short- and long-term solutions is critical to the future of goods movement in the region. Based on my estimates, the private sector absorbs roughly 96–97 percent of commercial congestion costs directly, which are eventually passed onto consumers (albeit, the proportion absorbed by consumers is unknown). The remaining 3–4 percent is the cost to society in the form of GHG and air pollutants from commercial vehicles. What is more, these are conservative estimates and represent only a fraction of the full costs to firms, individuals, and the natural environment. With improved data, more rigorous scientific estimates can be constructed.

In the short-term, this study recommends that local and regional governments establish a pilot program to encourage and facilitate night-time deliveries. To address the systemic long-term issues of road congestion, local governments, Metro Vancouver, TransLink, and the Province should implement time-of-day tolls on all of the region's tunnels and bridges. Ultimately, these options will increase the reliability, efficiency, and sustainability of goods movement in Metro Vancouver.

Political and civic leadership will be instrumental for addressing road congestion in Metro Vancouver. The tools already exist and are proven to work effectively in other cities. Creating a night-time delivery pilot program and implementing regional infrastructure tolls have significant potential for optimizing road space for commercial vehicles and help build a more sustainable transportation system. Night-time delivery programs can be implemented relatively quickly and require minimal resources from government, and can also be implemented at the municipal or regional level. Road pricing, by comparison, is a tool the regional and provincial government should implement in the next five or six years to not only reduce existing toll inequities in the region, but to better optimize road space. This process should begin with public education, data collection, and shaping the overarching goals and objectives of a regional pricing scheme through consultation and engagement. Together, the recommendations from this study serve as a foundation for building a comprehensive strategy for addressing the Metro Vancouver's systemic congestion problem.

## Chapter 1. Introduction

The trucking industry is an essential component of modern urbanization, goods movement, and the Canadian economy. By its very nature, urbanization puts great distances between where consumer goods are produced and where they are delivered and consumed. Trains, ships, and airplanes are important components of intermodal goods movement, but the trucking industry offers distinct advantages which make it invaluable to urban communities, especially for the last kilometre of deliveries. The responsiveness and versatility of trucking has facilitated a growing demand for 'just-in-time' deliveries and flexible inventories amongst businesses, matched by consumers' expectations for immediate and reliable purchasing.

With increasing trade with Asia-Pacific markets, the trucking sector plays an important role in Metro Vancouver. The port terminals in Metro Vancouver are the busiest in the country (Port Metro Vancouver, 2013) and serve as integrated hubs for goods movement for Western Canada and the United States. Within highly complex and integrated supply chains, trucks in Metro Vancouver connect rail lines, airports, and ships with local and international markets. Growth in container volumes is projected to increase by 105 percent by 2020 (Pacific Gateway Transportation Strategy, 2012), which is expected to increase container traffic through BC ports by 300 percent (Smart Commercial Corridors, 2009).

Despite the sector's significant economic contribution, trucks adversely affect other road users, the natural environment, and transportation infrastructure. Compared to passenger vehicles, trucks are heavier, bigger, and emit higher levels of air pollution and greenhouse gases (GHG). Moreover, partially due to the inflexible schedules of supply chains (ports, shippers, and receivers), the majority of truck traffic in Metro Vancouver occurs between Monday and Friday during typical workday hours (L'Allier, 2012). In this sense, the trucking industry is both an asset and an impediment to the

regional transportation network and to the urban environment (Smart Commercial Corridors, 2009).

Worsening road congestion poses a significant challenge for maintaining an efficient and reliable transportation network in Metro Vancouver. Based on trends of population growth and urbanization, vehicle ownership, and demand for goods and services, road infrastructure in the region is becoming increasingly congested during peak periods of the day. Conservative estimates from this study indicate that the costs of congestion for port container trucks – which represent less than four percent of daily truck trips in Metro Vancouver – is between \$27 and \$60 million in 2013.<sup>1</sup> Notwithstanding some methodological limitations, if the model is extrapolated for all commercial goods movement, congestion costs in 2013 are between \$400 million and \$2 billion.

The effects of congestion for the trucking industry are significant and resonate throughout the entire economy. Congestion slows the movement of goods and services and inhibits the region's growth and development. Roughly 90 percent of all goods consumed in the province travel by truck (BCTA, 2013), and congestion acts as a direct cost to truck companies and other components of the supply chain. Ultimately, these higher transportation costs are passed on to consumers and businesses.

A potential solution for addressing road congestion is to build more capacity: more roads, tunnels, bridges, and highways. This approach, however, is unsustainable in many respects and only addresses a symptom of the bigger problem. From an engineering perspective, increasing capacity to accommodate road demand has negligible impacts on reducing long-term congestion (Saleh and Sammer 2009). Increasing infrastructure capacity encourages more road use where, in the long-run,

<sup>1</sup> This figure includes the cost of time delays and the incremental costs from the release of critical air contaminants and GHG due to congestion.

traffic flows return to prior levels of gridlock (Lindsey, 2007). Furthermore, building new capacity is constrained geographically in Metro Vancouver. Mountains, the US border, the agricultural land reserve, land-use development, and the Pacific Ocean limit new projects and place an increasing premium on scarce land.

The government and the private sector have invested billions of dollars in infrastructure in the past decade to expand capacity and reduce congestion on strategic corridors. Recent infrastructure improvements have helped alleviate some of the pressures on the road network, such as the construction of the Port Mann and Golden Ears bridges, and the South Fraser Perimeter Road. However, based on future projections, capacity improvements will have a negligible impact on reducing demand for road space in the long-term and add to the already high levels of GHG and air pollution from the transportation sector. Some industry stakeholders interviewed in this study acknowledge that the high levels of investment in recent years will diminish and, more importantly, that the region cannot build its way out of the problem. Aside from medium-term projects for replacing the Pattullo Bridge and George Massey Tunnel, the region may have to make do with the infrastructure it currently has.

Considering the pressures from population growth and increasing demand for road space, coupled with the supply-side constraints of building new infrastructure, optimizing road space is imperative in Metro Vancouver. While the impacts of congestion on passenger vehicles are well-studied, the impacts on the trucking industry and goods movement are less known. Due to the industry's diversity (differences in business structure, size, services, etc.), the effects of congestion on the trucking industry and supply chains are multifaceted. Data on truck movements serve as the starting point for understanding the depth and scope of congestion, yet region-wide (or even municipal) congestion data on goods movement is scant. The advancement of Global Positioning System (GPS) and On-Board Diagnostic (OBD) technologies have made data collection easier, but the trucking industry remains hesitant to release sensitive data on travel routes to maintain what they believe is their competitive advantage.

Without an informed understanding of the costs of congestion for the trucking industry, determining how to properly address traffic volumes or where to allocate road improvements is a formidable challenge (MetroLinx, 2011). This subsequently creates a

barrier to developing sound public policies to enhance optimization, efficiency, and overall reliability. The last comprehensive region-wide study which estimates the costs of congestion on goods movement was in 1996, completed by the BC Trucking Association (BCTA). The study is still commonly cited as a baseline for congestion estimates for the trucking sector, despite being nearly two decades old. To this date, Metro Vancouver is without a comprehensive congestion reduction strategy for both passenger and freight vehicles.

The policy problem which I investigate is that without better data collection and information, and without comprehensive measures to reduce road congestion, the systemic impacts from traffic will continue to hamper goods movement in the region. This includes a range of adverse effects to businesses, consumers, citizens, and the natural environment. To help understand the scope and magnitude of these impacts in Metro Vancouver, this study investigates the private and social costs of congestion on the movement of trucks in the region, similar to the cost estimates provided by the BCTA's 1996 study.<sup>2</sup> To capture and quantify some of these impacts, port container trucks are used as a proxy for the trucking industry as a whole. Port container trips are the only sub-section of the trucking industry in Metro Vancouver with robust, reliable, and publicly available data. Although port container trucks represent less than four percent of total trucking activity in the region (Bickel et al., 2002), the costs of container trucks serve as an indicator for the scope and magnitude of congestion costs for all commercial goods movement in Metro Vancouver.<sup>3</sup>

The cost estimates in this study include the cost of time delay (measured by driver wages, vehicle costs, and congestion premiums), the incremental social cost of

<sup>2</sup> It should be noted that the BCTA's methodology for its 1996 study is unavailable. Therefore, the results of my study should not be compared with the estimates of the BCTA.

<sup>3</sup> This figure represents the most recent statistic for port trucks as a percentage of all commercial goods movement. The four percent figure comprises port trucks, airport cargo, and inter-modal yards.

GHG emissions, and the incremental damage costs from critical air contaminants (CAC). To reflect the uncertainty in some of these costs (e.g. the social cost of one tonne of carbon dioxide) several different scenarios are used. Other costs of congestion are discussed, but not monetized.

To provide regional context and perspective, nine semi-structured interviews with key industry stakeholders were conducted. Based on the academic literature and my cost estimates, a set of criteria and measures are developed to help evaluate the options available to government, culminating with a set of recommendations. In the short-term, this study recommends that local and regional governments establish a pilot program to encourage and facilitate night-time deliveries. To address the systemic long-term issues of road congestion, local governments, Metro Vancouver, TransLink, and the Province should implement time-of-day tolls on all of the region's tunnels and bridges. Ultimately, these options provide government with a portfolio strategy to increase the reliability, efficiency, and sustainability of goods movement in Metro Vancouver.

Chapter 2 provides background information on the regional context and a snapshot of the trucking industry in the province, in addition to discussing the issue of congestion and its impact on goods movement. Chapter 3 delineates the quantitative and qualitative methodologies used to investigate the policy problem; Chapters 4 and 5 discuss the results from this research. A series of criteria and measures are tabled and discussed in Chapter 6, which are used to evaluate the policy options described in Chapter 7. The analysis of each option is presented in Chapter 8, which includes an explanation of how the options are evaluated and ranked. My study concludes with recommendations for government in Chapter 9, and general conclusions in Chapter 10. The appendices include supplementary information and are referenced throughout the paper.

## **Chapter 2. Congested and Nowhere to Go**

Road congestion is a complex problem. From an engineering and governmental perspective, keeping the vast network of roads, bridges, tunnels, and highways in a state of good repair is a constant challenge, as well as ensuring smooth traffic flows. From a road user's perspective, the transportation network serves as a medium for getting from point A to point B, involving the interests of hundreds of thousands of users, all competing for the same road space. The transport needs of the trucking industry are drastically different from those of the average driver or transit rider. Within the commercial goods sector, interests and needs differ across companies. Compounding these complex interests is the fact that transportation policy is a shared responsibility of all levels of government which often acts as a barrier for policy development.

To provide context of the transportation network in Metro Vancouver and the problem of congestion for commercial goods movement, this Chapter discusses: the transportation regulatory environment; a snapshot of the trucking industry; the private and social costs of congestion; and, the lack of sufficient traffic data.

### **2.1. Regional Context**

Metro Vancouver, also referred to as the Lower Mainland, is located on the southwest coast of British Columbia. The region comprises of 21 municipalities, one electoral district, and one treaty First Nation, with a total population of 2.3 million residents. The population is concentrated in several notable municipalities; the combined population of the City of Vancouver, Burnaby, and Surrey represent over half of the total population (Statistics Canada, 2011). The region is characterized by several geographical constraints: it abuts the United States border in the south, mountains to the north, and the Pacific Ocean in the west. In total, the landmass of Metro Vancouver covers 2,883km<sup>2</sup> and is shared between residential, commercial, and industrial land-use,

with 21 percent protected under the Agricultural Land Reserve (Metro Vancouver, 2011). The region has multiple water crossings, connected by 22 bridges and two major tunnels (the Cassiar and Massey), and is one of few cities without a freeway in its downtown core. Four major highways connect the region, but are primarily located on the periphery, illustrated by the blue roads in Figure 2.1.

The region has four container port terminals which are spread across the region (Figure 2.1). They include: Delta Port (located in southwest tip of the region), VanTerm and CenTerm (located in the downtown core of Vancouver on the Burrard Inlet), and Fraser-Surrey Docks (located on the Fraser River). The ports play an important role in the Metro Vancouver economy and act as a hub for international trade. The overarching strategy for port growth in Metro Vancouver is guided by the Pacific Gateway Strategy. Led by the Government of British Columbia (BC), the Gateway Strategy is designed to create an integrated network of rail, road, and aviation infrastructure to better facilitate people and goods movement. To date, roughly \$22 billion has been invested by public-private partnerships, designated for port, road, rail and airport infrastructure (Pacific Gateway Transportation Strategy, 2012).

The main truck routes in Metro Vancouver include Knight Street, Southeast Marine Drive, Grandview Highway, Boundary Road, the Port Mann and Highway 1 corridor, the South and North Fraser Perimeter roads, and the South Shore Trade area (Bickel et al., 2002 and L'Allier, 2012).

## **2.2. Transportation Network and Governance**

Transportation policies and problems therein are largely dependent on the unique geographic, demographic, and land-use characteristics of a region, and also by the regulatory framework of government. Each of these factors plays a significant role in the evolution of Metro Vancouver's road transportation network and commercial goods movement. The following is a brief description of the transportation responsibilities at each level of governance:

**Federal Government:** in terms of the movement of goods and services, Transport Canada is primarily responsible for the rail network, the transportation

of dangerous goods, and marine safety. More specifically, the federal government is responsible for regulating container port terminals and providing funding to the province. Port Metro Vancouver (a crown corporation established by the Government of Canada) is responsible for the operation and development of the four container terminals in Metro Vancouver.

**Provincial government:** the Ministry of Transportation and Infrastructure is responsible for planning the region's transportation network and is directly responsible for the maintenance of the provincial highway network (illustrated by the blue roads in Figures 2.1 and 2.2). The Ministry is also responsible for administering legislation, regulation, and federal-provincial funding programs.

**TransLink:** was created in 1999 as the regional transportation authority for Metro Vancouver and is designated with a wide range of authority. TransLink has authority over the public transportation network, emissions testing, regional transportation growth planning, and four of the region's 22 bridges. TransLink also shares authority over the Major Road Network (MRN). The MRN includes regional highways and strategic municipal arterial roads, and serves as the main network of designated truck routes in Metro Vancouver. The municipalities own and operate the MRN, but TransLink provides funding for its operations, maintenance, and rehabilitation (TransLink, 2014). Regulatory authority to restrict or limit truck movements is shared between TransLink and the provincial Commercial Vehicle Safety Enforcement Branch and each of the 23 local governments (Cook et al., 2010).

**Metro Vancouver (Greater Vancouver Regional District):** is a political body and corporate entity representing the 23 local governments in the region. Metro Vancouver does not have jurisdiction over transportation; however, its political leadership helps coordinate policy between local and provincial government.

**Local governments:** are responsible for the maintenance and construction of municipal roadways (excluding provincial highways), and play an important role in creating municipal transportation plans. Local governments share their planning with TransLink and the province, and receive direct funds from

TransLink for the MRN. The municipal trucking routes are illustrated by the orange roads in Figures 2.1 and 2.2.

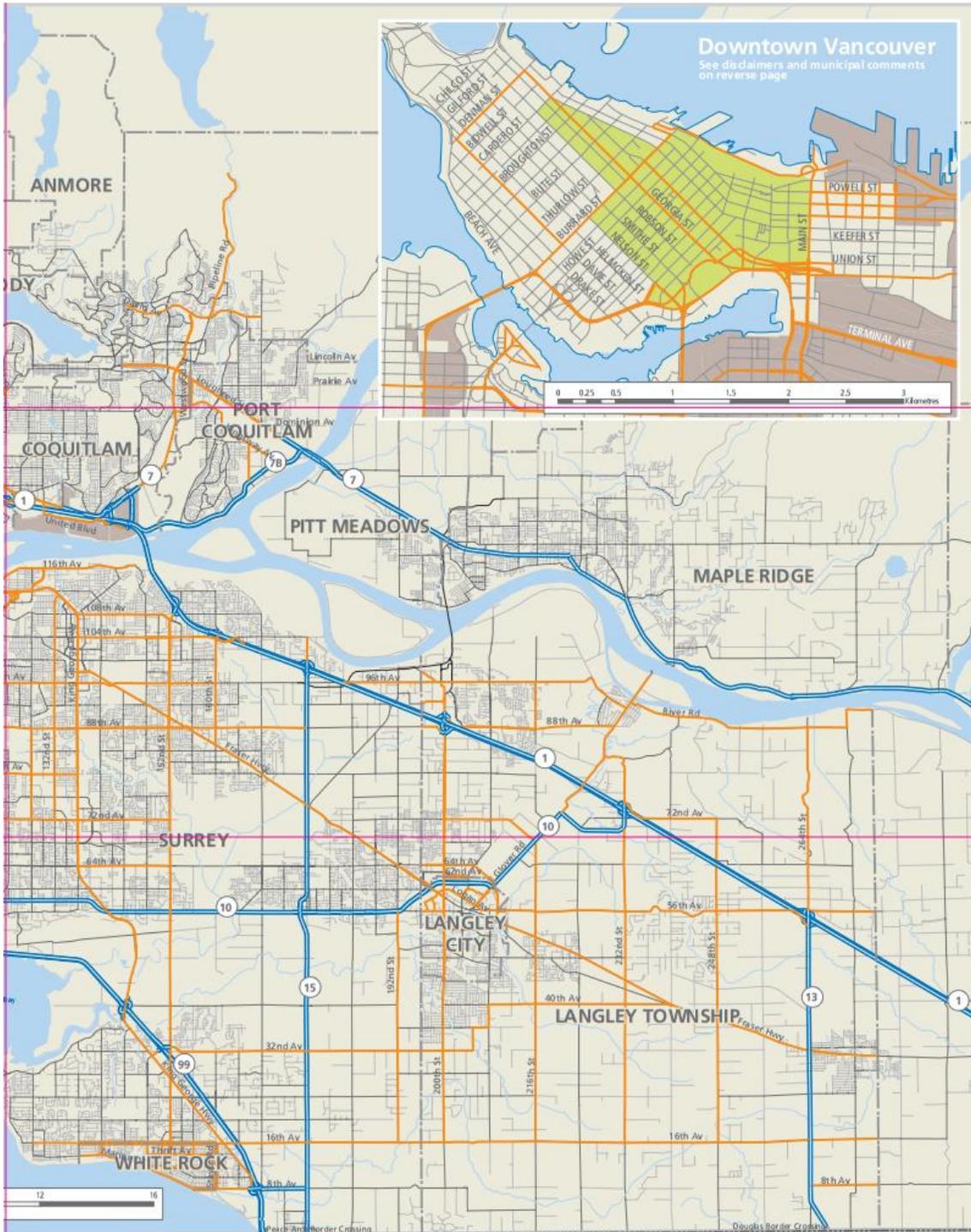
As illustrated by the outline of responsibilities, authority over transportation policy is both shared and fragmented in Metro Vancouver. Authority is shared in the sense that considerable overlap exists between municipal, regional, and provincial government; and fragmented in the sense that overlapping jurisdiction can lead to conflict and inaction. Historically, the governance and regulatory framework has made coordination and collaboration difficult. TransLink alludes to some of these challenges in its recent background report on goods movement, noting that the current institutional framework features “underdeveloped mechanisms to facilitate consensus-building, joint policy development, and public-private cooperation with respect to goods movement” (TransLink, 2013).

**Figure 2.1. Major Trucking Routes in Metro Vancouver (west half)**



Note. Reprinted with the permission of TransLink (November 19, 2013).

Figure 2.2. Major Trucking Routes in Metro Vancouver (east half)



Note. Reprinted with the permission of TransLink (November 19, 2013).

## 2.3. Industry Profile

The trucking industry in British Columbia is diverse and heterogeneous. Over 26,000 trucking companies operate in BC, with varying business structures, fleet sizes, cargoes, and operating schedules (BCTA, 2013). In Metro Vancouver, the size of trucking companies range from a fleet of one or two trucks, to hundreds for major companies.

The trucking industry is categorized by two types of businesses: private and for-hire companies. Private fleets are owned and operated by individual businesses and are vertically integrated within firms' supply chains, offering in-house goods movement. Privately owned companies range from multinational corporations (such as Canadian Tire, Esso, Wal-Mart, etc.) to local business that uses a single vehicle to transport inventory. Private companies represent roughly 85 percent of trucking activity in Canadian urban areas, typically comprised of small fleets that travel relatively short distances (L'Allier, 2012).

The primary focus of for-hire trucking companies is moving goods and services for other businesses. These companies are typically less flexible than privately owned companies (Holguín-Veras, 2008), as they are bound to the schedules of their clients. For-hire trucking services can also be managed through freight forwarders, who act as brokers between the shipper and the carrier. For-hire companies represent roughly 50 percent of the trucking industry for trips over 200 km in Canada, and 90 percent for trips over 2000 km (L'Allier, 2012).<sup>4</sup>

<sup>4</sup> A more in-depth overview of the trucking industry and some of the key local and international issues facing the industry are included in Appendix A (such as the industry's labour shortage, high turnover, high fuel prices, macroeconomic pressures, high land values, etc.).

## 2.4. Congestion in Metro Vancouver

Whether looking at commercial or at passenger vehicle travel, road congestion is a serious problem in Metro Vancouver. The most recent region-wide study on congestion in Metro Vancouver is the Travel Time Survey, commissioned by TransLink in 2003. The study tracked GPS movements on 20 passenger vehicles and collected information on the traffic speeds for 14 major routes during peak travel periods.<sup>5</sup> The main findings include:

- Trip travel time and average speeds are highly variable on most routes.
- Roughly one-quarter of the routes surveyed experienced speeds 60 percent below the posted speed limits.
- The bridges crossing the Fraser River experience the worst congestion during peak periods, with travel speeds between 0 and 60 percent of the posted speed limit.
- Traffic during mid-day (Monday-Friday) on some routes experienced higher levels of congestion than during peak morning hours, indicating a saturation point for certain roadways.
- High levels of congestion and variability in travel speeds suggest certain routes operate above capacity for the majority of the regular working week.

Although this study is 10-years old, recent indicators provide supporting evidence for worsening congestion in the Lower Mainland. Among the best indicators are population growth and vehicle ownership. The population of Metro Vancouver grew by 14 percent between 1999 and 2011, matched by a 23 percent increase in the number of licensed passenger vehicles and a 19 percent increase in commercial vehicles (BC Statistics, 2012). Most notably, the number of licensed medium-duty trucks (with a weight between 4.5 and 14.9 tonnes) increased by 120 percent from 2000 to 2009 (L'Allier, 2012).

<sup>5</sup> Four time-periods were used: Peak AM (7-9am), Mid-day (11am-1pm), Peak PM (3-6pm), and midday Saturday (12-2pm). Many of the routes in TransLink's study are on the major trucking routes identified in Figure 2.1.

As a direct impact of having more vehicles on the road, levels of congestion from 2002–2007 increased by 14 percent. Overall travel times increased by 30 percent from 1998–2008 (BC Ministry of Transport, 2007); though some of this increase was from an increase in commuting distance. Technical reports are supported by public opinion, as one-quarter of commuters in Metro Vancouver claim they are caught in traffic jams every day of the week (Statistics Canada, 2010).

Looking ahead, population growth will be the driving force for levels of congestion. From a demand perspective, the regional population is expected to grow by an additional 1.2 million residents by 2041 (based on the population in 2006). Based on 2002 traffic levels, preliminary modeling by TransLink estimates that this increase in demand could cause the proportion of severe congestion to increase by 120 percent by 2021 (Metro Vancouver, 2009). Similar statistics from the Greater Vancouver Gateway Council predict that population growth will cause the number of overall vehicle trips during the morning peak to increase by 39 percent from 1999 to 2021 (Delcan, 2003).

As the regional population grows, so too will the demand for goods and services. By 2030, the expected growth from the ports will increase container truck trips by 0.8–1.3 million based on 2005 projections (GVGC, 2007). The three biggest container terminals in Port Metro Vancouver (CenTerm, VanTerm, and DeltaPort) are expanding capacity and have invested billions to improve the efficiency and utilization of port operations. DeltaPort, for example, which handles roughly 70 percent of all containerized imports coming into Port Metro Vancouver, is expected to increase its capacity by 25 percent by 2014 (Port of Metro Vancouver, 2013). Moreover, major trucking routes connecting DeltaPort with the rest of the region cut directly through the Fraser River crossings and the areas with the highest rates of projected population growth.

In addition there is a projected increase in the number of trucking trips from non-port related activity. The Transportation Research Board (2007) estimates overall levels of trucking activity will increase by 50 percent by 2021 from 2001 levels. This includes businesses that use the road network to transport stock and inventory between store locations and/or warehouses in addition to port-related activity. As noted by Weisbrod and Fitzroy (2012), impacts from congestion and market growth will necessitate “more inventory as well as more drivers and vehicles.”

Despite rising levels of congestion, the Pacific Gateway initiative, stimulus spending, and Olympic spending have helped reduce levels of congestion in strategic locations. While the precise offsetting impact of these improvements on congestion is unknown, rising levels of congestion illustrate that demand for road space outweighs capacity. Compounding the problem, the region faces a substantial infrastructure deficit whereby upgrading and general maintenance has failed to keep pace with demand (BC Ministry of Transport, 2007).<sup>6</sup> Subsequently, many of the region's bridges, highways, and roads are approaching replacement age and are prone to bottlenecks.

The capacity to build new infrastructure in Metro Vancouver is limited. In addition to the geographical and practical constraints, the region faces considerable financial constraints for providing new investment. One of the primary reasons is declining fuel tax revenue. Fuel taxes are the traditional instrument for financing infrastructure projects and are declining due to increases in fuel efficiency, electric and hybrid vehicle sales, and leakages to other jurisdictions (TransLink, 2013).

Taken in concert, the rapid increase in demand for road space is outpacing the region's capacity to finance and build new infrastructure (Arnold, 2013). With a limited supply of road space, all indicators point towards worsening congestion in the future for both passenger and commercial vehicles. But unlike passenger travellers who have more options to shift to public or active forms of transportation, or drive during off-peak periods, commercial freight does not have the same flexibility. If no action is taken to optimize existing road space, the trucking industry and the movement of goods and services will bear the brunt of worsening congestion, causing adverse impacts to other road users, consumers, and the environment.

<sup>6</sup> Estimating the exact size of the Metro Vancouver's transportation infrastructure deficit is challenging; the deficit includes investments required to maintain the existing road network and capacity upgrades to meet increasing demand. The infrastructure deficit is spread amongst municipal, regional, provincial, and federal governments, and no organization to date has attempted to tabulate the shortfalls in investment spending at each level.

One potential question is whether congestion in Metro Vancouver and its impacts on commercial goods movement is an issue warranting government intervention or if the issue is better left to the private sector. To argue that government has a limited role to better manage congestion, however, fails to recognize the significant market failure inherent with the transportation system. Road congestion, by its very nature, is a collective action problem where “everyone would like to see a particular outcome (a reduction in traffic) but no one has the incentive to do what is necessary in order to bring it about” (Heath and Potter, 2004). This outcome is primarily due to the combination of rational self-interest (driving where/when is suitable to the individual or business) and a lack of pricing incentives. Mismatches in pricing signals produce road networks that are both underpriced and overused, whereby road users (both passenger and commercial vehicles) pay significantly less than the full social costs of building/maintaining roads.

When including the environmental, social, and economic consequences of congestion, drivers pay an estimated two-thirds of the full costs of driving (Victoria Transport Policy Institute, 2009). This pricing distortion has led to the common misconception of the road network being ‘free’ to use and does little to discourage motor vehicle use, especially during peak periods. While the private sector may be able to manage traffic times and route choice at the margin, congestion is a systemic problem that will not go away on its own. As such, government (provincial, regional, and municipal) have responsibility to improve the efficiency and reliability of the road network through optimizing the existing infrastructure in the region.

## **2.5. Private Costs of Congestion**

The costs of congestion are significant for the trucking industry, the economy, and society as a whole. For the trucking industry, the private costs of congestion result in wasted time, extra fuel, higher risk of accidents, lost productivity, and lower employee morale. Most of these private costs are internalized within the trucking industry and increase the overall costs of doing business. In this sense, congestion acts as a hidden tax on goods and services—absorbed by business and eventually passed onto consumers.

Despite the dearth of quantitative data on regional trucking movements, industry has a good understanding of how congestion affects the trucking industry and supply chains more broadly. At a high level, delay and variability in delivery times have a domino effect on economic competitiveness and efficiency (Greater Vancouver Gateway Council, 2007). Missed deadlines, wasted time sitting in traffic, increased vehicle maintenance costs, extra fuel, and worker fatigue are a sampling of how congestion inhibits goods movement.

A recent study by the Economic Development Research Group Inc. provides valuable insight into some of the micro and macroeconomic impacts of congestion. The study draws on the findings from research conducted by the Greater Vancouver Gateway Council, Chicago Metropolis 2020, and the Portland Business Council and Oregon Business Alliance (Weisbrod and Fitzroy, 2012). The key findings are summarized in Table 2.1.

**Table 2.1. The Business and Economic Impacts of Congestion for Supply Chains**

Type of Impact	Business and Economic Implications
<b>Market and Fleet Size</b>	<ul style="list-style-type: none"> <li>• Shrinks delivery area that can be served by trucking companies</li> <li>• Necessitates more commercial vehicles, drivers, and total trips</li> <li>• Greater unpredictability of shipping routes, causing ‘on the fly’ rerouting</li> <li>• Increase delivery costs, including labour and fuel</li> <li>• Increased inventories for businesses with “chronic delivery problems”</li> </ul>
<b>Business and Delivery Schedules</b>	<ul style="list-style-type: none"> <li>• Reduces the possibility of late afternoon deliveries due to heavy congestion</li> <li>• Forces shifts to start earlier in the morning for the trucking industry and receivers</li> <li>• Opportunities to adjust schedules and business operations to avoid congestion are becoming smaller</li> </ul>
<b>Intermodal Connections</b>	<ul style="list-style-type: none"> <li>• Industrial parks moving further from urban cores to avoid congestion, increasing the total number of freight vehicles and the average trip distance</li> <li>• The reliability of time sensitive air cargo is compromised due to large congested areas between the urban core and major airports</li> <li>• Missed or delayed deliveries at ports, resulting in “additional driver and vehicle scheduling, time reservation and operating costs</li> </ul>
<b>Business Inventory</b>	<ul style="list-style-type: none"> <li>• Increased inventory requirements and potential loss in sales</li> <li>• Added retail stocking and inventory management costs</li> <li>• Reduced cross-docking opportunities (matching incoming &amp; outgoing deliveries)</li> </ul>

Type of Impact	Business and Economic Implications
Worker Shifts	<ul style="list-style-type: none"> <li>• Earlier AM shifts place greater burden on workers (fewer transit options)</li> <li>• Increase in congestion-related delays for workers</li> <li>• Increases in employer paid business travel</li> </ul>
Business Location	<ul style="list-style-type: none"> <li>• Congestion limits the size of labour markets and freight delivery markets</li> <li>• Affects the location and/or relocation of distribution and production centres</li> </ul>

Weisbrod and Fitzroy (2012) highlight the extensive ripple effects from road congestion on commercial goods movement. A time delay for delivery trucks is felt by each component of the supply chain, including the intermodal connections, receivers, and retail businesses. In the long-run, these inefficiencies affect the decision-making of supply chains, including the assessment of “opportunities, risks and returns associated with location, production and distribution decisions” (Weisbrod and Fitzroy, 2012).

## 2.6. Congestion’s Burden on Society

A large portion of congestion costs from trucking are not internalized within supply chains and are borne by society. Increases in GHG emissions, air and noise pollution, longer delays for travelers, higher accident risk, and reductions in safety for pedestrians and cyclists are some of the major externalities associated with trucking activity. Other negative impacts of congestion are less obvious such as higher insurance premiums, increased likelihood of obesity, aggression and stress, and an overall negative impact on personal health and well-being. These external impacts carry a significant cost; they erode the liveability of the urban environment and burden the healthcare system (Frank et al., 2004).

The global environmental impacts from freight activity are significant and growing in magnitude. Transportation emissions account for roughly 23 percent of global emissions and 38 percent of BC emissions (Dalmer and Arnold, 2013), and represent the “greatest contributor to atmospheric warming” (Unger et al., 2011). While gains in efficiency are expected in the coming decades, the increase in transport activity is expected to outweigh fuel-efficiency improvements, as trucks have the highest ratio of GHG emissions per tonne-km compared with all modes of freight transport (L’Allier, 2012).

Beyond simply recognizing the existence of the social impacts from congestion, delineating and estimating their precise monetary costs is challenging. The adverse effects from passenger vehicle and trucking activity are difficult to quantify and measure, especially when attempting to measure the incremental impact from congestion. Unlike some of the private costs of congestion, the personal and environmental impacts cannot be valued using market prices. Damage cost estimates (which use proxy indicators to estimate monetary impacts) are suitable for some impacts, such as GHG emissions and air pollution; however, disaggregated and qualitative approaches are more appropriate for impacts such as noise pollution and land-use.

## **2.7. A Dearth of Data**

Transport Canada is one of few organizations that attempt to estimate the economic and social costs of congestion. From its most recent estimate in 2008, Transport Canada concluded the total costs of congestion in Canada's 11 biggest cities are between \$6 and \$9 billion (in 2013 dollars). In Metro Vancouver, the estimate is \$0.9–\$1.5 billion (2013 dollars).

As noted by Transport Canada, these estimates greatly understate the total impacts. The estimates only include the costs of passenger vehicles, measured by the time-costs spent in congestion, the costs of fuel, and GHG emissions. The impacts from commercial goods movement are not included, nor are the costs of air and noise pollution, health impacts, and wider economic effects (such as lost productivity, employment, and foregone economic activity). As with other studies on congestion, estimates are constrained by the methodological challenges of quantifying and monetizing the social and environmental impacts of congestion.

Demonstrated by the limitations of Transport Canada's work, estimating the costs of congestion is fraught with technical and theoretical challenges. These challenges are even more pronounced for measuring the impacts of congestion on the trucking industry. Researchers have studied the impacts of congestion on passenger vehicles since the 1960s, but the study of congestion and its effects on goods movement has largely remained a back-issue in academic, industry, and government research. The last study

specifically looking at the trucking industry in Metro Vancouver was commissioned in 1996 by the BCTA, which estimated the annual costs of congestion at roughly \$750 million for the province (BCTA, 2013).

Despite the magnitude of the impacts from congestion on goods movement, comprehensive data on truck volumes, origins, destinations, and delays is sparse in Metro Vancouver and in other cities/regions. This lack of valuable data gives decision-makers an incomplete view of the industry (Metrolinx, 2011). Without a clear or comprehensive understanding of commercial goods movement, designing effective public policy is a difficult task. By using the small amount of publicly available data, the following chapters aim to fill this void.

## **Chapter 3. Methodology**

As identified in the introduction, part of the policy problem is a clear lack of data and analysis on congestion in Metro Vancouver, and an insufficient understanding of its cost implications for commercial goods. The second component of the problem is an absence of congestion-reducing policies to improve the efficiency and sustainability of the road network. To evaluate and monetize the impacts of road congestion for goods movement in Metro Vancouver, and to explore policy tools in greater depth, this study uses three research methods: theoretical literature and illustrative cases from other cities, costing estimates and semi-structured interviews.

### **3.1. Literature Review & Case Studies**

The government has a wide range of policy tools that can be used to address road congestion for commercial (and passenger) vehicles. To help narrow the list of viable policy tools in Metro Vancouver, I consulted literature from a broad range of academic journals and illustrative case studies. Case studies include:

- Night-time delivery programs in New York City, Spain, and the Netherlands.
- Road pricing schemes in Germany, Stockholm, London, Singapore, and Oregon.
- Urban freight consolidation centres in Europe and New York
- Truck priority infrastructure projects in Vancouver, Ottawa, and the US

The information from these case studies, coupled with information from the academic literature, is used to help evaluate and assess the policy options (Chapter 6 and 7). These sources are also used for developing the costing methodology and the semi-structured interview questions.

## 3.2. Cost Estimates

A cost estimation model is developed in this study to highlight the magnitude of the private and social costs from congestion on commercial goods movement in Metro Vancouver. The costing model attaches monetary values to some of the adverse impacts and provides a clearer comparison between the different cost components.

Due to a lack of available data on commercial truck movements in Metro Vancouver, the costing model only includes port container truck activity. Although this is an incomplete metric for commercial goods movement, the costs associated with container trucks offer a glimpse into the magnitude of the problem. The container truck industry is homogenous and has publicly available data on drayage, travel movements, and emissions (Port of Metro Vancouver, 2013), and is well-tracked through the Port of Metro Vancouver, the Chamber of Shipping of BC, and the BCTA.

This study uses three costing scenarios to provide a range of total costs. Scenario one is based on low-range estimates for the average time delay, value of time, the social cost of carbon; scenario two uses middle or mean values; and scenario three represents upper bound estimates. The estimated values for each scenario are based on multiple sources of scientific literature. The cost estimates for port container trucks include three accounts: value of time, cost of GHG emissions, and the cost of critical air contaminants. Attempts to estimate the incremental costs from congestion for each account are as follows:

**Time lost from delays:** measures the opportunity cost of lost time for truckers and trucking companies. This measure also includes some of the wider economic impacts discussed in Table 2.1. Unlike valuing the costs of commuting or business travel, commercial goods movement involves not just the opportunity cost of the driver's time, but also operating costs and the value of goods being transported. For these reasons, the values of time (VOT) for commercial vehicles are higher than for commuters and business travel, and are based on more robust measures, such as fuel and wage costs.

Estimates for the VOT are dependent on the type of vehicle and cargo, but conventional VOT estimates for commercial activity in Canada range between

\$36 and \$95 per hour (Greater Vancouver Gateway Council, 2003).<sup>7</sup> The lower bound estimates typically include vehicle operating costs (fuel, repairs, etc.) and driver wages/benefits, while upper bound estimates include cost premiums for “added logistics, scheduling and productivity impacts” from congestion delays (Greater Vancouver Gateway Council, 2003).

This study uses the hourly variable costs of a six-axle container truck chassis as the baseline value for the opportunity cost of congestion. According to Transport Canada’s Trucking Cost Estimates for British Columbia (2010) the hourly variable cost is \$56/hour, which includes driver wages, fuel, repairs, etc. In 2013 dollars, this value increases to \$58/hour.

In addition to the hourly VOT, a premium is added to capture some of the productivity and scheduling costs associated with congestion. The suggested congestion premium from the Greater Vancouver Gateway Council of \$50 (2002 dollars) is used in this study. To adjust values in 2013 dollars, the congestion premium increases to \$60.

**Adding together the total variable costs (\$58) with the congestion premium (\$60), the baseline VOT for the costing model (Scenario 1) is \$118 per hour.**

Based on national and international literature, conventional estimates for commercial truck VOT may underestimate the full impacts of road congestion. In a study by Roeolfs and Springer (2007), where greater weight is given to the value of the cargo being transported, estimates for commercial VOT are as high as \$194/hour (Roeolfs and Springer, 2007). Similar estimates by William Waters (1992) suggest taking the total variable costs for heavy commercial trucks and multiplying them by 170 percent to reflect the economic impacts from congestion

<sup>7</sup> These VOT estimates are listed in 2002 dollars.

(Victoria Transport Policy Institute, 2013). Using the total variable cost for a 6-axle container chassis in 2010, this amounts to a cost per hour of \$151 ( $\$56 \times 2.7$ ). In 2013 dollars (adjusted for inflation between 2010 and 2013), this equals \$156 ( $151 \times 1.034$ ).

**Although some authors suggest using a value of time for commercial vehicles of roughly \$200/hour, the more conservative figure of \$156 will be used as the upper bound estimate (Scenario 3). The second scenario in the costing model takes an average of the two VOT estimates (\$137/hour).**

**GHG Emissions:** In order to calculate the cost of GHG emissions, the incremental amount of fuel burned in congestion for container trucks is first estimated. To estimate this incremental amount, the average trip delay serves as the reference point. The average delay is used to calculate the total distance that each truck spends in congested conditions for each trip. This is calculated by using an average speed of 8 km/hr., taken as the mean value for what the US Department of Transportation deems a 'creeping' speed (between 0–16 km/hr.). The 'creeping' speed is also used to estimate the range of CO<sub>2</sub>e emissions for container trucks (U.S. Federal Highway Administration, 2013).

The average distance spent in congestion per trip is multiplied by the total number of trips per day to estimate the total distance spent in congested conditions for all port container trucks in Metro Vancouver. This daily estimation is then extrapolated on an annual basis, multiplying the value by 310 working days.<sup>8</sup> To estimate the total emissions of carbon dioxide equivalent, the conversion rates from the US DOT are used to measure CO<sub>2</sub>e in grams per mile, which are then converted into tonnes per kilometre.

<sup>8</sup> The ports are not open on Sundays; 310 working days per year reflects a six-day workweek.

Based on the yearly CO<sub>2</sub>e emissions for port container trucks attributable to road congestion (in total tonnes), three different values for the social cost of carbon dioxide equivalent are used to estimate the monetary value.

Estimating the social cost of carbon is complex and is dependent on discount rates, predicted future impacts, and the jurisdiction under consideration. Generally, the cost of carbon is expected to increase over time as the impacts from climate change intensify (EPA, 2013). For the purposes of this paper, a wide range of values (reflected in each scenario) is taken based on the most recent estimates by the US Environmental Protection Agency. The values used for the cost model (Table 3.1) represent the social cost of carbon from a global perspective, ranging from \$40 to \$120 in 2013 dollars (EPA, 2013).<sup>9</sup> The value of the SCC can be changed over time to reflect the accuracy of scientific models.

**Table 3.1 Social Cost of Carbon Values**

	Scenario 1	Scenario 2	Scenario 3
Social Cost of Carbon (\$/per tonne)	\$40	\$63	\$120

**Air contaminants:** due to extensive air quality impacts from diesel fuel emissions, this study captures the monetary costs associated with five major air contaminants: Nitrous Oxide (NO<sub>x</sub>), Sulfur Dioxide (SO<sub>2</sub>), Volatile Organic Compounds (VOCs), and two types of particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>). Similar to measuring GHGs, the price associated with air contaminants is based on the social impacts from emissions, estimated by calculating the health and environmental costs attributed to marginal increases in air contaminants.

<sup>9</sup> The BC Carbon tax is not included within the fuel estimates in Transport Canada's *Operating Cost of Trucking*, therefore the social cost of carbon values in Table 3.1 represent the total external cost of the fuel from congestion.

The monetary values for CACs are based on a 2011 study by the European Environmental Agency (EEA), entitled “Revealing the costs of air pollution from industrial facilities in Europe.” Damage cost estimates would ideally be based on Canadian studies; however, the studies available by the Federal government are outdated and do not present per tonne estimates for each of the air contaminants associated with burning diesel fuel. Within the report by the EEA, damage cost estimates for Germany are used, based on comparable levels of GDP per capita and overall living standards. The report provides low and high estimates for each air contaminant; the average of each was taken for the congestion cost estimates and converted from Euros to Canadian dollar, using the exchange rate on December 3, 2013 (Table 3.2).

**Table 3.2 Damage Cost Estimates from Critical Air Contaminants**

Critical Air Contaminant	Damage Cost per tonne (CAD)
Sulfur Dioxide	\$33,495/tonne
Nitrogen Oxide	\$37,687/tonne
Volatile Organic Compounds	\$3770/tonne
Particulate Matter 2.5	\$122,345/tonne
Particulate Matter 10	\$79,656/tonne

The US Environmental Protection Agency’s MOBILE6 emission factor model provides estimates for the incremental impacts from air contaminants, based on container trucks moving at 4 km/hr. (RWDI, 2005). Using 4 km/hr. may underestimate the average speed of congestion and the rates of emissions; however, this is the best available data and is modelled for 2011 truck fleets. The unit estimates are in grams per hour, which makes for an easy conversion from average delay to total emissions in tonnes.

Estimates for critical air contaminants are constantly evolving. Measuring the human and environmental damage costs associated with each air pollutant is extremely complex and requires sophisticated scientific modelling techniques, along with economic assumptions on the value of human health and the physical environment. Diesel fuel emissions contain over 40 toxic air contaminants (Office

of Environmental Health Hazard Assessment, 2013), and the estimates in this study only include damage cost estimates for five of the most well-known pollutants.

### **3.2.1. Limitations**

The three cost accounts in this study are a starting point for quantifying the private and social impacts of congestion for container trucks in Metro Vancouver; in no way do they capture the full economic, social and environmental costs of congestion. First, my estimates do not include the multitude of cost considerations discussed in Chapter 2, such as driver stress and anxiety, and the cost implications for other components of the supply chain. These costs are difficult to track and quantify, with inherent overlap between impacts, and compounded by limited data. Environmental and social costs are particularly difficult to capture and measure, as most of these cost implications are non-market goods which occur over time. With these considerations in mind, estimates represent only a starting point for some of these wider cost factors.

Aside from the practical difficulties in capturing the full costs of congestion for port container trucks, methodological limitations underestimate the costs as well. The biggest limitation is in measuring truck trips, defined as the number of gate transactions at each of the four port terminals in Metro Vancouver (i.e. when a container is dropped off or picked up at the port). This means that if an empty truck drives to a port terminal to pick up a full container, the journey is counted as a single gate transaction, even though there were technically two trips. According to the Chamber of Shipping of BC (2013), up to 80 percent of total container trips are one-way. Effectively, the trips without cargo are not counted, nor are the potential congestion delays that the driver experiences for the empty portion of the trip. Moreover, roughly 1–2 percent of container trucks are required to travel to the container inspection facility in Burnaby which, for trucks travelling from DeltaPort, means up to an additional 50 kilometres to the overall trip distance. This extra distance is not included in my estimates.

Another factor which understates the estimates is that the delays on port property are not included within the average delay estimation. Delays from congestion are estimated at 15, 20, and 25 minutes for each costing scenario, which represents the

delays to and from deliveries and pick-ups, excluding delays on port property. But delays on port property can be significantly higher than the delays on the road network. The ports aim for an average turn time (which includes the waiting time and the loading time) of under 60 minutes (Port of Metro Vancouver, 2013). Depending on the terminal traffic, however, the turn time for many trucks is between 60 and 120 minutes, with a small portion exceeding 2 hours. During this time, the trucks and drivers sit idle for significant amounts of time.

To construct my estimation model, a range of assumptions are made (Table 3.3). Due to a lack of available data, estimates for the average delay – the most important assumption – are based on rough estimates from a container truck study in the City of Vancouver (2012), and reconciled by the stakeholder interviews. My estimates would ideally be constructed on trip delays based on Transport Canada’s thresholds of congestion (i.e. 50, 60, and 70% of posted speed limits); however, this requires having detailed data on truck distance, speed, and location. TransLink and Port Metro Vancouver were approached for their sophisticated traffic data, but, due to confidentiality concerns and time constraints, requests for data were unsuccessful.

**Table 3.3 Estimation Assumptions**

Assumptions	Scenario 1	Scenario 2	Scenario 3
Average number of trips per day	2859	2859	2859
Average delay per trip (minutes)	15	20	25
Value of time (\$/hr) (2013 dollars)	118	137	156
CO <sub>2</sub> e emissions at 8 km/hour (g/km)	3750	4063	4375
Average speed in congested conditions (km/hr) <sup>10</sup>	8	8	8
Social cost of carbon (\$/tonne) (2013 dollars)	40	63	120

<sup>10</sup> The estimation for air contaminants uses an average speed of 4km/hour, rather than the 8km/hour value which is used for estimating CO<sub>2</sub> emissions.

### 3.3. Semi-Structured Interviews

The second portion of this study uses semi-structured interviews with industry and government stakeholders. The interviews build on the expertise of several businesses and organizations in Metro Vancouver that are directly connected with commercial goods movement. They provide nuanced perspectives to the policy problem and help illuminate the anticipated impacts from the policy options, discussed in Chapter 7. While the cost estimates focus strictly on container truck movements, the semi-structured interviews focus on the trucking industry as a whole.

Nine interviews were conducted in total: two interviews were conducted in-person and seven by telephone. The interview participants were organized into two groups: representatives from trucking companies (n=3), and organizations and businesses that are connected with intermodal commercial goods movement (n=6). For the list of organizations and businesses that participated in the interviews, see Appendix B.

The interview questions were similar for group 1 and 2, but differ on specific questions about the trucking industry. A summary of the questions for groups 1 and 2 is provided in Table 3.4. Participants were given the opportunity to keep their identity, position title, and/or organization confidential. Interview questions are in Appendix C.

**Table 3.4 Summary of Interview Questions for Groups 1 and 2**

Questionnaire Section	Part 1: Starter Questions	Part 2: Policy Options	Part 3: Wrap-up Questions
Purpose of Section	Gauges the participants' perception of congestion in Metro Vancouver, in addition to other barriers to trucking activity.	Presents participants with a set of five policy options to rank and evaluate. Participants receive prompts for how each option would impact their organization/business and the region as a whole.	High-level questions which gauge how the policy options can achieve overarching goals of efficiency and sustainability

The interview participants were selected based on their influential roles in Metro Vancouver. A core group of participants were contacted through personal relationships, whereas others were contacted by using the snowball technique. Based on the small

sample size and recruitment criteria, the two samples are not representative and the results are not statistically significant.

## Chapter 4. Quantitative Results

The cost estimates in this study indicate that the cost of recurrent and non-recurrent congestion for Metro Vancouver's port container trucks is between \$27 and \$60 million in 2013.<sup>11</sup> This includes the vehicle and driver costs, damage costs from critical air contaminants, and the social cost of GHG emissions. With roughly 2000 port container trucks operating in Metro Vancouver, the costs of congestion per truck range from \$13,000 to \$30,000. Based on average trip delays of 15, 20, and 25 minutes, the estimates represent the incremental costs from congestion in Metro Vancouver. Screenshots of the estimation models are included in Appendices D, E, F, G, and H.

The value of time represents 96–97 percent of the total cost, with an annual value of \$26 to \$58 million. This is equivalent to port trucks spending 715–1200 hours each day sitting in traffic, or roughly 222,000–369,000 hours per year. The time lost represents a direct loss for truck companies and serves as a rough proxy for productivity loss. Trucking companies are paying not only for increased driver and vehicle costs when caught in traffic, but they lose the productive capacity of the vehicle when sitting idle (equal to the revenue lost from potential deliveries). These costs are compounded by missed connections, lost reputation from unreliability, higher risk of accidents, and driver fatigue and stress.

<sup>11</sup> For ease of reporting, the dollar figures from the cost estimates are rounded to the nearest million or, in the case of smaller figures, rounded to the nearest hundred thousandth or thousandth.

The damage costs associated with GHG emissions are the second largest cost component of congestion for port container trucks. However, because the social cost of carbon increases with each scenario (while the CAC value per tonne remains constant), the cost estimate for CACs in Scenario 1 exceeds the costs of GHG by a small margin (Table 4.1). GHG damage costs are roughly double the CAC damage costs in Scenario 2, and roughly triple in Scenario 3. The damage costs associated with GHG emissions represent roughly 1–3 percent of total costs, with a monetary value between \$265,000 and \$1.5 million per year.

The reason for the wide range of GHG costs is due to the uncertainty in the cost estimates for carbon dioxide equivalent. Despite growing consensus among the scientific community that the effects of climate change are occurring faster than expected (Intergovernmental Panel on Climate Change, 2013), estimating the severity of future impacts from climate change is highly uncertain. Some costing methods attempt to capture the predicted damage effects from climate change, while others use mitigation or avoidance costs. A range between \$40/tonne and \$120/tonne for the social cost of carbon is used to reflect differences in price estimates.

Even though the damage costs from air pollutants represent roughly one percent of the total costs of congestion, the total value is substantial—roughly \$273,000–454,000 per year. This cost represents the damage associated with human health and the environment in Metro Vancouver, based on the most recent studies by the European Environmental Agency.

The estimation results also need to be separated into non-recurrent and recurrent congestion effects. The former are costs associated with delays caused by inclement weather, accidents, or emergencies, whereas recurrent congestion encompasses the regular road network delays from consistently overcrowded roads. While the two types of congestion are inter-related, it is important to distinguish between their effects, as they require different policy responses. This study focuses primarily on recurrent congestion, as it is more predictable and demand-driven. Non-recurrent congestion is largely a result of poor weather or the expected risk from vehicle accidents, compounded by high levels of recurrent congestion.

To arrive at a rough estimate for the proportion of non-recurrent versus recurrent congestion, the findings by Transport Canada are used as the baseline. In its analysis of congestion in Metro Vancouver, Transport Canada (2006) concludes that recurrent congestion represents between 52–55 percent of total costs. Using Transport Canada’s lower estimate of 52 percent as the reference point, the recurrent portion of congestion costs for port container trucks is roughly \$14–31 million per year (Table 4.2 below).<sup>12</sup>

## **4.1. Maximum Throughput Estimates**

The cost estimates are based on the average daily truck transactions at the four container terminals in Port Metro Vancouver for August, September, and October. This daily average of 2859 transactions represents only 65 percent of total desired capacity, as indicated by the ports’ daily targets (Chamber of Shipping of BC, 2013). If each of the ports operate at desired capacity – a likely scenario in the medium-term given increasing container volumes – the total number of daily transactions could be as high as 4425 per day. For sensitivity analysis, the maximum capacity is used to forecast the magnitude of future impacts, using the same methodology as in the first estimation, at 2013 prices.

By using the maximum capacity throughput of 4425 truck transactions per day the cost of congestion rises from \$27–60 million to \$41–92 million per year. Holding constant the average delay from the first estimations, the new volumes result in 1100–1800 hours lost per day, with a loss of time valued at \$40–89 million per year. The cost of CAC is between \$422,000 and \$703,000 per year, while the annual cost of GHG emissions is between \$412,000 and \$2,397,000 (Table 4.1). Like the first estimations, these maximum estimates do not include the number of one-way trips and

<sup>12</sup> It should be noted that non-recurrent and recurrent congestion are not mutually exclusive; higher levels of recurrent congestion increase the probability of accidents and amplify the domino effects from non-recurrent factors.

underestimates the exposure to congestion. Recurrent congestion is assumed to represent 52 percent of the total costs, which means the total costs from regular delays are between \$21 and \$48 million per year (Table 4.2).

## **4.2. Extrapolating to All Commercial Goods Movement**

Notwithstanding the methodological and data limitations discussed above, the congestion costs for port container trucks serve as a rough proxy for the overall costs for commercial vehicles. Port container trucks represent less than four percent of all truck trips in Metro Vancouver, which helps in estimating the total volume of commercial traffic. But, given the rudimentary methodology of this analysis, scaling the costs for port container trucks to reflect all goods movement requires significant caution. Data for region-wide commercial activity is sparse, and the costing methodology for container trucks is unrepresentative of the diversity of commercial goods movement. Prior to extrapolating the port container truck model, these caveats require additional comment.

The estimation model used for port container trucks likely overestimates the operational costs for non-port trucks. Port container trucks are a homogeneous sub-sector of the trucking industry, where truck drivers earn consistent wages, drive on regular routes, and are subject to fairly consistent traffic conditions. Non-port related trucking is heterogeneous by comparison, and is highlighted by a wide variance in wages, business sizes, vehicle sizes, delivery routes, and average delays.

The values of time for port container trucks are likely much higher than the value of time for the average non-port truck. According to the Lower Mainland Truck Freight Study (2002), 68 percent of all trucking activity in the region is made by light trucks. To reflect smaller freight volumes of light trucks and lower average wages, the value of time needs to be adjusted downward. Also, light trucks typically make shorter and more frequent trips compared to port container trucks. Based on shorter trip distances, the average delay for light trucks is likely to be smaller than the 15, 20, and 25 minute delay assumptions made for port-trucks.

CAC and GHG emissions comprise a small portion of total congestion costs, but it is important to note that the extrapolation methodology likely overestimates the CAC

and GHG costs. Emission rates of CAC and GHG are based on port container trucks, which are likely higher than the emissions of non-port trucks (assuming the average non-port truck is smaller in size and has a higher fuel economy). Using the 2002 Truck Freight Study as a reference point, port trucks are generally bigger and heavier than the majority of commercial vehicles in Metro Vancouver. However, counter-balancing their increased size and weight, port trucks are subject to stringent air emissions standards. Additional research is required in order to establish a more nuanced analysis of emissions of non-port trucks.

With these considerations in mind, the findings by the 2002 TransLink study, which estimates an average of 187,000 commercial trips per day in Metro Vancouver, are used to generate a rough estimation for the region-wide costs of congestion for commercial goods movement? To modify the original estimation method to better reflect all goods movement, two major changes are made:

- Reduce the value of time to reflect smaller trucks and smaller cargo loads. The value of time is based on the variable costs of a two-axle (straight) truck, which Transport Canada estimates at \$47 (2013 dollars). For the three costing scenarios, a range of \$37–\$57/hr. is used with \$47/hr. as the mean value.<sup>13</sup>
- Reduce the average delay. Two-axle (straight) trucks travel less distance, on average, than port container trucks and are likely exposed to less congestion on a per trip basis. To reflect shorter trips, average delays of 5, 10, and 15 minutes are used.

To estimate the total number of commercial vehicle trips made on a daily and yearly basis, the estimates from the 2002 truck freight study are used as a baseline

<sup>13</sup> A congestion premium for the extrapolation model was not used. In the port-container truck model a congestion premium of \$60 is added to the hourly value of time; however, this premium is specific to large, 5 or 6 axle, port trucks. Smaller commercial vehicles, which represent the majority of trucks in Metro Vancouver, carry less cargo and therefore the congestion premium is smaller. Rather than estimating what the congestion premium is for smaller commercial vehicles, the congestion premium was excluded which results in a more conservative congestion cost.

estimate. To upscale the outdated figures to reflect increases in overall volumes in freight traffic, the increase in twenty-foot equivalent units (TEU) from 2000 to 2012 is used as a rough proxy for the level of trucking activity. Increases in TEU not only represent an increase in container truck traffic, but also reflect the general level of commercial activity. From 2000 to 2012, container port traffic increased by 120 percent; therefore the original number of 187,000 is multiplied by 2.2, producing an estimated daily commercial truck volume of 411,000 trips per day.

Given these assumptions, the annual cost of congestion for all commercial goods movement in Metro Vancouver is between \$417 million and \$2 billion (Tables 4.1 and 4.2). The magnitude and spread of costs is admittedly large, but this reflects both the subjective nature of these types of calculations and the uncertainty in data. The estimation is based on increasing values for the average time delay (in minutes) and the value of time. Without comprehensive data to produce a more accurate travel delay distribution, rudimentary estimates for the average delay (5–15 minutes) are used. A more scientific approach is desirable, and could follow as data becomes more available. The main purpose of these estimates is not to pin down the specific dollar values, but rather to gain a better understanding of the magnitude of congestion's impact on commercial goods movement.

**Table 4.1 Congestion Cost Estimates by Cost Component (000s) (2013 dollars)<sup>14</sup>**

	2013 Levels of Container Trucks	Maximum Trip Scenario Container Trucks	Extrapolation to all Goods Movement
Value of Time Lost	\$26,146–57,517	\$40,467– 89,021	\$370,126– 1,751,888
Value of CAC	\$273– 454	\$422– 703	\$13,023– 39,225
Value of GHG	\$265– 1,549	\$412– 2,397	\$12,690– 133,781
<b>Total Costs</b>	<b>\$26,684– 59,519</b>	<b>\$41,300– 92,121</b>	<b>\$416,989– 1,988,598</b>

**Table 4.2 Recurrent and Non-Recurrent Cost Estimates (000s) (2013 dollars)**

	2013 Levels of Container Trucks	Maximum Trip Scenario Container Trucks	Extrapolation to all Goods Movement
Recurrent Costs (per year)	\$13,876– 30,950	\$21,476– 47,903	\$205,836– 1,000,944
Non-Recurrent Costs	\$12,808– 28,569	\$19,824– 44,218	\$190,003– 923,949
<b>Total Costs</b>	<b>\$26,684– 59,519</b>	<b>\$41,300– 92,121</b>	<b>\$416,989– 1,988,598</b>

<sup>14</sup> Calculations may not add up to 100 percent due to rounding

## Chapter 5. The Ground Level Perspective: Interview Results

The semi-structured interviews help provide insight into the policy options for optimizing road space and provide a practical lens for understanding goods movement in Metro Vancouver. In addition to asking the participants specific questions about road congestion and its impact on the commercial goods sector, the semi-structured interviews presented the participants with five different policy options to better optimize road space for commercial vehicles. The policy options were identified through a comprehensive scan of the local, national, and international literature:

1. **Road Pricing:** internalizes the adverse effects of driving, such as congestion, air pollution, and greenhouse gas emissions by having road users pay a toll/fee. The most viable forms of pricing mechanisms that have been proposed in Metro Vancouver are used: tolling major bridges and highways, and creating a distance-based charging scheme whereby road users are charged on a per kilometer basis.
2. **Urban Consolidated Centres (UCC):** designates strategic areas in the region as intermodal freight hubs. These typically connect rail and road freight, and are designed to centralize and organize freight activity. It is assumed that creating a freight centre would involve substantial public funding.
3. **Truck priority infrastructure:** includes incremental improvements to infrastructure to give trucks greater priority (e.g. permitting commercial vehicles to use High Occupancy Vehicle (HOV) lanes, implementing reversible lanes on major roads to improve peak-period traffic flow, or targeting troublesome intersections and improving right-of-way to increase the flow of traffic).
4. **Extending delivery hours:** provides carriers and receivers with incentives to shift delivery times to night-time or other off-peak periods.
5. **Information-based technologies:** includes government led initiatives to help facilitate better information sharing and coordination across the trucking industry.

The options cover a wide range of government intervention, from a self-regulated approach as in the information-based option, to more interventionist policy options of managing land-use or creating pricing incentives. These policies are refined and discussed in more detail in Chapter 7.

The following is a brief summary of the perspectives and opinions from the two interview groups. A full summary of the interviews is included as Appendix I.

## **5.1. Group 1: Trucking Companies**

- Overall, the trucking companies perceive congestion as a major barrier to their businesses which has worsened over the past decade.
- Other major barriers facing goods movement in the region include: inconsistent regulation between municipalities; road restrictions for trucks; limited delivery hours at ports; a lack of adequate parking/loading space; and, insufficient public transit.
- Reliable and predictable delivery times are integral to the trucking industry and congestion results in missed deliveries, a loss in reputation, and decreased productivity.
- In terms of the most preferred policy option, building truck priority infrastructure is the most favourable, even though the companies recognize this option will not address long-term congestion.
- Broad support for bridge tolling as a mechanism to address long-term road congestion and environmental objectives (with the assumptions clearly stated, such as offsetting mechanisms, time-of-day pricing, etc.). The companies unanimously oppose distance-based pricing.
- Information-based options are already being utilized by the private sector, as most trucking companies equip their trucks with GPS devices to track and monitor delivery times and route conditions. Urban consolidation centres (freight villages) will not help address congestion and raise a host of logistic and practical concerns with trucking companies.
- Extending delivery hours has mixed support: container truck companies see this already being attempted by the ports and would like to see it expanded; extending delivery hours for all other commercial goods has potential but is difficult to get the buy-in from receivers. In both cases, the trucking companies have a willingness to extend deliveries to night-time hours.

## **5.2. Group 2: Supply Chain Stakeholders**

- Road congestion is identified as one of the biggest challenges facing goods movement in the Metro Vancouver region, especially during peak periods.
- Generally, participants believe that congestion has worsened over the past decade, albeit nominal improvements in infrastructure have helped offset increases in traffic. Traffic during off-peak periods moves fairly well; however, participants believe that peak periods are expanding.

- As a reflection of the diversity of the organizations interviewed, the participants list a wide range of other barriers facing goods movement in the region, including: uncoordinated municipal bylaws for vehicle weight and dimensions; inconsistent municipal noise by-laws; a lack of parking for commercial vehicles in urban areas; rail bottlenecks; a lack of data and analysis on the “optimal use of the road, rail, and marine systems for goods movement” (Kan, 2014); and, the inefficient use of one-way (or deadheaded) trips by container trucks.
- Although road congestion does not directly affect the organizations and participants in Group 2, participants believe road congestion and unreliable travel times have significant negative impacts to commercial goods movement and supply chains.
- Road pricing, building truck priority infrastructure, and expanding the use of information technologies are the most preferred policy options of participants; whereas building UCCs and extending delivery hours received mixed support.
- Generally, participants are receptive to road pricing, providing that offsetting mechanisms are integrated within the system (reduction/elimination of regional fuel tax) and that both passenger and freight are tolled.
- Several participants express the need for more truck priority infrastructure in the region, specifically by allowing trucks access to HOV lanes. Participants from TransLink, however, note that Metro Vancouver may not have a sufficient network of HOV lanes to produce major time savings.
- Overall, participants believe that road pricing, reducing one-way truck trips, and extending delivery hours are the best long-term solutions for reducing road congestion and its adverse environmental impacts. Expanding GPS technology and building truck priority infrastructure are regarded as short-term options which will have little impact on reducing long-term congestion.

## Chapter 6. Criteria and Measures for Policy Options

A set of criteria and measures, defined in Table 6.1, were developed *a priori* to assess the policy options in this study and are based on the research, outcomes, and considerations from congestion reduction policies in other jurisdictions. While Metro Vancouver faces its own unique transportation challenges, actions in other areas provide a foundation for policy development. Descriptions of each criterion and measure are included in Appendix J.

**Table 6.1 Criteria and Measures to Evaluate the Policy Options**

	Criteria	Measures
<b>Societal Objectives</b>		
<b>Efficiency</b>	Degree of congestion reduction for commercial vehicles	<ul style="list-style-type: none"> <li>• Impacts on delay times, average speed, and average/total number of trips.</li> <li>• Reductions in traffic on key commercial corridors</li> <li>• Predictability in travel time</li> </ul>
	Meeting projected demographic growth and demand	<ul style="list-style-type: none"> <li>• The long-term impacts of each policy</li> <li>• Does the policy align with regional growth strategy?</li> <li>• Does the policy defer the need for road infrastructure projects?</li> </ul>
<b>Sustainability</b>	Reduction in transportation emissions	<ul style="list-style-type: none"> <li>• Reductions in vehicle kilometers travelled</li> <li>• Reduction in the number of freight and passenger trips</li> </ul>
<b>Equity and Fairness</b>	Community impacts	<ul style="list-style-type: none"> <li>• Degree of re-routing of commercial and non-commercial traffic to other areas.</li> <li>• Impacts to neighbouring residential areas</li> </ul>
	Equity impacts to the trucking industry (industry acceptability)	<ul style="list-style-type: none"> <li>• Impacts to different segments of the industry (small vs. large businesses, type of freight, etc.)</li> <li>• Impact to the per-unit costs of deliveries</li> <li>• Does the policy treat commercial carriers differently within Metro Vancouver?</li> </ul>

	Criteria	Measures
	Inter-regional equity	<ul style="list-style-type: none"> <li>Impacts to trucks moving in and out of Metro Vancouver region</li> </ul>
<b>Societal Objectives</b>		
<b>Equity and Fairness (Continued)</b>	Impacts to Supply Chains	<ul style="list-style-type: none"> <li>Impacts to supply chains (manufacturers, distributors, receivers, ships, the ports, airports, etc.)</li> <li>Degree of acceptability among stakeholders</li> </ul>
	Impacts to non-commercial road users (Public Acceptability)	<ul style="list-style-type: none"> <li>Effects on the flow of non-commercial traffic and overall mobility</li> <li>Monetary implications to non-commercial road users</li> <li>Incentives for modal shift away from motor vehicles</li> <li>Safety of pedestrians/cyclists</li> </ul>
<b>Government Objectives</b>		
<b>Implementation</b>	Ease of Implementation	<ul style="list-style-type: none"> <li>Degree of private-public consultation and intra-governmental coordination.</li> <li>Physical infrastructure needed for the policy</li> <li>Amount of implementation time required</li> </ul>
<b>Affordability</b>	Public Cost	<ul style="list-style-type: none"> <li>Cost implications of the policy, based on the total capital and operating costs, minus new revenues</li> </ul>

## Chapter 7. Policy Options

Considering the high costs of congestion in Metro Vancouver and the strong desire to optimize road space among industry stakeholders, a range of policy options are available to government. Ultimately, the end goal is to optimize the Metro Vancouver road network for commercial vehicles by spreading demand across a wider time period (avoiding peak period congestion), reducing unnecessary trips, and/or reducing demand for road space for passenger and commercial vehicles. Policy options are evaluated based on their ability to maximize the efficiency of existing road infrastructure, while considering a range of equity, environmental, and logistical tradeoffs.

Based on information from the interviews and a further review of the literature, the five original policy options are narrowed to three options. First, the information-based option is dropped as a viable long-term solution. As identified in the stakeholder interviews, most trucking companies already use GPS technology to track their fleets, and some use this information to provide real-time traffic updates/re-routing information. Thus, integrating technology to curb congestion is primarily a private sector concern, expressed by several private sector interview participants. Furthermore, TransLink and Google already provide real-time traffic maps of Metro Vancouver, which are free of charge and based on comprehensive cell-phone data. Technology undoubtedly plays an important complementary role in identifying congested areas; on its own, however, technology-based options merely redistribute traffic flows. As congestion worsens and the road network becomes more saturated, the advantage of GPS technology diminishes.

Building UCC is also dropped from the list of viable options. UCC act as central logistic facilities for streamlining and coordinating the distribution of goods, and are typically in close proximity to dense urban consumer markets. They provide the trucking industry, receivers, and distributors with a centralized and multimodal distribution facility (Browne, 2005), and are often located on large tracts of industrial land and connect rail

and road freight. The goal of UCC is to better manage and coordinate goods movement, capitalizing on economies of scale through consolidating shipments.

Although some of the interview participants express interest in pursuing UCC in Metro Vancouver, the overall effect of UCC on reducing congestion, based on the literature, is uncertain. On one hand, UCC serve as a way to streamline goods movement, breaking big shipments into smaller and more direct deliveries. This, it is argued, encourages efficiency gains in supply chain management, and also reduces unnecessary truck trips (Browne et al., 2005). Contrary evidence, however, demonstrates that UCC can actually increase the number of vehicles on the road and increase total vehicle kilometres travelled (VKT). Even though trips may be shorter by using UCC to centralize goods movement, UCC may lead to a net increase in road activity (BCTA, personal communication, Dec. 5, 2013). To this extent, there is limited evidence on how many UCC are required to achieve a targeted reduction in congestion levels, and whether they offer a net benefit to the commercial goods sector and taxpayers.<sup>15</sup>

With technology-based options and UCC excluded, the policy options under further examination include: extending delivery hours, road pricing, and building truck priority infrastructure. Each option is fairly new as a commercial goods strategy; data and analysis is constantly evolving as cities around the world attempt to grapple with road congestion and infrastructure costs. Thus, the options explored in this study are at a fairly high level. The exact implementation details of each option are beyond the scope of this study and require further research and analysis. The goal here is to analyze the most effective and viable policies for Metro Vancouver at this point. A more comprehensive description for each policy option is the focus of this chapter, while

<sup>15</sup> To be viable, UCC also require significant amounts of public investment, both in terms of land financial capital (iTRANS Consulting Inc., 2011). With the effectiveness of UCC uncertain, this public investment carries a high degree of risk.

Chapter 8 assesses the tradeoffs among the policy options. For a list of excluded policy options and the rationale for their exclusion, refer to Appendix K.

## **7.1. Extending Delivery Hours**

Deliveries in Metro Vancouver are predominantly made during regular business hours, Monday through Friday. Commercial goods movement competes with the regular ebb and flow of passenger traffic, with a very small portion of deliveries being made outside of regular business hours. According to the most recent estimate, roughly 70 percent of truck deliveries are made between 9am–4pm (Bickel et al., 2002). Extending delivery hours gives businesses (both carriers and receivers) an incentive to reduce delays and the costs associated with congestion from increasing off-peak deliveries. The ultimate goal of extending delivery hours, from a societal perspective, is to reduce peak-period traffic flow and balance commercial traffic volumes.

The window for off-peak deliveries is narrowing during day-time periods in Metro Vancouver. Several of the interviewed participants from the trucking industry comment on worsening congestion from a first-hand perspective, noting that trucking companies already do everything in their power to avoid peak periods. TransLink's 2003 Travel Time Study makes a similar conclusion, finding that some of the major routes in Metro Vancouver are busiest in the early afternoon. A move to increase night-time deliveries is therefore both financially and pragmatically attractive.

Overall, two components are required to establish an effective extension of delivery hours. The first is to provide legal foreground for commercial activity to operate outside of typical day-time hours. This involves amending municipal noise by-laws to either exempt or permit commercial vehicles to load/unload during night-time hours. Noise bylaws dictate the amount of commercial activity during night-time hours (typically 10pm to 7am), but the limits and penalties are different across the municipalities. In some municipalities, such as New Westminster, noise levels during the day-time must be below 80 decibels and below 75 decibels during the night-time (New Westminster, 1999); whereas other municipalities, such as Surrey, use qualitative limits for noise control. Violation penalties range from \$100–\$250 in Delta to \$250–10,000 in

Vancouver. While individual municipalities are responsible for altering noise by-laws, one goal is to have municipalities harmonize by-laws to create a consistent regulatory framework for carriers and receivers.

The second component of extending delivery hours is to create demand-side incentives for businesses to use the non-peak hours. Merely changing noise by-laws is unlikely to generate a major shift in delivery schedules. As identified by Steve Brown, Project Manager with the City of Vancouver, noise bylaws may discourage night-time deliveries, but they do not prohibit all night-time activity. In fact, a small portion of companies already make deliveries during the night-time hours, grocery stores being the prime example. For the majority of trucking firms, the biggest barrier is the increased labour costs during night-time periods for both carriers (trucks) and receivers. Businesses are typically required to pay overtime wages for employees working during night-time hours, in addition to the incremental operational costs of keeping longer hours of operation. Even if uncongested roads save trucking companies' money in terms of lower operation costs, gains are offset by increased wage rates.

Another reason for providing demand-side incentives is due to the asymmetric relationship between carriers and receivers. Research by Holguín-Veras (2008) indicates that receivers often determine the terms of agreement for deliveries, especially regarding for-hire companies. For-hire trucking firms are bound by the scheduling demands of their client. Thus, even if 100 percent of trucking companies are willing to shift to night-time hours for a portion of their deliveries, it will have no effect unless the receivers also agree. As it currently stands, receivers have little or no incentive to have their receivers working late into the night, unless carriers are able to offer lower rates from the benefits of less congestion.

Incentive schemes might involve providing funding support to receivers to purchase secured locker facilities so that carriers can make unattended deliveries during non-working hours (Huschebeck, 2004). Cities in Japan and Europe have implemented this type of initiative with considerable success. Other tax-based incentives are possible, but would be difficult to implement—requiring the provincial government to amend tax legislation. As such, helping to pay for noise-reducing equipment and secure delivery lockers are the most viable forms of implementation.

## 7.2. Road Pricing

Road pricing mechanisms can take many forms, but the fundamental concept is to internalize the full costs of driving, such as congestion, air pollution, and GHG emissions by having road users pay a toll/fee. The charge “can be a function of time, distance, load, type of facility, or other parameters such as congestion, emissions and mode” (Deloitte, 2010). Generally, the motive for implementing road pricing – implemented in over eight countries – is to reduce congestion, lower transportation pollution/emissions, and/or raise revenue for transportation projects.

In order to evaluate the trade-offs associated with implementing a road pricing scheme in Metro Vancouver, it is necessary to make a number of assumptions regarding the goals, objectives, and implementation details for the scheme. David Levinson (2010), in his research on road pricing, estimates there are over 90 ways to implement road pricing—highly contingent on the geography, demography, and travel patterns of a region. To avoid getting overwhelmed by the technical details of implementation, the overarching assumptions are based on preliminary research on road pricing schemes for Metro Vancouver and in other major cities.

Two of the most viable forms of pricing that have been proposed in Metro Vancouver are used. A viable scheme is defined as one that is effective at reducing congestion, publically acceptable, and regionally equitable. As identified by Deloitte (2013) in a research paper prepared for TransLink, the two most viable options are: *tolling major infrastructure (i.e. bridges, tunnels, highways)*, and creating a *distance-based charging scheme* whereby road users are charged on a per kilometer basis.

For each road pricing scheme it is assumed that tolls and fees are priced based on the time of day and the level of congestion, and that road pricing would toll both trucks and passenger vehicles. To increase the public and industry acceptance of a road pricing scheme in Metro Vancouver, it is also assumed that other taxes/charges would be reduced (at least in the short-term) to offset increased costs, and that all revenues are reused to support other transportation projects. For example, this could involve reducing or eliminating the regional fuel tax (12 cents/litre), and/or creating a transparent fund for transit and road improvements. This follows the approach taken by the proposed

national UK road pricing scheme, which would replace the licensing fees and fuel taxes with a distance-based charge for all road users” (Verhoef, 2008).

As an aside, other road forms of road pricing are considered but excluded based on the unique characteristics of Metro Vancouver. Pricing schemes such as cordon tolling (which creates a tolled ring around a city centre and charges drivers to enter/exit) or High Occupancy Toll lanes are not viable based on Metro Vancouver’s geographic, demographic, and transportation infrastructure characteristics (Deloitte, 2013).<sup>16</sup>

### **7.3. Truck Priority Infrastructure**

The central concept of creating truck priority infrastructure is to use existing or new infrastructure to increase the flow of goods movement. The Transportation Association of Canada lists over six different ways to build truck priority infrastructure, ranging from creating physically separated lanes for trucks, to allowing trucks use of HOV lanes during certain times of the day. Truck priority infrastructure can also include making sure that major trucking routes are designed with minimal stop lights or building overpasses to ensure a more congruous, speedier truck flow. The new South Fraser Perimeter Road is a good example of this type of planning, which provides trucks with 35 kilometres of 4-lane expressway that connects the Robert Banks Port Terminal with Highway #15 and the US border.

Although creating new infrastructure for trucks is perhaps the most effective way for improving the flow of commercial goods movement in the short-term, such as the South Shore Perimeter Road, it the most expensive option. Whether the truck priority lane is physically separated (which does not currently exist in Metro Vancouver), or an

<sup>16</sup> For more information on the various forms of road pricing that have been considered in Metro Vancouver, see Deloitte’s “Metro Vancouver Road Pricing Research Study.”

expressway to improve the flow of goods and services (South Shore Perimeter Road), these types of mega-projects are not included for two underlying reasons. First, while building new infrastructure is an important and necessary component of transportation planning, it does little to address long-term congestion. The analysis is focused on policies which can optimize existing road space through minor adjustments to the existing network.

Secondly, physically separated truck lanes are likely to have negative impacts to passenger vehicles. In a report by Clement and Rogers (2012), a cost-benefit analysis was conducted on creating a truck-only lane down the Knight Street corridor. In this model, light and heavy trucks received an annual time-savings benefit of \$1.3 million, whereas the cost to passenger vehicles and transit users is roughly \$8.6 million—resulting in a net cost of 7.3 million (Clement and Rogers, 2012). While trucks clearly benefit from truck-only lanes, it would be to the detriment of other road users.

With mega-projects and physically separated truck lanes excluded from the analysis, the following is a list of strategies that provide trucks with increased priority, optimize existing road space, and involve minimal changes to the existing road network:

- Permitting commercial vehicles to use the existing network of HOV lanes and/or transit lanes during certain periods of the day.
- Implementing a reversible lane on major roads to improve peak-period traffic flow.
- Targeting troublesome intersections and improving right-of-way to increase the flow of traffic. Dedicated left-hand turns and overhead pedestrian walkways are two examples.
- Addressing areas of modal conflict, such as rail crossings.

Each of these strategies comes from the GTHA Urban Freight Study (2011) and TransLink's ongoing research on goods movement. These policies are considered forms of 'intelligent lane utilization', and are used as cost-effective policies to "adapt to the changing needs and patterns of goods movement" (TransLink, 2013). The main idea is to gain a better understanding of strategic areas for improvement (i.e. chokepoints and bottlenecks) and responding with an appropriate truck-priority strategy.

## **Chapter 8. Assessing the Policy Options**

The policy options in this study are not mutually exclusive; in fact, with sufficient resources, all three options could be implemented as a portfolio strategy for improving the flow of regional goods movement in Metro Vancouver. However, given the budgetary and resource constraints of local, regional, and provincial governments, this is an unlikely scenario. The most desirable policy option is therefore the one with the best performance on the criteria/measures from Chapter 6, meaning that the policy reduces congestion for commercial vehicles, optimizes road space, and is cost-efficient. It should also be a long-term strategy which defers the need for new infrastructure projects, reduces adverse environmental impacts, and is equitable and acceptable to the industry and to the public. Although the options are evaluated individually, a broader discussion of integrating and combining options is included in Chapter 9. Before evaluating each option, it is appropriate to provide an analysis of the current political context, along with the methodology for evaluating/ranking the options.

### **8.1. Weighting and Ranking**

Road congestion is a region-wide problem in Metro Vancouver and is not strictly defined by municipal boundaries. The most effective policy response, therefore, are policies that are regional in scope and options which can accommodate and address projected population growth. For this reason, the efficiency criteria (road optimization and long-term efficacy) are double-weighted compared to the other criteria. Thus, a policy option may rank highly for every indicator (environment, fairness and equity, implementation, etc.), but if it does not optimize road space and is short-term in nature, then the policy clearly fails to address the overarching problem of congestion for commercial vehicles.

With limited data on the criteria and measures considered in this study, each option is ranked based on a scale of low, medium, and high. In each case, a ranking of 'high' confers its overall desirability relative to the other options and that it scores highly against the established criteria. Equity considerations, however, are described and not ranked. Impacts to trucking firms, supply chains, and non-commercial vehicles are multi-dimensional, and the equity impacts within and between each group pull in different directions. Ranking in this case might oversimplify complex considerations. Furthermore, many of the inequities can be minimized with proper consultation and planning. For example, road pricing may result in a loss of welfare for trucking companies in terms of increased per-unit costs; however, this loss in welfare may be offset by fewer/shorter delays or reducing the regional fuel tax.

Many of the trade-offs with road pricing are similar for both infrastructure tolling and distance-based pricing; the underlying principle of implementing a user-pay system is the same in both forms of road pricing. Given the overlap between the two types of road pricing, they are evaluated concurrently in the analysis below. In some cases there is a marked distinction between distance-based and infrastructure tolling. The distinguishing implications will be clearly identified in these cases.

## 8.2. Efficiency Criterion: Congestion Reduction

Criterion	Low or no reduction in road congestion for commercial vehicles	Moderate reduction in road congestion for commercial vehicles	High reduction in road congestion for commercial vehicles
Policy Option Ranking		Truck Priority Infrastructure	Road Pricing Extending Delivery Hours

### Road Pricing

Based on theory and empirical evidence from cities such as London, Singapore, and Stockholm, road pricing in Metro Vancouver is likely to provide the greatest reduction in congestion levels. Assuming that tolls are priced according to the marginal social cost of congestion (i.e. dynamic pricing that reflects the flow of traffic), passenger and freight vehicles have a clear monetary incentive to shift driving behaviour. For

trucking companies with flexibility, this might involve choosing off-peak periods to make deliveries; companies with more rigid delivery schedules would likely pay a higher premium for driving in the region during peak periods. In both cases, delivery times are expected to be more predictable and reliable.

Stockholm's cordon pricing provides the most recent example of how road pricing can reduce congestion levels. Within one year of implementing tolls, traffic levels decreased by 20–25 percent (IBM, 2006)<sup>17</sup> and the number of VKT within the congestion zone decreased by 14 percent. As a direct consequence of tolling, trade for city businesses increased by 6 percent (IBM, 2006). Another estimate concludes that businesses within the congestion zone increased the number of daily deliveries by 25 percent (Moscovich, presentation, Nov. 29, 2013). While these figures are promising, it is important to note that Stockholm increased the provision of public transit prior to cordon pricing to help residents who were effectively 'tolled off' the roads. Having alternative travel choices is therefore a critical component of the success in Stockholm, and is an important lesson for Metro Vancouver.

As a general point, road pricing gives firms a greater incentive to increase efficiency. With time-of-day road pricing, flexible trucking firms are likely to respond with a number of changes in behaviour, including: making more deliveries during off-peak times, maximizing fleet efficiency through reducing one-way trips or increasing freight loads (Holguín-Veras, 2006). Similarly, the German Federal Office for Goods Transport notes that its nation-wide truck tolling scheme – which charges a per-km fee to all heavy trucks using its major highways – has reduced the number of one-way trips and “motivated transport companies to operate more efficiently” (EuroMed Transport Project,

<sup>17</sup> Road congestion is a non-linear phenomenon: each additional vehicle on the road causes a proportionally higher increase in the time delay to all road users. Accordingly, even a small reduction in the number of vehicles on the road can cause a big reduction in delay times. For more information on the economics of road congestion, see Appendix L.

2013). Research by Holguín-Veras et al. (2006) indicates that freight road pricing in New York incited trucking companies to implement changes to enhance efficiency, such as making better use of truck space, changing facility usage, and transferring costs to receivers and consumers.

Between infrastructure tolling and distance-based tolling, it is difficult to discern which type of road pricing would have a greater effect on traffic reduction. Ultimately, more research needs to be conducted in this area. Distance-based tolling theoretically has greater potential to reduce region-wide congestion levels based on its comprehensive approach in comparison to infrastructure tolls which may be avoided for some trips. A portion of freight and passenger vehicle trips do not involve crossing major pieces of infrastructure, which mean that the tolls will not enter drivers' calculus in whether to drive, take transit, or travel during off-peak periods. For this reason, distance-based pricing scores slightly higher than infrastructure tolling in terms of its congestion-reducing effects.

### **Extending Delivery Hours**

Research indicates that extending delivery hours is an effective way to optimize road space and reduce congestion for commercial goods movement. Providing that carriers and receivers are given sufficient incentives to increase night-time deliveries, a greater shift to off-peak hours can reduce congestion costs and improve the flow of goods and services (Holguín-Veras, 2006).

Although extending delivery hours is a relatively new policy tool, a pilot study in New York provides first-hand evidence of its success. Based on its implementation in 2009, trucks that shifted to night-time deliveries travel 8 km/hr. faster, reduced the average trip time by 48 minutes, and also reduced fuel costs and parking violations (Texas Transportation Institute, 2012). For the receivers participating in the New York pilot, accepting more night deliveries allowed their businesses to concentrate more on their clientele during the day with fewer disruptions from deliveries. Staff were found more productive, spending less time waiting for late deliveries (Texas Transportation Institute, 2012).

More research is ultimately required on the receiver-carrier relationship to help determine the efficacy of extending delivery hours in Metro Vancouver. Holguín-Veras (2006), from his research in New York City, finds that delivery times are largely determined by the receiver: receivers set the contract terms 40 percent of the time and only 22 percent of the time by the carrier. This evidence suggests that carriers are often unable to shift to night-time deliveries because they are beholden to the receivers' schedule. This issue is highlighted by one of the trucking companies, which said that it would operate 24 hours a day, seven days a week, if its clients would accept deliveries outside of regular business hours.

In comparison with road pricing, which takes a regional perspective and affects all vehicles, extending delivery hours is a more targeted approach to congestion reduction for specific commercial vehicles. Companies not participating in off-hour deliveries are unlikely to realize significant time savings, unless a sufficient number of trucks shift from day-time to night-time hours. By comparison, the gains from road pricing are systemic in nature and affect the commercial goods sector as a whole. For these reasons, road pricing is viewed as a more effective policy for reducing congestion.

### **Truck Priority Infrastructure**

Moderate reductions in travel delays are expected from giving trucks increased priority on the road network, albeit smaller than the reductions from road pricing and extending delivery hours. Improvements to road infrastructure (i.e. building dedicated left-turn lanes, rail overpasses, etc.) occur on a project-by-project basis, and are more location-specific than the effects of extending delivery hours. While municipal and regional planning can incorporate truck priority infrastructure in its future projects, this option is unlikely to create sweeping improvements in congestion delays for commercial vehicles.

The City of Vancouver, for example, has made several changes to the Clark Street corridor to help improve commercial traffic flow by building dedicated left-turn lanes. Left-turn lane improvements are roughly \$1–12 million per intersection, and are a clear way of optimizing road space with nominal changes to infrastructure (Brown, personal communication, December 5, 2013). To date, the City of Vancouver has not

conducted empirical analysis on how each of these improvements has improved traffic flow. Building truck priority infrastructure is a relatively new transportation strategy in Canada, and the empirical evidence on its effectiveness is limited (TAC, 2013).

### 8.3. Efficiency Criterion: Meeting Regional Growth Demands

Criterion	Fails to meet regional growth demands	Partially meets regional growth demands	Meets regional growth demands
Policy Option Ranking		Truck Priority Infrastructure Extending Delivery Hours	Road Pricing

#### Road Pricing

Both types of road pricing are long-term tools for transportation demand management and are consistent with the regional growth strategy. TransLink and Metro Vancouver openly advocate for stronger demand management tools, including road pricing. It is an option that can defer the need for future infrastructure projects, and make better use of the existing infrastructure. While the long-term effects of road pricing still require additional research (Litman, 2011), pricing will help reinforce one of the primary goals of the regional growth strategy—creating compact and sustainable communities.

Based on evidence from other cities, requiring drivers (freight and passenger) to pay on a per-trip basis can reduce the total number of VKT, increase public and active transit use, and encourage people to make shorter and more local trips (Walker, 2011). In the long-run, once road pricing is internalized into the decision-making calculus of businesses and individuals, people are more likely to live and work closer to home.

Similar to the total reduction in congestion levels, distance-based tolling is likely to have greater long-term benefits in terms of land-use, creating compact communities, and aligning with the regional growth strategy (Sigurbjörnsdottir, 2009). Infrastructure tolling, while still facilitating some of these effects, will not have the same comprehensive impact. Both options, however, allow transportation planners to continually adjust toll

rates based on traffic volumes which is a key defining characteristic compared with the other options.

### **Extending Delivery Hours**

If successful, extending delivery hours could become a new industry norm and create a permanent shift in how commercial goods are delivered. This is exactly what the pilot program in New York is now trying to accomplish. With the successful completion of the pilot program in 2010, the city is now trying to expand its participants to encourage permanent uptake of the idea. This has potential to redistribute the peak-traffic flows to night-time hours and reduce congestion in the short- and long-term.

The primary reason why this option ranks behind road pricing is that its long-term efficacy is contingent on several of factors. Many businesses, for example, will continue to use regular business hours for their operation. Furthermore, the effectiveness of congestion reduction has a limit—only so many companies can and will shift to night-time delivery hours, and establishing a region-wide program is unlikely due to shared jurisdiction.

### **Truck Priority Infrastructure**

In general, the idea of making nominal improvements to road infrastructure to facilitate smoother goods movement fits within the regional growth strategy. However, the optimization gains from building truck priority infrastructure only provide short-term relief. As the number of commercial and passenger vehicles increase in the region, these incremental improvements lose their effectiveness, necessitating more road priority improvements. Moreover, if a particular infrastructure improvement reduces congestion by a substantial amount, this encourages more traffic and the initial gains are lost. Similar to extending delivery hours, the long-term benefits of truck priority infrastructure are subject to diminishing returns.

## 8.4. Sustainability Criterion: Environmental Impact Reduction

Criterion	Little or no reduction in adverse environmental impacts	Moderate reduction in adverse environmental impacts	Strong reduction in adverse environmental impacts
Policy Option Ranking	Truck Priority Infrastructure	Extending Delivery Hours	Road Pricing

### Road Pricing

Of the options investigated in this study, road pricing has the greatest potential for reducing adverse environmental impacts from congestion. This is primarily due to the expected reduction in passenger vehicle traffic and increased efficiencies among road freight (Jensen-Butler, 2008). Based on road pricing schemes in other jurisdictions, reductions in traffic cause a commensurate reduction in GHG emissions and CAC.

Congestion pricing in Stockholm, for example, has resulted in a 10–14 percent reduction in GHG emissions and a 7–9 percent reduction in CAC (Márton Herczeg, 2011). The pricing scheme in London is achieving similar results, with a 7–15 percent reduction in nitrogen dioxide, carbon dioxide, and particulate matter (Márton Herczeg, 2011). In both cases, reduction in adverse environmental impacts is attributable to fewer passenger vehicle trips, increased efficiency among businesses, and greater uptake of public transportation. Even though reducing environmental pollution from congestion was not the primary motivation behind the cordon pricing schemes in London and Stockholm, pricing has nevertheless had a positive impact.

As an added benefit, infrastructure tolls and distance-based tolls can be designed to charge based on vehicle weight and emissions. This provides government with flexibility to target and charge vehicles proportionate to the environmental damage emitted.

Of the two options, distance-based pricing is expected to cause a greater reduction in adverse environmental impacts, all else equal. Similar to the expected reductions in congestion levels, distance-based pricing is likely to cause a systematic and region-wide reduction in VKTs and the associated environmental impacts.

Infrastructure tolling will not impact passenger and freight trips within an un-tolled area (i.e. a trip without a bridge or tunnel).

### **Extending Delivery Hours**

Shifting truck deliveries to night-time hours has potential to cause a moderate reduction in GHGs and CAC; however, limited data is available to predict its precise affects. The majority of environmental benefits are likely to accrue from the reduction in day-time congestion from trucks making night-time deliveries, but the precise reduction in environmental costs is dependent on the number of businesses that shift to night-time delivery schedules. Moreover, some of these impacts will be distributional: gains from reduced congestion during day-time periods will be partially offset by the increase in trucking activity at night. Considering all of these factors, an overall net reduction in environmental impacts from lower levels of congestion is expected.

The key difference between road pricing and extending delivery hours is that road pricing reduces passenger vehicle traffic while also stabilizing peak-period traffic flows, both of which cause a substantial reduction in adverse environmental impacts. By comparison, extending delivery hours will have little or no impact for passenger vehicle emissions, aside from nominal benefits of having fewer trucks on the road during the day.

### **Truck Priority Infrastructure**

The environmental gains from building truck priority infrastructure will likely result from the incremental reductions in congestion on specific corridors or intersections. By reducing congestion and increasing the average speed of traffic, truck priority infrastructure should reduce some of the negative environmental effects from congestion. However, these gains may be offset if the truck priority infrastructure increases congestion for passenger vehicle traffic, or if it encourages more VKT for commercial vehicles. For these reasons, truck priority infrastructure ranks behind road pricing and extending delivery hours in terms of environmental benefits.

## **8.5. Equity Considerations**

### **8.5.1. *Impacts on the Trucking Industry***

#### **Road Pricing**

Road pricing will affect trucking companies differently, based on their fleet size, cargo, and travel routes. The overall impact to the bottom line for trucking companies is difficult to predict and requires further analysis. If offsetting mechanisms are implemented, such as reducing/eliminating the regional fuel tax or using toll revenues to improve transit and road infrastructure, road pricing becomes a more attractive option for trucking companies (Verhoef, 2008). In effect, offsetting road pricing with reducing/eliminating the fuel tax prevents double taxation and helps compensate trucking firms. Conversely, if the pricing scheme is designed to generate revenue, these additional revenues can (and should) be reinvested in transportation projects. Without these offsetting features, the net impact to the trucking company is ambiguous. In one sense, road pricing results in higher per-unit costs for trucking companies. But, pulling in the other direction, less congestion results in greater reliability, shorter road delays, and reduced vehicle/operating costs—which, together, reduce per-unit costs. Without access to sophisticated modelling programs, it is impossible to predict the net outcome on per-unit costs.

The impacts to the trucking industry are partially dependent on whether companies are for-hire businesses or privately operated businesses. On the whole, privately operated fleets are more flexible and are able to respond more favourably to time-of-day pricing, whether distance-based or infrastructure tolls (Holguín-Veras, 2006). Private fleets have greater flexibility for rescheduling deliveries and can choose off-peak periods to make deliveries, whereas for-hire fleets make deliveries based on the time scheduling demands of their clients (Holguín-Veras, 2008). Being more flexible, private fleets are more likely to benefit from less congested roads and cheaper toll revenues by making more deliveries during off-peak periods.

In the case of infrastructure tolls, companies which rarely use the bridges for deliveries, or have large enough fleets to balance bridge routes with non-bridge routes,

are most likely to benefit. Smaller companies which rely on bridges to make deliveries will be hardest hit by tolls, even though these companies may realize significant time savings from less congestion on and around the bridges.

When confronted with the choice between distance-based and infrastructure tolling, the trucking companies strongly oppose distance-based charging. Each company is uneasy with the idea of paying on a per-kilometre basis and would much rather pay a toll to use bridges and tunnels. If this opposition to distance-based pricing is representative of the industry as a whole (which requires further surveying), then achieving industry buy-in will be a substantial barrier for distance-based tolling.

The equity impacts to the trucking industry are an important indicator for gauging overall levels of acceptance. In a report by Wood (2011), which surveys the palatability of road pricing schemes in the US amongst the trucking industry, an overwhelming level of opposition is found against all tolling mechanisms. Interestingly, these strong findings are not substantiated by the interviews conducted in this study. Although the interview participants are not a representative sample, they illustrate a general openness to tolling, providing a number of conditions are met (time-of-day pricing, offsetting mechanisms, more transit, etc.). This marked difference in opinion may be due to the fact that I presented the interview participants with a clear definition of road pricing, and made several assumptions of how it would be implemented. To properly assess the industry's opinions on road pricing in Metro Vancouver, a representative survey is required.

### **Extending Delivery Hours**

The trucking industry as a whole is expected to benefit from a night-time delivery program, as some companies will shift to night-time deliveries while others continue to make deliveries during peak day-time periods. The companies shifting to night-time deliveries are likely to experience reduced travel times and lower per-unit transportation costs. The companies which continue to make deliveries during regular business hours should benefit from having fewer commercial vehicles on the road. Additional benefits to the trucking industry from extending delivery hours include: safer road conditions for drivers and less stress (NYC Department of Transportation, 2013).

The TNT Innight program in the Netherlands, which allows trucks to use freight drop-boxes for making deliveries at night to avoid having staff on site, has resulted in substantial benefits to truck operators. Huschebeck (2004) concludes that truck operators save up to 20 percent in transportation costs from less fuel, reduced delays, and overall higher productivity during night deliveries. Similarly, the pilot program in New York has received unequivocal support from trucking companies and businesses, noting a 75 percent increase in travel speeds for the first delivery of the night, and a reduction of \$1000 in parking fines per truck (NYC DOT, 2013).

Not all trucking companies are able to shift to night-time deliveries. Similar to the case with road pricing, private trucking firms are able to benefit from extending delivery hours because most ship to their own enterprises and are more able to align the schedules of carriers and receivers. By comparison, for-hire trucking firms do not have the same flexibility. This inflexibility is illustrated by one of the trucking company participants in the interviews. The participant runs a small for-hire trucking company, and notes that the majority of his deliveries are to office buildings between 9am and 4:30-5pm. In this situation, he cannot expect someone from each office to accommodate off-peak deliveries either in the early morning or evening. Providing receivers with secure drop boxes could alleviate this constraint.

### **Truck Priority Infrastructure**

The equity implications for the trucking industry are straightforward for priority infrastructure. The benefits to the trucking industry should be equitably distributed across the firms utilizing said infrastructure. The main equity consideration with this policy is geography: the specific location of infrastructure improvements will largely dictate the companies that benefit.

In terms of per-unit costs for the trucking industry, all companies that use new priority infrastructure should benefit from reduced delays. Priority infrastructure is paid through the existing transportation budget, so unless the new infrastructure is tolled, the trucking industry should be the primary beneficiary.

## **8.5.2. *Impacts to Supply Chains & Industry Stakeholders***

### **Road Pricing**

Of the three policy options evaluated in this study, road pricing stands as the greatest shift from the status quo. As such, pricing is likely to have the greatest impact on the dynamics of supply chains, retailers, and industry stakeholders. In one sense, pricing will have little effect on parts of the supply chain prior to when goods movement hits the road. For example, an export container arriving at DeltaPort from Asia will not be affected by road pricing until it is loaded off the container ship and put onto a truck. Carriers, receivers, and importers are likely to be impacted the most by road pricing, regardless of whether it is a distance-based or infrastructure tolling scheme.

Preliminary evidence from Stockholm and London indicate that the overall impact to supply chains, retailers, and industry stakeholders is positive or, at worst, neutral. In surveys conducted after the implementation of cordon pricing in London, the majority of businesses report overall benefits and continue to support the pricing scheme (US DoT, 2013). By comparison, the pricing scheme in Stockholm is reported to have a neutral economic impact, although the system has not been in place long enough to discern noticeable effects.

### **Extending Delivery Hours**

The primary concern with extending delivery hours is the impacts to receivers. Truck companies demonstrate a willingness to shift to night-time hours, but are impeded by the limited hours of operation of their clients. Of the businesses participating in the New York pilot project, an overwhelming majority supports the initiative and continued to make night-time deliveries even after the pilot project expired. During the project, the city gave businesses financial incentives and strategies to facilitate night-time deliveries, which allowed businesses with no night-time staff to accept incoming shipments at all hours (NYC Dot, 2013).

Overall, extending delivery hours is expected to receive mild support from receivers, providing that the government implements some form of incentives for

accepting night-time deliveries. As in the New York pilot program, support can increase if receivers and carriers benefit.

### **Truck Priority Infrastructure**

As with the equity impacts to the trucking industry, supply chain stakeholders and retailers are expected to benefit or remain unaffected by constructing truck priority infrastructure. Priority infrastructure does not involve additional costs to the supply chain and is likely to reduce delays and improve reliability. Interview participants from both groups express strong support for this policy.

## **8.5.3. Community Impacts**

### **Road Pricing**

The overall impact to neighbourhoods from road pricing is dependent on the type of road pricing being considered. Distance-based tolling is unlikely to increase traffic volumes in residential communities. If anything, traffic levels in residential neighbourhoods will decrease due to an overall drop in VKT. By comparison, infrastructure tolling is more likely to cause unintended consequences for alternative non-tolled routes. Although bridges are difficult to avoid in Metro Vancouver, one example might be the Cambie Bridge and the alternative route down Quebec or Main Street. Excessive toll aversion would cause a big traffic pattern shift in, and around, this area. Additional data and analyses need to be conducted on areas that might experience higher volumes of traffic due to drivers averting bridge tolls.

One advantage of tolling all bridges from the existing limited number of tolled bridges (the Port Mann and Golden Ears bridges) is that current toll aversion could be eliminated. The City of New Westminster, for example, has complained repeatedly to the Provincial Government about increased traffic volumes through its main arteries based on people avoiding the high tolls on the Port Mann Bridge. If all bridges are tolled (perhaps at a lower rate than the current Port Mann tolls) then this would reduce aversive behaviour. If major highways are tolled as well (i.e. the Sea-to-Sky Highway or other parts of Highway 1), this will further reduce aversion and increase the overall equitability of the road pricing system.

## **Extending Delivery Hours**

The primary concern with increasing trucking activity during the night is a corresponding increase in noise levels; however, a 2003 pilot program in Barcelona demonstrates that increases in noise from night-time deliveries can be minimized. The municipality exempted the project participant (Mercadona, a large grocery chain) from delivery hour restrictions, allowing the store to make deliveries from 10pm–12am. To help reduce noise impacts, the municipality provided the delivery trucks with noise dampening equipment and closely monitored noise impacts. Over the course of the project, the increase in night-time deliveries increased noise by only 0.3Db above ambient levels (Hayes, 2007).

Increased truck traffic during night-time hours also increases accident risk for pedestrians and other road users; albeit some of this increased risk will be offset by a corresponding risk reduction during peak periods. Ultimately, communities in the region need to confront the tradeoffs between increased noise from night-time deliveries, versus the benefits from reduced peak congestion and deferred infrastructure investment.

## **Truck Priority Infrastructure**

Community and neighbourhood impacts from building more truck priority infrastructure is expected to be minimal. On one hand, truck priority infrastructure may reduce the noise levels from congestion in specific areas, but may be offset by increases in truck volumes. Truck priority infrastructure is not expected to cause major re-routing for trucks. If anything, it may lead to a higher concentration of trucks on major corridors, such as Knight and Clark Street, or the South Fraser Perimeter Road.

### **8.5.4. *Impacts to Non-Commercial Vehicles***

#### **Road Pricing**

Of the three options examined, road pricing will create the biggest change in welfare of non-commercial vehicles. A central assumption of implementing road pricing in this study is that it would apply to both passenger and freight vehicles. Ample

research has been conducted on the welfare implications of passenger traffic with the implementation of road pricing, concluding that the passengers who continue to use the road (who pay a toll and, in turn, experience faster travel time) stand to benefit from road pricing. Displaced passenger vehicles, however, will likely be disadvantaged by road pricing schemes as they are pressured to find new ways to travel. For this reason, giving these individuals better and more accessible transit options (public transit, cycling, walking, etc.) is an important strategy for minimizing the welfare loss of those who are ‘tolled off’ the roads. Moreover, if revenues are ear-marked for transportation projects, this is also likely to increase public acceptability.

Despite the welfare implications to non-commercial road users, empirical evidence from Stockholm illustrates that citizens are willing to support road pricing so long as the benefits are clear. Prior to Stockholm’s pilot project in 2006, opposition to road pricing was at 62 percent. Upon the completion of the pilot project and official implementation, approval for road pricing is at over 74 percent (Walker, 2011). Thus, the welfare implications from tolling are important to consider but can, in many ways, be mitigated by offsetting mechanisms.

### **Extending Delivery Hours**

Non-commercial vehicles are expected to benefit from extending night-time deliveries, albeit the benefits will be marginal. If a sufficient number of commercial vehicles shift to night deliveries, this should theoretically reduce congestion for passenger vehicles during the day-time.

### **Truck priority infrastructure**

Providing trucks with greater priority is expected to have negligible impacts to non-commercial vehicles. A new dedicated left-turn lane, for example, will benefit both passenger and commercial vehicles, whereas allowing commercial vehicles to travel in HOV lanes will benefit trucks but may result in slower travel speeds for non-commercial vehicles using the same HOV lane. These implications require further analysis.

### **8.5.5. *Inter-Regional Impacts***

#### **Road Pricing**

Distance-based pricing poses a big challenge for tolling trucks making deliveries in Metro Vancouver that originated from outside the region. Distance-based systems typically operate on GPS or on-board diagnostic systems, and integrating these systems for incoming freight would be challenging. By contrast, these inter-regional deliveries would be captured through tolling infrastructure through the use of cameras and license plate recognition.

Notwithstanding these technical details between the two forms, road pricing will have substantial regional affects that need additional consideration. In particular, the long-term implications for the Metro Vancouver economy need greater study. In one sense, road pricing will help lower the total private and social costs of congestion, which should have a positive impact on the long-term economic development in the region. On the other hand, if road pricing causes the price of consumer goods to rise, this will have trade implications with the rest of BC, Canada, and the US.

#### **Extending Delivery Hours**

The inter-regional impacts of extending delivery hours are expected to be relatively neutral. Deliveries originating from outside the region may have the option for making night-time deliveries, but due to the small percentage of these deliveries (between 4–13 percent) (Bickel et al., 2002), the major beneficiaries are expected to be within the Metro Vancouver region.

#### **Truck Priority Infrastructure**

Similar to extending delivery hours, the impact to inter-regional truck movement will be neutral, or slightly positive. If truck priority infrastructure increases the efficiency of traffic flow, then all trucks will benefit, including those that originate from outside the region.

## 8.6. Implementation Complexity

Criterion	Complex to implement	Moderately complex to implement	Easy to implement
Policy Option Ranking	Road Pricing	Extending Delivery Hours	Truck Priority Infrastructure

### Road Pricing

Recognizing that both forms of road pricing will be difficult to implement, tolling infrastructure will be relatively less complex than implementing a distance-based system, both in terms of time and resources. The technology for bridge tolling is readily available and is highly accurate. The road sensors in Stockholm, for example, have an error rate of roughly 0.1 percent (IBM, 2006). Moreover, tolling each bridge and tunnel in Metro Vancouver can be integrated within the existing tolling scheme on the Port Mann and Golden Ears bridges. With this said, substantial coordination is still necessary between TransLink, the provincial government, municipalities, and Transportation Investment Corporation (the crown corporation that manages the Port Mann Bridge).

By comparison, distance-based pricing requires significant administrative costs (outfitting cars with the required technology), along with the administrative capacity to track/charge road users. Installing GPS or OBD on cars also raises a host of logistic and privacy concerns that are significant barriers for garnering public acceptance. While systems in other jurisdictions illustrate these logistic and privacy concerns can be properly addressed, they add another layer of complexity to implementing a distance-based scheme.

In terms of implementation timelines, the cordon pricing scheme in London took two years to implement, not including the planning and design phases of implementation (Richards, 2006). Implementing road pricing in Metro Vancouver, whether distance-based or infrastructure tolls, will likely take longer given the fact that TransLink has conducted only preliminary research and needs to coordinate among two levels of government that include 23 local governments. Of the two options, infrastructure tolls may take less time to implement based on its integration with the existing tolling system. Infrastructure tolls will require agreement from all municipalities.

An additional barrier to implementing road pricing is that the provincial government would need to make legislative changes to enable TransLink (or some other institution) to design and implement road pricing. At present, TransLink does not have the authority to implement region-wide tolling. The provincial government would also need to amend its current tolling policy, which prohibits tolling bridges that do not have a “reasonable un-tolled alternative” for drivers (Beatty, 2010).

Demonstrated by the adoption of road pricing in other jurisdiction, political leadership is also a quintessential ingredient to implementation. Road pricing requires a “political champion with both the ability and desire to have (road pricing) implemented” (Deloitte, 2010). Moreover, due to the unique governance context of Metro Vancouver, support and leadership must be present at the local, regional, and provincial level.

Currently in Metro Vancouver, political support for road pricing is mostly at the local level. Metro Vancouver, the Mayor’s Council, and TransLink have consistently advocated for the adoption of road pricing, as early as 1993 (TransLink, 2013). However, without provincial support to make the necessary legislative and regulatory changes, region-wide road pricing cannot be implemented in Metro Vancouver, and thus increases the overall implementation complexity.

### **Extending Delivery Hours**

Extending delivery hours will require significant consultation with the private sector, labour unions and local governments. Raymond Kan, a regional planner with Metro Vancouver, estimates that 5–10 years of research, planning, and consultation is necessary prior to implementation; however, evidence from New York illustrates that a pilot program could be designed and implemented within two years (Texas Transportation Institute, 2012). Once stakeholders are adequately identified and consulted, creating a system of incentives for off-peak deliveries can be implemented relatively quickly.

If taken to the regional level, designing a comprehensive regional plan for extending delivery hours necessitates the coordination and consultation with each of the 23 local governments along with Metro Vancouver, TransLink, and the provincial government. Jurisdiction to implement a regional night-time delivery program is entirely

within the purview of local governments. Thus, the role of TransLink and Metro Vancouver is restricted to providing support and coordination. From this fact alone, developing a pilot program at a municipal level may be a pragmatic first step to achieving a regional framework—demonstrating the benefits on a small scale prior to full regional implementation.

### Truck Priority Infrastructure

Building truck priority infrastructure is the ‘path of least resistance’, as identified by one of the interviewed trucking companies. Infrastructure projects which give priority to commercial goods vehicles fits within the current approach for traffic management (i.e. supply-management instead of demand management), and is unlikely to receive pushback from government and industry stakeholders. Designing and implementing truck priority infrastructure still necessitates coordination and consultation between governments and industry; however, this approach aligns well with the goals and objectives of the trucking industry, government and supply chains.

## 8.7. Affordability: Net Project Costs

Criterion	High net project costs (\$50+ million)	Moderate net project costs (\$1-50 million)	Low net project costs (revenue-neutral or net positive)
Policy Option Ranking	Truck Priority Infrastructure	Extending Delivery Hours	Road Pricing

### Road Pricing

The clear benefit of road pricing is that it can be self-financing and, depending on the tolling structure, can produce surplus revenue. The biggest cost component of infrastructure tolls and distance-based tolls is the capital cost of infrastructure. In the case of infrastructure tolling, a system of cameras and sensors would need to be installed on all the bridges and tunnels in the region. By comparison, distance-based tolling would likely involve a combination of on-board diagnostic devices and GPS on all freight and passenger vehicles; a technology that is still evolving. The cost of these

technologies has fallen significantly over the past decade, and has improved in accuracy (Satellic Traffic Management, 2013).

The road pricing system in Stockholm, similar to the capital and operating costs necessary for tolling infrastructure in Metro Vancouver, costs roughly \$185 million in capital which was repaid after only 4 years from toll revenues (Walker, 2011). Despite the short return on the initial capital investment, the system in Stockholm was unusually expensive to implement based on several factors, such as: an oversized back office, transponders not being ready, and excessive transaction costs (Hamilton, 2011). Accordingly, the implementation and acquisition process in Stockholm provides Metro Vancouver with valuable lessons.

In a report by the Joint Technical Committee, comprised of staff from the Ministry of Transportation and Infrastructure, TransLink, and the Chief Administrative Officers (CAOs) from the cities of Surrey and Vancouver, tolling bridges can generate an estimated \$100–200 million per year. This revenue estimate is net of operating and administrative costs, but does not include capital start-up costs, and does not consider demand elasticity (i.e. the change in driving behaviour). To reach \$100–200 million per year in revenue, bridges would need to be tolled at least \$1.60 per vehicle crossing (Joint Technical Committee, 2012).

Tolling major pieces of infrastructure in Metro Vancouver could be a substantial source of revenue for the region. Depending on the tolling structure, toll revenues could fully replace the regional fuel tax. The existing regional gas tax of 12 cents/litre generates roughly \$330 million per year (TransLink, 2013). In order to replace the regional fuel tax, bridge toll estimates of \$1.60 – which generates between \$100–200 million – would likely need to be doubled or tripled. TransLink's estimates are based on one uniform toll price, so more research is needed to determine the behavioural and revenue effects from time-of-day pricing. Ultimately, whether tolls are designed to be revenue-neutral or generate a surplus is a decision that requires further discussion and engagement with the public, and is beyond the scope of this analysis.

## **Extending Delivery Hours**

The major cost component is primarily the administrative resources required to research, plan, and implement the extension of delivery hours. Depending on the policy's structure, other costs may include tax incentives provided by the government to encourage carriers and receivers to shift to night-time deliveries. The yearlong New York pilot project, involving 25 businesses and 8 delivery companies, operated on a budget of roughly \$1.8 million.

For container ports, evidence from Los Angeles and Long Beach suggests that a night-time delivery program in Metro Vancouver can be self-financing. The two Californian ports implemented a Traffic Mitigation Fee, which charges trucks to make port deliveries during peak periods. Revenue from peak deliveries is then used to pay for the extra labour costs for port employers to work night shifts.

## **Truck Priority Infrastructure**

Truck priority infrastructure has the highest cost of the three options. Although the capital costs of implementing a road pricing scheme is comparable to building major truck priority infrastructure projects, capital and operating costs for road pricing are recoverable through toll revenues. Unless the region starts to charge trucks for using specific infrastructure (an unlikely scenario), then the project costs quickly add up. Steve Brown with the City of Vancouver estimates that modifying a single intersection with a dedicated left-turn lane costs between \$1 to 12 million, depending on whether land acquisition is necessary (personal communication, Dec. 18, 2013). Assuming many of these types of priority improvements are undertaken in the region, the costs could easily exceed \$100 million.

## **8.8. Political Considerations**

The political context in Metro Vancouver, while not included in my criteria/measures analysis, is an important consideration for developing viable policy solutions. Transportation is a highly politicized issue in Metro Vancouver and consistently ranks near the top of municipal, regional, and provincial agendas. Road

congestion plays an ongoing role in discussions of regional mobility, but bigger issues such as infrastructure and transit financing are a current focal point of local politics.

In particular, mobility and transportation issues are expected to receive increased attention in 2014 with the looming regional transportation referendum. Although the date of the referendum is still uncertain, and the ballot question and the implications of the public vote unknown, the referendum is expected to steer the future of transportation funding in the region. If the referendum coincides with municipal elections, transportation planning and funding will be key election issues for municipal candidates. The Mayors' Council is working on a vision for the region that may serve as a basis for the referendum and a decision about the referendum's timing and coverage.

In addition to these upcoming decisions, TransLink is preparing its Regional Transportation Strategy and is expected to release its goods movement strategy in the coming year. The strategy is expected to provide a framework for addressing some of the major challenges facing the region (i.e. population growth, increased trucking/shipping activity, the Pacific Gateway, and congestion).

Support for road pricing continues to grow at the local level in Metro Vancouver. Having endorsed road pricing since 1993, the Mayor's Council is making a strong push for its adoption as both a funding instrument and for congestion management. Several mayors, including Mayor Dianne Watts of Surrey, suggest that tolling all the bridges could be implemented fairly quickly and would help redress regional inequities of the existing tolling framework (Sinoski, 2014). Considering local governments' support for adopting new transportation management tools, in addition to the upcoming transportation referendum, regional road congestion is expected to be a prominent issue moving forward.

## **Chapter 9. Recommendations**

Given that each option has the potential to reduce congestion for commercial vehicles, and that the options are not mutually exclusive, the recommendations focus on the time-line of implementation rather than whether one policy option should be adopted at the expense of others. Based on the evaluation and ranking from the analysis in Chapter 8, I present five recommendations to optimize road space in Metro Vancouver. The overall goal of these recommendations is to improve the efficiency and sustainability of the road network through gaining a better understanding of road congestion and its impacts, and developing a regional congestion-reduction strategy. If implemented, my recommendations serve as an effective framework for reducing the high costs of congestion for commercial vehicles.<sup>18</sup>

### **9.1. Recommendation 1: Improve Coordination and Consultation**

If Metro Vancouver is to address its systemic congestion problem, significant consultation and coordination among public and private interests is essential; more specifically, it requires active participation from the commercial goods sector in policy consultation and design. Transportation policy cuts across local, regional, and provincial government, and also involves multiple departments and agencies. Accordingly, in order

<sup>18</sup> Appendix M discusses several overarching recommendations which, while outside the scope of my study, aim to improve the regulatory and policy environment to facilitate smoother flow of goods and services.

to achieve a regional response to road congestion, the interests of all affected individuals and organizations need seats at the table. System integration, development of partnerships, and developing a clear long-term vision for congestion reduction are critical components to reaching effective outcomes.

## **9.2. Recommendation 2: Improve Data Collection for Trucking Activity**

In order to improve coordination and develop a congestion reduction strategy in Metro Vancouver, better data collection and analysis is a prerequisite. The quality and depth of the estimation models in this study are limited by inaccessible or non-existent data. The 2002 study conducted by Bickel et al. serves as the most recent comprehensive account of trucking movements in the Lower Mainland and helped form the foundation of the estimation model in this study. In order to get a better grasp of congestion and its impact to the trucking sector, better and more publically available data is a fundamental first step. This includes, for example, better data on trip and vehicle types, distances, time, routes, and average speeds.

Without a better understanding of freight and passenger activity, defining the parameters of congestion and its solutions will be increasingly difficult. Lacking this fact-base, creating a “sustained dialogue to build trust, resolve issues collaboratively and explore economic and infrastructure opportunities” will remain out of reach (Colledge, 2013). To improve data collection, TransLink, the Province and Metro Vancouver should commission an urban freight study with detailed data and analysis on passenger and freight activity.

## **9.3. Recommendation 3: Implement Night-time Delivery Pilot Program**

The analysis in Chapter 8 identifies the extension of delivery hours as a targeted and effective way to reduce congestion for commercial vehicles. Although road pricing is likely to cause a greater reduction in overall congestion levels (and adverse environmental impacts), creating a night-time delivery program is considerably less

complex to implement and avoids the plethora of equity concerns with road pricing. As such, Metro Vancouver should initiate a night-time delivery pilot program to test its effectiveness and determine whether a region-wide program is desirable.

Based on the pilot program in New York, a pilot program could be implemented relatively quickly in Metro Vancouver with a small number of participating businesses. Project costs from government would be relatively low (\$1.8 million for the New York program) and industry buy-in is likely to be high. The degree of government involvement in the pilot program can vary, depending on the goals and objectives of the program, and require further research and analysis. Government support might include financial compensation for purchasing equipment to reduce levels of noise from loading/unloading, or the purchase of secure night-time delivery boxes. If implemented in conjunction with the province, incentives may include tax deductions for participating businesses, though this is an unlikely scenario.

Such an initiative could be implemented by a single municipality, Metro Vancouver, TransLink, the provincial government, or a combination of all four levels of government. Ideally, the program would be regional in scope to allow all Metro Vancouver businesses the option of participating in the program; however, if the barriers to coordinating a regional scheme are too high, individual municipalities may be better suited to pursue a pilot program on their own.

Program evaluation needs to be a centerpiece of the pilot night-time delivery program. Data should be collected before and after the implementation of the program, specifically measuring the changes in delivery variables (reliability, per-unit costs, time savings, etc.), changes in the productivity for the receiving businesses, and the overall receptiveness of the participants to continue such a program. Noise levels are also a critical component to determining the environmental impacts of the program. Following the lead of pilot programs in Spain, regular testing should occur both before and during the pilot program.

## **9.4. Recommendation 4: Implement a Regional Infrastructure Tolling Scheme by 2020**

As a long-term strategy for optimizing road space, infrastructure tolling is one of the strongest policy instruments available to government. Tolls on bridges, tunnels, and highways have the potential to reduce congestion, raise revenue for road and public transit improvements, and defer the costs of multi-billion dollar infrastructure projects. In all, pricing the roads is a way to make better use of the existing road network, while also achieving other government objectives (such as fiscal prudence and environmental stewardship). More specifically, the technology for infrastructure tolling is readily available and can be integrated within the existing tolled infrastructure. Even though distance-based tolling has greater potential for congestion reduction, a wide range of privacy, equity, and economic concerns make it an unrealistic option at this time.

Using the examples of London, Stockholm, and Germany, implementing infrastructure tolls in Metro Vancouver is possible within a five-year time horizon. The arguments to support its adoption – increasing population, car ownership, and levels of congestion – are well-established, and the benefits to freight have been demonstrated in several areas around the world. The long-term implications of regional infrastructure tolling, however, are relatively understudied and require further analysis, including the impacts on land-use, value-added trade, boundary effects, labour markets, and the redistribution of social and economic welfare (Beatty, 2010).

Implementing tolls on the region's bridges, tunnels, and highways is a long-term commitment and requires significant planning, consultation, and engagement. To help build public literacy and education, the province and local governments should initiate engagement and outreach strategies to help define the overarching goals and objectives of a potential road pricing scheme. Key questions include: what types of offsetting mechanisms will be offered? What improvements are needed to the public transit network to ensure people have attractive transportation alternatives? Will tolls be revenue neutral, or will net revenues support future transportation projects? How will tolls affect the bottom line of trucking companies?

## **9.5. Recommendation 5: Incorporate Truck Priority Infrastructure into Future Infrastructure Projects**

Relative to road pricing and night-time delivery programs, building truck priority infrastructure is the least effective measure for reducing region-wide congestion for commercial vehicles. Building truck priority infrastructure is expensive, encourages road use, and has nominal effects in reducing long-term congestion. As such, truck priority infrastructure will have minimal impact on reducing noise, GHG, and air pollution, especially if truck priority infrastructure incents a greater number of vehicle trips.

With this said, road improvements will always be a necessary component to Metro Vancouver's transportation system, and truck priority infrastructure offers a way to make incremental improvements to the overall system. When infrastructure projects are being designed, it is important that the priority for commercial vehicles receive due consideration. The Gateway Strategy exemplifies a project which gives significant weight to the concerns of commercial goods movement, and this same sort of planning should be incorporated into all road infrastructure projects in the region and, specifically, Metro Vancouver's Regional Growth Strategy. Moreover, the trucking industry should have active input in the design and planning stages. Trucking companies use the roads for a living and have a practical understanding of the nuances and quirks of the transportation system—expertise that can augment the technical and planning expertise of government. The trucking companies interviewed in this study express a desire to be more involved with the consultation and planning processes.

Providing commercial trucks access to HOV lanes has perhaps the greatest potential for congestion reduction of all truck priority infrastructure options. More research and analysis is ultimately needed to explore its effectiveness, but there are several stretches of roadway where HOV lanes could produce significant time savings for commercial vehicles.

Given that the region's roads are owned and maintained by different levels of government, implementing a region-wide system will be difficult in the short-term. However, as a starting point, the provincial government should look at allowing trucks access to the HOV lane from the Iron Workers Memorial Bridge, along highway #1, and

across the Port Mann Bridge. Allowing trucks access to the HOV lane on highway #99 is also a potential option. Both stretches of highway are busy truck routes and are owned exclusively by the provincial government, meaning implementation barriers will be relatively low. Access to HOV lanes could be for certain times of the day or could be unlimited. This option can be implemented relatively quickly, requires minimal resources from government, and has potential to reduce congestion for commercial vehicles (and perhaps passenger vehicles as well).

## **Chapter 10. Conclusion: The Future of Goods Movement & Mobility**

Congestion is a costly burden for the trucking industry, supply chains, and society as a whole. But despite the significant implications of these costs – higher prices, lost productivity, and greater release of greenhouse gases and air pollutants – the topic is understudied in Metro Vancouver, and the magnitude of impacts are poorly understood. To help create a renewed dialogue, this study develops an updated estimate of congestion costs for the trucking industry. The estimates conclude that the cost of congestion for port container trucks is between \$26 and \$56 million per year, or roughly \$13,000 to \$28,000 per truck. If the ports operate at full capacity (which, currently ports are operating at 65 percent capacity) congestion costs for container trucks jump from \$26–56 million to \$40–87 million. Adjusting this model for all commercial trucks reveals total congestion costs of \$378–1,785 million per year in Metro Vancouver. These estimations include the cost of time delays, GHG emissions, and air pollution attributable to congestion.

Recurrent congestion represents roughly half of the total estimated dollar amounts. Effectively, this means half of the congestion costs are attributable to regular delays that are endemic to the transportation system; the other half represents delays from accidents, inclement weather, construction, etc. The policy recommendations presented in Chapter 9 are therefore targeted approaches to reducing these recurrent costs, although it can be reasoned that reducing recurrent congestion also reduces a portion of non-recurrent costs by reducing the probability of accidents.

A general consensus is emerging in the region that something needs to be done about road congestion; however, the options available to improve the flow of commercial goods are often overshadowed by broader discussions of mobility, transportation, accessibility, and affordability. These high-level issues are important to consider – as any viable policy response must fit within the bigger picture – but the considerations for

commercial goods movement are different from other road users and have clear economic consequences for the region.

Designing and implementing short- and long-term solutions is critical to the future of goods movement in the region. As demonstrated through the cost estimates, the private sector absorbs roughly 96–97 percent of commercial congestion costs directly, which are eventually passed onto consumers. The remaining 3–4 percent is the cost to society in the form of GHG and air pollutants from commercial vehicles. These are conservative estimates and represent only a fraction of the full costs to firms, individuals, and the natural environment. With improved data, more scientific estimates can be constructed.

Private trucking firms should be paying close attention to the rising costs of congestion. In one vein, trucking firms already pay a hefty premium for added labour and vehicle costs, reduced productivity, and unreliable delivery times (roughly \$25–55 million for port container trucks and \$370–1,700 million for all commercial vehicles). Equally important is the connection between congestion and the looming driver shortage in the trucking industry. While the exact link between congestion and high turnover rates requires further study, truck drivers experience the frustrations from congestion on a daily basis. Longer and more unreliable delivery times add to driver stress and, in some cases, results in financial penalty from employers. Reducing congestion means making the trucking industry more attractive for new labour and addressing one piece of the looming driver shortage.

Finding solutions to congestion for commercial goods requires a renewed approach. The traditional approach to reducing congestion (i.e. building more roads) fails to address the underlying causes of congestion and is extremely costly to taxpayers. This approach further subsidizes the use of motor vehicles and distorts the full cost of driving, creating problems of overuse and overcrowding on the roads. Furthermore, provincial, regional, and local governments face a substantial infrastructure deficit, whereby the pace of infrastructure development/maintenance is not keeping pace with demand. Contributing to the problem are falling revenues from fuel taxes, which pay for the bulk of road infrastructure and transit improvements. As congestion worsens in the

region, governments will be pressured to bolster transportation infrastructure yet will be constrained by fiscal realities.

Political and civic leadership will be instrumental in addressing road congestion in Metro Vancouver. The tools already exist and are proven to work effectively in other cities. Creating a night-time delivery pilot program and implementing regional infrastructure tolls have significant potential for optimizing road space for commercial vehicles and will help facilitate a more sustainable transportation system. Night-time delivery programs can be implemented relatively quickly and require minimal resources from government, and can also be implemented at the municipal or regional level. Regional infrastructure tolling, by comparison, is a tool the regional and provincial government should implement in the next five or six years to not only reduce existing toll inequities in the region, but to better optimize road space. This process should begin with public education, data collection, and shaping the overarching goals and objectives of a regional pricing scheme through consultation and engagement.

The road ahead is fraught with challenges, yet holds immense promise for revitalizing how we view mobility in Metro Vancouver. TransLink has already begun the push for conceptualizing transportation in terms of moving people and goods, instead of just moving vehicles. As a single company or individual, it is too easy to view the transportation network from a narrow lens. Naturally, we are more concerned about direct impacts to our lives or our bottom lines than with the overall mobility concerns of the region. To address the long-standing issues of road congestion in Metro Vancouver, government, industry, and the public need to take a step back and envision how to meet our complex mobility needs while balancing population growth, sustainability, and commercial goods movement.

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## Appendix A.

### Key Issues for the Freight Sector

Decades of deregulation in both Canada and the United States has created a fiercely competitive industry with profit margins typically between 2.5 and 5 percent (L'Allier, 2012). The industry operates within highly complex supply chains which depend on “tight schedules and reliable performance” (Weisbrod and Fitzroy, 2012). Highly sensitive to operating margins, trucking companies are exposed to greater risk and uncertainty from increasing levels of congestion—impacting shipping behaviour, transportation costs, and overall productivity.

In addition to the high level of industry competition, the sector is exposed to a wide range of local and international pressures. At a local level, perhaps the greatest challenge for the industry is the ongoing driver shortage and high rates of turnover. Both Canadian and American trucking companies consistently rank the driver shortage as one of the top concerns for the industry (BCTA, 2013). According to Canadian and US sources, the shortage is primarily due to an ageing workforce and increasing demand for trucking services, which puts upward pressure on wages and salaries to attract new drivers and constricts the growth of trucking companies looking to expand (Logistics Solution Builders Inc., 2005). In BC, the shortage of for-hire drivers by 2020 is projected to be between 2200 and 4500 drivers (Conference Board of Canada, 2013).

The high turnover rate of truckers is also a key concern within the industry and is linked with the driver shortage. The Canadian Trucking Human Resources Council completed a study in 2003 which estimates an annual industry turnover rate of 35 percent (Service Canada, 2013). Reasons for this high turnover rate include: working conditions, wages, long hours, lack of qualifications, seasonality of work, and health problems. Although not a primary cause, worsening congestion plays an indirect role in the shortage and high turnover of drivers, as it affects stress, anxiety, and the overall health of the trucking workforce.

Other local and international issues facing the trucking industry include:

**High land values and diminishing industrial land:** Space for trucking distribution centres is at a premium in the region, marked by a gradual exodus of trucking companies from the downtown core of Vancouver to surrounding cities south of the Fraser River, such as Richmond and Surrey (Metro Vancouver, 2007). While increasing land values in Vancouver and Burnaby are a partial cause of this move away from the city, shrinking industrial lands (rezoned for residential or commercial neighbourhoods) also play a role. Moving further away from the downtown core puts greater distance between distribution centres and the clients who depend on trucking services, and exposes trucking companies to more road congestion.

**Unloading/Loading Zones:** trucking companies have difficulty time finding space to load and unload goods in the dense areas of Metro Vancouver (BCTA, personal communication, November 28, 2013). This lack of adequate loading/unloading space can disrupt the normal flow of traffic during regular working hours, and puts pressure on the time and location of deliveries.

**Macroeconomic Pressures:** The trucking industry is highly sensitive to changes in international trade and levels of economic activity. As concluded by several studies, the level of trucking activity is strongly correlated with volumes of domestic and international trade (U.S. Bureau of Transportation Statistics and Garcia et al., 2008). Changes in international trade have strong influence on the profitability and levels of activity of trucking in Metro Vancouver. Other macroeconomic pressures affecting the trucking industry include: recessions, unemployment, inflation, and wage trends.

**Rising Fuel Prices:** After wages and benefits, fuel is the second largest input cost for most trucking companies in BC (Stats Canada, 2010). On average, diesel prices (in real terms) have risen 150 percent from 2002–2012 and are expected to continue to rise in the foreseeable future. While advancements in fuel efficiency technologies are expected to offset some of the pressure of increasing fuel prices, the International Energy Agency projects that energy efficiency gains in heavy duty trucks will be less than for passenger vehicles (IEA, 2012). Trucks also burn higher volumes of fuel when travelling at low and congested speeds (U.S. Department of Transportation, 2013).

**Reliability and Intermodal Connections:** Trucking is only one component of goods movement. Trucking companies have complex interactions with the four ports in Metro Vancouver, warehouse distribution centres, the airport, the US border, and other passenger and freight vehicles. Generally, trucking activity is determined by the interaction of shippers, carriers, and receivers (Holguín-Veras, 2008). The complexity of these interactions are compounded by the “multitude of vehicle types, shipment, business structures, logistic supply chains, attributes of trade routes, and the secrecy of information due to business competition” (Ismail et al., 2008). In order to properly understand the impacts of road congestion on the trucking industry, the wide ranging (and often conflicting) interests of stakeholders require careful consideration.

## **Appendix B.**

### **Participant Organizations**

#### **Group 1: Trucking Companies**

- Indian River Transport
- First Canadian Logistics Ltd.
- Harbour Link Container Services Inc.

#### **Group 2: Industry Organizations/Stakeholders**

- Chamber of Shipping of BC
- BC Trucking Association
- City of Vancouver
- Metro Vancouver
- Greater Vancouver Gateway Council
- TransLink

## Appendix C.

### Semi-Structured Interview Questions

**Purpose of interview:** The goal of this research is to provide a better understanding of the impacts of congestion for goods movement in Metro Vancouver. The interview questions aim to capture the opinions and perspectives of your organization regarding congestion and the available public policy options for optimizing road space. The ultimate goal is to explore and discuss policy options that encourage and create an efficient, reliable, sustainable road network.

#### Section 1: Starter Questions

- What are the three biggest barriers facing the movement of goods and services in Metro Vancouver?
- Over the past decade, do you believe that delays due to congestion have become worse, remained the same, or have improved?
- Does the City of Vancouver have any specific measures in place to minimize the effects of congestion?
- If so, what are some of these measures?
- How important is the reliability of deliveries to the movement of goods and services?
- What role do municipalities have to improve the optimization of road space in Metro Vancouver?

#### Section 2: Policy Option Questions

In the interest of optimizing road space to increase the efficiency, reliability, and sustainability of commercial activity in Metro Vancouver, there are a range of policy options available to government. This section of the interview focuses on the details of some of the most viable policy options. More specifically, I'm interested in how your organization perceives the benefits, costs, and overall efficacy of each option.

Building more capacity is not among the options in my research, as this is demonstrated to have little effect on reducing road congestion in the long-run. While building more capacity and maintaining existing capacity is a necessary component to the transportation network in Metro Vancouver, my research focuses on how to make the best use of existing road space. The options include:

**Pricing mechanisms:** can take many forms, but the main idea is to internalize the adverse effects of driving, such as congestion, air pollution, and greenhouse gas emissions by having road users pay a toll/fee. For the purposes of my research, I'm using the most viable forms of pricing mechanisms that have been proposed in Metro Vancouver: tolling major bridges and highways, and creating a distance-based charging scheme whereby road users are charged on a per kilometer basis. For both of these road pricing schemes, it is assumed that tolls and fees will be priced based on the time of day and levels of congestion. It is also assumed that road pricing would toll/charge both trucks and passenger vehicles.

**Designating strategic roads and highways as truck priority lanes:** this could include creating (tolled or un-tolled) truck priority lanes on strategic trucking routes or having

shared lanes for large vehicles (including buses, construction vehicles, etc.). The latter is similar to High Occupancy Tolloed lanes, whereby trucks would have the choice to pay to use faster moving lanes.

**Land-use planning and creating “freight villages”:** designating strategic areas in the region as intermodal freight hubs. These typically connect rail and road freight, and are designed to centralize and organize freight activity. It is assumed that creating a ‘freight village’ would involve a public-private partnership.

**Extending delivery hours:** this includes altering municipal by-laws to extend delivery times and encourage off-peak truck deliveries.

**Using GPS technology to improve coordination and information:** this includes government led initiatives to help facilitate better information sharing and coordination across the trucking industry.

Given these five options for optimizing road space in Metro Vancouver for commercial goods movement, please rank the options from most preferred to least preferred.

What are some of the reasons why \_\_\_\_\_ is your preferred policy option?

- Do you think \_\_\_\_\_ could be an effective tool to optimize road space in Metro Vancouver?
- Do you think \_\_\_\_\_ is a long-term solution for maintaining efficient, reliable, and sustainable commercial vehicle movement?
- Do you or the City of Vancouver have any specific concerns about \_\_\_\_\_?
- How do you think \_\_\_\_\_ will affect other road users or neighbouring communities?
- What impact, if any, \_\_\_\_\_ would this have for businesses of different sizes?
- What are some potential barriers to implementing \_\_\_\_\_?

You’ve listed \_\_\_\_\_ and \_\_\_\_\_ as your second and third most preferred options, what actors make these options less desirable to your most preferred choice?

- Why do you consider \_\_\_\_\_ and \_\_\_\_\_ as your least preferred options?
- If the city of Vancouver were to encourage off-peak deliveries, what steps would need to be taken? Is it a matter of changing noise bylaws?

### Section 3: Wrap-up Questions

Looking at the five policy options available to government...

- Can any of these policy options reduce operating costs of the trucking industry?
- Are there any policy options that I have missed that the City of Vancouver considers viable or desirable?
- If the Metro Vancouver were to initiate a regional dialogue for improving the long-term reliability, efficiency, and sustainability of commercial goods movement, is this something the city of Vancouver would participate in?

## Appendix D.

### Estimation Model: Port Container Trucks (Sheet One)

<b>Assumptions</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>	<b>Scenario 1(max)</b>	<b>Scenario 2 (max)</b>	<b>Scenario 3 (max)</b>
Average number of trips per day	2,859	2859	2859	4425	4425	4425
Average delay per trip (delay/60 mins)	0.25	0.33	0.416	0.25	0.33	0.416
Value of time (\$/hr)	118	137	156	118	137	156
Avg. Speed in Congestion (km/hr)	8	8	8	8	8	8
Social cost of Carbon (\$/tonne)	40	63	120	40	63	120
<b>Value of Time</b>						
Avg. Delay hours per day	715	943	1,189	1,106	1,460	1,841
<b>Value of Time (\$)/day</b>	<b>\$ 84,341</b>	<b>\$ 129,255</b>	<b>\$ 185,538</b>	<b>\$ 130,538</b>	<b>\$ 200,054</b>	<b>\$ 287,165</b>
<b>Value of GHGs (per day)</b>						
CO2 emissions (g/km @ 8km/hr)	3,750	4,063	4,375	3,750	4,063	4,375
CO2 emissions (tonnes/km)	0.003750	0.004063	0.004375	0.00375	0.00406	0.00438
Avg. Distance congested conditions (km/trip)	2.0000	2.6400	3.3280	2.0000	2.6400	3.3280
Avg. Distance congested conditions (km) per day	5,718	7,548	9,515	8,850	10,726	14,726
CO2 emissions (tonnes)	21	31	42	33	44	64
<b>Value of GHGs (\$)/day</b>	<b>\$ 858</b>	<b>\$ 1,932</b>	<b>\$ 4,995</b>	<b>\$ 1,328</b>	<b>\$ 2,746</b>	<b>\$ 7,731</b>
<b>Value of CACs/year (sheet two)</b>	<b>\$ 272,856</b>	<b>\$ 363,445</b>	<b>\$ 454,033</b>	<b>\$ 422,312</b>	<b>\$ 557,451</b>	<b>\$ 702,727</b>
<b>Totals (Per year)</b>						
Value of Time (\$)	\$ 26,145,555	\$ 40,069,170.90	\$ 57,516,676	\$ 40,466,625	\$ 62,016,818	89,021,088
Value of CACs	\$ 272,856	\$ 363,445	\$ 454,033	\$ 422,312	\$ 557,451	702,727
Value of GHGs (\$)	\$ 265,887	\$ 598,918	\$ 1,548,526	\$ 411,525	\$ 851,138	2,396,722
<b>Total (\$)</b>	<b>\$ 26,684,298</b>	<b>\$ 41,031,533</b>	<b>\$ 59,519,235</b>	<b>\$ 41,300,462</b>	<b>\$ 63,425,407</b>	<b>\$ 92,120,536</b>

## Appendix E.

### Estimation Model: Port Container Trucks (Sheet Two – Air Contaminants)

<b>Delay Assumptions</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>	<b>Scenario 1 (max)</b>	<b>Scenario 2 (max)</b>	<b>Scenario 3 (max)</b>
Average delay (hr)	0.25	0.333	0.416	0.25	0.33	0.416
Average number of trips/day	2859	2859	2859	4425	4425	4425
<b>Emission Assumptions</b>	<b>SO2</b>	<b>NOx</b>	<b>VOCs</b>	<b>PM2.5</b>	<b>PM10</b>	
Values for CACs (per tonne)	\$ 33,495	\$ 37,687	\$ 3,770	\$ 122,345	\$ 79,656	
Emission rates (4km/hr) (g/hr)	0.037	29.8	3.38	0.42	0.54	
<b>ESTIMATES</b>	<b>Scenario 1 (NOx)</b>	<b>Scenario 2 (NOx)</b>	<b>Scenario 3 (NOx)</b>	<b>Scenario 1 (SO2)</b>	<b>Scenario 2 (SO2)</b>	<b>Scenario 3 (SO2)</b>
Emissions per trip delay (g)	7.450	9.923	12.397	0.009	0.012	0.015
Grams/year=	6,602,861	8,795,010	10,987,160	8,198	10,920	13,642
Tonnes/year=	6.603	8.795	10.987	0.008	0.011	0.014
\$/year	\$ 248,842	\$ 331,458	\$ 414,073	\$ 275	\$ 366	\$ 457
	<b>Scenario 1 (PM2.5)</b>	<b>Scenario 2 (PM2.5)</b>	<b>Scenario 3 (PM2.5)</b>	<b>Scenario 1 (VOC)</b>	<b>Scenario 2 (VOC)</b>	<b>Scenario 3 (VOC)</b>
Emissions per trip delay (g)	0.105	0.140	0.175	0.845	1.126	1.406
Grams/year=	93,060	123,957	154,853	748,915	997,555	1,246,195
Tonnes/year=	0.093	0.124	0.155	0.749	0.998	1.246
\$/year	\$ 11,385	\$ 15,165	\$ 18,945	\$ 2,823	\$ 3,761	\$ 4,698
	<b>Scenario 1 (PM10)</b>	<b>Scenario 2 (PM10)</b>	<b>Scenario 3 (PM10)</b>			
Emissions per trip delay (g)	0.135	0.180	0.225			
Grams/year=	119,649	159,373	199,096			
Tonnes/year=	0.120	0.159	0.199			
\$/year	\$ 9,531	\$ 12,695	\$ 15,859			
<b>Totals/year</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>			
	\$ 272,856	\$ 363,445	\$ 454,033			

## Appendix F.

### Estimation Model: Port Container Trucks (Sheet Three – Max Scenario CACs)

<b>Delay Assumptions</b>	<b>Scenario 1 (max)</b>	<b>Scenario 2 (max)</b>	<b>Scenario 3 (max)</b>			
Average delay (hr)	0.25	0.33	0.416			
Average number of trips/day	4425	4425	4425			
<b>Emission Assumptions</b>	<b>SO2</b>	<b>NOx</b>	<b>VOCs</b>	<b>PM2.5</b>	<b>PM10</b>	
Values for CACs (per tonne)	\$ 33,495	\$ 37,687	\$ 3,770	\$ 122,345	\$ 79,656	
Emission rates (4km/hr) (g/hr)	0.037	29.8	3.38	0.42	0.54	
<b>MAX ESTIMATES</b>						
	<b>Scenario 1 Nox</b>	<b>Scenario 2 Nox</b>	<b>Scenario 3 Nox</b>	<b>Scenario 1 SO2</b>	<b>Scenario 2 SO2</b>	<b>Scenario 3 SO2</b>
<b>Grams/year</b>	10,219,538	13,489,790	17,005,310	12,689	16749.0675	21,114
<b>Tons/year=</b>	10.220	13.49	17.005	0.013	0.016749068	0.021
<b>\$/year</b>	\$ 385,144	\$ 508,390	\$ 640,879	\$ 425	\$ 561	\$ 707
	<b>Scenario 1 VOC</b>	<b>Scenario 2 VOC</b>	<b>Scenario 3 VOC</b>	<b>Scenario 1 PM10</b>	<b>Scenario 2 PM10</b>	<b>Scenario 3 PM10</b>
<b>Grams/year</b>	1,159,129	1530050	1,928,790	185,186	244445.85	308,150
<b>Tons/year=</b>	1.159	1.530	1.929	0.185	0.24444585	0.308
<b>\$/year</b>	\$ 4,370	\$ 5,768	\$ 7,272	\$ 14,751	\$ 19,472	\$ 24,546
	<b>Scenario 1 PM 2.5</b>	<b>Scenario 2 PM2.5</b>	<b>Scenario 3 PM 2.5</b>			
<b>Grams/year</b>	144,034	190124.55	239,672			
<b>Tons/year=</b>	0.144	0.190	0.240			
<b>\$/year</b>	\$ 17,622	\$ 23,261	\$ 29,323			
<b>MAX Totals/year</b>	<b>Scenario 1 (max)</b>	<b>Scenario 2 (Max)</b>	<b>Scenario 3 (max)</b>			
	\$ 422,312	\$ 557,451	\$ 702,727			

## Appendix G.

### Estimation Model: All Commercial Vehicles (Sheet One)

<b>Assumptions</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>
Average number of trips per day	411,000	411,000	411,000
Average delay per trip (delay/60 mins)	0.083	0.166	0.25
Value of time (\$/hr)	37	47	57
Avg. Speed in Congestion (km/hour)	8	8	8
Social cost of Carbon (\$/tonne)	40	63	120
<b>Value of Time</b>			
Results (per day)			
Value of Time (hr/day)	34,113	68,226	102,750
<b>Value of Time (\$)/day</b>	<b>\$ 1,262,181</b>	<b>\$ 3,206,622</b>	<b>\$ 5,856,750</b>
<b>Value of GHGs (\$)/day</b>			
CO2 emissions (g/km @ 8km/hr)	3,750	4,063	4,375
CO2 emissions (tonnes/km)	0.003750	0.004063	0.004375
Distance congested conditions (km) per trip/day	0.664	1.328	2.000
Distance congested conditions (km) per day	272,904	545,808	822,000
CO2 emissions/day (tonnes)	1,023	2,218	3,596
<b>Value of GHGs (\$)/day</b>	<b>\$ 40,936</b>	<b>\$ 139,710</b>	<b>\$ 431,550</b>
<b>Value of CACs/year (sheet two)</b>	<b>\$ 13,022,659</b>	<b>\$ 26,045,319</b>	<b>\$ 39,224,878</b>
<b>Totals (Per year)</b>			
Value of Time (\$)	\$ 391,276,110	\$ 994,052,820	\$ 1,815,592,500
Value of CACs	\$ 13,022,659	\$ 26,045,319	\$ 39,224,878
Value of GHGs (\$)	\$ 12,690,036	\$ 43,310,078	\$ 133,780,500
<b>Total (\$)</b>	<b>\$ 416,988,805</b>	<b>\$ 1,063,408,216</b>	<b>\$ 1,988,597,878</b>

## Appendix H.

### Estimation Model: All Commercial Vehicles (Sheet Two)

<b>Delay Assumptions</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>			
Average delay (hr)	0.083	0.166	0.25			
Average number of trips/day	411000	411,000	411,000			
<b>Emission Assumptions</b>	<b>SO2</b>	<b>NOx</b>	<b>VOCs</b>	<b>PM2.5</b>	<b>PM10</b>	
Values for CACs (\$ per tonne)	\$ 33,495.00	\$ 37,687.00	\$ 3,770.00	\$ 122,345.00	\$ 79,656.00	
Emission rates (4km/hr) (g/hr)	0.037	29.8	3.38	0.42	0.54	
<b>ESTIMATES</b>						
	<b>Scenario 1 (NOx)</b>	<b>Scenario 2 (NOx)</b>	<b>Scenario 3 (NOx)</b>	<b>Scenario 1 (SO2)</b>	<b>Scenario 2 (SO2)</b>	<b>Scenario 3 (SO2)</b>
<b>Emissions per trip delay (g)</b>	2.4734	4.9468	7.45	0.003071	0.006142	0.00925
<b>Grams/year=</b>	315135894	630271788	949204500	391276.11	782552.22	1178542.5
<b>Tonnes/year=</b>	315.135894	630.271788	949.2045	0.39127611	0.78255222	1.1785425
<b>\$/year</b>	\$ 11,876,526	\$ 23,753,053	\$ 35,772,670	\$ 13,106	\$ 26,212	\$ 39,475
	<b>Scenario 1 (PM2.5)</b>	<b>Scenario 2 (PM2.5)</b>	<b>Scenario 3 (PM2.5)</b>	<b>Scenario 1 (VOC)</b>	<b>Scenario 2 (VOC)</b>	<b>Scenario 3 (VOC)</b>
<b>Emissions per trip delay (g)</b>	0.03486	0.06972	0.105	0.28054	0.56108	0.845
<b>Grams/year=</b>	4441512.6	8883025.2	13378050	35743601.4	71487202.8	107661450
<b>Tonnes/year=</b>	4.4415126	8.8830252	13.37805	35.7436014	71.4872028	107.66145
<b>\$/year</b>	\$ 543,397	\$ 1,086,794	\$ 1,636,738	\$ 134,753	\$ 269,507	\$ 405,884
	<b>Scenario 1 (PM10)</b>	<b>Scenario 2 (PM10)</b>	<b>Scenario 3 (PM10)</b>			
<b>Emissions per trip delay (g)</b>	0.04482	0.08964	0.135			
<b>Grams/year=</b>	5710516.2	11421032.4	17200350			
<b>Tonnes/year=</b>	5.7105162	11.4210324	17.20035			
<b>\$/year</b>	\$ 454,877	\$ 909,754	\$ 1,370,111			
<b>Totals/year</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>			
	\$ 13,022,659	\$ 26,045,319	\$ 39,224,878			

# Appendix I.

## Interview Summaries

The interviews were broken into three segments. The first segment gauges the participants' general perception of road congestion and goods movement in Metro Vancouver. These questions help situate road congestion within the wider context of the transportation network and other ongoing issues facing goods movement in the region.

The second segment of the interview presents the participants with five different policy options to address road congestion for commercial traffic. Given the lack of data for road congestion and commercial goods movement, stakeholder expertise is a particularly valuable analytical tool. Participants were asked to rank and evaluate each option. Lastly, the final interview segment asks high level questions about the intended goals and outcomes of the policy options, focusing on how best to achieve economic, environmental, and government objectives.

### Group 1: Trucking Industry

The participants in Group 1 include owners and/or managers at three trucking companies from Metro Vancouver. Two interviews were conducted by telephone, and one in person.

#### *Part 1: High-level Questions*

According to the trucking companies, congestion has worsened significantly over the past decade. One participant lists the Knight Street corridor as one of the worst in the region—known as the 'gauntlet' in the industry. In the span of three years, the same trucking company estimates that congestion has reduced its number of deliveries per day. Where three round trips were possible in 2010, the average is now around two round trips per day.

Reliability is crucial to the trucking industry, a point raised by each of the participants. Delays from congestion cause significant domino effects with the supply chain, especially for port container trucks. In some cases, import crews waiting to load container ships are forced to wait for unpredictable amounts of time for their containers to arrive. As a result, delays from congestion cost the trucking companies and receivers, primarily from increased labour costs.

The delays to trucking companies are substantial and are built into the planning and logistics of the companies interviewed. One company, for example, gives its clients an estimated 4 hour window for delivery times based on unreliable road conditions. Another response to congestion by one of the trucking companies is through reversing its delivery schedule to move against the flow of commuter traffic and to start deliveries earlier (from 6am to 5am).

To deal with the effects of congestion, one of the companies uses GPS devices to track the movements of its fleet and to assist in providing drivers with route changes to adapt to changing traffic conditions. This option, however, is not available to all companies. Owner-operator companies do not have the same incentive to install GPS devices on its

trucks, as the vehicles are owned and operated by its employees, not the company. Even though GPS information could be helpful, owner-operator companies are hesitant to make the investment.

All of the trucking companies interviewed believe that government has a role in reducing the impacts from congestion and are willing to participate in government consultation on road congestion.

### ***Part 2: Policy Option Evaluation***

Each participant was provided a brief description of the policy options, which was included in the preliminary email prior to conducting interviews. To ensure each participant understood the terms of reference for each option, they were asked if they required further clarification. The participants in Group 1 are very familiar with the five options presented; their questions were simply to clarify some of the assumptions of how each option would be implemented (detailed in Chapter 7).

To gauge the overall desirability of each policy, participants were asked to rank the options based on their preference for optimizing road space. Overall, truck priority lanes and road pricing are the most preferred options. Although trucking firms were initially reluctant to the idea of road pricing, the assumptions made (revenues recycled, time-of-day pricing, passenger vehicles included, and offsetting mechanisms) increased the option's attractiveness. Under these assumptions, one of the trucking participants believe that road pricing can actually reduce per-unit costs, providing that all of the bridges are tolled at the same rates and that the existing tolls on the Port Mann and Golden Ears bridges are reduced from their current (high) rates.

Truck priority infrastructure ranks highly among each of the three participant companies. Participants believe that truck priority infrastructure provides a clear benefit to the trucking industry, although each participant believes that there are limits to its effectiveness in the long-term. Suggestions for priority projects include: prohibiting trucks from using the left-most lane on highways, building a third lane on highway #99, and giving trucks access to HOV and transit lanes. The latter is viewed as perhaps the most viable solution with the greatest benefits and the lowest costs to government. One trucking company suggested that trucks should be given access to HOV lanes on provincial highways #1 and #99. This, according to the trucking company, would provide immediate time-saving benefits and would be relatively easy to implement.

Urban consolidation centres are the third most preferred option for two of the trucking participants, while extending delivery hours ranks as the third most preferred option for the other trucking company participant. This may be explained by the type of trucking firms interviewed. Two of the participants represent port-container truck companies, while the other company is a small-scale company which predominantly hauls office supplies. The two port container companies rank urban consolidation centres more highly than extending delivery hours, perhaps because extending delivery hours is already in operation at three of Metro Vancouver's ports (with limited success in reducing congestion). By comparison, extending delivery hours would have significantly different implications for a small for-hire trucking firm and is currently untried in Metro Vancouver. Moreover, urban consolidation centres stand to benefit port-container trucks more than for general commercial delivery companies. UCCs are often connected to rail lines and offer space for empty container storage. This clearly stands to benefit port-

container trucks more than for small-scale for-hire trucking companies. The small for-hire company does not see UCCs as a viable option for non-port container trucking companies and would have no interest in moving locations to a UCC.

Overall, information-based technology is the least preferred option. Two of the three companies outfit their fleets with GPS technology already, and all of the participants believe this is something the private sector can provide on its own, without government intervention. However, there was a general consensus that the existing data available from government (i.e. TransLink's real-time traffic map and provincial highway cameras) are helpful tools, but not long-term solutions to congestion.

### ***Part 3: Wrap-up Questions***

Overall, there is little agreement among the trucking companies on what option(s) can best optimize road space in the long-term. One participant believes that building truck priority infrastructure and implementing regional bridge tolls will have the biggest positive impacts on stabilizing peak-hour traffic and optimizing road space. Whereas another participant believes that the biggest positive impacts will accrue from building a satellite distribution hub along the Fraser River (for port trucks) and improving public transit. The remaining participant believes that the best solution is a combination of all five policy options.

For the two port-container truck companies, a reduction of one-way (deadhead) trips is the clearest way to reduce the adverse environmental impacts from commercial goods movement. However, as noted by one participant, the existing reservation system at the ports is the biggest barrier to achieving this reduction. If they could, companies would already be reducing one-way trips to save labour and fuel costs, but they are inhibited by the current port reservation system.

Each company participant expresses interest in engaging in a regional dialogue for addressing road congestion in Metro Vancouver.

## **Group 2: Supply Chain Stakeholders**

The participants in Group 2 cover a wide range of professions within the goods movement sector in Metro Vancouver. Representatives were interviewed from the BC Trucking Association, TransLink, Port Metro Vancouver, the City of Vancouver, the Chamber of Shipping of BC, and the Greater Vancouver Gateway Council. The questions focus on the impacts of congestion on road freight, and are broader in scope than the questions in Group 1. Participants in Group 2 are experts within the goods movement sector, but are further removed from the daily ebb and flow of trucking activity.

### ***Part 1: High-level Questions***

To gauge perceptions of road congestion, participants were asked whether congestion has worsened over the past decade, stayed roughly the same, or has improved. Overall, participants in Group 2 believe congestion in the region has worsened or remained roughly the same over the past decade. All of the participants recognize increased traffic volumes in an absolute sense, but qualified their responses by mentioning the significant investments in infrastructure and public transit. Several participants discussed the

nominal improvements on strategic corridors, such as the South and North Fraser Perimeter roads and the Port Mann Bridge.

Stephen Brown, president of the Chamber of Shipping of BC, believes the frustration from the trucking industry helps tell the story of congestion. With specific focus on port container movement, he argues that road infrastructure has not kept pace with the continued increase in container movements, which has a domino effect on goods movement throughout the supply chain. Accordingly, the result is longer queuing and loading time for truckers, with the majority of trips being made during peak periods to meet the needs of their clients (personal communication, December 5, 2013).

Two other participants believe that nominal gains have been made by expanding infrastructure in certain areas, but diminished by regional growth. Ongoing projects such as the South and North Perimeter roads will alleviate a number of choke-points in the near-term, but these gains will be offset by increasing traffic volumes (barring the overall reduction in traffic in the City of Vancouver). Phoebe Cheung and Helen Cook of TransLink believe – based on TransLink survey results – that congestion has remained roughly the same over the past decade and is more stable.

To get an overall sense of the current transportation challenges in Metro Vancouver, the participants were asked what they, or their respective organizations, perceive as the three biggest barriers facing goods movement. Participants from TransLink and the Gateway Council list congestion, population growth, and a lack of reliability as top barriers for goods movement, while other participants list the lack of night-time or off-peak deliveries as a major barrier.

At the government level, inconsistency between municipal by-laws in the region is a common grievance from the participants. The primary concern is that municipal bylaws regarding vehicle weights and dimensions are not standardized for the region which, in turn, creates an administrative and logistical burden for trucking companies. One participant goes further to argue that there is also inconsistency with the implementation of provincial weight and dimension regulations, and inconsistency with the national Memorandum of Understanding on Vehicle Weights and Dimension Policy. The same participant states that only a select number of municipalities in Metro Vancouver (ex. the City of Vancouver and Surrey) give consideration for the permits required for transporting oversized and overweight commodities. With no centralized permitting agency in the region, trucking companies are often forced to approach the municipalities on an individual basis. For businesses serving more than one municipality, this acts as a substantial transaction cost of doing business—a cost that could be minimized with better planning and coordination at the regional level.

Another inconsistency across municipalities, discussed by two participants, deal with noise bylaws. Similar to weight and dimension regulations, municipalities have different levels of acceptable noise volumes during day and night-time hours, with varying levels of enforcement. As one participant mentioned, these inconsistencies curtail the ability of the trucking industry to “move goods during off-peak periods and in particular overnight.”

Other barriers discussed by participants include: the completion of current/upcoming infrastructure projects (namely, the South and North Fraser Perimeter roads, the Patullo Bridge, and the George Massey Tunnel); one-way container trips to and from port facilities; the inconvenient location of container terminal services (such as the inspection

facility in Burnaby); and the lack of parking for unloading/loading for commercial vehicles.

Participants share an overarching consensus on the importance of reliability for goods movement, and that reliability is extraordinarily important to goods movement. As noted by the Chamber of Shipping of BC, unreliability from congestion can cause losses in profit and reputation, and disrupts the intermodal connections of goods movement. Unreliable delivery times increase the cost of doing business and decrease the competitiveness of the regional economy, resulting in higher prices for consumers. More specifically, one participant discussed the connection between unreliability and the current labour shortage and aging workforce in the trucking industry. On one hand, drivers paid on a per-delivery basis are penalized for unreliable deliveries through docked pay or through the opportunity cost of lost time (being unable to make additional deliveries), while trucking companies suffer from a loss in productivity of both its drivers and its vehicle fleet.

## ***Part 2: Policy Option Evaluation***

Each participant was provided a brief description of the policy options, which was included in the preliminary email prior to conducting interviews. To ensure each participant understood the terms of reference for each option, they were asked if they required further clarification. The participants in Group 2 are familiar with the five options presented with only two participants requiring additional details—one for road pricing and another for freight villages. In the former case, the participant required further detail on how to choose the specific implementation details for the road pricing scheme (such as time-of-day pricing or tolling bridges), given that there are numerous ways road pricing could be implemented in Metro Vancouver. The latter participant had never heard of the term freight villages, but is familiar with freight consolidation centres. It was merely the language that required further clarification.

To gauge the overall desirability of each policy, the participants were asked to rank the options based on their preference for optimizing road space.<sup>1</sup> Overall, participants chose road pricing as their preferred policy option to optimize road space, although some participants made qualifying remarks. One participant, for example, chose road pricing and extending delivery hours as complementary policies that should be implemented simultaneously. Another participant advocates for implementing tolls on infrastructure rather than a per-kilometer charge; tolling bridges could be integrated with existing tolling infrastructure for the Port Mann and Golden Ears bridges and would have a positive impact on reducing regional congestion and improving commercial goods movement.

<sup>1</sup> The semi-structured interview questions were amended specifically for the interview with TransLink. The two interview participants from TransLink did not feel comfortable ranking the options and, instead, discussed the individual tradeoffs of each option separately.

There is only one participant that did not consider road pricing as the most preferred choice. Instead, this participant preferred the government look at more feasible short-term options that require less intervention—such as using GPS technologies and extending delivery hours. With this said Mr. Wilds recognizes the potential effectiveness and comprehensiveness of road pricing and sees it as a long-term solution. Road pricing is an option that the Gateway Council might support if the government can more finely define the terms and conditions of a potential road pricing scheme.

Aside from implementing pricing mechanisms, the participants showed a mixed response to the other four policy instruments. Implementing truck Priority Infrastructure, for example, ranked as the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> most preferred option. Similarly, three participants listed freight villages as their third most preferred option, with one participant listing freight villages as the fourth preferred option. Technological-based solutions received mixed support as well, with two participants listing it as their 1<sup>st</sup> and 2<sup>nd</sup> most preferred option, whereas two other participants viewed technology-based options as their least preferred.

Based on the participants' preferences for policy instruments, a series of follow-up questions were asked to delve into the economic, environmental, and social trade-offs associated with each.

### ***Part 3: Wrap-up questions***

As a general finding, several participants made the point that the five options presented are not stand-alone policies. Congestion is a complex problem with no silver bullet policy; rather, addressing the issue involves a coordinated and multifaceted approach. Specifically, participants from TransLink found it difficult to compare and contrast the trade-offs of each policy option, and chose not to rank or the relative effectiveness of each option.

Overall, the majority of participants believe that road pricing (or a variant thereof) has the most potential for reducing regional congestion. Bob Wilds, while cautious about the cost and revenue implications of road pricing, believes that road pricing can address long-term transportation challenges by optimizing existing road infrastructure. Similarly, another participant argues that the most effective option is to combine road pricing with other incentives for commercial vehicles to move towards off-peak deliveries. Only one participant, Stephen Brown, believes that freight villages are the most effective option for reducing congestion.

In terms of achieving environmental goals of emission and pollution reduction, road pricing was the preferred option for three participants. These participants believe that road pricing can cause the greatest modal shift in passenger traffic, in addition to encouraging businesses to maximize trips and deliver during the most cost effective period of the day.

The financial burden of each option on the trucking industry is of utmost importance, given that any additional costs will be absorbed by businesses and consumers. Without the specific implementation details of each option, it is difficult to tell what the exact impacts to the trucking industry would be. Moreover, given the heterogeneity of the trucking industry, the impacts are likely to be felt differently according to the type and size of business. With these considerations in mind, Bob Wilds and Stephen Brown believe that reducing two-way trips will provide the biggest net benefit to the trucking

industry, while the other participants chose not to select an option based on limited details.

Looking forward, all participants in group 2 are willing to participate in a regional dialogue on exploring ways to optimize road space in the region. Each of the participants' organizations is already working with Metro Vancouver and municipalities on a regular basis. A coordinated regional dialogue would expand on ongoing efforts.

## **Appendix J.**

### **Description of Criteria and Measures**

#### **Societal Objectives**

##### ***Efficiency***

The most important benchmark for evaluating the policies is whether the option optimizes road space and facilitates more efficient goods movement. This can manifest itself through speedier delivery times, reductions in delay, or higher average speeds. Using each of these indicators, and holding the supply of infrastructure constant, will show whether a policy option is likely to increase roadway efficiency for commercial vehicles.

In a similar vein, the policy's long-term efficacy is also an important consideration. Population growth will continue to put pressure on transportation infrastructure and inhibit both passenger and commercial activity. The long-term effectiveness is measured, in part, by its ability to reduce demand for roads, increase productivity, spread out peak traffic volumes, and align in policy with regional growth strategies.

These efficiency criteria were the primary screening tool for deciding which policy options to consider in the analysis. While cost was also an important screening criterion, the fundamental problem is long-term congestion in Metro Vancouver, policy options that reduce congestion, defer the need for future road infrastructure projects, and optimize road space are of primary importance.

##### ***Environmental Sustainability***

Given the significant environmental and social costs imposed by congestion, both for passenger and freight vehicles, the environmental implications of each option play an important role. In particular, the options should be assessed according to how they interact with provincial GHG and CAC standards and targets.

Evaluating the environmental implications of each policy is challenging due to the increasing volume of commercial and passenger vehicles on the road network in Metro Vancouver. Identifying the incremental impacts of GHG emissions from congestion, for example, become tangled with overall increases in freight traffic. Theoretically, greater optimization of road space should lead to less congestion and therefore fewer GHG and CAC emissions; however, if greater optimization encourages more commercial vehicle traffic, the net impact might be negative. With limited data on the environmental impacts for each policy, the options are evaluated against the outcomes from other jurisdictions, and supplemented by the semi-structured interviews with stakeholders.

##### **Fairness and Equity**

The first criterion for evaluating the equity impacts deals with the community impacts from each policy option. Some policies, such as extending delivery hours and road pricing, may have impacts to communities in the form of increased traffic volumes and

noise levels. To evaluate each option, case studies from other areas are considered in addition to the input from the stakeholder interviews.

How each policy impacts the structure and day-to-day operations of the trucking industry is also critical. In particular, how each policy affects the bottom line of trucking companies is perhaps the biggest concern. The implications of each policy will vary across the industry, including such considerations as: the impacts to small versus large businesses, the location of businesses, the difference for private and for-hire fleets, or the type of freight being hauled (food stuffs, bulk goods, or commercial items). Equity considerations for trucking companies also serve as a gauge for the acceptance level among the industry of each option. If a particular option is expected to raise costs for the industry, or is likely to negatively impact for-hire companies, this provides a good indication of the industry's acceptance levels. While literature from other cities is used to predict the equity impacts in Metro Vancouver, the information from the interview participants is insightful.

Similarly, inter-regional impacts for trucking companies are also important to consider, especially with the amount of trade between Metro Vancouver and US markets. Although inter-regional truck activity represents a fairly small portion of total truck activity in Metro Vancouver (roughly four percent), the implications for incoming and outgoing deliveries could be substantial. The inter-regional implications are specific to Metro Vancouver, but examples from other jurisdictions serve as the primary evaluative tool for measuring this criterion. The responses from the trucking companies (Group 1) also help with the implications of each option.

For non-commercial transportation users (passenger vehicles, transit users, cyclists, pedestrians), the impacts to the road network are of foremost concern. Whether an option results in less road space for passenger vehicles or less commercial traffic vying for road space during peak hours, the impacts to road users serves as a proxy indicator for public acceptability.

## **Government Objectives**

### ***Implementation***

This criterion encompasses the administrative complexity of implementing each policy option. A policy may be extremely effective at achieving the primary societal objectives, but may also be highly complex to implement. How long will the policy take from its initial planning and design to its complete fruition? How many organizations need to be consulted? What are the demands for public consultation? These are all critical questions that affect the bureaucratic burden of each policy and warrant careful consideration.

To evaluate the ease of implementation, information from other regions serves as the primary yardstick for comparison, with supplementary information from the stakeholder interviews. Policies which are complex to implement are less desirable, and may signify long timeframes and a high degree of planning and consultation.

### ***Public Sector Cost***

The immediate and long-term cost implications of each policy are a critical budgetary consideration, especially in a period of fiscal restraint. Without exact details on the implementation plan of each option, the specific budgetary implications are difficult to predict accurately; however, a rudimentary estimate is provided for each option. This helps gauge the magnitude of costs, offset by potential revenue streams that are generated. The public sector costs for each option are based on similar policies in other jurisdictions, and supported by the stakeholder interviews.

### ***Political Acceptability***

The litmus test for any public policy is whether it is politically acceptable among elected officials.<sup>2</sup> All of the options in this study are regional in scope and, therefore, any viable solution will involve municipalities, Metro Vancouver, TransLink, and the Ministry of Transportation. The political context is different at each level, as each institution has its own policy agenda, mandate, and vision. Not only is it necessary to achieve buy-in from each level of government, but cooperation, coordination, and leadership is what will move the issue forward. This criterion therefore gauges the acceptability (perceived or actual) of each policy option.

This criterion is evaluated primarily on the public statements and policy platforms of the various political actors in Metro Vancouver, complemented with the responses from the stakeholder interviews.

<sup>2</sup> Public acceptability, while critical to defining the success or failure of public policy, is captured by equity considerations for communities and non-commercial vehicles.

## Appendix K.

### Excluded Policy Options

In addition to UCCs and information-based options (see Chapter 7), several other options were considered but excluded from the analysis section. The following are a list of options that were eliminated, with a brief rationale for their exclusion. First, a more detailed explanation is provided for excluding UCCs.

**Urban Consolidation Centres:** In addition to its uncertainty in reducing levels of commercial congestion (covered in Chapter 7), another reason for excluding UCC from the analysis is the significant amount of public and private investment required to build and operate UCC. International literature on UCC indicates significant public investment is required to make UCC viable on a large scale, both in terms of land and financial capital (iTRANS Consulting Inc., 2011). And with the long-term effectiveness of UCC highly uncertain – both in terms of congestion reduction and the required cooperation from private companies – public investment carries a high degree of risk.

The final rationale for excluding UCCs from my analysis is the push-back from trucking companies. Consolidation centres require businesses to operate alongside each other and share the same facility, and the competitiveness of the industry stands as an important barrier to this cooperation. The trucking companies interviewed in the study believe a UCC on a big scale is unrealistic for this reason. The idea has been considered in Metro Vancouver on several occasions, but has failed to garner support.

One potential way to capitalize on the idea of UCC is to build an export/import distribution centre on the outskirts of the region for goods destined outside Metro Vancouver. One of the trucking companies suggest that a distribution centre upstream the Fraser River could save approximately 500 container truck trips per day. By using barges to transport containers on the Fraser River from Delta Port and/or Fraser-Surrey Docks, containers could be distributed from a single distribution centre and connect directly with the South Fraser Highway. Although time did not allow for follow-up analysis, it might be a viable concept in the region and is needs additional research.

**Truck bans:** this option can be used in dense urban cores to eliminate truck traffic during certain periods of the day. Given the geographical size of Metro Vancouver and its dependence on freight, implementing a truck ban is simply not a feasible option and would receive tremendous opposition from the private sector.

**Water-based commercial goods movement:** this option would utilize the Fraser and Pitt rivers to transport larger volumes of freight and reduce truck trips. Little research

exists for using Metro Vancouver's waterways for moving goods and services, and its effectiveness is uncertain.

**The Trum:** this is a relatively new concept and uses public transit rail infrastructure to move commercial goods. While an excellent idea for creating more sustainable goods movement, implementing this option requires significant infrastructure and logistic support. Also, the economic viability and the overall effectiveness of the trum are yet to be proven.<sup>3</sup>

**Road Pricing for Trucks Only:** Road pricing schemes specifically targeted at the trucking industry, while popular in European countries, are excluded as a potential option. Austria, Switzerland, Germany, and Slovakia have each implemented 'lorry-charging' schemes whereby trucks are charged on a per-kilometre basis (Walker, 2011). One of the primary reasons for implementing truck tolls in Europe is to capture the damage costs to road infrastructure from international trucks (Walker, 2011). Charging only trucks in Metro Vancouver would be seen as highly inequitable, especially considering the damage costs from passenger vehicles.

**High Occupancy Toll lanes for freight vehicles (and passenger vehicles):** this is an impractical option in Metro Vancouver for reducing congestion in the long-term. From a practical standpoint, Metro Vancouver does not have a robust network of HOV lanes to create sufficient region-wide time savings. Deloitte considers the option of changing the HOV lanes to HOT lanes in its analysis of road pricing schemes in Metro Vancouver, but concludes that significant infrastructure investments are required to achieve modest time savings (either for commercial or freight).

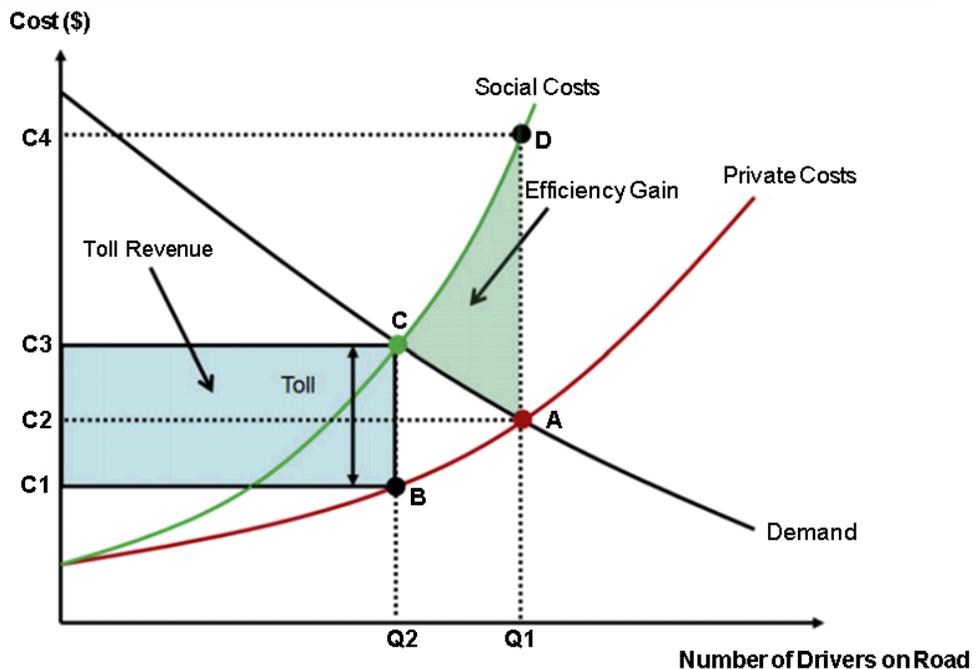
<sup>3</sup> For more information on the Trum, see Simon Allier's (2012) graduate thesis, entitled, "Integrating Goods Delivery with Electrical Surface Transit Networks."

## Appendix L.

### The Economics of Road Pricing<sup>4</sup>

The figure below provides a more detailed description of how road pricing works. It represents the individual costs of using the roads during peak times. To better understand the mechanics of how it works, imagine the graph depicting your daily commute and your interaction with the other drivers on the road. The private and social costs are presented on the Y axis, denoted in dollars, while the number of other drivers on the road is on the X axis. There are two non-linear cost curves. The first is the private cost curve. It includes the direct costs of using your car (i.e. gas, insurance, car depreciation) and the cost of your time.

Figure 1 – How Road Pricing Works: The Private and Social Costs of Congestion



\*Figure was adapted from Robin Lindsay's "Road Pricing and Investment." *Economics of Transportation*, Vol. 1, 2012.

<sup>4</sup> Copied from Arnold, 2013

The social cost curve is more abstract. It includes the private costs plus the costs drivers do not pay directly, such as the time costs imposed on the flow of traffic (drivers usually only consider their own time costs, but your decision to drive slows everyone down). Other social costs are more intuitive, such as environmental damage (greenhouse gases and air pollution), and the wear and tear on road infrastructure. Both cost curves are upward sloping, meaning as the number of drivers on the road increases (i.e. as traffic gets worse), the incremental private and social costs become greater. The other curve in the diagram is the downward sloping demand curve. It illustrates that as the costs of driving decrease, more and more people are willing to drive to work.

Without road pricing, traffic flow is at an equilibrium where private costs equals demand (at point A). This point represents the status quo for the untolled roadways and bridges in Metro Vancouver. The people to the right of this equilibrium are unwilling to pay the costs of sitting in traffic, and decide not to drive (as private costs are greater than their willingness to pay). When there are fewer people on the roads (to the left of point A), the private costs are lower and encourages more drivers onto the road until the equilibrium is reached. At this equilibrium, the private cost to you, as a driver, is denoted by C2. However, this is a suboptimal level of traffic, as there are significant costs not being paid (indicated by the distance from A to D). These are considered the externalities of congestion.

To alleviate the problem, road pricing is introduced. Once implemented, these external costs previously unpaid are now included in using the road. The objective is to match the total costs (private plus social) with demand (at point C). To achieve this new and more efficient equilibrium, drivers must pay a fee (the distance from C1 to C3). At the new equilibrium, some drivers now choose to take another form of transportation (public transit, car pool, or active transit) or choose another time of day to commute. Hence, the level of congestion is reduced.

While drivers now pay slightly more out of pocket (C3 instead of C2), there are several benefits gained: less traffic means shorter and more reliable commute times, less environmental damage, and less damage to the road infrastructure. These benefits are denoted by the area of the green triangle, labeled 'Efficiency Gain'. Furthermore, the revenue collected from the tolls, which is the price of the toll multiplied by the number of drivers (illustrated by the blue box), can be used to fund road improvements and alternative forms of transportation (public and active transit).

Whereas road pricing unambiguously improves efficiency and reduces congestion, it also creates winners and losers. Those who cannot afford the toll (Q1 to Q2) are now worse off and must find alternative modes of transportation. Alternatively, those who pay the toll and continue to drive are better off, as less time is spent sitting in traffic. For this reason, road pricing creates a series of equity concerns which are discussed in this section.

## **Appendix M.**

### **Overarching Recommendations**

#### **Centralize and Standardize the Regional Regulatory Framework**

Standards for truck weights and size are different in each municipality, along with licensing requirements, creating an inconsistent and burdensome regulatory environment for commercial goods movement (iTRANS Consulting Inc., 2011). Even though centralizing or standardizing the regulatory framework will not necessarily optimize road space, it is an issue which can lead to a more manageable governance system and remove unnecessary transaction costs for the trucking industry.

For trucks operating in multiple municipalities, inconsistent regulations and enforcement create unnecessary transaction costs for business. Municipalities currently have different noise by-laws, weight and dimension restrictions, and permitting processes, with varying degrees of enforcement. These different regulatory approaches also stem from each municipality's overall receptiveness to the trucking industry. As identified by one of the interview participants, certain municipalities are more accommodating to truck activity than others.

While achieving consensus on harmonizing or centralizing standards will be difficult across local governments, the end-goal of reducing the burden on the trucking sector should provide ample motivation for change. As a first step, Metro Vancouver should have a centralized permitting process to reduce redundancies and inconsistencies, which could also reduce administrative costs for government. These efforts should include providing the trucking industry with adequate signage and outreach material for truck routes, and also providing businesses with advance notice of road maintenance, construction closures, and detours. The Metro Vancouver regional government is best suited for taking the leadership role in coordinating these improvements.

#### **Improvements to Parking Laws**

Lack of adequate parking and space to load/unload is a common complaint among trucking companies. This indirectly affects congestion whereby trucks are forced to drive extra distances to try and find adequate parking or, in some cases, park illegally (and get ticketed). As a straightforward strategy for reducing street congestion and increasing the efficiency of deliveries, municipalities should ensure that new developments have adequate off-street loading areas or reserved street-level parking for trucks. Minor improvements in parking laws can go a long way in improving the flow of people, goods, and services. Greater consultation with the trucking industry for developing municipal loading/unloading policies is strongly encouraged.

#### **Reduce One-Way Trips for Port Container Trucks**

Because port container trucks are the focus for the quantitative analysis of this study, a number of interview participants had criticisms/suggestions about this industry sub-sector. Specifically, interview participants are concerned with the high number of one-way trips made by port container trucks, which are roughly 80 percent of total trips. One-

way trips are unequivocally inefficient—they increase the operating costs to trucking firms, add more trucks on the road, and produce additional amounts of GHG, air contaminants, and noise pollution. Road pricing theoretically provides container truck companies with a greater incentive to reduce one-way trips but, according to one trucking company, the main barrier is the port reservation system and not the trucking companies.

To reduce one-way trips, the four terminals in Port Metro Vancouver should look at creating a centralized port reservation system. Implementing a centralized reservation system, across all terminals and distribution centres, has potential to enhance the utilization of empty containers, reduce one-way trucking trips, and maximize valuable port space. Moreover, a streamlined reservation system can reduce port congestion, idling time, and GHG emissions associated with delays on port property (Transport Canada, 2006). Port Botany, Sydney, has successfully implemented a centralized reservation system and provides an excellent example for the adoption at Port Metro Vancouver.