Assessing the relationship between Ride-Hailing and Sustainable Transportation modes in Vancouver

by

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Abstract

The relationship between ride-hailing and urban mobility has challenged governments and policy-makers worldwide to advance overall mobility options. The main challenges are related to how ride-hailing can improve mobility without increasing problems associated with car-based trips.

On January 23, 2020, Vancouver finally concluded the provincial and municipal regulatory framework and issued the Licence Application Decision for Uber and Lyft to operate as ride-hailing services.

This thesis seeks to identify the risks that ride-hailing poses to other transportation modes, specifically public transit, walking, and cycling in Vancouver, by assessing the interactions between mobility and socio-demographic data with public opinion and the current ride-hailing policies and regulations.

The main findings show a very heterogeneous mobility pattern across the city, with different risks of ride-hailing modal substitution to particular neighborhoods. Additionally, it suggests improvements to the current regulatory framework in areas like environment, accessibility, congestion, labor rights, infrastructure, and open data.

Keywords: Ride-hailing; Vancouver; Sustainable Transportation; Public Transport; Mobility; Transportation Network Services;

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Table of Contents

List of Tables

List of Figures

Chapter 1.

Introduction

1.1. Background

The ever-growing motorized mobility volumes pose huge challenges for humanity, especially for those living in urban centers. The perceived benefits of endless mobility co-exist with actual problems caused by the excessive motorized mobility associated with car-centric urban planning. For a long time, the discussion about the benefits and problems associated with urban mobility was mostly centered on the share between private and collective modes of motorized transportation. However, in the last decade, new disruptive players and transportation modes became very popular among users, introducing the technological component and new business models in the historical debates, which soon became a critical part of the government agendas worldwide. The new "deregulated" reality increased the financial and operational pressure in cities around the world with exponential adoption rates of ride-hailing among users (Clewlow and Mishra, 2017). Such a disruptive situation demanded public solutions to incorporate the benefits of the high-tech newcomers without destroying the advantages offered by traditional transportation modes and without increasing problems associated with the car culture, such as more traffic, congestion, pollution, accidents, and health problems.

One of these new disruptive transportation modes with huge potential to either complement or compete with traditional transportation modes is called ride-hailing. It is a shared mobility service based on technology and sharing economy concepts, where users can hail and pay for a ride from a driver through a smartphone application (Rayle *et al.*, 2016). Companies providing ride-hailing services are also known by other names, such as ridesharing companies, on-demand ride service, ridesourcing, and TNC – transportation network companies, among others (Tirachini, 2020). The official terminology in British Columbia – Canada is Transportation Network Services - TNS, as defined in Bill 55 (2018), PASSENGER TRANSPORTATION AMENDMENT ACT, 2018. Examples of companies providing this service are Uber, Lyft, Didi, and Grab, among several others (Henao and Marshall, 2019a).

Since the launch of Uber in 2009, ride-hailing services have experienced exponential growth around the world supported by the rapid ICT (Information Communication Technology) revolution and fuelled by the predominant belief at the time of the benefits of the so-called "sharing economy" concepts (Clewlow and Mishra, 2017). According to the authors, the service exhibited a rapid adoption by users, disrupting urban mobility around the world and creating new and significant challenges, problems, and opportunities for transportation researchers, policymakers, and planners worldwide.

Vancouver, for a long time, resisted this trend as a remarkable ride-hailing free city. The main barrier to such service was the lack of proper regulation. Since the first attempt of a ride-hailing company to enter Vancouver's market, marked by Uber's operation between May and November 2012, no provincial and city regulatory framework was developed to accommodate the different features of ride-hailing when compared to the previous vehicle for hire requirements included in the provincial legislation (Ngo, 2015). Still, on January 23, 2020, after years of discussion and political struggle, ride-hailing was approved in the Lower Mainland to be initially operated by Uber and Lyft companies. The ride-hailing regulatory framework comprises the following three main structures. First, their services are regulated by the provincial legislation described in Bill 55 of 2018: Passenger Transportation Amendment Act proclaimed by the British Columbia government. Second, on the municipal front, three by-laws issued by the city of Vancouver[1] are used to regulate particular aspects of ride-hailing like road use and fees. Finally, it uses the first two licence application decisions for the companies Uber and Lyft issued by the Passenger Transportation Board[2]. The licence application decision is the formal authorization process to operate in the province where applicants are evaluated by the Passenger Transportation Board in the face of the provincial legislation terms and sets operational and administrative requirements.

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[1] BY-LAW NO. 12649. A By-law to enter into an Inter-municipal TNS Business Licence Scheme, Enacted on February 26, 2020. BY-LAW NO. 12648. A By-law to enter into an agreement among the Participating Municipalities regarding an Inter-municipal Transportation Network Services Business Licence Scheme. Enacted on February 26, 2020. BY-LAW NO. 12556. A By-law to amend Street and Traffic By-law No. 2849 regarding Transportation Network Services. Enacted on October 2, 2019.

[2] Licence Application Decision (Transportation Network Services - New), number TNS6988-19. Applicant Uber Canada Inc., decision date January 23, 2020. Licence Application Decision (Transportation Network Services - New), number TNS6990-19. Applicant Lyft Canada Inc., decision date January 23.

1.2. Hypothesis and theoretical propositions

Curiously, during the period between the unofficial attempt of entering the market and the final approval of ride-hailing, in specific from 2013 to 2019, Vancouver showed significant progress in the usage of public transit, walking, and cycling among transportation modes in the city, City of Vancouver (2020). These modes are defined as green transportation in the Vancouver Transportation 2040 plan (2012). During this period, they grew from 48% of combined mode share of the green transportation modes in 2013 to 53% in 2019 (City of Vancouver, 2020). The same analysis still points out a consistent reduction in the distance driven per person over time, moving from a total of 4,840 km on average in 2013 to 3,730 km in 2019. The green modes of transportation are defined by Schiller and Kenworthy (2018:158) as the “key building blocks” of sustainable transportation (ST). Brundtland (1987:54) summarizes sustainable development as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Even though the definition of Sustainable Transportation modes could be expanded to different transportation modes based on the sustainability development concepts, for the scope of my research, sustainable transportation (ST) always refers to the combination of walking, cycling, and public transit. The role of sustainable transportation in enabling a greener, healthier, and more equitable world is assessed in section 2.1. Preserving and promoting such modes is essential for economic, environmental, and social sustainability, and it is also crucial to avoid problems associated with automobile dependence (Schiller and Kenworthy, 2018; Tumlin, 2012; Goldman and Gorham, 2006).

The relationship between ride-hailing and sustainable transportation modes presents a wide range of considerations and variables, with many risks and opportunities, as explained later in Chapter 2.

My research hypothesis claims that Vancouver's current ride-hailing policies and regulations do not consider promoting or preserving sustainable modes of Transportation (ST), such as walking, cycling, and public transit. Instead of targeting ride-hailing integration with sustainable transportation modes as a priority, such policies and regulations are creating a stand-alone transportation option, ready to compete and attract customers from other modes, including sustainable ones.

In replacing trips made by ST modes with ride-railing trips, the city changes its transportation mix, moving from "green" shared modes, as defined in the Vancouver Transportation 2040 plan (2012), to a private transportation mode dependent on automobiles. This research considers the problems of such transition as externalities related to car-based trips. In transportation, as in many other urban phenomena, individual activities or actions may produce consequences for the whole society and not only for the individuals involved in them. These actions are defined as externalities, and they are generally used in economics for activities involving the identification of actual costs to support the development of policies to adequately define activities' taxation or regulations (Meiners, 2016).

Negative externalities associated with ride-hailing, as described in section 2.2, are usually represented by increased greenhouse gas emissions, pollution, traffic, accidents, and congestion. This group is almost entirely dependent on the analysis of two variables. The first one is the vehicle-kilometer-traveled (VKT) analysis, which aims to understand whether or not users are traveling more than usual due to ride-hailing. The theory for increases in VKT by expanding mobility options may be similar to those found in the induced-demand phenomenon. The concept refers to how improvements in road capacity to improve traffic generates more traffic and eventually worse traffic conditions (Hymel *et al.*,2010; Lee Jr *et al.*, 1999; Litman and Colman, 2001). The second one is "modal substitution." Its focus is to identify if ride-hailing is absorbing ST modes' users or reducing car ownership and adding new users to ST modes. Finally, a question of utmost importance is whether a local problem originated by this eventual shift in transportation modes, combined with a possible increase in traveling, may represent an additional global concern for climate change.

On the other hand, ride-hailing may have an essential role in complementing more sustainable transportation modes, covering service area gaps and working as a solution for the first and last mile (i.e., travel between the starting point or final destination and the nearest transit stop/station) in places where walking or biking is not an option. Moreover, it may even contribute to a change in vehicle ownership figures by replacing individual trips in private cars, especially when the transportation portfolio aligns good ride-hailing services, efficient public transportation, and car-sharing options in the mobility matrix.

The theoretical propositions of this research hypothesis are twofold: first, my assumption is that each neighborhood[3] in Vancouver is impacted by ride-hailing in a particular way. Therefore, some of them are more likely to replace sustainable trips with ride-hailing trips, with more intense negative externalities. Secondly, my proposition is that current policies do not adequately address social and economic differences between the neighborhoods and do not consider how ST trips are divided into the city of Vancouver, placing ride-hailing as a competitor of sustainable transportation modes instead of a new complementary mobility mode.

1.3. Research Question

In order to address these propositions and test the hypothesis, my thesis is focused on the following research question:

What are the risks to sustainable transportation modes (walking, cycling, and public transit) posed by ride-hailing in the city of Vancouver? And how do the city's and province's policies and regulations address these risks?

To understand this complex relationship, I assessed each of the neighborhoods' commuting and mobility patterns in Vancouver, based on data gathered from the Statistics Canada Census, the Annual Transportation Mobility Panel, and the TransLink Trip Diary Survey, to identify the different usage patterns of ST modes. With this unique dataset, a composite indicator named NSTP (Neighborhood Sustainable Transportation Profile) was aggregated to make it possible to calculate the ST trips' substitution risk by ride-hailing trips. The results of these two analyses were then compared to current policies and regulations in Vancouver, considering the main risks identified in the literature review, to study their relationship.

[3] Vancouver does not have an official geographical division for neighborhoods. However, on its website, the city government provides a list of 22 distinct areas with rigid geographic division and even explaining that they are not official, they refer to them as neighborhoods or areas of the city (City of Vancouver, 2021). For the geographical purposes of my research, every time I mention one or more neighborhoods, I am referring to such geographical divisions.

1.4. Outcomes and significance

My research aims to identify risks to sustainable transportation modes associated with current ride-hailing policies and regulations in Vancouver. Additionally, the calculation of the NSTP shed light on the neighborhood's different commuting patterns, offering a methodology to calculate the mode substitution risk (when ST trips are replaced with ride-hailing trips). Moreover, the correlation between the NSTP and social-demographic indicators supports the understanding of equity and social problems related to ride-hailing.

The NSTP indicator uses the same concept available on the Statistics Canada Website, described as the indicator named Sustainable Transportation (Statistics Canada, 2019). The difference is only the geographic scale because neighborhood data is not available on the Statistics Canada website. The analysis of transportation modes by neighborhoods in Vancouver is also seen in other studies like the assessment developed by Mclaren (2016) to understand the mobility practices of parents with young children in the city and the study about patterns of workplace neighborhood mobility developed by Amram *et al.* (2019).

The uniqueness of this research consists of exploring the relationship between ride-hailing policies and regulations and ST modes in a city with late ride-hailing adoption and that has remarkably invested in promoting ST modes.

The results of this research are expected to be applicable for mobility analysis in different ways. It may provide valuable insight to support governments and transit agencies in understanding different perspectives of how commuting patterns influence or protect the ST modes, so they can use the concepts to evaluate – or re-evaluate - their own set of policies and regulations. Likewise, ride-hailing companies may use these findings to develop a more sustainable integration strategy, placing their operation as a fundamental mobility piece to support the achievement of sustainability goals. Finally, users may better understand the consequences of their travel behavior, which might help in their future mobility choices and advocacy for a more sustainable and equitable mobility.

Chapter 2.

Conceptual Framework

This literature review was designed to provide knowledge about the relationships between ride-hailing policies, externalities, and commuting patterns with ST modes. It aims to contextualize the role of ST modes and the discussion about the interactions between ride-hailing and ST modes, offering valuable insights, opposing views, and different perspectives related to the research question. This combination also helps to delineate the topic's significance within urban studies scholarship. That being said, it is worth noting that to reach these goals, the structure of this chapter was divided into the following three bodies of literature:

1) Literature identifying the role of ST and its relationship with climate change and equity;

2) Literature analyzing ride-hailing externalities and their relationship to ST modes; and

3) Literature exploring policies and regulations to leverage ST through its integration with ride-hailing.

The first literature contextualizes ST as a global concern and highlights the importance and relevance of these modes of transportation to enhance life quality and equity as well as to promote environmental behaviors and actions to fight climate change. It supports explaining why this research is significant and how ST modes are crucial to urban development and human life.

The second literature provides a ride-hailing overview focusing on its consequences by analyzing how the non-regulated approach of the new "sharing" economy may affect ST modes. The scope of the externalities' analysis covers social, economic, and environmental effects, motivated mostly by two variables, the VKT (vehicle-kilometers-traveled) and the modal substitution. By exploring these effects, this body of literature demonstrates why it is essential to establish efficient policies and regulations to create harmony between ride-hailing and ST modes, especially in urban environments.

After explaining why ST modes are essential and how they are impacted by ride-hailing, a new window is opened in the third literature to discuss how cities worldwide are developing new policies and regulations to integrate ride-hailing without cannibalizing ST modes.

In combination, these three literatures provide a rich background to analyze ride-hailing policies and legislation in Vancouver and are of further significance to illustrate the findings on commuting patterns to determine whether or not the current set of regulations can ensure a sustainable and equitable future for mobility in Vancouver.

2.1. The role of Sustainable Transportation in advancing a greener, healthier, and more equitable world

The dilemma between individual and collective transportation affects us all. While a small global elite has time and resources to expand mobility to its limit, in a process defined as the glamorization of mobility, others are naturally excluded from mobility benefits, living with limited options for essential activities and directly impacted by the consequences of too much mobility from others (Cohen and Gössling, 2015).

The concept of excessive mobility is demonstrated in the work of John Adams (2001) by exploring the consequences of "too much" mobility in a forecasting exercise based on the Britons' travel behavior since 1950. In his study, he defines this excess of mobility as "hypermobility" and projects that besides the common problems of congestion and pollution, hypermobility will lead us to a world with more inequalities and segregation, including health and safety problems, like accidents, crime, and a hostile atmosphere in a less democratic and tolerant society.

Notably, sustainable transportation scholarship offers a critical view of hypermobility impacts and implications, focusing on collective mobility needs instead of individual preferences, as explained by Schiller and Kenworthy (2018). The authors define sustainable transportation (ST) or sustainable mobility as a three-legged stool composed of three transportation modes: walking, cycling, and public transport. Additionally, they discuss ST modes as an antithetical idea to the automobile dependence culture and its environmental, economic, and social problems. By contrast, the goal in ST is to promote "better and healthier ways of meeting individual and community needs while reducing the social and environmental impacts of current mobility practices," based on reducing resources inputs and waste outputs as well as minimizing harmful effects of transportation on the public realm (Schiller and Kenworthy, 2018:1).

Expanding on that topic, Banister (2011) argues that the current relationship between climate change, cities, and mobility, characterized by him as the carbon society, is unsustainable and presents irreversible long-term consequences for the world due to the increase in carbon emissions. Similarly, Solomon *et al.* (2009: 1704) claim that carbon dioxide emissions lead to adverse climate changes for short and long time perspectives and cite as “illustrative irreversible impacts” caused for the increase in atmospheric carbon dioxide concentrations the “irreversible dry-season rainfall reductions in several regions” and “inexorable sea level rise.” Moreover, the intergovernmental panel on climate change – IPCC (Allen *et al.*, 2018) states that human activities since the mid-20th century have been the main cause of rising greenhouse gas (GHG) emissions and, consequently, climate change. Such activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels and may reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. The IPCC summarizes the main consequences caused by reaching 1.5°C of global warming in a list called "five integrated reasons for concern," including items such an increase in extreme weather events, accentuated inequalities, global monetary impacts, change, degradation and loss of ecosystems and biodiversity, and finally large scale singular events like the disintegration of the Greenland and Antarctic ice sheets (Allen *et al.*, 2018).

Would ST help in fighting climate change?

In Tumlin's (2012) assessment, ST aims to prevent the main causes of global warming. According to his study, ST is a fundamental concept to integrate "competing objectives" in equity, ecology, and economy. Moreover, he argues that ST involves environmental, social, and economic sustainability. Besides, it is supposed to remediate transportation problems such as air pollution, water pollution, stormwater runoff, greenhouse gases, and health problems. Likewise, Banister (2011: 1541) notes that ST is a key to achieve carbon reduction targets based on the sustainable mobility paradigm, which is anchored in four principles: reducing the need to travel by replacing trips by “non-travel activies” or using technology to substitute it like online shopping or working from home, policies promoting ST (walking, cycling, and transit), land use planning to reduce the distance traveled, and the efficient use of technology innovations to increase the efficiency of transportation modes.

ST modes may also play a fundamental role in solving problems related to mobility equity. Litman (2002) describes equity in transportation as "the fairness with which impacts (benefits and costs) are distributed." More specifically, Fan *et al.* (2019: 2) include in their definition of equitable transportation "systems that support multi-modal options that are affordable, sustainable, reliable, efficient, safe, and easy to use." These authors also associate inequality and segregation in transportation with automobile dependency, noting that this culture has led to several problems, including racial, spatial, and economic segregation.

2.2. Ride-hailing: from a disruptive promise of the sharing economy to an urban planning nightmare

The impressive adoption of ride-hailing was also connected to how the service was advertised to the public. Button (2020) notes that in the very beginning, ride-hailing was presented as a cost-saving and optimization platform that could easily connect empty seats from normal car owners with users with similar destinations through app-based solutions. Such an equation suggested a promising future in terms of reducing congestion, car dependence, traffic, pollution, and GHG emissions. Moreover, ride-hailing could be integrated with other transportation modes to increase mobility accessibility and affordability.

As ride-hailing became more and more popular, the conflicting discussions about its effects, problems, and benefits also grew. Much of the available ride-hailing literature is focused on understanding and evaluating its externalities.

The externalities produced by ride-hailing services are shaped by different factors such as policies, regulations, income, safety, and several others, as described by Rodier (2018). This complex analysis is discussed by Tirachini (2020). In his assessment, the main methods to measure ride-hailing externalities are usually associated with variations in the increase or decrease in vehicle-kilometers-traveled (VKT) and in the analysis of modal substitution. In other words, it is necessary to understand if ride-hailing users, in general, are traveling more and what mode of transportation, if any, ride-hailing trips are replacing. The main traffic-related externalities linked to ride-hailing, namely greenhouse gas emissions, congestion, pollution, and accidents, are almost entirely dependent on the combination of the VKT and modal substitution (Hall *et al.*, 2018).

A number of authors have recognized that ride-hailing causes a significant increase in VKT (ranging from 6.5% to 85%) in various studies across different cities and countries, mainly driven by two factors. First is the so-called deadheading, a practice where ride-hailing cars travel without passengers when searching for them or driving in between hired trips. Second, ride-hailing induces trips that would not have been made at all without its presence as a transportation option, also defined as trip generation (Henao and Marshall, 2019b; Anair *et al.*, 2020; Clewlow and Mishra, 2017; Tirachini, 2020; Rodier 2018, Schaller, 2018).

Similarly, many studies suggest a substitution effect, indicating that ride-hailing services have replaced ST modes in different scales, causing deterioration of sustainable urban mobility and a perceived shift in demand from the public transportation modes to private companies (Rodier, 2018; Sadowsky and Nelson, 2017; Graehler *et al.*, 2019; Babar and Burtch, 2020; Gehrke *et al.* 2019; Schaller, 2018).

Rodier (2018) reviewed eight travel behavior studies in American cities, plus seven modeling studies applicable to ride-hailing travel, using a common framework to evaluate impacts on VKT and Greenhouse Gas Emissions, based on the variation of five variables: auto ownership, trip generation, mode choice, network travel (deadheading), and destination choice and Land use. Finally, she found that ride-hailing substitutes for transit in a range between 16% to 33% of the time, also that between 8% and 22% of the trips would not exist without ride-hailing, and finally that traveling without passengers accounts for 10% to 60% of the total traveling, concluding that ride-hailing operations tend to increase VKT and GHG emissions.

In Mexico, Moody *et al.* (2021) used stated preference surveys to assess modal substitution caused by shared and non-shared ride-hailing trips in Mérida, Toluca, and Aguascalientes. The authors concluded that 4% of the non-shared trips and 5% of the shared trips would not have been made if ride-hailing was not available and found that non-shared ride-hailing trips substitute 33% of ST trips while shared ride-hailing trips substitute 27% of ST modes.

Acheampong *et al.* (2020) assessed the travel behaviors, adoption factors, and mode substitution effect in the cities of Accra and Kumasi in Ghana, Sub-Saharan Africa, and found that 37% of ride-hailing trips replaced public transit trips. Additionally, they stated that ride-hailing has a weak integration with other transportation modes in mostly single-occupancy trips, acting as an individual door-to-door mode instead of a first/last-mile solution. Their survey also presented a strong relationship between the increase in income and ride-hailing usage.

The same substitution rate was found in China by Tang *et al.* (2020) in an extensive travel behavior survey with ride-hailing users using the DIDI Chuxing app in ten different cities across the country. The authors found that 37% of ride-hailing trips replaced public transit trips and that 0.4% of all trips would not have been taken if ride-hailing was not available. They also concluded that ride-hailing is especially attractive for short and fast trips and that it may reduce future car purchases, as stated by 6.6% of respondents that would not buy a new car if "ride-hailing were permanently available."

Tirachini and del Río (2019) also found a very similar modal substitution rate from an intercept survey with ride-hailing users in Santiago, Chile. Their survey pointed out that 37.6% of ride-hailing trips replace public transit, with an average occupancy rate of 1.9 passengers per vehicle, and that only 3.3% of ride-hailing trips were combined with public transportation modes. The authors calculated that ride-hailing replaces eleven times more transit trips than it creates intermodal trips with due to the dominant door-to-door characteristic of this transportation mode.

In the city of Madrid, Spain, Gomez *et al.* (2021) developed a travel behavior survey to understand the ride-hailing characteristics of adoption, frequency, and modal substitution. The authors claim that ride-hailing trips substitute 38.9% of trips previously taken by ST modes, and 1.5% of the trips would not have been made at all if ride-hailing was not available. Additionally, the authors found a correlation between higher environmental consciousness and the reduction of ride-hailing usage.

In the Greater Boston region, in the U.S., the modal substitution effect between ride-hailing and public transit was significantly higher. According to a survey with ride-hailing users developed by Gehrke *et al.* (2019), ride-hailing trips replaced 59% of public transit trips. Moreover, the survey indicated that trips with lower value, between $10 and $20, are more likely to have replaced public transit trips, and that ride-hailing trips with passengers have an occupancy rate of 1.52 passengers per trip.

The Big Data Innovation Team (City of Toronto Transportation Services, 2019) assessed the ride-hailing impact in Toronto using actual ride-hailing data combined with a travel behavior survey of ride-hailing users. The authors noted that ride-hailing already represents between 5-11% of the total traffic in Downtown Toronto and that from September 2016 to March 2019, ride-hailing trips in the city have grown by over 180%. Additionally, they found a 49% modal substitution rate between ride-hailing trips replacing public transit.

De Souza Silva *et al.* (2018) analyzed travel behaviors and socio-demographic aspects of ride-hailing in Brazilian cities, concluding that 30.2% of ride-hailing trips substituted for public transit trips. The authors developed an online survey to identify the most important factors in ride-hailing modal choice, resulting in safety and cost as the leading factors in the modal choice. In Sao Paolo specifically, Quest Inteligência and Gaesi/USP (2019) claim that the modal substitution effect of pooled ride-hailing trips found in an intercept survey in the city was 62% and that the occupancy rate of all the trips was 1.4 passengers per trip.

In a quasi-natural experiment as a ride-hailing driver followed by a stated preference survey with their passengers in the Denver Metropolitan Region, Colorado - US, Henao and Marshal (2019b) found that ride-hailing leads to an increase of 83.5% in VKT. According to the authors, the main reasons are the excessive number of deadheading miles (i.e., driving without a passenger) and the low vehicle occupancy, which reaches 0.78 when weighted with the total traveled distance, including deadheading. Additionally, the authors claim that ride-hailing substitutes for 34% of the trips that would have been taken in sustainable transportation modes (walking, biking, or transit), and 12% of the trips would not have been taken if ride-hailing not existed. Moreover, the large majority of trips consist of door-to-door rides, and only 5.5% of the trips are combined with other transportation modes. Similar results were found in California, according to the study of Circella *et al.* (2019). Based on stated preference surveys, the authors concluded that 17% of ride-hailing trips and 31% of shared ride-hailing trips replaced trips previously taken by ST modes. Moreover, the authors claim that 7.5% of the ride-hailing trips would not have been taken if ride-hailing was not an option.

In a different approach, Agarwal *et al.* (2019) assessed the impact of ride-hailing on congestion and modal substitution in Indian cities. The author used real-time traffic data based on Google Maps and ridership data from the Delhi Metro to study ride-hailing and metro usage variations on dates where ride-hailing operations were not available. Their findings suggest that ride-hailing contributes significantly to congestion and indicate that in Delhi, between 15.2% and 20.3% of the total ride-hailing ridership would use Delhi Metro if ride-hailing was not available.

Lesteven and Samadzad (2021) used a stated preference survey to study the role of ride-hailing in the mobility system of Tehran, the capital of Iran. The authors found an induced demand of 12.5%, represented by trips that would not happen if ride-hailing was not available, and a modal substitution rate of 23.2% for ride-hailing replacing public transportation. According to the authors, most respondents indicated that comfort and lower travel times are the main reason to choose ride-hailing over public transit.

An example of both the VKT increase and the substitution effect is included in the results of a travel and residential survey of seven major urban centers in the USA conducted by Clewlow and Mishra (2017). They concluded that between 39% of ride-hailing trips replaced trips that would have been made by ST modes, and 22% would not have been made at all (trip generation). The authors also found that 30% of all adults use ride-hailing, and the main reasons for substitute private driving for ride-hailing are avoiding parking costs and drinking and driving. For public transit substitution, the main reasons were shorter travel times and poor transit availability. Finally, the authors note that after using ride-hailing, the average reduction in transit use is 6% and that ride-hailing is likely to increase VKT.

In consonance with the study of Clewlow and Mishra (2017), Shen *et al.* (2020) found a correlation between ride-hailing, increase in VKT, air pollution, and modal substitution in the city of Nanjing, China. The authors concluded that 34% of ride-hailing trips substitute public transit and that most users are younger than average and usually attracted to ride-hailing modes based on their tech appeal and price strategy. Moreover, the authors found a negative effect in air pollution emissions, increasing emissions of carbon dioxide (CO_2) by 116%, carbon monoxide (CO) by 92%, hydrocarbons (HC) by 43%, and nitrogen oxides (NOx) by 33%. On the other hand, Young and Farber (2019) argue that ride-hailing does not negatively influence ridership levels in other modes, but for specific market segments, there is a correlation between the rise in ride-hailing, decrease in taxi use, and rise in active modes of travel (walking and cycling). Sadowsky and Nelson (2017) assessed the relationship between public transit and ride-hailing in major U.S. urban areas. They concluded that the number of ride-hailing companies in a city defines whether ride-hailing complements or substitutes public transit. According to the authors, if a city has one ride-hailing company, it seems to complement public transit with a positive ridership effect. However, if a city has two or more ride-hailing companies, ride-hailing works as a substitute for transit with increasing substitution effects over time.

The relationship between ride-hailing and pollution is described by Barnes *et al.* (2020). Using a difference-in-difference method, the authors studied 57 cities in China comparing publicly available pollution data and information about the presence of the ride-hailing service operated by the country's biggest operator, the company Didi Chuxing, to identify whether the introduction of such services increases or decreases fine particulate matter (PM2.5) pollution. Their findings show that rapidly after the introduction of ride-hailing in a city, in about three months, the emission level of PM2.5 already surpasses the pre-launch level, reaching an increase of 48.8% and remaining continuously higher for all the periods after that, driven by an increase in car sales and in the vehicle-kilometer-traveled (VKT).

As a possible solution to remediate the pollution problem caused by the exponential growth of ride-hailing worldwide, Slowik *et al.* (2019) claim that it is necessary to accelerate the transition to electric ride-hailing vehicles to make zero-emission travels largely available and accessible. Anair *et al.* (2020) expand on that topic by including the need for a zero-emission fleet combined with pooled rides to revert the current ride-hailing emissions figures. The authors calculated the emissions of carbon dioxide per trip and passenger and concluded that a typical ride-hailing trip pollutes 47% more than a private car trip, 117% more than a bus trip, and 563% more than a train trip. Ward *et al.* (2021) used actual publicly available ride-hailing data from Ride Share Austin, plus the cities of New York and Chicago, and the state of California to simulate the negative and positive impacts of traffic-related externalities caused by the ride-hailing modal substitution in six U.S. cities. Through the assessment of cold-start emissions, fleet fuel efficiency, and deadheading, the authors claim that ride-hailing has a positive impact on air pollution and GHG emissions when only private car trips are replaced. However, when all external costs of vehicle travel are considered (e.g., air pollution and GHG emissions, congestion, crashes, noise, and social carbon costs), they note that shifting private car trips by ride-hailing trips would increase the externalities cost between 30 and 35%, adding between US$0.32 and US$0.37 per trip on average. Moreover, if ride-hailing trips replace trips taken by ST modes, the result is even worse. In this case, the overall impact on externalities is more than three times higher, reaching an additional US$ 1.20 per trip on average.

An essential variable for determining ride-hailing negative and positive externalities, particularly the increase or decrease of VKT, is pooling, as indicated in Tirachini and Gomez-Lobo (2020). The authors used a survey in Santiago, Chile, to develop a scenario analysis based on Monte Carlo simulations, concluding that current average occupancy rates in ride-hailing trips do increase VKT by 1.7 km per trip on average, but if the mean occupancy rate is increased to 2.9 passengers per vehicle, or higher, then VKT has more than a 50% chance to be reduced by ride-hailing. Additionally, the authors found a substitution rate of 36.2% for ride-hailing replacing ST modes and 5.4% for induced demand.

Ride-hailing may also be part of a broader mobility strategy for areas with limited solutions, as noted by Wang and Odoni (2016), the lack of options to solve the last/first-mile problem (travel in between the final destination and the nearest transit stop/station) is the main accessibility problem of public transportation in urban areas. The authors argue that the availability of services solving the last/first-mile problem increases transit ridership. Similarly, according to Watkins *et al.* (2019), Uber has complemented transit and is correlated with increased transit ridership and may have an important role in improving overall mobility. As an example, the authors researched the interactions between ride-hailing and healthcare transportation and found that accessibility may be increased with improvements in booking patient trips and the expansion of healthcare transportation options, based on promising partnerships in place between healthcare providers, health insurers, and ride-hailing companies. Additionally, they claim that transit agencies may benefit from this framework by developing similar partnerships to provide Paratransit services in low-density areas.

The benefits of ride-hailing may also represent new behaviors in car ownership and travel. Smith (2016: 5) reports that American ride-hailing frequent users are "significantly less likely to own or drive a car" with 64%, against 78% from occasional users or non-users and that frequent users rely on a wide variety of modes such as walking, biking, and transit as part of their travel behavior. Haddad *et al.* (2019) assessed the relationship between ride-hailing and economic growth in São Paulo, Brazil. The author used appropriate data provided by one of the major ride-hailing providers in the city, the company 99 – owned by Didi Chuxing, to compare with public data from the origin-destination survey from 2007 and then developed projections over socioeconomic indicators based on the Brazilian table of municipalities from 2008. Their findings show that ride-hailing has a low substitution rate, 17%, for public transportation and that ride-hailing does not substantially increase travel times and congestion in the city. Moreover, it has a positive impact on the economy and increases accessibility and equity.

Feigon and Murphy (2016) summarize all the ride-hailing benefits mentioned previously by noting a positive correlation between the use of shared modes like ride-hailing, car sharing, and bikesharing and the usage of public transit, placing such modes as a complement of public transit and not a competitor. Moreover, they claim that frequent use of shared modes reduces car ownership and transport expenses. The authors also suggest that the importance of shared modes will keep growing and that the public sector should partner with them to ensure that benefits will be "widely and equitably shared" (2016: 4). Equity, however, does not seem to be one of the "sharing economy" premises as indicated in the assessment of Rauch and Schleicher (2015) by explaining how companies from the "sharing economy" have successfully fought and lobbied against any kind of regulation over their services. For instance, the way in which most ride-hailing companies deal with their workforce is a good example of inequity.

In a comprehensive review of the economic dimension of ride-hailing, Button (2020) notes that these companies are not profitable and that precarious financial conditions are in place for their drivers. The authors provide an extensive list of such conditions, including the lack of labor rights, no social insurance, no liability or support for third-part victims, and income lower than the minimum wage, to cite a few. The latter problem was also noted by Henao and Marshall (2019a) in their research about ride-hailing in the Denver region, Colorado, where they found that most drivers earn less than the local actual minimum wage when costs per passenger are deducted from the income. Additionally, the "privileges" of using ride-hailing are also something far from equitable. Like most of the private motorized modes of transportation, ride-hailing adoption varies according to income class, education, age, and place, meaning that its users are younger, more educated, have a higher income, and less chance to live in the suburbs, as demonstrated in the study by Clewlow and Mishra (2017).

Schwieterman (2018) assessed ride-hailing and public transit's travel characteristics in a comparison of 50 paired trips between public transit and UberPool, a ridesharing service offered by ride-hailing companies in Chicago - Illinois. His findings show that ride-hailing is more time and cost-effective where public transit is least convenient, because it requires transfers, long waiting times, and walking long distances. This characteristic was mostly found in trips between neighborhoods, where ride-hailing was 67.6% faster than public transit on average, but less effective in the neighborhood–downtown–neighborhood trips where the service would still be too expensive for most commuters.

Later in the same year, Schwieterman and Smith (2018) assessed an evolution of pooled services, named Uber Express Pool and Lyft Shuttle, which are services based on the same concept of lower fares and shared rides but requires riders to walk to a close meeting point. According to the authors, the new service is way more appealing to public transit riders than other ride-hailing service types, especially for short-distance travels, as it is priced well below the previous cheapest services.

Even with so much contradiction, most of the scholarship about ride-hailing has at least one common gap, the shortage of data. Ride-hailing data is usually unavailable with scarce exceptions, as authors noted in studies with results pro and against ride-hailing (Henao and Marshall, 2019a; Feigon and Murphy, 2016; Clewlow and Mishra, 2017; Watkins *et al.*, 2019; Tirachini and Gomez-Lobo, 2020; Ngo, 2015; Gehrke *et al.*, 2019; Acheampong *et al.*, 2020).

Perhaps the lack of information is part of the business strategy, so the contradictory discussions may go on indefinitely while ride-hailing adoption keeps growing in a disintegrated and deregulated way, as it was conceived from its very beginning.

2.3. Policies and regulations to integrate ride-hailing with ST modes and to leverage ST and mobility equity

As demonstrated by the literature review explored in the preceding section, the ride-hailing "problem or solution" has a wide and controversial interpretation with a huge field for different opinions, case studies, and discussions of why, when, and how. Similarly, when it comes to ride-hailing policies and regulations, a vast range of options is in place, used for different reasons and with different expected outcomes in mind. Probably, part of that diversity is due to the ideological differences and part due to the uniqueness of each urban experience worldwide in terms of mobility infrastructure, policies, players, etc.

On the other hand, a number of authors recognize that policies and regulations could define whether ride-hailing will be a substitute for ST modes and increase the VKT or an important component of transportation modes that move towards a less auto-centric world, ensuring equity and covering blind service spots to work as a proper solution for the first and last mile in places where walking or biking is not an option (Tirachini, 2020; Clewlow and Mishra, 2017; Anair *et al.*, 2020; Rodier, 2018; Button, 2020). Furthermore, Schaller (2018) argues that undoubtedly, without public policy intervention, the result will be an increase in the VKT and less public transit. However, he notes that ride-hailing services can become a valuable complement of public transit if policies are implemented to subsidize their integration. Expanding on that topic, Okraszewska *et al.* (2018: 3) claim that to reach sustainable urban mobility, it is necessary to implement a comprehensive and inclusive strategy, including all transportation modes, pursuing a balance between the economic, social, and spatial areas, aiming to provide "an accessible, sustainable, safe, integrated, environment friendly and efficient system meeting the mobility needs of citizens, businesses and industry."

Hall *et al.* (2018) note that there is no such thing as one-size-fits-all for ride-hailing policies and regulations as local characteristics do influence the possible integration between different modes of transportation and may define whether ride-hailing will be a competitor or a complement of ST modes. The lack of a general policy consensus over ride-hailing services leads to a considerable variation in how cities are implementing policies to manage this transportation mode. Beer *et al.* (2017) demonstrated such discrepancy in a study with 15 of the 50 largest cities in the United States, where the authors used a framework based on four different Driver Regulations plus three Company Regulations, showing an enormous variation and also that none of the 15 cities have reached the maximum score.

In a comprehensive assessment of ride-hailing policy options, Joshi *et al.* (2019) analyzed ride-hailing-related public policies from 12 different cities worldwide. According to their report, the initial deregulation of ride-hailing services has led to more problems than solutions, which has created a new wave of regulations with four main drivers: data access, fees destinated to boost public transit, policies to protect the environment and prevent the increase in the VKT, and regulatory protection for drivers and passengers. Based on these premises, they developed a framework to evaluate each of these cities, identifying policies and regulations that are already in place and future implementations. Additionally, the authors claim that isolated approaches to regulations do not benefit cities or regulators as they don't consider failures or success of expected effects in similar situations. Conversely, Deighton-Smith (2018) suggests that an efficient regulatory framework should focus on the market failures with targeted and light-handed regulation, ensuring equal conditions among taxis and ride-hailing to allow for competition, despite their different business models and technological conditions.

In a balance between both perspectives, Tirachini and Gomez-Lobo (2020) argue for flexible regulations, in the form of a fee, that could consider the main externality drivers associated with ride-hailing applied according to time periods and location. Speaking about time, place, and regulations, Young *et al.* (2020) developed a study in Toronto, Canada, and found that travel choices are much more connected to travel characteristics than personal attributes. In other words, the authors argue that the competition with ride-hailing affects transit modes in different ways, depending on the location, timing, and the comparative fastest transit alternative. Therefore, they proposed a regulatory framework based on a tax applied for trips originated in locations where there are competitive transit alternatives, meaning trips with a difference lower than 15 minutes between ride-hailing and public transit.

The regulatory developments of ride-hailing in Toronto, Canada, were assessed by Monteiro and Prentice (2017), showing an intensive dispute with the taxi industry since the very beginning of their coexistence. The authors also claim that ride-hailing might have triggered the necessary development in the taxi industry, which was so comfortable in their extremely regulated environment that it could not evolve in the internet age to face the upcoming competitors. Perhaps the ride-hailing strategy's success in attracting and retaining many former transit riders is also influencing the public transportation development based on new technology and more flexible regulations, as demonstrated in the analysis from Pettersson (2019). The author analyzed 35 cases of demand-responsive transport (DRT) service using technology and indicated that it is inconclusive whether new technology improves DRT systems' productivity and that on-demand transit is not a transport revolution so far.

From a different perspective, Sperling and Brown (2019) argue that ride-hailing and carpooling, in general, are the most important innovations for reaching sustainable transportation goals. Moreover, they claim that it can be an essential tool to reduce inequalities, air pollution, and GHG emissions while improving accessibility in poor transit areas. Therefore they note that a favorable policy framework should be used to stimulate pooling in ride-hailing.

From a different perspective, Li *et al.* (2019) assessed the ride-hailing regulatory framework in a comprehensive study about three proposed ride-hailing regulations: minimum wage for drivers, limitations in the number of drivers or vehicles, and a congestion tax per trip. The outcome of their simulation for New York City shows that enforcing a minimum wage for drivers will benefit the system, passengers, and especially drivers, while, alternatively, limiting the number of drivers or vehicles will mostly benefit ride-hailing companies. Finally, they found that a congestion surcharge in ride-hailing trips relieves traffic congestion, reduces the number of ride-hailing vehicles, and raises significant funds to subsidize public transit.

Sikder (2019) conducted a descriptive analysis over the 2017 National Household Travel Survey results, led by the Federal Highway Administration in the U.S., to investigate socio-demographic characteristics of ride-hailing users. He concluded that as factors such as age, race, income, and access to private vehicles are positively correlated with ride-hailing usage, governments should consider new policy strategies for ride-hailing to promote equity and modal integration.

Similarly, Liu *et al.* (2019), in a simulation using New York City data, concluded that a policy intervention where a tax is imposed on ride-hailing trips, without allowing ride-hailing companies to increase prices, would result in VKT reduction and transit ridership growth. A similar viewpoint is found in Schaller's (2017) work in an extensive report about ride-hailing implications in New York. He claims that in three years, ride-hailing added "600 million miles" to the city and that without proper regulation to address its growth, new transit riders will migrate to ride-hailing in an unsustainable continuous flow of VKT, congestion, and pollution increase. Another perspective of regulations is provided by the work of Zhang and Nie (2019). The authors simulated the impacts of ride-hailing regulations over solo and pooling rides, concluding that both policies, congestion tax and minimum wage, when applied together, can increase social welfare and result in a higher rate of pooling, which would mean fewer trips and less car-related externalities. Based on their assessment of ride-hailing externality costs, Ward et al. (2021) suggest two rationales for ride-hailing public policies aiming to increase the benefits and reduce the externality cost of ride-hailing. As their first and ideal option to increase public transit usage and pooled ride-hailing trips, the authors suggest the use of Pigouvian taxes, which are taxes directly associated with externalities, in this case, air pollution and GHG emissions, congestion, crashes, noise, and social carbon costs. Their alternative is based on higher fees or taxes directly applied to some ride-hailing trips, like non-pooled trips and trips in routes or areas well served by public transit.

In general, taxation may be a relevant funding source for improving public transit and can support reducing inequalities through vertical subsidies (Litman, 2014). Ngo (2015) shows that this is also true for ride-hailing services in many cities worldwide, where fees charged over ride-hailing trips are destined to increase accessibility and improve mobility. Taxation may also have environmental purposes, as underlined in the analysis of Nocera *et al.* (2015). The authors developed a framework to consider GHG emissions in urban mobility planning by suggesting the implementation of comprehensive policies that consider and monetize the individual and quantified emissions, costs, and benefits of different transportation measures and modes.

The combined operation of ride-hailing, car-sharing, and bike-sharing with traditional modes in a Mobility as a Service (MaaS) scheme may effectively reduce energy consumption, but it is not financially sustainable, as demonstrated by Becker *et al.* (2020) in a simulation for Zurich, Switzerland. Moreover, such an operation would demand specific subsidies to all new shared modes (ride-hailing, car-sharing, bike-sharing) to reach the optimum level. For instance, a recent study from Xie *et al.* (2019) using a MaaS simulation platform indicated that incentives associated with energy-saving in sustainable modes are more valued by users than purely money savings. They also noted that the acceptance rate was higher in lower-income populations and for trips without time constraints.

The tension between different viewpoints in ride-hailing regulations is also demonstrated in Mulley and Kronsell's (2018) work. The authors argue that while policymakers are more focused on regulating marketing outcomes, ride-hailing operators focus on marketing experience and demand fewer regulations for ride-hailing services, especially for items related to the car's negative externalities like congestion and pollution. Conversely to the focus of ride-hailing operators, Schaller (2018) argues that undoubtedly, without public policy intervention, the result of ride-hailing will be an increase in the VKT and less ridership in public transit. However, he notes that ride-hailing services can only become a valuable complement of public transit if policies are implemented to subsidize their integration. A similar conclusion is shared by Chan and Shaheen (2012). The authors argue that modal integration is one of the most promising opportunities for ridesharing's future and claim that governments should develop policies supporting modal integration, with flexible regulations and ridesharing incentives.

Modal integration can also be the key to a successful introduction of Shared Autonomous Vehicles in the future, and ride-hailing may have an essential role in this complex puzzle. The possible synergy between technology and shared transportation modes is demonstrated in Fagnant and Kockelman's (2014) work. The authors used an agent-based simulation for Shared Autonomous Vehicles (SAV) operations in a multi-modal system and found that each SAV introduced in the market could replace ten cars' work, with substantial savings in emissions, pollution, and congestion due to the significant reduction in car ownership. The benefits of integrating SAVs and public transit despite reducing car-based externalities, such as congestion, pollution, and accidents, is shown by Ohnemus and Perl (2016) as a viable alternative to reduce auto dependence and increase transit accessibility, efficiency, and coverage as the service could offer a solution for the first/last mile problem and a cost-effective solution for low-density areas.

According to Tirachini (2020), the availability of anonymized ride-hailing trip data is a crucial element for defining effective policies and regulations and should therefore be especially considered in agreements with ride-hailing companies. The author claims that such data is an essential component for governmental agencies to effectively assess the implications of ride-hailing in the variations of VKT, road congestion, and parking. By expanding the knowledge of actual ride-hailing externalities, such agencies would be able to make better decisions towards ride-hailing regulation.

Table 1 presents a summary of the main sustainability impacts associated with ride-hailing in Chapter 2, described by location and source. As the measures included in each source have a wide range of options, this summary focus on car-related externalities. The initial idea behind Table 1 was to rank the findings from least sustainable to most sustainable. However, as it relies on a heterogenous set of findings, I kept the overall concept from the least to the most sustainable output but selected just one indicator, when available, to organize the results. I based the rank on the modal substitution rates because this is the most present indicator across Table 1. This indicator reflects the substitution rate in which ride-hailing substitutes other transportation modes. The replaced mode is indicated after each figure. Another common output found in Table 1 is the induced demand, which represents how many trips would not have been taken if ride-hailing was not available.

Table 1 - Highlights on ride-hailing sustainability findings from Chapter 2

Location	Sustainability Impact - highlights	Source
Brazil Sao Paolo	• Modal substitution: 62% (public transit) • Average occupancy rate: 1.4 passengers per trip	Quest Inteligência and Gaesi/USP (2019)
U.S. Boston	• Modal substitution: 59% (public transit) • Trips between US$10 and US$20 are more likely to replace transit • Average car occupancy: 1.52 passengers per trip	Gehrke et al. (2019)
Canada Toronto	• Modal substitution: 49% (public transit) • Ride-hailing trips grew more than180% in 30 months • Ride-hailing represents between 5% and 11% of the total traffic in Downtown Toronto	City of Toronto Transportation Services (2019)
U.S. 7 Cities	• Modal substitution: 39% (ST modes) • Induced demand: 22% • After using ride-hailing, the average reduction in transit use is 6% • VKT variation: ride-hailing is likely to increase VKT • 30% of adults use ride-hailing services • Positive correlation between urbanization, education, income, and ride-hailing usage	Clewlow and Mishra (2017)
Spain Madrid	• Modal substitution: 38.9% (ST modes) • Induced demand: 1.5% • Correlation between higher environmental consciousness and reduction in ride-hailing usage	Gomez et al. (2021)
Chile Santiago	• Modal substitution: 37.6% (public transit) • Average car occupancy: 1.9 passengers per trip • 3.3% of ride-hailing trips are combined with public transit	Tirachini and del Río (2019)
China 10 Cities	• Modal substitution: 37% (public transit) • Induced demand: 0.4% • Car ownership: 6.6% would not buy if ride-hailing is available	Tang et al. (2020)
Ghana Accra and Kumasi	• Modal substitution: 37% (public transit) • Weak integration with other transportation modes • Mostly single occupancy trips • Strong positive correlation between income and ride-hailing use	Acheampong et al. (2020)
Chile Santiago	• Modal substitution: 36.2% (ST modes) • Induced demand: 5.4% • Average car occupancy: between 1.55 passengers per trip • VKT variation: each ride-hailing trip increases VKT by 1.7 km. • VKT reduction depends on drastic increases in pooled trips	Tirachini and Gomez-Lobo (2020)
China Nanjing	• Modal substitution: 34% (public transit) • Air pollution increase: 116% CO_2, 92% CO, 43% HC, and 33% NOx • VKT variation: ride-hailing inevitably increase the overall VKT	Shen et al. (2020)
U.S. Denver	• Modal substitution: 34% (ST modes) • Induced demand: 12% • VKT variation: increase of 83.5% • Average car occupancy: 0.78 (weighted by travelled distance) • 5.5% of ride-hailing trips are combined with other modes	Henao and Marshal (2019b)
Brazil 51 Cities	• Modal substitution: 30.2% (public transit) • Safety and cost are the main factors in ride-hailing travel choice	De Souza Silva et al. (2018)
Mexico 3 Cities	• Modal substitution: between 27% and 33% (ST modes) • Induced demand: between 4% and 5%	Moody et al. (2021)
Iran Tehran	• Modal substitution: 23.2% (public transit) • Induced demand: 12.5% • Comfort and shorter travel times are the main factors in ride-hailing travel choice	Lesteven and Samadzad (2021)
U.S. California	• Modal substitution: between 17% and 31% (ST modes) • Induced demand: 7.5%	Circella et al. (2019)

U.S. Multiple Cities	• Modal substitution: between 16% to 33% (public transit) • Induced demand: between 8% and 22% • Deadheading: between 10% and 60% of total travelling • Ride-hailing tend to increase VKT and GHG emissions	Rodier (2018)
India Delhi	• Modal substitution: between 15.2% and 20.3% (Delhi Metro) • Ride-hailing significantly increases congestion	Agarwal et al. (2019)
Brazil Sao Paolo	• Modal substitution: 17% (public transit) • Ride-hailing does not substantially increase travel times • Ride-hailing does not substantially increase congestion • Ride-hailing has positive impact on the economy, increases accessibility and equity	Haddad et al. (2019)
China 57 cities	• Ride-hailing increases $PM_{2.5}$ (Particulate matter) emissions by 48.8% • Ride-hailing leads to an increase in car sales • VKT variation: Ride-hailing leads to an increase in VKT	Barnes et al. (2020)
U.S. 7 cities	• Air pollution increase: a typical ride-hailing trip emits 47% more CO_2 than a private car trip, 117% more than a bus trip, and 563% more than a train trip.	Anair et al. (2020)
U.S. 6 cities	• Traffic-related externalities costs (e.g., air pollution and GHG emissions, congestion, crashes, noise, and social carbon costs) increase between 30% and 35% when ride-hailing trips replace private car trips • Traffic-related externalities costs increase by 114% per trip when ride-hailing trips substitute for ST modes	Ward et al. (2021)
U.S. Multiple Cities	• Ride-hailing companies are not profitable • Ride-hailing companies offer precarious financial conditions for drivers (lack of labor rights, no social insurance, no liability or support for third-part victims, and income lower than the minimum wage)	Button (2020)
U.S. Denver	• Most ride-hailing drivers earn less than the local actual minimum wage when costs per passenger are deducted from the income	Henao and Marshall (2019a)
U.S. Multiple Cities	• If a city has two or more ride-hailing companies, then it works as a substitute for public transportation, with increasing substitution effects over time	Sadowsky and Nelson (2017)
U.S. 7 cities	• Ride-hailing and other shared modes complement public transit • Ride-hailing and other shared modes have a positive correlation between their use and transit ridership	Feigon and Murphy (2016)
U.S. 2 cities	• Ride-hailing complements public transit • Ride-hailing is positively correlated with transit ridership • Ride-hailing may improve health accessibility	Watkins et al. (2019)
Canada Toronto	• Ride-hailing does not influence public transit ridership levels • Correlation between ride-hailing use, decrease in taxi use and increase in walking and cycling • Correlation between age, employment, income, and ride-hailing usage	Young and Farber (2019)
U.S. Multiple Cities	• Ride-hailing frequent users are 14% less likely to own a car than occasional users or non-users	Smith (2016)

In order to establish a comparative view of ride-hailing policies and regulations in Vancouver, the framework developed by Joshi *et al.* (2019) was applied to contextualize the city among other examples. Their framework summarizes the main topics discussed in the literature review summarized in Table 1, and enables the comparative assessment of ride-hailing regulation. Their study includes ride-hailing information of 13 international cities: New York City, Toronto, Chicago, Los Angeles and San Francisco, Mexico City, São Paulo, London, Moscow, Accra, Beijing, Mumbai, and Melbourne, to elaborate a descriptive analysis of the regulatory strategy considering both, measures already in place in 2019 or under discussion for future implementation.

The authors claim that even with mobile ride-hailing applications that look and work with many similarities, policies and regulations have a wide variety of regulations at different governmental levels. Such combination results in a complex set of policy and regulations options designed to deal with aspects of quality, economics, demand management, legal rights, traffic, congestion, environmental concerns, among others. Moreover, they state that “an isolated approach to regulation deprives cities of the ability to learn from the experience of others and prohibits true appreciation of the similarities of the effects these services have on larger infrastructure and communities” (Joshi *et al.,* 2019: 3).

Their work has a descriptive focus, which qualitatively compares cities without quantitative measures, and it is segmented into four topics discussed for each of the 13 cities as described below:

1. *Data:* mainly focused on how cities collect data about trips, cars, drivers, and ride-hailing operations in general.

2. *Service Standards:* considers operational regulations over drivers, cars, or the service itself, to understand how cities are implementing measures to increase safety and comfort basically.

3. *Environment:* covers requirements set to regulate and mitigate GHG emissions related to ride-hailing.

4. *Economics:* details regulations based on taxes over ride-hailing operations aiming to increase revenues destined to different areas such as infrastructure and public transit, among others, or those dedicated to regulate prices or drivers' pay.

For each of these topics, a comparative assessment of the regulatory framework in Vancouver will be developed in section 4.5.2. However, before delving into the policies and regulations framework, the next chapter explains how data was gathered and used to identify relevant aspects of mobility, ride-hailing, and ST modes in the city.

Chapter 3.

Methodology and Research Design

This research uses data to contextualize ST and mobility, to compare it subsequently to socio-demographic indicators, and then apply the results to inform a content analysis of the current ride-hailing legislation and policies.

This chapter explains in detail all the data included in this thesis, its sources and limitations, and introduces the research methods used to discuss my hypothesis and theoretical propositions.

3.1. Research Design

The research design seeks to identify the different usage patterns of ST modes in Vancouver to evaluate the possibility for ST trips' substitution by ride-hailing trips in particular neighborhoods. To pursue this objective, my methodology is anchored on social indicators that rely on existing data and statistics to analyze census data, using descriptive statistics and multiple time-series designs to interpret the relationship between social-demographic and mobility variables.

After assessing the relationship between the variables, two content analyses were developed to better understand the public opinion and regulations around ride-hailing in Vancouver. After that, ride-hailing regulations were assessed using the framework provided by Joshi *et al.* (2019). Later, all the information was combined to project the Neighborhood Sustainable Transportation Profile (NSPT) and the risks to sustainable transportation modes, based on reflections about two variables, the vehicle-kilometer-traveled (VKT) and modal substitution, as identified in the literature review. These macro-steps are represented in Figure 1, showing the information flow along with the main processes designed for this research.

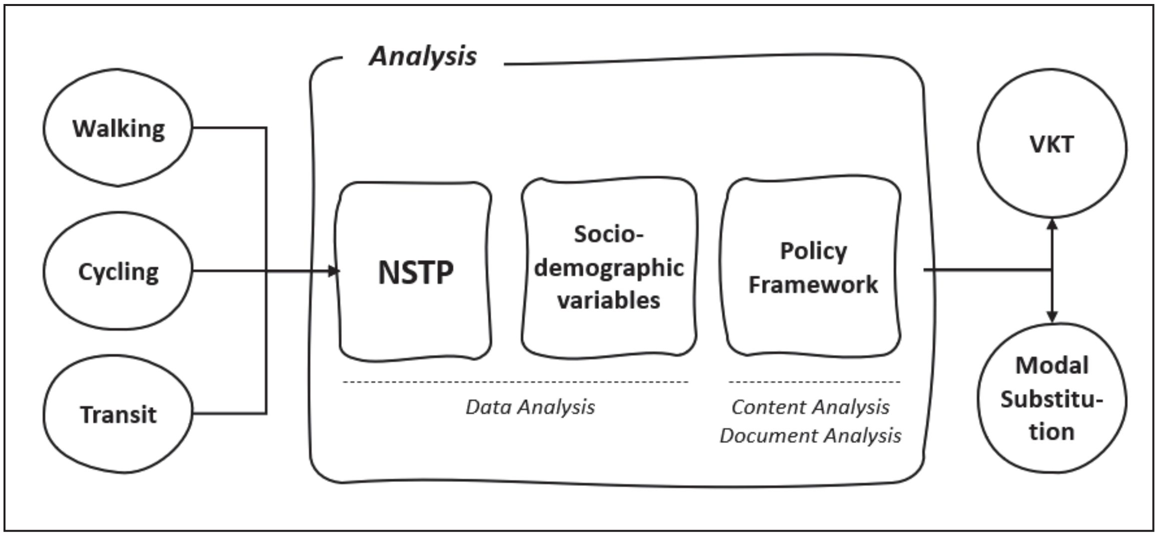

Figure 1 - Research Framework

The NSTP indicator represents the total number of trips made through the sustainable modes of transportation (walking, cycling, and public transit), divided by the total of trips of all the transportation modes present in the census results for the question "main mode of commuting to work." The goal of developing this indicator is twofold. First, it describes the city's different mobility patterns in a socio-spatial analysis based on the distance of each group of neighborhoods from Downtown Vancouver. Second, it allows for the future calculation of scenario analysis as the main data entry.

The assessment of the NSTP indicator and the Socio-demographic variables, classified as Data Analysis in Figure 1, uses descriptive statistics, time series and cross-sectional analysis, and relies upon other graphic elaborations. As mentioned in section 1.4, Statistics Canada uses the same concept to calculate an indicator called Sustainable Transportation. However, information about this indicator is only available on the Statistics Canada website for geographic scales other than a neighborhood, either smaller census tracts, or greater collections of data from the whole city or province, but not on a neighborhood scale. I have used data from the Open Data Portal (2020) from the city government webpage to calculate the NSTP for my research.

The policy framework was assessed using two methodologies. The first is a pair of content analyses over media coverage and the regulations included in Uber's operation licence. The second is a document analysis using the main regulatory instruments of ride-hailing in the city in comparison with the framework developed by Joshi *et al.* (2019).

The NSTP variable was used to discuss how the concept of local mobility could help in reducing the risks for sustainable transportation modes, in particular modal substitution and VKT increase. The discussion also addresses how the NSTP could be integrated into the current environment, data, service standards, and economic policies to build a more comprehensive regulatory framework, as discussed in section 4.6.

3.2. Data collection framework

This research relies on three singular datasets. The first one is "mobility" data, which aims to contextualize the mobility patterns of each of Vancouver's neighborhoods, making it possible to identify how ST modes are used. This dataset allows for the subsequent development of time-series analysis and descriptive statistics of individual subsets or comparisons among the three of them. Most importantly, it provides the necessary information to calculate a composite index which is labeled the Neighborhood Sustainable Transportation Profile (NSTP).

The second dataset consists of "socio-demographic" information. Its main goal is to provide specific variables to be used in the study between this dataset and the composite index NSTP to characterize the social-demographic aspect of mobility in each neighborhood. Additionally, its variables can be individually assessed in time series analysis and descriptive statistics.

Finally, the third dataset is a compilation of ride-hailing "regulation," composed of provincial legislation and Vancouver's local policies. This dataset is used to understand its relationship to the risks identified in the literature review and the NSTP indicator.

3.3. Data Sources

Data sources were grouped into three main clusters: mobility, socio-demographics, and regulations. Additionally, an explanation of how census data was obtained is included in section 3.3.4.

3.3.1. Mobility

Vancouver has three major sources of mobility data. The first one comes from the Census question related to the main mode of commuting to work. Provided by Statistics Canada and available on the Vancouver's Open Data Portal website, this is the most reliable source of mobility data for my research as it comes geographically segregated in a way where it is possible to analyze different neighborhoods (defined as local area geography on Census files provided by the City of Vancouver in the Open Data Portal) across time. The second source is the "Annual Transportation Mobility Panel - Vancouver," a survey from the city of Vancouver, and the third is the "TransLink Trip Diary Survey," which is another mobility survey conducted by TransLink. Both surveys are based on samples and have distinct purposes, formats, and geographies. The uniqueness of each survey, especially when it comes to different segregated data for neighborhoods, does not allow their combined use to create the NSTP indicator. Therefore, the last two sources, named the "Annual Transportation Mobility Panel - Vancouver" and the "TransLink Trip Diary Survey," were used only to contextualize the general figures for the city of Vancouver, which is the only convergent geography across the three sources, while the NSTP indicator, the primary variable of this study, relies solely on Census information.

All "mobility" data for my research was collected, cleaned, and organized in the form of tables divided into the Census data from 2001, 2006, and 2016, while both surveys used static data from their 2017 results.

As mentioned above, the information collected for the mobility dataset comes from the question: "Main mode of commuting for the employed labor force aged 15 years and over". The results are grouped according to the following classification: Total, Car, truck, van - as a driver, Car, truck, van - as a passenger, Public transit, Walked, Bicycle, and Other method, as illustrated in Table 2, Table 3, and Table 4. As part of the methodology, the neighborhoods were distributed into three zones, further explained in section 4.1.

Table 2 - Census 2016: Main mode of commuting

2016 - number of trips								
Group	Neighborhood	Total	Car, truck, van - as a driver	Car, truck, van - as a passenger	Public transit	Walked	Bicycle	Other method
1	Downtown	32,995	10,025	715	7,010	13,655	1,020	570
1	Kitsilano	23,825	10,235	575	7,240	2,755	2,570	450
1	Fairview	19,260	7,360	400	5,795	3,825	1,590	290
1	Mount Pleasant	20,735	8,060	580	6,210	3,030	2,520	335
1	West End	28,785	7,125	550	7,665	10,795	2,095	560
1	Strathcona	3,750	1,080	100	985	915	585	80
1	GROUP 1	129,350	43,885	2,920	34,905	34,975	10,380	2,285
2	Dunbar-Southlands	7,730	4,840	360	1,455	420	455	205
2	Arbutus-Ridge	5,010	3,100	220	1,180	195	205	105
2	Grandview-Woodland	16,485	6,830	510	5,395	1,280	2,220	250
2	Kensington-Cedar Cottage	25,665	12,665	1,240	8,915	965	1,580	300
2	Riley Park	11,310	5,460	390	3,205	925	1,155	170
2	Shaughnessy	2,855	1,845	105	475	215	175	50
2	South Cambie	3,620	1,640	80	1,055	500	295	45
2	West Point Grey	4,860	2,535	150	1,270	345	510	55
2	GROUP 2	77,535	38,915	3,055	22,950	4,845	6,595	1,180
3	Kerrisdale	4,775	3,070	210	1,020	180	205	90
3	Killarney	13,710	8,745	700	3,695	290	180	95
3	Hastings-Sunrise	16,610	9,425	830	4,735	665	755	195
3	Marpole	11,185	5,740	410	4,130	515	295	100
3	Oakridge	4,365	2,530	225	1,270	210	70	60
3	Renfrew-Collingwood	26,075	13,020	1,230	10,540	675	370	235
3	Sunset	18,185	9,625	1,030	6,400	510	430	190
3	Victoria-Fraserview	14,155	8,615	820	4,125	345	110	140
3	GROUP 3	109,060	60,770	5,455	35,915	3,390	2,415	1,105
Vancouver CSD		315,330	143,185	11,405	93,675	43,160	19,355	4,550
Vancouver CMA		1,159,215	745,815	58,040	235,985	77,830	27,235	14,305

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

Table 3 - Census 2006: Main mode of commuting

2006 - number of trips								
Group	Neighborhood	Total	Car, truck, van, as driver	Car, truck, van, as passenger	Public transit	Walked	Bicycle	Other method
1	Downtown	22,660	8,665	735	3,685	8,580	445	540
1	Kitsilano	24,075	11,650	935	6,545	2,885	1,715	345
1	Fairview	17,155	7,975	595	4,115	3,470	750	245
1	Mount Pleasant	13,720	5,615	540	4,965	1,325	1,135	140
1	West End	24,795	6,865	825	6,015	9,810	805	460
1	Strathcona	3,705	1,160	170	1,250	790	255	75
1	GROUP 1	106110	41930	3800	26575	26860	5105	1805
2	Dunbar-Southlands	8,950	6,210	560	1,305	315	425	125
2	Arbutus-Ridge	5,525	3,885	380	800	270	145	50
2	Grandview-Woodland	14,825	6,295	870	5,060	1,205	1,080	310
2	Kensington-Cedar Cottage	21,910	11,960	1,875	6,440	690	690	250
2	Riley Park	10,610	5,600	615	2,850	695	690	165
2	Shaughnessy	3,435	2,385	240	415	205	120	70
2	South Cambie	3,485	1,710	230	655	470	370	50
2	West Point Grey	5,775	3,375	245	1,020	460	555	105
2	GROUP 2	74515	41420	5015	18545	4310	4075	1125
3	Kerrisdale	5,735	3,905	380	890	310	165	80
3	Killarney	12,150	7,910	925	2,815	265	145	85
3	Hastings-Sunrise	15,440	9,290	1,350	3,655	625	380	125
3	Marpole	10,685	6,380	680	2,900	465	150	115
3	Oakridge	4,205	2,770	385	755	205	55	30
3	Renfrew-Collingwood	22,935	12,915	1,910	7,430	395	125	160
3	Sunset	16,360	9,800	1,570	4,035	595	180	165
3	Victoria-Fraserview	12,865	8,465	1,140	2,925	235	25	70
3	GROUP 3	100375	61435	8340	25405	3095	1225	830
	Vancouver CSD	280,550	144,485	17,150	70,470	34,245	10,415	3,780
	Vancouver CMA	1,003,025	675,075	70,985	165,435	63,415	16,585	11,515

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

Table 4 - Census 2001: Main mode of commuting

2001 - number of trips								
Group	Neighborhood	Total	Car, truck, van, as driver	Car, truck, van, as passenger	Public transit	Walked	Bicycle	Other method
1	Downtown	13,965	5,690	530	1,645	5,325	445	330
1	Kitsilano	23,655	13,925	1,360	3,160	2,985	1,910	320
1	Fairview	16,670	8,720	750	2,645	3,520	825	220
1	Mount Pleasant	13,255	6,550	675	3,030	1,650	1,095	260
1	West End	23,910	8,010	780	3,555	10,230	805	535
1	Strathcona	3,125	920	235	630	1,035	250	35
1	GROUP 1	94580	43815	4330	14665	24745	5330	1700
2	Dunbar-Southlands	8,800	6,570	585	825	400	375	55
2	Arbutus-Ridge	5,190	3,705	330	650	335	150	30
2	Grandview-Woodland	14,165	6,970	875	3,620	1,340	1,090	270
2	Kensington-Cedar Cottage	19,770	11,960	1,815	4,485	765	550	200
2	Riley Park	10,240	6,235	865	1,745	715	595	100
2	Shaughnessy	3,425	2,565	215	245	180	120	115
2	South Cambie	3,230	2,025	170	360	415	195	65
2	West Point Grey	5,740	3,690	295	690	460	580	20
2	GROUP 2	70560	43720	5150	12620	4610	3655	855
3	Kerrisdale	5,325	3,950	330	515	325	155	50
3	Killarney	10,700	7,580	795	1,890	235	130	65
3	Hastings-Sunrise	14,460	9,540	1,190	2,595	650	340	155
3	Marpole	9,645	6,365	730	1,680	495	275	120
3	Oakridge	3,710	2,735	305	415	165	55	40
3	Renfrew-Collingwood	19,975	12,330	1,665	5,085	535	190	175
3	Sunset	14,070	9,270	1,505	2,505	565	150	65
3	Victoria-Fraserview	10,770	7,620	1,075	1,690	205	80	95
3	GROUP 3	88655	59390	7595	16375	3175	1375	765
Vancouver CSD		253,325	146,525	17,065	43,625	32,465	10,345	3,290
Vancouver CMA		905,995	654,055	63,650	104,020	58,705	16,845	8,720

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

3.3.2. Socio-demographics

This dataset is entirely obtained from the Census files provided by Statistics Canada and gathered through the City of Vancouver Open Data Portal (2020). The variables extracted to analyze the correlation with the NSTP indicator are Average

Population, Income, Unemployment rate, and Working from home, as presented in Table 5 and Table 6 below.

Table 5 - Census 2016, 2006, and 2001: Socio-demographic variables – Part A

Socio-economic Variables		Unemployment rate			Working from home		
Group	Neighborhood	2016	2006	2001	2016	2006	2001
1	Downtown	5.6	5.8	10.5	11%	11%	11%
1	Kitsilano	5.2	4.2	5.7	12%	11%	10%
1	Fairview	4.6	4.4	5.7	10%	10%	8%
1	Mount Pleasant	4.7	5.5	8.5	8%	7%	6%
1	West End	5.3	5.7	7.7	9%	10%	8%
1	Strathcona	8.5	11.1	21.1	9%	11%	8%
1	GROUP 1	5.3	5.5	8.4	10%	10%	9%
2	Dunbar-Southlands	6.2	5.2	6.8	16%	14%	13%
2	Arbutus-Ridge	6.6	5	5.2	16%	15%	13%
2	Grandview-Woodland	5.3	7.8	11.8	9%	8%	7%
2	Kensington-Cedar Cottage	5.9	7.4	10.2	5%	5%	4%
2	Riley Park	4.9	5.9	6.5	9%	9%	9%
2	Shaughnessy	4.7	6	4.2	21%	17%	18%
2	South Cambie	6.7	5	4.9	12%	10%	11%
2	West Point Grey	6.4	5.1	6.2	17%	15%	13%
2	GROUP 2	5.8	6.4	8.2	11%	10%	9%
3	Kerrisdale	7.5	6.2	8.2	16%	15%	17%
3	Killarney	5.4	6.1	9.5	5%	6%	7%
3	Hastings-Sunrise	5.9	6.7	8.2	6%	5%	5%
3	Marpole	7.2	6.8	8.4	8%	8%	7%
3	Oakridge	5.7	6.8	6.9	16%	14%	13%
3	Renfrew-Collingwood	5.8	6.6	7.9	5%	4%	3%
3	Sunset	5.2	5.9	9.7	4%	5%	4%
3	Victoria-Fraserview	6.5	6.3	8.7	5%	6%	5%
3	GROUP 3	6.0	6.4	8.5	7%	7%	6%
Vancouver CSD		5.6	6	8.3	9%	9%	8%
Vancouver CMA		5.8	5.6	7.2	8%	8%	8%

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

Table 6 - Census 2016, 2006, and 2001: Socio-demographic variables – Part B

Socio-economic Variables		Average Income			Population		
Group	Neighborhood	2016	2006	2001	2016	2006	2001
1	Downtown	$ 63,251	$ 43,365	$ 34,807	62,030	43,415	27,990
1	Kitsilano	$ 63,092	$ 45,444	$ 41,445	43,045	40,595	39,620
1	Fairview	$ 61,627	$ 45,491	$ 40,628	33,620	29,295	28,405
1	Mount Pleasant	$ 54,260	$ 30,021	$ 25,677	32,955	23,615	24,535
1	West End	$ 47,253	$ 35,016	$ 31,980	47,200	44,560	42,120
1	Strathcona	$ 31,534	$ 18,434	$ 15,446	12,585	11,920	11,575
1	GROUP 1	$ 56,718	$ 39,034	$ 34,010	231,435	193,400	174,245
2	Dunbar-Southlands	$ 78,117	$ 59,270	$ 48,085	21,425	21,480	21,310
2	Arbutus-Ridge	$ 62,675	$ 48,496	$ 44,508	15,295	16,145	14,515
2	Grandview-Woodland	$ 42,896	$ 26,713	$ 23,228	29,175	28,205	29,085
2	Kensington-Cedar Cottage	$ 38,411	$ 25,757	$ 22,424	49,325	44,665	44,560
2	Riley Park	$ 53,060	$ 33,588	$ 27,753	22,555	21,815	21,990
2	Shaughnessy	$ 118,668	$ 126,310	$ 58,402	8,430	8,900	9,020
2	South Cambie	$ 65,459	$ 42,155	$ 35,587	7,970	7,070	6,995
2	West Point Grey	$ 82,042	$ 62,018	$ 53,321	13,065	12,990	12,680
2	GROUP 2	$ 57,218	$ 42,912	$ 33,765	167,240	161,270	160,155
3	Kerrisdale	$ 77,248	$ 66,543	$ 54,460	13,975	14,615	14,035
3	Killarney	$ 39,013	$ 29,210	$ 25,536	29,325	27,180	25,785
3	Hastings-Sunrise	$ 38,258	$ 26,916	$ 23,374	34,575	33,130	33,045
3	Marpole	$ 39,020	$ 30,099	$ 26,881	24,460	23,785	22,415
3	Oakridge	$ 46,515	$ 38,465	$ 33,198	13,030	12,725	11,795
3	Renfrew-Collingwood	$ 33,360	$ 25,102	$ 21,629	51,530	48,885	44,950
3	Sunset	$ 34,212	$ 24,322	$ 21,534	36,500	35,230	33,425
3	Victoria-Fraserview	$ 34,298	$ 25,669	$ 23,315	31,065	29,200	27,150
3	GROUP 3	$ 38,984	$ 29,798	$ 25,937	234,460	224,750	212,600
Vancouver CSD		$ 50,317	$ 36,605	$ 31,017	631,485	578,040	545,675
Vancouver CMA		$ 46,821	$ 36,123	$ 31,350	2,463,430	2,116,580	1,986,965

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

3.3.3. Regulations

This dataset's sources are the British Columbia government, the City of Vancouver government, and the Passenger Transportation Board of British Columbia. The following documents were assessed to provide a complete picture of ride-hailing regulations to operate in Vancouver: Bill 55 – 2018: Passenger Transportation Amendment Act, 2018; BY-LAW NO. 12649. A By-law to enter into an Inter-municipal TNS Business Licence Scheme, Enacted on February 26, 2020; BY-LAW NO. 12648. A By-law to enter into an agreement among the Participating Municipalities regarding an Inter-municipal Transportation Network Services Business Licence Scheme. Enacted on February 26, 2020; BY-LAW NO. 12556. A By-law to amend Street and Traffic By-law No. 2849 regarding Transportation Network Services. Enacted on October 2, 2019; Licence Application Decision (Transportation Network Services - New), number TNS6988-19. Applicant Uber Canada Inc., decision date January 23, 2020. Licence Application Decision (Transportation Network Services - New), number TNS6990-19. Applicant Lyft Canada Inc., decision date January 23. Policy Report RTS 12938 - Confirmation of Regulatory Principles related to ride-hailing; and Policy Report RTS 12922 - Adapting to Provincial Legislative Changes Related to Passenger Directed Vehicles;

The regulations dataset allows me to assess the policy framework considering different mobility scenarios and perspectives as discussed in the LAD content analysis in section 4.5.1 and the comparative regulations assessment included in section 4.5.2.

3.3.4. Census Data

Although the primary source of information is Statistics Canada, the aggregated data divided into the 22 local areas was obtained from the City of Vancouver Open Data Portal (2020) because it is a local geographic division, not present on the Statistics Canada website. All census files since 2001 were downloaded (2001, 2006, 2011, and 2016), organized, and treated. However, as mentioned at the beginning of this chapter, data about the journey to work question is not included in the 2011 file available on the Open Data Portal (2020). A formal request to access this information was sent to Vancouver's Open Data team to remediate this problem. As there was no answer to this query, I opted to remove 2011 from the analysis.

3.4. Validity and Feasibility of the NSTP indicator

The NSTP indicator is calculated based only on census information, which originally asks about the main mode of commuting to work. Actually, this does not represent the real division among all transportation modes for all trips. Such information would be better represented by mobility surveys like the "Annual Transportation Mobility Panel - Vancouver," a survey from the city of Vancouver, and the "TransLink Trip Diary Survey," a mobility survey conducted by TransLink, as described in section 3.3.1, but both have different scales and would not make my analysis feasible.

Therefore, I acknowledged this weakness of the methodology and sought to remediate that by comparing the three results on a greater scale of the city of Vancouver. Both surveys display their results for the whole city of Vancouver, and to calculate that for my research, I calculated the sum of all neighborhoods, where the total represents the city of Vancouver results. By using a standard scale for the NSTP and both surveys, I was able to establish a margin of variation used over my research.

The variation in the utilization of Sustainable Transportation modes is minimal among the three different sources, and technically if we consider the margin of error of both surveys, there is no difference at all. By comparing the share of ST modes over the total mobility I calculated 49.5% using data from the Statistics Canada Census, as shown in Table 7 in section 4.1. On the other hand, the “Annual Transportation Mobility Panel - Vancouver 2017” reaches 48.4% of total ST modes share with a confidence interval of 95% and the margin of error between + or - 5% (McElhanney and Mustel, 2018:32), and the Translink Trip Diary Survey 2017, available online, reaches 45.6% with a confidence interval of 90% and the margin of error between + or – 3.8% (Translink Trip Diary Survey, 2017).

Chapter 4 aims to analyse the datasets presented here. It will use the mobility and socio-demographic data collected here to assess possible relationships and interactions among them. Later in section 4.6, the relationship identified among these indicators will be used to understand the opportunities and vulnerabilities of current policies and regulations in the face of risks to ST modes, as presented in Chapter 2.

Chapter 4.

Analysis

The time frame defined for my project consists of the last 20 years of Census information (2001, 2006, 2011, and 2016). However, 2011 was not included as this year used a different methodology (National Household Survey - NHS), and also the data is not available on the same geographic level (Vancouver's 22 local areas) used for the other years, not allowing for the calculation of the NSTP indicator. Each of the 22 local areas of Vancouver is also defined, in this research, as a neighborhood.

As shown in Figure 1 from section 3.1, my research pursues two modes of analysis: Data Analysis and Content Analysis. The first phase concentrates on assessing the NSTP, its composition, its behavior across time and space, and its relationship with other variables. The second phase builds upon the former analysis, including information about policies from different perspectives, like public opinion and regulations in Vancouver. Finally, the information is combined to project the risks and opportunities of using the NSTP as a policy indicator.

At the core of my research, the NSTP indicator represents the total number of trips made by the sustainable modes of transportation (walking, cycling, and public transit), divided by the total of trips made by all the transportation modes present in the census results for the question "main mode of commuting to work." The goal of developing this indicator is twofold. First, it describes the city's different mobility patterns in a socio-spatial analysis based on each neighborhood's distance from Downtown Vancouver (Figures 2 and 3). Second, it allows for the subsequent development of a scenario analysis based upon this key indicator.

4.1. Mobility indicators

In order to facilitate the investigation and the data visualization, the results of the NSTP indicator were divided into three different zones, according to the distance of each neighborhood from Downtown, as demonstrated in Figure 2. The rationale for this choice is explained later in this section.

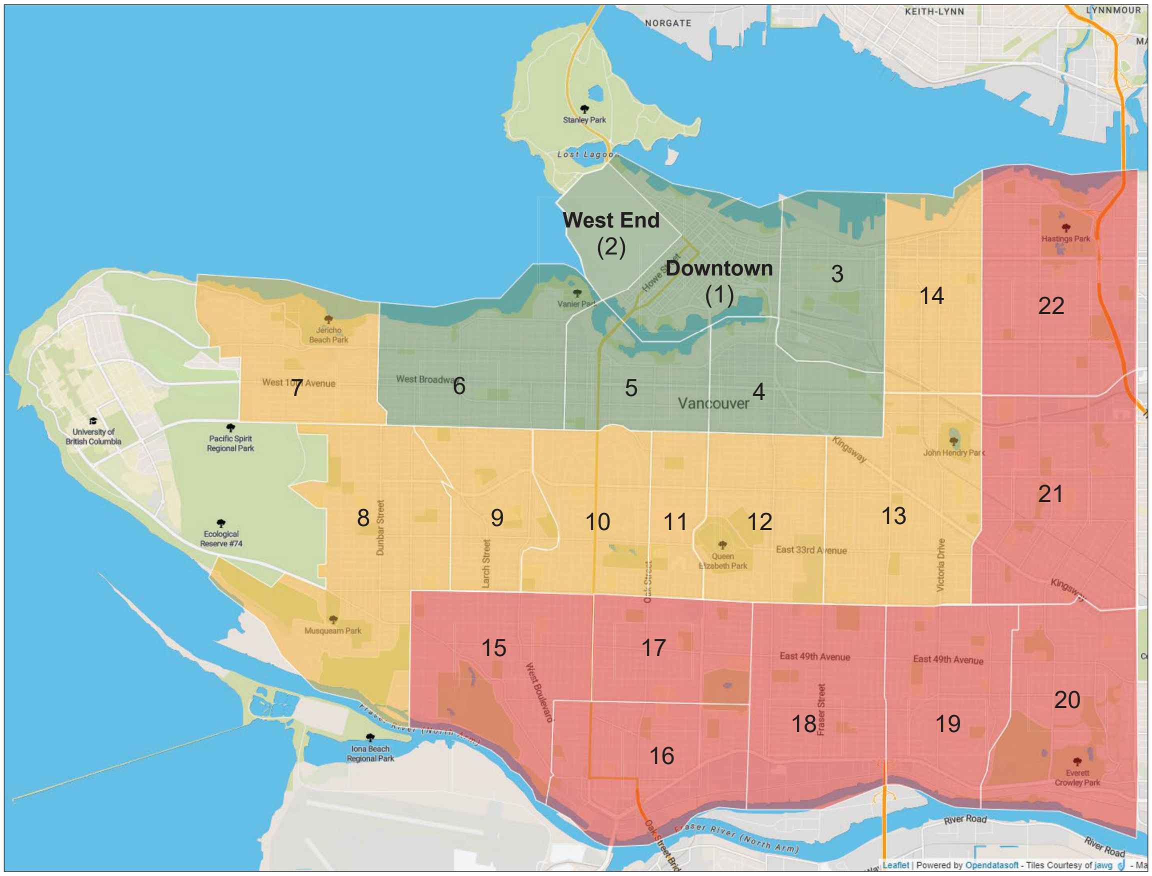

Figure 2 - Grouping Neighborhoods according to Downtown Distance
Source: Local Area Geography adapted from the City of Vancouver Open Data Portal (2020)

The list of local area geographies, defined in this research as neighborhoods, is linked to the numbers displayed in Figure 2. This list is organized according to the following classification: 1 = Downtown, 2 = West End, 3 = Strathcona, 4 = Mount Pleasant, 5 = Fairview, 6 = Kitsilano, 7 = West Point Grey, 8 = Dunbar-Southlands, 9 = Arbutus-Ridge, 10 = Shaughnessy, 11 = South Cambie, 12 = Riley Park, 13 = Kensington-Cedar Cottage, 14 = Grandview-Woodland, 15 = Kerrisdale, 16 = Marpole, 17 = Oakridge, 18 = Sunset, 19 = Victoria-Fraserview, 20 = Killarney, 21 = Renfrew-Collingwood, and 22 = Hastings-Sunrise.

The spatial selection to define the neighborhood in the green, yellow, and red zones, as shown in Figure 2, considered two different aspects. The first relies on a usual methodology of assessing mobility choices based on distance as a variable (Ding *et al*., 2017; Asensio, 2002; Buehler, 2010; Limtanakool *et al.,* 2006; Scheiner, 2010). The second is related to the actual distribution of total trips and trips taken by ST modes in the city. As previously presented in Table 2, Downtown leads both the share in the total volume of trips and the share of ST trips, followed closely by West End. As Downtown led both categories, my logic was to evaluate the spatial distribution based on the neighborhood with the highest participation in trips and ST trips and then, moving from this starting point to the other extreme of the city by creating zones according to their distance from the epicenter of ST trips.

The city of Vancouver provides the following definition for the Downtown neighborhood on its website:

> Vancouver's primary business district, houses many arts, entertainment, and sports venues, and is close to several vibrant residential communities. A peninsula, Downtown is bounded by Burrard Inlet on the north, False Creek and the popular district of Yaletown to the south. The West End neighbourhood and world-famous Stanley Park are to the west, and the popular historic districts of Gastown, Chinatown, and Strathcona are to the east (City of Vancouver, 2021).

Starting from Downtown, I defined three neighborhood zones based on the connections of its boundaries to create distance-based zones. To the best of my knowledge, such criteria for grouping the neighborhoods in distance-based zones in Vancouver was not used in any other piece of research. Below I explain the criteria of each zone and their list of neighborhoods:

1: Green - inner zone

This group is composed of areas that have a direct physical connection to Downtown. Neighborhoods included in this zone are Downtown, West End, Kitsilano, Fairview, Mount Pleasant, and Strathcona.

2: Orange - middle zone

The middle ring is defined by areas where only one neighborhood needs to be crossed to get to Downtown or the West End. This zone comprises eight regions: Dunbar-Southlands, Arbutus-Ridge, Grandview-Woodland, Kensington-Cedar Cottage, Riley Park, Shaughnessy, South Cambie, and West Point Grey.

3: Red - outer zone

The remaining eight districts form this zone. It is defined based on the need to cross two or more areas to get to Downtown or the West End, as shown in Figure 2. The list of areas included in this zone is composed of Kerrisdale, Killarney, Hastings-Sunrise, Marpole, Oakridge, Renfrew-Collingwood, Sunset, and Victoria-Fraserview.

Some challenges to harmonize the data were part of the process, even with data from the same source (Census). The datasets presented many different configurations in how segregated data were displayed over the census cycles. So, to make it comparable, it was necessary to homogenously organize the datasets to finally calculate the NSTP indicator, which is presented below in Table 7.

The equation to calculate the NSTP is expressed by:

NSTP = (Total of Walking + Cycling + Transit Trips) / (Total Trips)

In addition to the NSTP indicator, Table 7 also presents the indicator Active Transportation, which consists of the total trips included in the options Bicycle and Walked from the commuting to work question.

Similarly, the calculation of the Active Transportation indicator is represented by the following equation:

Active Transportation = (Total of Walking + Cycling trips) / (Total Trips)

Both indicators are used to identify mobility patterns in each district, allowing for comparisons between them and the socio-demographic variables. Additionally, its analysis will support my research in the scenario analysis and policy framework topics.

Table 7 - NSTP and Active Transportation: Intra neighborhood indicators

GROUP	NEIGHBORHOOD	NSTP			ACTIVE TRANSPORTATION		
		2016	2006	2001	2016	2006	2001
1	Downtown	65.72%	56.09%	53.10%	44.48%	39.83%	41.32%
1	Kitsilano	52.74%	46.29%	34.05%	22.35%	19.11%	20.69%
1	Fairview	58.20%	48.59%	41.93%	28.12%	24.60%	26.06%
1	Mount Pleasant	56.72%	54.12%	43.57%	26.77%	17.93%	20.71%
1	West End	71.41%	67.07%	61.02%	44.78%	42.81%	46.15%
1	Strathcona	66.27%	61.94%	61.28%	40.00%	28.21%	41.12%
1	**ZONE 1**	**62.05%**	**55.17%**	**47.30%**	**35.06%**	**30.12%**	**31.80%**
2	Dunbar-Southlands	30.14%	22.85%	18.18%	11.32%	8.27%	8.81%
2	Arbutus-Ridge	31.54%	21.99%	21.87%	7.98%	7.51%	9.34%
2	Grandview-Woodland	53.96%	49.54%	42.71%	21.23%	15.41%	17.15%
2	Kensington-Cedar Cottage	44.65%	35.69%	29.34%	9.92%	6.30%	6.65%
2	Riley Park	46.73%	39.92%	29.83%	18.39%	13.05%	12.79%
2	Shaughnessy	30.30%	21.54%	15.91%	13.66%	9.46%	8.76%
2	South Cambie	51.10%	42.90%	30.03%	21.96%	24.10%	18.89%
2	West Point Grey	43.72%	35.24%	30.14%	17.59%	17.58%	18.12%
2	**ZONE 2**	**44.35%**	**36.14%**	**29.60%**	**14.75%**	**11.25%**	**11.71%**
3	Kerrisdale	29.42%	23.80%	18.69%	8.06%	8.28%	9.01%
3	Killarney	30.38%	26.54%	21.07%	3.43%	3.37%	3.41%
3	Hastings-Sunrise	37.06%	30.18%	24.79%	8.55%	6.51%	6.85%
3	Marpole	44.17%	32.90%	25.40%	7.24%	5.76%	7.98%
3	Oakridge	35.51%	24.14%	17.12%	6.41%	6.18%	5.93%
3	Renfrew-Collingwood	44.43%	34.66%	29.09%	4.01%	2.27%	3.63%
3	Sunset	40.36%	29.40%	22.89%	5.17%	4.74%	5.08%
3	Victoria-Fraserview	32.36%	24.76%	18.34%	3.21%	2.02%	2.65%
3	**ZONE 3**	**38.25%**	**29.61%**	**23.60%**	**5.32%**	**4.30%**	**5.13%**
Vancouver CSD		49.53%	41.04%	34.12%	19.83%	15.92%	16.90%
Vancouver CMA		29.42%	24.47%	19.82%	9.06%	7.98%	8.34%

Source: adapted from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

For example, Figure 3 shows the variation in the NSTP indicator from 2016 in a bar chart organized from the highest to the lowest result, including zones 1, 2, and 3 data and the Vancouver CSD (census subdivision) and CMA (census metropolitan area) averages.

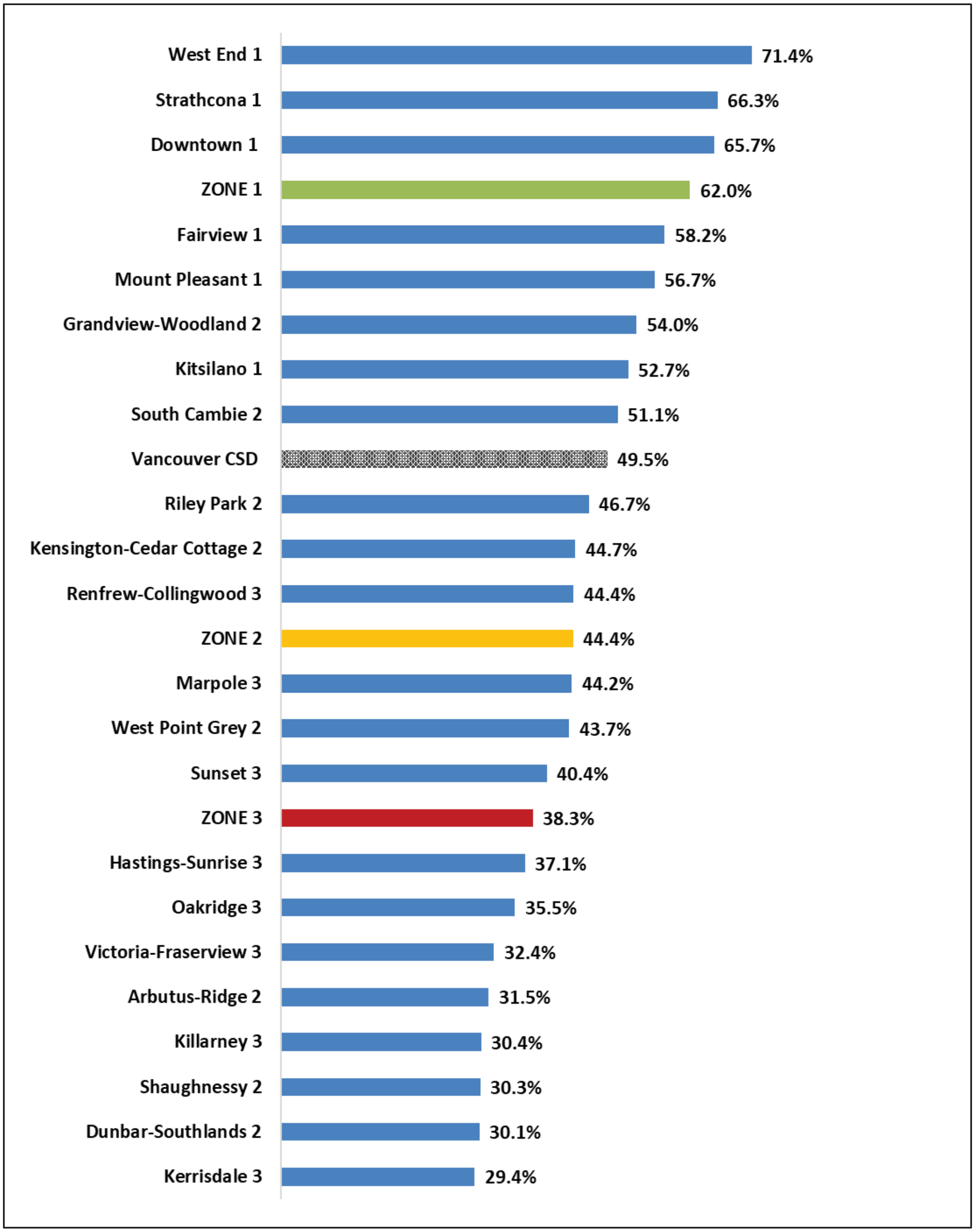

Figure 3 - NSTP indicator 2016 (Neighborhood Sustainable Transportation Profile)
Source: adapted from Statistics Canada data from the City of Vancouver Open Data Portal (2020)

The NSTP indicator presented in Figure 4 compares the behavior of the three different zones over time, indicating that distance from Downtown influences the usage of ST modes.

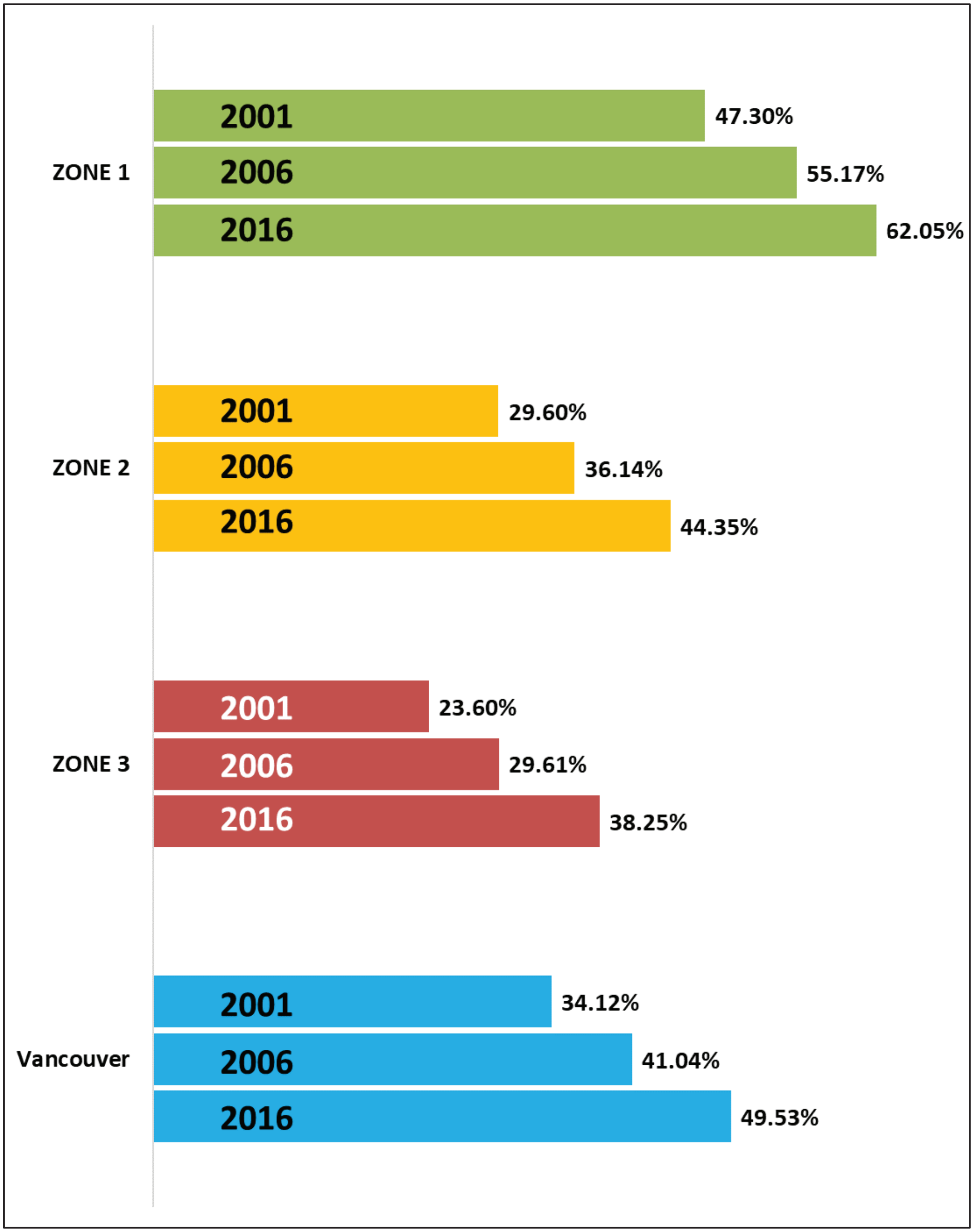

Figure 4 - NSTP indicator per analysis zone
Source: adapted from Statistics Canada data from the City of Vancouver Open Data Portal (2020)

Figure 4 also shows a consistent growth pattern among the usage of ST modes. Conversely, when active modes of transportation are focused upon, a different pattern is found, with a general decrease over the zones in 2006 compared to 2001, followed by growth to reach the highest levels in 2016, as shown in Figure 5.

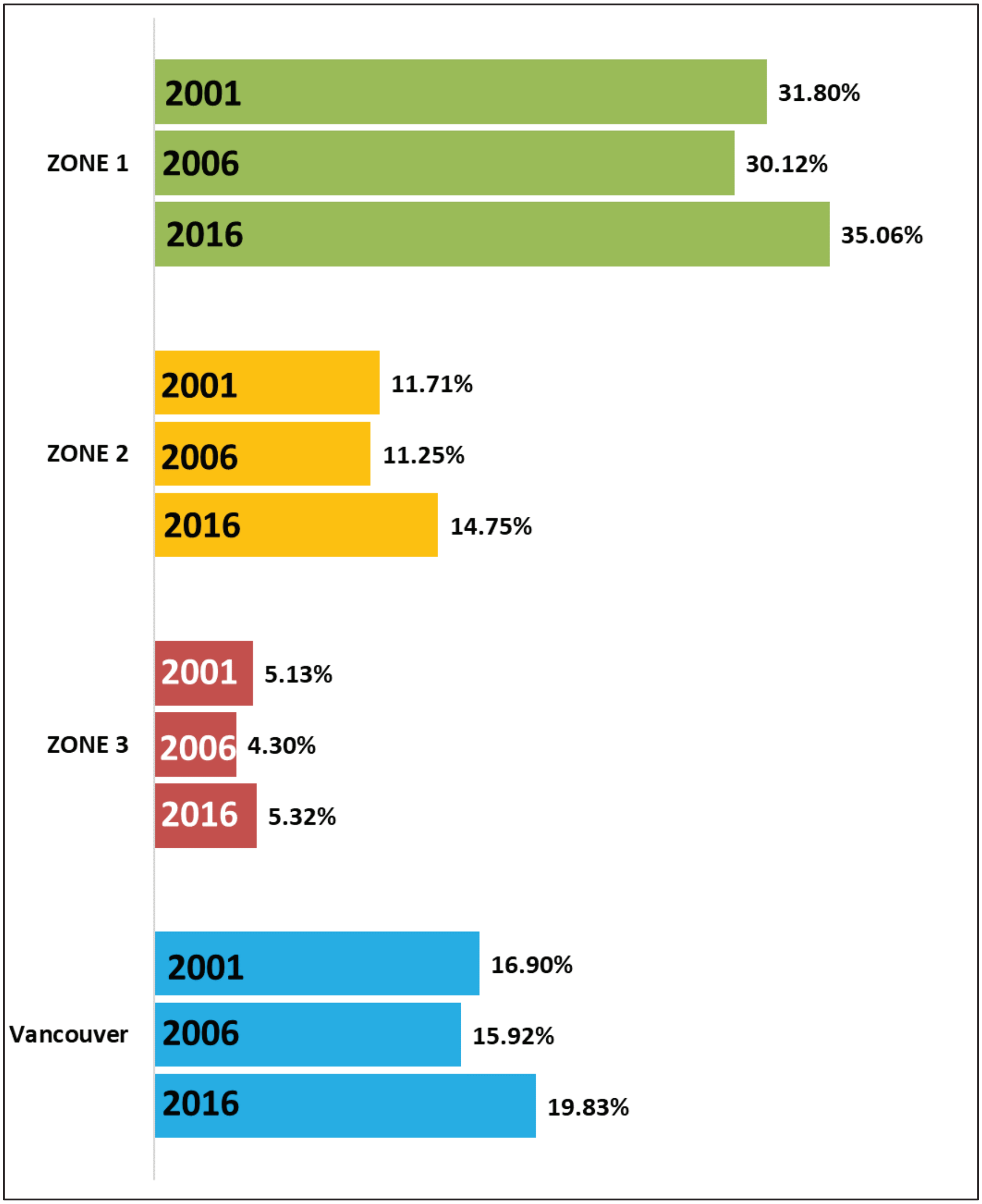

Figure 5 - Active Transportation per Analysis Zone
Source: adapted from Statistics Canada data from the City of Vancouver Open Data Portal (2020)

The results of the NSTP and other variables from the socio-demographic dataset were analyzed with descriptive statistics and diverse time-series and cross-sectional analysis to compare the NSTP indicator's evolution and eventual relationships. However, before digging into these comparisons, a brief analysis of trips and population evolution over the census cycles is presented below.

4.2. Trips and population distribution over time

Figure 6 shows how total trips were distributed over the census cycles. It indicates that zone 1 is continuously increasing its share over the cycles, growing from 37.3% in 2001 to 41.0% in 2016. On the other hand, an opposite situation is found in zone 2, with a constant decline over the cycles, reducing its share from 27.9% to 24.6%. This zone also presented the greatest drop between cycles when 2016 is compared to 2006, with a negative variation of 2%.

Interestingly, zone 3 was the only one to oscillate between increasing and decreasing its share over the three census cycles. It grew from 35.0% in 2001 to 35.8% in 2006 and then diminished its share to 34.6% in 2016. Comparing the extremes, 2001 versus 2016, zone 1 shows a consistent increase, with a +3.7% variation, while zone 2 shows the highest decline with a negative variation of 3.3%, and zone 3 presents a more stable pattern, with a negative variation of 0.4%.

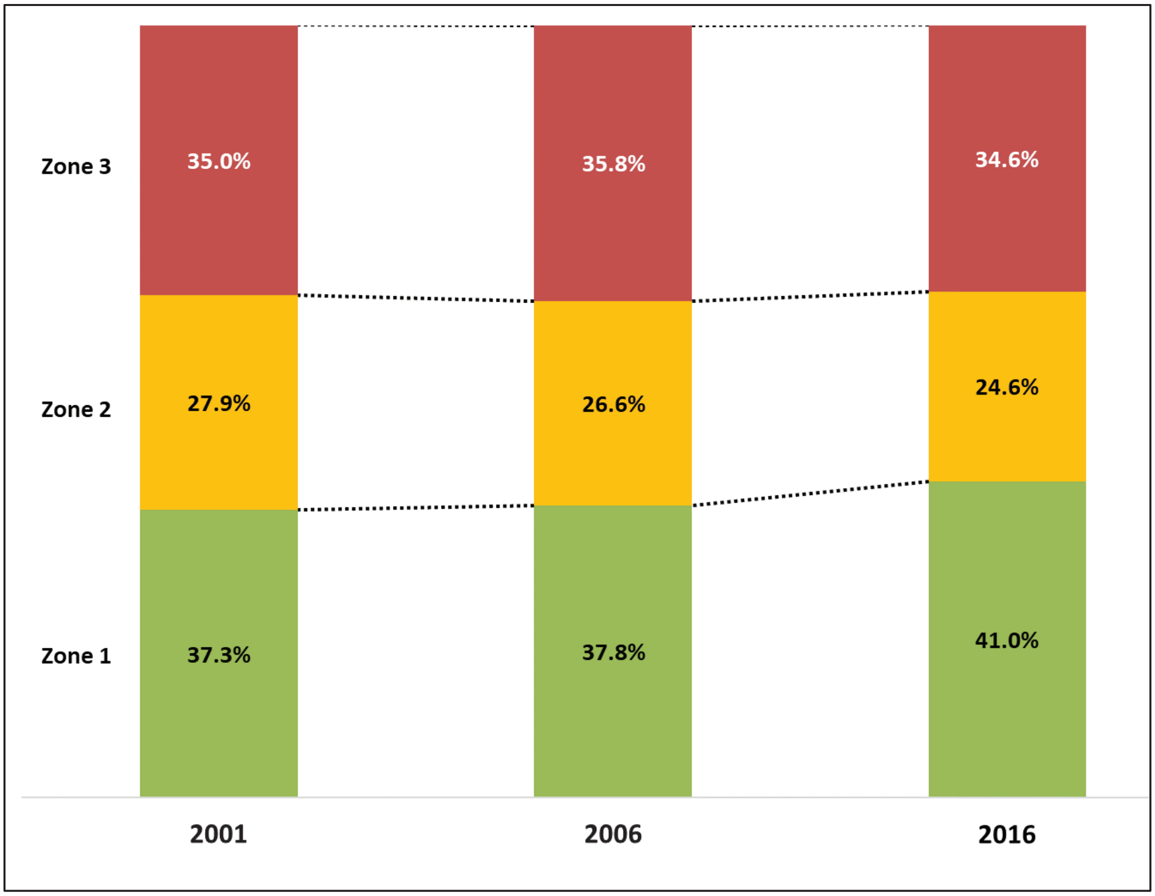

Figure 6 - Trip distribution between zones over census cycles
Source: adapted from Statistics Canada data from the City of Vancouver Open Data Portal (2020)

Figure 7 compares how the shares of each zone's population developed over time, showing a strong similarity with trip distribution, especially when comparing the extremes, 2001 versus 2016. Once again, zone 1 presents the highest increase, with a positive variation of 4.7%, while zone 2 has the strongest decline, losing 2.9%, and zone 3 lost 1.8%. Also, similar to the trip's distribution analysis, the population in zones 1 and 2 shows a gradual increasing and decreasing pattern, respectively. Zone 3 remains steady between 2001 and 2006, but then in 2016, it shows the highest drop between cycles.

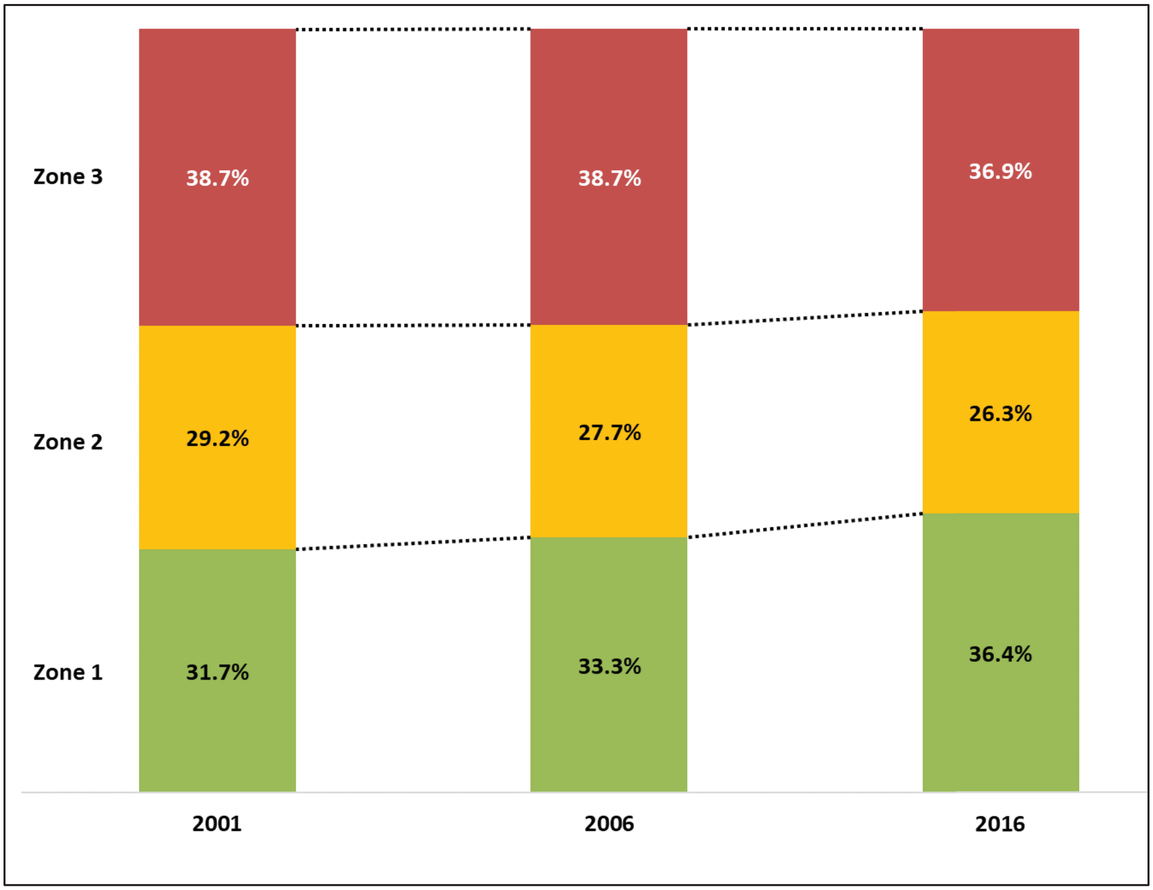

Figure 7 - Population distribution between zones over census cycles
Source: adapted from Statistics Canada data from the City of Vancouver Open Data Portal (2020)

Even considering the similarities in how zones evolved in terms of trips and population over the census cycles, one should consider that within each zone, many disparities are found when neighborhoods are individually assessed. To better understand this difference, I compared the extremes of both trips and population to calculate how each of the indicators has changed from 2001 to 2006.

This equation involves the calculation of the trips factor by dividing the 2016 total trips by the 2001 total trips, and the population factor, which follows the same concept using population figures instead of total trips. After calculating both indicators, it is possible to identify how each neighborhood, or zone, has changed within our timeframe. Table 8 illustrates the results of this calculation, showing the divergences found in this sample. When results are positive, it means that trips grew more than population, while for negative results, it means exactly the opposite.

Table 8 - Trips and Population factors – figures from 2016 divided by 2001

Trips and Population factors				
Zone	Neighborhood	Trips factor (A)	Population Factor (B)	Trips factor (A) / population factor (B)
1	Downtown	2.36	2.22	6.6%
1	Kitsilano	1.01	1.09	-7.3%
1	Fairview	1.16	1.18	-2.4%
1	Mount Pleasant	1.56	1.34	16.5%
1	West End	1.20	1.12	7.4%
1	Strathcona	1.20	1.09	10.4%
1	Zone 1	1.37	1.33	3.0%
2	Dunbar-Southlands	0.88	1.01	-12.6%
2	Arbutus-Ridge	0.97	1.05	-8.4%
2	Grandview-Woodland	1.16	1.00	16.0%
2	Kensington-Cedar Cottage	1.30	1.11	17.3%
2	Riley Park	1.10	1.03	7.7%
2	Shaughnessy	0.83	0.93	-10.8%
2	South Cambie	1.12	1.14	-1.6%
2	West Point Grey	0.85	1.03	-17.8%
2	Zone 2	1.10	1.04	5.2%
3	Kerrisdale	0.90	1.00	-9.9%
3	Killarney	1.28	1.14	12.7%
3	Hastings-Sunrise	1.15	1.05	9.8%
3	Marpole	1.16	1.09	6.3%
3	Oakridge	1.18	1.10	6.5%
3	Renfrew-Collingwood	1.31	1.15	13.9%
3	Sunset	1.29	1.09	18.4%
3	Victoria-Fraserview	1.31	1.14	14.9%
3	Zone 3	1.23	1.10	11.5%
Vancouver CSD		1.24	1.16	7.6%
Vancouver CMA		1.28	1.16	10.6%

Source: calculated using data from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

In the zone comparison, Table 8 shows that, in general, trips grew more than the population between 2001 and 2016. This might be associated with several factors such as population age, family composition, and unemployment rates, among others. Even with an unknown cause, Table 8 shows that zone 1 presented the smallest difference between trips and population, with a final rate of 3%, while zone 2 figures resulted in a difference of 5.2%, and finally, zone 3 reached an impressive rate of 11.5% in the relation between trips and population considering both extremes (2001 and 2016), meaning that the rate of trips per capita of zone 3 is growing more than twice as much when compared to zone 2, and almost four times the rates found in zone 1. When only zones are considered, the relationship between the trips factor and the population factor, as explored in Table 8, reveals a distance correlated pattern, where the final rates of this equation will lead to an assumption that as farther from downtown a zone is, higher will be the increase of trips per capita, represented by the calculation of the trips factor divided by the population factor.

4.3. Socio-demographic indicators

The leading position of zone 1 over the mobility indicators is not reflected in the social-demographic variables. Actually, zone 1 achieved the best unemployment rate in all census cycles, but the remaining two variables, named Average income and Working from Home, were led by zone 2, as demonstrated in Table 9. Zone 3, however, kept the same pattern observed in the mobility indicators, presenting the worst results for all the three socio-demographic variables in all the census cycles. Moreover, in the comparison between 2016 and 2001, zone 3 showed the lowest reduction in the unemployment rate and the lowest increase in the indicators Average Income and Working from Home.

Table 9 - Socio-demographic indicators divided by zone

Unemployment Rate	ZONE 1	ZONE 2	ZONE 3	Vancouver
2016	5.35	5.78	6.01	5.6
2006	5.52	6.37	6.41	6.0
2001	8.37	8.19	8.54	8.3
2016/2001	-36%	-29%	-30%	-33%

Average Income	ZONE 1	ZONE 2	ZONE 3	Vancouver
2016	$ 56,718	$ 57,218	$ 38,984	$ 50,317
2006	$ 39,034	$ 42,912	$ 29,798	$ 36,605
2001	$ 34,010	$ 33,765	$ 25,937	$ 31,017
2016/2001	67%	69%	50%	62%

Working from Home	ZONE 1	ZONE 2	ZONE 3	Vancouver
2016	10.2%	10.8%	6.6%	9%
2006	9.9%	10.0%	6.5%	9%
2001	8.8%	9.1%	6.2%	8%
2016/2001	15%	19%	5%	11%

Source: calculated using data from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

The zone analysis suggests that higher income levels are associated with low unemployment rates and high rates of people working from home. It is worth mentioning that differently from the mobility indicators, the gradual evolution between zones 1, 2 and 3, occurs only in the unemployment rates, with zone 2 leading the two remaining indicators as illustrated in Table 9. This pattern invalidates the assumption that distance from Downtown could influence both indicators, Average Income and Working from Home. However, zone 3, which is the most distant zone from Downtown, our ST trips epicenter, presented the highest unemployment rates for all census cycles. It also has the lowest Average Income, 31% below zones 1 and 2 on average for 2016, and presents the lowest evolution in such indicator when 2001 and 2016 are compared. A similar pattern is found on the indicator Working from Home, where zone 3 presents the lowest indicators for all census cycles, although with a higher difference from the other zones in 2016 with a result 38% lower on average. The evolution of this indicator in zone 3 also seems to be in a very different pace when compared to zone 1 and 2. Zone 3 has increased Working from Home figures between 2001 and 2016 in only 5%, a number three times lower than zone 1 and almost four times lower than zone 2.

4.4. Mobility versus Socio-demographic indicators

The purpose of the combination of mobility and socio-demographic indicators is to assess the relationship between the NSTP indicator with indicators such as average income, unemployment, and working from home to understand possible accessibility and affordability problems that could be potentially associated with the NSTP indicator. The hypothesis is that such association could demonstrate correlations between all those indicators. Nevertheless, even with a possible confirmed correlation, there would be many necessary intervening steps before assuming that such correlation would automatically turn into causation. Yet, if the hypothesis is confirmed, it may delineate a new research path where it would eventually require a more profound assessment from the relationship of mobility and socio-demographic indicators that could lead to a more concrete analysis to realize the potential association of these variables in practice, for example, linking sustainable transportation usage, represented by the NSTP indicator, with improvements in income, education, unemployment and working from home.

When all the indicators are put together, as in the example from 2016 included in Table 10, the results infer that the association observed in the socio-demographic indicator can be expanded to mobility indicators in a way where the NSTP and Active Transportation would be linked to higher levels of income and share of people working from home as well as low unemployment rates, confirming the hypothesis. Table 10 shows an adapted table using blue scales to show their distribution, where results are ordered per column from the lightest (worst) to the darkest (best) tones to express the difference among each other. Population figures were excluded from the colored analysis as quantity differences do not imply better or worse.

Table 10 - Consolidated zone indicators 2016

ZONE	NSTP (Sust. Transp.)	Active Transportation	Unemployment Rate	Average Income	Working from Home	Population
1	62.05%	35.06%	5.3	$ 56,718	10.2%	231,435
2	44.35%	14.75%	5.8	$ 57,218	10.8%	167,240
3	38.25%	5.32%	6.0	$ 38,984	6.6%	234,460
Vancouver	49.53%	19.83%	5.6	$ 50,317	8.9%	631,485

Source: calculated using data from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

However, even with the zone averages pointing to an association between the mobility and socio-demographic indicators, when districts are individually assessed, a different picture is found, indicating that the association between both indicators' clusters is not so clear nor obvious. Table 11 shows the districts with their respective rankings in each variable (columns) where the values used the same methodology of the colored table as explained before for Table 10.

Table 11 - Consolidated indicators per district 2016

ZONE	District	NSTP (Sust. Transp.)	Active Trans - portation	Unemploy- ment rate	Average income	Working from home	Population
1	Downtown	3	2	10	6	9	1
1	Kitsilano	7	6	5	7	7	5
1	Fairview	4	4	1	9	10	8
1	Mount Pleasant	5	5	2	10	15	9
1	West End	1	1	7	12	13	4
1	Strathcona	2	3	22	22	12	20
2	Dunbar-Southlands	21	12	15	3	3	15
2	Arbutus-Ridge	18	16	18	8	5	16
2	Grandview-Woodland	6	8	7	14	14	12
2	Kensington-Cedar Cottage	10	13	13	17	18	3
2	Riley Park	9	9	4	11	11	14
2	Shaughnessy	20	11	2	1	1	21
2	South Cambie	8	7	19	5	8	22
2	West Point Grey	13	10	16	2	2	18
3	Kerrisdale	22	15	21	4	6	17
3	Killarney	19	21	9	16	20	11
3	Hastings-Sunrise	15	14	13	18	17	7
3	Marpole	12	17	20	15	16	13
3	Oakridge	16	18	11	13	4	19
3	Renfrew-Collingwood	11	20	12	21	21	2
3	Sunset	14	19	5	20	22	6
3	Victoria-Fraserview	17	22	17	19	19	10

Source: calculated using data from Statistics Canada data through the City of Vancouver Open Data Portal (2020)

An example of this divergent pattern is found in the assessment of the three best and the three worst-ranked districts in the NSTP (Neighborhood Sustainable Transportation Profile) indicator, which offers a very contrasting situation in terms of the association between mobility and socio-demographic indicators. For example, in the comparison between NSTP and Average Income, the worst-ranked district in the NSTP indicator is Kerrisdale on zone 3, which is ranked 4 in Average Income, followed by

Dunbar-Southlands, which is ranked 3, and finally, Shaughnessy, which is the highest-ranked district in Average Income. On the other extreme, appearing as the best-ranked district in the NSTP, West End is only ranked 12 in Average Income, while Strathcona, the second-best district, has the worst result in Average Income. The exception would be Downtown, the third best-ranked district in the NSTP and ranked 6 in Average Income. Of course, these districts would offer several historical and political explanations for such results, even though this latter analysis stresses that sustainable transportation in Vancouver, represented by the NSTP indicator, should not be directly associated with improvements in the average income or other socio-demographic variables considered by this research.

4.5. Policy and regulations: public narrative versus framework assessment

Ride-hailing has a long history in Vancouver, BC – Canada. Starting in 2012, when Uber had a secret, and unofficial, operation in the city (Ngo, 2015), going through many situations involving many discussions, surveys, and political lobbying over policies and regulations in order to finally obtain the so expected green light on January 23, 2020, to begin its official operations in the city, as demonstrated in Figure 8.

Figure 8 - Ride-hailing timeline in Vancouver
Adapted from Nair (2020)

Understanding the ride-hailing timeline in Vancouver is useful to interpret my assessment of ride-hailing policies and regulations in the city. The strategy used for this examination was based on a two-step evaluation where the first step is meant to assess the relationship between public opinion with the articulation of practical and political solutions of the policymakers, and the second uses the framework developed by Joshi *et al.* (2019), described in section 2.3, to evaluate the set of policies and regulations condensed in a document analysis.

The relationship between public opinion with the decision-making process is based on a content analysis focused on better understanding the context under which ride-hailing was authorized to operate in Vancouver. Such content analysis relies on the Licence Application Decision, so I can draw a parallel between both analyses to compare them and to analyse whether there are similar concerns or eventual relationships in both analyses or not. Perl *et al.* (2018) explain how an eventual judgment based on erroneous concepts, ignorance, or over false news can influence the decision-making process integrity. Taking this concept into consideration, I developed a conceptual model based on a composite content analysis involving two different sources: press and online media, and the Uber Licence Application Decision number 6988-19 (LAD) issued by the Passenger Transportation Board, which contains all the relevant transcriptions of the submissions pro and against the applicant (Uber), plus the board considerations and support documentation included in the license application process. Section 4.5.1 explains the criteria used to select only Uber Licence Application, as well as the Passenger Transportation Board responsibilities and the license application process.

The second step uses the main regulatory instruments included in the set of ride-hailing policies and regulations in a document analysis to understand how aspects of Data, Service Standards, Environment, and Economics, as described in the work of Joshi *et al.* (2019), detailed in section 2.3, intersect with ride-hailing in Vancouver. The documents on which my analysis are based are the Bill 55 2018: Passenger Transportation Amendment Act issued by the British Columbia government, the BY-LAW numbers 12649, 12648, and 12556, the Licence Application Decision (Transportation Network Services - New), number TNS6988-19 and TNS6990-19, and the policy reports issued by the city of Vancouver, number RTS 12938 and RTS 12922.

4.5.1. Policy framework part I: Content analysis

Content Analysis - Media coverage

The unit of study and analysis defined for this assessment was “news articles,” extracted from four different data sources: 1 - Canadian Newsstream, 2 - Canadian Business and Current Affairs, both 1 and 2 were accessed online through SFU Library, 3 - CBC website and 4 - Globe and Mail website. Items three and four were added to my database in order to increase the range as they were not present in items one and two and offered some additional substantive content about the subject.

The sampling strategy was based on a five-month range between the last three months before the ride-hailing approval, which are October, November, and December 2020, plus January 2020 as the starting point, and February 2020, as the first full operational month. All news articles related to ride-hailing in BC and their cities within this timeframe were selected.

The expression used in the search engine of the SFU library website to filter the news articles was “ride-hailing Vancouver.” Sources number 1:Canadian Newsstream and 2:Canadian Business and Current Affairs were selected, and they were both set to display only news articles defined as Newspapers or Blogs, Podcasts, and Websites. The resulting selection was exported to an excel file sheet named 'Export DB 1' with 194 potential news. The same search was extended to CBC and Globe and Mail websites, returning 151 results from CBC and 338 from Globe and Mail, resulting in 683 potential samples. This dataset was cleaned and refined, eliminating duplicated news (from the same day and the same newspaper or website), news unrelated to the topic (false results), and news out of the time range. As a final output, I had a sample of 45 registers from sources 1 and 2 (all of them actually came from source 1, source 2 brought only dismissed results), 19 from CBC, and 18 from *The Globe and Mail*, which composed my final sample, a set of 82 news articles.

The coding developed for the media content analyses was based on the interpretation of each news article using side notes as a pre-coding, in a free interpretation through the “open coding” methodology described by Babbie and Roberts (2018:343). These side notes were later refined and grouped in core concepts, using the “axial coding” concept where the previous codes are linked to the main concepts of the study (Babbie and Roberts, 2018:341). As a result, our code list was composed of three macro indicative classifications, in a group named “Core messages,” plus six derivations of subjects used to identify the specific concerns addressed in each of the news articles, defined as “Subjects,” totaling nine different codes applied to each of my units of analysis.

The three codes included in the “Core messages” group are:

a) Neutral: used for general information about the meeting, its participants, regulations, or concepts. When there is no message against nor pro ride-railing.

b) Against: when the information included in the paragraph is negative and works against Uber’s application.

c) Pro: used to classify information usually about the advantages and benefits of ride-hailing or the company Uber itself, used to support Uber’s application.

The result points out that a vast majority of the analyzed articles support ride-hailing operations, as illustrated in Figure 9. Further interpretation of the content analyses included in this topic and also in the Licence Application Decision is included in the subsection named analysis, placed right after the section named “Content Analysis: Licence Application Decision.”

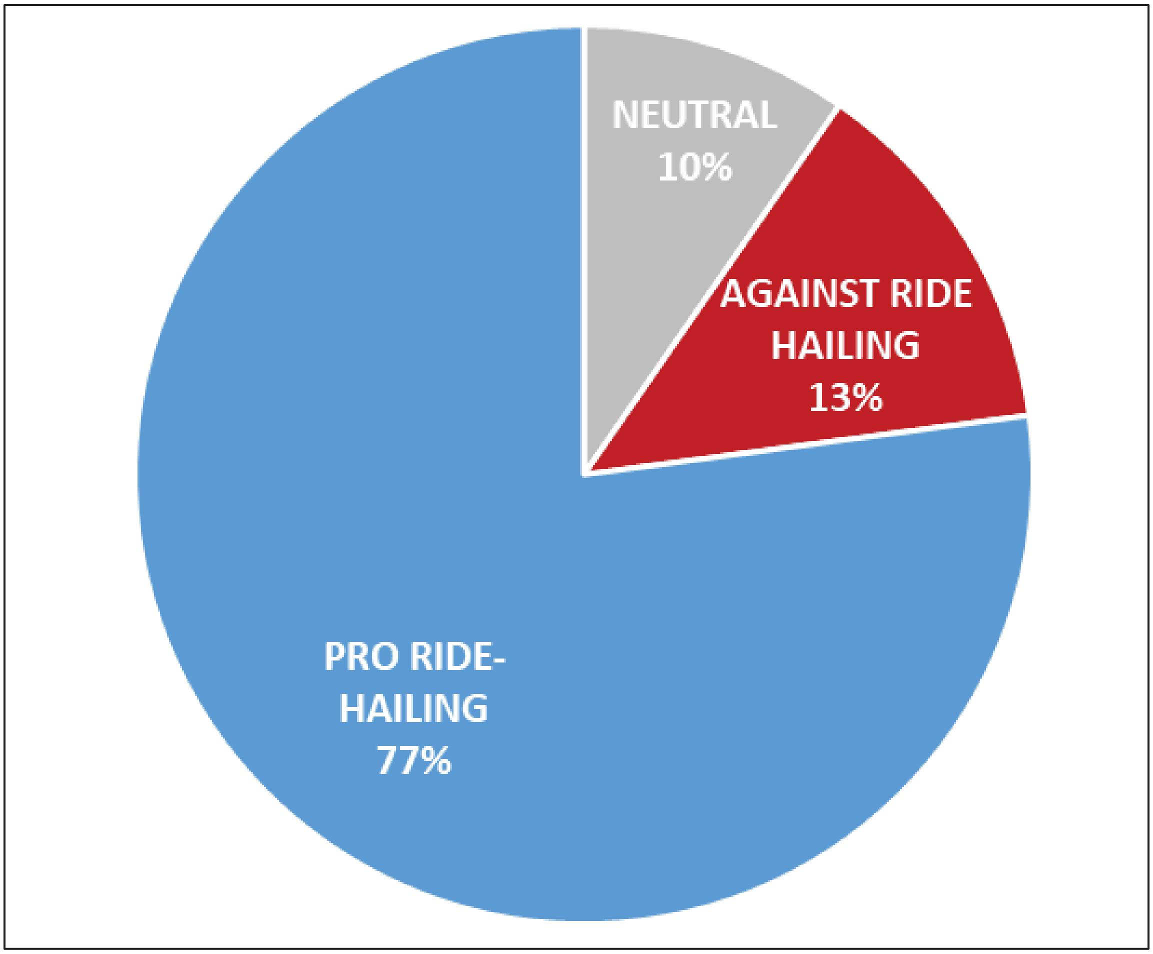

Figure 9 - Media Coverage – "Core Messages" of the Content Analysis
Source: Calculated by the author

After identifying the core messages, I defined the second tier of classifications as explained above to clarify the specific concerns addressed in each news article. This group of classification is named "Subjects," and it is divided into the remaining six codes listed in Table 12 below.

Table 12 - Coding for the content analysis of Media Coverage - Subjects

Code	Definition
Taxis	It covers news related to taxis in general, including taxi versus ride-hailing, economic and operational losses, regulations, risks, studies, research, etc.
Problems	Any news articles identifying operational or safety issues of ride-hailing, like data breaches, safety, privacy concerns, driver behavior, wages, congestion, accidents, and others.
Promoting	News articles supportive of ride-hailing, stressing its qualities, or just giving general positive information about ride-hailing.
Barriers	Articles related to obstacles to increase ride-hailing such as congestion fees, drivers and vehicles' requirements, registrations, fleet limitations, etc.
Environment	News articles covering issues related to greenhouse gas emissions or other types of pollution.
Public Transit	Any news articles discussing the relationship or interactions between Public Transit and ride-hailing

The results of the coding from the “Subjects” group applied to the samples are summarized in Figure 10. From all the news articles assessed in this content analysis, only two were classified in more than one code.

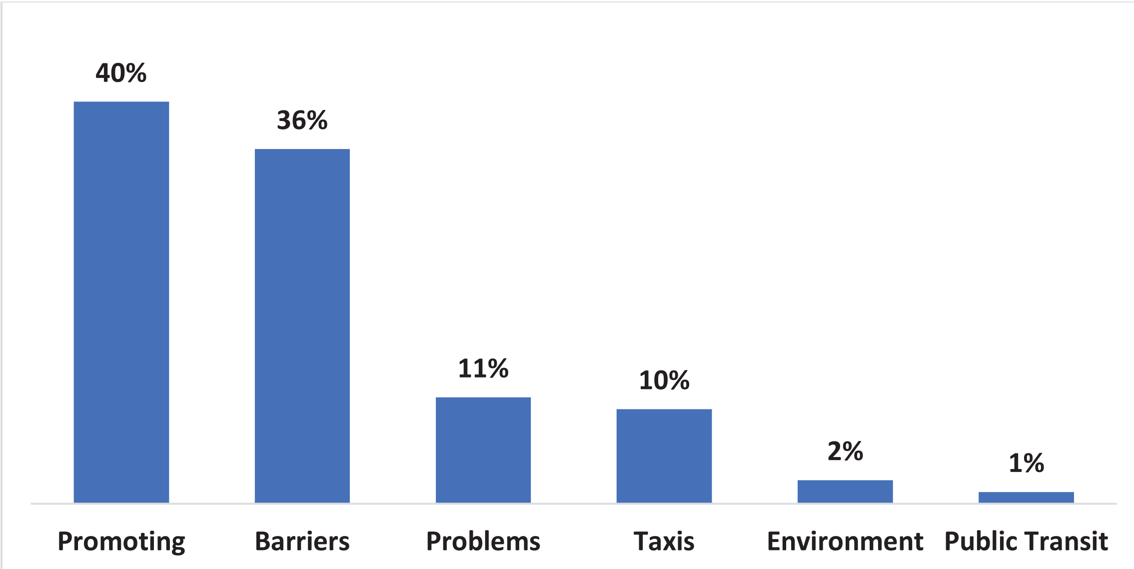

Figure 10 - Media Coverage coding results - Subjects
Source: Analysis by the author

The leading code in the media coverage analysis refers to news promoting ride-hailing with 40% of the classifications, followed by news citing barriers to the introduction of ride-hailing in BC. While items classified as “Problems” or “Taxis” had a similar share with 11% and 10%, respectively, “Environment” and “Public Transit” appear as the least cited subjects with only three citations in total, two for the “Environment” and only one for “Public Transit.”

Content Analysis: "Licence Application Decision" (LAD)

According to the Passenger Transportation Board (2020a: 2), the LAD is the instrument by which “in general terms, the Board has authority to make decisions on licence applications for passenger directed vehicles” or in other words, that may give passenger vehicle operators the necessary authorization to operate. These final licence decisions involve any commercial passenger vehicles, including ride-hailing companies, which the Board describes as transportation network services (TNS). Such authority is regulated by “section 7 of The Passenger Transportation Act, S.B.C. 2004, c. 39.”

The process to obtain a TNS licence involves an application for a TNS authorization, a public notice of the application, and a formal arrangement for receiving written submissions from any person about the application process (Passenger Transportation Board, 2020a). The Passenger Transportation Board may decide if these submissions will be written, electronic, oral hearing, or any eventual combination of those. Still, for the two first issued TNS LAD, granted for the applicants Uber Canada Inc. (Passenger Transportation Board, 2020a) and Lyft Canada Inc. (Passenger Transportation Board, 2020b) on January 23, 2020, only written submissions were accepted. The Board then assesses the application and all its related submissions and "the approval may be granted after the Board considers whether: (a) there is a public need for the services that the applicant proposes to provide under the special authorization; (b) the applicant is a fit and proper person to provide, and is capable of providing, those services; and (c) the application promotes sound economic conditions in the passenger transportation business in British Columbia" (Passenger Transportation Board, 2020a: 3, 2020b: 3). The LAD is organized into five main chapters: Introduction, Procedural Matters, Uber's application, Analysis and Findings, and finally Conclusion, followed by four additional Appendixes.

Despite the fact that both applications have exactly the same structure as detailed above, many other similarities are found in the application and decision processes of Uber and Lyft. Both companies applied on September 3, 2019, and the panel members responsible for the analysis were the same, "Catharine Read, Chair, Spencer Mikituk, Roger LeClerc" (Passenger Transportation Board, 2020a: 2, 2020b: 2), and so was the decision date on January 23, 2020. Moreover, all the submitters involving both processes were exactly the same: Abbotsford Taxi Ltd., Mission Taxi (1980) Ltd., Matsqui Taxi Ltd., Agassiz & Harrison Taxi Ltd., BCTA, Canadian Centre for Policy Alternatives, Chilliwack Taxi Ltd., City of Burnaby, City of Delta, City of Richmond, City of Surrey, Lyndon Enterprises Ltd., Progressive Intercultural Community Services, Prospective Drivers Group, Salmon Arm Taxi (178) Ltd., BC Federation of Labour ("BCFED"), Syd's Taxi et al, and VTA (Passenger Transportation Board, 2020a: 3, 2020b: 3). Additionally, the "background materials" described by the Passenger Transportation Board (2020a: 7, 2020b: 7) counts on precisely the same documents for both processes: "the 2018 TNC Report; the 2018 Hara Report; the 2019 TNS Report; and, the 2018 Hansard Debates relating to the Passenger Transportation Amendment Act."

The similarity of these processes is also recognized by the Passenger Transportation Board (2020a: 4, 2020b: 4), when they state that "many of the Submitters responded to a number of these applications globally rather than individually, with a focus on" Uber and Lyft. This global focus on both companies is well represented in the numbers. Uber's LAD comprises 33 pages and 127 paragraphs, while Lyft's LAD has 31 pages and 126 paragraphs. Summary and Conclusions of both LADs also had the same content, with differences only in the applicant names.

As both processes offered the same content in terms of discussions from submitters and also the same considerations from the panel members, I selected the longer LAD to develop my content analysis. Therefore, as Uber's LAD is slightly longer than Lyft's LAD, it was used as the only source of my analysis to represent how the Board has analysed the application and the considerations from all submitters before issuing the first two Licence Application Decisions in British Columbia on January 23, 2020.

The units of study and analysis defined for this content analysis are the paragraphs included in the source named "Licence Application Decision (Transportation Network Services - New)," application number TNS6988-19, Uber Canada Inc., issued on January 23, 2020, by the Passenger Transportation Board (Passenger Transportation Board, 2020a).

As previously explained, Uber's LAD comprised 33 pages and 127 paragraphs divided into five main chapters: Introduction, Procedural Matters, Uber's application, Analysis and Findings, and finally Conclusion, followed by four additional Appendixes which are not considered in these figures. As the three first topics were aimed to provide general information about the Passenger Transportation Board, licence process, dates, submitters, and the legislative framework, the sampling strategy was developed to focus only on item 4, *Analysis and Findings*. This is the most extensive chapter in the document, covering from page seven, starting on paragraph number 22, to page 32, ending on paragraph number 123. Such selection resulted in a sample of 102 paragraphs originally organized in three different questions: a) Is there a public need for the service that Uber proposes to provide under the special authorization?, b) Is the applicant a fit and proper person to provide that service and is the applicant capable of providing that service?, c) Would the application, if granted, promote sound economic conditions in the passenger transportation business in British Columbia? These three questions guided the discussions over the authorization of Uber, and consequently ride-hailing, for Region 1, defined by the Passenger Transportation Board as – Lower Mainland and Whistler (Passenger Transportation Board, 2020a).

This content analysis relies on the same methodology explained for the previous analysis, using “open coding” and “axial coding” methodologies (Babbie and Roberts, 2018:341). It also has the same macro analysis, defined by the groups “Core Messages” and “Subjects.” Each of these groups counts precisely on the same codes for both content analysis Media Coverage and Licence Application Decision, resulting in nine different codes applied to each of my units of analysis, as listed below:

Macro Analysis group: Core Messages

The group “core messages” is divided into three categories, starting with “Neutral,” when there is no message against or pro ride-railing in the paragraph. The second code is “Against,” which means that the paragraph contains any kind of negative perspective against Uber’s application. Finally, the last code of the “Core Messages” group is “Pro,” used to classify information promoting ride-hailing or the company Uber itself in support of Uber’s application.

The results included in Figure 11 show a good balance between the codes neutral, against, and pro ride-hailing in the LAD document, with a slight advantage for codes against ride-hailing.

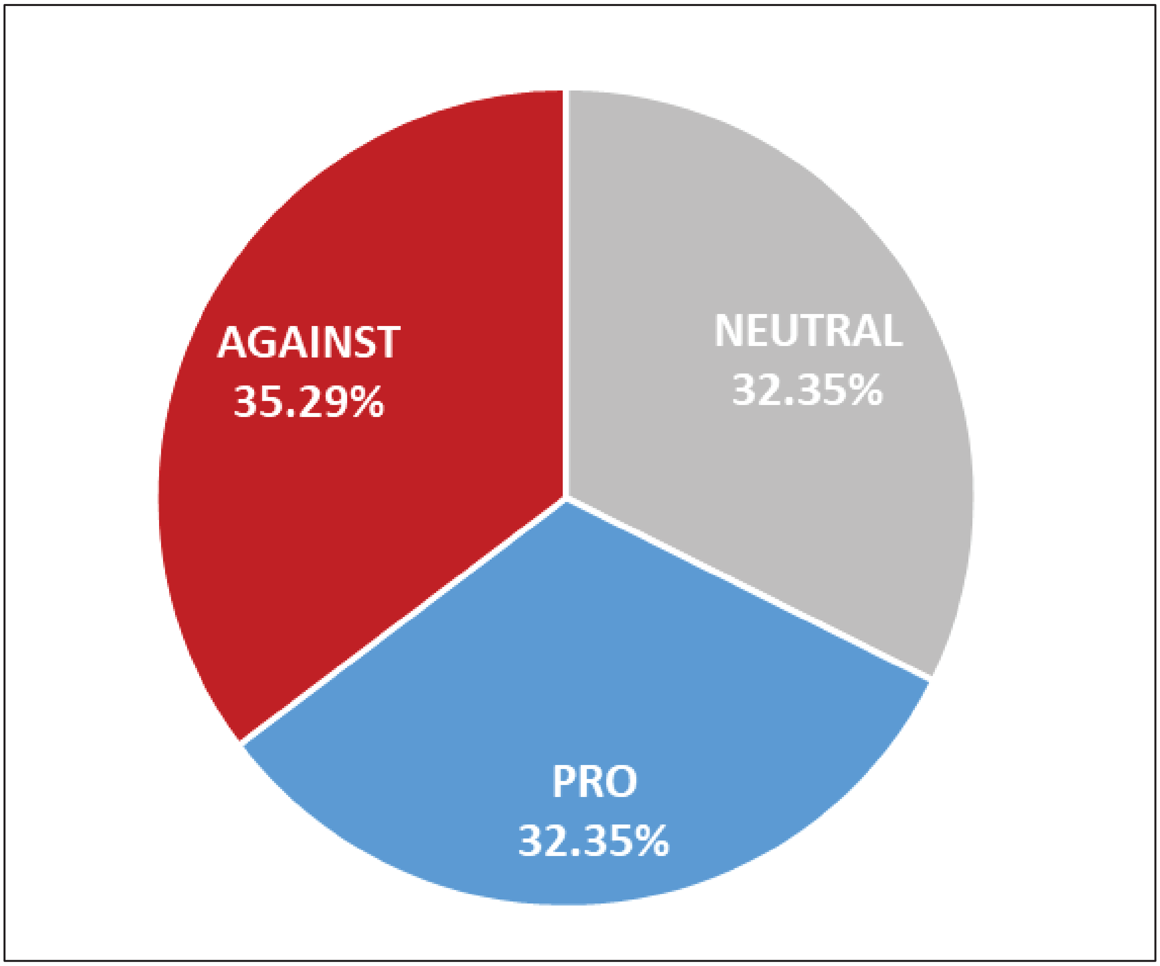

Figure 11 - Content Analysis - Core Messages codes LAD document
Source: Calculated by the author

The remaining six codes used in the macro analysis group named "Subject" follow the same pattern found in Table 12, adapted to the current unit of analysis (paragraphs) as listed in Table 13 below.

Table 13 - Coding for the content analysis of the LAD document

Code	Definition
Taxis	Information related to taxis in general. Including taxi versus ride-hailing, economic and operational losses, regulations, risks, studies, research, etc.
Problems	Paragraphs containing information about operational or safety issues of ride-hailing, like data breaches, safety, privacy concerns, driver behavior, wages, congestion, accidents, and others.
Promoting	Paragraphs supportive of ride-hailing, stressing its qualities, or just giving general positive information about ride-hailing.
Barriers	This group covers information related to obstacles to increase ride-hailing such as congestion fees, drivers and vehicles' requirements, registrations, fleet limitations, etc.
Environment	Paragraphs with information covering issues related to greenhouse gas emissions or other types of pollution.
Public Transit	Information related to public transit, discussing the relationship or interactions between Public Transit and ride-hailing

The content analysis of the LAD document resulted in 223 classifications (average of 2,2 per paragraph) divided into the “Subjects” group, which contains the codes listed in Table 13, plus the three codes included in the “Core messages” group described above. The different magnitudes in sample sizes from both content analyses are explained by the usage of sources that are not essentially connected and the differences in the unit of analysis.

The figures consolidated in Figure 12 point to a different distribution compared to the media coverage analysis as further detailed in the Analysis topic ahead.

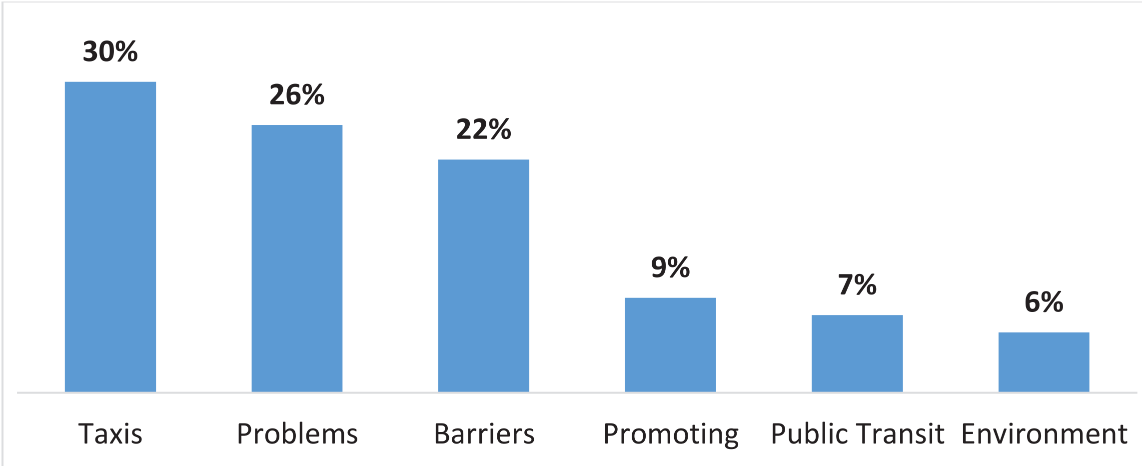

Figure 12 - Content Analysis – Subjects – LAD document
Source: Calculated by the author

Analysis

Due to the current discussions around ride-hailing, as discussed in chapter 2, I expected that the content analysis of the media coverage could show more of the discussions about ride-hailing externalities, including risks and benefits, and more analysis of the proposed policies and regulations in comparison to ST modes and especially the environment. Based on these expectations, I also believed that I would find a different scenario for the "Core Messages" group, with a small difference between articles pro and against ride-hailing. Still, the fact is that the media coverage content analysis, represented by the "core messages" group included in Figure 9, shows that the vast majority of the news articles assessed in our sample were pro ride-hailing with 77% of the total, while only 13% were against and 10% were neutral with general information about the process, without a clear positive or negative association.

The results of codes included in the 'Subjects" group followed the same direction, with articles that intended only to promote ride-hailing or to talk about the barriers that the regulation has created for ride-hailing operations in BC, without further considerations of possible implications of such removing such barriers. This conclusion was evidenced in Figure 10 with the analysis of the "Subjects" group, where these two items (pro ride-hailing and barriers against ride-hailing), when combined, comprise 76% of all the news articles, aligned with the information obtained from the "Core Messages group." The analysis of the remaining codes resulted in only 11% of the codes classified as problems, defined by articles discussing general ride-hailing operational and safety problems. Figure 10 also shows that media coverage demonstrated a few expositions of questions related to the environment with only two news articles or 2% of the total, and only one mention to Public Transit, 1% of the total. Issues related to the taxi industry and their continuous struggle against ride-hailing similarly had few cases in the media with 10% of the total. My interpretation is that based on the news articles within the established timeframe, the media coverage offered important support for the ride-hailing business with dominant positive information about the service and about the public need for ride-hailing, underestimating its social, economic, and environmental sustainability problems.

Such massive support may impact public opinion and put extra pressure on policymakers, like the findings included in the work of Shanahan *et al.* (2008: 131). The authors assessed the role of media in policy change by the analysis of print media coverage and concluded that media works as a contributor in the policy change process by “framing strategies that are consistent with the expected policy orientation associated with their advocacy coalition.” Similarly, Wolfe *et al.* (2013: 176) argue that the “effect of the media in highlighting aspects of political issues” are “pervasive” and should not be ignored.

The relationship of media, public opinion, and policy change related to ride-hailing approval in Vancouver may have the same association found in the work of Baum and Potter (2008) about their study of mass media, public opinion, and foreign policy. The authors placed mass media as a “strategic actor” playing a “critical role” in framing public opinion and influencing foreign policy. In his comprehensive review of public opinion's impact on public policy, Burstein (2003: 29) comes to the same conclusion, arguing that public opinion has a strong influence on policy most of the time.

As demonstrated in Figure 12, the procedures involving the LAD document had a good balance in terms of information that was pro ride-hailing, which represented 32.35% of the total, with evidence against ride-hailing, with 35.29%. Additionally, another 32.35% of the paragraphs were considered as Neutral. Each code had a share of about 1/3, with a small advantage of paragraphs against ride-hailing. This distribution is very different from the dominance of pro ride-hailing results observed in the media coverage content analysis, as demonstrated in the comparison included in Figure 13.

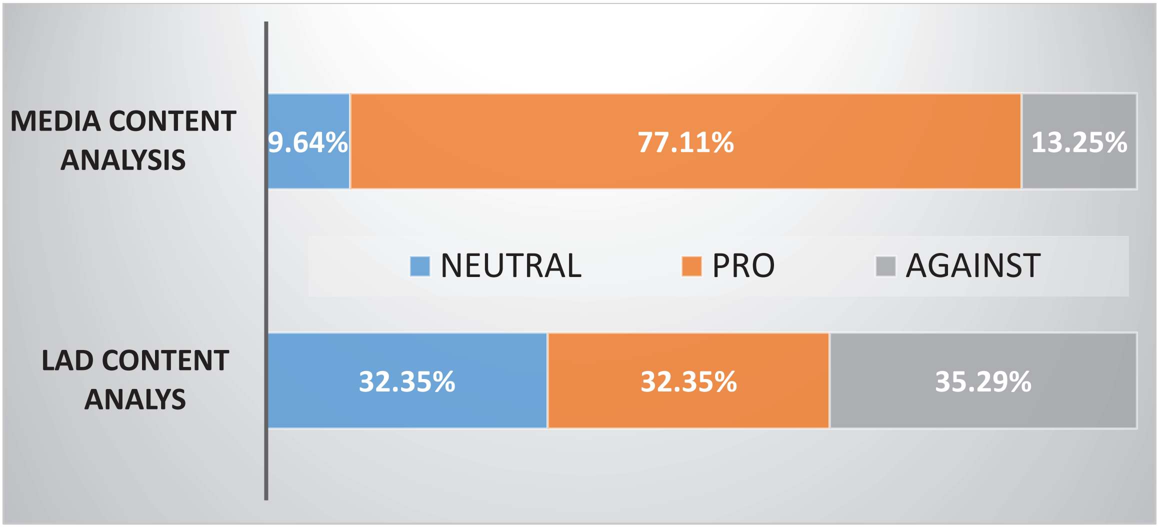

Figure 13 - Core Messages codes comparative
Source: Calculated by the author

The results of the "Subjects" coding groups from the LAD content analysis, displayed in Figure 12, also presented a different distribution and a more diverse range of discussions, with taxis as a leading topic accounting for 30% of the total, followed by paragraphs concerned with ride-hailing problems with 26% and then barriers to ride-hailing operations, like fleet size, drivers and vehicles' requirements reaching 22%, 9% of the paragraphs had information to promote ride-hailing, mostly offered by the applicant (Uber). As a negative aspect, discussions about environmental issues and the relationship between Public Transit and ride-hailing occupied only 7% and 6% of the paragraphs, respectively, which could be explained by the lack of submitters from associations representing both subjects in the LAD application process as explained in the section Content Analysis: "Licence Application Decision" (LAD) above.

Another possible explanation for the low levels of discussion about Environment and Public Transit may reside in the low media exposition of both codes as demonstrated in the Media Coverage content analysis, where both combined were considered in only three out of 84 articles. Despite the general associations between public opinion, media coverage, and policy, as discussed earlier in this section, Lesteven and Godillon (2020) offered a specialized perspective of media influence in policy during Uber's arrival in Paris and Montreal. The authors used an approach similar to my research, using press media content analysis to identify the relationship between public opinion and ride-hailing policy. They found a convergence between media and policy agenda and concluded that both cities had extensive media coverage, which helped shape public opinion and political responses to Uber's arrival. The differences between the LAD content analysis and the Media content analysis can be observed in Figure 14. While the biggest difference resides in the "Promoting" code, where media reached 40% against 9% in the LAD, the smallest differences are found in the codes Public Transit and Environment, which had the lowest representation in both analyses.

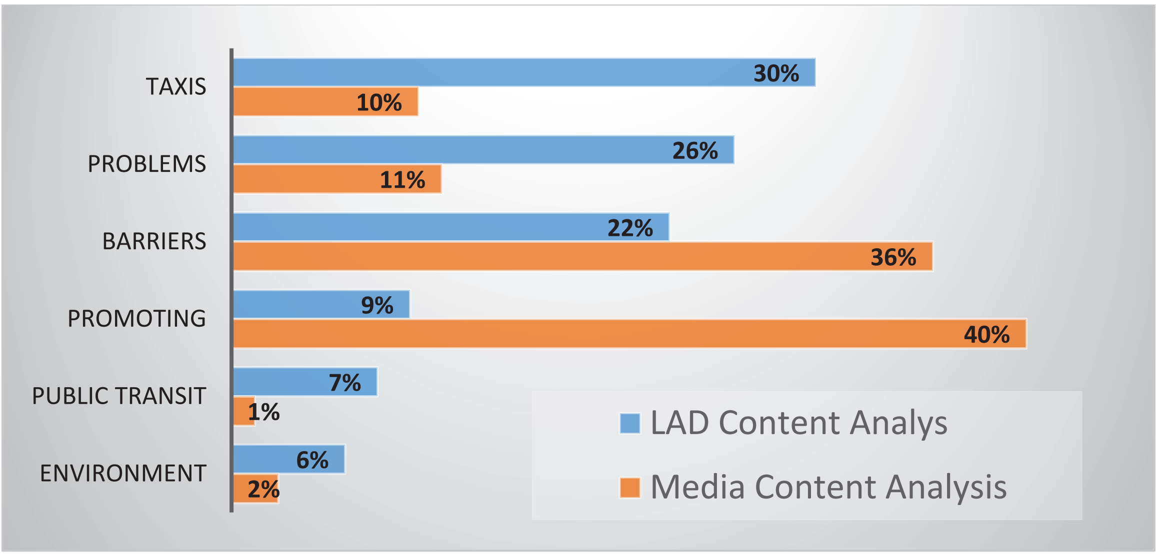

Figure 14 - Subjects codes comparative
Source: Calculated by the author

Nevertheless, the total absence of public transit associations or representatives as submitters in the LAD process appears intriguing. After all, it was such a crucial decision about a new transportation mode that was about to enter the marketing and could eventually disrupt urban transportation in the city. The reason behind this absence may also be linked to a former agreement from the local transportation agency, as found in the public statement below. Two months before ride-hailing approval, still within the deadline for Submissions in the LAD process, the TransLink CEO, Mr. Kevin Desmond, supported the provincial regulatory framework in the face of future interactions between ride-hailing and public transit in the city (Bernardo, 2019).

> "The regulatory framework the province has put in place is a wise framework. We benefit from going last because we are able to see what happened in other cities where it started without any kind of regulatory environment." (Bernardo, 2019)

However, a few months earlier, in January 2019, during his presentation in the province's select committee, Mr. Desmond declared that ride-hailing companies could only perform as a complement of transit if there is a pricing mechanism in place forcing such connection and also suggested the implementation of fees to "discourage trips that seem to be cannibalizing transit services, such as short trips only in the downtown area" (Bula, 2019).

After the end of the topic *Analysis and Findings* in the LAD document, there are only four more paragraphs. Two of them belong to the sub-section *Summary*, which is still part of *Analysis and Findings* but was not considered in the assessment as it is just an interpretation of the previous paragraphs, and finally, another two paragraphs that encapsulate the very concise *Conclusion* of the LAD document.

While the *Conclusion* paragraphs of the LAD document only state that the board approves Uber's application without any further explanation and then refers to the rules described in the Appendices, the *Summary* section clearly demonstrates the board's view of all the pieces of evidence and information presented by the applicant and submitters. By saying that "Many of the factors identified by various Submitters opposing Uber's Application are overlapping and largely based on experience with TNS generally or Uber specifically in other jurisdictions" (Passenger Transportation Board, 2020a: 32), the board ignores that the main negative externalities related to ride-hailing do overlap between different modes and sectors of society with different burdens among them. Pollution, congestion, increase in traffic, and economic losses can affect us all in different ways and scales, from ordinary citizens, neighborhoods, public transit, and the taxi industry, to cite a few.

Reliability and Validity

Even considering that I used trusted and official information sources, the analysis and classifications presented in this content analysis represent my personal interpretation of the language and information included in my samples. Therefore, the work presented might be influenced by a subjectivity and interpretation bias as discussed by Hammersley and Gomm (1997), where the researcher is the research instrument and will interpret the events based on his own perspective. To avoid and minimize such biases, I engaged in the concepts of reflexivity, which, as explained by Probst (2015), could be defined as the awareness of the influence that the researcher has on the topic being studied. From the perspective of the research conducted here, I used tables and clear definitions for the codes to make their definition as less subjective as possible.

4.5.2. Policy framework part II: Regulations

As described earlier, the policy framework analysis aims to identify how policies and regulations in Vancouver interact with the four main clusters defined in the work of Joshi *et al.* (2019). In other words, ride-hailing information in Vancouver will be compared with the findings included in the analysis developed in the work of Joshi *et al.* (2019). Their analysis relies on the assessment of the following 13 international cities in the clusters detailed below: New York City, Toronto, Chicago, Los Angeles and San Francisco, Mexico City, São Paulo, London, Moscow, Accra, Beijing, Mumbai, and Melbourne.

The work of Joshi *et al.* (2019), detailed at the end of section 2.3, is segmented into four topics discussed for each of the 13 cities listed above. The first one is *Data*, mainly focused on how cities collect data about trips, cars, drivers, and ride-hailing operations in general. The second topic is *Service Standards* and considers operational regulations over drivers, cars, or the service itself, to understand how cities are implementing measures to increase safety and comfort. The third, *Environment*, covers requirements set in order to regulate and mitigate GHG emissions related to ride-hailing. Finally, *Economics*, as the fourth topic, details regulations based on taxes over ride-hailing operations aiming to increase revenues destined to different areas such as infrastructure and public transit, among others, or those dedicated to regulate prices or drivers' pay.

The parameters used to assess Vancouver policies and regulations in relation to the cities mentioned above are based on a segmentation of each cluster in macro topics, followed by their classification according to a three-point scale designed to evaluate coverage, significance, and reduce subjectivity as explained in Table 14 below.

Table 14 - Classification criteria for policy assessment in Vancouver

Level	Denomination	Criteria
0	No provision	Meaning that Vancouver has no provision at all to cover this macro topic
1	Basic provision	It means that Vancouver has considered this macro topic in its policy and framework regulations but lack significant improvements when compared to the benchmark cities listed in Joshi *et al.* (2019)
2	Benchmark	The city has the same or higher standards for this macro topic when compared to the benchmark cities listed in Joshi *et al.* (2019)

A total of 13 macro topics were defined aiming to capture the essence of the main aspects discussed in each cluster according to my interpretation of the content available in Joshi *et al.* (2019). The list of macro topics is detailed below. They were individually assessed and further explained at the end of each cluster's discussion, and a condensed view is offered at the end of this section.

A) Data: operational data, financial data, and open data.

B) Service Standards: vehicles' requirements, drivers' requirements, and accessibility requirements.

C) Environment: vehicles' requirements, corporation's requirements, and environmental fees, or incentives.

D) Economics: regular government taxes, licence fees, congestion fees, and Infrastructure funding

Data

Ride-hailing data requirements are detailed in Appendix 3 of the LAD document. The range of required data presents an interesting variety of information, including data about the company, trip, driver, and vehicle, covering interesting topics such as the driver's shift, waiting times, pickup and drop-off geo-location, the total cost of a trip, and trip status among others. There is no provision in Appendix 3 related to how the collected data will be used or if such data will be open to public inspection. In Appendix 1 - Terms and Conditions, there is a mention that data should be sent to the Registrar or the Passenger Transportation Board.

> "The licensee must provide to the Registrar any information, including personal information, and data that the Registrar or Board may require, and as may be set in any applicable supplemental terms and conditions and orders of the Registrar or Board, within time periods that the Registrar or Board may require, which may include, without limitation, information and data set out in section 28(5) (a) to (c) of the Passenger Transportation Act." (Passenger Transportation Board, 2020a: 34)

Some parts of the LAD document suggest that all collected data will be stored and analysed by the Passenger Transportation Board in order to get a clear picture of the TNS (ride-hailing) influence over items such as supply and demand, minimum rates, public transit ridership, congestion, and fleet size (Passenger Transportation Board, 2020a). It is also stated that "The Board will also engage in discussions about that data with TransLink and B.C. Transit on a regular basis" (Passenger Transportation Board, 2020a: 28), indicating that Translink might have access to the collected data.

Interestingly, the only mention in the LAD document about the possibility of making data public is about drivers' earning and working hours, a set of data that is not required in Appendix 3 – Data Requirements. Such mention is included in the subtopic named "Treatment of TNS Drivers" and states the following:

> "The Board will require Uber, as a term and condition of its licence, to provide quarterly information on drivers' earnings and hours in a format prescribed by the Board. The Board can publish this information. If data shows that earnings are low, the Board can consider whether rate or fleet change measures should be taken" (Passenger Transportation Board, 2020a: 31).

By not making ride-hailing data public, the Passenger Transportation Board goes against the recommendation included in one of their background materials, as described in the LAD document. When discussing if the applicant will promote sound economic conditions in the passenger transportation business in British Columbia, the Passenger Transportation board discuss the absence of data in general and notes that the 2019 TNS Report, which is one of their background materials, “recommends collecting and sharing data on TNS to ensure that accurate information is available for the purpose of assessing and managing the industry and for informing any future regulatory adjustments” (Passenger Transportation Board, 2020a: 18).

Data transparency would be leveraged if precise information about TNS data requirements, mainly those periodically collected, were laid down in section V of Appendix 3 – Data Requirements. The fact that some of the data classified as required along the LAD document, like drivers’ earnings and working hours, is not included in Appendix 3 – Data Requirements, leaves room for discussions about its collection, format, and availability. Such data would play an important role in studying the relationship between public fares and drivers' earnings to ensure, or at least understand, the economic balance between company income and driver earnings, as discussed in the LAD document.

Even with a good dataset, some important topics are missing in Appendix 3, especially concerning information about single, shared or pooled rides. Such data could be valuable information as this can directly influence public policies related to transportation and the environment, as well as public transportation planning. Additionally, crash reports and problems reported about drivers could provide new information regarding the safety of passengers and the whole service. However, I understand that the most critical aspects of the data requirements reside in two factors that were somehow put aside in the data requirements and regulations. First, all the information listed in Appendix 3 must be delivered to the Passenger Transportation Board, without any mention of making it accessible to cities or the general public, as discussed earlier (Passenger Transportation Board, 2020a). Such a lack of regulatory data in the cities may create barriers to future open-data initiatives and delay eventual planning strategies relying upon such data, even considering that municipalities from the lower mainland are requesting such data to provide the regional ride-hailing business licence (Saltman, 2020).

As a consequence, the second aspect is the “lack of transparency” regarding ride-hailing data. As one of the latest global cities to regulate the service, there is no public data about ride-hailing available in Vancouver. Examples described in Joshi *et al.* (2019) show New York and Chicago to be leading cities in terms of ride-hailing public open-data, and Toronto, as a Canadian example of a more comprehensive data collection, and also public information through Toronto’s Big Data Innovation Team, designed to be used by public agents in planning and policymaking activities. Transportation data's transparency and availability seem to be in limited supply for the three most populated urban regions in Canada, Montreal, Toronto, and Vancouver, as described by Perl *et al.* (2020). Even with a recent ride-hailing data regulation, Vancouver's lack of transparency over ride-hailing information follows a familiar pattern. The absence of public data discussed in section 2.2 is a typical trace of ride-hailing operations worldwide, as identified by many authors (Henao and Marshall, 2019a; Feigon and Murphy, 2016; Clewlow and Mishra, 2017; Watkins *et al.*, 2019; Tirachini and Gomez-Lobo, 2020; Ngo, 2015; Gehrke *et al.*, 2019; Acheampong *et al.*, 2020).

A summary with the level assessment of each of the data macro topics discussed above is included in Table 15 below.

Table 15 - Data – Vancouver Level Assessment

Macro Topic	Level Assessment	Observation
Operational data	1 = Basic provision	Missing info: single, shared, or pooled rides, accidents, and problems reported about drivers
Financial data	1 = Basic provision	Missing info: driving earnings per trip
Open data	0 = No provision	No public data available

Service Standards

The service requirements applied to the qualification of drivers and vehicles in Vancouver found on Bill 55 (2018) and summarised by the Government of British

Columbia (2021a) on its website, are compatible with the best practices listed in the cases studied by Joshi *et al.* (2019), like Chicago, New York, and Toronto. To be eligible to drive a passenger directed vehicle, which is how a ride-hailing car is defined on Bill 55 (2019), a BC driver must have a commercial driver's license, two years of experience as a non-learner driver, a driving record and police background check. This set of driver's requirements places the city as the most restrictive in this matter when compared to the cities assessed by Joshi *et al.* (2019). Vehicles must be less than ten years old, carry commercial insurance, pass an annual inspection, or semi-annual if less than 40,000 km were driven in the previous year. Additionally, while in operation, all the vehicles must clearly display an identification of the ride-hailing company to be visible for incoming passengers. As another interesting service requirement, ride-hailing companies in Vancouver must comply with several requirements related to their app, including but not limited to data safety, app functions and features, languages, accessibility standards, pre-ride fare and general information, information records, and payment options.

While drivers and vehicles' qualification offers a reasonable set of requirements, the operational service standards still present room for improvement. Examples from Joshi *et al.* (2019), such as New York, Chicago, Los Angeles, and San Francisco, show growing concern over controlling the drivers' working hours to avoid the point of fatigue, and as a consequence, increase safety by controlling and capping daily or weekly working hours even if a driver works for more than one ride-hailing company.

Some gaps in the accessibility strategy appear as another considerable problem of the current ride-hailing service standards. Vancouver provides an incentive for wheelchair accessible vehicles in their license and operating fees. According to the information included in the BY-LAWs numbers 12556 and 12648, these vehicles do not pay the annual license and neither the CCMP - Congestion and Curbside Management Permit, but, on the other hand, there is no requirement of minimum fleet or passenger waiting times for wheelchair accessible vehicles. As there is no control over the trips payment division between companies and drivers, it is hard to understand how the accessibility incentive of the operational fees, represented by the CCMP discounts, are located and how representative they are in moving towards a more accessible fleet. Both fees mentioned here will be detailed later in the *Economics* section. The level assessment summary of each of the Service Standards macro topics discussed above is included in Table 16 below.

Table 16 - Service Standards – Vancouver Level Assessment

Macro Topic	Level Assessment	Observation
Vehicles' requirements	2 = Benchmark	Same technical qualifiers found in other cities with minor variations in vehicles' age and inspections periodicity
Drivers' requirements	2 = Benchmark	Requiring a commercial driver licence restricts the number of drivers and offers more quality
Accessibility requirements	0 = No provision	No requirements for wheelchair accessible vehicles or minimum waiting times

Environment

In early 2019, the City of Vancouver released the Policy Report number 12938, aiming to confirm their regulatory principles related to ride-hailing (City of Vancouver, 2019a). Such regulatory principles are divided into the following list: 1. Regional coordination of service, 2. Passenger safety, 3. Enhanced mobility, 4. Enhanced accessibility, 5. Reduced carbon emissions, and 6. Economic viability. The report discusses how the legislative changes included in Bill 55 (2018), which changes the Vancouver Charter, preventing British Columbia cities from regulating the number of ride-hailing cars, companies, and rates, could impact the regulatory principles. Environmental concerns are addressed on principle five, "Reduced carbon emission," designed as an ambitious and clear goal to mitigate the potential environmental negative externalities associated with ride-hailing.

The consequences are further detailed in Policy Report number 12922 (City of Vancouver, 2019 b:9), which states that Bill 55 (2018) has "no provisions to promote zero or low emission vehicles" for ride-hailing in Vancouver. Moreover, it clarifies that the Vancouver Charter changes now prohibit the City from setting vehicle requirements or imposing the use of zero-emission vehicles, restraining the range of applicable measures in order to pursue the regulatory principles detailed in the previous report.

Therefore, the approach used by the city consisted in both, first the confidence that ride-hailing companies will provide effective programs to encourage drivers towards low or zero-emission vehicles (City of Vancouver, 2019), and second, a discount combo including a reduction in the annual inter-municipal fee per vehicle from $150 to $30, as described in the BY-LAW number 12648[4], plus 50% off the CCMP - Congestion and Curbside Management Permit for ride-hailing Vehicles, detailed in the BY-LAW 12556[5]. However, one may question both incentives' efficacy because they are not financially significant even when combined. For example, the savings projection of both fees for a hypothetical vehicle with 2,000 yearly rides with 50% of them inside the metro core (where the CCMP is applicable for both pick-up and drop-off) would represent monthly savings of about CAD 35.00. It's worth mention that zero-emission vehicles do cause congestion exactly like all other vehicles. Thus, a reduction in the CCMP is questionable as there are no concrete gains attached to the core purpose of this fee.

Such a sparse framework places Vancouver as one of the least prepared cities to face environmental ride-hailing challenges when compared to the set of cities included in Joshi *et al.* (2019). Out of 13 cities listed in their work, only Chicago in the US, Moscow in Russia, and Accra in Ghana didn't have specific ride-hailing environmental regulations in place or under development. Most of the best examples include one or more of the following actions: dedicated environmental fees, requirements for low or zero-emission vehicles, substantive financial incentives, protection to sustainable transportation modes, and goals of progressive savings of GHG emissions for ride-hailing companies.

The best way to summarize how the environmental policy framework of ride-hailing in Vancouver can be described is found in Newman *et al.* (2013). In their assessment of climate change and transportation policy paradigms in Canada, the authors argue that "Transportation policy options in Canada are developed to advance goals of improving market competition, increasing private carrier revenues, and decreasing government intervention" (Newman *et al.,* 2013:25). As concluded by the City of Vancouver (2019b:9) itself, the environmental regulatory principle was

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[4] BY-LAW NO. 12648. A By-law to enter into an agreement among the Participating Municipalities regarding an Inter-municipal Transportation Network Services Business Licence Scheme. Enacted on February 26, 2020

[5] BY-LAW NO. 12556. A By-law to amend Street and Traffic By-law No. 2849 regarding Transportation Network Services. Enacted on October 2, 2019;

compromised after Bill 55 (2018). The media coverage content analysis presented earlier may be the connection between loose ends, the lack of ride-hailing environmental regulations, and public convenience and necessity claims. The level assessment of the environmental macro topics is presented in Table 17 below.

Table 17 - Environment – Vancouver Level Assessment

Macro Topic	Level Assessment	Observation
Vehicles' requirements	0 = No provision	There are no requirements for a minimum share of zero-emission vehicles
Companies' requirements	0 = No provision	Requiring a commercial driver licence restricts the number of drivers and offers more quality
Environmental fees or incentives	1 = Basic provision	There are provisions of incentives for zero-emission vehicles, but they are not financially relevant

Economics

Ride-hailing trips in Vancouver and all British Columbia cities do not pay provincial taxes (British Columbia, 2021b). Still, according to the Canada Revenue Agency (Government of Canada, 2021), they are subject to a 5% federal Goods and Services Tax (GST). As an option, costs and expenses like fuel, maintenance, insurance, cell phone, tolls, parking, and sales charges in general, can be deducted from the GST using input tax credits, or if the "Quick Method of Accounting for GST" is used, the rate is automatically reduced to 3.6% (Government of Canada, 2021).

At the provincial level, the Passenger Transportation Board (2020a: 37) implemented price control over the minimum ride-hailing rates per trip in Vancouver, fixing it at CAD 3.35, which is basically balanced to the taxi industry rates. Whether such a measure will produce a balance between ride-hailing and other transportation modes is, however, to say the least, very challenging considering that this is the only price control included in the regulations. In other words, companies are free to establish aggressive pricing policies if they want to do so, as long as they preserve the minimum rate. The Passenger Transportation Board actually notes that this lack of price regulation, represented by the dynamic pricing or surge pricing, is important for ride-hailing companies and that this can benefit market competition, as detailed below:

> "The Board concludes that allowing Uber to charge flexible rates and use dynamic pricing will encourage healthy competition in the passenger transportation industry and promote sound economic conditions in this province" (Passenger Transportation Board, 2020a: 23)

The LAD document shows a discussion about dynamic prices where some submitters claimed such practice to be discriminatory (Passenger Transportation Board, 2020a: 22). The Passenger Transportation Board did not accept such claim, arguing that "the price of countless goods and services are dictated by market conditions," and later states that "those who are unwilling or incapable of paying the surge prices will still have the option of using taxis or public transit" (Passenger Transportation Board, 2020a: 23).

The changes in the Vancouver Charter, in particular those represented by the "restrictions on local government jurisdiction" included in Bill 55 (2018: 34), left the city with only two regulatory conditions in which the city could try to accommodate the regulatory principles, as long as these measures would not restrict a provincially licensed company or vehicle from operating in the City as explained by the City of Vancouver (2019b). The first addresses licence requirements, named "licence companies and vehicles," and the second is defined as "manage street use and traffic."

As part of their first responsibility, the licence fees defined by the city consist of two annual fees, described in both BY-LAWs numbers 12648 and 12649[6]. One licence is designed for ride-hailing companies, and the other one is for ride-hailing vehicles. Companies will pay an annual licence fee of CAD 155 and an annual per-vehicle fee of CAD 150. As mentioned in the previous section, wheelchair accessible vehicles do not pay the annual per-vehicle fee, while zero-emission vehicles pay an annual per-vehicle fee of CAD 30.

For the second item, "manage street use and traffic," the city designed the Congestion and Curbside Management Permit (CCMP), which is regulated by the BY-LAW number 12556, which is a By-law to amend the Street and Traffic By-law No. 2849

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[6] BY-LAW NO. 12649. A By-law to enter into an Inter-municipal TNS Business Licence Scheme, Enacted on February 26, 2020

regarding Transportation Network Services, enacted on October 2, 2019. The CCMP consists of a fee to access any curbside for pick-up or drop-off within the Vancouver Metro Core between 7 AM and 7 PM, aiming to regulate the demand for vehicle-based transportation and mitigate the negative externalities related to ride-hailing during this already congested area (City of Vancouver, 2019b).

The conditions included in BY-LAW 12556 stipulated a cost of CAD 0.30 per pick-up or drop-off within the Vancouver Metro Core, which is the area bounded by Burrard Street, 16th Avenue, Clark Avenue, and the Burrard Inlet. Additionally, the BY-LAW also establishes 50% and 100% discounts provided to zero-emission vehicles and wheelchair accessible vehicles, respectively.

The financial impacts of ride-hailing in the city of Vancouver, and in the province of British Columbia, in general, are part of a complex puzzle, which will depend on the number of ride-hailing trips, fleet composition, labor wages, variations in the VKT (vehicle-kilometer-traveled) and modal substitution, as discussed in chapter 2, among other factors. So far, there is no public data available about ride-hailing operations in Vancouver. However, the way in which policies and regulations were designed, from the financial perspective, seem really able to increase market competition and decrease government intervention. A consideration here concerns the burdens of ride-hailing. The negative externalities such as congestion, pollution, infrastructure usage, economic imbalance, and accidents will be present in different ways and intensities. The economic framework assessed here shows that currently, the city and the province do not have enough additional provisions to deal with such externalities now or in the future if current regulations are kept and ride-hailing becomes widely adopted in the city. Such provisions would prioritize regulations where ride-hailing could be destined to fulfill the gaps of the current transportation system in an integrated approach by protecting the environment and avoiding both modal substitution and an increase in VKT.

Joshi *et al.* (2019) mention that seven out of 13 cities included in their work are raising revenues from ride-hailing to be used for purposes like infrastructure maintenance (roads and curbs), investing in climate change related incentives, stimulating pooled trips, reducing congestion, and promoting sustainable transportation modes, especially public transit. Unfortunately, none of the fees included in Vancouver's regulations seem to have the potential to address any of these public investment options effectively.

As discussed earlier, high adoption rates of ride-hailing in Vancouver may represent a threat to adapt the current set of policies and regulations in the city if such demand exists in the future. On the other hand, the start of ride-hailing in Vancouver may also represent an opportunity as the city, or the Passenger Transportation Board, will have enough data to understand the real externalities produced by ride-hailing in the city, offering an opportunity to improve the current set of policies and regulations. Table 18 presents the level assessment of the economic “macro topics” considering the discussions presented above.

Table 18 - Economics – Vancouver Level Assessment

Macro Topic	Level Assessment	Observation
Regular government taxes	1 = Basic provision	Federal taxes are applied, no provincial nor municipal taxes
Licence fees	2 = Benchmark	The city requires licences fees for companies and also per vehicle
Congestion fees	1 = Basic provision	The CCMP, 0.30 per pick-up or drop-off, is in place with discounts of 50% for zero-emission vehicles and 100% for accessible vehicles. Low financial impact.
Infrastructure funding	0 = No provision	Fees to improve road infrastructure, ST infrastructure, or infrastructure to promote zero-emission vehicles are not considered in the current policies.

Considering the numeric representation from zero to two of each of the macro topics assessed in the clusters Data, Service Standards, Environment, and Economics, the final average of policy assessment in Vancouver comes to 0.8, wherein my scale, defined at the beginning of this section, zero means that individually Vancouver has no provision of policies or regulations, one means that the city has basic provisions, and two places the city in the benchmark group. Figure 15 offers a visual representation of the assessment developed for the clusters extracted from Joshi *et al.* (2019) and the macro topics defined based on my interpretation of the core concepts included in each cluster.

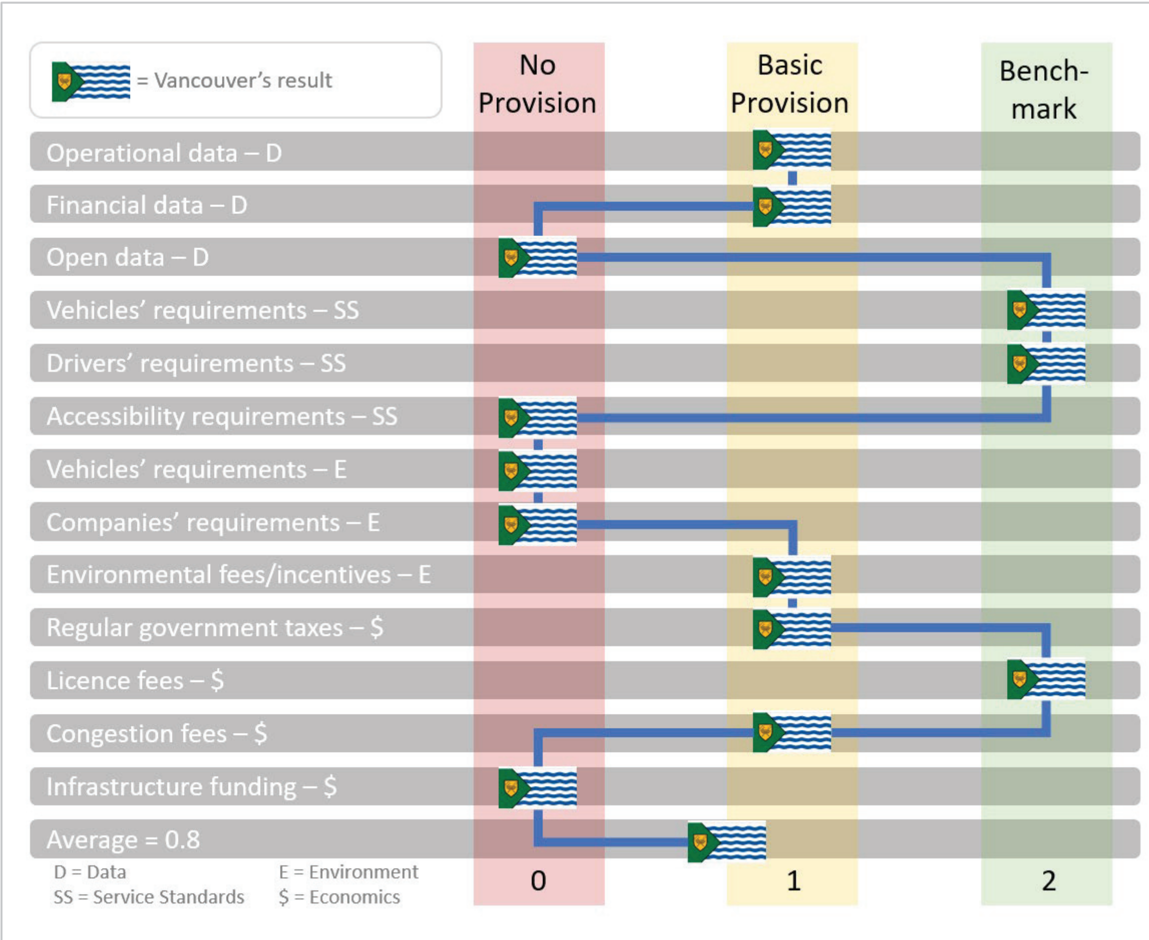

Figure 15 - Graphic representation of Vancouver's policy assessment

The compilation of all policy assessments presented in Figure 15 shows a regulatory framework with an average below basic provisions. About 40% of the macro topics discussed in this section, represented by the topics environmental requirements for vehicles, environmental requirements for companies, accessibility requirements, open data, and infrastructure funding, are not included in the current regulatory framework. The same share of topics, represented by operational data, financial data, environmental incentives, regular government taxes, and congestion fees, is classified as basic provision, meaning considerable room for improvement. The benchmark group is populated by the remaining three macro topics, vehicles requirements for service standards, drivers' requirements for service standards, and licence fees. The comparative distribution found in Figure 15 indicates that the current regulatory framework focuses more on enabling and leveraging ride-hailing instead of promoting a comprehensive set of regulations to prevent the negative ride-hailing externalities discussed in section 2.2.

4.6. NSTP as a component of ride-hailing policies

The analysis of the NSTP supports the exploration of my research question by adding a new perspective of how each neighborhood can be individually affected by ride-hailing trips. Under such a perspective, my research analyses the ST modes' risk in the face of the current transportation policies and regulations.

Before delving into details of the NSTP indicator in Vancouver, it is worth noting as a comparative exercise, the main effects on Sustainable Transportation modes observed in other jurisdictions, as displayed in Table 19. Such comparison was summarized using information from the literature review presented in chapter 2.

The information displayed in Table 19 is organized by alphabetical order using the column "country" followed by "city or state." It contains 19 different studies with data regarding the ride-hailing modal substitution effect of one or more ST modes. The number of cities assessed in each individual study varies from a mono-city analysis to studies based on country-level databases. Whenever possible, the number of geographies included in each assessment is noted in the column "city or state." The sample listed in Table 19 covers information from ten different countries, divided into ten multiple-cities studies and nine focused only on one or two cities. Among the studies included in Table 19 that offered actual figures of modal substitution rates, a heterogeneous pattern is found with results ranging from 15.2% to 62%. Sao Paolo with 62%, Boston with 59%, and Toronto with 49% lead the highest rates of modal substitution among the single city studies. On the other extreme, Delhi, in India, presents the lowest rate, between 15.2% and 20.3%, but considers only one transportation mode, the Delhi Metro. From the comparisons based on the whole public transportation system or ST modes in general in single cities, Tehran, in Iran, with 23.2%, leads as the lowest substitution rate for public transit, followed by Denver, in the U.S., which accounted for a modal substitution rate of 34% for ST modes.

Table 19 - Influence of ride-hailing in ST modes

City or State	Country	Modal Substitution effects	Source
51 Cities	**Brazil**	30.2% modal substitution rate of ride-hailing trips replacing public transit.	De Souza Silva et al. (2018)
Sao Paolo	**Brazil**	17% modal substitution rate of ride-hailing trips replacing public transit.	Haddad et al. (2019)
Sao Paolo	**Brazil**	62% of modal substitution rate of pooled ride-hailing trips replacing public transit	Quest Inteligência and Gaesi/USP (2019)
Toronto	**Canada**	49% modal substitution rate of ride-hailing trips replacing public transit.	City of Toronto Transportation Services (2019)
Santiago	**Chile**	37.6% modal substitution rate of ride-hailing trips replacing public transit	Tirachini and del Río (2019)
10 Cities	**China**	37% modal substitution rate of ride-hailing trips replacing public transit	Tang et al. (2020)
Nanjing	**China**	34% modal substitution rate of ride-hailing trips replacing public transit	Shen et al. (2020)
Accra and Kumasi	**Ghana**	37% modal substitution rate of ride-hailing trips replacing public transit	Acheampong et al. (2020)
Delhi	**India**	Between 15.2% and 20.3% of modal substitution rate of ride-hailing trips replacing Delhi Metro trips	Agarwal et al. (2019)
Tehran	**Iran**	23.2% modal substitution rate of ride-hailing trips replacing public transportation	Lesteven and Samadzad (2021)
3 Cities	**Mexico**	27% and 33% of modal substitution rate of ride-hailing (shared and non-shared, respectively) replacing ST trips	Moody et al. (2021)
Madrid	**Spain**	38.9% modal substitution rate of ride-hailing trips replacing ST modes	Gomez et al. (2021)
22 Cities	**U.S.**	After ride-hailing companies are operating, a city can expect an incremental decrease of 1.3% a year in rail ridership and 1.7% in bus ridership.	Graehler et al. (2019)
7 Cities	**U.S.**	39% of modal substitution rate of ride-hailing trips replacing ST modes	Clewlow and Mishra (2017)
Boston	**U.S.**	59% modal substitution rate of ride-hailing trips replacing public transit	Gehrke et al. (2019)
California State	**U.S.**	17% modal substitution rate of ride-hailing trips and 31% of shared ride-hailing trips have replaced trips previously taken by ST modes	Circella et al. (2019)
Denver	**U.S.**	34% modal substitution rate of ride-hailing trips replacing ST modes	Henao and Marshal (2019b)
Multiple Cities	**U.S.**	Between 16% to 33% of modal substitution rate of ride-hailing trips replacing public transit	Rodier (2018)
Multiple Cities	**U.S.**	If a city has two or more ride-hailing companies, then it works as a substitute for public transportation, with increasing substitution effects over time	Sadowsky and Nelson (2017)
Multiple Cities	**U.S.**	Ride-hailing led to a significant reduction in city bus ridership	Babar and Burtch (2020)
Multiple Cities	**U.S.**	About 60% of ride-hailing users would have taken ST modes or not made the trip	Schaller (2018)

The perspective for ST modes after introducing ride-hailing in a city presents a wide modal substitution variation. It suggests a significant and continuous migration of users from ST modes to different modes of ride-hailing, as summarized in Table 19. The reasons for different results should be the focus of additional studies to clarify the conditions associated with each scenario assessed by the authors, including additional variables like population density, income, economic activity, demographic variables, policies and regulation, and others to provide more concrete evidence of the correlations involved in such relationship between ride-hailing and ST modes.

That been said, it is possible to draw a parallel between the international studies in Table 19 and Vancouver. As in the study of international cities in Table 19, the assessment of the main aspects identified in the analyses of mobility and socio-economic indicators, along with the content and document analyses in Vancouver, points to a scenario with very heterogeneous results. The data analysis in the neighborhoods presented a wide range of different usage of ST modes, and the regulatory framework shows significant room for improvement, as demonstrated in section 4.5.2.

Ride-hailing policies and regulations in Vancouver are effective in defining technical regulations for vehicles and drivers and in aspects associated with the licencing process. Requirements in place for drivers, which demand a commercial driver's licence, seem to be the bottleneck in controlling the rapid expansion of ride-hailing in Vancouver. Of course, this can be only confirmed or not when the city or the province makes ride-hailing data public. If such speculation proves to be true, then one can expect that once the bottleneck is eliminated by new flexible regulations or by having enough drivers conquering the commercial driver’s licence, a new adoption and growth scenario will be formed, eventually in a situation similar to Toronto. Unfortunately, if this comes to be the case, all other parts of the regulatory framework, such as the ones described in the macro topics included in Figure 15, regarding data, service standards, environment, and economics, have basic or no provision at all in the current set of policies and regulations, as demonstrated in section 4.5.2.

The combination of high adoption rates and low regulatory framework presents a high risk to sustainable transportation modes, as the concepts of free competition among transportation modes stimulated by the regulatory framework may cause significant rates of modal substitution in the future, with many users of sustainable transportation modes migrating to ride-hailing. The calculation of the NSTP sheds light on this risk by creating a concrete measure based on geographic areas powerful enough to provide guidance for regulations concerned with the preservation of sustainable transportation modes. Table 20 shows the modal substitution risk by neighborhood in Vancouver, divided into two single measures. Substitution risk of sustainable transportation trips and substitution risk of car-based trips, both expressed in the percentage of trips compared to the total trips of each neighborhood. The substitution risk of car-based trips was calculated using the number of sustainable transportation and deducting one.

The results in Table 20, in general, show a distance-based risk, meaning that a ride-hailing trip taken inside zone 1 boundaries presents, on average, a risk of about 62% of replacing a trip that would be normally taken by sustainable transportation modes, and about 38% of replacing a car trip, what would present a null effect in terms of negative externalities associated with private vehicles. On the other hand, zone 3 presents an opposite situation, with a risk of 38% for sustainable transportation modes and 62% for cars, while zone 2 present an intermediate scenario for both variables. Based on the gradual changes in the substitution risks from Table 20 according to downtown distance, ST modes in Vancouver have a higher replacement risk in the centre, where incentives to ride-hailing are likely to increase car-based trips and reduce ST trips. Contrastingly, ride-hailing seems to be a more suitable transportation mode for the urban periphery, in special those with low rates of ST usage, where ride-hailing trips are more likely to replace car-based trips than ST trips.

Expanding from working with zones, if neighborhoods are considered in the calculation, it will result in an even more heterogeneous situation in terms of risks, with values ranging from 28.59% to 71.41%. A simple reading of Table 20 shows that each neighborhood will present a unique scenario in terms of risks to sustainable transportation modes. Moreover, neighborhoods like West End, Downtown, and Strathcona present about 70% substitution risk for ST modes, while in other places highly dependent on cars, ride-hailing could be a solution for the first and last mile problem like Kerrisdale, Dunbar-Southlands, Killarney, and Shaughnessy.

Table 20 - Modal substitution risk per neighborhood

ZONE	2016	Substitution risk (replacement)	
		Sustainable Transportation Modes	Car based modes
1	Downtown	65.72%	34.28%
1	Kitsilano	52.74%	47.26%
1	Fairview	58.20%	41.80%
1	Mount Pleasant	56.72%	43.28%
1	West End	71.41%	28.59%
1	Strathcona	66.27%	33.73%
1	ZONE 1	62.05%	37.95%
2	Dunbar-Southlands	30.14%	69.86%
2	Arbutus-Ridge	31.54%	68.46%
2	Grandview-Woodland	53.96%	46.04%
2	Kensington-Cedar Cottage	44.65%	55.35%
2	Riley Park	46.73%	53.27%
2	Shaughnessy	30.30%	69.70%
2	South Cambie	51.10%	48.90%
2	West Point Grey	43.72%	56.28%
2	ZONE 2	44.35%	55.65%
3	Kerrisdale	29.42%	70.58%
3	Killarney	30.38%	69.62%
3	Hastings-Sunrise	37.06%	62.94%
3	Marpole	44.17%	55.83%
3	Oakridge	35.51%	64.49%
3	Renfrew-Collingwood	44.43%	55.57%
3	Sunset	40.36%	59.64%
3	Victoria-Fraserview	32.36%	67.64%
3	ZONE 3	38.25%	61.75%

Source: Created for the author based on Statistics Canada data from the City of Vancouver Open Data Portal (2020)

It is worth stressing that zone 3, despite being the most car-dependent zone, also presents the worst socio-demographic indicators with the lowest average income, highest unemployment rate, and the lowest percentage of people working from home. As shown in Table 10, in zone 3, the chances of an active trip, made by bicycle or walking, are seven times lower than in zone 1. For this reason, I claim that the use of the NSTP, more than addressing protection to sustainable transportation modes, also provides the city an opportunity to privilege the population that needs mobility options, affordable transportation, and an alternative to the use of private cars. A per-trip tax based on the NSTP concept would also be an effective instrument to avoid congestion as it would always privilege the use of sustainable transportation modes. Such tax could be incorporated into the current CCMP framework by expanding its geographic coverage to the whole city instead of the metro core and increasing its significance by establishing a new dynamic price level, ranging from the current CAD 0,30 to half of the current public transit fare price, per pick up or drop-off. In such a scenario, the final CCMP value would be calculated based on equal gradual rates according to NSTP, segmented by zones or smaller neighborhood groups. As an essential feature of such regulation, incentives for zero emissions and wheelchair accessible vehicles should remain in place for licence fees and be adjusted for the CCMP discount to a maximum of 50% for both options. The adapted CCMP fee should also be calibrated with different discount levels to incentivize pooled trips and multimodal integration by defining different tax levels based on the number of passengers and the transportation modes used in the whole trip.

Young *et al.* (2020:8) proposed a similar tax structure to the one proposed above in their assessment of ride-hailing in Toronto. The authors assessed the difference in travel times between transit and ride-hailing and found that areas with transit alternatives to ride-hailing with a difference equal to or lower than 15 minutes, called by them as “Type A,” are areas where transit alternatives should be protected as they present a reasonable transit infrastructure and direct competition with ride-hailing trips. The authors proposed an additional tax for ride-hailing trips based on the available public transit infrastructure and noted that “our recommendation is to impose an additional tax upon Type A trips, as these we argue, should be discouraged since they have viable transit alternatives and compete directly with trips that fall within reasonable transit service expectations.” Additionally, they also recommend that ride-hailing regulations should consider incentives to modal integration, especially for areas with poor transit offer, and should prioritize “discouraging single-occupant vehicle trips.”

Of course, the NSTP itself, if put alone in the regulatory framework, would never solve the current ride-hailing free-market policy in Vancouver. For example, the congestion taxes in Vancouver regulated by the BY-LAW number 12556 (City of Vancouver, 2019 b), considering a regular rate for one pick-up or drop-off, is CAD 0.30. In New York (New York State, 2021), the same congestion tax for a regular ride-hailing trip is US$2.75 per trip, which converted to Canadian dollars would represent CAD 3.48[7]. This represents a difference of 11.6 times when both taxes are compared. Additionally, the congestion tax in New York aims to increase the average vehicle occupancy in the congestion zone by promoting pooled ride-hailing through a reduced congestion tax of US$ 0.75 for shared trips. Chicago, where ride-hailing usage has grown by 271% since 2015, uses a very similar approach with a US$ 3.0 Downtown Zone Surcharge for single trips and US$ 1.25 for shared trips in the same zone (City of Chicago, 2021).

Even the world's most advanced ride-hailing regulation would only work with the use of substantial fiscal leverage in the form of taxes or any other kind of monetary control, allied with clear environmental, accessibility, and working rights regulations. Such measures must be able to influence the modal choice when it is price-based or raise enough funds to inhibit car-based negative externalities, investing in accessibility options and infrastructure to sustainable transportation modes, so perhaps in the near future, neighborhoods in zone 3 may have as many active transportation trips as those in zone 1. By protecting ST modes through the use of a significant tax, the NSTP could also support creating barriers against the induced-demand phenomenon, discussed in Section 1.2, for trips that would not be taken if ride-hailing was unavailable.

Geo-based regulations are a common feature in the transportation regulatory framework found in different scales and purposes, from zones used to define transportation fares in transit systems (Yang *et al.* 2020) to taxes developed to regulate congestion in high traffic areas as those found in Singapore, London, Stockholm, Milan, and Gothenburg included in the work of Lehe (2019), and even taxes used to moderate

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[7] Converted on October 2, 2021 through the website https://www.currencyconverterrate.com/usd/2.75-usd-to-cad.html

ride-hailing traffic like the congestion surcharge in New York (New York State, 2021) or the administrative per-trip fee for all trips in King County in Seattle (Seattle Regulations, 2018). Using the NSTP by neighborhoods or zones as a component in the regulatory framework would be a disruptive new scale in the current geo-based form of policy-making dedicated to ride-hailing. The concept merges the traditional geo-based analysis with the surging prices used by ride-hailing companies but uses the demand of ST modes, represented by the NSTP, to regulate the prices instead of the demand for ride-hailing services.

Chapter 5.

Conclusions and recommendations

Writing about ride-hailing in Vancouver led me back to one of my first classes in Urban Studies, particularly to the discussions about postcolonial theory in an amazing article from Roy (2016). I was actually concerned that my global south mindset could somehow blind me to the “obvious” superior western methodologies and to the intrinsic historical relationship between place, knowledge, and power. I feared that I would have limited ability to understand such different perspectives and that such limitation could lead to a feeling like if I don’t have permission to narrate and assess a local problem, as discussed by Roy (2016).

It was not clear for me, after decades of listening to the environmental narratives from the developed world over the barbarities happening in non-developed countries, that a western Green Party could take the lead to support and incentive a fossil-fueled and car-based transportation mode (Zwick and Spicer, 2018; Furstenau, 2021). I confess that so far, I could not understand why the major public transportation players from British Columbia did not submit any question to the Passenger Transportation Board during the licence application decision process, where the first two ride-hailing licence were conceived (Passenger Transportation Board, 2020a; 2020b). Similarly, I found myself thinking about the forces behind the reasons for the local media to largely ignore environmental matters in the discussion of ride-hailing in the province, as shown in section 4.5.1.

Even harder to understand is the resurgence of TransLink urging for a regional ride-hailing business licence claiming that such a measure would address the “unfair advantage that ride-hailing companies currently have over taxi companies” (Saltman, 2020:na). I could imagine TransLink or BC Transit both discussing ride-hailing regulations and possible reflections on transit ridership but never claiming for more favorable ride-hailing conditions. Perhaps this is just business as usual. After all, the effects of ride-hailing on sustainable transportation modes were mentioned just once in the media coverage content analysis and barely present, with only 6% of the paragraphs, in the LAD content analysis. So, why would TransLink or the Mayor’s

Council publicly raise this question after ride-hailing was approved by the Passenger Transportation Board?

The lack of discussion about the environment and about public transportation in both content analyses leaves a clear impression that the link between car trips and global warming is not strong enough to be recognized either in the media or Passenger Transportation Board. For a city aiming to be the greenest in the world, this is not necessarily a fit.

Luckily, I was enlightened by the discussions about transportation and climate change in Canada included in the work of Newman *et al.* (2013). Their explanation about the influence of the “Freedom to move” white paper, released by the Canadian federal government in 1985, in the current transportation legislation, represented by the *Canada Transportation Act*, helped me to better understand this complex puzzle. A lot of what I covered here can be simply explained using the premises of both documents, in particular, the goal of promoting deregulation in the transportation sector to encourage competition in a market with low entry barriers, replacing “public interest” with “public convenience and necessity” (Newman *et al.*, 2013: 24). Assuming that this represented the theory and the goals behind the ride-hailing regulatory framework, then a perfect match is found.

Marshall (2020) wrote about how Vancouver, after a free ride-hailing decade and posing as the last major city on the continent to get ride-hailing services, wanted to use the experience from other cities to avoid the common mistakes with Uber and Lyft. Conversely, what is demonstrated by the local regulations in section 4.5.2 is exactly the opposite situation. Even after being without ride-hailing for a long time, Vancouver did not opt for an innovative approach to the ride-hailing policy framework. Instead, the city decided to keep the premises embedded in the *Canada Transportation Act*. Policy learning was definitely not a parameter for the regulatory framework in Vancouver, even with the statement in the Summary section of the LAD document analysis, where the board says that “TNS amendments to the Act have been crafted with these other jurisdictional experiences and “lessons learned” in mind.” It happens that in the sentence immediately before the board disqualifies the arguments against ride-hailing, saying that they were “largely based on experience with TNS generally or Uber specifically in other jurisdictions” (Passenger Transportation Board, 2020a:32).

My understanding is that, as discussed before, the only regulation holding back a ride-hailing demand explosion in the province, considering a return to a pre-pandemic scenario, is the requirement for a commercial driver's licence. This is by far the principal bottleneck of the complex supply and demand equilibrium in the regulatory framework currently in place. However, if somehow the ride-hailing lobbyists manage to find a detour or remove this last barrier, there will be a huge growing avenue for the service in BC without anything in place to hold it back. Such a requirement regulating the drivers' supply is the strongest one included in the regulatory framework and deserves much credit.

After assessing the risks for sustainable transportation modes in the current policy framework, what I found was an absence of key regulations and some "nice to have" features, where few practical results may be expected. Many requirements like incentives for accessibility and zero-emission cars are only figurative without substantial impact for drivers and cannot motivate ride-hailing companies towards both goals. Similarly, the congestion tax presents a symbolic value that cannot help in preventing congestion by imposing monetary barriers or supporting infrastructure investment. Controls over drivers' working hours, drivers' pay, and minimum wage were also neglected as if the free market would solve these issues by itself. The regulations also do not privilege different types of riding with a unique interpretation of solo or pooled rides. Likewise, the regulatory framework does not impose quantitative requirements for wheelchair accessible or zero-emission vehicles.

It would be highly recommended to review the current set of regulations to include the items discussed above. The NSTP could be combined with such items to support the implementation of eventual policy and regulations' adaptations or insertions by adding a local geo-based component of the ST modes usage in the framework. As a starting point, Table 21 presents some examples of alternative benchmark policies in different domains that could strengthen Vancouver's current policy framework.

Table 21 - Policy examples

City & Country	Policy domain	Policy effects	Source
California U.S.	Environment	Through the Clean Miles Standard and Incentive Program, ride-hailing companies must meet annual GHG and electrification targets	California State (2018)
Chicago U.S.	Accessibility	US$0.10 fee per trip for the Accessibility Fund, used to provide incentives for wheelchair accessible vehicles (purchase and adaptation)	City of Chicago (2021)
New York U.S.	Congestion	$2.75 surcharge for trips in the congestion zone, $0.75 for pooled trips	New York State (2021)
Seattle U.S.	Labor rights	The “Fare Share Plan” requires that ride-hailing drivers are paid a minimum compensation equivalent to Seattle's minimum wage plus benefits and expenses	Seattle Government (2021)
Sao Paolo Brazil	Infrastructure	The city charges a per km fee as a road pricing to support infrastructure and public transportation	Prefeitura de São Paulo (2016)
Chicago U.S.	Open Data	The open data portal host three publicly accessible ride-hailing datasets, with aggregated and geo-referenced data, about trips, drivers, and vehicles.	Chicago Open Data (2021)

Considering the pros and cons of the current policies and regulations, the use of NTSP in the elaboration of a differential regulatory framework would allow for efficient protection to sustainable transportation modes against the highest ride-hailing risk, the modal substitution, the effects of which are summarized in Table 19 on a global scale. One example would be using the NSTP to calibrate congestion or environmental fees, by neighborhood or zones, in a way where it would incentive ride-hailing for those neighborhoods with low risk for sustainable transportation modes or impose a significant financial barrier to avoid the modal substation effect on those neighborhoods with high replacement risk, as shown in Table 20. Policies considering incentives for focused trips in areas with poor transit options could also add an equity component to the transportation matrix. This could be done by suppressing taxes in trips starting and ending in neighborhoods with low substitution risk, geo-fenced for specific transit locations, like transit stops or stations, and with distance within stipulated targets according to the city’s mobility strategy.

Provisions about the NSTP periodic update should also be included in the regulations, as it may present considerable changes over time due to several reasons like transit infrastructure, zoning, housing, economic factors, etc.

As discussed previously, to understand such changes, data availability would be necessary. An essential recommendation is towards the data policy. The city must include ride-hailing data in the Open Data Portal so more ride-hailing research can be conducted, using actual local data to understand how this service interacts with mobility options in the city. If Vancouver decides to advance its data policy by making ride-hailing data public, the NSTP would also enrich the data analysis by providing a geographic visualization of ST modes usage, which could be combined with ride-hailing data to expand the possibilities towards transportation-oriented studies. More grounded research about local operations would be vital to elucidate the effects of ride-hailing in Vancouver and give a concrete basis for the theoretical discussion of potential implications.

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