Fear and loathing on public transportation: Applying a spatial framework to crime patterns on Vancouver's Canada Line SkyTrain System

by

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Abstract

The expansion of mass forms of public transportation systems have often been resisted due to fears and concerns over an increased level of crime. The following study seeks to determine whether the SkyTrain's Canada Line has increased levels of reported crime in six criminal offence categories: commercial burglary, residential burglary, mischief, theft, theft from vehicle, and theft of vehicle between January 2003 and December 2015 in Vancouver, British Columbia. Time series regression, panel data analysis, and spatial point pattern tests are applied to determine whether such concerns should be merited or disregarded in the study of crime and transportation. Results demonstrate that census tracts that host a Canada Line SkyTrain station do not increase levels of crime. Rather, census tracts that host multiple SkyTrain stations and/or are situated in socially disorganized neighbourhoods are at a higher level of risk for criminal victimization. These findings are critical in removing the negative stigma surrounding mass forms of public transportation systems. Additionally, these results assist local police, transit authorities, and urban planners to create appropriate crime prevention strategies to prevent crime while restructuring public discourse about the potential criminogenic effects from public transportation systems.

Keywords: Crime; Mass forms of public transportation systems; land use; spatial point pattern test, panel data analysis, time series regression

Dedication

I would like to dedicate this dissertation to each and every single person who has struggled to overcome obstacles in their life to pursue their dreams.

"You are braver than you believe, stronger than you seem, smarter than you think, and loved more than you know" – A.A. Milne

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List of Acronyms

Term	Meaning
AAL	Accessibility and activity level
CCTV	Closed Circuit Television Camera
CL	Canada Line
CMA	Census Metropolitan Area
CPTED	Crime Prevention through Environmental Design
CSI	Crime Severity Index
CT	Census Tracts
C-Train	Calgary's light rail transit system
DTES	Downtown Eastside
EL	Elevated railroad station(s)
Expo 86	World's Fair hosted in Vancouver in 1986
GIS	Geographical Information Systems
HBLR	Hudson Bergen Light Rail
ICA	Interstitial Crime Analysis
IMPD	Indianapolis Metropolitan Police Department
LAPD	Los Angeles Police Department
LRT	Light Rail Transit
MARTA	Metropolitan Atlanta Transit Authority
MTPD	Metro Transit Police Department, Washington
MTR	Hong Kong's Subway System
NIMBY	Not in my backyard syndrome
OLS	Ordinary Least Squares
PRIME	Police Records Information Management Environment
RCMP	Royal Canadian Mounted Police
SCRTD	Southern California Rapid Transit District of Los Angeles
SES	Socio-economic status
SLR	South Light Rail
UCR	Uniform Crime Reporting System
VPD	Vancouver Police Department
WMATA	Washington Metropolitan Area Transit Authority
YVR	Vancouver International Airport

Chapter 1. Introduction

The environment is a critical aspect to consider in the development and application of crime reduction strategies. According to Smith & Clarke (2000), crime cannot be explained or effectively prevented without a thorough understanding of the environment in which crime(s) take place. Studies of spatial-temporal patterns of criminal offending seek to study crime by asking where and when crime(s) occur by looking at different aspects of the urban landscape. Aspects include the built environment, the social characteristics of the location that the crime occurred in, the routine activities of the offender, and the target that allowed them to interact at the particular point in time (Andresen, Brantingham & Kinney, 2010, p.6). This approach to study crime is a vast departure from traditional criminological studies that focus exclusively on the criminality of the offender (Paulsen & Robinson, 2009).

Transportation is a key feature of any given urban landscape. Overwhelmingly, transportation in the Western World is based on the consumption and use of private motor vehicles. Private motor vehicles offer a number of advantages that make it popular amongst users. Individuals are given a greater range of movement to freely travel, have more efficient ways to travel that reduce commuting time (especially when required to travel to multiple destinations within a single day), and carry a large number of personal items effortlessly (Weitz, 2008). However, while private automobiles provide individuals with the flexibility and ease to travel effortlessly within a given region, economic, health, environmental, and social costs of basing a society on automobile transportation have proven to be both destructive and costly. Billions of dollars are spent each year for owners to maintain and operate their vehicles while burdening local governments to invest financial resources into the creation and maintenance of roads, highways, and bridges. In addition to financial costs, automobile pollution has significantly raised the risk of illness and disease among individuals while impacting carbon dioxide emissions on levels of

global warming (Weitz, 2008). For these reasons, cities around the globe have attempted to divert ridership from the private automobile to public transportation.

Public transportation systems have exponentially evolved from the late 19th century. Movement of people and technological advancements have made it possible for people to abandon walking and horse-drawn carriages to adopting faster modes of travel such as buses, trains, and private automobiles (Knowles, Shaw & Docherty, 2008). The term bus was originally derived from the Latin word, omnibus, meaning 'for all' (Lesley, as cited in Garrett, 2014, p. 332). Public transportation systems like buses and subways can help contribute to the growth of cities without placing intense mobility demands upon their urban infrastructure like private automobiles do (Keeling, 2009). As a result to the growing need to find alternative transportation, local governance has expanded and shaped many forms of urban transport infrastructure to meet the needs of a growing region. This evolution has resulted in highly intricate systems that comprise of a number streets, stations, bus stops, and passenger vehicles. Such systems provide several advantages for urban regions. Benefits include the ability to provide congestion relief, reduce energy consumption, improve air quality, and promote economic development (Kim, Gudmundur & Hennessey, 2007; Stucky & Smith, 2014; Tay, Azad, Wirasinghe & Hansen, 2013).

Further, the spatial imprint of an urban transport system as well as the adjacent physical infrastructure can, together, confer a level of spatial arrangement of cities (Rodrigue, Comtois & Slack, 2009). Moreover, within such relationships lie underlying interactions between people, freight and information (Rodrigue et al., 2009). Therefore, it can be assumed that the spatial structure of transport systems can influence many aspects of an urban centre, including the level of crime within and surrounding public transportation systems.

Transit settings can attract and generate a number of different types of criminal offences. Broadly, targets of crime on mass forms of public transportation can be divided into three categories: crimes against passengers, crimes against transit employees and crimes against the transit system itself (Smith & Clarke, 2000). Smith & Cornish (2006) argue that the public transit environment is particularly conducive to crime as such areas host a large volume of overcrowding during peak periods of travel and have a lack of

supervision from transit staff. Commonly, offences committed include robbery, pickpocketing, physical and/or sexual assault, motor vehicle theft (park and ride lots), vandalism and fare evasion. However, the volume and frequency of such offences may vary between mode of transport (i.e. bus or train), location of the station (urban centre vs. suburban station), the time and day of week (weekends).

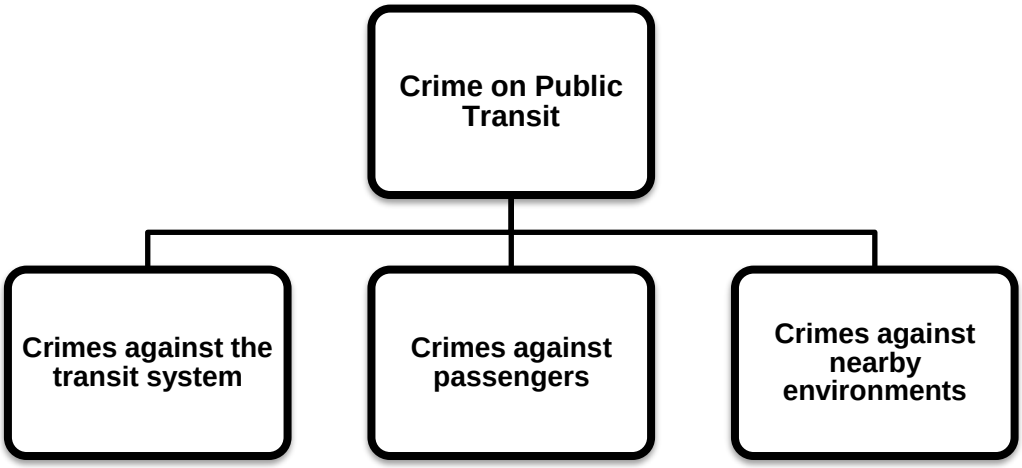

Figure 1: Categories of transportation crime, adapted from Cozens, Neale, Whitaker & Hillier, 2003, p.122

Mass forms of public transportation systems manifest crime in several ways. First, public transit systems are public places that allow any number and type of individual to enter and exit the system (Smith & Clarke, 2000). Passengers must travel through the same entry and exit points as offenders, thereby; bringing people together that would not normally come into contact with one another (Brantingham & Brantingham, 1998). There are a diverse group of passengers who use public transit (Brantingham, Brantingham & Wong, 1991). Most commonly, passengers tend to be young teenagers; unattached males from a low-socio-economic background. These groups are more likely to be exposed to higher levels of offending and victimization compared to other groups of passengers (Brantingham et al., 1991). Clarke, Belanger & Eastman (1996) found a similar transit-victim profile in their study of robbery on New York's subway system. Victims of robbery projected a profile of a young male with an increased probability of being intoxicated commuting away from the inner downtown core and entertainment

corridor (Clarke et al., 1996). Thus, criminal opportunities within transit settings are a result of vulnerability of high risk targets within a confined space.

Second, transit environments are configured in predictable temporal and spatial patterns of movement. Passengers must arrive and depart at the same boarding platforms based on a fixed departure schedule for buses and trains. Clarke et al. (1996) found that robbery rates were highest on subway platforms between 9:00 pm and 5:00 am due to the fewer number of people travelling during this time period. Ceccato & Uittenbogaard (2014) found that victimization most often occurred between the hours of 4:00 pm and midnight, peaking between the hours of 8:00 and 9:00 pm. Brantingham et al. (1991) suggest that in order to determine forces and conditions that structure crime patterns through public transit, one must consider both victim and criminal mobility. The authors suggest that the type of transportation used by an individual affects crime patterns in five distinct ways:

1) **Different forms of transportation cluster people together in different ways**
2) **Different modes of travel shape travel times differently**
3) **Different modes of transport cluster destinations differently**
4) **Different modes of transportation tend to cluster travel paths differently**
5) **Different modes of transit shape the types of crimes occurring by creating different opportunity sets for crime**

(Brantingham et al., 1991, p.93)

For example, a passenger may be more at risk travelling within a closed, self-contained subway train than within a bus, as the subway train may be travelling at faster speeds with less frequent stops compared to a bus. As a result, the passenger(s) is more vulnerable to become victimized by an offender as they may feel trapped in a train with no opportunity to easily leave. Another example can include commuters who may feel more vulnerable to criminal victimization waiting for a train at an underground subway system compared to an elevated subway system where more by-standers can view the platform and potentially intervene, if an offence took place.

Passenger mobility on transport systems demonstrates a whole journey approach from point of origin to destination (and back again). Mobility on public transport systems can be difficult to study. Criminal events can occur in moving vehicles creating difficulties in capturing the precise locations of where they begin and end. Newton (2004) examined this phenomenon on public transit through the consideration of static and non-static criminal events. Static events provide a precise location of where a crime occurred, whereas non-static events occur in between destinations along a route and can occur on different transport modes (Newton, 2004). It becomes troublesome to determine where the crime occurred as public transit environments contain a mixture of both static and non-static criminal events. Newton (2004) suggests categorizing movement into three situations: the walking, waiting and en-route environments. It is important to recognize that crime is not suppressed to a transit station alone. Transit-generated crime can occur within the mode of travel, the station and the surrounding environment of the station. Many studies have begun to recognize the need to examine nearby transit surroundings in relation to crime. Some studies have suggested that a transit station can generate crime up to 750 meters away from the station itself (Robinson & Giordano, 2012; Gallison, 2016). Thus, the incorporation of such classifications can help transit authorities increase measures of target hardening and uniform patrol in those areas most vulnerable within the transit environment.

Third, commuters represent an easy target for an offender to commit a crime against. Most commuters are tired, pre-occupied and tend to carry an assortment of bags with small, but valuable objects within them (Myhre & Rosso, 1996). Consequently, offenders can easily victimize passengers as their movement is highly predictable and thus, gives the offender the upper hand in preparing and committing an offence on public transit. This varies as offenders and passengers travel away from the outside of a station. Offenders lose the predictability of the transit environment and may not know what people may decide to do next (Smith & Clarke, 2000, p.171).

Transit environments also have the potential to negatively impact residential homes and businesses located near major transit routes and stations. Mass forms of transit can assist in exporting local and non-local offenders to new geographical zones to commit crime (Loukaitou-Sideris, Liggett & Iseki, 2002). Communities located near transit

stations may be equally as vulnerable to experience an increase in crime as do stations themselves. Journey-to-crime literature suggests that crime trips tend to be short in distance (Brantingham & Brantingham, 1981; Snook, 2004; Townsley & Sidebottom, 2010). Motivated offenders may seek out ways to commit crime by choosing targets close to an anchor point, most commonly an offender's home or place of employment (Rengert, 2004). The notion of an offender choosing targets close to their anchor points reflects Zipf's (1965) theory of least effort. Zipf (1965) stated that people will naturally choose the path of least resistance (effort). By providing a new means to travel in a short period of time, offenders may be drawn to commit crime in and nearby transit stations as it exerts little effort to seize such opportunities. New pathways can lead offenders to seek out more alluring targets as they become more familiar with the local area (Sedelmaier, 2003). Belanger (1999) found that most repeat offenders committed crimes within 10 stops of their home, suggesting public transit time can be an important factor as the distance in the journey to commit crime. Therefore, the transit system may become a new tactic of connecting the criminal with a victim by travelling substantial distances in little time (Billings, Leland & Swindell, 2011).

Consequently, potential public transit expansion routes have been fiercely resisted by the general public in light of the unfavourable conditions it fosters for crime. Opponents of public transit expansion fear that crime from the inner city will be displaced to suburban neighbourhoods that host a new transit station. Billings et al. (2011) note that public meetings, local newspaper stories, political cartoons and activist blogs are replete with examples of fears that public transit and the various stations and stops will increase crime at the station and/or in the neighbourhood around the station (p.550). The opposition for such expansion plans mimics the notion of 'not in my backyard' (NIMBY) syndrome. Similar to ex-offenders being released back into the community after serving their sentence, the local neighbourhood rallies together to force the offender to move elsewhere. "The prospect of increased crime helps to fuel the 'not in my backyard' attitude that individuals may display when facing the introduction of a new transport system stop to their neighbourhood" (Wattrick, 2011 as cited in Sedelmaier, 2014, p.1).

Critics of public transportation neglect to indicate how crime may be displaced by new transport systems and routes. Crime displacement is the relocation of crime from

one place, time, target, offence or tactic to another as result of some crime prevention initiative. Crime displacement is often viewed as a negative consequence of crime prevention efforts as it may increase crime in other areas and/or transfer risk to other groups. Anti-transit critics frequently state that inner city crime will be displaced to suburban neighbourhoods. Rengert (2004) found the opposite in the study of journeys-to-crime; offenders were more likely to travel away from a suburb to a city centre to commit crime. To date, there is a lack of research to empirically support the claim that public transportation can displace crime to suburban neighbourhoods (Billings et al., 2011).

Media portrayals of crime on public transit have also contributed to a wide-spread fear of passengers becoming victims of crime on buses and trains. Crimes that occur within and/or near public transportation systems are often over-sensationalized by media outlets that create a stigma against public transit. However, much of the work on crime and the presence of a mass public transit system have focused on perceptions of crime as opposed to crime statistics (Loukaitou-Sideris et al., 2002; Billings et al., 2011). Lynch & Atkins (1988) argue that personal security can have a significant influence on travel patterns. Public concerns over safety may be one of the most important reasons why many individuals choose not to use transit (Hartgen et al., 1993 as cited in Loukaitou-Sideris et al., 2002). Block & Block (2000) contend that a dual relationship exists between transit crime and the environment that may give rise to the perception that transit increases crime. The authors argue that the socio-physical characteristics (such as household income and housing type) of the immediate station area affect the level of dangerousness at a transit station. Furthermore, the presence of a station affects the danger in the immediate neighbourhood (Block & Block, 2000). This has prompted major transit system authorities to take pre-cautionary steps to make passengers feel safe, regardless of how much actual crime may or may not be occurring (Smith & Clarke, 2000).

The design and structure of transit stations can influence the level of crime and perceived safety of commuters. The influence of a city's design and layout can influence the mobility of both victims and offenders (Ceccatto & Uittenbogaard, 2014). Some station designs make it difficult for 'outsiders' to see what is happening because of obstructed visibility such as hidden corners and poor lighting (Ceccatto & Uittenbogaard, 2014). The location of escalators and elevators at the end of a platform, ticket booths, overpass

walkways and separation of passenger flows are factors that can affect safety at stations (Jeffrey, 1971; Newman, 1972; Gaylord & Gahiller, 1991; Myhre & Rosso, 1996; La Vigne, 1996). Gaylord & Galliher (1991) found that Hong Kong's MTR subway service reported low crime rates due to the design and construction of the subway system. The MTR was built upon the principle of 'design out' where a number of CPTED (crime prevention through environmental design) principles were applied to eliminate opportunities for offenders to commit crime. The system had improved lighting, limited number of entry points to the system and the removal of public chairs and benches to discourage loitering. La Vigne (1996) found similar results in her examination of Washington DC's subway system, the Metro. La Vigne (1996) concluded that the structural design and maintenance of the Metro were factors that impacted the level of reported crime on the subway system. Design features included increased closed circuit television cameras (CCTVs) surveillance, few entry and exit points and increased number of signage. Transit passengers feel more at ease and secure when pre-cautionary measures have been taken to help address crime concerns at transit stations. Ceccatto & Uittenbogaard (2014) argue that 'the environment of stations is important because it directly or indirectly affects visibility, the possibility to be seen and to see others; in other words, the natural surveillance of the location' (p.134).

Fear of crime is often associated with female passengers who use public transportation. Fear of crime surveys report that women are more fearful of crime than men (Gordon & Riger, 1989 as cited in Loukaitou-Sideris, 2014). Yavuz & Welch (2010) noted that women's fear of public space can limit their freedom and enjoyment of public life. This in turn restricts their ability to benefit from opportunities and convenience (p.2491). However, research has demonstrated that males are more often crime victims on public transportation compared to their female counterparts (Smith, 2008). Exceptions to this trend have been noted for women; female passengers are more likely to experience higher levels of sexual assault and 'snatch' thefts (Smith, 2008). Loukaitou-Sideris (2014) adds that women fear crimes such as rape, intimidation, groping, sexual comments, harassment and threats. Beller, Garelik & Cooper (1980) argue that the convergence of large, shifting, distracted populations of passengers presents easy opportunities for offenders to commit crime. Offenders can easily make physical contact with another passenger due to the limited space and convergence of passengers in a short span of

time. As a result, female passengers employ precautionary measures and strategies that affect their travel patterns such as choosing specific routes, travel modes and transit environments over others (Loukaitou-Sideris, 2014, p.242). Kim et al. (2007) study of passenger travel behaviour indicated that female passengers in fearing crime, were more likely to be picked up and dropped off at transit stations at night to avoid being alone. Loukaitou-Sideris & Fink (2009) found that women tended to feel safer being watched by a police officer than being in the vicinity of a security camera.

Transit authorities and local governances have attempted to overcome the challenges presented for safety and security of passengers using public transit systems. Many established public transit systems have taken preventive steps to help reduce crime by implementing CCTVs, removing public restrooms and benches, utilizing CPTED measures in the construction of the physical station itself, safety campaigns, and uniformed transit officers to help deter and thwart potential offenders (Felson, Belanger, Bichler, Bruzinski, Campbell, Fried, Grofik, Mazur, O'Regan, Sweeney, Ullman & Williams, 1996; Gaylord & Gahiller, 1991; Myhre & Rosso, 1996, La Vigne, 1996). Transit authorities try to utilize a holistic approach to cover all safety and security concerns from a 'whole journey' approach (Kruger & Landman, 2007, 114). This expansive strategy addresses crime problems encountered by both passengers and transit staff during "any part of the journey whether travelling by foot, waiting at a stop or station or travelling on a mode of public transport (Smith & Clarke, 2000 as cited in Kruger & Landman, 2007, 114). However, this strategy's objectives may not be met due to the complexity of crime. A whole journey approach aims to implement a number of targeted crime reduction strategies aimed to decrease the level of crime committed in transit environments. Without any specification, these initiatives do not address individual crimes. Crimes may have different spatial and temporal patterns that may not work within a general pattern of offending. Thus, to reduce transit crime, a wide range of context specific approaches and strategies should be used to tackle particular crime patterns at a local level.

Adverse perceptions of public transit and crime have created both fear and resentment amongst the general public. Negative perceptions of mass transit systems can threaten the long term viability of a metropolitan city (Poister, 1996). Such perceptions and fears can adversely impact the economy, the environment and the social welfare of a

population. Thus, it is important to undertake spatial analysis of transit crime to more fully understand the spatial patterns of transit crime. As cities plan and implement transit system expansion and growth, several research questions emerge to help validate concerns regarding transit crime. First, can mass transit systems export offenders to new hunting grounds to seek out targets? Second, do neighbourhoods adjacent to new transit stations experience an increase in crime after transit service begins? Last, can transit crime be influenced by nearby land uses?

The following research seeks to apply a spatial perspective to identify crime patterns along the Canada Line, one of Vancouver's SkyTrain routes. This research expands upon previous work undertaken to examine the potential criminogenic impact of the Canada Line in Richmond, BC. This analysis will focus exclusively on the Vancouver stations of the Canada Line to determine whether the implementation of the Canada Line route has led to an increased level of reported crime in census tracts located within and nearby Canada Line stations. The study hypothesizes that the levels of reported crime will demonstrate a null and/or decreased level of crime of the associated census tracts.

This dissertation demonstrates the importance of providing empirical research to refute claims that public transportation negatively impacts cities as well as the importance of considering the effect of nearby land uses on public transit crime. Such work helps transit staff, local police and urban planners to implement situational crime prevention strategies to help lower the number of crimes that are committed within the transit environment as well as address fears and concerns amongst residents and passengers of the SkyTrain system.

The first part of this dissertation outlines the relevant theoretical framework to understand how mass forms of public transportation systems can attract, generate, and deter crime. Additionally, an in-depth of examination of previous empirical research will be included. The second half of this dissertation will focus on the methodology used to examine the spatial patterns of criminal offending within and nearby the Canada Line in Vancouver. The results demonstrate the statistical significance of applying spatial-measures to the field of public transit and crime. Concluding the current research will have an in-depth discussion of the implications of under-taking research in the study of

public transportation systems and crime and provide future direction for key stakeholders in policing and designing mass forms of public transit systems.

Chapter 2. Environmental Theories of Crime

2.1. Introduction

There are four basic dimensions for understanding the criminal event: the legal dimension, the offender dimension, the victim dimension and the place (or situational) dimension (Brantingham & Brantingham, 1981). Criminological research has mostly studied the first three elements of the criminal event, with little emphasis on the place dimension. However, spatial-temporal patterns of crime can help explain crime through the interactions between human behaviour and the built environment. As humans, we respond, adapt and change as a result of the environment of which we are a part of. Consequently, criminal behaviour is one form of adaptation to the environment (Andresen, Brantingham & Kinney, 2010). By applying environmental theories of crime to the study of mass forms of public transit, we can better understand how, when, where, and why individuals decide to commit crime within and along major transport stations.

2.2. Crime Attractors and Generators

Spatial crime analysis plays an important role in identifying and determining the characteristics and dynamics of the criminal event. Criminology of place literature has established that crime is found concentrated close to crime attractors and generators (Brantingham & Brantingham, 1995). Crime attractors are locations that attract offenders based on known criminal opportunities that exist at these sites. Crime generators are considered land uses that tend to attract criminal behaviour that is already established or being committed (Kinney, Brantingham, Wuschke, Kirk & Brantingham p.62). Crime generators produce crime by channelling large numbers of people past a set of criminal opportunities. Some potential offenders are mixed into the people gathered at generator locations. As a result, crimes are committed based on available opportunities. This contrasts against activity nodes that have special characteristics that can pull in individuals with high levels of criminal motivation and histories of repeat offending, also known as crime generators (Kinney et al., 2008). The attraction is created by an ecological label, often supplemented by the intending offender's past history, establishing that particular

location as a known place to go to commit a specific type of crime. Further, crimes committed in such locations are committed by area outsiders. Offenders engaging in crime at crime attractor locations are likely to engage in a staged target search process in the vicinity of the crime attractor. To complicate matters, many activity nodes can be classified as both crime attractors and generators. It can be difficult for local law enforcement to patrol and implement effective crime prevention strategies to help reduce and prevent the onset of crime at such locations.

Mass forms of public transportation systems are often labelled as crime attractors and generators. Transit environments are conducive for crime to occur given a number of opportunity structures present within the spatial and temporal movement of passengers. Potential offenders who use mass transit can seek out criminal activities that can expand their awareness spaces by using new pathways to reach different targets, often found at different activity nodes. An offender does not have to be limited to his or her own immediate environment, as the ease and accessibility provided by public transportation can lead offenders to new hunting grounds to seek targets. Other activity nodes that may have once been difficult to access are now easily accessible and can provide the foundation for crime to increase in those areas marked by an increase in pathway accessibility. This can especially influence the local crime rate if the creation and expansion of new urban transport systems can expand an offender's awareness space and provide new means of accessibility to reach such targets (Poister, 1996; Liggett, Loukaitou-Sideris & Iseki, 2003; Sedelmaier, 2003; Brantingham et al., 1991; Pearlstein & Wachs, 1982 and Plano, 1993).

A review of mass forms of public transportation systems and crime demonstrate that a combination of different physical and social variables may impact crime at a transit station (Loukaitou-Sideris et al., 2002). Crime levels vary for different parts of the transit system and can be correlated to neighbourhood crime (Richards and Hoel, 1980, DeGeneste and Sullivan, 1994, as cited in Loukaitou-Sideris et al., 2002). However, past research has largely ignored the spatial environment and the immediate vicinity of transit stations in relation to crime (Poister, 1996; Loukaitou-Sideris et al., 2002). Further, most crime incidents occur within and nearby stations themselves rather than on modes of travel such as trains and buses. Station environments are vulnerable to crime as they

often lack transit employees who can potentially discourage motivated offenders. Crime and disorder are more likely to occur when people are moving in different rates and in different directions and interstitial idleness, where people are neither in motion nor in a legitimate behaviour setting (Felson et al., 1996, p.78).

Some studies have demonstrated the importance of station design within transit environments. Defensible space characteristics such as lighting, fencing, specific security hardware, open design) can discourage crime from taking place (La Vigne, 1996, Loukaitou-Sideris et al., 2002). Additionally, some studies have shown that the urban form characteristics of neighbourhoods are critical to consider in relation to crime. Certain types of land uses (i.e. schools, bars, liquor stores, pawnshops, abandoned buildings) have been found to attract more crime within the surrounding area (Block & Block, 2000; Loukaitou-Sideris et al., 2002). The presence of physical disorder and incivility signified by dilapidated buildings, presence of panhandlers, drug dealers, & prostitutes and the concentration of graffiti and vandalism can also impact the perception and level of neighbourhood crime (Wilson & Kelling, 1982).

2.3. Rational Choice Theory

Public transit systems reflect a high level of both offender and victim decision making. Commuters consciously make a series of decisions to select when, where, and how one should travel in order to arrive at their desired destination(s). However, commuters do not decide with whom they travel with. Transit stations are public domains where anyone can enter and exit the system. Motivated offenders are drawn to such settings as it allows them to search for appropriate targets to victimize against. An important theory that can help explain the importance of choice in the commission of crime is Cornish & Clarke's (1986) Rational Choice Theory.

Expanding upon previous research into the study of situational crime prevention, Cornish & Clarke produced the *Reasoning Criminal* (1986) that details why offenders choose to commit crime. According to the authors, an individual make a rational decision(s) whether or not to commit a crime (Cornish & Clarke, 1986). The individual will gauge his or her personal needs and wants with the risk of becoming apprehended, the

severity of the punishment as well as the gain earned from the commission of the offence. The offender will then react selectively to particular situational factors, or cues of the given environment to determine whether or not a target is worth pursuing.

The decision making of individuals is not a simple choice whether to act upon an opportunity or not. Rather, individuals go under an intricate thought process of deciding whether or not to participate in crime. Furthermore, these individuals contemplate the consequences of those actions, regardless of whether they are positive or negative. Rational Choice Theory is a critical perspective to use in the current analysis of the Canada Line in Vancouver. Within transit environments, offenders have a number of opportunities to commit crime. However, the opportunity to commit a crime must also demonstrate a low risk of being caught and what the potential penalty may be for committing such an offence.

Offenders who commit crimes on public transit may be successful in committing crime(s) based on the location of a particular train or bus station, the level of surveillance (both mechanical and personal) as well as the number of passengers using transit. For example, a transit station that has poor design structure (i.e. obstructing walls, hidden corridors), little to no uniform transit officers and few passengers may be more vulnerable to criminal offending as offenders have assessed the risk of committing crime low while potential to gain, high. Another example of this thought process could include an offender who sees a passenger waiting at a SkyTrain platform holding an expensive cell phone. The offender can run from behind the passenger, steal the cell phone and flee without being apprehended (thus no punishment) and is able to leave the SkyTrain station with the stolen goods. Thus, it is important to be aware of both the physical and social structure of a transit environment to help identify potential weaknesses and implement safeguards to try to prevent crime from occurring. Rational Choice Theory is a resourceful perspective to apply to environmental criminology as it helps focus on the criminal event and situational factors that contribute to the commission of crime instead of offender characteristics alone (Lersch, 2007).

2.4. Routine Activity Theory

Equally as important in the study of criminal offending within public transit environments is the role of routine activities of both passengers and motivated offenders. Cohen & Felson (1979) proposed that the routine activities of individuals can reveal highly predictable patterns of criminal offending. The radical transformation of the routine activities of households within the 20th century led to a marked increase in crime. Following World War II, more people began to leave home to attend school, enter the workforce and engage in recreational activities (Cohen & Felson, 1979). To explain this dramatic shift in the routines of a person, Cohen & Felson (1979) contended that when offenders and victims converge, the possibility for a crime to occur increases. A perpetrator has the ability to intentionally take or harm a target through illegal activities. Such activities are classified as 'direct contact predatory violations' (Cohen & Felson, 1979, p.589). In order for such violations to occur, three elements must be present: a suitable target (a person or a piece of property), a motivated offender, and a lack of a capable guardian (anyone who engages in protective behaviours toward family, friends, strangers and/or property). Without any one of the three elements, the likelihood of a crime occurring greatly decreased. By changing one's routine, the temporal and spatial patterns of interaction with different people increased the likelihood of becoming a victim of a crime and/or having one's property victimized against.

The movement of individuals within a city's road and transit networks can demonstrate how offenders select and victimize desirable targets. Motivated offenders and potential victims travel in a similar fashion; each must travel in order to reach home, work and leisure activities. Specifically within the context of public transportation, individuals who commute using buses and/or subways tend to travel based on specific schedules due to transit departure times. Predictable commuting times can lead to a number of criminal opportunities. Offenders can travel to stations during heavy volume periods to victimize passengers travelling to and from their anchor points.

Mass forms of public transit produce a large volume of commuters that travel between various anchor points. Inadvertently, the number of people located at each transit station serves to become natural forms of surveillance. One could argue that a

large number of individuals clustered together at a transit station can present an easy target for offenders to commit crime. However, one could also argue the contrary. Instead, an increase in the number of people within a station can serve to provide capable guardians willing to detect different forms of crime and thus prevent the commission of crime. Motivated offenders may become reluctant to seize upon a criminal opportunity based on the inability to approach the target without being detected and apprehended. Therefore, any increases in the number of motivated offenders or the number of targets could have no impact on the crime rate as long as there are more capable guardians present. Subsequently, whether more suitable targets or greater levels of guardianship dominate, still remains an empirical question.

2.5. Geometric Theory of Crime

As both passengers and motivated offenders travel throughout their daily routines, each individual begins to develop and possess a mental map; a conceptual framework of one's surrounding environment. Mobility heavily relies on the ability for an individual to make an informed spatial decision(s) by acquiring, processing, and synthesizing spatial information from a variety of settings. An individual develops a mental map, also known as cognitive mapping, by acquiring, storing, recalling, and coding information about the relative locations and attributes of the phenomena in his or her everyday spatial environment. Jacobson (2006) suggests mental maps can serve several functions: (a) acting as a common referent when exchanging and communicating spatial information (e.g., facilitating the description of a route to another location or to another person), (b) acting as a rehearsal mechanism for spatial behavior (e.g., to mentally prepare and preplan a journey), (c) acting as a mnemonic device used to facilitate the memorizing of information by spatially referencing the information (e.g., by locating items to be remembered within a certain spatial context), (d) acting as a shorthand device for structuring and storing spatial knowledge, and (e) acting as a device for constructing imaginary or other worlds in the mind's eye (e.g., the ability of an individual to mentally build an awareness of a landscape that he or she has never visited from a traveler's description) (Jacobson, 2006, p.301-302 as cited in Warf, 2006).

Over a period of time, an individual can refine their cognitive map of the area based on the travel paths they use to reach their desired destination(s) and thus, can be intimately aware of their nearby surroundings. Mondschein, Blumenberg & Taylor (2013) note that cognitive maps may differ based on the travel mode selected. Cognitively-active modes of travel such as walking or driving reflect higher levels of accuracy describing the location of common destinations. This contrasts against cognitively-passive modes of travel such as being a passenger in a car and/or on public transit where individuals were less able to accurately describe their location. This is an important distinction to make for understanding the relationship between public transit and crime. Passengers of public transit often engage in both active and passive cognitive mapping. Passengers will often walk (active), drive (active), be driven (passive) to reach a mode of public transit. Thus, transit users become well-rounded individuals with a vast knowledge of their surroundings.

These maps can be very revealing of a person's spatial choices and behaviour. Humans rely on mental maps to store knowledge of places and routes in order to engage in travel and activities (Mondschein et al., 2013). Within the context of crime, mental maps can help illustrate the movement of potential offenders and victims as they carry out their routine activities within a given setting. As a result, criminologists can derive how offenders may seek out opportunities to commit crime. Further, if offender movement can follow a routine series of movement, criminologists may be able to identify and predict potential hotspots of criminal offending based on the spatial behaviour of an offender.

Mental maps depict Brantingham & Brantingham's (1993) Geometric Theory of Crime. This theoretical approach can help explain the criminal event by looking to the physical and mental templates that both offenders and victims use within the built environment. Brantingham & Brantingham (1993) argue that an awareness space is a customized template of an individual's experiences and surrounding environment. Within such templates exists nodes, pathways and edges. Nodes can be best described as areas where an individual spends a vast majority of their time. Such areas can include one's home, place of employment, areas of recreation and shopping as well as school. Brantingham & Brantingham (1993) state that crime tends to occur within and around nodes due to the convergence of offenders and victims sharing the same use of space. Brantingham & Brantingham (1993) state that thousands of people share the same nodes,

such as shopping at the same malls, working in the same office buildings and changing buses at the same bus loops. Therefore, such nodes have the ability to attract crime.

Pathways are the routes between an individual or a group`s various activity nodes. As a consequence of the way the physical environment is shaped within urban centers, most pathways are channeled by major transportation routes such as main roads, highways, and public transportation routes. Many crimes cluster along or close to these major paths. Clustering tends to occur due to the volume of non-offenders and offenders converging in the same time and space, resulting in a larger number of crimes found within such areas (Brantingham & Brantingham, 1993, pg.17).

Lastly, edges are defined as places where there is an identifiable distinction from one area to another (Brantingham & Brantingham, 1993, pg.17). Edges can take on both physical and perceptual forms. Physical edges include geographical borders, such as where land meets water, or when a road is used as a boundary between two different cities. They are easily identifiable as one notices a change immediately. Perceptual edges are harder to determine, as they are subjective in nature. Perceptual edges rest on social boundaries, such as when one enters a lower income slum compared to a wealthy neighbourhood.

When combined together, nodes, pathways and edges form the basis for one's awareness space. A potential offender will conduct a primary search for criminal opportunities based on their own experiences and familiarities within the surrounding environment. Often times, it is said that one's awareness space overlaps with their activity space (Andresen, Kinney, & Brantingham, 2010, pg.20). These areas overlap with high intensity because offenders will search areas immediate to themselves rather than pursue targets at a further distance. This notion is also supported through Rengert & Wasilchick's (1985) study of burglary. Rengert & Wasilchick (1985) found that offenders use a funneling approach to seek areas to commit burglary. Offenders will select a search space for finding target selections from their awareness space. This process is further refined once an offender has found an appropriate space to commit crimes within. It is often difficult based on these activity patterns to single out offenders, as they easily blend in and become part of the same environments shared by non-offenders. As a result, offenders

do not appear to be ‘outsiders’ and can exercise their criminal motivations without a high likelihood of being detected.

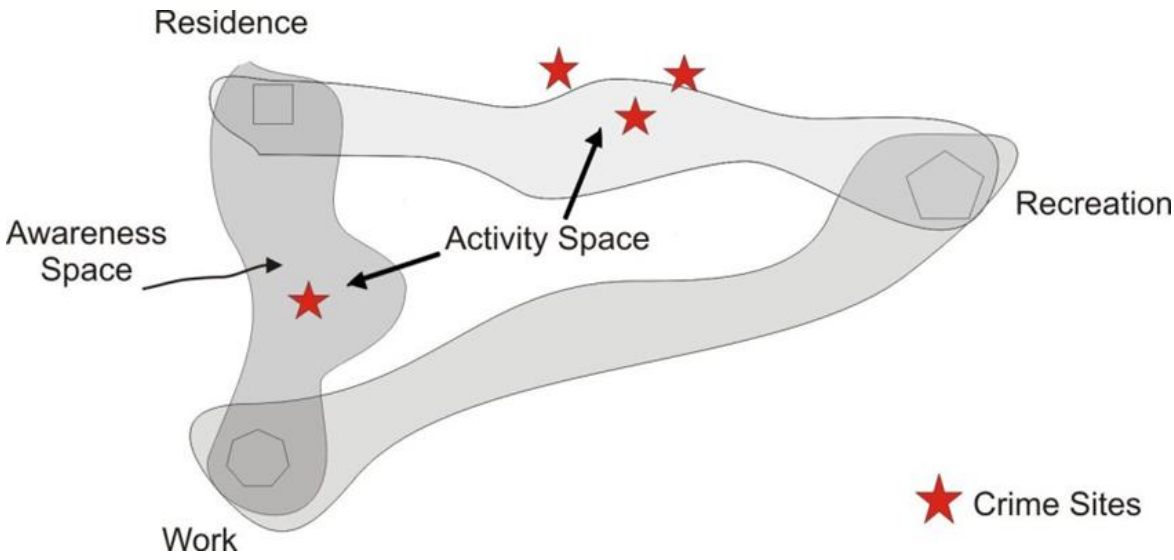

Figure 2: An individual’s awareness space according to the Geometric Theory of Crime, adapted from Brantingham & Brantingham, 1993

In the context of the mass transportation systems, it is easily identifiable how the buses and trains can serve to facilitate crime through the mobility of passengers. Potential offenders who use public transit to seek out criminal activities can expand their awareness spaces by using new pathways to reach different targets, often found at different activity nodes. An offender does not have to be limited to his or her own immediate environment, as the ease and accessibility provided by public transit can lead offenders to a new community to choose targets from. Other activity nodes that were once difficult to reach can now be easily accessible and provide the foundation for crime to increase in those areas marked by an increase in pathway accessibility.

Offenders may also decide to pursue criminal opportunities outside the physical boundaries of a transit station. Offenders may be drawn to lucrative targets found within a close proximity of the transit station such as residential homes, park and ride facilities, and commercial businesses. This change in both the quantity and quality of targets may

provide offenders justification in changing their hunting grounds from one location to another.

Target selection behaviours of offenders are highly influenced by their awareness spaces as they are defined by nodes and paths in their daily travel routines. Therefore, it is expected that crimes will be committed along the routes between offenders' homes and activity node locations (Frank, Dabbaghian, Reid, Singh, Cinnamon & Brantingham, 2011). Offenders are very alike to any other passenger utilizing public transportation to travel. By recognizing that offenders and victims travel in a similar fashion, it becomes easier to begin mapping and understanding the travel behaviour of offenders. As well, it helps provide comprehensive strategies on how to alter the transit environment to deter offenders from committing crime in the first place.

2.6. Land Use

Transit crime is highly correlated to surrounding land use of transit stations and routes. Public transport systems foster two elements within their land use: the nature of land use indicating where activities are taking place and the level of spatial accumulation that indicates their intensity and concentration (Rodrigue et al., 2009). Central areas have higher levels of spatial accumulation and corresponding land uses than peripheral areas with lower levels of accumulation. Regardless of the level of spatial accumulation, land use implies a set of relationships with other land uses. Therefore, each type of land use has its own specific mobility requirements (Rodrigue et al., 2009). The expansion of urban land uses can occur through various circumstances such as infilling (near the city centre) or sprawl (far from the city centre) where transportation systems play a role in each. Urban transportation aims at supporting transport demands generated by the diversity of urban activities in a variety of contexts (Rodrigue et al., 2009). Together, several relationships emerge that reflect the complexity between transport systems, spatial interactions and land use; a combination that serves to facilitate the potential growth of crime in public transportation systems.

Some land uses can generate crime and disorder but even amongst highly facilitative land use types, some will have combinations of location characteristics that will

be attractive to potential offenders (Kinney et al., 2008). The importance of location indicates that within a city, there will be a mixture of both high and low crimes areas (Knight & Trygg, 1977; Kinney et al., 2008; Andresen & Linning, 2012). Therefore, there will be land uses that have higher crime rates but not all units in that category will experience crime. Land use can be seen as a selection filter that helps make the patterning of crime in an urban context more understandable (Kinney et al., 2008).

Historically, land use patterns were first utilized to identify concentric impacts on agricultural land (Von Thunen as cited in Rodrigue et al., 2009). This expansion to include crime was later adopted by Burgess (1925) and Shaw & McKay (1942). Such models were one of the first attempts to study spatial patterns at the urban levels. Initially, the model was developed to analyze social classes but it began to recognize that transportation and mobility were important factors behind the spatial organization of urban areas (Burgess, 1925). The formal land use representation of this model is derived from commuting distance from the central business district creating concentric circles. Each circle represents a specific socio-economic urban landscape (Burgess, 1925).

Shaw & McKay (1942) further explored the relationship between crime and geography. Shaw & McKay (1942) sought to demonstrate how an ecological approach could be taken to understand the interaction between neighbourhood environments and crime. The authors built upon work of Burgess (1925) to illustrate that concentric circles existed within the urban social structure of cities (in this case, Chicago). Furthermore, such circles were related to crime patterns. Results from the study indicated that neighbourhoods that suffered higher rates of crime were characterized as suffering from high residential turnover, high unemployment and low rates of home ownership (Shaw & McKay, 1942). Results also showed that the central business districts within Chicago suffered the highest recorded level of crime compared to their suburban counterparts further away. The outcome of the study was critical for the development of crime and space, as it acknowledge that crime and space has geography (Andresen, 2006). Such models are critical to understand as it helps demonstrate how individuals move from one area to another to reach their activity nodes. In doing so, it provides a mapping template of how offenders can travel within an urban centre to seek out criminal targets and what types of areas are more attractive for offenders to commit crime.

Rodrigue et al. (2009) contend that transportation and land use are part of a dynamic system that is subjected to many external influences. Each component of the system is constantly evolving due to changes and advancement in technology, policy, economics, demographics and culture. Such changes result in interactions between land use and transportation changing the outcome of many decisions made by different levels of governance and the community. The authors suggest that there are five significant components of an urban dynamic system. They include land use, transport network, movements, employment & workplaces, and population & housing. In focusing on movement, Rodrigue et al. (2009) suggest this aspect is the most dynamic component of the system as movement of passengers and freight reflect almost immediate new changes to the environment. Movements therefore tend to be more of an outcome of the urban dynamics than a factor shaping them. If you were able to alter movement on transit systems, you could have an immediate impact on crime, both positive and negative.

Newton & Bowers (2007) examined the geography of bus shelter damage in relation to the criminogenic and socio-economic characteristics of its neighbourhood and the local land use context. Findings of the study demonstrated that shelter damage was related in a known and predictable way to known characteristics of its neighbourhood, and that shelters in areas with high levels of anti-social behaviour and violence against the person were more susceptive to bus shelter damage. More importantly, the presence of parks, children's play areas and schools were positively correlated with shelter damage. Surprisingly, negative relationships were found between shelter damage and the presence of pubs, clubs, and off-licenses. These results demonstrate the role land use plays in relation to criminal activity.

Public transportation systems benefit from operating in urban centres based on ideal conditions such as high density, short distances and shared services. Transit routes that operate along major business and commercial corridors experience an influx of business but also may witness an increase in crime. A greater number of opportunity structures may exist within heavily populated areas surrounding a transit route. More targets may become available for potential offenders to victimize resulting in a possible increase in crime.

2.7. Conclusion

Transit settings have demonstrated that a number of different opportunity structures are available for motivated offenders to victimize against. Offenders may be drawn to transit stations to commit crime due to the target rich environments that help gather targets in both time and space, thereby providing ease and accessibility for offenders to commit crime. By examining the relevant criminological theory, our discussion demonstrates how the built environment can help explain offender mobility and target selection within particular settings, such as modes and stations of public transportation systems. To provide further insight into the relationship between public transit systems and crime, a review of empirical studies examining transit crime will be studied.

Chapter 3. Transit & Crime Literature Review

3.1. Introduction

Public perceptions express fears and concerns that public transit spreads crime. This belief is often a major reason for opposing the implementation and expansion of urban mass transit systems. However, research that has explored this relationship between transit and crime has provided mixed results. Block & Block (2000) state that geographic patterns of crime can reflect public transit routes, however, this correlation may be due to other factors than the causal effect of access to public transit on crime. The following provides a comprehensive examination of past empirical research studies that have explored the impact on crime from the implementation and/or expansion of a mass public transportation system.

3.2. United States

Capone & Nichols (1976) sought to explore the relationship of criminal mobility as the structure of an urban city provides considerable insight into the spatial distribution of crime (Capone & Nichols, 1976). Offenders are constrained by the number of criminal opportunities within any given environment, thus, by understanding how the urban structure of cities works, one can understand how offenders make decisions. Capone & Nichols (1976) sought to determine the distance biases of robbery offenders within Miami, Florida to demonstrate that individual offender behaviour is related to the movement of Miami's urban transit system. As well, the frequency of robbery trips within urban spaces declines with increasing distances from the residential locations of offenders. Data was collected in 825 robbery trips (642 cleared robberies) within Miami in 1971. Data was drawn from Dade County's police records, presenting both the urban core and suburban neighbourhoods. Trip distances to commit robbery were calculated for all 825 offenders through plotting the origin of the trip (location of residence) and the destination (location of occurrence). Results demonstrated that trip frequency declines dramatically with distance, with 33% of all robbery trips occurring within one mile of the offender's residence. Capone & Nichols (1976) found that premises such as liquor stores, super markets and

loan companies were more indicative of offenders making lengthier trips to commit crime opposed to residences, grocery stores and gas stations. Overall, Capone & Nichols (1976) assert that robbery trip distance is a function of the distribution of opportunities and their different attractiveness to offenders. This study is a good example of demonstrating how offender mobility and the level of crime on transit systems are a direct function of land use.

Pearlstein & Wachs (1982) studied the criminal impact of extending bus routes in Los Angeles, California. The study selected the Southern California Rapid Transit District (SCRTD) of Los Angeles to employ both interviews and official crime data to determine whether crime in surrounding communities of the bus route increased crime. The SCRTD borders 5 communities that host over 8 million people. The system boasts over 3000 buses with approximately 200 routes (Pearlstein & Wachs, 1982). To determine whether the number of criminal incidents increased crime within the surrounding neighbourhoods of the rail system, a statistical analysis was applied. The study was conducted over a 10 year period and employed several in-person interviews with transit security, law enforcement and planning officials to gain further insight into the phenomenon of transit crime.

Results from the study demonstrate that crime on transit had increased, but only in proportion to the level of transit ridership, a number that is concentrated in both space and time (Pearlstein & Wachs, 1982). Communities that witnessed an increase in crime had already experienced high crime rates, with crime disproportionately higher during the evening hours of the day. Bus drivers experienced much higher rates of exposure to the dangers of criminal incidents than transit passengers (Pearlstein & Wachs, 1982). The authors suggested that transportation planning must consider the environment in that transit extension takes place in order to best implement measures to prevent further crime from occurring.

Plano (1993) made one of the first attempts to study the relationship between transit expansion and crime. Plano (1993) argued that crime occurrences are added without concerns as to how the offender travelled to his or her destination or without delineation of where exactly the crime occurred on a transit system. The study analyzed

crime patterns within neighbourhoods surrounding three new Baltimore light rail stations over a period of six years. Plano (1993) utilized Part 1 offences from the Uniform Crime Report (UCR)[1]. Results indicated an unpredictable upward trend in offending for the three subject neighbourhoods. However, the results display similarities to county-wide trends during the same time period. Both the transit system and the local level of crime attributed to the increases witnessed in this study.

Poister (1996) examined the criminal impact of expanding public transit systems into suburban neighbourhoods in Atlanta, Georgia. The study utilized two stations: one station in an urban centre and one station in a suburban neighbourhood to determine whether the two recently added stations had impacted the local crime rate[2]. The author hypothesized that the number of reported criminal incidences during the first fifteen months of the new stations would be significantly greater from pre-intervention patterns of the rail system. Thus, the level of post station reported criminal incidents would be greater than pre-station levels, indicating that the expansion of transit stations would facilitate greater levels of crime.

Results demonstrated that larceny within the Kensington station increased after the implementation of the station with similar trends found within the Indian Creek station. However, increases in burglary at the suburban stations should not be directly correlated to the introduction of the new station, as burglaries within the adjacent neighbourhood to the suburban station began increasing several months prior to the opening of the station. The author suggests that despite some small increases in the number of reported criminal incidences surrounding the two stations, the trend of crime tends to return to pre-transit station levels (Poister, 1996). Therefore, the light rail transit system should not be held responsible for the small increases witnessed in both stations in this particular case.

Block & Block (2000) considered the effects of rapid transit stops on nearby surroundings. The authors state that characteristics of an area affect the relative danger at a transit station, and the presence of a transit station often affects the relative danger

[1] Offences included robbery, burglary, aggravated assault, arson, larceny, auto theft, forcible rape and homicide.

[2] Twelve types of crime were included in the study: larceny, assault, burglary, auto theft, criminal trespass, robbery, vagrancy, criminal damage, drugs, disturbing the peace and homicide.

in the immediate area (Block & Block, 2000, p.138). To help negate feelings of fear and danger on transit systems, transit authorities have made great efforts to enhance the safety of passengers through the design of stations and hiring personnel to help limit criminal behaviour. However, such efforts are mainly targeted to the stations alone and ignore the surrounding area of a transit station. To help address the effects of mass rapid transit stops on nearby spaces, Block & Block (2000) conducted a study to explore robbery patterns in two metropolitan cities. Specifically, the authors explored patterns of street robbery that occurred near elevated railroad stations (ELs) on the Northeast Side of Chicago and Bronx of New York.

For the Chicago study, Block & Block (2000) used crime data from the Chicago Police Department. Offence included actual and attempted street robberies known to police between 1993 and 1994. Important to note, the data did not include robberies that occurred on public transit or inside of a transit station. Block & Block (2000) state that 'although a street robbery may have occurred near a rapid transit station; there is no indication within the data as to whether the victim was en-route to or from a station' (p.138). The analysis examined the risk of street robbery in the area surrounding 10 EL stations that covered approximately 25 kilometers. For the Bronx study, crime data was supplied by the New York City Police Department and examined robberies that occurred between October 1995 and October 1996. Unfortunately, limited census and land use data prevented the authors from creating a substantial spatial analysis.

Results for the Chicago study demonstrated that a total number of 1,793 street robberies occurred at 1,563 different places in the area. Thirty-six percent of the 1,793 incidents occurred within two block lengths of a transit station. Fifty-seven percent occurred within four blocks of a transit station. Block & Block (2000) found that of the 11 hotspots identified through the analysis, 10 included a rapid transit station. The study argues that surrounding land use of the transit stations influences the level of street robbery that occurs. Near the transit stations were bars, convenience stores, laundromats, and currency exchanges. All of these businesses are open late and primarily conduct cash transactions. Therefore, such businesses attract and create additional risk.

Despite the Bronx subway system being considerably larger in size in both structure and level of ridership, Block & Block (2000) found similar results between street robbery and proximity to a transit station. Of all reported robbery to the police between October 1995 and October 1996, (4,092), half occurred on the street at 2,661 different addresses. Similar to their counterparts in Chicago, the densest concentrations of street robbery occurred near rapid transit stations. Of 7 hotspots identified, each hotspot had 1 transit station, with one hotspot containing 5 stations. Additionally, nearby land uses influenced the level of crime committed near the transit stations.

Overall, Block & Block (2000) demonstrate the importance of taking into consideration the neighbourhood characteristics that can generate crime. The backcloth, the stations, and shops & services that serve transit riders may attract legitimate customers as well as predatory offenders. The authors note that travel on rapid transit systems 'may widen the mental map of young street criminals from other neighbourhoods who are looking for attractive targets in communities with more affluent residents" (Pyle, 1974 as cited in Block & Block, 2000, p.149). Although knowledge of an area can decay with distance from home, rapid transit stations can create nodes of knowledge far from home.

Loukaitou-Sideris et al. (2002) explored the relationship between transit crime and the socio-demographic environment surrounding the Los Angeles Green Line Rail System. Loukaitou-Sideris et al. (2002) sought to determine the amount, type and frequency of criminal incidents along the line to help understand the influence transit crime can have on both the physical and social characteristics surrounding the station and the nearby neighbourhood(s). Loukaitou-Sideris et al. (2002) sought to explore the distribution of crime along the Green Line by determining where transit crime occurs (on the train, platform, parking lot or escalators/elevators), and determining a potential link between neighbourhood density, station ridership and socio-demographic characteristics to crime.

Findings from the study indicated that certain stations do have a greater number of crimes compared to others; however, this does not make the whole line any less unsafe (Loukaitou-Sideris et al., 2002). Type 1 UCR offences were mostly concentrated in the

park and ride lots; most offences were motor vehicle related theft, burglary and larceny. Type 1 offences such as robbery and assault concentrated on train platforms. Type 2 UCR offences (mostly vandalism) were significantly correlated to the size of the population living in vicinity of the station (Loukaitou-Sideris et al., 2002). Type 2 offences were also concentrated in stations located in densely populated neighbourhoods where the average level of education was less than a high school diploma. The study also reported a strong correlation between station crime and the existence of liquor stores in the vicinity. The study demonstrates a clear indication that a combination of social and physical variables at the light-rail stations and its surrounding neighbourhoods impact the level and type of transit crime.

Ihlanfeldt (2003) explored the criminal impact of public transportation on levels of neighbourhood crime in Atlanta, Georgia. The author argues that despite the potential for crime to increase with the introduction of a new route, there are reasons to believe that crime can decrease. Although a station may increase access to the neighbourhood by outside criminals, it may also induce criminals living within the neighbourhood to commit their crimes elsewhere by lowering commuting costs between the home neighbourhood and other neighbourhoods (Ihlanfedlt, 2003). To determine whether new rail systems could impact the local crime rate, Ihlanfedlt (2003) utilized economic models of crime data on Atlanta's MARTA system. Results indicated that rail stations have a statistically significant effect on neighbourhood crime. The effect, however, varies with three characteristics of the neighbourhood: median income level, density of poverty and average distance to low income earners living outside the neighbourhood (Ihlanfedlt, 2003). Transit increased crime in central city neighbourhoods whereas suburban neighbourhoods witnessed a decrease and/or null effect from transit. Overall, the results demonstrate that fears and concerns over station-induced neighbourhood crime are unfounded and that extensions of rail transit into suburban neighbourhoods will not necessarily cause further decentralization of the population and employment.

Sedelmaier (2003) undertook a study to examine the effects of a new public transit system upon local crime patterns along the Hudson-Bergen light rail system in Jersey City. The author argued that the introduction of a new public transit system may impact crime patterns in the neighbourhoods adjacent to the new route. Previous research has

contended that new public transport systems are a concern as they have the ability to bring potential targets and offenders together in both time and space; thus, crimes are committed at a greater level within and surrounding the station(s). Further, the expansion of transit systems can introduce offenders to previously unexplored hunting grounds to see out new targets to victimize against. Sedelmaier (2003) sought to empirically test his hypothesis of transit system expansion and crime growth.

Findings revealed that the new light rail system had a minimal impact upon the station area's crime patterns. The average monthly number of calls for service decreased or remained the same following service introduction and was significantly distant from the light rail stations (Sedelmaier, 2003). Lastly, this system did not appear to have introduced non-local offenders to its adjacent neighbourhoods. Overall, this study demonstrates that the addition of public transport options does not result in a necessary increase in crime.

Liggett, Loukaitou-Sideris & Iseki (2003) sought to examine how transit lines can potentially increase the level of crime within communities' adjacent to major public transportation systems. The Los Angeles Green Line was selected as the focal point of the study to determine whether the Green Line could export crime from high crime inner city areas to low crime suburban neighbourhoods (Liggett et al., 2003). Results indicate that the Green Line has not exported crime from inner city neighbourhoods to suburban neighbourhoods. Most station neighbourhoods either did not witness any changes or noted a reduction in crime after the implementation of the Green Line. The authors identified a small crime increase within the inner city, where 'limited spillover effects of crime from more high crime to less crime-ridden areas were observed' (Liggett et al., 2003, p.110). Therefore, a relationship between hot spots of crime and the proximity of a transit station did not exist. Rather, the presence of certain land uses was more likely to facilitate crime than a transit system itself.

Yu (2009) investigated the relationship between bus stops and crime in Newark, New Jersey. A variety of data sources were used including crime data from Newark City Police, Verizon's Yellow Book New Jersey database, New Jersey Transit Corporation mass transit data, and the Newark land use and zone district information, for the year of 2007. UCR classified offences such as robbery, aggravated assault, motor vehicle theft,

theft from motor vehicle, and burglary were examined. The crime data contained information on the data, time, weapons used, location, and type of crime premises. The data generated a total number of 2,118 bus stops that were analyzed.

The study employed a variety of methods to test the hypothesis. First, the study examined the magnitude and structure of spatial dependence in the data. Second, spatial process models were performed and compared with ordinary least squares (OLS) results to examine the impact of spatial aspects on the regression results. Lastly, to address non-normality and spatial dependence of the data, a count response model was used by adding spatial lag as one of the predictors (Yu, 2009). Results illustrated that both bus stops and commercial establishments were associated with increased crime in the neighbourhoods. Among business types, the category of 'food store' was almost always significant to increased crime (Yu, 2009). Surprisingly, banks were not found to be statistically significant across crimes types and regression (Yu, 2009).

Billings et al. (2011) sought to determine whether fears of public transit systems as crime generators should be merited. The authors conducted a study examining the South Light Rail (SLR) corridor in Charlotte, North Carolina, using crime statistics rather than perceptions to determine the criminogenic effect public transportation systems can have on local levels of crime. Results of the study indicated that the announcement of rail transit led to a decrease in property crimes. Furthermore, the decrease in crime was maintained after the stations opened, and did not return to pre-announcement levels. Such results contrast commonly held perceptions that public transit 'breeds crime' (Billings et al., 2011, p.560). These results are significant in the study of public transit and crime as it indicates that transit systems may actually impede crime. The authors account that the decrease may be attributed to public and private decisions to invest along rail transit corridors. In turn, such investments help to gentrify surrounding neighbourhoods and thus, decrease criminal activity.

Robinson & Giordano (2012) studied whether crime occurring in areas in close proximity to public transit locations was influenced by land use. Past research has demonstrated that higher levels of crime and fear of crime are related to particular land uses such as shopping malls, fast food establishments and transit stations (Robinson &

Giordano, 2012). As a result, nearby land use can become an extremely important tool in explaining crime. The current study sought to explore the possible relationship between locations of transit stations to land uses to crime patterns within the urban environment. Robinson & Giordano (2012) coin the term 'spatial interplay' to describe the combination of criminogenic influences of intersecting land uses. The study explores spatial interplay in areas surrounding transit locations in Boston, Massachusetts.

Crime data was obtained from the Boston Police Department and covered a time period of January 2002 to September 2005. Incidents included all UCR Part 1 crimes (excluding arson) as well as citizen complaints/calls for service for many disorder offences such as panhandling, prostitution and noise complaints, resulting in a total number of 281, 803 incidents (Robinson & Giordano, 2012). The authors examined the influence of different types of land use upon the rates of calls for service at distance radii of 50, 200, 400, 500, 600, and 750 meters away from each station. Findings of the study demonstrated that incident rates were highest within the 50 meter distance radius and rates declined further away from the stations (Robinson & Giordano, 2012). This pattern was consistent amongst the 12 separate incident categories except for residential burglary; burglary rates were slightly higher in the 200 meter radius than in the 50 meter zone. The results suggest a distance decay pattern as most incidents tended to be more concentrated, the closer one was to the station.

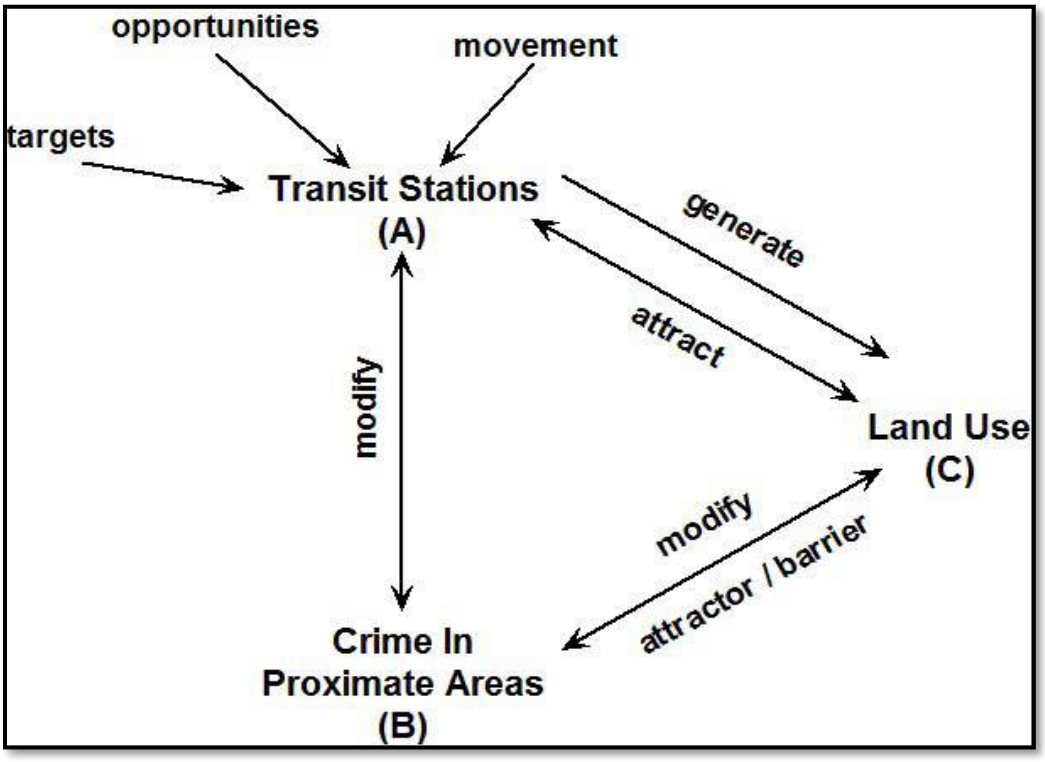

Figure 3: Spatial interplay between transit, land use as the intervening variable, and criminal incidents, adapted from Robinson & Giordano, 2012

The results presented by Robinson & Giordano (2012) illustrate the importance of considering land use within the context of transit crime. The results provide support that the presence of transit stations 'could be related to the pattern of incidents, in conjunction with the types of land uses that are present within the station areas' (Robinson & Giordano, 2012, p.144). The combined presence of a transit station, sports arena, parking lots and liquor establishments were related to higher rates of robbery, aggravated assault, larceny, and motor vehicle theft. Alternatively, the combination of public transit and residential land use may be related to higher rates of residential burglary.

Sedelmaier (2014) performed a similar study on transport system expansion and crime in Jersey City, New Jersey; expanding upon his previous research in 2003. The author sought to determine whether a newly introduced light rail system has altered the crime opportunity structure in neighbourhoods located nearby the Hudson-Bergen Light Rail (HBLR) system. Adult offender arrest data was provided by the Jersey City Police Department to help determine if adult offenders utilized the HBLR to reach new

neighbourhoods to seek out alluring criminal targets. Mapping software was utilized to first select offences committed within a light rail station area and then categorize based upon the distance of the arrestees' last known address from the nearest light rail station. Chi-square tests were used to examine the proportion of local and increasingly distant arrestees connected with crimes committed within each service zone before and after the system entered service. The arrest data covered a time period of January 1998 to October 2001. The data provided information about the location of the incident, location of arrest and the home address of the arrestee's. To address incidents that involved a single arrest but accounted for more than one offence, crime was re-classified into four main groups: violent offences[3], property offences[4], morals/narcotics offences[5], and other offences[6] (Sedelmaier, 2014).

Findings demonstrated 'little support for the hypothesis that HBLR has been a catalyst for introducing distance offenders to new offending areas' (Sedelmaier, 2014, p.175). The Newport Service zone was the only area that appeared to have instances where outsider arrest formed a majority and were primarily responsible for property crimes committed at the nearby shopping mall. The author found some evidence to suggest that larger, well-established transport systems may deliver offenders to criminal opportunities, particularly within the Newport service zone. Many of the arrestee addresses falling outside the boundaries of Jersey City in this area were located in Newark, Manhattan and Brooklyn, New York. This finding suggests that many of the arrestees could have used other systems to reach the shopping centre asides from the HBLR. Overall, Sedelmaier (2014) demonstrates that improving access to new areas is only part of the journey-to-crime equation; the perceived availability of suitable targets is at least equally important.

Stucky & Smith (2014) pursued whether the effects of bus stops on crime were direct characteristics of the areas surrounding the bus stops (land use). Secondly, the authors also explored whether the effect depends on the type of crime (i.e. robbery and assault). Crime data was obtained from the Indianapolis Metropolitan Police Department

[3] Violent crimes included: homicide, assault, sexual assault and robbery
[4] Property crimes included: burglary, theft and automobile theft
[5] Morals/narcotics crimes included: drug-related or low-level sex offences
[6] Other crimes included: criminal mischief, disorderly conduct, weapons possession

(IMPD) in 2010, bus stop locations from the City of Indianapolis and socio-economic characteristics from the census bureau (Stucky & Smith, 2014). The authors utilized 500 feet x 500 feet square grid cells overlaid on the IMPD service area within the city. The IMPD UCR crimes included bust stop-crime relationship for individual UCRS crimes counts for homicide, rape, robbery, aggravated assault, burglary and larceny. Land use variables included schools, cemeteries, hospitals, parks, industrial land use, commercial businesses, high-density housing, and primary and secondary highways.

Results indicated that the average number of reported UCR violent and property crimes was lowest when there were no bus stops in the cell and increased as the number of bus stops in the cell increased (Stucky & Smith, 2014, p.7). Thus, bus stops were associated with consistently higher UCR violent and property crime counts in grid cells, except for homicide. In regards to land use, the study found that commercial and industrial land uses enhanced the bus stop-crime relationship; whereas the presence of density housing weakened it. A limitation of the study was its inability to distinguish crimes that took place on the bus versus near the bus stop. Additionally, Stucky & Smith (2014) were unable to examine specific characteristics of each bus stop itself to determine if this had an influence on the level of crime at the bus stop.

The characteristics of transit stations can play a crucial role in the number of crimes committed within transit settings. Irvin-Erickson & La Vigne (2015) investigated the potential relationship between Metro transit stations and station characteristics in Washington, DC. The authors employed a negative binomial regression to model the dependent variables as a function of nodal and place-based crime-generating and crime-attracting characteristics of the station (N=86) (Irvin-Erickson & La Vigne, 2015). The crime data was provided by the Metro Transit Police Department (MTPD). The study's independent variables included connectedness, remoteness, accessibility, and activity level (AAL), socio-economic status (SES), and other crimes such as alcohol violations, public urination, and vandalism. The dependent variables of the study included Part 1 UCR crime offences[7] for the year 2008 and occurred directly within the metro rail station. The dependent variables were assigned to three different groups to reflect the counts of

[7] Part 1 UCR offences included: robbery, larceny, aggravated assault, and disorderly conduct

the dependent variables during peak and non-peak hours of the Metro system (Irvin-Erickson & La Vigne, 2015). Peak hours included: 4:30 am to 9:30 am and 3:00 pm to 7:00 pm. Non-peak day hours are 9:00 am to 3:00 pm and lastly, non-peak night hours are 7:00 pm to 4:30 am (Irvin-Erickson & La Vigne, 2015).

Irvin-Erickson & La Vigne (2015) observed a number of key findings. First, stations were attractors of larcenies during peak hours and were attractors of disorderly conduct during non-peak hours (Irvin-Erickson & La Vigne, 2015). Stations that offered connections to other parts of the metro station were found to be generators of larcenies and disorderly conduct during peak hours. During non-peak day hours, these same stations were found to be generators of robberies (Irvin-Erickson & La Vigne, 2015). Accessible stations were found to be crime generators robberies and larcenies during non-peak night hours. Stations that were housed in the block groups with low SES were crime attractors for robberies during peak hours and non-peak night hours. Stations that were housed in the block groups with high SES were crime attractors for larcenies during peak and non-peak day hours. Stations that experienced other crimes were crime attractors for robberies and aggravated assaults during peak hours, and they were attractors for disorderly conduct during non-peak night hours.

Overall the findings from this study not only suggest that stations assume different nodal and place-based crime-generating and crime-attracting characteristics, but also these roles vary for different crimes at different times. The indicators used in this study, in particular, the level of activity and the accessibility of the station, the level of crime at the station, and the connectedness of the station to other stations were consistent indicators that had a positive correlation with crime rate ratios. Different characteristics of the station—such as being a remote station or belonging to a high or low SES block group—were identified to be significant correlates for particular crime outcomes such as disorderly conduct, robbery, or larceny. Lastly, the findings demonstrate that the level of crime at Metro station was dependent on the immediate and edges of the environment that the stations were located in.

Phillips & Sandler (2015) sought to explore whether temporary rail station closures had a deterrent effect on the level of reported crime in Washington, DC. The study

employed geo-coded data on reported crimes made available by the Washington Metropolitan Police Department. Data for all crimes reported to the District of Columbia from January 1, 2011 to October 7, 2013 for 8 types of crime: assault, sexual assault, robbery, arson, burglary, stolen auto, theft, and theft from arson. Each crime entry provided the date, time, type of crime, and the geo-coded block location of the offence. The crime data was then combined with geo-coded locations of transit stations to measure crime in the neighbourhood of each station. For each date-hour time period and station in the sample, Phillips & Sandler (2015) measured the number of crimes committed within a quarter of a mile of the station. To enhance specification, the authors made use of 'rings' around each station of various radii. For example, the authors define the half-mile ring around a station as the number of crimes occurring between ¼ and ½ mile from the station. These values were then multiplied by 100 so that it could be interpreted as a percent of a crime (Phillips & Sandler, 2015, p.15). Ridership data was also applied to gauge the mechanism by which station closures affect crime. The crime and ridership data were then combined on maintenance-motivated station closures and delays in the Washington Metropolitan Area Transit Authority (WMATA) rail system. The data covered 41 stations and 4 train lines inside the District of Columbia and included a total of 4897 station-hour closures. The study focused solely on instances in which rail access to a station is completely eliminated and replaced by shuttle buses. Using the above data sets, the study used a regression framework to determine the effect of public transit on crime.

Results demonstrated that closing one station reduced crime by 5% in the vicinity of stations on the same train line (Phillips & Sandler, 2015). Most of this effect remains after controlling for decreased ridership, indicating that a decrease in the availability of victims does not drive most of the results. Evidence suggests that crime falls more at stations that tend to import crime (i.e. stations where offenders are less likely to live). Additionally, larger decreases at stations on the same line when the transit authority closes stations that tend to export crime. The results suggest that the response of offenders to increased transportation costs contributes to the decrease in crime.

3.3. Canada

Beavon, Brantingham & Brantingham (1994) undertook a study to explore the relationships amongst the concentration of criminal targets and the accessibility of street networks. The authors hypothesized that the design of street networks will influence the mobility of people within a city and thus will affect their familiarity of places. Areas with the most complex of road networks and fewest destination points should report the lowest levels of property crime (Beavon et al., 1994). The study utilized ex post factor research designs in two suburban municipalities within the Lower Mainland of British Columbia to empirically validate their hypothesis. Further, the study also sought to compare the relative amount of property crime in each street segment with the segment's relative accessibility, traffic volume and quantity of potential targets. Results demonstrated that both road network complexity and traffic flow were of great significance. Levels of crime were higher in more accessible and highly used areas and lower in less accessible and less used areas. It was noted that the concentration of potential targets was extremely related to accessibility, traffic flow and overall property crime totals. Results indicate that the urban background is a fundamental aspect to consider in crime analysis as it has been created through zoning and road network development. This is extremely important to implement in studies of urban transport and crime as they may help indicate which stations may be at higher risk of victimization based on the surrounding road network and intersection of streets.

Also in support of transit systems facilitating a greater level of crime is the study of Vancouver's SkyTrain system by Buckley (1996). Buckley (1996) utilized calls for service data provided by the Vancouver Police Department to determine whether an increased volume of police calls for service was generated within a 750 meter radius around each SkyTrain station in Vancouver. Results demonstrated that high rates of criminal activity were situated within fifty meters of a SkyTrain station. Specific land uses such as parks, stadiums and liquor establishments also contributed to a greater number of calls (Buckley, 1996). Such findings illustrate how land use and the location of a station can impact the level of crime, not solely the physical presence of a station.

Tillyer (2003) sought to explore the potential criminal impact of Vancouver's SkyTrain route, the Expo Line. Tillyer (2003) chose to focus on four Expo line stations within the City of Burnaby: Metrotown, Patterson, Edmonds, and Royal Oak. Crime data was provided by the Burnaby RCMP that included all calls for service for assault, commercial break and enters, mischief, possession of cocaine for the purpose of trafficking[8], and residential break and enter. Crime types were analyzed across each of the four stations using a visual inspection of their spatial occurrence using a variety of geographical information system (GIS) techniques.

Results of Tillyer's (2003) work indicated that the stations of Patterson, Royal Oak and Edmonds did not demonstrate a significant amount of clustering across any of the crime types. However, Metrotown station demonstrated a high occurrence of assault, commercial burglary, mischief and residential burglary in its surrounding area. The study attributes the level of reported crime to surrounding land use opposed to the SkyTrain stations themselves. A general pattern that emerged demonstrated that crime clustered around stations built in commercial areas as opposed to those built in residential areas. The author notes the importance of considering the role of land use in relation to transit crime. A SkyTrain station may not necessarily increase crime, but rather, the type of environment in which a station is placed could be responsible instead. Due to the study being exploratory in nature, further research should be undertaken in the form of time series regression to determine before and after effects of implementing a mass transit system in a city.

Tay et al. (2013) examined the effect of public transportation on neighbourhood crimes. In particular, the authors sought to evaluate the impact of the introduction of new transit train stations on different crime rates in the surrounding communities. The study utilized station community crime data from the City of Calgary's light rail transit (LRT), C-Train system. Data was collected and provided by the Calgary Police Service between a period of 2000 to 2009 and included 5 stations of the C-Train system. The study employed a 600 meter radius to identify surrounding communities to be included in the treatment

[8] The inclusion of possession for cocaine for the purpose of trafficking was requested by the Burnaby RCMP to determine if there was a possible link between trafficking the illegal substance and drug dealers who use the SkyTrain to exchange services.

group. The authors used a before-after approach to witness any changes to the crime rate. Results demonstrated a mixed outcome on crime; the effects of the opening of a train station on neighbourhood crimes depended on the locations and types of crime involved (Tay et al., 2013). This study helps emphasize the importance of studying transit crime in relation to land use and location of stations. By identifying characteristics of the locations of the new or proposed stations, more target interventions can be employed to help combat a potential rise in crime.

Gallison (2016) examined the potential increase in crime from the implementation of a new SkyTrain route in Metro Vancouver, British Columbia, Canada. Gallison (2016) sought to determine whether fears and concerns over a new SkyTrain route, the Canada Line, should be validated, examining whether an increase in the number and types of crimes were occurring within communities located nearby the Canada Line's stations. The Canada Line is the most recent addition to Metro Vancouver's rapid transportation system, the SkyTrain. The line was built to alleviate traffic between the cities of Vancouver and Richmond, a residential suburban area in Metro Vancouver with the international airport. The line was also aimed to help transport visitors and athletes for the 2010 Winter Olympic Games that were held in February and March of 2010. According to previous reports from concerned residents, merchants, and police, crime was viewed as one of the immediate repercussions from expanding the system.

Crime data (PRIME-BC)[9] was provided by the Richmond Royal Canadian Mounted Police (RCMP) that included a time period from January 2006 to August 2011 (Gallison, 2016). Stations selected for the analysis include Bridgeport, Aberdeen, Lansdowne, Richmond-Brighouse, Templeton, Sea Island Centre and YVR Airport, all of which are located in the City of Richmond. Offences were categorized as violent, property or other. Overall, there were a total of 9386 offences with 851 of these violent in nature, 6538 classified as property, and 1997 classified as other. Crime statistics were derived from 'actual offences', indicating crimes that upon preliminary police investigation were deemed to have occurred or been attempted. Criminal incidents were included within the analyses if they occurred within a 250 meter buffer zone surrounding each Canada Line station in

[9] PRIME-BC stands for Police Records Information Management Environment for British Columbia.

Richmond. Therefore, criminal events were included within the current sample either directly occurred within the station or very close to the transit station. The author selected a time series regression technique to determine whether stations of the Canada Line within Richmond, BC experienced a greater number of offences since the implementation of the new mass transit system. Such changes would take place from August 2009. Additionally, whether all categories of crime would begin to decrease to pre-Canada Line crime trends by August 2011. Therefore, crime may initially increase with the implementation of the new route but may return to previous crime trends as the route becomes stabilized within the community.

Results of the study demonstrated that the introduction of the Canada Line did not yield a substantial increase in the number of crimes reported to police. Instead, the number of offences began to decrease after the implementation of the new route in August of 2009. The results of the study suggest a possible deterrent effect the SkyTrain may have had on crime within the adjacent neighbourhoods to the route (Gallison, 2016). The study acknowledged some limitations including the dark figure of crime, parameters of offences and the generic categorizing of offences. Overall, the analysis demonstrates the importance of examining mass transit routes to determine whether perceptions and fears of crime and transit should be merited. Further, it also shows the importance of considering the built environment in relation to the location of mass forms of public transportation systems.

3.4. International

Clare, Fernandez & Morgan (2009) aimed to build upon Bernasco and Nieuwbeerta's (2005) study to examine the presence of barriers and connectors between residential neighbourhoods and their impacts upon target choices made by residential burglars in Perth, Australia. Previous literate examining burglars' offending location choices has produced mixed results about the influence of physical barriers and connectors on offender movement patterns. Residential burglary data was obtained from the Western Australian Police. Information regarding each burglary incident contained details on the nature of the burglary (attempted or actual) and the general location of the burglary (i.e. suburb). Findings from the study suggest that physical barriers and

connectors exert significant influence on offender decision-making. Further, the influence of impermeable barriers increased with proximity of these obstacles to the offender's point of origin. Within the context of public transit, Clare et al. (2009) found that connectivity had a significant impact upon target choice, as burglars living in neighbourhoods with rail stations were twice as likely to choose targets in neighbourhoods located along that system. Although these findings do not explicitly state that offenders used the system to reach the point of offence, the results are highly suggestive that the transport system influenced the offenders' awareness spaces (Clare et al., 2009).

Ceccato, Uittenbogaard & Bamzar (2013) undertook a study to explore crime in underground train stations in Sweden. The authors contend that different parts of an underground station are exposed differently to crime and disorder (Ceccato et al., 2013). The design of the stations and the internal and external environments of the stations may influence the level of crime. At the stations, crime is a product of two dimensions: the environment of the transport node itself and the social interactions that take place in these environments (Ceccato et al., 2013). To empirically test the conceptual model discussed above, Ceccato et al. (2013) used the stations of Stockholm, Sweden's underground transportation system as their case study. In doing so, the authors could assess the security conditions in underground stations and the surrounding areas where individuals' trips take place. This can be achieved by exploring environmental attributes of the stations and their surroundings to explain variation in the nature, levels and patterns of crime and disorder in the underground stations over time and space.

Findings demonstrate that an overwhelming amount of reported events within the underground stations are public disorder in nature. The majority of recorded crimes at the stations included fights, vandalism and threats. The results demonstrate clear temporal and spatial variations of both crime and public disorder events. Ceccato et al. (2013) argue that this environment is highly criminogenic because it is composed of mixed land use such as pubs, restaurants and other transport nodes. End stations showed higher rates of events (crime and public disorder) than stations located in the inner city areas. The authors suggest that these stations may be more vulnerable to experience higher levels of crime and public disorder events as they do not easily allow guardianship and natural surveillance from the outside. Overall, the study demonstrates that security in

underground stations is a function not only of the local conditions, but also of the surroundings in that such transport nodes are located.

Ceccato & Uittenbogaard (2014) conducted a case study of Stockholm's subway system to explore daily, weekly, and seasonal variations of crime at underground stations. The authors advocate the need to explore the role of the environment on crime in transport nodes. Any given transit system is a complex interaction of settings (buses, trains), facilities (stops, stations, and interchanges) and uses (staff and passengers) (Ceccato et al., 2014, p.134). The design of these facilities and the internal and external environments can influence the level of crime and/or perceived level of safety experienced on the system. Offenders can easily commit crime in transport settings as there is often easy access to transport nodes, unfamiliarity of the passengers in these public places, and their poor willingness to exercise guardianship in areas of convergence, such as settings (Ceccato et al., 2014).

Recognizing that some station designs may make it more difficult for offenders to commit crime than other stations; the authors set out to demonstrate that crime in underground stations reflect rhythmic variations of human activities. Therefore the convergence of passengers using public transit during particular times would result in higher levels of victimization than other time periods; the specific vulnerability to crime of a transport node varies over time and space. A transit node's environmental features are can be perceived as risky to an offender; thus, may not commit crime due to the station's design that blocks criminal opportunities and/or during time periods where potential guardians at stations may be fewer (i.e. colder seasons, non-peak times).

Ceccato et al. (2014) used data from the Stockholm public transport database that consisted of crimes reported to the central alarm service covering from 2006 to 2009. Crimes recorded in the database are categorized according to year, date, time of day (by minute), station, line, crime code, crime type, and description, resulting in a total number of 62, 265 events reported. The study also utilized observations gathered from all underground stations and their immediate surroundings between 2010 and 2011. Observations were made during different time periods of the day to gain a better understanding of rush, peak times on the subway. Results of the study demonstrated

several key findings. First, more victimization took place between the hours of 4:00 pm and midnight, with peaks between the hours of 8:00 pm and 9:00 pm. Rush hours in the morning were found to be not as criminogenic as those in the afternoon (Ceccato et al., 2014). Most crimes that took place in the evening were violent in nature. However, it should be noted that the higher levels of violence can be attributed to particular routes that have more stations; some stations had longer operating hours and also were located nearby high crime neighbourhoods.

Vandalism took place more often during late evenings and theft in the afternoon and early evening hours. Holidays demonstrated the highest crimes rates, followed by weekends (Friday through Sunday) and weekdays (Monday through Thursday). Lastly, crime at stations varied seasonally. More crime was committed against people during the winter. Ceccato et al. (2014) contend that this may be due to the fact that low temperatures experienced in the winter forces passengers to wait indoors for trains at the stations, thereby creating situations more prone to violence than in the summer. Also, poor weather forces many people to abandon their private automobiles in favour of public transportation to make commuting easier. The study demonstrates the importance of considering the physical environment of transit stations along with the characteristics of the station's social environment to help explain the variation of crime rates in public transit settings.

Newton, Partridge & Gill (2014) sought to gain a better understanding of the possible transmission of risk of pick-pocketing offences above and below underground rail stations. The study acknowledged that the location of an offence within a transit setting can subtlety vary rather than be aggregated to just the station itself. Newton et al (2014) note that theft from person can occur in the vicinity of station but outside its boundary, inside a station boundary before the paid access barrier, within the paid access barrier outside of carriages, and inside a rail carriage (p.1). It is important to distinguish between the various locations within a transit environment in order to best understand the likelihood of different types of crime from occurring. Newton et al (2014) utilized data on theft offences that occurred both above and below ground between April 2011 and March 2012. Crime data was extracted using 100, 250, and 400 meter buffers of the London Underground system. The study employed a technique, interstitial crime analysis (ICA),

to improve measurement estimates of the location of below ground theft on transit systems.

Results of the study concluded that theft from person on the London Underground system is concentrated at particular stations and particular times (peak hours) of the days. A large number of thefts occurred at a small proportion of stations in both above and below settings. Also, stations with high levels of theft tend to have environs (settings adjacent to the station) with similarly high levels of theft (Newton et al., 2014, p.12). Newton et al. (2014) contend that there are three possible mechanisms of theft that emanate on transit systems and their nearby settings. First, the presence of 'uni-nodal' offenders (individuals who operate at only one station or a limited number of proximate stations), the presence of 'multi-nodal' offenders (those who operate between multiple stations), and system causes of theft (created by the juxtaposition of busy stations and favourable opportunities for theft created by the presence of transit settings). Newton et al.'s (2014) findings demonstrate the significance of situational crime prevention techniques.

Ajayi & Ajayi (2013) undertook a spatial analysis of crime on public transportation systems in Ibadan, Nigeria, Africa. Growing concerns over the safety on public transportation systems prompted the authors to examine the level of crime occurring at bus terminals. The utilization of crime data and questionnaires were employed to determine changes to the level of crime at 5 large motor parks: Ojoo, Sango, Iwo Road, Challenge, and Dugbe (Ajayi & Ajayi, 2013). Crime incident data was provided from the Oyo State Headquarters of the Nigerian police in Eleyele, Ibadan. Criminal offences included: grievous wounding/mugging, indecent assault and rape, theft, stealing, and pick pocketing, burglary and store breaking, gambling/obtaining by tricks, and being in possession of hard drugs and breach of public peace between 2003 and 2008 (Ajayi & Ajayi, 2013). In addition to examining crime incident data, the authors administered a questionnaire to 250 respondents that were a passenger, driver, or trader of the bus system. 50 respondents were randomly selected from each of the five selected motor parks. The questionnaire contained a number of questions related to the respondents' socio-economic background and experiences and perceptions of crime. Questions asked included: age, sex, occupational status, the nature of crime (if witnessed and/or victimized), and their perceptions toward what was causing higher levels of crime.

The study used multi-variate statistics of analysis of variance to examine if there was a significant variation in the incidence of occurrence of these crimes among the parks for the period under consideration. Results show that in 2003, an F-statistics value of 2.890 was obtained at a significance level of 0.005, indicating a significant variation in the dependent variable of crime. The test was repeated for the remaining years and similar results were obtained that illustrate that crime had strong regional differentials. Survey responses demonstrated that 161 respondents admitted that they have witnessed a crime or another being committed in and around the parks. A larger proportion of the respondents (n=156) admitted that they have never been a victim of a criminal attack in and around the parks, while some respondents (n=95) reported that they had been a victim of a criminal act, with respondents (n=43) were victims of mugging, affray, and fighting, followed by theft and robbery (n=34), primarily at night. Females reported higher levels of vulnerability and fear compared to their male counter parts. A total figure of 101 believed that unemployment and poverty were the leading causes of crime within and around motor parks in the city. This was followed by those who believed that the high numbers of bad elements among the members of road transport workers, lack of security, and the physical environment (lack of perimeter fencing and electricity at night) surrounding the motor parks led to higher levels of crime. The findings of the study demonstrate that some distinctive spatial pattern of crime occurrence has been illustrated in the selected motor parks in Ibadan. Further, there is homogeneity in the nature of crime type found in parks and the risk of becoming a crime victim is heightened as a female, minor, aged, and a solitary figure. Lastly, the findings offer insight into problems associated with the location, maintenance, and management of bus stops/motor parks in Ibadan.

3.5. Conclusion

Transit and crime literature has demonstrated the difficulties associated with conducting empirical research on mass forms of public transportation. Transit environments present an infinite number and type of criminal opportunities that span across a number of settings (stations, buses, trains) and victims (passengers, staff, facilities). It is necessary to identify factors that could influence the impact of a transit system on crime in nearby environments; not only the station itself. The examination of

the Canada Line in Vancouver, BC, Canada, provides a case study to observe the impact of a new transit line on the level of criminal offending in the city of Vancouver.

Empirical studies examining mass forms of public transportation and crime have often overlooked the role that the spatial environment can have on levels of reported crime. The spatial environment includes a number of aspects including types of land use (e.g. commercial, residential, mixed), activity nodes (home, work, school locations), and pathways (arterial roadways, transit routes, bike paths) (Kinney et al., 2008). Previous research has shown there is a correlation of certain environmental attributes with transit crime (Loukaitou-Sideris et al., 2002). Particular land uses such schools, bars, liquor stores, pawn shops, and abandoned buildings have been found to attract more crime in their vicinity (Loukaitou-Sideris et al., 2002; Ihlanfeldt, 2003; Liggett et al., 2003; Grubesic & Pridemore, 2011). The presence of physical disorder and incivility, signified by deteriorating building stock and public environments, with concentration of graffiti and litter, is also likely to have an impact on the neighbourhood (Perkins, Abraham, Richard, & Taylor, 1993 as cited in Loukaitous-Sideris et al., 2002, p.137).

To date, there a limited number of transit and crime studies that have incorporated the spatial environment into the examination of public transportation systems and crime (Loukaitou-Sideris et al., 2002; Liggett et al., 2003; Yu, 2009, Billings et al., 2011; Robinson & Giordano, 2012; Stucky & Smith, 2014). These studies typically were restrained to a single year of land use data due to availability concerns. Despite this gap in the literature, there are a number of renewed attempts to incorporate longitudinal crime and land use data through a number of statistical measures.

By utilizing the information gathered from past empirical studies, the current analysis can provide further insight and understanding into the complex relationship between mass forms of public transportation systems and crime. Consideration of multiple statistical techniques have led the current case study of the Canada Line to propose utilizing time series regression, panel data analysis, and spatial point pattern tests to best capture the spatial-temporal dimensions of crime within and along census tracts that host a Canada Line station(s) in Vancouver. The following section provides a contextual

background of the Canada Line, including the implementation, operation, and controversy that has plagued this SkyTrain route.

Chapter 4. Study Settings

4.1. Canada Line

4.1.1. History of the SkyTrain

Metro Vancouver's SkyTrain is the main mode of public transit for residents of the Lower Mainland. The SkyTrain system expands across a variety of suburban communities including Vancouver, Burnaby, New Westminster, Surrey and Richmond. Currently, the SkyTrain operates and maintains three routes: the Expo Line, the Millennium Line and the Canada Line. A fourth route, the Evergreen Line, was recently added to accommodate passengers travelling to the cities of Port Moody and Coquitlam. The focus of the current study will be on the Canada Line.

The SkyTrain system was first conceptualized and introduced to Vancouver in 1985, in preparation for the world's fair, Expo 1986 (Mackett & Sutcliffe, 2003). Expansion of the SkyTrain occurred in 2002, as a secondary line was implemented to mark the turn of the new century, called the Millennium Line. This secondary route extended from East Vancouver at station VCC-Clarke along the Lougheed Highway to Columbia Station in New Westminster. The Canada Line was the third line to be added to the transit system in 2009. Originally, the Canada Line (previously known as the RAV Line) was supposed to be constructed during the early 1990s to help alleviate traffic congestion between the cities of Vancouver and Richmond (Chiu & Rault, 2003). However, plans were abandoned due to financial costs and other competing transit priorities (Chiu & Rault, 2003). However, plans were revisited in 2003, when the city of Vancouver was announced as the host city for the XXI Winter Olympics Games[10]. The line became imperative to the success of the Olympic Games as additional transportation was needed to help accommodate an influx of athletes and fans travelling to see the different sporting games throughout the Lower Mainland. Due to the necessity of building a new SkyTrain route, extra funding and

[10] Vancouver was the host city for the XXI Olympic Winter Games in 2010. Sporting events and ceremonies took place February 12th, 2010 – February 28th, 2010. The Paralympics portion of the event took place March 12th, 2010 – March 21st, 2010.

support was provided from multiple business partners and the provincial government of British Columbia.

Construction of the Canada Line began in 2005 and was met with resistance and hostility from local residents and business owners within both Vancouver and Richmond. Construction noise, disruption to businesses and fear of crime were amongst the top concerns from residents and merchants. Despite economic and legal consequences due to the construction of the line, the Canada Line was completed 15 weeks ahead of schedule, opening on August 17th, 2009 (Chiu & Rault, 2003).

4.1.2. Structure

The Canada Line is 19.2 kilometers long and has sixteen stations with the ability to add three additional stations in the future if desired. In Vancouver, stations include Waterfront, Vancouver City Centre, Yaletown-Roundhouse, Olympic Village, Broadway-City Hall, King Edward, Oakridge-41st Avenue, Langara-49th Avenue and Marine Drive. Stations located in Richmond include Bridgeport, Aberdeen, Lansdowne, Richmond-Brighouse, Templeton, Sea Island Centre and YVR-Airport. The SkyTrain system does not remain open continuously through the day. Instead, trains and stations open approximately 5:00 am to 1:00 am. For the average commuter, travel times between downtown Vancouver to YVR Airport or Richmond-Brighouse station is approximately 25 minutes in duration (TransLink, 2017a).

The stations were designed based on principles of CPTED (City of Richmond, 2006). The stations were uniformly constructed to reduce the number of opportunities to commit crime based on weak infrastructure and poor design. The stations have limited seating for passengers, have few obstructing walls, and have high levels of surveillance (both CCTV and natural). Such efforts can have a dramatic impact on the level of offending, especially within transit environments (Gaylord & Galliher, 1991; La Vigne, 1996).

Direction	First Train	Last Train
Waterfront to YVR/Airport	**4:48 am**	**1:05 am**
Waterfront to Richmond-Brighouse	**5:30 am**	**1:15 am**
YVR/Airport to Waterfront	**5:07 am**	**12:56 am**
Richmond-Brighouse to Waterfront	**5:02 am**	**12:47 am**

Table 1: Opening and closing departure times for the Canada Line (TransLink, 2017a)

The Canada Line differentiates from the Expo and Millennium line based on its geographical location. Unlike its counterparts of the Expo and Millennium Lines, the Canada Line does not run parallel to a pre-existing railroad track. The Expo line follows an old interurban tram line route that was established in 1890 (Russwurm, 2016). The Millennium Line runs similar to the Expo Line along the Lougheed Highway, travelling from East to West. Both the Expo and Millennium lines have stations that are mostly elevated, further adding to the brand of "SkyTrain". However, the Canada Line is much different from its counterparts. The Canada Line utilizes underground tunnels that cross the Fraser River and run vertical from Waterfront to YVR and Richmond-Brighouse (City of Richmond, 2006). This new line now serves communities that were never previously exposed to mass public transportation and gives more alternative routes to reach important destinations for passengers.

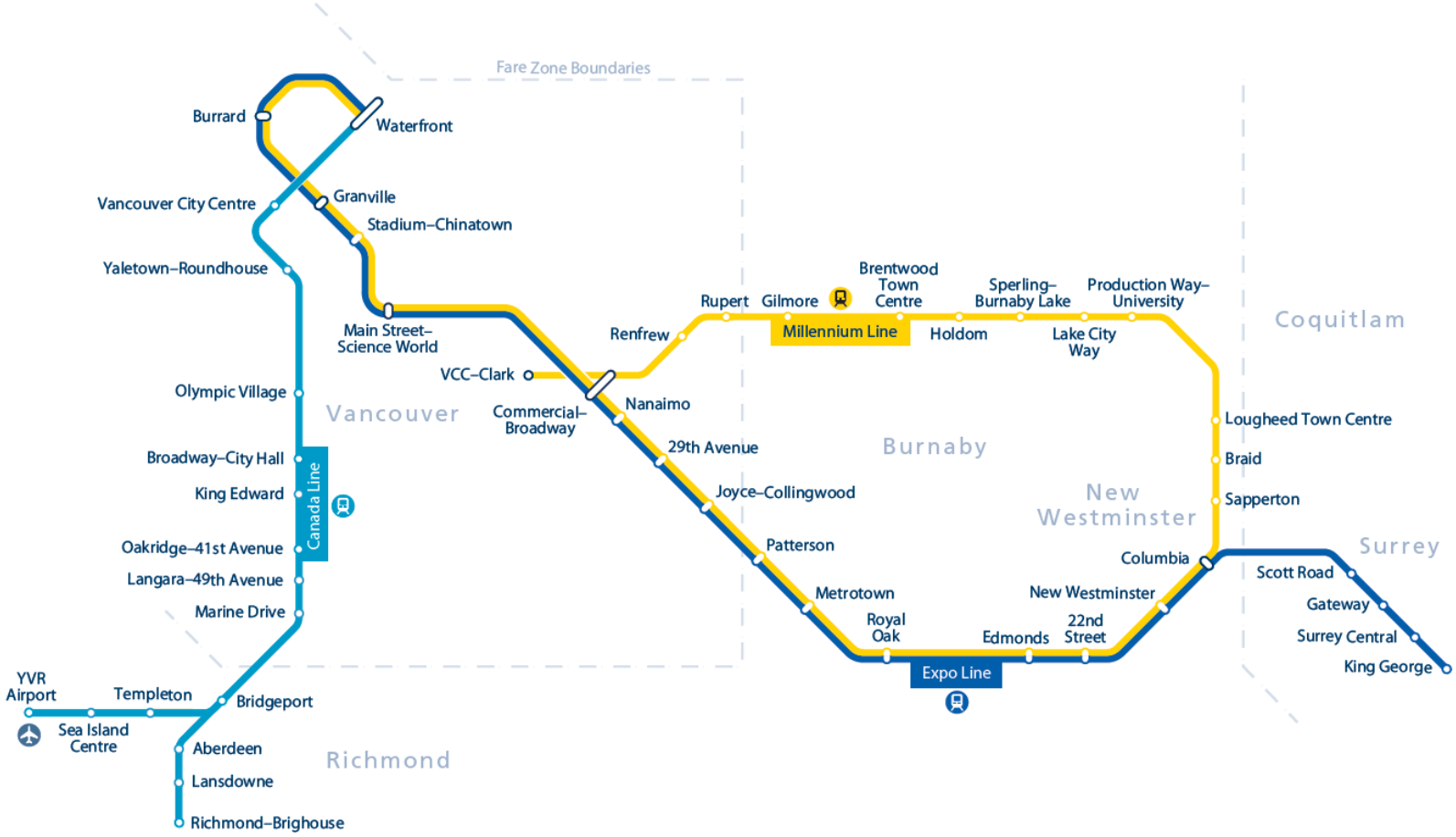

Figure 4: Transit Network for the Greater Vancouver Regional District, Translink

4.1.3. Transfer Points

The Canada Line has two transfer points to help connect to the city's bus system and other SkyTrain routes. The first transfer point is located at Bridgeport Station in Richmond. Bridgeport Station serves as the junction point between the two different arms of the Canada Line, where commuters can travel to or from Vancouver's International Airport (YVR) located on Sea Island or along No.3 Road in Richmond at the terminal Richmond-Brighouse. Commuters boarding the SkyTrain at Brighouse-Richmond can also commute back to Vancouver, reaching the terminal of Waterfront.

Waterfront is the second transfer point on the Canada Line. This station connects commuters travelling to or from the Canada Line to the Expo Line and subsequently, the Millennium Line. The station also connects the Canada Line to the Seabus that travels to Lonsdale Quay in North Vancouver as well as the Westcoast Express Train that services commuters from Vancouver to Mission. Although not officially indicated as a transfer point, Vancouver City Centre is a third transfer point for commuters using the Canada Line. Vancouver City Centre allows passengers to travel to opposite sides of Pacific Centre in order to board other SkyTrain Lines, primarily the Expo. Unlike the official transfer points, commuters using the Vancouver City Centre stop to connect to other lines must walk further distances in order to reach the different stations. Due to the inconvenience for some, passengers tend to remain on the Canada Line and travel to the Waterfront Station in order to make switches to different lines.

4.1.4. Fare System

The SkyTrain has undergone a number of changes to the way its collects fare since its inception in 1986. As part of being fully automated, the SkyTrain was designed without fare collectors, turnstiles, or gates, with periodic ticket checks as the only method to enforce fare payment (Russwurm, 2016). This has led to some concern regarding the potential for some individuals to not only ride for free, but also to have an easy and quick route to and/or from a criminal event (Tillyer, 2003). This honour system incurred major economic losses from passengers who do not pay fare to ride the SkyTrain system. To help counter-attack fare evasion, TransLink retrofitted stations with fare gates and has recently implemented a new smartcard fare system called Compass. Commuters

purchase fare based on the number of zones they plan to travel through[11]. The Compass Card is an electronic payment system that uses a smart card based payment system. The card requires riders to 'tap in' when entering a transit mode, and 'tap out' when exiting. Passengers can pre-purchase a Compass card and add fare credit online, by phone or at vending machines located at Sea Bus terminals, West Coast Express stations, and SkyTrain stations.

The introduction of the Canada Line witnessed the beginning of additional add-on fares for commuters travelling to and from Sea Island in Richmond. Passengers destined to Bridgeport Station and beyond must pay an additional $5 dollar charge for rides on the Canada Line. The surcharge was implemented as a provision set out in TransLink's funding plan in 2004 (TransLink FAQ, n.d.). The charge is intended to help make up additional funding 'in order to make the Canada Line viable' (TransLink FAQ, n.d.). Therefore, passengers travelling from Vancouver International Airport pay additional charges.

4.1.5. Ridership

Ridership of the Canada Line has steadily increased each year since it became operationalized in August of 2009. Ridership has risen from over 8 million to 28 million passenger trips within four years. According to TransLink (2017c), the Canada Line carries more than 122,000 people on any given weekday, which is equivalent to more than ten lanes of highway. This level of ridership has exceeded the original forecast of 100,000 by fall 2010. During the Olympics, the Canada Line witnessed a ridership of 287, 397 during a single day.

[11] Zone 1 encompasses all of the Greater Vancouver area; Zone 2 covers the cities of North & West Vancouver, Burnaby, New Westminster and Richmond; Zone 3 encompasses Coquitlam, Port Coquitlam, Port Moody, Surrey, and Langley.

Passenger Trips	Canada Line
2009	**8, 611, 301**
2010	**29, 189, 349**
2011	**28, 293, 579**
2012	**29, 413, 218**
2013	**28, 895, 663**
2014	**28,929,619**
2015	**29,453,840**

Table 2: Ridership of the Canada Line, 2009 to 2015 (Metro Vancouver, 2017)

4.1.6. Safety Measures & Initiatives

The SkyTrain has implemented a plethora of measures to help hinder the onset of crime within its various modes of transport. SkyTrains are equipped with CCTVs, on-train passenger silent alarms, and on-train speakerphones (TransLink, 2017d). In 2005, the Greater Vancouver Transportation Authority Police Service was established to help combat crime and protect those who use the transit system. The Transit Police has a mandate to:

"To preserve and maintain the public peace, prevent crime and offences against the law, aid in the administration of justice and enforce the laws of British Columbia. Transit Police Officers also issue violation tickets for transit infractions including tickets for fare evasion." (TransLink, 2017d).

The Transit Police has launched various safety campaigns such as "See Something, Say Something", "Text SMS Non-Emergency Reporting", and "Transit Police OnDuty App" to help prevent crime on the SkyTrain. These initiatives rely on passengers to be pro-active. Passengers should be aware of their surroundings and report any unusual behaviour or incidents to the transit police. However, these suggestions may not necessarily help a passenger in need of help.

4.1.7. Negative Perceptions of the SkyTrain

Despite valiant efforts to reduce crime, transit environments continue to earn a negative reputation amongst the public as a dangerous mode of travel to use. Crimes that occur within and/or near public transportation systems are often over-sensationalized by media outlets that have created a stigma against such systems. Within Vancouver, the SkyTrain has long been a highly debatable subject amongst local government, the public and the media. Many critics of the SkyTrain have dubbed the transit system as the 'crime-line' and/or "crime train", as a large number of criminal incidents took place within and nearby SkyTrain stations (Bennett, 2008). Common headlines in Vancouver include "Woman beaten at Vancouver SkyTrain station"[12], "Man charged after SkyTrain passengers terrorized"[13], "Transit terror: Teen stabbing suspects no strangers to police"[14], "Robber steals SkyTrain riders' phones at knifepoint"[15], "Suspect on the loose following SkyTrain stabbing"[16], "Suspect sought in trio of SkyTrain sex assaults"[17], and "Do SkyTrain stations attract crime?"[18]. Such headlines induce a moral panic amongst local residents that the SkyTrain is synonymous with danger and crime.

4.1.8. Construction Controversy

The implementation of the Canada Line was a contentious and hostile affair in the City of Vancouver. Consultations with local residents and merchants in 2004 opposed the construction of the line fearing that the route construction would be detrimental to their businesses as well as fearing an increase in crime to the nearby community. Due to its reputation for being a 'crime train', both the cities of Vancouver and Richmond feared that the newest addition to the mass transit system would see an influx of crime and disorder to both the stations and the communities that reside nearby the stations.

[12] Woman beaten at Vancouver SkyTrain station, CBC News, April 17, 2007
[13] Man charged after SkyTrain passengers terrorized, CTV News, August 21, 2012
[14] Transit terror: Teen stabbing suspects no strangers to police, CTV News, March 19, 2013
[15] Robber steals SkyTrain riders' phones at knifepoint, CTV News, December 10, 2013
[16] Suspect on the loose following SkyTrain stabbing, CTV News, July 27, 2014
[17] Suspect sought in trio of SkyTrain sex assaults, CTV News, September 3, 2013
[18] Do SkyTrain stations attract crime?, News 1130, October 1, 2014

During the construction of the new SkyTrain line, many merchants along Cambie Street asserted that their stores suffered from an increase in theft (Boei, 2006). The store owners claimed that offenders were hiding behind scaffolding in order to steal from the stores. This lack of visibility would cause an increase in drug users and dealers to be drawn into the Cambie area to consume and sell drugs. Furthermore, residents and retailers alike feared that an increase in mugging could also occur from a lack of visibility (Boei, 2006).

City councillors in the City of Richmond feared that the Canada Line could become a crime train if the city did not do more to address public safety concerns during the rapid transit system's design phase (Bennett, 2006). City councillors were advised by local police that there were many potential problems with the Richmond segments of the Canada Line that could result in increased criminal activity (Luba, 2006). Many of the issues, outlined by police, relate to the visibility and lighting of areas surrounding transit stations and walkways (Luba, 2006). Law enforcement, according to Richmond City Council, may have to increase their workload equivalent to 14 police officers within the first year alone of the operation of the Canada Line in order to combat potential crime and the fear of it from the transit line (Bennett, 2008). According to Richmond RCMP, 'the entire No.3 Road commercial corridor, the precinct in which the River Rock Casino and the Bridgeport park-and-ride facility are located, and the terminus station at the YVR passenger terminal, all become target-rich environments for criminal activity" (Bennett, 2008, p.B2) This concern was further validated when Staff Sgt. Doug Wright of the Vancouver Airport RCMP detachment warned the city of Richmond's community safety committee that police need greater input in the design of the line and its stations, if the city wants to avoid creating a crime magnet (Bennett, 2006). However, despite fears, the Richmond RCMP have established two community police stations in Canada Line stations and hired four additional officers (Sherlock, 2008). Richmond RCMP spokeswoman Nycki Basra stated, "we want to address the issues before they arise through environmental design, (raising) awareness of businesses in the area and showing a police presence, so we are being very pro-active to make Richmond unfriendly for criminals" (Sherlock, 2008).

4.2. Vancouver, B.C.

4.2.1. Geographical Profile

The census metropolitan area (CMA) of Vancouver, British Columbia is considered the largest populated metropolitan area in Western Canada and the third largest CMA in Canada (Statistics Canada, 2016a). Vancouver has a land area of 114.97 square kilometers with a population density of 5,249.1 persons per square kilometre (Statistics Canada, 2016b). This compares to the provincial land area of 922, 509.29 square kilometers with a population density of 4.8 persons per square kilometre (Statistics Canada, 2016b). Vancouver's population has witnessed a substantial growth in size in the last quarter of the 20th century and into the 21st century. The 2001 Canadian census reported a population size of 1,986,965, in 2006, 2,116,581, and in 2011, 2,313,328 (Statistics Canada, 2016a, 2016c). This significant increase has allowed the city flourish as it consistently ranks high in global surveys as one of the most livable cities found in the world ("Vancouver, Calgary, Toronto among world's 5 most 'livable cities'", 2016).

4.2.2. Crime Patterns and Trends in BC and Canada

The level of reported crime has steadily decreased since the early 1990s around the world. The phenomenon is often referred as the 'crime drop', as many industrialized countries have witnessed crime rates plummet due to many changes at both a micro and macro level of society. Major decreases in crime were first witnessed in the United States, where violent crime including homicide fell 40 percent over the 1990s and similar patterns emerged in countries such as the United Kingdom, Australia, Canada, and Japan (Farrell, Tilley, Tseloni & Mailley, 2011). There are a number of competing hypotheses that aim to explain what catalyzed such decreases. Some partially tested hypotheses include demographic changes, prison populations, policing strategies, more police, gun control and concealed weapon laws, changing drug markets, increased abortion, stronger economies, and lead exposure to help account for the decline in crime (Farrell et al. 2011). However, there are many other plausible causes that could help explain the decline in crime that have yet to be empirically tested. Farrell et al. (2011) list the following to examine more closely to understand a possible link to the decline of crime: increased

levels of security, changing lifestyles and routine activities, increased religiosity, cultural changes, immigration, and repeat victimization.

Within Canada, the crime rate has steadily declined at both a national and provincial level. Statistics Canada employs two ways to measure crime: the crime severity index (CSI) and the crime rate. The CSI measures both the volume and seriousness of crime (Boyce, 2015). The crime rate measures the rate of criminal incidents per 100,000 populations (Boyce, 2015). Together, both techniques can provide insight into the potential changes that may exist for police-reported crime. Canada reported a CSI of 66.7 in 2014; this is a substantial drop in crime compared to a decade before where Canada reported a CSI of 104.1 in 2004 (Boyce, 2015, p. 29). This decline helps mark the eleventh consecutive decrease of the CSI and the lowest CSI recorded since 1998 (the first year the CSI was available) (Boyce, 2015, p.4). Similarly, the police reported crime rate in Canada recorded a rate of 5,046 per 100,000 in 2014 compared to a rate of 7,600 per 100,000 in 2004 (Boyce, 2015, p.29). The decrease in the police-reported crime rate began in the early 1990s, mirroring the phenomenon of the crime drop in other parts of the Western world.

At a provincial level, British Columbia reported a CSI value of 91.6 in 2014; a violent CSI value of 77.0, and a non-violent CSI value of 96.8 (Boyce, 2015, p.30). British Columbia's reported crime rate for 2014 was 7,599 per 100,000. Asides from Alberta, British Columbia was one of the few provinces within Canada to report an increase (+6%) in their non-violent CSI in 2014. The increase in the non-violent CSI score is attributed to increases in particular offence types such as theft of/under $5000, child pornography, breaking and entering, and motor vehicle theft (Boyce, 2015, p.19).

At a CMA level, Vancouver reported a CSI value of 96.7 (the third highest CSI in Western Canada), a violent CSI value of 78.2, and a non-violent CSI value of 103.2 (Boyce, 2015, p. 31). Vancouver's reported crime rate for 2014 was 7,425 per 100,000 (Boyce, 2015, p. 32). It should be noted that all CMAs within British Columbia recorded increase in their non-violent CSI in 2014. It is important to take note of these crime trends across British Columbia and Canada as a whole as it may have the ability to serve as a

rival plausible cause while examining crime patterns within and nearby census tracts that host a Canada Line station in Vancouver

4.2.3. Special Events in Vancouver, BC

Vancouver's population growth has often been attributed to the success of the 1986 World Exposition on Transportation and Communication, better known as 'Expo 86'. Expo 86 was a World's Fair held in Vancouver, BC from May to October 1986. The fair's theme, 'Transportation and Communication: World in Motion – World in Touch', coincided with Vancouver's centennial and featured several events and exhibitions to showcase the city's beauty and liveability (O'Leary, 2006). The fair was attended by 22 million people and is still considered 'the biggest single catalyst for the dramatic change in the City of Vancouver' (Mackie, 2011).

One of the main attractions at Expo 86 was the introduction of the SkyTrain. The SkyTrain served as the first official route of the transit system and was built to help serve the Expo fair and to help serve the Lower Mainland with a new form of public transit. The SkyTrain served as the primary shuttle link between the main exhibitions of the fair, providing accessibility between the Canada Pavilion and False Creek (O'Leary, 2006). Since its introduction, the SkyTrain has become the focal point of the city's metropolitan transit system and has been extended a number of times to include new routes to different parts of the Lower Mainland.

The 2010 Winter Olympics, also known as the XXI Olympic Winter Games also facilitated an increase to the population growth witnessed in the city of Vancouver. The Winter Olympics were a major international multi-sport event that was held from February 12 to 28, 2010 in Vancouver, BC. Reports estimate that approximately 2,566 athletes participated in the coveted event and media viewing audience of 1.8 billion viewers (International Olympic Committee, 2011). The Winter Games witnessed a record use of mass transit that led to an increase of mass transit ridership increasing by more than 50 per cent during the Games (International Olympic Committee, 2011). In preparation for the Games, TransLink launched a large expansion plan to improve the transit system that included 48 new SkyTrain cars, a new SeaBus, 180 diesel-electric hybrid buses, and a

new SkyTrain route, the Canada Line, to transport athletes and spectators between the various game sites within the Lower Mainland of Vancouver (International Olympic Committee, 2011). This spectacular event rivals the successes witnessed during Expo ’86 as the Games help broadcast Vancouver has a first-class city to an audience of approximately 3.8 billion people worldwide with approximately 1.8 billion viewers (International Olympic Committee, 2011). Furthermore, a number of legacies were created during the time period that has helped boost Vancouver’s economy including but limited to the employment rate, tourism, social housing, environmental sustainability, and sports.

4.3. Conclusion

To advance research in the field of public transportation and crime, this dissertation will utilize several spatial statistical techniques to determine whether the implementation of the Canada Line has impacted the level of reported crime in census tracts hosting a station in Vancouver, British Columbia. There are inconclusive results in the current literature that address whether public transit can facilitate a higher number of crimes within environments located in and nearby transit systems. Some studies suggest that forms of mass transit can increase crime within and nearby transit stations (Plano, 1993; Poister, 1996; Ihlanfedlt, 2003), while others suggest a null and/or deterrent effect (Billings et al., 2011; Gallison, 2016; Sedelmaier 2003, 2014). The current study on the Canada Line will aim to provide more insight into this phenomenon to help demystify concerns of safety on mass forms of public transportation systems. Utilization of time series regression, spatial point pattern testing, and panel analysis will help provide a greater understanding to the phenomenon of crime and transit systems.

Chapter 5. Methodology

5.1. Introduction

The most commonly used empirical approach to studying the relationship between mass transit and crime is the use of pre-post design. According to Rossi, Lipsey & Freeman (2004), a simple pre-post design is 'one in which outcomes are measured on the same targets before program participation and again after sufficiently long participation for effects to be expected…comparing the two sets of measurements produces an estimate of the program effect" (p.290).

This approach can be quite challenging when applied to research examining the relationship between public transit and crime. The difficulty lies within the ability to control for rival plausible causes that may influence both the level and types of reported crime witnessed within transit environments. The researcher, while trying to examine one particular effect on a transit system, may have difficulties in ascertaining that this is the sole reason to a possible change; they cannot simultaneously control for other factors that may influence a change to the transit environment and impacting the results. Transit and crime studies have often encountered factors such as seasonality, city-wide crime trends, prevention initiatives, etc. as underlying causes to potential changes witnessed in crime patterns. Eck (1998) notes that it is difficult to determine if any changes have occurred due to an initiative and/or external factors, as places within systems are linked, thus internal changes to part of a system can influence crime in other parts of the system. Further, if untreated, parts of the system are used as controls, diffusion of benefits or displacement effects can confound the findings (Eck, 1998). This design type may be more appropriate for short term impact assessments of programs attempting to affect conditions that are unlikely to change much on their own. Inclusion of multiple measures of the outcome that span the pre-program to post-program periods would strengthen the study design.

The current study seeks to address some of these methodological issues by choosing techniques that help explain potential crime patterns while considering the role of rival plausible causes. Billings et al. (2011) note that often, in the study of crime, transit

studies are not placing the station areas in larger metropolitan contexts. Therefore, one cannot determine whether the apparent increase in crime is a net increase for the area, a relocation of existing crime within the area, or consistent with changing crime rates for the city and/or region as a whole (thus, not attributable to the presence of the station). The current study aims to overcome this obstacle by incorporating variables that could help explain crime patterns. Such variables include socio-demographic factors such as unemployment, population, education levels, etc., while also examining the current city, provincial, and national trends, as well as seasonal changes.

Time series regression will be applied to assess the potential criminal impact of the Canada Line within the City of Vancouver. Relative risk ratios will be used to determine the current crime trends to help identify the immediate impact, on-going impact and general crime trend of the Canada Line throughout the selected time period of January 2003 to December 2015. Exploration of each station is performed to account for both general and specific trends witnessed from the Canada Line stations in Vancouver. Multiple variables will be utilized to help account for rival plausible causes influencing the level of reported crime. Seasonality, crime trends before the Canada Line, crime trends during the construction of the Canada Line, and crime trends after the implementation of the Canada Line. Results will be presented by each census tract that will demonstrate each crime offence and each variable used in the regression models.

Panel data analysis will be conducted to help examine if changes to the level of reported crime have changed in neighbourhoods surrounding the Canada Line over time. This will be achieved by implementing a fixed effect panel as it can help identify potential influences that have had an impact on the level of crime within census tracts surrounding the Canada Line in Vancouver. This model will include a number of socio-demographic variables that could influence the level of reported crime in the census tracts that host and/or are located nearby a SkyTrain station. The current analysis will be able to provide a longitudinal analysis that is extremely uncommon in current transit and crime literature.

Lastly, spatial point pattern tests will be applied to identify the spatial distribution of crime within Vancouver, BC, from January 2003 to December 2015. The statistical output of the spatial point pattern test provides a visual representation of the study area

with varying degrees of crime density that are colour coded and easily analyzed. This technique can help identify potential changes to the crime count at the dissemination area level in Vancouver. Results of the tests will also be presented in a table format to provide the global measure of similarity for the entire study areas as well as the local results that identify similarity for each of the units.

5.2. Data Sources

5.2.1. Crime Data

Crime incident data from the Vancouver Police Department was obtained from the City of Vancouver's Open Data Catalogue (City of Vancouver, 2015). At the time of data gathering, the dataset contained crime data on a month-by-month[19] basis, covering a time period from January 1, 2003 to December 31, 2015. This data set helps provide a significant baseline to compare the differences in spatial patterns of crime before and after the implementation of the Canada Line in Vancouver.

The following crime types were made available for analysis: criminal offences included residential break and enter, commercial break and enter, other theft, mischief over $5000, mischief under $5000, theft from vehicle over $5000, theft from vehicle under $5000, theft of vehicle over $5000, and, theft of vehicle under $5000. It should be noted that for the categories of mischief, theft from vehicle, and theft of vehicle, the categories of over and under $5000 were aggregated. The crime data used for these reports were extracted from the Vancouver Police Department's computer system. These systems are considered 'live'; therefore the offences reported here can change on a daily basis as events occur, evidence is determined and outcomes change (City of Vancouver, 2015). Further, the numbers are current as of a certain data, monthly totals may not add up to yearly totals. Each record includes information on the type of incident, the year and month of the incident, and a generalized location of the incident such as an intersection or a one hundred block.

[19] Crime data is now available to the minute through the City of Vancouver's Open Data Catalogue, http://data.vancouver.ca/datacatalogue/crime-data.htm

Year	All	Comm BNE	Res BNE	Mischief	Theft	TFV	TOV
2003	51625	3146	6809	6306	12226	16818	6320
2004	50638	3250	6471	5538	12056	17250	6073
2005	45871	2617	5484	5017	12086	15652	5015
2006	42370	2815	5586	5121	11221	13964	3663
2007	37569	2407	4940	4777	10467	11680	3298
2008	34931	2204	4380	5179	10215	10540	2413
2009	31679	1840	3469	4407	10630	9455	1878
2010	29604	1642	3245	4463	10568	8222	1464
2011	28076	1555	3232	4585	10462	7153	1089
2012	29321	1664	3296	4202	11324	7686	1149
2013	29846	1754	3007	4175	11862	8018	1030
2014	33460	2215	3043	4483	12691	9743	1285
2015	34280	2389	3112	4149	13070	10190	1370

Table 3: Reported crime between January 2003 and December 2015, City of Vancouver

It should be noted that the current data set has some limitations that could affect the statistical analyses. Crime incident data obtained from Vancouver's Open Data Catalogue consists of police-reported criminal activity only. Thus, the proportion of actual criminal activity (the dark figure of crime) may be far greater than what is presented. More crimes may have occurred within and nearby census tracts that host a Canada Line station. Additionally, this data set does not indicate whether crimes reported directly to the Transit Police are included within Vancouver Police Department's calls for service. This ambiguity may not reflect an accurate depiction of the frequency of crime within the designated census tracts.

5.2.2. Census Tracts

According to Statistics Canada (2016), census tracts are small, relatively stable geographic areas that usually have a population between 2,500 and 8,000 persons. They are located in census metropolitan areas and in census agglomerations that had a core population of 50,000 or more in the previous census. The city of Vancouver has approximately 110 census tracts (Statistics Canada, 2016). For the current study, census tracts will be employed as the unit of analysis when examining reported crime trends in neighbourhoods within and nearby Canada Line Stations.

Station Name	Census Tract ID	SkyTrain Route
Marine Drive	9330004.01	Canada Line
Oakridge- 41st Ave	9330012.00	Canada Line
Langara-49th Ave	9330012.00	Canada Line
29th Avenue	9330016.04	Expo Line
Joyce-Collingwood	9330016.04	Expo Line
King Edward	9330030.00	Canada Line
Nanaimo	9330035.01	Expo Line
Renfrew	9330035.02	Millennium Line
Rupert	9330036.02	Millennium Line
Broadway	9330037.02	Expo Line
Broadway City Hall	9330039.01	Canada Line
Olympic Village	9330049.02	Canada Line
Commercial	9330050.02	Millennium Line
VCC-Clark	9330050.03	Millennium Line
Yaletown-Roundhouse	9330059.03	Canada Line
Waterfront – Expo	9330059.05	Expo Line
Waterfront – CL	9330059.05	Canada Line
Granville	9330059.05	Expo Line
Stadium-Chinatown	9330059.05	Expo Line
Main Street	9330059.05	Expo Line
Vancouver City Centre	9330059.05	Canada Line
Burrard	9330066.00	Expo Line

Table 4: Census tracts with a SkyTrain station

5.2.3. Canada Line Stations

For purposes of the current research, nine stations located in Vancouver, BC will be examined as part of the Canada Line. Stations included for analyses are: Waterfront, Vancouver City Centre, Yaletown-Roundhouse, Olympic Village, Broadway-City Hall, King Edward, Oakridge-41st Avenue, Langara-49th Avenue and Marine Drive. The current study expands upon previous research undertaken to determine the potential criminogenic effect of the Canada Line in Richmond, BC. Results from the analysis of the Canada Line in Richmond demonstrated a null and/or deterrent effect for the property crime offences and other criminal offences. The inclusion of the Vancouver data will determine if a similar effect is found for the stations located in Vancouver and help provide robustness to the study of crime and the SkyTrain.

To determine whether the presence and/or the number of stations influenced the level of reported crime in Vancouver, two transit variables were created to account for a possible change. First, a dummy variable was created for the presence of a station (1 indicated the presence of a station while 0 accounted for no presence of a station) within a census tract. Secondly, an additional variable was created to account for the number of stations found in each census tract, regardless of the type of route the station serviced. Therefore, stations found along the Expo and Millennium Lines in Vancouver were included. Station count varied from 0 to 6[20]. Both variables were temporally sensitive to the creation and implementation of the stations as some census tracts did not host a SkyTrain station until a later date.

5.2.4. Ecological Variables

All ecological data are obtained through the Canadian census for the years 2001, 2006, and 2011. There are a number of variables that are applicable to the study of public transportation and crime. The current study utilized 15 independent variables from the Canadian census to empirically test whether or not crime could be attributed to something other than the presence of the Canada Line in Vancouver. Variables included population, population change, unemployment, post-secondary, recent immigrants, ethnic heterogeneity, rented, major repairs, average dwelling values 000s, average family income 000s, average income 00s, average rent 00s, median family income 000s, and median income 000s. These socio-economic variables are often employed in studies of the geography of crime in the context of social disorganization theory and routine activity theory (Cohen and Felson 1979; Felson and Cohen 1980, 1981; Shaw and McKay 1931, 1942).

Social disorganization can be categorized such as ethnic heterogeneity, population turnover, and social and economic deprivation. Ethnic heterogeneity is measured using the percentage of recent immigrant population per ecological unit.

[20] It should be noted that although there are six SkyTrain stations, some stations are located within the same location. For example, Waterfront SkyTrain station is listed as a separate station for both the Expo and Canada Line routes despite existing within the same geographical location.

Population turnover is measured using two census variables of population change. The first variable counts the number of residents who have moved into the census tract within the past year, population change. The second variable is the percentage of rental units because renters tend to be more mobile compared to home owners. Social and economic deprivation is measured using the unemployment rate, the percentage of people with a post-secondary degree/diploma/certificate, the percentage of housing units under major repair, average family income, and average dwelling value.

Routine activities that may lead to criminal occurrence are illustrated using variables that would affect targets and guardianship. These types of variables include population measures and characteristics, employment status, income levels, and dwelling values. Guardianship is measure using variables such as population density and the percentage of rental residences; increased volumes of people are expected to provide guardianship through the presence of other people and increases in owned residences is expected to increase territorial behaviour of census tract residents. The presence of suitable targets or victims is represented using average family income, average dwelling values, and percentage of rental residences; average family income and average dwelling value increase target suitability; and increases in (disposable) income as well as the percentage of rental residences increase routine activities away from the home domain through greater spending ability and younger populations. Lastly, the percentage of the population being males 15-24 years old captures the presence of offenders.

5.3. Research Questions

Previous transit and crime studies have produced inconsistent outcomes on whether mass forms of public transportation can facilitate a higher level of reported crime (Plano, 1993, Poister, 1996, Loukaitou-Sideris et al., 2002, Ihlanfeldt, 2003, Billings et al., 2011, Sedelmaier, 2014, Gallison, 2016). The current research will be examined through multiple spatial analyses of crime before and after system introduction. Measures such as time series regression, panel data analysis, and spatial point pattern tests will be used. The analyses should be able to help answer the following research questions.

The first research question asks whether socio-economic characteristics of neighbourhoods influence the level of crime found in census tracts that host a Canada Line station. It is hypothesized that socio-economic characteristics will influence the level of crime found in those census tracts that host a Canada Line station. Factors such as income, level of education, population density will play a greater role in the level of crime than the Canada Line. The second research question asks whether the presence of a SkyTrain station influence the level of crime found in census tracts that host a Canada Line station. It is hypothesized that the presence of a SkyTrain station should not negatively impact the level of crime. Instead, it is expected that the presence of a Canada Line station will have a null effect on the level of crime.

The third research question asks whether the number of SkyTrain stations influence the level of crime found in census tracts that host a Canada Line station. It is hypothesized that census tracts that have multiple SkyTrain stations may report higher levels of crime. This increase may be attributed to an increased level of foot traffic generated from the SkyTrain and therefore increasing the number of suitable targets found in such settings that would attract motivated offenders to the area. The fourth research question asks whether any changes observed in the level of reported crime differ from other census tracts without SkyTrain stations over the same time period. It is hypothesized that census tracts without a SkyTrain station would have similar crime patterns compared to census tracts with a SkyTrain station.

This dissertation empirically tests whether the presence of a SkyTrain route and its stations, in particular, the Canada Line, has made any changes to the level of reported crime at the census tract level between the time periods of January 1, 2003 to December 31, 2015. This research will help expand on the limitations of previous studies that have attempted to explain the complex relationship between transit and crime. In turn, the results will provide support to debunk myths and negative perceptions that mass forms of public transportation produce crime.

5.4. Conclusion

The following chapters explore the methodology and results for each empirical test applied to the study of the Canada Line and crime in Vancouver, BC. First, a panel data analysis will be conducted followed by a time series regression and spatial point pattern test to address research questions 1 through 4. A discussion of the results will follow and the policy implications that arise from the research.

Chapter 6. Time Series Regression

Time series analysis is the collection of observations made sequentially through time (Chatfield, 2003). Time series analysis has been popularized in the field of statistics and economics as they can help identify changes to the phenomenon while taking into account several rival plausible causes simultaneously (Andresen & Tong, 2012). An advantage of using time series data (rather than simply looking at singular before and after statistics) is that it helps to put any pre-post changes that are observed in context, so that one can see the overall trend that existed in the data when the independent variable came into effect (Palys & Atchison, 2008). It is particularly useful for identifying threats due to regression toward the mean and for showing the maturation of the trend line.

Time series approaches are not restricted to singular cases; instead when time-series data exists for interventions at different times and in different places, more complex analyses can be undertaken. This form of time series regression will be applied to the current examination of the Canada Line in Vancouver. The study will utilize a pooled cross-section time-series analysis with a dummy code (0 or 1) to identify the years before and after the implementation of the Canada Line. Other variables in the model will include city wide crime trends, seasonality, etc.

Time series regression is an appropriate measure to use in the current analysis of the Canada Line SkyTrain in Vancouver, as there are different time intervals that need to be examined to determine whether the addition of the Canada Line negatively contributed to the levels of reported crime in Vancouver. The analysis can provide considerable insight into the relationship between crime and mass transportation as it can help identify significant changes to the crime count over a period of time. By applying time series regression to the level of crime reported, the analysis can help test for the presence of structural breaks to detect changes to the crime count while taking into account rival plausible causes such as regional and national crime trends, seasonality, and crime prevention strategies. This can help demonstrate whether changes to the reported level of crime can be attributed to variables other than the Canada Line.

In order to test for changes within the crime counts surrounding Canada Line SkyTrain stations in Vancouver, negative binomial regression models using robust standard errors were used to consider the association between crime and public transportation using monthly counts of crime data for each census tract and crime type. Negative binomial regression is a specific type of count model regression. This model was selected instead of a Poisson regression model as it allows the variance to differ from the mean; a theoretical assumption that would be violated under the Poisson model (Hible, 2014). The results are displayed using a relative risk ratio. A value of 1 is statistically insignificant. A value greater than 1 indicates a positive relationship. For example, a value of 1.10 indicates a 10% increase in the level of relative risk. Last, a value less than 1 indicates a negative relationship. For example, a value of 0.90 indicates a 10% decrease in the level of relative risk.

Each Canada Line station in Vancouver will be examined to determine the impact that the SkyTrain has had on the level of reported crime. In order to determine the impact of the Canada Line on crime levels in Vancouver, criminal offences will include commercial break and enter, residential break and enter, theft, mischief, theft from vehicle, and theft of vehicle. It was beneficial to aggregate the over and under $5000 classifications because of low counts in each category. In total, six categories will be used as the dependent variables within the study to empirically test for changes to the crime count during the selected time period. Crime was estimated in the following equation:

$$\boldsymbol{Crime = a + \beta_1 Trend + \beta_2 Month + \beta_3 Month^2 + \beta_4 CL + \beta_5 CL\,Trend} + (\mathbf{1})$$

The Trend variable was included to account for the crime trend within Vancouver. The Trend variable takes on sequential values of each monthly observation (1, 2, 3...). Month and Month Squared serve as seasonality variables. The variable Month takes a value of “1” for January, “2” for February and so forth. Month-squared is the squared value of Month. Such independent variables account for crime peaking in the summer months and decreasing during the winter months (Harries, Stadler & Zdorkowski, 1984). CL (Canada Line) is a dichotomous dummy variable used for taking a value of unity (one) from August 2009 onward. This variable helps eliminate any possible influences these particular months may have in relation to crime within a given city (Andresen & Tong,

2012). CL (Canada Line) Trend variable is an additional dummy variable used. The CL Trend variable is very similar to the Trend variable except the CL Trend variable begins its sequential values (1, 2, 3...) at the time of the intervention and is otherwise, zero beforehand. This variable accounts for the crime trend after the intervention of the Canada Line was made operational. Such indicators help provide analysts to determine what the current crime trend is within the region (Andresen & Tong, 2012).

To help account for any potential changes in levels of reported crime in census tracts that host a Canada Line Station in Vancouver, control groups will be implemented. The analysis will utilize census tracts that host a Canada Line station, census tracts that host a SkyTrain station from a different route (Expo and/or Millennium), and census tracts that do not host a SkyTrain station. In total, there are 30 census tracts (15 census tracts with a SkyTrain station and 15 census tracts without a SkyTrain station) that will be used in the time series regression analysis to help demonstrate whether potential changes witnessed in census tracts that host a SkyTrain station are similar to those census tracts found elsewhere in the city. If the potential changes are different, it may lend support to the notion that the Canada Line SkyTrain route has had an impact on the level of reported crime.

Each Canada Line station and its corresponding control groups in Vancouver will have separate analyses completed to demonstrate any differences witnessed in the level of reported crime within and surrounding neighbourhoods that host a station. In doing so, there is an incorporation of a number of spatial statistics that may reveal differences in measures used to determine any changes. The analyses will attempt to identify crime patterns before the Canada Line was introduced, during construction of the Canada Line, and finally, after the implementation and subsequent operation of the Canada Line. It is predicted that the results will demonstrate a decrease and/or null effect on commercial break and enter, residential break and enter, mischief, theft, theft from motor vehicle, and theft of motor vehicle.

6.1. Regression Results

Previous studies of mass forms of public transportation and crime have reported mixed results in explaining whether such modes of transport can facilitate a higher number of crimes in such settings (Pearlstein & Wachs, 1982; Plano, 1993, Poister, 1996, Loukaitou-Sideris et al., 2002; Ihlanfeldt, 2003; Liggett et al., 2003; Billings et al., 2011; Sedelmaier, 2014; Gallison, 2016). Risk assessments were conducted on 30 census tracts to examine whether the introduction of the Canada Line SkyTrain route increased the likelihood of crime in and surrounding census tracts that host a SkyTrain station. 3 groups were created to compare the potential differences in level of risk: census tracts with a Canada Line SkyTrain station (N=7), census tracts with an Expo and/or Millennium Line SkyTrain station (N=8), and census tracts that did not host a SkyTrain station but were located nearby (N=15). The results of the negative binomial regression using crime data from Vancouver between January 2003 and December 2015 are reported in Tables 5 through 10, organized by offence type, census tract, and SkyTrain presence. The following discussion will examine the results for each offence type and the relative risk found in each census tract with or without the exposure of the SkyTrain system[21].

6.1.1. Commercial Break and Enter: Census Tracts with a Canada Line SkyTrain Station

Commercial burglary revealed a number of significant statistical relationships between the census tracts, crime, and exposure of the SkyTrain system. Within the first group of census tracts with a Canada Line SkyTrain station, a small number of census tracts reported change in the relative risk of criminal victimization. The Trend variable was significant in two census tracts; 9330012.00 (RRR = 0.99, $p < .05$) and 9330059.05 (RRR = 1.00, $p < .05$). The reported RRR values indicate an insignificant change to the level of risk for increased levels of commercial burglary. Although, this finding appears to be inconsequential for the current analysis, it does provide considerable insight into the level of reported crime within the city of Vancouver itself. The finding support the crime drop

[21] Qualitative comments regarding surrounding land use found at each census tract was checked using Google Street View and Maps to provide up-to-date information. Maps were checked multiple times to determine historical and current features of the land use in the selected census tracts.

hypothesis and indicates that crime is already experiencing a gradual decline world-wide and Vancouver is no different in also experiencing a decrease in crime.

Significant changes were observed in the CL Dummy variable in two census tracts; 9330059.03 (RRR = 0.63, $p < .05$) and 9330059.05 (RRR = 0.70, $p < .01$). The reported relative risk ratio values indicate that the implementation of the Canada Line may have not caused an adverse effect on the level of reported commercial burglary in those census tracts. Instead, the implementation of the Canada Line may have helped decrease the level of criminal victimization. This finding may be explained through the increased level of potential guardianship found in transit settings. As more individuals use public transportation to travel to work, school, and home, there are an increased number of both targets and guardians. As a result, the increased number of potential guardians may offset the elevated level of risk for victimization (Cohen & Felson, 1979). These guardians may help intervene in potential situations where offenders may be tempted to commit crime but are thwarted by the presence of these guardians.

Additionally, this level of decision-making is reflected in the work of Cornish and Clarke (1986)'s Rational Choice Theory. An offender will make a series of decisions that will ultimately try to minimize their consequences of committing a certain act, and in this case, avoiding detection and apprehension by the police. There are a number of stores and restaurants located within these census tracts, including an assortment of small shops, cafes, restaurants as well as a large shopping center, Pacific Centre. Offenders may be less likely to want to commit crime in these settings as there is a greater likelihood of being stopped and identified by by-standers. Many transit settings have a number of CCTVs located within and outside of the train and its stations. Offenders may not want to risk being seen on CCTV surveillance as the police have the ability to export footage to nearby stores and the community via the media. Once the offender's image is released to the public, they may have a much harder time committing crime without being recognized. As a result, the number of attempts to break and enter into a commercial store may decrease.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts with a Canada Line SkyTrain Station	**9330004.01**	1.00	1.09	0.99	0.99	0.99
	9330012.00	**0.99***	0.85	1.01	0.52	**1.02****
	9330030.00	0.99	1.08	1.00	1.12	1.00
	9330039.01	1.00	0.96	1.00	0.92	1.00
	9330049.02	0.99	1.12	0.99	1.07	**1.02****
	9330059.03	1.00	1.03	1.00	**0.63***	1.00
	9330059.05	**1.00***	0.96	1.00	**0.70****	**1.01****
Census Tracts with an Expo or Millennium Line SkyTrain Station	**9330016.04**	1.00	0.98	1.00	0.50	1.01
	9330035.01	**0.98***	1.11	0.99	**7.67***	1.01
	9330035.02	0.98	1.03	1.00	0.96	**1.02****
	9330036.02	**0.99****	1.01	1.00	**0.31****	1.04
	9330037.02	**0.99****	0.95	1.00	**0.91***	1.02
	9330050.02	**0.99****	1.09	1.00	0.84	**1.02****
	9330050.03	0.99	1.05	1.00	**0.63***	1.03
	9330066.00	**0.99****	**1.13***	**0.99***	0.82	**1.02****
Census Tracts without a SkyTrain Station	**9330013.01**	1.00	1.04	1.00	**0.49****	**0.98****
	9330013.02	0.99	**0.97****	1.00	0.56	1.02
	9330028.00	0.99	0.89	1.01	0.65	1.02
	9330032.00	**0.99****	0.95	1.00	0.63	**1.02****
	9330034.01	0.99	0.76	1.02	0.68	1.01
	9330040.01	0.99	0.99	1.00	1.43	1.00
	9330040.02	1.00	1.06	1.00	0.80	1.00
	9330041.01	**0.99****	0.98	1.00	0.80	1.01
	9330041.02	**0.99****	0.88	1.01	1.41	1.00
	9330051.00	**0.98****	1.23	0.98	0.39	**1.03****
	9330057.01	1.00	1.16	0.99	**0.40****	**1.02****
	9330060.02	1.00	1.01	1.00	**0.49****	**1.01***
	9330063.00	**0.99***	0.92	1.01	1.00	**1.02****
	9330065.00	**0.99****	1.08	1.00	0.67	1.02
	9330068.00	1.00	1.08	1.00	0.88	1.01

*Note: * Significance under .05, ** Significance under .01*

Table 5: Negative Binomial Regression Results, Commercial Break and Enter

The CL Trend variable reported a small number of increased levels of risk in census tracts 9330012.00 (RRR = 1.02, $p < .01$), 9330049.02 (RRR = 1.02, $p < .01$), and 9330059.05 (RRR = 1.01, $p < .01$). The level of risk denoted in the aforementioned census tracts is very minimal. This finding is consistent with transit and crime literature as mass forms of public transportation may initially increase crime in those areas that host a station due to the influx of commuters using the station to travel (Poister, 1996). Passengers may be exposed to new areas of the city with the introduction of the new route and its subsequent stations. Individuals may see new targets to victimize against as their awareness space expands to include this new region (Brantingham & Brantingham, 1984).

The slight increase could be attributed the level of commercial burglary adjusting to the presence of the new SkyTrain station within its built environment. It may take some time for crime levels to stabilize and return to pre-Canada Line trends.

Alternatively, the level of risk may increase in those census tracts due the introduction of a new station and it subsequent growth in land development. Often, developers will try to build new infrastructure like retail stores and restaurants in areas that are close to the station. Station foot traffic will help generate revenue and as such, available land surrounding stations is highly desirable and sought out by investors. For that reason, the development of new stores may in turn, increase the level of risk for commercial burglary as there are more targets to choose amongst for motivated offenders tempted to break into commercial stores located nearby to a SkyTrain station.

6.1.2. Commercial Break and Enter: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

Within the second group of census tracts with an Expo and/or Millennium Line SkyTrain station, there were a number of census tracts that reported significant changes in the relative risk of criminal victimization. The Trend variable was significant in a number of census tracts; 9330035.01 (RRR = 0.98, $p < .05$), 9330036.02 (RRR = 0.99, $p < .01$), 9330037.02 (RRR = 0.99, $p < .01$), 9330050.02 (RRR = 0.99, $p < .01$), and 9330066.00 (RRR = 0.99, $p < .01$). The slight decreases witnessed in these census tracts demonstrate the overall declining level of crime within the city of Vancouver while supporting the crime drop hypothesis.

The Month and Month^2 variable was significant in only one census tract; 9330066.00 (RRR = 1.13, $p < .05$) and (RRR = 0.99, $p < .05$). This finding suggests that the level of risk for commercial burglary may be dependent on seasonal patterns of criminal offending. Motivated offenders are more likely to target property during ideal climates; but climate may be subjective to the individual preferences of the offender in question. For some offenders, warmer temperatures may be more ideal to commit commercial burglary as there more individuals around that may in turn help conceal the offender and provide an opportunity to flee a crime scene by blending in with a large number of people. Alternatively, some offenders may prefer to commit crime during colder

weather. There are fewer capable guardians present outside during harsher weather and can provide an opportunity for motivated offenders to victimize against vulnerable stores and businesses as the likelihood of being apprehended is lower.

The CL Dummy variable revealed a number of significant changes to the level of risk for criminal victimization in a number of census tracts. Most census tracts experienced a decreased level of risk for commercial burglary; 9330036.02 (RRR = 0.31, $p < .01$), 9330037.02 (RRR = 0.91, $p < .05$), 9330050.03 (RRR = 0.63, $p < .05$). The substantial decrease in risk for census tracts 9330036.02 and 9330050.03 require a closer examination to determine the settings in which these stations reside within. Census tract 9330036.02 hosts Rupert SkyTrain station as part of the Millennium Line while census tract 9330050.03 hosts VCC-Clark, also part of the Millennium Line. The reduction in the level of risk within these two census tracts could be a product of the SkyTrain system itself expanding; thereby spreading the level of crime further across the region. Motivated offenders may not be required to stay within one particular hunting ground and may use the extended SkyTrain route to travel to different, unexplored areas of the city to victimize against. As a result, areas that once reported higher levels of crime may actually begin to experience a decrease as crime is being displaced to elsewhere along the SkyTrain system.

The only exception to the above pattern is census tract 9330035.01 (RRR = 7.67, $p < .05$). This finding is rather surprising; most of the RRR values reported in the analysis report a decreased level of risk in the CL Dummy variable. For this single census tract to report such a drastic increased level of risk for commercial break and enter suggests that the presence of the SkyTrain station may have exacerbated pre-existing problems within this census tract. Moreover, the problem may have become more apparent after the introduction of the Canada Line. Motivated offenders travelling from Richmond and South Vancouver may have been able to travel to this new hunting ground to find appropriate targets to victimize against. The introduction of this new pathway that adjoins to the pre-existing Expo Line may have manifested the problem and now is experiencing the effects the extension of the SkyTrain route may have had in this vulnerable census tract. Further examination should be given to this census tract to determine what the social cohesion

and the layout of the built environment looks like in order to develop customized safeguards to help combat against the elevated risk of victimization.

The CL Trend variable reported a small number of census tracts with an elevated risk for commercial burglary including census tracts 9330035.02 (RRR = 1.02, $p < .01$), 9330050.02 (RRR = 1.02, $p < .01$), and 9330066.00 (RRR = 1.02, $p < .01$). The extension of the SkyTrain system to include the Canada Line may tempt motivated offenders to leave the familiarity of their routine and awareness spaces to travel to other parts of the city to find appropriate targets to victimize against. Census tract 9330035.02 hosts Renfrew station, as part of the Millennium SkyTrain Line. This station is situated between two large arterial roadways in Vancouver: Grandview Highway and East Broadway. There are a number of businesses located along these two popular streets that can provide a number of establishments to target against. Further, the accessibility of the main roadways can also allow motivated offenders to quickly flee a crime scene by various modes of transport. Beavon et al. (1994) concluded that both road network complexity and traffic flow were significantly related to higher levels of crime. Therefore, the elevated risk found in this census tract since the implementation of the Canada Line could indicate the possibility that due to increased accessibility to the census tract, the likelihood of criminal victimization also increases. Appropriate safeguards should be considered and implemented to try to reverse this trend.

Similarly, census tract 9330050.02 hosts Commercial station, as part of the Millennium SkyTrain Line has also witnessed an elevated risk in commercial burglary. Commercial station is situated in a high density area where a number of commercial stores are located. The station is located at the intersection of Commercial Drive and East Broadway. The concentration of businesses located along both streets draws a large number of individuals to the area, and subsequently, potential offenders. Offenders who utilize the SkyTrain system and either board or depart from Commercial station have an intimate knowledge of the surrounding neighbourhood. They may be tempted to victimize businesses located nearby the station and use the SkyTrain to flee after committing a crime. Alternatively, offenders may also be using the Canada Line to transfer to the Millennium Line to explore new hunting grounds for their criminal needs. As there is a heavy concentration of businesses within the region, offenders would have a wide

selection of stores to target against without exerting much effort. Zipf (1965) has argued that individuals have the tendency to select the option that will provide the least amount of effort. Therefore, offenders will seek out neighbourhoods close by to the SkyTrain to commit crime against. Last, census tract 9330066.00,that hosts Burrard station, as part of the Expo SkyTrain Line has also witnessed an elevated risk for crime. Offenders can travel to this region from Richmond and South Vancouver to this area as there are a plethora of commercial stores to break into. Burrard is situated in a highly desirable retail-area of the city and attracts a number of tourists and residents alike to shop in the stores located within the census tract. Offenders can easily use the SkyTrain to not only select appropriate businesses to target for burglary, but also use the expanded system to flee the area before becoming apprehended by the police. Overall, the extension of the SkyTrain system may increase the likelihood of victimization as offenders can travel further distances while expelling little energy in order to find criminal targets.

6.1.3. Commercial Break and Enter: Census Tracts without a SkyTrain Station

The third group of census tracts that host no SkyTrain station at all, revealed similar findings to the previous two groups of census tracts with a SkyTrain station. In the Trend variable, a number of census tracts reported slight decreases in the level of risk for commercial burglary; census tract 9330032.00 (RRR = 0.99, $p < .01$), 9330041.01 (RRR = 0.99, $p < .01$), 9330041.02 (RRR = 0.99, $p < .01$), 9330051.00 (RRR = 0.98, $p < .01$), 9330063.00 (RRR = 0.99, $p < .05$), and 9330065.00 (RRR = 0.99, $p < .01$). The slight decline witnessed in these census tracts is reflective of the overall crime level within Vancouver where crime has steadily declined since the early 1990s. These changes are also found in the groups of census tracts that host a SkyTrain station. This finding helps establish that the decline witnessed is not solely found in census tracts without a SkyTrain station and is wide-spread.

In the Month variable, only census tract 933013.02 was significant (RRR = 0.97, $p < .01$). As previously discussed, seasonality plays an important role in levels of criminal offending. The slight decline in relative risk may be related to individual offender's preferences to commit crime during ideal climate. Since this census tract does not host a

SkyTrain station, the decrease may be attributed other factors that coincide with the local climate. The presence of capable guardians or lack of targets within the census tract may help decrease the risk for commercial burglary to occur.

In the CL Dummy variable, census tract 9330013.01 (RRR = 0.49, $p < .01$), 9330057.01 (RRR = 0.40, $p < .01$), and 9330060.02 (RRR = 0.49, $p < .01$) were significant. These census tracts demonstrate a decline in the level of relative risk of victimization. Census tract 9330013.01 is located nearby to Canada Line SkyTrain stations, Oakridge-41st Avenue and Langara-49th Avenue and census tract 9330057.01 is located nearby to Expo and Millennium Line SkyTrain stations, Waterfront, Granville, Stadium-Chinatown, Main Street, and Vancouver City Centre. The proximity to these census tracts that host a SkyTrain station may suggest a diffusion of benefits generated from the SkyTrain system. The presence of the SkyTrain could deter offenders from committing crime not only within the station itself but also the vicinity of the station; sometimes beyond the census tract that hosts the station. Transit stations can generate crime up to 1000 meters away from the station itself (Buckley, 1996; Robinson & Giordano, 2012). Therefore, it is plausible to think that the same principle would apply to a diffusion of benefits where the station acts as a buffer to crime due to the presence of by-standers and transit police and can extend that guardianship to census tracts located nearby.

Last, in the CL Trend variable, a series of small significant changes were witnessed in census tracts 9330013.01 (RRR = 0.98, $p < .01$), 9330032.00 (RRR = 1.02, $p < .01$), 9330051.00 (RRR = 1.03, $p < .01$), 9330057.01 (RRR = 1.02, $p < .01$), 9330060.02 (RRR = 1.01, $p < .05$), and 9330063.00 (RRR = 1.02, $p < .01$). These small changes in the level of relative risk could be a symptom of the overall level of crime adjusting to the presence of a SkyTrain station within close proximity of these nearby census tracts. The fluctuation should be monitored over a long period of time to determine whether the level of relative risk may change as levels of commercial burglary adjust to pre-Canada Line crime levels.

6.1.4. Residential Break and Enter: Census Tracts with a Canada Line SkyTrain Station

Residential burglary revealed a number of significant statistical relationships between the census tracts, crime, and exposure of the SkyTrain system. Within the first

group of census tracts with a Canada Line SkyTrain station, a number of changes occurred that influenced the level of relative risk of criminal victimization. The Trend variable was significant in three census tracts; 9330004.01 (RRR = 0.99, $p < .01$), 9330012.00 (RRR = 0.99, $p < .05$), and 9330030.00 (RRR = 0.99, $p < .01$). Although the decrease in risk is minimal, the trend does mirror the overall crime trend within the city of Vancouver as well as Canada as a whole.

Seasonality played an important role in influencing the level of risk of criminal victimization in the Month and Month^2 variable in two census tracts; 9330059.03 (RRR = 1.21, $p < .05$) and (RRR = 0.99, $p < .05$) and 9330059.05 (RRR = 1.20, $p < .01$) and (RRR = 0.99, $p < .01$). Motivated offenders seeking to break and enter into residential homes may be more likely to target homes dependent on the season and temperature (Harries et al., 1984). Some offenders may be more likely to target homes in warmer months as there is a greater likelihood that homes are empty, as more home owners may travel and take vacations. Thus, there is a lack of capable guardians to overlook and protect their home premises. It is easier for an offender to identify homes that are vacant in the summer as property may have uncared for landscaping (i.e. tall grass), uncollected mail and/or newspapers, and have their windows and doors locked throughout the day as their home owners are away. Therefore, offenders who commit crime based on these conditions will have greater success in the summer. Comparatively, some offenders may be more inclined to commit crime during the winter. Motivated offenders may be more likely to break into homes during the holiday season leading up to Christmas. More individuals are likely to leave their homes to see family and friends in addition to shopping for gifts. Offenders can be tempted to break into a house with the potential for a large gain as there may be more valuable items to steal and can take their time as the home will be vacant for an extended period of time. Additionally, home owners may not realize they are advertising their homes have a number of desirable targets to choose from when they leave packaging and gift wrap in the garbage collection pick-ups. Offenders may see the garbage collection and realize there are valuables and goods worth stealing from that property. As a result, they would prefer the winter months to commit crime in order to be selective of homes that will provide the greatest return for their criminal effort. Regardless of the offender's preferences to commit crime based on the weather, motivated offenders will be drawn to commit crime in situations that will benefit them the most; empty premises

with little to no opportunity for the home owners to disrupt the process of breaking and entering into the house to steal.

The CL Dummy variable yielded a number of census tracts that demonstrated a decrease in the level of criminal victimization; census tract 9330039.01 (RRR = 0.55, $p < .01$), 9330059.03 (RRR = 0.42, $p < .01$), and 9330059.05 (RRR = 0.55, $p < .01$). This finding supports the notion that mass forms of public transportation may not increase crime in areas that host a station. Instead, mass transit stations may have the ability to deter crime from occurring due to the increased number of individuals within the station vicinity. Often, the creation of a new transit station will prompt the local transit authority to re-design bus loops and stations to accommodate the increased flow of commuters. Bus routes may be altered to allow the SkyTrain to service more riders while eliminating particular bus routes that travel in the same direction of the SkyTrain route. As a result, more people are likely to be around and can serve as potential capable guardians to both passengers and the station itself. This argument is well-supported using the theoretical framework provided by Cohen & Felson (1979). Although the station may have new opportunities for offenders to seek out appropriate targets, such as a residential property to break into, there are more people within the area that are more likely to observe any attempts that may be made to break into a house.

Last, the CL Trend variable demonstrated a slight increase level of risk for residential burglary in two census tracts; 9330004.01 (RRR = 1.01, $p < .05$) and 9330049.02 (RRR = 1.01, $p < .01$). The slight increase in relative risk in these census tracts could be attributed to unstable levels of crime adjusting to the presence of new pathway, such as the Canada Line. However, closer examination should be made to explore the increase in relation to the level of ridership. Pearlstein & Wachs (1982) concluded in their study of the expansion of the SCRTD in Los Angeles that crime had increased but only in proportion to levels of transit ridership. This finding helps provide insight into the current analysis of Vancouver as the crime trend since the Canada Line became operational may be due to a larger number of passengers using the route to travel. The greater the number of passengers found in stations along the Canada Line, the greater the number of targets offenders can pursue. Therefore, the Canada Line may

demonstrate a small increased level of offending but should be proportional to the number of passengers utilizing the system to travel.

6.1.5. Residential Break and Enter: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

Within the second group of census tracts with an Expo and/or Millennium Line SkyTrain station, changes to the level of reported residential burglary were witnessed in a small number of census tracts. The Trend variable was significant in two census tracts; 9330016.04 (RRR = 0.99, $p < .01$) and 9330050.03 (RRR = 0.99, $p < .01$). The minor decrease is similar to earlier findings that suggest the overall level of crime in Vancouver is gradually declining and close to becoming stabilized.

Within the CL Dummy variable, only one census tract was found to be significant; 9330037.02 (RRR = 0.69, $p < .05$). This finding is intriguing as the level of relative risk within this census tract is much lower regardless of not hosting a Canada Line station. Instead, this census tract hosts Broadway SkyTrain station, as part of the Expo Line. This station is one of the few stations along the entire SkyTrain system that offers a transfer point to board other SkyTrain lines. As such, one would expect to see higher levels of risk found at these stations based on the additional number of people using the station to travel to different parts of the region. Using Cohen & Felson's (1979) Routine Activity Theory, the convergence of more passengers may help deter motivated offenders from wanting to commit crime in the nearby vicinity of the station. Motivated offenders may be more reluctant to commit residential burglary as there are a significantly higher proportion of individuals within the transit setting and can intervene and disrupt the offender from successfully carrying out their crime. Further, the level of relative risk may be related to number and availability of residential homes to target against. As this area within the city of Vancouver is quite congested with a number of different stores and restaurants, offenders may not view this census tract as an ideal hunting ground to select vulnerable property to break into. Instead, they may select a different neighbourhood that is located elsewhere along the SkyTrain route to increase their odds of being successful in committing crime.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts with a Canada Line SkyTrain Station	**9330004.01**	**0.99****	0.99	1.00	1.42	**1.01***
	9330012.00	**0.99***	1.01	1.00	1.52	1.00
	9330030.00	**0.99****	1.17	0.99	1.20	1.00
	9330039.01	1.00	1.07	1.00	**0.55****	0.99
	9330049.02	0.98	1.01	1.00	1.14	**1.01****
	9330059.03	1.00	**1.21***	**0.99***	**0.42****	1.01
	9330059.05	1.00	**1.20****	**0.99****	**0.55****	1.00
Census Tracts with an Expo or Millennium Line SkyTrain Station	**9330016.04**	**0.99****	0.93	1.00	1.36	1.00
	9330035.01	0.99	0.93	1.00	0.74	1.00
	9330035.02	0.99	1.10	0.99	1.00	**1.01****
	9330036.02	**0.99****	0.93	1.01	1.04	1.01
	9330037.02	0.99	1.06	1.00	**0.69***	1.01
	9330050.02	0.99	1.06	1.00	1.37	1.00
	9330050.03	**0.99****	1.03	1.00	1.43	1.00
	9330066.00	0.98	1.12	0.99	0.88	**1.02***
Census Tracts without a SkyTrain Station	**9330013.01**	1.00	1.04	1.00	0.85	1.00
	9330013.02	0.99	0.92	1.01	1.26	**1.01****
	9330028.00	0.99	1.00	1.00	1.15	**1.01****
	9330032.00	1.00	1.10	0.99	0.72	1.00
	9330034.01	**0.99****	0.93	1.00	0.74	**1.00****
	9330040.01	1.00	0.90	1.01	**0.30****	1.01
	9330040.02	1.00	0.96	1.00	**0.29****	1.00
	9330041.01	1.00	0.89	1.01	0.30	1.01
	9330041.02	**0.99****	0.96	1.00	**0.60****	**1.01***
	9330051.00	**0.99****	1.02	1.00	**1.40***	**0.99***
	9330057.01	1.00	1.07	0.99	0.65	1.00
	9330060.02	0.99	0.94	1.00	0.96	1.00
	9330063.00	**0.99****	1.10	0.99	**0.57***	1.00
	9330065.00	0.99	1.04	1.00	**0.52***	1.01
	9330068.00	**0.99****	1.10	0.99	**0.44***	**1.02****

*Note: * Significance under .05, ** Significance under .01*

Table 6: Negative Binomial Regression Results, Residential Break and Enter

Last, the CL Trend variable revealed two census tracts that demonstrated a subtle increase in the level of relative risk of residential burglary victimization; census tract 9330035.02 (RRR = 1.01, $p < .01$) and 9330066.00 (RRR = 1.02, $p < .05$). These stations host Renfrew and Burrard SkyTrain stations. The small increase witnessed in these two census tracts could be related to the development of more residential property in the station's vicinity. In the same way that commercial businesses grow in communities surrounding a new transit station, residential property also expands to profit from the new station. Therefore, the land use that once existed prior to the introduction of a SkyTrain station may be very different once the station is implemented and becomes operational to

the public. The land use may alter the criminal opportunity structure for offenders and could potentially witness a gradual increase in crime due to the availability of new targets. In the current context, offenders may seek out new residential homes, condos, and apartments located nearby the station to commit burglary.

6.1.6. Residential Break and Enter: Census Tracts without a SkyTrain Station

The third group of census tracts that host no SkyTrain station displayed similar findings to the previous two groups of census stations in the analysis of residential burglary. Within the Trend variable, there were five census tracts that demonstrated a small decrease in the level of relative risk for residential burglary victimization. Census tracts 9330034.01 (RRR = 0.99, $p < .01$), 9330041.02 (RRR = 0.99, $p < .01$), 9330051.00 (RRR = 0.99, $p < .01$), 9330063.00 (RRR = 0.99, $p < .01$), 9330068.00 (RRR = 0.99, $p < .01$) support the crime drop hypothesis. Crime has steadily declined and continues to do in Vancouver. Furthermore, the decline is similar across all three groups of census tracts included in the analysis, demonstrating that the level of crime in Vancouver is declining and is not influenced by an external factor such as the SkyTrain system.

Results for the CL Dummy variable demonstrated a number of significant relative risk ratios. Census tracts 9330040.01 (RRR = 0.30, $p < .001$), 9330040.02 (RRR = 0.29, $p < .01$), 9330041.02 (RRR = 0.60, $p < .01$), 9330063.00 (RRR = 0.57, $p < .05$), 9330065.00 (RRR = 0.52, $p < .05$), and 9330068.00 (RRR = 0.44, $p < .05$) experienced a reduced level of criminal victimization. The decline in risk of criminal victimization may be attributed to diffusion of benefits.

The only exception to the decreased level of risk as found in the aforementioned census tracts, is census tract 9330051.00 (RRR = 1.40, $p < .05$). The level of risk within this particular census tract is significantly higher. This census tract is situated in a highly densified part of Vancouver and is located nearby major arterial roadways such as East 1st Avenue, Victoria Drive, East Broadway, Grandview Highway, and Renfrew Street. These busy arterial roads connect to a number of residential side streets that may make it more conducive for offenders to commit crime. Census tract 9330051.00 is located nearby Renfrew and Rupert SkyTrain stations and may inadvertently displace crime from

the station and the vicinity of the station to areas located further away. Since there are more commercial businesses located nearby these two SkyTrain stations, it may make more sense for an offender to use the SkyTrain system to travel to the area but then travel a short distance away to find appropriate homes to break into. This part of the city has a number of residential homes in the vicinity of the stations that it make attract offenders to scout out the area for the most ideal home to victimize against. Further, the accessibility of the side streets adjoining to some of Vancouver's major roadways will make it easier for offenders to escape and avoid detection and apprehension from the police. As Beavon et al. (1994) discussed in their study of criminal targets and accessibility of street networks, the more accessible a street was, the higher the level of crime was, particular within property related offences. Therefore, the increase in criminal victimization risk would be expected within this census tract despite not hosting a SkyTrain station.

However, despite the decline in level of risk found in the CL Dummy variable, the subsequent crime trend after the implementation of the Canada Line has witnessed a slight increase in crime. Census tracts with an elevated risk include: 9330013.02 (RRR = 1.01, $p < .01$), 9330028.00 (RRR = 1.01, $p < .01$), 9330034.01 (RRR = 1.00, $p < .01$), 9330041.02 (RRR = 1.01, $p < .05$), 9330051.00 (RRR = 0.99, $p < .05$), 9330068.00 (RRR = 1.02, $p < .01$). The initial development and implementation of the new SkyTrain route may have caused a disruption to the built environment surrounding the station and may start to influence nearby census tracts in relation to the level of criminal offending. The census tracts that host a SkyTrain station may begin to change over time and develop into both crime generators and attractors. Initially, offenders may not be aware of the opportunity structure found within transit settings that makes it conducive to commit crime. However, over time, the station may transform into a crime attractor as offenders become more aware of the transit environment and opportunities to commit crime. Their refined awareness spaces will allow them to recognize the opportunities that exist within those environments that would allow them to carry out crime and can facilitate more offenders to be drawn into the region as word is spread that there are ideal targets to select within this particular environment.

6.1.7. Mischief: Census Tracts with a Canada Line SkyTrain Station

Mischief exhibited a number of significant relative risk ratios in the analysis. Within the first group of census tracts with a Canada Line SkyTrain station, a small number of census tracts reported a change in the level of criminal victimization risk. The Trend variable was significant in two census tracts; 9330030.00 (RRR = 0.99, $p < .05$) and 9330059.03 (RRR = 0.99, $p < .01$). Again, the results garnered from this analysis demonstrate and support the overall notion that crime is relatively stable within the city of Vancouver, with minor decreases. However, the level of risk does differ while examining the Month and Month^2 variables for census tracts that host a Canada Line SkyTrain station. Census tracts 9330049.02 (RRR = 1.19, $p < .01$) and (RRR = 0.99, $p < .05$) and 9330059.03 (RRR = 1.13, $p < .01$) and (RRR = 0.99, $p < .01$) both demonstrate a significant increase in the level of victimization for the offence of mischief. Mischief is a crime that will be highly dependent on the temperature and season; mischief is more likely to occur during dry and warm weather as the routine activities of individuals will be spent more likely outdoors. Therefore, victimization is more likely to occur. Especially within transit settings, individuals who are waiting for a SkyTrain to arrive will have some unstructured free time as they wait to be picked up. This time can be spent causing vandalism to the station itself and/or the nearby environment, which can include residential homes and commercial businesses. The increases should be expected as motivated offenders will have the opportunity to expand and develop their awareness spaces with the introduction of a new pathway (Brantingham & Brantingham, 1981). Their awareness space may now include a hunting ground that was once inaccessible. As offenders explore their new grounds, they may have new opportunities to commit mischief.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts with a Canada Line SkyTrain Station	**9330004.01**	0.99	1.09	1.00	1.17	1.00
	9330012.00	1.00	1.05	1.00	1.18	**0.99***
	9330030.00	**0.99***	1.17	0.99	1.12	1.01
	9330039.01	1.00	1.08	0.99	0.71	1.01
	9330049.02	0.99	**1.19****	**0.99***	1.25	**1.01****
	9330059.03	**0.99****	**1.13****	**0.99****	1.12	1.00
	9330059.05	1.00	1.06	1.00	1.06	1.00
Census Tracts with an Expo or Millennium Line SkyTrain Station	**9330016.04**	1.01	0.97	1.00	0.61	**0.98***
	9330035.01	1.00	0.93	1.01	**0.64***	1.00
	9330035.02	0.99	1.05	1.00	1.33	1.00
	9330036.02	1.00	1.07	1.00	**1.42***	1.00
	9330037.02	1.00	1.09	0.99	1.10	1.00
	9330050.02	**1.00***	1.05	1.00	0.85	1.01
	9330050.03	**0.99****	1.06	1.00	1.20	**1.01***
	9330066.00	**0.99****	1.02	1.00	1.03	1.00
Census Tracts without a SkyTrain Station	**9330013.01**	1.00	1.03	1.00	0.94	0.99
	9330013.02	**0.99****	1.03	1.00	1.07	1.00
	9330028.00	**0.99***	1.11	0.99	0.99	**1.01***
	9330032.00	1.00	1.07	0.99	0.9	1.00
	9330034.01	1.00	0.91	1.01	1.14	1.00
	9330040.01	**0.99***	0.92	1.01	1.01	1.01
	9330040.02	**0.99***	0.91	1.01	**2.04****	1.01
	9330041.01	0.99	0.90	1.01	1.14	1.00
	9330041.02	**0.99****	1.10	0.99	1.26	1.00
	9330051.00	1.00	**1.16****	**0.99***	0.80	1.00
	9330057.01	**1.01****	1.06	0.99	**0.74***	1.00
	9330060.02	**0.99****	1.04	1.00	1.13	1.01
	9330063.00	**0.99****	1.05	1.00	1.50	**1.01***
	9330065.00	1.00	1.07	1.00	0.84	1.00
	9330068.00	**0.99****	**1.25****	**0.98****	1.37	**1.01***

*Note: * Significance under .05, ** Significance under .01*

Table 7: Negative Binomial Regression Results, Mischief

Last, within the CL Trend variable, there were few census tracts that reported changes to the level of relative risk of crime. Census tracts 9330012.00 (RRR = 0.99, $p < .05$) and 9330049.02 (RRR = 1.01, $p < .01$) reported only slight changes to the likelihood of mischief occurring. Within census tract 9330012.00, the relative level of risk was slightly lower. This finding is a bit surprising given the fact these census tracts hosts two Canada Line SkyTrain stations, Oakridge-41st Avenue and Langara-49th Avenue. This location has a number of opportunities to commit mischief within. One reasonable explanation could be attributed to the increased level of capable guardianship found within the transit environment. More passengers using the system

will result in a greater number of individuals boarding, departing, and waiting for the train. As a result, these individuals may disrupt offenders seeking to commit crime in this location as the likelihood that crime will decrease with the increase of intervention to stop the criminal act from potential capable guardians. Within census tract 9330049.02, the relative level of risk was the opposite, a slight increase. This census tract hosts Olympic Village SkyTrain station.

6.1.8. Mischief: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

Within the second group of census tracts with an Expo and/or Millennium Line SkyTrain station, changes to the level of reported mischief were witnessed in a small number of census tracts. Within the Trend variable, three census tracts were significant; 9330050.02 (RRR = 1.00, $p < .05$), 9330050.03 (RRR = 0.99, $p < .01$), and 9330066.00 (RRR = 0.99, $p < .01$). The relative level of risk is either neutral or experienced a slight decrease. Despite, the minimal changes reported, this finding is still important to recognize as it demonstrates that the crime drop hypothesis still holds true.

Within the CL Dummy variable, two census tracts were significant; 9330035.01 (RRR = 0.64, $p < .05$) and 9330036.02 (RRR = 1.42, $p < .05$). Census tract 9330035.01 hosts Nanaimo SkyTrain station, as part of the Expo Line. The level of risk has dramatically decreased since the implementation of the Canada Line. The decreased level of risk may be best understood through Cohen & Felson's (1979) Routine Activity Theory and Cornish & Clarke's (1986) Rational Choice Theory. Previous studies on vandalism on public transportation systems has demonstrated that more damage occurs to buses and trains without conductors, particularly within parts of the bus and/or train that have little supervision (Sturman, 1980 as cited in Smith & Clarke, 2000). The number of passengers found within this particular SkyTrain station may help deter motivated offenders from committing mischief as the risk of getting caught is too great. The fear of becoming apprehended demonstrates the decision-making process of the offender. A motivated offender is not likely to risk getting apprehended by the police for the sake of committing a crime, in this case a form of mischief, in front of a number of potential by-standers. The presence of the by-standers alone may be enough to deter

some offenders from committing mischief at the station. Instead, the offenders are more likely to select another SkyTrain station that offers little supervision in order to carry out their crimes successfully.

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Unlike the decline witnessed in mischief at Nanaimo SkyTrain station, census tract 9330036.02 (that hosts Rupert SkyTrain station) experienced a significant increase in the level of risk. Rupert SkyTrain station is situated in heavily commercial land use. Due to the abundance of businesses located nearby, there may be a greater opportunity for motivated offenders to carry out different acts of mischief without intervention from a capable guardian. Most individuals who use this SkyTrain station are more likely to work at one of the nearby businesses, and therefore, are not spending vast amount s of time around the station. Instead, their presence will be found primarily before and after their work hours. Motivated offenders may use their temporal pattern at the station to their advantage; commit crime while fewer people are around and therefore, escape the possibility of becoming apprehended.

Within the CL Trend variable, only one census tract, 9330016.04 (RRR = 0.98, $p < .05$) experienced a slight decline in the level of risk for mischief to occur. This census tract hosts two SkyTrain stations; 29th Avenue and Joyce-Collingwood. The reported decline is minimal but does demonstrate that the criminal opportunity structure has changed since the implementation of the Canada Line. This slight decline could be attributed to the fact that motivated offenders are more likely to travel further along the SkyTrain system as there are potentially new, unexplored hunting grounds to engage and commit mischief within. Ihlanfedlt (2003) concluded in his study of transit and crime that although a station may increase access to the neighbourhood by outside criminals, it may also encourage offenders living within the neighbourhood to commit their crimes elsewhere. In doing so, the commuting costs between the home neighbourhood and other neighbourhoods are lower (Ihlanfeldt, 2003). Instead of being forced to concentrate in one particular section of the SkyTrain system, offenders now can travel larger distances to find new opportunities to commit mischief. This particular census tract should be monitored over time to determine whether this subtle decline returns to pre-Canada Line trends or whether the new line has subsequently shifted the level of relative risk found in census tract 9330016.04.

6.1.9. Mischief: Census Tracts without a SkyTrain Station

Within the third group, census tracts without a SkyTrain station, there were some notable changes witnessed in the levels of relative risk for mischief. A number of census tracts witnessed slight changes in the Trend variable; 9330013.02 (RRR = 0.99, $p < .01$), 9330028.00 (RRR = 0.99, $p < .05$), 9330040.01 (RRR = 0.99, $p < .05$), 9330040.02 (RRR = 0.99, $p < .05$), 9330041.02 (RRR = 0.99, $p < .01$), 9330057.01 (RRR = 1.01, $p < .01$), 9330060.02 (RRR = 0.99, $p < .01$), 9330063.00 (RRR = 0.99, $p < .01$), 9330068.00 (RRR = 0.99, $p < .01$). This pattern is consistent amongst the other groups of census tracts included in this analysis.

Within the Month and Month^2 variables, there were a small number of census tracts that demonstrated a change in the level of relative risk; 9330051.00 (RRR = 1.16, $p < .01$) and (RRR = 0.99, $p < .05$) and 9330068.00 (RRR = 1.25, $p < .01$) and (RRR = 0.98, $p < .01$). This small increase is reflective of Harries et al.'s (1984) argument that crime is related to seasonal patterns of temperature. There may be a small increase due to an ideal climate for offenders to select and victimize against vulnerable properties. Ideal climates may vary depending on the type of offender and their daily routine. Some offenders may prefer the summer to commit crime as they may have less restrictive schedules where they have more free time outside of school and work and can search a greater number of opportunities to destroy and vandalize property. Both census tracts are situated nearby larger arterial roads that help connect downtown Vancouver to East Vancouver and North Vancouver. Census tract 9330051.00 is nested within the busy streets such as Victoria Drive, East 1st Avenue, and East Broadway while census tract 9330068.00 is located at the entrance of Stanley Park, Robson Street, and West Georgia Street. There are countless targets located along these large roadways that offenders can easily vandalize against. Further, the road connectivity may help offenders escape apprehension from their ability to connect to other parts of the city, either through walking, private vehicle, and/or public transportation. Both census tracts are located within walking distance to the SkyTrain system and therefore could easily travel on foot or car to a station and leave without detection.

Within the CL Dummy variable, census tracts 9330040.02 (RRR = 2.04, $p < .01$) and 9330057.01 (RRR = 0.74, $p < .05$) demonstrated changes to the level of relative risk.

In the first census tract, 9330040.02, the relative level of risk is two times greater compared to other census tracts in the analysis. This census tract is located nearby Broadway-City Hall SkyTrain station, Vancouver General Hospital, in addition to roads such as Granville Street, West 12th Avenue, and Oak Street. Previously this census tract was primarily accessed by those travelling on foot, bus, or private vehicle. However, with the introduction of the Canada Line and its subsequent station, Broadway-City Hall, the accessibility of this area is much greater. As a result, there is a larger influx of travellers to the region, increasing the number of targets to victimize against. Motivated offenders have a surplus of targets to choose amongst to commit mischief. They can easily travel in and out of the region without appearing to be an outsider. It is difficult to single out offenders as they can easily blend in and become part of the same environments shared by non-offenders. As a result, offenders do not appear to be outsiders and can exercise their criminal motivations without a high likelihood of being detected and stopped.

Within the CL Trend variable, 9330028.00 (RRR = 1.01, $p < .05$), 9330063.00 (RRR = 1.01, $p < .05$), and 9330068.00 (RRR = 1.01, $p < .05$) each demonstrated a minor increased level of relative risk for mischief. These census tracts are located nearby to census tracts that host a SkyTrain station and heavily densified parts of the city, including the hospital precinct near Vancouver General Hospital, English Bay, and Stanley Park. Each of these areas draws in a large number of individuals seeking out attractions to visit. As a result, there are a number of targets that may be suitable for an offender to victimize against. The increased level of risk may be attributed to a spillover effect from the SkyTrain system, where crime and nuisance may be displaced to areas within a close vicinity of the mass transit system.

6.1.10. Theft: Census Tracts with a Canada Line SkyTrain Station

Within the first group of census tracts, those with a Canada Line SkyTrain station, a small number of census tracts demonstrated a change in the level of relative risk for theft. In the Trend variable there were two significant findings; census tract 9330012.00 (RRR = 0.99, $p < .01$) and 9330049.02 (RRR = 0.99, $p < .01$). Not surprisingly, these results mimic earlier findings in each census tract group, regardless of offence type. The slight decrease demonstrates the overall level of crime in Vancouver is stable.

Again, the seasonality and temperature of Vancouver may influence the level of reported crime in the offence category of theft. In the Month and Month^2 variables, census tracts 9330030.00 (RRR = 1.16, $p < .01$) and (RRR = 0.99, $p < .01$) and 9330039.01 (RRR = 1.16, $p < .01$) and (RRR = 0.99, $p < .01$) were found to have altered levels of risk for the crime of theft. Routine Activity Theory contends that as temperatures change, so to do the activities of people (Cohen & Felson, 1979). Activities dependent on weather can encourage individuals to leave their home and engage in outdoor activities, thereby increasing the risk both to individuals and their belongings and property to be victimized by motivated offenders. Motivated offenders are included in this group of individuals seeking out enjoyment away from their homes. In turn, the overlap between potential victims and offenders increases the odds that crime will take place. Both offenders and victims may be more enticed to use public transit during these peak seasonal changes in order to travel to special events. As a result, the number of available targets available for motivated offenders is much higher, compared to regular weather patterns that force individuals to remain to their daily routines. As such, the level of relative risk would be considerably higher during ideal temperatures that encourage people to leave their home surroundings.

The CL Trend variable reported some changes within census tracts 9330004.01 (RRR = 1.02, $p < .01$), 9330012.00 (RRR = 1.01, $p < .05$), 9330030.00 (RRR = 1.01, $p < .01$) and 9330049.02 (RRR = 1.01, $p < .01$). The minor increase in theft could signify a greater number of passengers using the new transit route to commute throughout Vancouver and being exposed to a greater number of targets to offend against. There are a number of commercial stores, restaurants, and a post-secondary institution located within these census tracts and could be very appealing to those motivated offenders who use the SkyTrain to commute. With the SkyTrain close by, offenders could easily steal and use the train to be able to flee the area without being seen nor apprehended. With the addition of a new pathway within the region, the level of crime is expected to increase. However, how long offenders may be willing to travel and the intensity of this increase in their target hunting may change over time. Closer examination should be given to determine whether this trend will remain to be increasing over time.

6.1.11. Theft: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

Within the second group of census tracts, those with an Expo and/or Millennium Line, the Trend variable followed a similar pattern to other offence categories. Census tracts 9330016.04 (RRR = 0.99, $p < .05$), 9330037.02 (RRR = 1.00, $p < .05$), 9330050.02 (RRR = 0.99, $p < .01$), and 9330066.00 (RRR = 1.00, $p < .01$) each displayed very minimal changes to the overall level of criminal offending within Vancouver.

Theft appears to be influenced by the temperature of the weather in Vancouver. Three census tracts: 9330035.02 (RRR = 1.10, $p < .05$) and (RRR = 0.99, $p < .01$), 9330037.02 (RRR = 1.09, $p < .01$) and (RRR = 0.99, $p < .01$) and 9330050.02 (RRR = 1.12, $p < .01$) and (RRR = 0.99, $p < .01$) appear to have experienced an increase in the level of relative risk. Temperature variations may help explain why some census tracts that host an Expo and/or Millennium Line SkyTrain station are more vulnerable for crime to occur. Crime tends to have seasonal peaks; certain activities will draw individuals away from their home and into the built environment, typically engaging in leisurely/pleasurable activities. The increased number of individuals may increase the pool of motivated offenders within the built environment. There may be new criminal opportunities found in census tracts that host an Expo and/or Millennium Line SkyTrain station that will attract motivated offenders to commit crime. During warmer months, offenders may be more inclined to pick pocket and steal items from unsuspecting passengers who use the SkyTrain system to travel. Also, during colder weather, offenders may be forced to select stationary targets found indoors, as the likelihood for individuals spending time outside in the cold weather is much lower. Renfrew, Broadway, and Commercial SkyTrain stations belong in the aforementioned census tracts. Broadway and Commercial are unique stations as they both service the same general station, but have two different platforms that services each line. Broadway platform is elevated while Commercial is submerged. Although they are found in two separate census tracts, they have more vulnerability for crime to occur due to the transfer point it serves between the two different SkyTrain lines. As passengers board and unload the train to transfer to different lines, bus routes, or to depart on foot, there are a number of opportunities for offenders to select amongst. Especially with poor weather, passengers are more likely to remain inside the station's compound that provides some protection from the elements, whether it is extreme heat or

cold, wet weather. As a result of this concentration, offenders can easily blend in the crowds and select the ideal target to steal. They can effortlessly leave the transit station without arousing suspicion for theft.

Only one census tract was found to be significant while examining the CL Dummy variable; census tract 9330037.02 (RRR = 0.75, $p < .01$). This census tract hosts Broadway SkyTrain and the overall trend since the implementation of the Canada Line demonstrates a decreased level of risk. This finding further supports the significance of the month variables as risk will be dependent on the season and weather; during mundane periods of weather, risk for theft is lower compared to periods of extreme temperature. This finding may also suggest that the extension of the SkyTrain system to include the Canada Line has caused crime concentrations to spread more evenly across the system itself and not limited to a select number of stations.

Last, results garnered from the CL Trend variable demonstrate a minimal change to the overall trend for theft since the implementation of the Canada Line in census tracts: 9330016.04 (RRR = 1.01, $p < .05$), 9330036.02 (RRR = 1.01, $p < .01$), 9330050.02 (RRR = 1.01, $p < .05$) and 9330066.00 (RRR = 1.01, $p < .01$). This finding is expected as the introduction of a new pathway within region will change the crime opportunity structure. Increased levels of ridership tend to be proportional to the level of crime reported within the area (Pearlstein & Wachs, 1982). Therefore, the slight increase in criminal offending since the implementation of the Canada Line is expected. Close monitoring of the levels of reported crime should be regularly done to ensure the increase does not continue; the trend should return to pre-Canada Line levels once the station has stabilized within the region.

6.1.12. Theft: Census Tracts without a SkyTrain Station

Census tracts without a SkyTrain station yielded some significant variables that have influenced the level of relative risk for theft. The Trend variable reported two significant census tracts; 9330041.01 (RRR = 1.00, $p < .05$) and 9330063.00 (RRR = 0.99, $p < .01$). Just like the previous analyses of the other crime types, the pattern remains consistent that the overall level of crime within Vancouver is stable. In the Month and

Month^2 variables, four census tracts were significant in relation to the level of relative risk for theft; 9330013.01 (RRR = 1.13, $p < .05$) and (RRR = 0.99, $p < .05$), 9330032.00 (RRR = 1.19, $p < .01$) and (RRR = 0.99, $p < .01$), 9330041.02 (RRR = 1.11, $p < .01$) and (RRR = 0.99, $p < .01$), and 9330063.00 (RRR = 1.20, $p < .01$) and (RRR = 0.99, $p < .01$). Theft may peak in the summer months as there are a greater number of individuals spending time away from their homes and exposing themselves to motivated offenders within the built environment. Alternatively, theft may also peak in the winter months due to monetary motives such as the pressure to provide gifts to others, limited employment opportunities, and to obtain necessities such as food, clothing, and shelter.

Changes to the level of relative risk after the implementation of the Canada Line (CL Dummy) were noted in three census tracts within the third group of census tracts without a SkyTrain station. Census tracts include 9330040.02 (RRR = 1.48, $p < .05$), 9330060.02 (RRR = 0.79, $p < .01$), and 9330065.00 (RRR = 0.76, $p < .01$). Both census tract 9330060.02 and 9330065.00 both experienced significant decreases in the level of relative risk. These census tracts are located nearby Bute Street, Burrard Street, Davie Street, and Nelson Street. Although there are a number of SkyTrain stations located nearby these two census tracts, they are located far enough away that it would take motivated offenders extra effort in order to use the system to commit crime. Offenders are more likely to search for appropriate targets within close proximity of their activity spaces. Further, offenders are less likely to want to exert more effort to search for a target when there may be a more viable option closer to the SkyTrain station. Therefore, the level of relative risk becomes much lower, the farther away the census tract is to a SkyTrain station. The exception to this pattern is the results for census tract 9330040.02, where an increase of 1.48 was witnessed. This census tract contains major roadways such as Oak Street, Granville Street, West 12th Avenue, and Marpole Avenue. For many, this area is considered the hospital precinct of Vancouver due to the number of medical offices and services within the area, including Vancouver's General Hospital. The increase in the level of relative risk could be due to the presence of a Canada Line SkyTrain station located nearby; Broadway-City Hall. As previously mentioned, the accessibility of this area was once more challenging for commuters to reach; one was limited primarily to bus service or private vehicle. With the introduction of the Canada Line now servicing this area, motivated offenders have more opportunities to select appropriate

targets to steal from. Offenders may be travelling from different parts of the city that were once too challenging to do by bus or private vehicle and now have new pathways to travel to fulfill the criminal desires. With the abundance of targets to choose amongst such as medical items/equipment, goods, food, etc., motivated offenders do not have to exert much effort in fulfilling their criminal desires. As a result, this once inaccessible area presents a greater level of criminal victimization.

Finally, the CL Trend variable reported changes to the level of relative risk in six census tracts: 9330032.00 (RRR = 1.01, $p < .01$), 9330040.02 (RRR = 1.01, $p < .01$), 9330051.00 (RRR = 1.01, $p < .01$), 9330060.02 (RRR = 1.01, $p < .05$), 9330065.00 (RRR = 1.00, $p < .05$), 9330068.00 (RRR = 1.01, $p < .01$). The increase is slightly elevated but is consistent with other offence categories included in this analysis. The small change may be attributed to the built environment adjusting to the presence of a new pathway. It may take some time before the new pathway; the Canada Line adjusts within the region. Close monitoring should be conducted regularly to ensure the increase does not significantly increase. It is expected that the level of reported crime for theft should return to pre-Canada Line trends once the adjustment has been made and patterns of crime become stable once again.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts With a Canada Line SkyTrain Station	**9330004.01**	0.99	1.14	0.99	0.66	**1.02****
	9330012.00	**0.99****	1.09	0.99	1.31	**1.01***
	9330030.00	1.00	**1.16****	**0.99****	0.93	**1.01****
	9330039.01	1.00	**1.16****	**0.99****	0.88	1.00
	9330049.02	**0.99****	1.69	0.96	1.03	**1.01****
	9330059.03	1.00	1.30	0.98	1.05	1.00
	9330059.05	1.00	1.10	0.99	1.05	1.00
Census Tracts With an Expo Or Millennium Line SkyTrain Station	**9330016.04**	**0.99***	1.10	0.99	1.10	**1.01***
	9330035.01	0.99	1.14	0.99	1.02	1.01
	9330035.02	1.00	**1.10***	**0.99****	0.88	1.00
	9330036.02	1.00	0.95	1.00	1.44	**1.01****
	9330037.02	**1.00***	**1.09****	**0.99****	**0.75****	1.00
	9330050.02	**0.99****	**1.12****	**0.99****	0.98	**1.01***
	9330050.03	0.99	1.23	0.98	1.16	1.01
	9330066.00	**1.00****	1.17	0.99	1.13	**1.01****
Census Tracts Without a SkyTrain Station	**9330013.01**	1.01	**1.13***	**0.99***	0.86	0.99
	9330013.02	1.00	0.95	1.00	0.98	1.00
	9330028.00	0.99	1.10	0.99	1.10	1.01
	9330032.00	1.00	**1.19****	**0.99****	0.98	**1.01****
	9330034.01	1.00	1.04	1.00	0.94	0.99
	9330040.01	1.00	1.05	1.00	0.86	1.00
	9330040.02	0.99	1.05	0.99	**1.48***	**1.01****
	9330041.01	**1.00***	0.95	1.00	0.98	1.00
	9330041.02	1.00	**1.11****	**0.99****	0.91	1.00
	9330051.00	1.00	1.01	1.00	0.87	**1.01****
	9330057.01	1.00	1.15	0.99	1.54	1.00
	9330060.02	1.00	1.21	0.99	**0.79****	**1.01***
	9330063.00	**0.99****	**1.20****	**0.99****	1.31	1.00
	9330065.00	1.00	1.12	0.99	**0.76****	**1.00***
	9330068.00	0.99	1.93	0.95	1.14	**1.01****

*Note: * Significance under .05, ** Significance under .01*

Table 8: Negative Binomial Regression Results, Theft

6.1.13. Theft from Vehicle: Census Tracts with a Canada Line SkyTrain Station

Within the first group of census tracts, those with a Canada Line SkyTrain station, a small number of census tracts demonstrated a change in the level of relative risk for theft from vehicle. In the Trend variable, there were four significant findings; census tracts 9330004.01 (RRR = 0.99, $p < .01$), 9330012.00 (RRR = 0.99, $p < .01$), 9330030.00 (RRR = 0.99, $p < .01$) and 9330039.01 (RRR = 0.99, $p < .01$). These census tracts demonstrate very minimal change in the level of relative risk for theft from vehicle. As was the case

with other offence types, the pattern is stable and consistent across each offence category within Vancouver. The overall level of crime is stable with slight decreases.

Only one census tract was found to be significant in relation to the Month and Month^2 variable; 9330049.02 (RRR = 1.20, $p < .01$) and (RRR = 0.99, $p < .01$). The elevated increase in the level of relative risk for theft from vehicle was found to be in the census tract that hosts Olympic Village SkyTrain station. This geographical region has dramatically changed in recent years due to the 2010 Winter Olympic Games in Vancouver and the subsequent expansion of the SkyTrain system to include the Canada Line. This station serviced athlete housing that was found along False Creek for competing athletes of the Winter Olympics. It is located nearby to a number of major pathways within Vancouver, including the Cambie Street Bridge, West 2nd Street, West 6th Avenue, and Ash Street. This area is very popular during warmer weather due to the number of outdoor activities it offers for individuals to engage in such as walking and biking around False Creek, going to sporting events at the local stadiums, BC Place and Rogers Arena, and engaging in gambling at the local casino, Edgewater. In order to avoid traffic congestion, availability, and the expense of parking, many individuals may choose to park their cars close to a SkyTrain station in order to reduce their costs and stress related to travelling via car. As a result, motivated offenders have a number of targets available to them if they follow individuals from the SkyTrain station to the location of their parked cars. Furthermore, during warmer weather, people are more inclined to leave windows open to make the vehicles cooler but inadvertently place a greater amount of risk for victimization. Offenders do not have to exert much energy in breaking into a vehicle as car owners have done that for them instead. Therefore, it is not surprising to see an increased level of risk within this census tract given the nature of the built environment and the behaviour commuters engage in to make their travels quicker.

The implementation of the Canada Line has impacted some census tracts that host one of the line's new stations. Census tracts 9330004.01 (RRR = 0.52, $p < .01$), 9330039.01 (RRR = 0.54, $p < .01$), 9330059.03 (RRR = 0.65, $p < .05$), and 9330059.05 (RRR = 0.59, $p < .01$) all reported significant decreases in the level of relative risk in the CL Dummy variable. The decreased levels of risk may be attributed to a greater number of transit users leaving their vehicles at home to commute, and thereby decreasing the

possibility of theft from their vehicles. Within these census tracts, there are a number of Canada Line stations: Oakridge-41st Avenue, Langara-49th Avenue, Broadway-City Hall, Yaletown-Roundhouse, Vancouver City Centre, and Waterfront. All of these stations are located in areas of the city that offer very limited parking in and around the stations. The only exceptions to this would be Langara College's parking lot found nearby Langara-49th Avenue and the underground parking lot at Oakridge centre nearby Oakridge-41st Avenue. Vancouver City Centre is located adjacent to Pacific Centre, however, this station is solely accessible by foot traffic only, and therefore there would be no opportunities for offenders to search for vehicles to break into from this station.

The crime trend since the implementation of the Canada Line yielded four census tracts that experience a very minimal increase in the level of relative risk for theft from vehicle victimization; 9330030.00 (RRR = 1.01, $p < .01$), 9330039.01 (RRR = 1.01, $p < .01$), 9330049.02 (RRR = 1.01, $p < .05$) and 9330059.05 (RRR = 1.01, $p < .01$). This pattern is consistent with earlier analyses of the other criminal offences included in the current study. The expected increase can be attributed to the presence of a new pathway within the vicinity of census tracts that host a Canada Line SkyTrain station and may take some to adjust the level of reported crime.

6.1.14. Theft from Vehicle: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

The Trend variable reported a number of small, yet consistent findings for the overall level of offending within census tracts that host an Expo and/or Millennium Line SkyTrain station. Census tracts included: 9330035.01 (RRR = 0.99, $p < .01$), 9330035.02 (RRR = 0.99, $p < .01$), and 9330037.02 (RRR = 0.99, $p < .01$). The small decreases are consistent with previous findings of the overall trend of criminal offending in Vancouver and provide support that crime is stabilized in Vancouver with slight decreases in the level of relative risk.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts with a Canada Line SkyTrain Station	**9330004.01**	**0.99****	1.05	1.00	**0.52****	1.02
	9330012.00	**0.99****	1.10	0.99	1.25	1.00
	9330030.00	**0.99****	1.05	1.00	0.93	**1.01****
	9330039.01	**0.99****	0.95	1.01	**0.54****	**1.01****
	9330049.02	0.99	**1.20****	**0.99****	0.69	**1.01***
	9330059.03	0.99	1.04	1.00	**0.65***	1.01
	9330059.05	0.99	1.03	1.00	**0.59****	**1.01****
Census Tracts with an Expo or Millennium Line SkyTrain Station	**9330016.04**	0.99	0.91	**1.01***	0.94	**1.01****
	9330035.01	**0.99****	1.09	1.00	0.73	**1.02****
	9330035.02	**0.99****	1.05	1.00	0.83	1.02
	9330036.02	0.99	0.97	1.01	1.19	**1.01****
	9330037.02	**0.99****	0.91	1.01	1.11	**1.02****
	9330050.02	0.99	0.95	1.00	0.91	**1.01****
	9330050.03	0.99	1.07	1.00	0.74	1.02
	9330066.00	0.99	1.05	1.00	**0.73***	1.00
Census Tracts without a SkyTrain Station	**9330013.01**	1.00	1.00	1.00	1.11	1.00
	9330013.02	0.98	0.99	1.00	1.47	**1.01****
	9330028.00	**0.98****	1.13	0.99	0.71	1.02
	9330032.00	1.00	0.96	1.00	1.07	1.00
	9330034.01	**0.99****	1.05	1.00	1.10	**1.01***
	9330040.01	**0.99***	0.99	1.00	0.89	**1.01***
	9330040.02	**0.99****	0.91	1.01	0.87	**1.01***
	9330041.01	0.99	0.94	1.1	0.87	**1.02****
	9330041.02	0.99	0.97	1.00	1.08	**1.01***
	9330051.00	0.99	1.01	1.00	0.83	1.02
	9330057.01	1.00	**1.18****	**0.99****	0.80	1.00
	9330060.02	0.99	1.04	1.00	0.79	1.01
	9330063.00	0.98	0.99	1.00	0.91	1.02
	9330065.00	1.00	1.02	1.00	0.45	1.01
	9330068.00	0.99	1.36	0.98	**0.70****	**1.01****

*Note: * Significance under .05, ** Significance under .01*

Table 9: Negative Binomial Regression Results, Theft from Vehicle

There was a very small change in the level of relative risk for theft from vehicle in the Month^2 variable in census tract 9330016.04 (RRR = 1.01, $p < .05$). This slight increase is found in the census tract that hosts 29th Avenue and Joyce-Collingwood SkyTrain stations. The seasonality of Vancouver could contribute to the reported change in level of criminal victimization. Commuters who use the SkyTrain to travel to work may try to reduce their commute time by splitting their journey into a shared service between private vehicle and public transportation. Some commuters may feel inclined to use park and rides or street parking to leave their vehicles while boarding a train at a SkyTrain station in order to avoid the stress of parking fees, parking availability, and the length of the

commute, particularly if there is traffic congestion that could lead to long delays in order to get to or from work or home. As a result, motivated offenders may seek out areas close to the station within the census tract to target vulnerable cars to steal from. The length of time a vehicle is parked and unoccupied can be anywhere between 8-10 hours, depending on the individual's work schedule. As a result, the motivated offender would have a large time frame to break into the vehicle and choose items that they can steal. This issue is further exacerbated when the weather is warmer and people may become ignorant or forgetful of locking their vehicle's doors and windows from car thieves. By the time the owner of the vehicle returns, the offender is nowhere to be found and the owner now faces a number of financial losses due to their careless of act of leaving windows open.

The CL Dummy variable reported one census tract with a decreased level of risk for theft from vehicle: 9330066.00 (0.73, $p < .05$). This finding is not surprising given the location of this SkyTrain station. Burrard is one of the busiest SkyTrain stations in downtown Vancouver. It is situated near a number of major arterial roadways including Burrard Street, Robson Street, West Georgia Street, and West Hastings Street. There are limited to no parking available within this area due to heavy traffic volume that passes through on a daily basis. Many vehicles that do travel to the region have restricted underground parking attached to their office buildings, making it much tougher for motivated offenders to break into those vehicles. Due to the unavailability of targets to choose amongst, offenders are forced to travel elsewhere in order to criminally profit and thereby decreasing the level of risk within census tract 9330066.00.

The CL Trend variable reported changes in the level of relative risk in five census tracts including: 9330016.04 (RRR = 1.01, $p < .01$), 9330035.01 (RRR = 1.02, $p < .01$), 9330036.02 (RRR = 1.01, $p < .01$), 9330037.02 (RRR = 1.02, $p < .01$), and 9330050.02 (RRR = 1.01, $p < .01$). The increases are subtle and are reflective of the trend found in other crime categories after the implementation of the Canada Line. The Canada Line adds a new dimension to the pre-existing urban landscape and its effect will take quite some time to adjust and stabilize. It may take a number of years for the new line to settle and adapt to its surroundings, including the level of reported crime.

6.1.15. Theft from Vehicle: Census Tracts without a SkyTrain Station

Within the third group of census tracts that do not host a SkyTrain station, the Trend variable produced a small number of census tracts that had a change in the level of relative risk for theft from vehicle victimization. Census tracts 9330028.00 (RRR = 0.98, $p < .01$), 9330034.01 (RRR = 0.99, $p < .01$), 9330040.01 (RRR = 0.99, $p < .05$), 9330040.02 (RRR = 0.99, $p < .01$) each demonstrate a slight decrease in the level of criminal victimization risk. These findings are reminiscent of earlier observations of the different criminal offence categories that show crime in Vancouver is on the decline and is reaching a stable level.

Census tract 9330057.01 (RRR = 1.18, $p < .01$) and (RRR = 0.99, $p < .01$) was the only significant census tract found in the Month and Month^2 variables. This census tract is situated along East Hastings Street and Main Street in Vancouver's notorious Downtown East Side. Often dubbed "Canada's poorest postal code", the DTES is one of the city's oldest neighbourhoods. In recent years, it has become well known for its overt drug trade, prostitution, poverty, mental illness, infectious disease, homelessness, and crime. The elevated risk for theft from vehicle within this census tract is expected. Despite the unfavourable conditions found in the DTES, a number of individuals utilize street parking found within the area to park their vehicles to attend various stores, businesses, pubs, and restaurants that are located nearby. As a result, the vehicles left behind are unattended for long periods of time and will attract motivated offenders to break into vehicles to steal. For many of the offenders, the items stolen from vehicles are fenced in order to provide an income to support basic necessities such as food and shelter alongside drug habits. Despite the fact the census tract does not host a SkyTrain station, it is susceptible to increased levels of crime based on the social disorganization of the census tract.

The CL Dummy variable produced one census tract with a decreased level of risk for theft from vehicle: 9330068.00 (RRR = 0.70, $p < .01$). This census tract is found in downtown Vancouver and is located nearby major arterial roads such as Robson Street, Alberni Street, Denman Street, and Nelson Street. This area has limited accessibility for vehicles to travel through, making it an undesirable area for individuals to park their vehicle. Instead, more car owners are likely to park further away, such as the parking lots

found in Stanley Park in order to avoid the hassle of trying to find limited parking space in the English Bay area. As a result, motivated offenders will be unlikely to want to target this particular census tract for breaking into vehicles to steal as there are less targets to choose amongst. Instead, the offenders will be forced to travel further to find more desirable targets. Offenders will also be deterred from committing crime within this census tract due to the heavy volume of foot traffic English Bay produces. Using the arguments provided by Cohen & Felson's (1979) Routine Activity Theory, the greater the number of potential capable guardians, the less likely it is for offenders to be successful in carrying out their crimes. The number of patios from restaurants and cafes in the area allow for natural supervision to take place within the area and can help protect vulnerable vehicles from break-ins.

The CL Trend variable produced a number of census tracts that experienced a slight increase in the level of relative risk for theft from vehicle. Census tracts included 9330013.02 (RRR = 1.01, $p < .01$), 9330034.01 (RRR = 1.01, $p < .05$), 9330040.01 (RRR = 1.01, $p < .05$), 9330040.02 (RRR = 1.01, $p < .05$), 9330041.01 (RRR = 1.02, $p < .01$), 9330041.02 (RRR = 1.01, $p < .05$), and 9330068.00 (RRR = 1.01, $p < .01$). Although these census tracts do not host a station, they are located nearby to census tracts that host a station from one of the SkyTrain's routes. The elevated risk could be attributed to the displacement some stations can produce to nearby environments. Again, it may take some time to determine whether these slight increases continue to surge or if they return to pre-Canada Line patterns.

6.1.16. Theft of Vehicle: Census Tracts with a Canada Line SkyTrain Station

Within the first group of census tracts with a Canada Line SkyTrain station, the Trend variable revealed two census tracts that experienced a slight decrease in the level of relative risk for vehicle theft victimization. Census tracts 9330030.00 (RRR = 0.99, $p < .01$) and 9330059.05 (RRR = 0.99, $p < .01$) demonstrated that risk had slightly changed. The pattern is consistent with other criminal offence types. Regardless of the type of crime examined, the overall level of crime within the city of Vancouver is stable, with minor

decreases to the level of relative risk. These results further validate the arguments made by the crime drop hypothesis.

The level of relative risk for theft of vehicle victimization witnessed large decreases in the CL Dummy variable in three census tracts, including: 9330030.00 (RRR = 0.40, $p <$ .01), 9330039.01 (RRR = 0.47, $p < .01$), 9330059.05 (RRR = 0.41, $p < .01$). These census tracts host King Edward, Broadway-City Hall, Waterfront, and Vancouver City Centre SkyTrain stations. Similarly to trends found in the analysis of theft from vehicle, the aforementioned census tracts are located in very congested parts of the city of Vancouver and do not offer much space for an individual to park their vehicle. These results in a shortage of vehicles found in and around the stations, forcing motivated offenders to look elsewhere to steal vehicles. Forcing motivated offenders to move elsewhere creates an adaptation and may make census tracts further away more vulnerable for crime to occur.

The crime trend since the implementation of the Canada Line has remained mostly stable, with the exception of two census tracts that witnessed an elevated risk for theft of vehicle victimization. Census tracts 9330004.01 (RRR = 1.02, $p < .05$) and 9330039.01 (RRR = 1.01, $p < .05$) both slightly increased their respective levels of risk. The census tracts host Oakridge-41st Avenue, Langara-49th Avenue, and Broadway-City Hall. These census tracts were once difficult to access; commuters to the region had to rely on bus service or private vehicle in order to reach their destination within these census tracts. With the introduction of the Canada Line, motivated offenders may be searching for new hunting grounds to seek out appropriate targets. Offenders may use the extended SkyTrain system to travel to these census tracts and to commit crime. Although the area does not offer a large array of parking options for commuters, nevertheless, offenders may try to scour areas within walking distance of the station. This may draw offenders to the Langara College campus for example as the campus offers open-air parkades for students to use while attending class. Oakridge Centre is also a viable option for motivated offenders to steal cars from. The mall offers a large multi-level parking garage that stores a large number of cars for those who work or shop at the mall. Individuals will typically be away from their vehicles for a minimum of 1-2 hours, providing ample time for an offender to search an appropriate vehicle to steal and to be able to leave the parking garage without arousing suspicion. Without adequate capable guardianship and the ability to blend in

with their surroundings, offenders will prefer to steal from this location, prompting such nodes as potential crime attractors in the future. Close monitoring of these trends should be made over time to ensure appropriate crime prevention strategies can be implemented to help deter offenders from returning to these areas to commit crime.

6.1.17. Theft of Vehicle: Census Tracts with an Expo and/or Millennium Line SkyTrain Station

The level of relative risk within the second group of census tracts with an Expo and/or Millennium Line SkyTrain station for vehicle theft was small in comparison to some of the other crime categories examined in the current analysis. The Trend variable reported one census tract with a change in the level of relative risk; census tract 9330035.01 (RRR = 0.99, $p < .01$). The slight decrease in the likelihood of vehicle theft is quite minimal. However, it does reflect earlier patterns of the overall trend of crime within Vancouver.

There was only one census tract that reported changes to the level of relative risk in the Month and Month^2 variables. Census tract 9330037.02 (RRR = 0.88, $p < .05$) and (RRR = 1.01, $p < .01$) demonstrated a decline in the level of risk for victimization. This tract hosts Broadway SkyTrain station. One would expect a decreased level of vehicle theft within this census tract due to lack of space available for cars and the increased level of guardianship provided by the station. Broadway SkyTrain station is located in one of the busiest intersections within the city of Vancouver; Broadway and Commercial Drive. When the weather is poor, individuals may choose to drive their vehicles completely to their destination opposed to using public transportation partially. The number of available vehicles substantially decreases, thereby making target selection much smaller for offenders to choose amongst. However, when the weather is more ideal, some passengers may decide to take public transportation for some of their commuting journey. Car owners may try to find parking within the area close to the station and use the bus and/or train to commute the rest of their travels. But this can be extremely challenging; street parking is meager around this station, forcing individuals to park their cars farther away if they plan to use public transit to commute elsewhere in the city. Motivated offenders hoping to steal a vehicle from around the station will have a much more difficult

time in finding an appropriate target. As reflected in both Cornish & Clarke's (1986) Rational Choice Theory and Zipf's (1965) theory of least resistance, motivated offenders will not exert any effort in situations that will not benefit them. Instead, the offenders will need to search another area that they feel relatively familiar with in order to fulfill their criminal needs. Further, the increased level of guardianship at Broadway station is the result of heavy foot traffic generated at this transfer point, and in turn, can help deter crime from occurring due to the number of capable guardians present that can disrupt an offender from stealing a vehicle. There are number of passengers that travel in and out of the station on a daily basis in addition to the number of passengers that wait to board one of the buses that picks up passengers from this stop. As passengers wait for the next bus to appear, they can inadvertently keep an eye out for any suspicious persons, particularly if offenders are 'casing' a vehicle in anticipation of stealing it during the right moment. These passengers serve as a form of natural surveillance and will likely deter offenders from wanting to break into the small number of vehicles parked on the street near the station due to the presence of these by-standers. As a result, the changes in climate influence the travelling behaviour of commuters and thereby changing the level of risk for vehicle theft.

The CL Dummy variable reported two census tracts with a change in the level of relative risk for vehicle theft. Census tracts 9330016.04 (RRR = 1.59, $p < .05$) and 9330066.00 (RRR = 0.32, $p < .01$) reported varying changes. Within the first tract, 9330016.04, where 29th Avenue and Joyce-Collingwood SkyTrain stations are located, the level of relative risk increased substantially. The local environments surrounding these stations are primarily located in residential neighbourhoods that rest on the geographical boundary between the cities of Burnaby and Vancouver. According to Brantingham & Brantingham (1981), this physical border can be seen as an edge. Edges are places within an individual's awareness spaces that find a disproportionate amount of crime. Using the theoretical tenants of the Geometric Theory of Crime, crime would be expected to increase in this census tract due to the proximity of this physical edge. Further, these stations rest along a perceptual edge. Joyce-Collingwood SkyTrain station is the first station travelling westbound on the SkyTrain station that is part of Zone 1, resulting in an increase in the amount of fare a commuter must pay to travel. The increased amount of fare may force some individuals, particularly motivated offenders to exit the SkyTrain and

search the surrounding environment for an appropriate target. The residential neighbourhood offers a plethora of vehicles to steal from as most households have at least 1 vehicle in their household. Offenders can target homes that have visible car parks or drive-ways in search for a vehicle that fits their criminal needs. As a result, the proximity of this census tract to the geographical border between Burnaby and Vancouver raises the vulnerability for vehicle theft to occur.

Census tract 9330066.00 on the other hand, experienced a dramatic decrease in the level of relative risk, with 0.32. This census tract hosts Burrard SkyTrain station and is found in the busy downtown core of the city of Vancouver. The decline in the level of risk found within this station may be attributed to the physical layout of the nearby environment. There are very few areas to park one's vehicle close to Burrard SkyTrain station and as a result, car owners must either travel further away to a designated parking lot (for a fee) or park in a reserved spot in a parking garage attached to their place of employment. The selection for vehicles to steal becomes much smaller and may force some motivated offenders to travel elsewhere to steal. Due the unavailability of targets, the likelihood for car theft is much lower compared to areas with more selection of vehicles.

Last, the CL Trend reported two census tracts with small increases in the level of relative risk for car theft; census tracts 9330035.02 (RRR = 1.01, $p < .01$) and 9330037.02 (RRR = 1.02, $p < .01$). These census tracts host SkyTrain stations Renfrew and Broadway. The small increase could be attributed to the built environment adjusting to the presence of an extended pathway. The stations could experience the slight increase as the concentration of crime found elsewhere along the SkyTrain system has displaced. However, since the change is very minimal, it would be beneficial to examine this trend over a longer period of time to determine if this change is permanent, or temporary as the level of crime tries to stabilize to pre-Canada Line trends.

	Census Tract	Trend	Month	Month^2	CL Dummy	CL Trend
Census Tracts with a Canada Line SkyTrain Station	**9330004.01**	0.98	1.00	1.00	0.84	**1.02***
	9330012.00	0.99	1.03	1.00	1.03	1.00
	9330030.00	**0.99****	1.10	0.99	**0.40****	1.01
	9330039.01	0.99	1.10	0.99	**0.47****	**1.01***
	9330049.02	0.98	1.06	1.00	0.57	1.01
	9330059.03	0.99	1.08	1.00	0.36	1.01
	9330059.05	**0.99****	1.01	1.00	**0.41****	1.01
Census Tracts with an Expo or Millennium Line SkyTrain Station	**9330016.04**	0.98	0.95	1.00	**1.59***	1.00
	9330035.01	**0.99****	0.96	1.00	0.58	1.01
	9330035.02	0.98	0.99	1.00	0.75	**1.01****
	9330036.02	0.99	1.11	0.99	1.08	1.00
	9330037.02	0.98	**0.88***	**1.01****	0.62	**1.02****
	9330050.02	0.98	1.05	1.00	1.14	1.02
	9330050.03	0.98	1.10	0.99	0.70	1.03
	9330066.00	0.99	0.97	1.00	**0.32****	1.00
Census Tracts without a SkyTrain Station	**9330013.01**	0.98	1.05	1.00	**0.86***	1.01
	9330013.02	0.99	1.09	1.00	0.55	1.00
	9330028.00	0.98	**1.26***	**0.98****	0.51	**1.02***
	9330032.00	0.99	1.04	1.00	0.36	**1.02****
	9330034.01	0.98	**0.84****	**1.01****	0.75	1.01
	9330040.01	0.98	1.07	1.00	0.50	1.01
	9330040.02	0.98	1.01	1.00	**0.28****	**1.02****
	9330041.01	0.98	1.03	1.00	**0.42***	**1.02****
	9330041.02	0.98	0.95	1.00	1.39	1.00
	9330051.00	0.98	0.99	1.00	0.93	1.01
	9330057.01	0.98	1.16	0.99	0.67	**1.02****
	9330060.02	0.98	0.97	1.00	1.37	1.01
	9330063.00	0.98	**0.80***	1.02	1.35	1.02
	9330065.00	0.98	0.95	1.01	0.82	1.02
	9330068.00	0.98	**1.21****	**0.99***	1.19	1.01

*Note: * Significance under .05, ** Significance under .01*

Table 10: Negative Binomial Regression Results, Theft of Vehicle

6.1.18. Theft of Vehicle: Census Tracts without a SkyTrain Station

Seasonality and temperature played a significant role in the level of relative risk for vehicle theft in a number of census tracts, including: 9330028.00 (RRR = 1.26, $p < .05$) and (RRR = 0.98, $p < .01$), 9330034.01 (RRR = 0.84, $p < .01$) and (RRR = 1.01, $p < .01$), 9330063.00 (RRR = 0.80, $p < .05$) (only Month), and 9330068.00 (RRR = 1.21, $p < .01$) and (RRR = 0.99, $p < .05$). Two of the census tracts reported an elevated risk in car theft: 9330028.00 and 9330068.00. These census tracts are located near major roadways such as West 33rd Avenue, Granville Street, Oak Street, Robson Street, Denman Street, and

Nelson Street. Although these census tracts do not host a SkyTrain station, they are located in a close radius of census tracts that do host a station. The proximity to the SkyTrain system may make these census tracts more vulnerable for crime to occur. Many of the SkyTrain stations are located in very busy sections of the city of Vancouver and do not offer much availability for parking vehicles. As a result, car owners may travel to census tracts 9330028.00 and 9330068.00 to try and find parking in order to continue in daily errands and responsibilities.

Theft of vehicle tends to have two major seasonal peaks; in the summer and the winter. During the summer months, motivated offenders are more likely to target vehicles that are located nearby major nodes that attract out-of-town tourists and local visitors. Within these census tracts, nodes like this can include areas such as Stanley Park, English Bay, and the Vandusen Gardens. Due to the interest nodes like these generates for visitors, a large number of individuals will travel to these destinations. The time spent at these nodes varies in length but can probably be estimated at least 2 hours at a minimum. This time frame provides ample opportunity for car thieves to target parking lots and street parking to find an appropriate target to steal. During the winter months, a similar pattern emerges, where a number of visitors engage in holiday themed activities that require car owners to leave their cars behind and unsupervised for long periods of time. Motivated offenders will target these vehicles to steal as there will be a surplus of vehicles to choose amongst. As a result, the increase witnessed in these census tracts is appropriate given the context of their built environments.

Census tracts 9330034.01 and 9330063.00 experienced the opposite effect; a decrease in the level of risk for car theft. Census tract 9330034.01 is situated along Kingsway, East 33rd Avenue, and Dumfries Street, while census tract 9330063.00 is located near Davie Street, Denman Street, and Broughton Street. There are fewer visitor attractions within these regions making it more difficult to isolate a potential reason why car thieves are unlikely to steal in these areas. Poor weather may prompt offenders to seek refuge in underground parking lots to remain dry and warm while seeking out an appropriate target. Another reason could be attributed to the fact that most vehicles parked in these census tracts are located near multi-unit apartment towers and may have parking lots that are gate operated, making it more challenging for offenders to gain

access and to steal a vehicle. Further examination would be required over a longer time frame to determine whether this decrease would continue.

The CL Dummy variable revealed three census tracts that showed a significant decrease in the level of relative risk for vehicle theft: 9330013.01 (RRR = 0.86, $p < .05$), 9330040.02 (RRR = 0.28, $p < .01$), and 9330041.01 (RRR = 0.42, $p < .05$). The decline in risk can be found near major arterial roadways such as Fraser Street, East 49th Avenue, East 41st Avenue, Argyle Street, West 12th Avenue, Granville Street, Oak Street, Burrard Street, West 16th Avenue, and West Broadway. These roadways are extremely busy with both car and foot traffic. Motivated thieves may not want to commit crime within these census tracts because the level of guardianship is high (leading to lower chances of committing a crime successfully), poorer selection of vehicles (people may avoid driving to the region due to the volume of traffic), and the distance between the census tracts and the nearest available SkyTrain station may be too far for an offender to travel (distance decay). These elements combined make the prospect of committing car theft very low for offenders.

Last, the CL Trend variable yielded a number of census tracts with a slight increase in the level of relative risk for car theft: 9330028.00 (RRR = 1.02, $p < .05$), 9330032.00 (RRR = 1.02, $p < .01$), 9330040.02 (RRR = 1.02, $p < .01$), 9330041.01 (RRR = 1.02, $p < .01$), 9330057.01 (RRR = 1.02, $p < .01$). The negligible increment in crime may be the by-product of crime displacing from elsewhere in the city to census tracts nearby tracts with a SkyTrain station. The expansion of the system could help disperse crime elsewhere in the city of Vancouver. The increase in these census tracts may be temporary and may return to pre-Canada Line crime trends and patterns once the new route has adjusted to the environment and helped stabilize the level of reported crime.

6.1.19. Conclusion

The results of the spatial analyses of reported crime in Vancouver, BC from 2003-2015 have demonstrated the importance of adopting a spatial perspective to understand mass forms of public transportation and crime. The analyses conducted time series regression analysis using relative risk ratios to help identify census tracts that experienced a change in their relative risk levels. The results demonstrate that the implementation of

a mass transit station does not necessarily facilitate a higher level of reported crime. Instead, the number of transit stations within a singular census tract may be related to a higher level of criminal victimization. If a census tract has more than one transit station, the level of risk increases due to the increase in the number of available targets, a potential increase in the number of motivated offenders, the potential for a lack of capable guardians.

Chapter 7. Panel Data Analysis

Panel data, also known as longitudinal data, are data for multiple entities in which each entity is observed at two or more time periods (Stock & Watson, 2003, p.13). Panel data is often regarded as a subset of time-series and cross sectional data as it has the ability to incorporate a temporal dimension to examine a phenomenon in question. As a result, it offers flexibility when statistically modelling characteristics across cross-sectional units (Greene, 2000). These benefits include increased degrees of freedom for statistical testing, the reduction of collinearity between explanatory variables to improve efficiency, and allows for a better assessment of the impact of changes in explanatory variables on the outcome of interest (Hsiao, 2003).

A limited number of criminological studies have incorporated an ecological approach to the study of crime at the neighbourhood level (Andresen, 2006; Ceccatto & Haining, 2005; Ceccato, Haining & Signoretta, 2002; Cahill & Mulligan, 2003). Traditionally, empirical studies examining neighbourhood level crime tested the theoretical predictions of the ecology of crime that represented a single year. Analyzing only a single year of ecological data can impose particular relationships between crime and other ecological data, something that should be avoided in the context of testing theory (Andresen, 2012).

There are two basic frameworks for analyzing panel data: fixed effects estimation and random effects estimation (Andresen, 2012). Fixed effects estimation uses group-specific constant terms to account for cross-section heterogeneity, whereas random effects estimation uses a group specific disturbance term (Greene, 2000). For the purpose of the current study, a fixed effect panel specification is employed. The fixed effect panel specification is preferred as it allows for the analysis that follows to identify the variables that are modifiable to policing and/or crime prevention strategy changes that will impact crime and test theory, rather than identifying the general ecological distribution of crime. The dependent and independent variables used in the study are estimated in the following panel data specification:

$$Y_{ijt} = \alpha + \gamma_j + \sum_{k=1}^{12} \beta_k x_k + \varepsilon_{ijt} \quad (1)$$

where *yijt* is crime rate *i* in census tract *j* at time *t*, α is the common intercept, γ*j* represents the fixed effects, *βk* is the matrix of parameter estimates for the *k* independent variables, *xk* is the matrix of *k* independent variables, and ε*ijt* is the *iid* error term. All variables are measured yearly with crime data aggregated to the year per census tract per crime type; yearly ecological variables were obtained through linear interpolation between census years, 2003 to 2011. Final model selection is undertaken through a general-to-specific methodology. For each calculated crime rate, the panel data equation is estimated with all independent variables; all estimated parameters are rested for statistical significance ($p \leq 0.X$), and removed if insignificant; the final models for each calculated crime rate are reported in the output tables, below, displaying the remaining statistically significant independent variables for each model. White's heteroskedastic consistent standard errors are used for all statistical significance testing.

One must be cautious when using panel data, as differences that exist within each cross section can make it difficult to measure, often referred as cross-section heterogeneity (Baltagi, 2001 as cited in Andresen, 2012). These differences can be problematic if they are correlated with the explanatory variables in a regression context. If cross-section heterogeneity is not addressed and/or controlled for in appropriate manner, a statistical bias will occur (for a further discussion of statistical bias in cross-section heterogeneity, refer to Moulton, 1986, 1987). Without controls for cross-section heterogeneity, the estimated residuals are correlated with the explanatory variables leading to a violation of one of the assumptions of ordinary least squares, causing statistical bias.

7.1. Introduction

Past attempts to explore the relationship between mass forms of public transportation and crime have often ignored the role of the social cohesion of nearby environments. The current study employs the use of a panel data analysis to determine what socio-demographic factors may influence the level of crime in census tracts that host and/or located nearby Canada Line SkyTrain stations. The results of the panel data analyses using crime data from Vancouver between January 2003 and December 2015 are reported in Tables 11 through 17. The adjusted-R^2 for each crime type is moderate to high in magnitude for an ecological cross section, ranging from 0.27 to 0.69, with the best fit being for theft.

Variable	Mean	Standard Deviation	Minimum	Maximum
Commercial Break & Enter	22.92	36.72	0	413
Mischief	48.31	58.79	0	794
Other Theft	109.76	248.27	0	2624
Residential Break & Enter	46.21	24.74	0	163
Theft from Vehicle	122.44	217.25	0	2950
Theft of Vehicle	32.85	29.33	0	331
Population	5561.73	1811.06	1920	18430
Population Change -5 years	-1.30	83.40	-1252	258
Unemployment	213.94	89.57	35	810
Post-Secondary	2522.56	1113.03	495	11495
Recent Immigrants	438.11	318.38	45	2365
Ethnic Heterogeneity	57.55	13.92	20	80
Rented	1280.79	876.55	120	5695
Major Repairs	200.24	103.56	35	631
Average Dwelling Values, 000s	684.17	364.76	166	2955
Average Family Income, 000s	93.63	51.07	33	509
Average Income, 000s	39.52	19.65	14	182
Average Rent, 00s	10.06	3.15	4	31
Median Family Income, 000s	71.01	24.79	24	216
Median Income, 000s	26.62	8.87	11	87

Table 11: Descriptive statistics for dependent and independent variables

7.2. Inferential Analyses

7.2.1. Commercial Break and Enter

Inferential results of commercial break and enter demonstrated a number of variables that influenced the level of reported crime in census tracts that host a Canada Line station and/or are located nearby. The first variable of significance is unemployment. Unemployment shows a positive relationship with a coefficient 0.109. This is an expected relationship; with fewer legitimate opportunities to seek gainful employment, the likelihood that individuals may be motivated to commit commercial break and enters in order to obtain the necessary means to live is higher. This relationship is theoretically supported by Routine Activity Theory by Cohen and Felson (1979) and Rational Choice Theory by Cornish and Clarke (1986). An individual will be drawn to commit crime when an opportunity presents itself; typically in the form of a suitable target and a lack of a capable guardian. Commercial stores are vulnerable for burglary as they have limited guardianship throughout business hours and the premises rely on target hardening measures to secure themselves at night when there are no longer any employees working. Each business also contains a number of valuable items that may entice an offender to break in, ranging from cash to alcohol and drugs to merchandise. Offenders will make a series of decisions to determine whether or not the risk of getting identified and apprehended by law enforcement is outweighed by the potential benefits gained from breaking and entering. For offenders with little to no job prospects, the rational decision would be to commit crime in order to survive.

The introduction of a SkyTrain station often spurs an extensive expansion of commercial development. Business owners can profit from selecting locations for their establishments that are located along and/or outside of a SkyTrain station due to the increased volume of foot traffic the transit system generates. Commuters are more likely to utilize the services found within these areas as they enter and exit the system in addition to waiting at a station for a particular departure time. Although businesses may flourish financially through the location of their business, it may also attract and generate crime from motivated offenders seeking to break into the premises. Stores with fewer safeguards to protect their premises will be more vulnerable for a potential burglary. The

elevated level of risk for commercial burglary is higher in census tracts with a station, but this level of risk can exponentially increase with a number of SkyTrain stations located within the vicinity.

Variable	Within Group Effects, Coefficient
Population	-0.00
Population Change – 5 years	-0.02
Unemployment	**0.11*** **
Post-Secondary	**0.01*** **
Recent Immigrants	**-0.02*** **
Ethnic Heterogeneity	0.35
Rented	0.01
Major Repairs	0.01
Average Dwelling Values, 000s	0.01
Average Family Income, 000s	-0.23
Average Income, 00s	0.71
Average Rent, 00s	-0.12
Median Family Income, 000s	-0.00
Median Income, 000s	-0.68
Station – Presence	**-51.73*** **
Station – Count	**47.52*** **
Adjusted R^2	0.49

*Note: *** Significance under 0.01*

Table 12: Regression Results, Commercial Break and Enter

The second variable of interest is post-secondary education, demonstrating a weak positive relationship with commercial burglary with a coefficient of 0.009. This variable is expected to show a negative relationship with crime as the higher the level of education someone has, the less likely it is for those individuals to commit crime. This reported coefficient of 0.009 may suggest an emerging trend where higher education may not imply a lack of motivation. Instead, education may provide motivated offenders with a wider range of information and/or skills to commit crime. Additionally, post-secondary education has become more common place, where many individuals in later generations have obtained at least a Bachelor's degree at a post-secondary level. As a result, this may not be an influential on the level of crime compared to an earlier period of time in society.

The third variable of significance is recent immigration. This variable demonstrated a negative coefficient of -0.024. This finding goes against the traditional notion that recent immigrants would lack the legitimate means to succeed in their new surroundings, and thus, be forced to adapt by committing crime. Within the current context, it appears that Vancouver is an outlier to this notion. British Columbia (dominantly reflected by the situation in Vancouver) receives a significantly large amount of high-level socio-economic immigrants relative to its share of the Canadian population: 27 and 14 percent, respectively (Ley, 1999; Ley & Smith, 2000). Furthermore, the entrepreneurial class and investor group segments of these immigrants are particularly high: 35 and 54 percent respectively. This is an important aspect to consider in the current context as this group of individuals tend to have an average wealth in excess of $1 million. Therefore, the average wealth of these individuals resettling in Vancouver allows them the opportunity to not only move into the wealthier areas of Vancouver that tend to have lower levels of criminal activity, but also have a disposable income that does not include criminal offending in order to survive.

The final two variables that demonstrated significance in the analyses were station presence and station count. Station presence had a coefficient of -51.73 while station count had a coefficient 47.52. This is an unexpected finding, as it suggests that the presence of a SkyTrain station is not necessarily a factor in explaining higher levels of reported crime in census tracts that host a SkyTrain station. Instead, the number of stations seems to play a bigger role in explaining the level of reported crime. This finding suggests a saturation effect; the higher the number of stations within a census tract, the greater the odds that crime will also be higher. It should also be noted that when examined together, both station presence (-51.73) and station count (47.52) are nearly equal in absolute value. Station presence initially demonstrates a significant decrease but when examined together with station count, it becomes apparent that the change in the level of reported crime is minimal.

There are three census tracts that contain more than one SkyTrain station; census tract 9330012.00 hosts Oakridge-41st Avenue and Langara-49th Avenue stations, census tract 9330016.04 hosts 29th Avenue and Joyce-Collingwood stations, and census tract 9330059.05 hosts Waterfront (both Expo and Canada Line), Granville, Stadium-

Chinatown, Main Street, and Vancouver City Centre stations. Each census tract has a very high population density; there are a number of nodes that attract a number of people, such as shopping centers like Oakridge Mall and Pacific Center, post-secondary institutions such as Langara College, and major transportation and arterial road networks such as Hastings and Main Street. As a result, the more people that concentrate in these census tracts, the higher the likelihood that crime will also increase. Therefore, commercial businesses located in these census tracts would thrive based on the number of potential customers travelling in the area but also become vulnerable to potential theft. Commercial businesses should strive to be pro-active in combating potential crime. Cooperation with local police in addition to crime prevention awareness and education should be regularly practiced in order to help combat against in census tracts that host more than 1 SkyTrain station.

7.2.2. Residential Break and Enter

Inferential results for residential break and enter yielded fewer significant variables in the panel model compared to its counterpart, commercial burglary. The first significant variable was recent immigration. Recent immigration demonstrated a negative relationship with a coefficient of -0.025. As previously discussed, many recent immigrants who have moved to Vancouver have a higher levels of income compared to the average person. As a result, these individuals will likely choose to move into wealthier neighbourhoods where there are lower levels of reported crime. Therefore, it is unlikely for these individuals to experience residential burglary based on the fact that their property is located in wealthy neighbourhoods and is less likely to find a vulnerable home to break into. These homes are more likely to have target hardening measures found on the property such as alarms systems, guard dogs, and closed-circuit television cameras, making the offender less likely to exert a greater level of effort to commit crime while increasing the level of risk for being apprehended. Furthermore, individuals who are motivated to commit crime may be unable to easily blend into their surroundings in these wealthy neighbourhoods. Offenders are more likely to be regarded as an ‘outsider’ and would not have the luxury to be able to loiter and ‘case’ vulnerable property without having a resident report the suspicious behaviour to the police.

Variable	Within Group Effects, Coefficient
Population	0.00
Population Change – 5 years	-0.00
Unemployment	0.00
Post-Secondary	0.00
Recent Immigrants	**-0.03*** **
Ethnic Heterogeneity	0.09
Rented	0.00
Major Repairs	**0.09*** **
Average Dwelling Values, 000s	0.00
Average Family Income, 000s	-0.03
Average Income, 00s	0.21
Average Rent, 00s	1.21
Median Family Income, 000s	-0.006
Median Income, 000s	-0.84
Station – Presence	-4.51
Station – Count	4.73
Adjusted R^2	0.27

*Note: *** Significance under 0.01*

Table 13: Regression Results, Residential Break and Enter

The second significant variable from the model was major repairs, with a coefficient of 0.087. Residential properties in disrepair may attract motivated offenders to break and enter. Using Zipf's (1965) theory of least resistance, an offender will be more drawn to commit crime in homes that require less effort to break into. Homes that have a number of infrastructure issues would appeal to the offender as they would have little to overcome in order to break into the home and to steal items within it. However, because these homes are neglected, there is also the potential for there not to be any desirable items within it. Additionally, homes in need of major repairs could also be disproportionality found in socially disadvantaged neighbourhoods that lack the resources to make improvements to their homes. In turn, these properties may be flagged by offenders as potential homes to break and enter into as they present a limited number of obstacles in gaining access to the property. These homes are less likely to have the financial means to invest in target hardening measures such as home security systems, secure locks and fencing, and active territoriality.

7.2.3. Mischief

Inferential results for the offence of mischief yielded the largest number of significant variables. Unemployment (1.529) and recent immigration (-4.354) both demonstrated a similar pattern found in the earlier offences of commercial and residential burglary. Additional variables such as rental properties, median family income, and median income demonstrate the financial impact on levels of crime within the city of Vancouver. Rental properties yielded a coefficient of 1.720. This is a weak positive relationship, but an important variable to consider in the relationship between public transit and mischief. Social disorganization theory by Shaw and McKay (1942) suggests that high levels of mobility can result in weakened bonds to the neighbourhood. In the context of mischief, this may suggest a possibility that individuals who engage in activities in census tracts that host a SkyTrain station may feel more inclined to commit mischief as they have fewer ties to the neighbourhood. An individual is less likely to want to engage in mischief if they are planning to stay long term in the neighbourhood, such as purchasing a residential property. If you stay permanently in an area, there is a greater chance you will want to ensure the area is not riddled with acts of mischief as it could influence property value. Also, the odds of being recognized by neighbours also increases which could lead to negative stigma and isolation.

Median family income 000s (6.500) and median income 000s (-2.625) are highly related to Cohen and Felson's (1979) Routine Activity Theory. Motivated offenders may be drawn to neighbourhoods that have a higher level of wealth as it may indicate the presence of valuable targets to vandalize against. The most frequent targets of vandalism are those located in public spaces, without surveillance personnel or devices, or those on private properties that are open to public view (McCorkle, as cited in Fisher & Lab, 2010). Less-guarded properties, where no one has direct responsibility for the area, or those properties that are *perceived* as less guarded by potential vandals, are also frequent targets of vandalism or graffiti. As any urban resident knows, vandalism is common on trains, buses, bus shelters or stations, traffic signs, sides of freeways, park benches, billboards, vacant buildings, schools, or other large, plain, light-colored surfaces (McCorkle, 2010 as cited in Fisher & Lab, 2010). Therefore, an increase in the median family income of a neighbourhood may lead to an increase in crime, specifically mischief.

Median income 000s was negatively correlated with mischief, with a coefficient of -2.63. This finding may be explained through the routine activities of offenders and victims. Offenders may be less likely to target property to vandalize and/or destroy if the target is not considered attractive enough. Neighbourhoods that have lower levels of wealth do not have disposable income to make their properties aesthetically pleasing; as a result, the level of attraction for an offender is low and will force the offender to search for a more appropriate target that will be worth his and/or her time. Alternatively, individual households that earn lower incomes compared to their wealthier counterparts may have a greater desire to stay indoors and not engage in activities away from home. As a result, these individuals help provide guardianship and protection of their property as offenders will be likely deterred from committing mischief in areas where they can be observed and therefore apprehended for their criminal behaviour.

Station presence and station count reported significant findings with coefficients of (-9.899) and (9.217). These findings demonstrate a negligible effect on the level of reported crime as both variables effectively produce a net result of zero on the level of reported mischief. When the variables are examined individually, the results demonstrate that the presence of multiple stations plays a significant role in the level of reported crime. Within these census tracts that host more than one SkyTrain station (census tracts 9330012.00, 9330016.04, and 9330059.05); there are a number of features within the environment that could facilitate mischief. Features that attract a large number of individuals and targets include a number of areas to loiter, graffiti, and vandalise that can take place in major shopping centres such as Oakridge Mall and Pacific Center, post-secondary institutions such as Langara College, and the physical infrastructure of the stations themselves. Motivated offenders can cause havoc to the surrounding transit environment as they wait to board the SkyTrain in between departure times. The amount of unstructured waiting times could prompt bored offenders to victimize property. This is particularly troublesome for transit environments during off-peak hours as the amount of waiting time tends to increase as SkyTrain service begins to decline into the late hours of the evening. Therefore, the likelihood for mischief to occur within these census tracts would increase.

Variable	Within Group Effects, Coefficient
Population	7.30
Population Change – 5 years	-1.55
Unemployment	**1.53*** **
Post-Secondary	3.85
Recent Immigrants	**-4.35*** **
Ethnic Heterogeneity	2.46
Rented	**1.72*** **
Major Repairs	1.49
Average Dwelling Values, 000s	9.14
Average Family Income, 000s	-3.14
Average Income, 00s	8.12
Average Rent, 00s	5.20
Median Family Income, 000s	**6.50*** **
Median Income, 000s	**-2.63*** **
Station – Presence	**-9.90*** **
Station – Count	**9.22*** **
Adjusted R^2	0.63

*Note: *** Significance under 0.01*

Table 14: Regression Results, Mischief

7.2.4. Theft

Inferential results for the offence of theft demonstrated a number of significant variables including unemployment (4.19), recent immigration (-9.36), rented (3.79), station presence (-5.11), and station count (4.82). Unemployment revealed a coefficient of 4.19. If an individual does not possess the means to seek gainful employment, they may have limited to no other choice but to steal in order to survive. There are a number of opportunities for theft to occur within Vancouver. Individuals may steal things such as food and/or clothing in order to meet the needs of their basic survival. For some individuals, they may be under-employed; suggesting the income they do earn from a legitimate job is simply not enough and may try to be innovative to earn more money to compensate for their low income. In turn, they may be tempted to steal in order to fence items on the black market. Targets can range from a number of things including electronics, tools/equipment, wallets/money, etc. This relationship is theoretically supported by Rational Choice Theory by Cornish and Clarke (1986) as offenders will make a number of decisions to determine whether it will be worthwhile to steal. For individuals

that lack no financial means to succeed in their personal lives, the decision to steal would be a viable option to succeed.

Variable	Within Group Effects, Coefficient
Population	-1.81
Population Change – 5 years	4.96
Unemployment	**4.19*** **
Post-Secondary	3.93
Recent Immigrants	**-9.36*** **
Ethnic Heterogeneity	7.11
Rented	**3.79*** **
Major Repairs	2.32
Average Dwelling Values, 000s	2.57
Average Family Income, 000s	-6.73
Average Income, 00s	1.77
Average Rent, 00s	5.55
Median Family Income, 000s	8.52
Median Income, 000s	-5.50
Station – Presence	**-5.11*** **
Station – Count	**4.82*** **
Adjusted R^2	0.69

*Note: *** Significance under 0.01*

Table 15: Regression Results, Theft

Recent immigration demonstrates a similar pattern to other offence categories, in which an increase in immigration does not necessarily increase levels of theft. Instead, the reported coefficient for theft and recent immigration was -9.36. Many recent immigrants who have relocated to Vancouver have a higher level of wealth compared to the average household. Therefore, the likelihood for theft is much lower in this category. These individuals do not have a need to steal; they have large levels of disposable income that can be spent towards luxury items. Instead, one could argue that these individuals are much more likely to become victims of theft as they will attract motivated offenders as a result of having the ability to afford expensive goods. As premised in the theoretical arguments of Routine Activity Theory, individuals that make suitable targets based on an offender's preferences will be more likely to be vulnerable to crime, particularly if such individuals find themselves in situations without a capable guardian present to intervene and deter the offender from committing crime (Cohen & Felson, 1979).

Rental properties were found to be statistically significant in the current analysis, with a coefficient of 3.79. Traditionally, neighbourhoods with a high degree of rentals tend to have younger residents with routine activities outside of the home placing themselves and their property at risk of criminal victimization (Cohen & Felson, 1979). Due to the transient nature of renters, the level of guardianship in these neighbourhoods is unstable, thereby attracting motivated offenders to the area to search and establish new hunting grounds to commit crime. This finding is particularly important to consider when examining the relationship between mass forms of public transportation and crime. Public transit routes tend to be implemented in areas where a large number of rental property is available; suburban neighbourhoods often resist the implementation of transit routes over concerns that the new pathway will feed crime into these areas from the inner city. As a result, these neighbourhoods that offer more rental properties already may experience a higher level of instability as well as a higher risk for criminal victimization with the emergence of a new transit route. Urban planners must consider the location of the stations in a greater regard as implementing a transit route can make the level of cohesion in the neighbourhood significantly less.

Station presence and the number of stations demonstrated significant results with coefficients of (-5.11) and (4.82) respectively. There is a slight change recorded in the number of reported thefts in census tracts that host a SkyTrain station when examining the variables of station presence and count separately. When examined together, these findings illustrate that level of crime in census tracts in Vancouver is dependent on the availability and number of stations found in each census tract. Census tracts that host a SkyTrain station may not be at an elevated risk for theft to occur. The presence of a singular SkyTrain station may help alter the criminal opportunity structure found within transit environments. The number of criminal opportunities may increase but this increase may be accompanied by an increase in the number of capable guardians. Offenders will likely be deterred from committing crime in areas with an increased level of supervision as the risk of becoming caught and apprehended is too great. Instead, offenders may select a census tract that has multiple stations as the volume of passengers can help offenders blend into their surroundings and may not necessarily arouse the attention of passengers who are in the midst of entering and exiting the SkyTrain and station.

There are a number of activities that may draw offenders into census tracts with multiple stations to commit theft. For example, in census tract 9330012.00, there is a local post-secondary college, a large shopping centre, and a high volume of foot traffic generated from the local bus and SkyTrain service. The local college has a number of desirable targets for a motivated offender to steal. Common items found on students include laptops, tablets, cell phones, mp3 players, clothing, wallets, purses, etc. Motivated offenders may target the student population as they may be more unaware of their vulnerability for theft compared to the average adult. Students tend to spend a large quantity of time at school and as a result, have more items on their personal selves in order to get through the school day. Thieves may target the campus as students may have items not only themselves but also in their vehicles if they drive to school, in bags and purses left on the floor of the classroom, desks at the library, and so forth. Students may be more inclined to leave their property at their workstations as they leave to grab food and/or something to drink, go the bathroom, or make a phone call. Alternatively, thieves may target shopping centres like Oakridge as there are a number of high-end and luxurious stores within the mall that would help profit the offender. Motivated offenders can easily steal from these stores and use the SkyTrain station found outside of the mall to avoid capture from the police.

7.2.5. Theft from Vehicle

The inferential results for the offence of theft from vehicle yielded two significant variables: station presence (-3.62) and station count (3.50). Again, the overall net effect is effectively zero on the level of reported theft from vehicles when examining station presence and count together. However, when examined individually, station presence signifies a potential decrease in the number of crimes that occur within census tracts that host a station. However, the level of risk for criminal victimization increases when a census tracts hosts more than 1 SkyTrain station. There are 3 census tracts that are vulnerable for an increased level of theft from vehicle; 93300012.00, 9330016.04, and 9330059.05. Although, theft from vehicle is not a crime traditionally thought of in relation to transit crime, it is an important to take into consideration for the current study. Many transit routes now offer a number of park and ride facilities that are located adjacent to some transit stations. This offers an incentive for commuters to take advantage of as they

will not be required to waste additional gas, kilometers, and parking fees by venturing further into the city and can travel the rest of the commute via public transit. In addition to park and rides, there are a number of other parking lots and street parking available for those who commute to and from Vancouver. The presence of an unguarded vehicle may be attractive for an offender to break into a vehicle to steal the contents of the car. Many people are not attentive to what they leave behind in their cars and inadvertently provide a number of valuable targets that would be desirable for an offender to steal. Loose coin, global positioning systems (GPS), cell phones and chargers, large bags, etc. will attract offenders to steal. Offenders can become in sync with an individual's work schedule; most individuals will work an 8 hour day in addition to 1-2 hours of travel time. As a result, these vehicles are often left unattended for more than 10 hours a day. This time frame provides thieves plenty of time to select an appropriate vehicle to steal from and may be able to target more than one vehicle within that time frame.

7.2.6. Theft of Vehicle

The inferential results for the offence of theft of vehicle demonstrate a consistent pattern that was witnessed with the aforementioned offences. Significant coefficients include ethnic heterogeneity (2.99), major repairs (4.05), station presence (-1.71), and station count (1.98). Ethnic heterogeneity was positively correlated with crime. This finding may be explained best using the arguments of Social Disorganization Theory by Shaw & McKay (1942). Shaw & McKay (1942) posited that neighbourhoods that have a large diverse group of ethnic minorities are more likely to experience crime. The propensity for crime to occur is related to the level of socio-economic wealth these individuals possess. Many individuals, who immigrated to Chicago during this time, came from a variety of countries; as they arrived in the United States, they had little means to afford suitable housing, leading many of them to seek refuge in urban slums due to the low level of rent and undesirability of the region. Many of these immigrants would stay in these neighbourhoods for a short period of time; as soon as an opportunity and/or the means became available to leave; these individuals would in order to make a better life for themselves. As a result, these neighbourhoods lacked any 'deep roots' for individuals to make long term plans to stay in the region, contributing to lack of territoriality. This is an important aspect to consider in the current analysis as many new immigrants in

Vancouver are forced to live in areas that can be considered by many as urban slums. The lack of community cohesion and territoriality can attract motivated offenders to the region to commit crime. Offenders may target these areas as they are aware that many of the households found in these neighbourhoods would lack the appropriate means to invest in security measures such as anti-theft devices in their vehicle. The make and model of these vehicles may also be antiquated and may be more vulnerable for theft.

Variable	Within Group Effects, Coefficient
Population	-1.28
Population Change – 5 years	-3.49
Unemployment	2.05
Post-Secondary	4.34
Recent Immigrants	-8.94
Ethnic Heterogeneity	1.46
Rented	3.20
Major Repairs	1.20
Average Dwelling Values, 000s	4.35
Average Family Income, 000s	-2.80
Average Income, 00s	6.85
Average Rent, 00s	-1.31
Median Family Income, 000s	8.47
Median Income, 000s	-3.16
Station – Presence	**-3.62*** **
Station – Count	**3.50*** **
Adjusted R^2	0.53

*Note: *** Significance under 0.01*

Table 16: Regression Results, Theft from Vehicle

Major repairs were found to be statistically significant in the current analyses. This positive relationship is expected. Areas that are in greater need of major repair are considered socially disorganized and in turn, tend to attract motivated offenders to the area to take advantage of vulnerable property. Broken Windows Theory by Wilson & Kelling (1982) argues that disorder can lead to increased fear and withdrawal from residents that allow more serious crime to move in because of decreased levels of informal social control. Motivated offenders may be drawn to commit crime, particularly; theft of

vehicle in such neighbourhoods as the likelihood for a capable guardian to interfere and stop the commission of the criminal act is quite low.

Variable	Within Group Effects, Coefficient
Population	3.94
Population Change – 5 years	7.78
Unemployment	3.32
Post-Secondary	4.05
Recent Immigrants	-5.63
Ethnic Heterogeneity	**2.99*** **
Rented	5.28
Major Repairs	**4.05*** **
Average Dwelling Values, 000s	1.23
Average Family Income, 000s	2.60
Average Income, 00s	-7.66
Average Rent, 00s	-1.06
Median Family Income, 000s	-1.36
Median Income, 000s	6.45
Station – Presence	**-1.71*** **
Station – Count	**1.98*** **
Adjusted R^2	0.37

*Note: *** Significance under 0.01*

Table 17: Regression Results, Theft of Vehicle

Last, station presence and count were significant in the analysis of theft of vehicle and crime. When the variables of station presence and count are examined together, we see that there is a minimal effect overall on the level of reported vehicle thefts. Therefore, the net result is effectively zero on this type of crime. The presence of the SkyTrain system demonstrated a small, negative relationship with theft of vehicle offences with a coefficient of -1.71. The introduction of a new SkyTrain route and its subsequent stations may provide increased levels of guardianship to the environment within the immediate vicinity of the station. Passengers waiting for the arrival of the SkyTrain serve as a form of natural surveillance and can potentially thwart a crime from taking place as their presence may deter offenders from wanting to commit crime and be apprehended by the police. This is especially beneficial for SkyTrain stations that offer specified parking lots for transit commuters. The availability of targets is much greater for offenders but with passengers located nearby, offenders may be tempted to look elsewhere to commit crime in order to avoid being caught.

The number of SkyTrain stations is positively correlated with crime with a coefficient of 1.98. It appears that the greater the number of SkyTrain stations within a single census tract, the greater the level of car thefts. This finding may be attributed to the ability for the SkyTrain to transport offenders to different areas within the city to find appropriate targets to victimize against. Motivated offenders may no longer be confined to their own neighbourhoods to commit car theft and can travel to other neighbourhoods located along the transit route to find appropriate vehicles to steal. Offenders may be lured to search for vehicles to steal in census tracts with multiple stations as their presence may not be noticed due to heavy volume of traffic generated from the SkyTrain. Offenders can easily blend into their surroundings and may not attract the attention of commuters passing by. Motivated offenders can commit crime without having their suspicious behave our noticed. Subsequently, these census tracts that host more than one SkyTrain station are much more vulnerable for criminal victimization.

7.3. Conclusion

The inferential results of the panel data analysis demonstrate the importance of considering the socio-demographic characteristics of census tracts in relation to mass forms of transit crime. Unfortunately, the current panel data analysis was unable to incorporate longitudinal land use data. Population and/or user data by station number and yearly measured land use data would have been needed in order to account for any specific changes found in census tracts with multiple SkyTrain stations. Due to this obstacle, it was excluded from the analyses.

It is important to compare station presence and station count both individually and together. The differences are important to take into consideration because at one level, it appears that there is a significant change to the level of reported crime. However, when examined together, we see that census tracts with only one SkyTrain station are having an inconsequential effect on crime. Only when there is more than one SkyTrain station found within a singular census tract that there is a positive impact on the level of reported crime. Therefore, the presence of a transit station is not indicative of census tracts with higher levels of crime. Rather, census tracts with multiple transit stations demonstrate a higher level of reported crime. The question that emerges is why are census tracts with

multiple stations more vulnerable to higher levels of crime? One explanation could be the fact that census tracts with multiple transit stations may be situated in pre-existing socially disorganized areas. If stations were placed in such census tracts, there may have been little regard to improving the area with target hardening and pro-active policing measures.

Chapter 8. Spatial Point Pattern Test

To examine the potential criminal impact of the Canada Line Skytrain route in census tracts surrounding the transit system, the spatial point pattern test developed by Andresen (2009), will be employed. This test is used to help identify possible changes or differences in the spatial patterns of crime at the local level (Andresen & Malleson, 2014). This is achieved by measuring the degree of similarity at the local level between two spatial point patterns (Andresen & Malleson, 2014). Using this technique can help independently identify changes or differences in the spatial patterns of crime at different spatial scales (Andresen & Linning, 2012). Additionally, the spatial point pattern test is versatile in its ability to be conducted on various spatial patterns using any geographically defined unit (i.e. street segments, census areas, etc.). According to Andresen & Malleson (2014), the output of the spatial point pattern test is a global measure of similarity for the entire study area, as well as local results that identify similarity for each of the units.

The following provides the necessary steps needed to perform the spatial test.

> **1) Nominate one of your data sets as the "base" data set.**
>
> **2) Repeatedly sample from the other (test) data set to generate a confidence interval for testing.**
>
> **3) For each spatial unit, see whether the percentage of points within the base data is within the range of percentages generated for the test data using the sampling procedure and whether it is within the range that unit is deemed similar.**
>
> **4) Calculate an index of similarity that is the percentage of units that are defined as similar, ranging from 0 to unity.**
>
> **(Andresen & Malleson, 2014, p.192)**

By applying the spatial point pattern test, one can create variability within the data set so that it can be compared statistically with another set. The 85% samples generated each maintain the spatial pattern of the test data set and allows for a confidence interval to be created for each spatial unit that may be compared to the base data set. The output

of the test consists of two parts. First, there is a global parameter that ranges from 0 (no similarity) to 1 (perfect similarity): the index of similarity, S, is calculated as:

$$\frac{S = \sum_{i=1}^{n} S_i}{n}$$

where *si* is equal to 1 if two crimes are similar in spatial unit *i* and 0 otherwise, and *n* is the total number of spatial units. The *S*-index represents the proportion of spatial units that have a similar spatial pattern within both data sets.

Spatial point patterns tests can be extremely helpful when trying to identify criminal hot spots. Andresen & Malleson (2014) state "that knowing where hot spots are located is clearly important information for the allocation of police resources" (p.192). Further, by understanding why a hot spot has emerged in the first place can provide police with more information and thus a better response to reduce and prevent crime from occurring. The spatial point pattern test has been applied to various other spatial criminological studies seeking to identify similarities and differences in crime at the local level. It has previously been applied to test the stability in crime patterns, the appropriateness of aggregating crime types as well as the degree of spatial heterogeneity within commonly used spatial units of analysis in spatial criminology (Andresen & Malleson, 2011; Andresen & Linning, 2012; Andresen & Malleson, 2013). Thus, this technique will be extremely beneficial in determining the potential criminogenic effect mass forms of public transportation can have within geographical regions located within and/or nearby transit stations.

8.1. S-Index Values by Crime Type

The results generated from the spatial point pattern test are twofold: first an S-Index value is generated for each offence type followed by spatial map output for each criminal offence type. The results of the spatial point pattern test for the individual crime types are presented in Table 18. An index value of 0.8 or greater is sufficient to assume two point patterns share a high degree of similarity. The S-Index values for each crime reveal that crime between the two data sets is highly unstable. The results demonstrate

that individual crime types have experienced significant changes when compared between the two time periods of 2003-2008 and 2010-2015.

Crime Type	S-Index Value
All	**0.25**
Commercial Break & Enter	**0.44**
Mischief	**0.33**
Theft	**0.27**
Residential Break & Enter	**0.29**
Theft from Vehicle	**0.28**
Theft of Vehicle	**0.39**

Table 18: S-Index Values, 2003-2008 versus 2010-2015 Levels of Reported Crime

8.2. Spatial Map Output

8.2.1. Introduction

The results generated from the spatial point pattern test can be viewed in Figures 5 through 11. The blue coloured census tracts indicate that crime as greater than the baseline, where grey coloured census tracts indicate that crime was less than the baseline and hollow coloured census tracts were found to be insignificant. The solid blue line indicates a SkyTrain route while the red circles indicate a SkyTrain station. The data presented demonstrates the importance of coupling both the S-Index value generated from the spatial point pattern test with the spatial mappable output. The S-Index values alone do not provide a full picture of what, where, or why crime is occurring within Vancouver. The S-Index solely provides a value that allows one to determine the relative degree of stability. The shape files generated from the SPPT test help overcome this limitation by providing a visual analysis of the results to examine where these changes to crime are occurring. In doing so, one can attempt to look at the location and the context of the changes and incorporate appropriate strategies to reduce crime in the affected unit of analyses.

8.2.2. All Crime

The results for all crime demonstrate a high degree of instability amongst the two time frames, 2003 to 2008 versus 2010 to 2015 levels of reported crime in Vancouver. When examining the visual analysis for all crime, it is noted that a number of census tracts that host a Canada Line station and/or located nearby a Canada Line station have experienced a higher level of crime.

Burrard SkyTrain station is located within and located nearby to census tracts with higher levels of reported crime. This finding is not surprising; the proximity of a large shopping centre to Burrard station provides an ideal setting for an offender to target as there are a number of opportunities to commit crime. Further, with the transit network located nearby, offenders can quickly flee through various exit points that can lead to major arterial roads in downtown Vancouver as well as commuting away from the downtown core using the SkyTrain. Oakridge-41st Avenue is another station that is located beside a large shopping center. Similar to the Burrard SkyTrain station, offenders may make use of the transit network in order to quickly flee from the scene of a crime as they can quickly blend in within a SkyTrain car while trying to avoid detection from being apprehended. Both stations are located in close proximity to their respective shopping centre's parking lots. These parking lots are quite large and provide a number of criminal opportunities to a motivated offender. Vehicles themselves can be alluring to thieves as they may be able to steal the vehicle to sell for parts or to use for joyriding and/or another commission of crime. Additionally, vehicles parked in the shopping centre's lot may contain a number of valuables such as recent purchases made within the shopping centre, wallets, cell phones, house and garage keys, iPods, and so forth. Offenders may make use of the fact that shoppers leave their vehicles for extended periods of time and as a result, have a large time frame to select the ideal target.

Yaletown-Roundhouse is another station that reported census tracts with a higher level of crime. This station is located in the heart of downtown Vancouver and is within close vicinity to a number of commercial stores, restaurants/cafes, a recreation centre and a large urban park and seaboard that follows False Creek. Offenders may be lured to commit crime in such settings as they can choose from a number of targets to commit crime against. There are a number of opportunities to steal, assault others, commit

mischief, and so forth. Due to the heavy amount of foot traffic generated from the nearby stores and restaurants, offenders can easily blend into their surroundings and can commit crime without fear of being detected as an outsider amongst legitimate users of the space. In particular, David Lam Park and its seaboard offer a number of advantages for offenders choosing to commit crime. The park consists of a number of entry points and obstructing sightlines that may make it difficult for a potential target of crime to avoid victimization. Offenders may make use of trees, shrubbery, sea walls, and other urban infrastructure to hide and/or take targets to that would shield potential on-lookers from intervening to help prevent a crime. Especially during after-dark hours, offenders only need to avoid the street lamps located along the seaboard in order to avoid being illuminated and seen by others. Offenders can then commit a number of offences without fear of detection and/or apprehension. Light coloured surfaces found within the park's infrastructure would provide a perfect 'easel' for offenders to graffiti, damage, and destroy without worry of being stopped. Joggers and walkers at night may be at a higher risk of becoming a victim of assault as offenders can attack targets as they move from busy to isolated areas within the park.

Marine Drive is another station of concern when examining the overall level of reported crime in census tracts located within and nearby the Canada Line. Marine Drive is located in a heavily industrial land use. Marine Drive is the last Canada Line station in Vancouver before the SkyTrain enters the City of Richmond. The site has a number of industrial companies located nearby and offers very little areas for passengers of the Canada Line to seek out shops and restaurants to enjoy. As a result, there is a lower level of foot traffic generated at this station and may be preferred by offenders to commit crime. Offenders may be tempted to exploit the quiet surroundings of Marine Drive station to break and enter into nearby companies and potentially homes that are within walking distance of the station. With a lower level of guardianship present, offenders may be able to commit crime without fear of detection and apprehension. However, some may argue that the lower level of guardianship may serve as a deterrent for crime to occur. With a lower level of foot traffic, offenders may easily 'stick out' as an outsider and/or someone who does not belong. This may result in the offender feeling uncomfortable to commit a crime as legitimate users of the station may be more inclined to report suspicious behaviour to the Vancouver police and/or Transit police. Additionally, with fewer

individuals around there is a lesser likelihood for the by-stander effect[22] to occur. If an offender were to attempt a crime, the likelihood of a passer-by intervening may increase as there is a greater onus to help someone with fewer people around.

8.2.3. Commercial Break and Enter

Commercial break and enter results of the spatial point pattern test demonstrate a number of census tracts within and nearby Canada Line stations that report higher levels of commercial break and enter. There appears to be a high concentration of such census tracts located within the downtown district. These stations are located in an area where a large number of stores and restaurants are located. These results are expectant as offenders are drawn to areas that have a high level of foot traffic, allowing them to easily blend within their surroundings to select appropriate targets to victimize against. Cohen & Felson (1979) argue that the occurrence of crime increases when opportunity, a motivated offender and a lack of a capable guardian converge in both time and space. Downtown districts such as Vancouver would provide ample opportunities for offenders to commit crime. The SkyTrain system in the downtown core (Waterfront, Burrard, Granville, Vancouver City Centre, and Yaletown-Roundhouse) provides additional transfer points to the transit network, allowing offenders a number of ways to enter and exit their hunting grounds without arousing much suspicion. The Canada Line route connects to the Pacific Shopping Centre, the Expo and Millennium Line, the West Coast Express, as well as a number of buses that travel anywhere from Vancouver to Burnaby to North Vancouver. This allows an offender a wider search to select appropriate targets. As the transit network aims to provide commuters easy access to services and goods found at commercial establishments, it also allows offenders an opportunity to select a target.

This trend is also witnessed in other parts of Vancouver that are not associated with the downtown core. Stations such as Broadway-City Hall, King Edward, Oakridge-41st Avenue, Langara-49th Avenue and Marine Drive are located close by or within census tracts with higher levels of reported commercial break and enter crimes. These results

[22] *For more information about the by-stander effect, refer to "Bystander intervention in emergencies: Diffusion of responsibility", J.M. Darley and B. Latane (1968), Journal of Personality and Social Psychology, 8(4), 337-383.*

demonstrate the arguments presented by Brantingham and Brantingham (1981) in relation to the Geometric Theory of Crime. By expanding a transit network, commuters have new opportunities to reach geographical locations that were once inaccessible or too difficult to travel to. For the average commuter, the awareness space and mental maps begin to further develop and enhance as they are exposed to new areas that were not previously serviced by the SkyTrain. One could argue that offenders may also be included within this group. Offenders, who were used to the downtown core only to offend within, would now have the chance to explore new hunting grounds away from their familiar awareness spaces and find new targets to victimize against. There are a number of different stores, restaurants and other services that are located along and within other major corridors and arterial routes in Vancouver. West Broadway, Cambie Street, Kingsway, and Main Street are just some of the major travel routes used by commuters and where a large number of commercial establishments are located. Offenders would have an endless supply of new targets to choose from as they can simply 'hop on and hop off' the Canada Line to travel through Vancouver providing easy accessibility to travel to commit crime. The pathways of their awareness spaces have dramatically changed and thus would have a significant impact on offender decision making in terms of the location, frequency, and type of offence committed.

8.2.4. Residential Break and Enter

Results for residential break and enter generated from the spatial point pattern test illustrate a large number of census tracts located within and/or nearby Canada Line stations with higher levels of reported crime. What is surprising of the results is the fact that most of those census tracts are located in the downtown core. One would expect to see any increases to the level of residential break and enter in residential neighbourhoods that are located further away from the downtown core. Instead, the results indicate this is not the case. Rather, the majority of census tracts that demonstrated higher levels of reported break and enter at the residential level are found within downtown Vancouver. Upon closer examination of the results, an interesting pattern begins to emerge that could help explain why residential break and enter appears to cluster in downtown. Residential break and enter does not have to occur in only single-family detached homes; instead, due to population growth and intense densification within Vancouver, many people are

forced to live in apartment buildings and complexes. There are a large number of apartment structures found within downtown Vancouver and would be extremely lucrative for offenders to target against.

Typically when a new form of mass public transportation is constructed and implemented, property investors tend to build a number of high rise complexes to help attract potential buyers. As in Vancouver, typically a SkyTrain station and/or route are an appealing factor when considering buying an apartment. Investors are able to gain large returns as potential buyers typically look for places that can easily connect them to different parts of the city and region. As a result, new apartment buildings and complexes tend to be located nearby future transit stations once the construction of a new line is announced. As a result of a number of SkyTrain routes within the Lower Mainland, a large number of apartment complexes are located within close vicinity of SkyTrain stations, in particular, the Canada Line. Offenders would be drawn to commit residential break and enter within close proximity of a Canada Line station as they would have a number of suites to target and can exert very little effort in the process, leading to more potential targets to victimize against. Security and crime prevention within apartment buildings is a growing, but lacking concern of interest. Apartment complexes are vulnerable to residential break and enter due to a number of limitations such as multiple entry ways, shared public areas such as interior hallways, elevators, laundry rooms, parking areas, none to limited number of CCTVs, and lack of ownership. These factors combined make it extremely easy for offenders to be able to gain access to a building's premises and continue to find a vulnerable target such as an unlocked suite. If offenders target suites during the day while tenants are away at work or school, offenders have the potential to victimize a large number of suites without detection and can easily blend in with their surroundings to avoid arousing suspicion.

Further, offenders may also feel they have a better chance of successfully breaking into a suite to steal compared to breaking into a house as many older apartment complexes may lack updated security measures such as peep holes, locks, and door frames. Older buildings may be targeted as offenders would not have to be required to exert a lot of energy to break into a suite compared to an apartment building that has

updated security features such as FOB accessed entry ways, elevator-specific floors, CCTVs, and active crime prevention programs in effect.

8.2.5. Mischief

The results indicate that there are a number of Canada Line stations that are located within and/or nearby census tracts that appear to have an increase in mischief. Mischief contains a large number of different misdemeanors that aim to destroy, alter, or deface property. Such offences commonly include graffiti, light smashing, breaking windows, removing/bending signage or ornamentation, and destroying plants/bushes (McCorkle, 2010). This finding is consistent with the literature that suggests that transit stations make for ideal settings for youth to vandalize and damage property (Carr & Spring, 1993; Loukaitou-Sideris, Liggett, Iseki & Thurlow, 2001). As people wait for trains to arrive, there is a time gap that can encourage offenders, particularly youth to pass time by committing crime. Their awareness spaces may evolve as they have more time to take in their surroundings and choose vulnerable targets that were previously unnoticed. This is especially problematic for stations locate in commercial land zones as fewer guardians are available to protect the transit station and its immediate surroundings.

Stations that demonstrate high levels of reported mischief include Yaletown-Roundhouse, King Edward, and Marine Drive. These stations vary in their land use, appealing to different types of offenders. Yaletown-Roundhouse station is located within a busy section of downtown Vancouver. The station is close in proximity to False Creek, a community art and recreation center, David Lam Park, residential apartment towers, and the Quayside Marina where many boats are kept. This diverse geographical region would provide ample opportunity for an offender to seek out areas to commit mischief. Some of the areas such as David Lam Park and the marina would be busy during peak times of the day for human activity while at night would have fewer people around. This may entice offenders to visit this area as they would be able to commit mischief such as vandalism or graffiti without any interference from a by-stander and/or capable guardian. Due to the park having multiple entry and exit points, offenders may aim to destroy plants and bushes located within the park, vandalize and/or ‘tag’ the seawall, outdoor playground, and other infrastructure found within the park. As previously mentioned, offenders may make the

most of after-dark hours after exiting the Canada Line to commit mischief. Offenders may be more easily able to avoid street lamps located along the seaboard in order to avoid being illuminated and seen by others. Offenders can then commit a number of offences without fear of detection and/or apprehension. This would allow offenders to graffiti, damage, and destroy without worry of being stopped.

King Edward and Marine Drive stations are located in a mixed land use area that contains both residential and commercial premises. Mischief is not limited to urban areas and can be found in suburban neighbourhoods as well. Mischief may be found in the form of graffiti, vandalism, destroyed plant life, slashed car tires, and keyed vehicles (McCorkle, 2010 as cited in Fisher & Lab, 2010). Offenders, particularly young offenders, may use the public transportation system as a means of exploring new areas to target. Young offenders may not have reached the age of obtaining a driver's license and may use the Canada Line SkyTrain as a means of travelling to and from home and school. After school hours, particularly between the hours of 3:00 pm and 6:00 pm may be ideal for those seeking ways to become devious and cause mischief. With a large majority of households that see both parents working, young adolescents have a number of hours that lack supervision and as a result can lead to youth getting into trouble. Young offenders may like areas located close by to such SkyTrain stations as they can quickly seek out an appropriate target to damage or destroy and can quickly flee to avoid detection.

8.2.6. Theft

Results for other theft generated from the spatial point pattern test illustrate a large number of census tracts located within and/or nearby Canada Line stations with higher levels of reported crime. A large proportion of census tracts with high levels of theft are found within downtown Vancouver. This trend is not surprising; downtown Vancouver is densely populated and offers a number of opportunities to steal from. Predictably, there are a number of stores and restaurants that could suffer from theft but there are also different areas that offenders may target as it could yield more benefits. Vancouver is a highly sought after travel destination and many people who visit Vancouver arrive via cruise ships and air travel. Vancouver Tourism reports that Vancouver gets approximately 230 cruise ships annually (Vancouver Tourism, 2017) while YVR welcomed 20.3 million

passengers in 2015, including arriving, departing, and connecting passengers (Vancouver International Airport, 2017). This large mobile population represents a number of targets for motivated offenders to choose amongst. Many tourists wander the streets of Vancouver and carry a large assortment of goods and valuables that would be appealing to an offender. Tourists are lucrative targets as they are more likely to be relaxed, off-guard, and unaware of their surroundings. Tourists are easily identifiable as they tend to stand out in their surroundings. Tourists are profitable targets because they often carry expensive goods on themselves such as cameras, watches, jewelry, large amounts of foreign currency, and passports (Sacco & Kennedy, 2011). Some tourists arrive to Vancouver using the Canada Line SkyTrain that travels from Vancouver's International Airport (YVR) to Waterfront station in the middle of downtown Vancouver. These passengers tend to carry a number of suitcases, purses, and bags that could easily be stolen from a wary and tired commuter.

8.2.7. Theft from Vehicle

There seems to be a large increase in theft from vehicle in stations located past False Creek, going into a wealthier suburb of Vancouver. There are a number of residential neighbourhoods that would make perfect hunting grounds for offenders to target. With Oakridge mall's parking lot and the number of households located in the region that own 1+ vehicles, the results demonstrate that the Canada Line has had some sort of influence over the criminal activity within the region. If commuters have decided to seek parking for their car in streets located within walking distance of the Canada Line train, this may create a spatio-temporal opportunity for crime. As most people work anywhere between 6-8 hours each day, this allocated time away from one's car provides an absorbent amount of time for offenders to cherry-pick through their targets and find ideal targets to steal from. If home owners are at work themselves, there are fewer guardians available to keep eyes on the cars and to interfere with a break in. Offenders essentially are provided with a route to easily travel around Vancouver to offend with an uninterrupted time frame.

Perhaps the most surprising finding of theft of vehicle is the area surrounding Langara-49th Avenue SkyTrain station. This station is located nearby to a large college

campus that offers a number of opportunities to select unoccupied vehicles to steal items from while students and staff are working in the school. One would think that large parking lots found on campus would provide an ideal hunting ground for offenders to search for targets. However, this finding may be explained through two reasons. First, school schedules of college students vary drastically between semesters and within the week. Students may only attend school for a limited number of hours per day or week and thus it may not provide an offender with much time to select a target to steal, especially if more students are arriving and departing within the same parking lot. Offenders may be easily detected and their crimes interrupted if there is a constant level of foot traffic within the surrounding area. Also, many post-secondary institutions employ security services to overlook their campuses and to provide a safe setting for students to attend school. Offenders may be aware of this and may be more reluctant to want to search for targets within such a heavily watched area. Second, offenders may not have as many vehicles to steal items from in a parking facility found at a college campus compared to a shopping centre parking lot. This may be due to fewer students choosing to drive to school. Much like offenders, many college students may not have access or the finances to own or operate a motor vehicle. Instead, students who may be more financially restraint due to other costs such as paying for tuition may opt for other ways to travel to school such as carpooling or taking public transit. Many post-secondary schools in British Columbia have a transit pass program in place that students pay into each month to have an unlimited transit pass to travel to school. This initiative provides students with a low-cost option to attend school, decrease the number of vehicles on the road, and reduce parking congestion at the campus. As a result, the proportion of students travelling via public transit compared to a private vehicle would be much higher and as a result, may not provide as many options for offenders actively seeking appropriate targets.

8.2.8. Theft of Vehicle

The results for theft of vehicle demonstrate that most CL stations are located within or nearby census tracts that have experienced an increase in the level of criminal activity. The results are not surprising for downtown Vancouver; most car owners will park at a park-and-ride and take the train to commute to work. These park and ride facilities are typically not located near the downtown core and are more likely to be found outside the

city's limits in suburban neighbourhoods. The stations that do show an increase are more varied. First, Olympic Village is located extremely close the Vancouver Police Department. This finding is surprising given the assumption that would-be offenders would be less likely to engage in crime in areas with higher levels of surveillance. According to Cornish & Clarke (1986), offenders are less likely to commit crime when the consequences of committing the crime outweigh the potential benefits. The increased level of reported theft of vehicle in these census tracts are located nearby Vancouver Police Department's Headquarters and would not expect to see a necessary increase in crime due to the presence of formal guardians. However, further exploration of the local region indicates that the displacement of crime and other social disorder from East Vancouver may help explain the results witnessed. Vancouver's Police Department is located close to Vancouver's notorious Downtown Eastside (DTES). This area is characterized with high levels of drug use, prostitution, mental illness, and poverty. Offenders may be more willing to steal motor vehicles regardless of the proximity to the police headquarters as they are in more dire need to find ways to survive. Using the rational choice perspective offered by Cornish & Clarke (1986), we can see that the rationality of these offenders is formed at a more basic level, ensuring survival. Stealing a vehicle may be a necessity in order to find ways to eat, seek shelter, and/or supply a drug habit.

In addition to the increased level of theft of vehicle found at Olympic Village, census tracts that are located nearby and host Oakridge-41st SkyTrain station also witnessed an increase in theft of vehicle crimes. Oakridge-41st is located at Oakridge Mall which hosts a large underground parking lot. This may make this location extremely attractive to offenders as it can provide a one-stop-shop for stealing cars without much surveillance from passers-by. This station is also situated in a wealthy part of South Vancouver. There is a higher proportion of high end, wealthy vehicles that are driven by residents. Offenders may be extremely motivated to travel to these census tracts, particularly the mall parking lot as they can a bigger selection of targets that are typically not found in the offender's immediate awareness space. With many obstructing views within the parking lot, offenders can easily conceal themselves from mall security and passers-by from being identify and can carry out their illegitimate plans.

Lastly, Marine Drive as mentioned previously is located in an industrial area and may have less guardianship to look after parked cars. With fewer individuals using the space immediately outside of the SkyTrain station, offenders may have more time to select a target to victimize against without arousing suspicion. Furthermore, if vehicles are parked for long periods of time (over 8 hours), particularly overnight, offenders will have a large time frame to commit crime without the threat of detection and apprehension. By the time a car owner would return to their vehicle from work, the offender and the vehicle would have already left. Additionally, Marine Drive station is located near major arterial roads in Vancouver such as Cambie Street and South West Marine Drive, and the Oak Street Bridge. Offenders would have a number of escape routes to select amongst once they have taken a vehicle. As a result, it makes it more challenging for authorities and the car owner to determine where the vehicle left and may be eventually located.

8.2.9. Conclusion

The results of the spatial point pattern test illustrate that the Canada Line has the ability to alter the opportunity structure for crime. Census tracts that host and/or are located nearby Canada Line SkyTrain stations are at an elevated risk for criminal victimization across six offence types: commercial break and enter, residential break and enter, mischief, theft, theft from vehicle and theft of vehicle. The findings help validate some of the research questions posed in the current analysis. The following section provides a comprehensive discussion of the overall analysis of the Canada Line and levels of reported crime within Vancouver. A discussion of the implications of this research is also considered, including the repercussions for pro-active policing, urban planning and, crime prevention education.

Chapter 9. Discussion

9.1. Current Study

A spatial analysis of the Canada Line SkyTrain route in Vancouver, British Columbia demonstrates the importance of studying the magnitude mass forms of public transportation can have on levels of crime reported at the census tract level. As witnessed in the analyses, the presence of a SkyTrain station does not necessarily increase the level of reported crime in census tracts that host and/or are located nearby the transit route. The results of the study indicate that the Canada Line SkyTrain route in Vancouver has not influenced the level of reported crime; the level of crime is relatively stable regardless of this new form of mobility. Instead, caution should be made toward census tracts that host multiple SkyTrain stations, as these areas are more vulnerable for motivated offenders to commit crime.

9.2. Implications

There are several implications that arise from the current research into the relationship between crime, offender mobility, and mass forms of public transportation. The results of the current research demonstrate that the SkyTrain system has garnered an unfair label of being criminogenic; instead elevated levels of risk found in census tracts that host a SkyTrain station, in particular, the Canada Line, have other underlying factors that have influenced the level of reported crime. Factors include the location of the station (socio-economic status of neighbourhood) and the number of stations within a single census tract. Instead of increasing hostility toward the expansion of mass forms of public transportation, greater efforts need to be made to implement appropriate safeguards to strengthen the nearby environments of the SkyTrain stations and to increase cooperation amongst various partnerships such as the local police, city officials, urban planners and architects, and the general public.

9.3. Policing

The role of policing is an important feature in combating transit related crimes within any metropolitan city. Within the Vancouver context, policing agencies such as the Vancouver Police Department and the Transit Police would be the primary authorities to help keep the Canada Line SkyTrain route and its stations safe and secure. These policing authorities can be pro-active in reducing the level of reported crime found within SkyTrain environments by being routinely positioned at stations, educate the public on a number of crime prevention and target hardening measures, and removing opportunities to commit crime. Strategically, it would be most beneficial for police officers to patrol not only within the station itself but also in the surrounding environment. As previous studies have suggested, transit crime can exceed the physical boundaries of the station and travel to the nearby environment, sometimes as far as 750 meters away (Robinson & Giordano, 2012). This environment is often overlooked in patrols as it falls in a "grey" area of patrol; no longer within the immediate confines of the station, making Transit Police less likely to respond while Vancouver Police are more likely to see this area as a continuation of the transit station, and thus, more likely to shift responsibility to the Transit Police. As a result of this ambiguity, this environment suffers and in turn, can breed more opportunities for crime to occur. As of 2015, the Transit Police have employed a community policing model to help combat jurisdictional issues when patrolling SkyTrain stations (Transit Police, 2017). This community-focused approach has enabled transit officers to better connect with the community by building trust and relationships with residents, help protect vulnerable people, prevent crime and target problem issues, in addition to building and maintaining partnerships with community groups and other policing agencies within the area (Transit Police, 2017). The Lower Mainland is divided into different community teams, also known as hubs to help better provide services to the local community. There are six different hubs: Area 1 (Downtown), Area 2 (East Vancouver/North Shore, Area 3 (South Vancouver/Richmond), Area 4 (Northeast), Area 5 (Surrey/Langley), Area 6 (South Burnaby/New Westminster) (Transit Police, 2017). This model is extremely beneficial and can help combat against crime and public disorder that can be found within transit environments. Also, the use of volunteers from local community police offices may assist in the Transit Police's community policing model. These volunteers would help promote visibility of the police and could help identify problematic areas that could require further

assistance from regular police officers. Volunteers would also be able to communicate with the community and relay important information between community members and the police. Additionally, the creation of new community police offices within census tracts that are particularly vulnerable to criminal victimization may help mediate the level of criminal victimization risk. These offices could help educate community members on issues related to personal safety and target hardening measures.

9.4. Urban Planning

Municipalities within Metro Vancouver need to work closely with its urban planners, transit authorities, and local law enforcement to ensure that the introduction of a new mass transit route will not negatively impact the surrounding land use within a particular community. As witnessed in the panel data analysis, it is very critical for planners to consider the pre-existing social character of a proposed transit station location prior to the construction of a new transit route. Locations that have a high level of social instability need to have the underlying conditions of the instability addressed prior to the implementation of a new station. If these conditions are left unaddressed prior to construction of a station, crime in these census tracts may be further compounded. A greater level of concern must be paid in order to prevent increasing the risk of crime at transit stations. This in turn may require local authorities to invest in a greater level of preventive measures and promoting awareness surrounding personal safety in order to help combat the level of risk. Educational measures can easily be adopted and promoted by local authorities that will help negate the potential increase in risk with the introduction of a new station and route.

Additionally, the creation and expansion of mass forms of public transportation systems can alter and change the surrounding land use of a region. Often, the creation of a new transit route will propel new infrastructure projects such as multi-unit high rises, commercial stores, and community focal points. Due to the shift, the criminal opportunity structure can change. As realtors know, location, location, location is one of the most important aspects to consider in land use and infrastructure. The pre-existing land use of an area may have had enough safeguards in place to help buffer the potential impact of a transit station within the area. However, as the population within the area densifies and

new opportunities for individuals to purchase property and find employment grow, those safeguards may not be enough to buffer the new criminal opportunities. Instead, these safeguards may need to be replaced or altered to better suit the needs of the new opportunity structure. This issue addresses the complexities that transit growth present on land use and the importance to be thorough with evaluating the location prior and after construction of the station and its subsequent route are complete. Metro Vancouver is set to start construction on a number of transit projects aimed at providing more feasible options for travelling throughout the region. Projects include the expansion of the Millennium Line Broadway Extension, Surrey-Newton-Guilford LRT, upgrade of the Expo Line, and the creation of a new Pattullo Bridge (Slattery, 2017). These projects would benefit by having a crime prevention perspective applied to the design of these routes and the overall integration within the community. Proposed sites for stations should be carefully investigated and evaluated prior to and after construction to ensure they will not be susceptible to an increase in crime.

9.5. CPTED

Although CPTED was not the focus of this study, the results of the analysis demonstrate the importance of implementing appropriate safeguards from the design to implementation phase to ensure areas will not experience an increase in crime that host a new station. Urban planners, architects, and local transit authorities should work together in order to develop a uniform response in ensuring passenger safety in transit environments. This response should include mandatory minimum safeguards within the design phase to ensure that the criminal opportunity structure at the new stations will not attract motivated offenders. In some jurisdictions, CPTED is now a mandatory component that must be included in blueprint designs and plans prior to approval from the local city municipality. CPTED has proven to be an extremely advantageous form of situational crime prevention and can help inhibit transit routes and its subsequent stations from becoming crime attractors and generators.

9.6. Limitations

There are some limitations associated with the current research. Like many studies of crime, the study only includes reported criminal incidents. The dark figure of crime, where more crime occurs but is not reported, can influence the results obtained from the current study. Further, the crime data used for these analyses were extracted from the Vancouver Police Department's computer system. These systems are considered 'live' and therefore, can change on a daily basis as information comes forth in an investigation. The data that was publically available also did not contain many specific attributes of a criminal event. Many identifying features were generalized in order to help provide anonymity to the data set. Each record includes information only on the year, month, type of incident and the general location of the incident such as an intersection or one hundred block. This may influence the results of the spatial analyses as the output is unable to specify to the exact address.

Further, the study used six types of offences and excluded other, more common types of crime associated with public transportation systems. Including more offence categories may have yielded a different outcome. However, the results show that a public transportation system does not necessarily have to be positively related to crime. Thus, the study is able to show the importance of not aggregating individual crime types when investigating the relationship between crime and public transportation.

A major limitation found within the current analyses of the Canada Line and levels of reported crime in Vancouver stems from the availability of longitudinal land use data. Land use data is often missing from empirical studies on crime and public transportation. The limited amount of studies that are able to obtain this type of data often consists of only one year worth of data. The City of Vancouver does not provide a comprehensive land use data set that extends beyond one year. In order to ensure the current analyses did not misrepresent the data, it was decided to exclude this aspect in the analyses and focus on the longitudinal crime data only. The City of Vancouver has undergone a number of changes to its built environment within the past decade. Significant increase in residential development, commercial expansion, and gentrification projects have helped change the structure, dynamic, and livability of the region. Therefore, it would not be appropriate for

the study to include only a limited amount of land use data for the City of Vancouver as it would be an injustice to the many changes witnessed within the city.

9.7. Future Research

The results obtained from the current research into the relationship between mass forms of public transportation and crime holds several implications for future research within the field. Future studies examining the transit and crime paradigm should utilize a greater number of spatial and temporal techniques to understand crime at the micro level. Analyses should be conducted on each SkyTrain line to determine whether changes should be implemented to help safeguard the transit environment from potential crime. Future research should utilize a spatio-temporal approach to transit and crime to understand specific changes that occur with transit settings and their nearby environments. This is especially beneficial as the Lower Mainland is set to begin a number of expansion projects to help combat against pollution, increase mobility, and increase overall viability within the region. Future research should expand the number of criminal offences examined in relation to transit settings to include crimes such as sexual assault, physical assault, and robbery, to name a few.

Additionally, future research should strive to include longitudinal land use and ridership data whenever possible. It often becomes difficult for researchers to account for rival plausible causes without having the ability to confer with competing factors that may influence the level of reported crime within a given region. In the context of the Canada Line in Vancouver, future studies would benefit from using population and/or user data by station number and yearly measured land use data to help account for changes found in census tracts that boast more than one SkyTrain station.

Chapter 10. Conclusion

Expansion of mass forms of public transportation are often feared and loathed over concerns for an increased level of crime. Transit environments tend to attract and generate crime due to their ability to attract a large number of people traveling to and from work, school, and home along a limited number of pathways. Transit stations provide both predictable spatial and temporal patterns of mobility thereby providing motivated offenders with ideal hunting grounds in pursuit of targets. Although mass forms of public transportation create a unique opportunity to commit crime, it does not necessarily mean that such crime will take place. Careful planning and consideration of the implementation of these systems does not have to signify higher levels of crime in those regions that host and/or are located nearby a station.

The goal of the study was to determine whether the implementation of the SkyTrain's Canada Line in Vancouver, British Columbia had increased the level of reported crime in census tracts that hosted and/or were located nearby to a Canada Line station. Exploration of census tracts, crime, and the Canada Line has illustrated that census tracts with high levels of social disorganization and host multiple stations are much more vulnerable for criminal victimization. The presence of a SkyTrain station does not negatively impact the level of reported crime in Vancouver; rather, location of the station plays a bigger role in determining the likelihood of crime. To answer the study's research questions, the current analysis was able to demonstrate: the presence of a Canada Line SkyTrain station does not increase levels of reported crime. Instead, particular offences and census tracts that host a station have some elevated levels of risk but can be attributed to other external factors such as the level of social disorganization of the neighbourhood and the number of SkyTrain stations. Socio-economic characteristics of the local neighbourhood do influence the level of crime in census tracts that host a Canada Line station. The number of SkyTrain stations found within a single census tract tends to increase the level of risk for criminal victimization. Too many stations within a given census tract, regardless of the SkyTrain route, has a negative impact on the level of crime. Last, census tracts that do not host a SkyTrain station have comparable levels of reported crime, further debunking myths that public transit facilitates crime.

The findings of the current research highlight several important aspects in the study of mass forms of public transportation and crime. First, the location and placement of transit stations must be thoroughly examined and evaluated prior to construction. Areas that have high levels of social disorganization may be more vulnerable to criminal activity due to the lack of buffers put in place to help combat the increase number of victims traveling throughout the station. Second, land use is more likely to change after the implementation of a new transit route; commercial stores and residential property are more likely to be built within the immediate environment of the transit station in order to help attract more people to live and work within the region. This changing dynamic may provide additional criminal opportunities that were not first present in the initial evaluation of the land prior to construction. Certain establishments such as retail stores and restaurants can attract motivated offenders to the area based on a new selection of targets that were once not available. As a result, it is equally important to implement appropriate safeguards such as crime prevention initiatives like CPTED and local police foot patrols in order to help combat the potential increase in criminal opportunities. Key stakeholders within the region such as urban planners, police and transit authorities would benefit from working alongside each other in a uniform stance toward safety and security of the transit station and its passengers. Such preventive measures can help decrease both the level of offending in addition to eliminating misconceptions and fears over the expansion of mass forms of public transportation within the built environment.

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Appendix A.

Spatial Point Pattern Maps

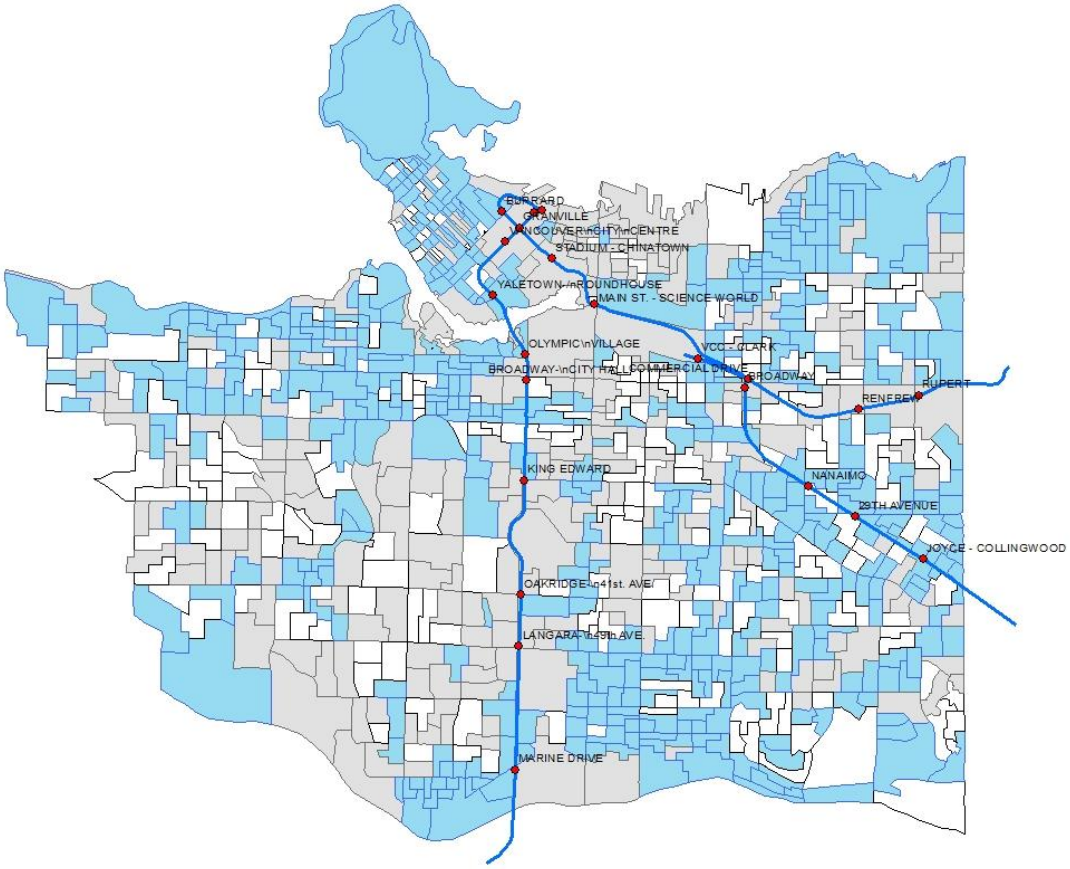

Figure 5: SPPT Results, All Crime

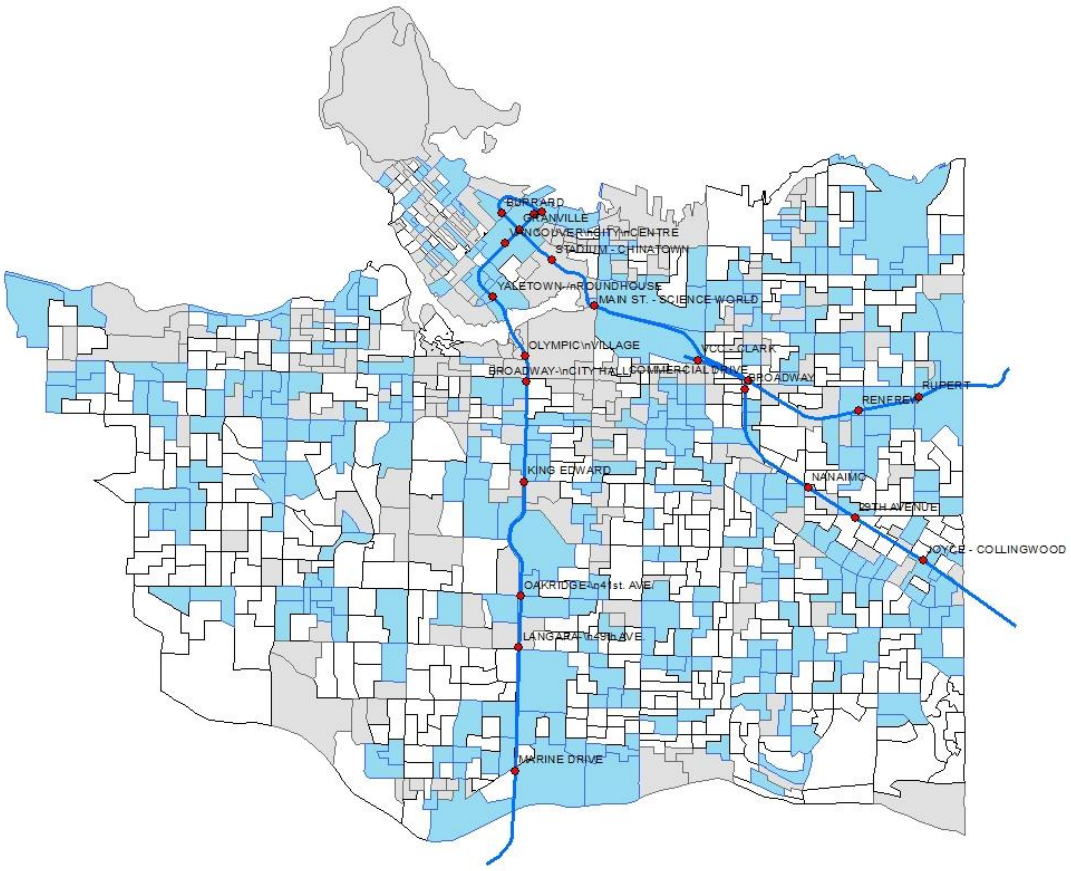

Figure 6: SPPT Results, Commercial BNE

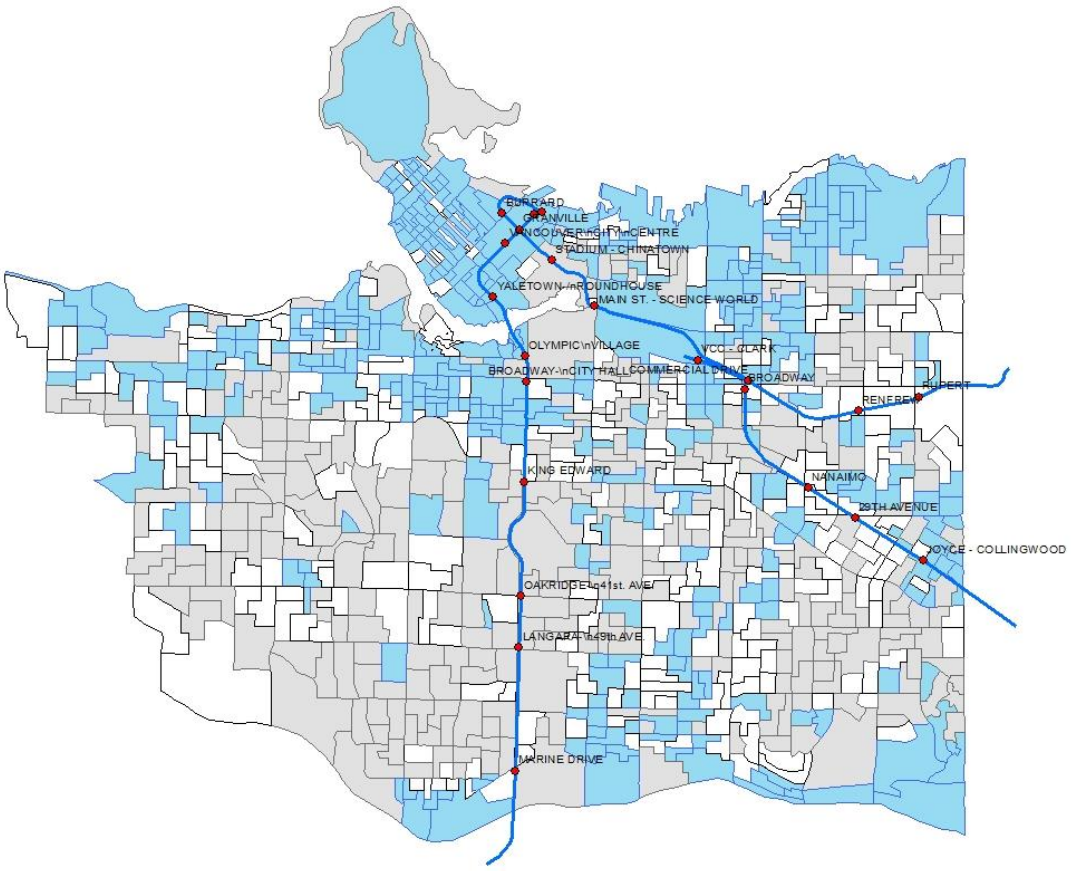

Figure 7: SPPT Results, Residential BNE

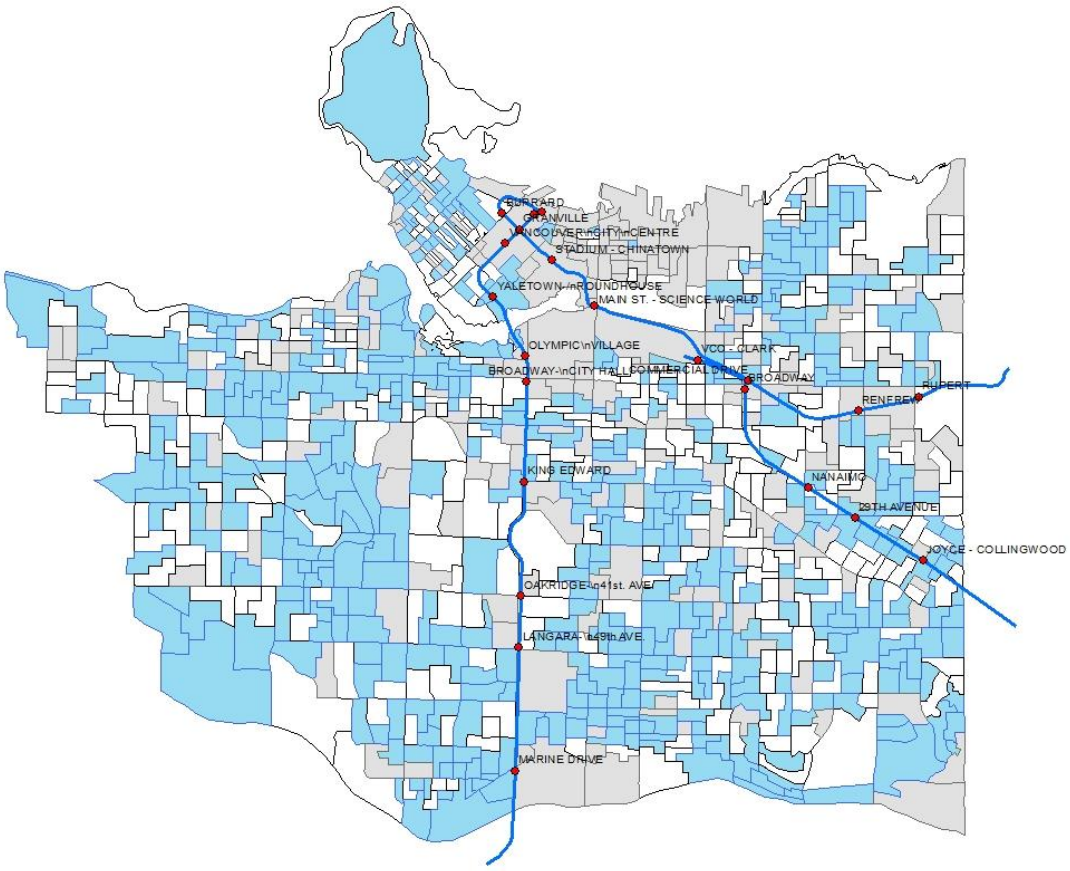

Figure 8: SPPT Results, Mischief

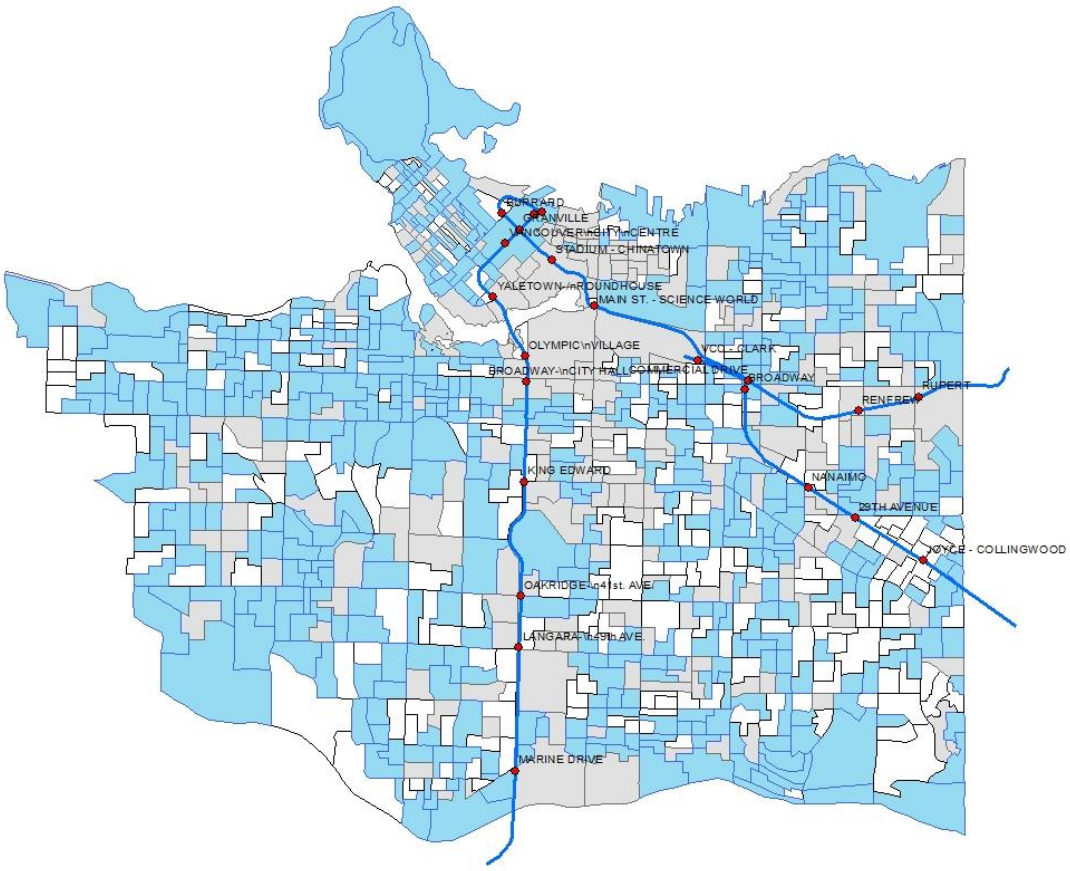

Figure 9: SPPT Results, Theft

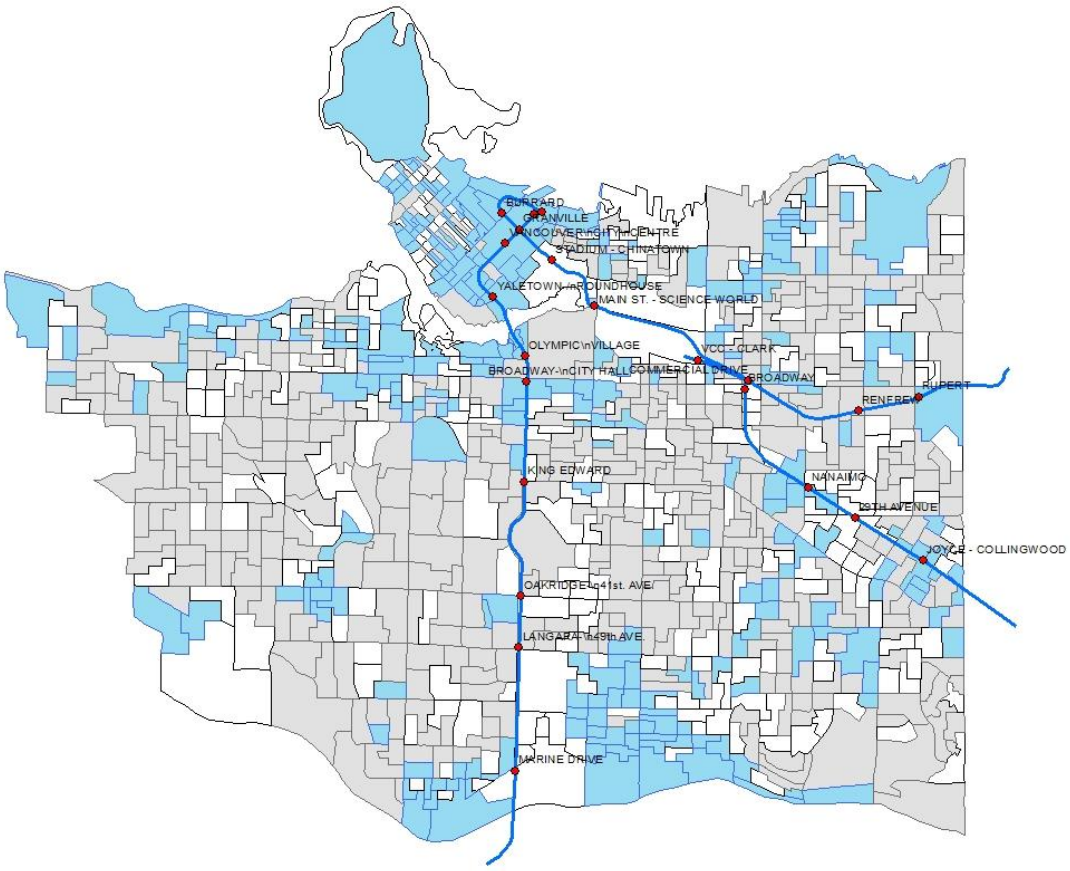

Figure10: SPPT Results, Theft from Vehicle

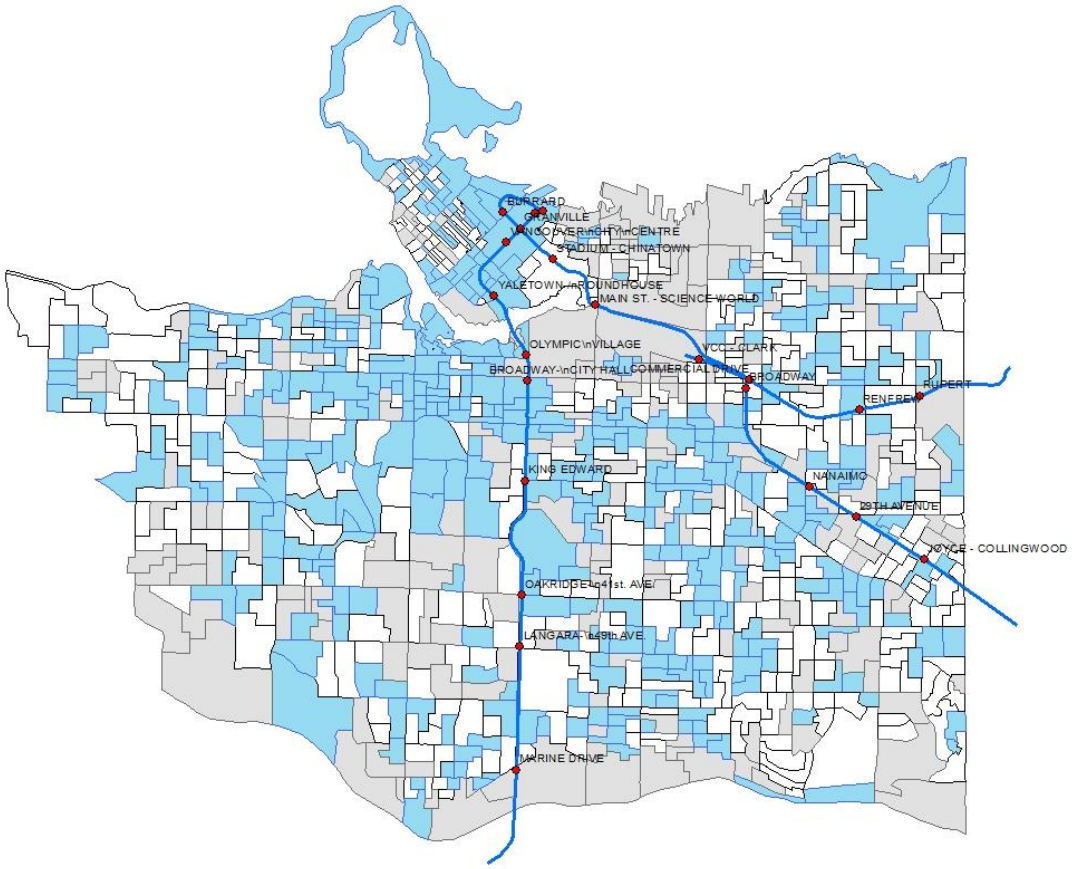

Figure 11: SPPT Results, Theft of Vehicle