

**The Built Environment and Urban Crime Patterns:
A spatial analysis of land use and property crime in
Surrey, BC**

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Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts

in the
School of Criminology
Faculty of Arts and Social Sciences

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SIMON FRASER UNIVERSITY
Summer 2017

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Abstract

As we grow our urban space, it is important to understand the influence of the built environment on criminal opportunity. Using a theoretical foundation that synthesizes routine activity theory and social disorganization theory, this study examines the spatial relationship between land use and property crime in a large metropolitan city. A series of spatial analyses were used to explore the geographic distribution of three types of property crime: residential break and enter, commercial break and enter, and theft of motor vehicle. Results found support not only for a spatial relationship between the built environment and property crime occurrences but also for the effect of the socio-economic variables of routine activity theory and social disorganization theory.

Keywords: spatial analysis; land use; property crime; routine activity theory; social disorganization theory

*To my parents, Bob and Judith,
thank you for your endless encouragement
of my academic pursuits.*

Acknowledgements

Firstly, I would like to thank my senior supervisor, Dr. Martin Andresen. I am sincerely grateful for your patience and support during the completion of my master's degree. I greatly appreciate your knowledge and for always being available for questions and guidance. I am genuinely thankful for the opportunity to learn from you.

I would also like to thank my supervisory committee member, Dr. Bryan Kinney. Thank you for all of your guidance and support during my degree and time at the Institute for Canadian Urban Research Studies. I really appreciated your humour and teaching. Thank you as well to Dr. Paul Brantingham and Dr. Patricia Brantingham for the opportunity to be a Research Assistant at the Institute for Canadian Urban Research Studies.

Allison Campbell, Neena Tiwana, and Shannon Linning, I'm so glad I met you. Your laughter and friendship have made great grad school memories. To "The Avengers": Jessica Bouchard, Nicole Melenka, and Rahul Sharma, thank you for making classes and course work so much more entertaining. I'm glad we got through that together. I wish you all the best!

Thank you to all my family and friends who were so supportive over the years. I am so grateful for your encouragement.

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Chapter 1.

Introduction

The field of crime analysis has a long history of utilizing geographic and social components in explaining the distribution of crime in society, and through ongoing developments in technology, this field has moved beyond push-pins in paper maps to advanced statistical and spatial analysis (Chainey & Ratcliffe, 2005; Boba, 2009; Andresen et al., 2010; Hill & Paynich, 2014). Integrating and maintaining the spatial component of data adds a crucial level of understanding to crime analysis. Crime does not occur in the absence of place, and utilizing spatial data allows analysts to look beyond just the “who” and “what” of crime and to see the relational influence of the “where” (Chainey & Ratcliffe, 2005; Boba, 2009; Hill & Paynich, 2014). By understanding the geographical context of crime, police and policy makers can target their attention directly at the area most in need of crime reduction or prevention strategies. The purpose of this research is to demonstrate how the built environment and socio-economic profile of a city are spatially related to the geographic distribution of crime. The conclusions reached through the following analyses seek to contribute to the field of crime analysis by illustrating the benefit and application of utilizing the spatial aspect of data in understanding the criminal event patterning of a region.

What causes crime is a complex and often divisive topic with many theories in criminology seeking causal relationships with either social, economic, cultural, or behavioural factors. Of importance to studies of the geography of crime, however, are the opportunity and ecological theories of criminology that approach the identification of crime correlates from the perspective of an offender’s interaction with the environment (Shaw & McKay, 1969; Cohen and Felson, 1979; Felson & Clarke, 1998). These two types of theories distinguish themselves by not seeking to change the individual offender but rather to change the situation in which crime is occurring (Cohen and Felson, 1979; Shaw & McKay, 1969; Clarke, 2012). By combining opportunity and ecological theories to explain the occurrence of crime, the conditions and location of crime become the focus.

As one of the most prominent opportunity theories of crime, routine activity theory is of importance when examining the geography of crime (Anderson et al., 2010; Weisburd et al., 2012). According to routine activity theory, the distribution of crime will parallel the location of suitable targets that lack sufficient guardianship (Felson, 2011). Cohen and Felson believe that the presence of a motivated offender is a given, and they point to people's routine activities as providing the opportunity for crime (Felson, 2011). Where people are and what people are doing is what brings motivated offenders in contact with suitable targets in a situation lacking guardianship, and thus, a criminal opportunity arises. Crime prevention strategies incorporating this theory focus on reducing criminal opportunity by increasing guardianship and decreasing the perceived suitability of targets. Routine activity theory contributes a macro-level societal look at criminal opportunity (Felson & Clarke, 1998, Felson, 2011). The immediacy and practical approach of this theory to crime prevention continues to make it a relevant theory in criminology and policing (Andresen, 2006; Clarke, 2012).

The opportunity for crime is created not only by the physical structure of a place but also by the social context (Shaw & McKay, 1969). Social disorganization theory contributes this necessary ecological component to spatial crime analysis (Shaw & McKay, 1969; Kennedy & Ford, 1990). This theory seeks to explain the presence of delinquency through measures of relative deprivation and lack of social control in an area. Variables that represent ethnic heterogeneity, family disruption, population turnover, and socio-economic deprivation are utilized to express an area's vulnerability towards social disorganization and thus criminality (Shaw & McKay, 1969). Social disorganization and a lack of community cohesion build a foundation for delinquent behaviour. Through exploring the correlation of these influences with crime in a geographic area, resources can be directed to increase civic capacity and build community resources that will lead to lower rates of delinquency over time (Shaw & McKay, 1969).

Opportunity theory is practiced every day in the small actions that people take to reduce the possibility of criminal victimization in their lives. From locking houses and cars to walking in well-lit areas and keeping a hand on a purse, opportunity theories of crime reduction are in use all around us. If opportunity reduction did not work, then we would not take precautions (Felson & Clark, 1998). Opportunity is created in the built and social environment, and it is here that situational crime prevention is effective.

Interventions that reduce opportunity and increase an offender's risk of being caught will achieve a reduction in crime (Miethe, 1991). Opportunity is a real and tangible entity that can be effectively reduced by crime prevention strategies (Felson & Clark, 1998). In using a combination of social disorganization theory and routine activity theory, the following analysis examines the spatial relationship between land use and property crime and seeks to demonstrate how the built environment shapes criminal opportunity.

Chapter 2.

Theories in Spatial and Environmental Criminology

Crime analysis, when supported and interpreted with a theoretical background, aids in explaining the context of crime occurrence patterns, and by mapping criminal events and utilizing spatial data, these correlative crime variables can be geographically located within a region. By considering both routine activity theory and social disorganization theory in the context of land use, then not only will the social framework that is influencing crime in an area be identified (Shaw & McKay, 1969; Cohen & Felson, 1979) but also how the built environment can contribute to creating criminal opportunity (Cohen & Felson, 1979; Poyner, 1983; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Felson & Clark, 1998; Felson, 2011; Weisburd et al., 2012).

2.1. Routine Activity Theory

Routine activity theory was first proposed by Lawrence Cohen and Marcus Felson (1979) in their publication *Social Change and Crime Rate Trends: A Routine Activity Approach*. Here, these pivotal authors offered a theory to explain why crime rates increased between 1947 and 1974 despite the striking positive social changes seen after WWII, such as a decrease in unemployment and an increase in high school graduations. Based on their principle that crime is the result of the meeting in time and space of three specific conditions, a motivated offender, a suitable target, and a lack of guardianship, Cohen and Felson argue that it was the many post-WWII social changes that increased such conditions and created an environment with increased susceptibility to criminal victimization (Cohen & Felson, 1979). The authors cite the rise in activities that drew people out of their homes and away from their family groups as the source of growth in criminal opportunity. This change in people's routine daily activities brought offenders and potential victims in to contact more regularly and increased the vulnerability of targets (Cohen & Felson, 1979).

For Cohen and Felson (1979), criminal motivation was a given, but it was the intersection of a motivated offender with a suitable target at a location that lacked

guardianship that was the determinant of criminal victimization. This opportunity for crime was created during people's routine activities when, for example, they left their homes unattended to go to work, left their cars unattended while shopping, or carried their portable personal belongings with them in public places. Cohen and Felson (1979) noted that much of the opportunity for illegal activity followed the same structure as that for legal activity. As such, people were more or less vulnerable to criminal victimization based on their lifestyle and routine activity choices.

To test their theory, Cohen and Felson (1979) developed a "household activity ratio." Their calculation measured risk of victimization by using socio-economic variables to estimate the degree to which people would engage in activities away from their household or family (Cohen & Felson, 1979). The authors selected their variables to reflect the social changes witnessed at the time. Those thought to be more at risk of victimization because their routine activities took them away from their household and family included: single adults, employed people, adolescents and young adults, those attending school or in the military, and those homes with a young head of household. Conversely, those thought to be less at risk of victimization based on their routine activities included: married people, the unemployed, older adults, those homes with an older head of household, and households with a larger number of members.

Using their "household activity ratio" and control variables for age and unemployment, Cohen and Felson (1979) applied their theory using a time series analysis of crimes of "direct predatory victimization" or personal violent crimes; burglary, a property crime, was also included in their analysis. Their findings showed positive results of statistical significance. It was shown that changes in crime rates were explainable by the "household activity variable" and, thus, demonstrated the impact that people's routine activities have on the rise and fall of opportunities for criminal activity (Cohen & Felson, 1979). The inclusion of an unemployment variable showed negative or near zero coefficients, but when age was included, the coefficients were positive (Cohen & Felson, 1979). Overall, these conclusions led to the development and acceptance of socio-economic variables as proxy for routine activities and measures of criminal opportunity.

In 1990, Kennedy and Ford tested routine activity theory in their analysis of victimization in Canada. Through a comparison of personal and property crime

victimization, Kennedy and Ford (1990) looked at the routine activities that victims engaged in and how their activities may have increased their exposure to criminal victimization. The authors believed that, in addition to the variables of routine activity theory, factors pertaining to victims' lifestyles and demographics mediated between routine activity theory and the criminal events. It was the difference in the environments of different activities that expose people to situations of conflict and thusly increase the likelihood of victimization (Kennedy & Ford, 1990). Their results showed that property crime, more so than personal crime, was the product of opportunity and not conflict, but that engaging in activities that were away from their home increased the likelihood of a person's victimization (Kennedy & Ford, 1990). The findings of this test of routine activity theory not only supported the original theory and the effect of routine activities on criminal opportunity but also expanded on it with mediating factors pertaining to specific lifestyle and victim demographics and demonstrated the continued relevance of this theory in studies of victimization and crime.

2.2. Social Disorganization Theory

Clifford Shaw and Henry McKay's influential theory of social disorganization was the product of years of research into the casual factors behind delinquency rates in American cities (Shaw et al., 1929; Shaw & McKay, 1931; Shaw & McKay, 1942; Shaw & McKay, 1969). Through their work, Shaw and McKay (1969) developed their theory that social disorganization, or the lack of organization or social cohesion in a community, led to delinquency and could be assessed using socio-economic and structural variables. Shaw and McKay (1969) looked to not only the social setting of a community to explain delinquency but also the physical structure and distribution of land use within and between communities. They divided their measures into three categories: physical status, economic status, and population composition (Shaw & McKay, 1969). Shaw and McKay's (1969) methodology began with mapping delinquency rates and socio-economic variables by zones and looking for visual correlations; however, quantitative data was available for some of their indices, and statistical correlations were conducted where possible. They were seeking to establish similar patterns in the geographic distribution of delinquency and social disorganization and to demonstrate the explanatory power of social disorganization measures.

To assess the physical status of a community, Shaw and McKay (1969) looked at the location of industrial and commercial areas, the location of condemned buildings, and the percentage change in population. For these first two variables, no quantitative data was available so a visual correlation was assessed through mapping. Here, results showed that the highest delinquency rates corresponded to those areas with more industrial and commercial developments. For population changes, it was shown that small changes in population had a greater negative effect on delinquency than larger changes in population, at least in the short term. To assess the economic status of a community, Shaw and McKay (1969) considered the percentage of families on social assistance, the median cost of rental housing, and the percent of home ownership. The percentage of families on social assistance showed a strong positive correlation with delinquency rates, and the median cost of rental housing showed a strong negative correlation. The relationship of delinquency to the percentage of home ownership was not as straightforward, but in general Shaw and McKay (1969) determined a negative correlation. A combination of two variables was used as the measure of population composition: percentage of foreign-born residence and African-American heads of families. For this, a strong positive correlation was found with delinquency rates; however, Shaw and McKay concluded that no one nationality demonstrated greater delinquency rates than another. Together, these variables illustrate the effect of physical deterioration and disorganization on a community (Shaw & McKay, 1969). Overall, Shaw and McKay (1969) found that delinquency rates were highest in the low-income central city areas nearest industrial developments and lowest in higher-income residential areas further from the city, and they suggest that this pattern of social conditions is the result of how a city develops structurally over time. The economic segregation created by this type of distribution of industry, commerce, and residence created the disorganized relationships within these communities and facilitated delinquency (Shaw & McKay, 1969).

For Shaw and McKay (1969), the key to lower delinquency rates was preventative intervention at childhood, and they did not believe that mapping and statistical analysis alone would provide all the needed insight. For a full explanation of what leads to delinquency, and thus a foundation on which to build prevention, the relationships and values of a community must be understood (Shaw & McKay, 1969). These are the causal mechanisms of delinquency that have grown out of the

surrounding socio-economic makeup and physical history of a city. Shaw and McKay (1969) concluded that these disorganized relationships were inherent to communities and that treatment of the problem of delinquency must include both social and structural considerations. The different values and attitudes that communities had were commensurable with their levels of disadvantage and relative deprivation of resources; therefore, interventions needed to be community-wide and not just individualized, focused on improving socio-economic conditions, provide jobs and activities for citizens, and empower the community to change their situation and work together to improve their lives and the lives of their children and in so doing reduce delinquency for the long term (Shaw & McKay, 1969).

Testing of social disorganization theory was undertaken by both Sampson and Groves (1989) and Lowenkamp et al. (2003). Sampson and Groves' (1989) test of Shaw and McKay's theory utilized community-level data from the 1982 British Crime Survey to represent the variables of social disorganization as well as variables of social organization that the authors believed to mediate between the structural variables of social disorganization theory and crime rate. These intervening factors of social organization were categorized into three groups: local friendship networks, control of teenage groups, and level of organizational participation (Sampson & Groves, 1989). In their analyses, Sampson and Groves (1989) found support not only for Shaw and McKay's theory on the effects of community structure on crime but also for their own additional measures of social organization, which were all shown to have significant mediating effects.

Lowenkamp et al. (2003) assessed social disorganization theory through a retest of Sampson and Groves' 1989 study. Lowenkamp et al.'s (2003) purpose was to seek support for the ongoing relevance of social disorganization theory as a general theory of criminology by duplicating Sampson and Groves' research and comparing their results. In using the 1994 British Crime Survey, Lowenkamp et al. were able to adopt similar variables as Sampson and Groves (1989) and determine if their methodology continued to measure the effects of social disorganization theory. The conclusions of Lowenkamp et al. found that the measures and methodology used by Sampson and Groves (1989) remained relevant more than 10 years later, and they suggest that, while social disorganization theory's importance is enduring, additional research is needed in to intervening variables that mediate between disorganization and crime rate. Overall,

Sampson and Groves (1989) and Lowenkamp et al. (2003) demonstrated the persistent relevance of social disorganization theory, the applicability of its measures in communities beyond the United States of America, and the need to explore and expand additional mediating variables within social disorganization theory that may be acting on crime rate.

2.3. Synthesis of Routine Activity Theory and Social Disorganization Theory

It is not necessary to pick just one theory by which to interpret research findings and risk being left with an analysis that requires further theoretical testing (Bernard & Snipes, 1996). If theories make different but compatible and not contradictory predictions, then combining them is preferable to attempting to falsify one or the other (Bernard & Snipes, 1996). As no one theory may hold all the explanatory power given the complexity that is the phenomena of crime, it is theoretically sound to begin with many variables instead of a few in a regression analysis (Bernard & Snipes, 1996). Through this sort of testing, the most and least relevant variables of each theory can be determined and provide a larger framework by which to interpret and explain results (Bernard & Snipes, 1996).

In a spatial analysis of crime in Vancouver, BC, Andresen (2006) used a synthesis of social disorganization theory and routine activity theory. Some variables from each theory were more influential than others, but the results of this study showed support for both theories (Andresen, 2006). Had this study used just one or the other of these spatial criminological theories, the author notes that the predictive power of the model would likely have been diminished. In this study, variables were aggregated to the census tract level and both unexpected negative relationships and insignificant relationships were found. Andresen encourages the continued use of this synthesis model to explore these results and find the mitigating factors that may exist within a city to explain these phenomena (2006).

Using a combined theory of routine activity theory and social disorganization theory brings together the influences of opportunity, built environment, and socio-economic setting in a unified discussion of crime correlates. As demonstrated in

previous research on the spatial relationship of crime and place, uniting these theories has shown to be a contributor to the explanation of variance in analyses (Kennedy & Forde, 1990; Andresen, 2006; Weisburd et al., 2012).

2.4. Opportunity and Crime

Felson and Clark proposed that opportunity is the principle cause of crime, and as such, the reduction of criminal opportunity represents the best method for situational crime prevention (Felson & Clark, 1998). Felson and Clark (1998) gave ten principles that describe decisively how opportunity relates to crime and crime prevention. While opportunity is relevant to all types of crime, the characteristics of opportunity itself varies by circumstance, and each crime type requires its own prevention plan (Felson & Clark, 1998; Clark, 2012). Plainly, an opportunity reduction plan for commercial burglary that involved increasing the number of security guards in an industrial park would clearly not be applicable to a credit card fraud scheme perpetrated against elder people. Each circumstance and type of crime is a function of a combination of different environmental opportunities and requires customized crime prevention planning to be successful.

The important aspects of this theory are where criminal opportunity is found and how the activities of people influence the frequency and timing of criminal opportunity every day (Cohen & Felson, 1979; Felson & Clark, 1998). Routine activity theory and crime pattern theory, both discussed further in this section, provide an explanation for why crime occurs in particular areas and not others and how this is related to the presence of opportunity. Furthermore, a single crime can produce or necessitate the opportunity for many others (Felson & Clark, 1998). For example, an opportunity arises for shoplifting, a criminal takes advantage, and steals something; there is now a further opportunity for selling that stolen product, and as well, perhaps the success of the first theft will encourage the criminal to seek more criminal opportunities. Reducing a single criminal opportunity may prevent a series of criminal occurrences over time, and crimes of opportunity can be most effectively targeted through design changes to the built environment (Poyner, 1983; Felson & Clark, 1998; Felson, 2002).

2.5. Crime and Place

The combination of routine activity theory and social disorganization theory adds an understanding of the social characteristics of an area when viewing crime through the environmental criminology concept of crime and place (Weisburd et al., 2012). Crime and place is the general acknowledgement that criminal occurrences and the place where they occur are not randomly related but rather that the social and physical built environment of an area may either increase or decrease the likelihood of criminal opportunity. The purpose of studying the physical landscape of crime occurrences is to determine what specific types, combinations, or concentrations of locations contribute to criminal victimization, and, thusly where to target crime reduction strategies and how to anticipate issues as the urban landscape changes.

For Brantingham and Brantingham (1995) the arrangement of different land uses form the environmental backcloth of our lives, and in distinguishing locations that attract crime, generate crime, are crime neutral, or are fear generators, the appropriate crime prevention intervention can be implemented in an area. While these definitions are not mutually exclusive, identifying any of these four types of areas within a city will likely correspond to or predict crime patterns. Crime generators are locations that produce crime incidental to their everyday purpose (Brantingham & Brantingham, 1995). Brantingham and Brantingham (1995) suggested that shopping or entertainment districts, which are designed for and used by people for non-criminal activities daily, generate crime by being locations that bring people together and create targets for motivated offenders. Crime attractors are defined as areas that are already known for their criminal element and are places where criminals intentionally go to commit crimes. Brantingham and Brantingham (1995) used the examples of bars or known drug and prostitution areas. Crime neutral areas experience crime infrequently and may be adjacent to higher crime areas (Brantingham & Brantingham, 1995). Areas that are considered fear generators may not currently experience crime but have the necessary conditions to do so in the future if people continue to avoid or neglect the area. Identifying the areas and businesses within a city that generate or attract crime provides a map with which to focus crime prevention activities.

Kinney et al. (2008) explored the concept of crime attractors and crime generators within the built environment in an analysis of land use, crime, and urban

design. The authors proposed that crime and criminal opportunity cluster around legitimate activity nodes in a community and will follow a similarly legitimate spatio-temporal pattern. However, the composition of the built environment and land use of an area influence the structure of these activity spaces and thusly the location of crime (Kinney et al., 2008). Using a crime rate by land use type, the results of their study revealed that assaults concentrated in commercial land use areas more than residential areas and similarly so did theft of motor vehicles (Kinney et al., 2008). These findings affirmed that certain land use types are more likely to be crime generators or attractors and that crime follows a similar pattern to regular daily life activities (Kinney et al., 2008). Following these conclusions, police and policy makers can more effectively predict policing resource needs and the criminogenic impact of urban developments.

In a study using longitudinal crime data in Seattle, WA, Weisburd et al. (2012) drew further conclusions about the relationship between crime and place. Crime concentrates in “hot spots” within a city that persist over time and, as such, focusing crime prevention strategies in these high-crime areas will lead to the greatest reduction in crime rates (Weisburd et al., 2012). The targeting should be narrowed to specific streets or blocks and needs to include an understanding of both the social and physical factors that are contributing to criminality in these localized areas (Weisburd et al., 2012). Weisburd et al (2012) recognized in their analysis how the location of public facilities and businesses can act as crime generators and attractors. Such locations that are frequented by people for legitimate reasons may at the same time put those people or their property at risk of victimization by motivated offenders who are also using a facility for legitimate reasons or who may be in the area. The presence of either public facilities or business was used as a measure of increased target availability, and Weisburd et al. referred to both of these types of areas as hot spots of criminal opportunity (Weisburd et al., 2012). Further land use considerations were the percentage of vacant land in a given area as an indicator of reduced guardianship in an area. Weisburd et al. (2012) concluded that the construction of new businesses, high-density housing, or transit hubs in an area should be partnered with proactive crime prevention strategies undertaken by both the police and the community. While these results are based on a street segment analysis, they are equally applicable to larger-scale redevelopment or urbanization projects within a city.

2.6. Pattern Theory of Crime

Pattern theory incorporates some of the concepts of routine activity theory to further explain the spatial distribution of crime (Eck & Weisburd, 1995). Pattern theory of crime parallels the location of crime with the location of everyday activities and the movement of people through the physical environment (Felson & Clarke, 1998). Crime is not evenly distributed across time and space but rather clusters distinctly around opportunity (Felson & Clarke, 1998; Eck & Weisburd, 1995). Concentrations of high and low-crime rates are indications of what features a place has that either precipitates or prevents crime and give clues about what brought offenders and victims together at a location (Eck & Weisburd, 1995).

An integral part of environmental criminology, crime pattern theory was developed by Patricia and Paul Brantingham (Eck & Weisburd, 1995). Brantingham and Brantingham (1993) discussed the complex relationship between crime and place. Mobility of both offenders and victims is described using three elements: nodes, paths, and edges (Brantingham & Brantingham, 1993). Nodes are central locations or popular destinations, such as malls or transit hubs, which bring people together. Paths are the routes that people take to, from, and between these nodes. Finally, edges are the areas just outside of normal travel patterns that exist between communities or neighbourhoods. Offenders and the general public engage in these patterns and have spatial habits such as visiting favourite places or routes frequently taken. It is around these locations and routines of daily activity that crime is expected to occur because it is these areas that are best known to an offender and opportunistic crime is most likely to occur where an offender feels most knowledgeable about an area (Brantingham & Brantingham, 1993).

Both offenders and victims have legitimate routine activity patterns that take them to nodes via regular paths and occasionally to edges (Brantingham & Brantingham, 1993; Eck & Weisburd, 1995). Collectively, these spaces make up an individual's awareness and activity space and are comprised of the area of which they have the most knowledge and feel most comfortable (Brantingham & Brantingham, 1993). Crime and victimization are most likely to occur within these zones of routine activities and awareness space. Offenders, passively or actively, become aware of criminal opportunities through their routine activities, and only a motivated offender will actively seek criminal opportunity beyond their awareness space (Brantingham & Brantingham,

1993). This supports the theory that much of crime is opportunistic in nature, especially property crime. This process represents the relationship between target selection, the physical environment, and offender mobility. Pattern theory demonstrates not only the complexity of crimes relationship with the environment but also the integrated nature of crime with the daily activities of our lives (Brantingham & Brantingham, 1993).

2.7. Conclusions

As demonstrated, literature and research that support the influence of the built environment on crime patterns is abundant. Offenders and victims do not live entirely separate lives. They are likely to meet in the same time and space as each other. It is in these spaces that, by understanding what factors are contributing to criminal opportunity, crime prevention can take place. By recognizing what land use types are associated to higher victimization rates, police, policy makers, and urban planners can be aware of the impact of developments in their city.

Chapter 3.

Region of Study: Surrey, BC

Bounded to the north by the Fraser River and to the south by the United States, the city of Surrey sits as part of the Metro Vancouver Region of British Columbia. Surrey is a census subdivision of the census metropolitan area of Vancouver (Statistics Canada, 2013a). In 2006, the city had 78 Census Tracts and was made up of six neighbourhoods: Whalley/City Centre, Guildford, Fleetwood, Newton, Cloverdale, and South Surrey (City of Surrey, n.d.b.; Statistics Canada, 2013a).

The following chapter illustrates the demographic profile of Surrey as the focal area of this research. Several of the socio-economic variables explored are of theoretical importance in the field of criminology and have been shown in previous literature to be associated to the occurrence of crime. These variables support the theoretical orientation of this research and serve as the foundation of the hypotheses being tested. Given the importance of the geographic and social context of crime, a broad description of this city and its populace will be given as background to the analyses to follow in later chapters. While every city is unique, to better illustrate Surrey's profile, comparisons will be made with the cities of New Westminster, BC, and Burnaby, BC, due to their similar transit infrastructure and proximal location to the city of Vancouver. Crime does not occur in a vacuum. It is influenced by the social, economic, and built environment of a region. The following presents the context for the occurrence of property crime of the city of Surrey, BC, in 2006.

3.1. Demographics

Based on the 2006 Canadian Census of Population, Surrey had a population of 394,976 and was BC's second-largest city (Statistics Canada, 2007d). Between 2001 and 2006, Surrey saw a population growth of 14%, which was more than twice that seen, during this same period, in the province as a whole that experienced a growth of just 5% (Statistics Canada, 2007d). With a total land area of 317.19 km², Surrey had a population density of 1,245 people per square kilometer (Statistics Canada, 2007d).

This was relatively low when compared to the neighbouring cities of New Westminster, with a population of 58,549, which had a density of 3,800, and Burnaby, with a population of 202,799, which had a density of 2,276 (Statistics Canada, 2007b; 2007d). Despite having smaller populations, New Westminster and Burnaby had much higher population densities than Surrey. Both New Westminster and Burnaby are north of the Fraser River to Surrey and are more proximal to the city of Vancouver, thus giving greater commuter access to Vancouver and other surrounding cities. Due to the geographic desirability of their locations, these cities have increased the construction of high-density housing over the years to meet demand, which led unsurprisingly to their higher population density. Despite the seemingly disparate location of Surrey, the city did continue to grow and sought to establish itself as an emergent and desirable metropolis. Surrey was well positioned to capitalize on the increasing popularity of living in the lower mainland of British Columbia.

At the time, Surrey's median age was 37 years, which was below that of the province as a whole at 41 years (Statistics Canada, 2007d). Of Surrey's total population, 80% were 15 years or older, and this again was lower than the provincial figure of 84%. Together these statistics indicate that Surrey had a young population and more children than the provincial average. Of those 15 years or older, approximately 57% were legally married (and not separated), and 29% were never legally married/single (Statistics Canada, 2007d). Among those identified as never legally married/single, 19% were in common-law relationships. Similar statistics were seen across BC; however, Surrey had more married people and thus slightly lower numbers for all other types of relationships. So while Surrey had a young population, it also had more married people than the provincial average. Surrey's population profile revealed a youthful and growing city that may have been a desirable location for young married couples.

3.1.1. Diversity and Mobility

Surrey, often described as an ethnically diverse city (City of Surrey, 2011), was home to a population of a variety of cultural, religious, and language backgrounds according to Census results. While for 68% of the population English was still the language spoken most at home, for 28% of the population, a language other than English or French was used most often at home (Statistics Canada, 2007d). As a

comparison, in BC as a whole, just 16% of people spoke a language other than English or French at home (Statistics Canada, 2007d). The city of Surrey alone had 17% of the province's total population who reported speaking a language other than English or French at home. In Metro Vancouver, this rate is second only to the city of Vancouver

Surrey's language demographics are understandable in light of the level of immigration and cultural diversity seen in the city. As of 2006, more than 150,000 immigrants resided in the city (Statistics Canada, 2007d). Comprising approximately 38% of Surrey's total population, immigrants to Canada were a considerable proportion of the city's residents. Of BC's total immigrant population in 2006, Surrey was home to approximately 13%. The degree of cultural diversity present in this city is further exemplified by the generation status of its residents. Almost half of the Surrey's population over the age of 15 years were first generation Canadian, which exceeds the provincial average of just 33% (Statistics Canada, 2007d).

As a measure of population mobility, census respondents were asked if their current address was the same as it was one year prior and if it was the same as five years prior (Statistics Canada, 2007d). Surrey demonstrated residential mobility comparable to its neighbouring cities of New Westminster and Burnaby (Statistics Canada, 2007b; 2007c; 2007d). Of the sample, 83% indicated their address was the same as one year prior, and 49% continued to reside in the same address as five years prior (Statistics Canada, 2007d). This indicates that many people remained in the same community over time. While Surrey did not experience an above-average degree of movement within its borders, the amount of immigration seen to the city caused it to stand out as a diverse city of multinational citizens. Given these statistics, it is clear that Surrey as a city was home to great cultural diversity and residents who were new to Canada and interested in living in Surrey for the long term.

3.1.2. Education and Employment

Measures of educational attainment were also available from the census. These figures gave an indication of the levels of education of Surrey's residents as well as what areas of employment were most prevalent. According to the sample, 22% of Surrey's population had no certification, diploma, or degree (this includes those who have not completed high school), and 30% had only completed high school (Statistics Canada,

2007d). A further 10% had completed an apprenticeship, trades certificate, or diploma, and 37% had either a college or university diploma or degree (Statistics Canada, 2007d). New Westminster and Burnaby both had higher rates of college or university diploma or degrees and lower rates for both those having no certificate, diploma, or degree and for those with just high school completion or equivalent (Statistics Canada, 2007b; 2007c). Surrey's figures were also lower than the provincial averages for level of education: 48% high school completion or lower, 11% apprenticeship or trades certificate, and 41% college or university education (Statistics Canada, 2007d). With over half of the city's population possessing just high school completion or a lower achievement (53%), Surrey's population exhibited a level of educational attainment lower than the provincial average and that of neighbouring cities (Statistics Canada, 2007d).

For residents of Surrey, the two most common fields of post-secondary study were architecture, engineering, and related technologies, followed by business, management, and public administration (Statistics Canada, 2007d). However, the most common occupations were, firstly, sales and service occupations; secondly, trades, transport and equipment operators and related occupations; and thirdly, business, finance, and administration occupations. Management occupations ranked as fourth most common (Statistics Canada, 2007d). It is not surprising that trades and related fields would be a prevalent occupation in this area as Surrey was home to the largest dock and shipping yard on the West Coast of North America and Port Metro Vancouver is one of the largest employers in the region (Fraser Surrey Docks LP, n.d.; Port Metro Vancouver, n.d.).

In 2006, Surrey's unemployment rate was 6%, which was a decrease of 2% since the 2001 census (Statistics Canada, 2007d; 2013b). The province experienced a similar decrease dropping from 9% to 6% (Statistics Canada, 2007d). While Surrey displayed a lower level of educational attainment than its neighbouring cities and the province as a whole, it successfully showed a lower unemployment level and a higher labour market participation rate, with improvements in both figures since 2001 (Statistics Canada, 2007d; Statistics Canada, 2013b). Together, these statistics on education, occupation, and employment suggested that Surrey had a population with mixed education attainment and fields of employment but overall were more often employed than the provincial average.

3.2. Land Use

Given Surrey's large population, the population density is much lower relative to surrounding cities. However, Surrey is larger geographically than other lower mainland areas at 317.19 km² compared to New Westminister, 15.41 km², and Burnaby, 89.12 km², and approximately 29% of the city is part of the Agricultural Land Reserve and contains very few residential dwellings (City of Surrey, n.d.a; Statistics Canada, 2007b; 2007c; 2007d). An Agricultural Land Reserve designation indicates that land should principally be used for farming or other agricultural activities. Historically, Surrey has been part of the agricultural region of the lower mainland, with some of its primary agricultural activities including beef, dairy, berries, field vegetables, and recreational horse farms (Ministry of Agriculture, Food, and Fisheries, 2004). With such a large area and an abundance of agricultural land, the population of Surrey was most commonly found concentrated in a number of neighbourhood dispersed urban areas.

Despite Surrey's prominent agricultural land use, the city displayed growing urbanization. In 2006, Surrey had approximately 139,193 private dwellings and saw a further 4,896 new residential unit building permits issued that year (BC Stats, 2015d). This was a 225% increase over the number of permits issued in 2001 and was part of a steady and ongoing increase in development (BC Stats, 2015). During this period, the value of commercial building permits increased 35%, the value of industrial building permits increased 12%, and the value of institutional and government building permits increased 8% (BC Stats, 2015a; 2015b; 2015c). These increases in both the number of residential building permits issued and the value of non-residential permits issued were key measures of the growth that was occurring in Surrey. The progress of the city was further evident by the addition of a large post-secondary institution. In 2006, the Surrey campus of Simon Fraser University expanded from 74,000 square feet to over 350,000 square feet when a new tower was constructed at the Central City Shopping Centre in Surrey's downtown City Centre area (Reynolds, 2012).

Approximately 75% of residential dwellings in Surrey were owned, which was higher than the provincial average of 70% and that seen in New Westminister, 54%, and Burnaby, 62% (Statistics Canada, 2007b; 2007c; 2007d). The average value of owned dwellings was \$446,307, which was just above the provincial average of \$418,703 (Statistics Canada, 2007d). Surrey also exceeded the provincial average for the number

of rooms per dwelling and the number of dwellings that have more than one person per room. Further to this, Surrey had considerably more single-detached houses and vastly fewer apartment buildings than its neighbour cities (see Table 3.1). Overall, Surrey displayed a residential housing profile consisting of owned single family homes occupied by large families, and this data lends further explanation to the city's relatively low population density.

Table 3.1. Occupied private dwelling characteristics: Percent of total private dwellings occupied by usual residents

Housing Type	Surrey	New Westminister	Burnaby	Provincial Average
Single-detached houses	43.8%	18.7%	27.5%	49.2%
Semi-detached houses	2.7%	0.4%	3.4%	3.1%
Row houses	11.7%	3.9%	9.2%	6.9%
Apartments, duplex	17.4%	10.8%	13.9%	10.0%
Apartments in building < 5 floors	21.2%	40.0%	26.9%	20.9%
Apartments in building > 5 + floors	1.9%	26.1%	18.8%	7.1%
Other dwellings	1.4%	0.2%	0.2%	2.8%

Note: adapted from Statistics Canada, 2007b; 2007c; 2007d.

3.3. Transportation

By 2006, the city of Surrey was serviced by several types of transportation and transportation routes. To its north, the city was accessible directly by two bridges over the Fraser River: the Pattullo bridge out of New Westminister and the Port Mann bridge out of Coquitlam (Translink, n.d.b.; n.d.c.). Two major highways were also adjacent to the city: the Trans-Canada Highway 1 and the Vancouver-Blaine Highway 99 (City of Surrey, n.d.b.). On a local level, Metro Vancouver's light-rail transportation system, the SkyTrain, had four stations in Surrey's northern neighbourhood of Whalley, including the city's new downtown core of City Centre (City of Surrey, n.d.c.). Surrey also had several transit bus exchanges located throughout the city that provided service to its different neighbourhoods (City of Surrey, n.d.c.).

Despite this transit infrastructure, 76% of Surrey's employed labour force reported driving a car, truck, or van to work, and 9% were regularly passengers in a car, truck, or van as their transportation to work (Statistics Canada, 2007d). Just 4% walked, biked, or used another mode of transport to work. Only 20,040 people, or 11%, regularly used public transit to get to work (Statistics Canada, 2007d). This is a small increase of

3% over the 2001 figure of 8% of workers using transit; however, this rate of transit use is well below half that of the cities of New Westminster and Burnaby (Statistics Canada, 2007b; 2007c). These figures could be a reflection of the need for Surrey residents to travel a greater distance to work or that the public transit system did not adequately meeting their needs for daily commuting. Whatever the reason, Surrey's employed population was highly mobile by car.

3.4. Policing and Crime

Policing in Surrey was principally provided by the Royal Canadian Mounted Police (RCMP). The RCMP divided the six neighbourhoods of Surrey into five district offices: Whalley/City Centre, Guildford/Fleetwood, Newton, Cloverdale/Port Kells, and South Surrey (Surrey RCMP, 2014). The land use, residential population, and area of each of these districts were not equal, but each represented a major centre of activity in Surrey. In 2006, the Surrey RCMP had an authorized strength of 572 members, which allowed a service rate of 138.5 police officers per 100,000 population (Statistics Canada, 2014). This was higher than the police-to-population rate found in Burnaby, 125.9, but lower than that of New Westminster, 176.8, and lower than the provincial average, 149.8 (Ministry of Justice, 2012).

Additionally, since December 2005, supplemental police services were provided by the South Coast British Columbia Transit Authority Police Services (SCBCTAPS) (Ministry of Justice, n.d.a). Known as the Transit Police, these officers had the same powers and responsibilities of other police services; however, they operated exclusively on, or in near proximity to, Transit Authority property or services and did not typically investigate serious crimes (Ministry of Justice, n.d.a). Approximately 165 Transit Police officers served the entire Metro Vancouver Region (TransLink, n.d.a.).

Surrey's crime rate, at this time, was experiencing a similar downward trend as seen across the province (Ministry of Justice, 2013a; 2013b). As a whole, Canada had been seeing a steady decrease in the rate of crime since the early 1990s (Statistics Canada, 2013c). The 2006 Crime Severity Index for Surrey was 152.9, and there was an overall crime rate of 113 (per 1 million population)(Statistics Canada, 2014; Ministry of Justice, 2012). Surrey's crime rate was higher than that seen in Burnaby, 109, and

the provincial average, 100, but lower than that of New Westminister, 129 (Ministry of Justice, 2012). Overall, Surrey had an authorized police strength below provincial average and an above-average crime rate in 2006.

According to Statistics Canada, between 2001 and 2006, the total Criminal Code offences (excluding traffic offences) in Surrey decreased by more than 1,600 offences or just over 1% (see Table 3.2) (Statistics Canada, 2015). Burnaby (-1.03%) and New Westminister (-1.12%) saw similar decreases, and the province as a whole decreased 1% (Statistics Canada, 2015). In Surrey, total property crime and specifically both Break and Enters and Theft of Motor Vehicle each saw an approximate decrease of 1% in the number of total offences (see Table 3.2) (Statistics Canada, 2015).

Table 3.2. Crime trends in Surrey,¹ BC, in 2001 and 2006

Crime Type	2001	2006	Total Change	% Change
Total <i>Criminal Code</i> offences ²	48,385	46,708	-1,677	-1.03%
Total Property Crime ³	36,565	31,546	-5,019	-1.14%
Total Break and Enter ⁴	5,739	4,691	-1,048	-1.18%
Total Theft of Auto	7,014	4,775	-2,239	-1.32%

(CANSIM 252-0081: retrieved April 17, 2016)

¹Surrey includes Surrey municipal and Surrey rural

²Total *Criminal Code* offences excluding traffic

³Total Property Crime includes total Break and Enter, and total Theft of Auto, and all other Property Crimes under the *Criminal Code*

⁴Total Break and Enter includes residential and commercial break and enters

3.5. Conclusions

With population growth well beyond the provincial average and a population density lower than other communities, both the census and land use profile of Surrey showed that it was positioned to experience expansion both residentially and commercially and had the room to do so. Development could be expected in all sectors, and an important consideration would be what effect this would have on the region's crime rate. Although crime had been decreasing across the country during this time, Surrey showed risk factors associated with the criminological theories of routine activity theory and social disorganization theory that could result in an increase in crime.

Chapter 4.

Methodology

Statistical models of multivariate spatial regression were chosen as the primary method of analysis for the data presented in this thesis. This method retains and represents the spatial attributes of data and was selected to best explore the relationship between the crime occurrences, land use, and socio-economic variables of the study region. Use of this technique is supported by Tobler's First Law of Geography that states: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970 as cited in Chainey and Ratcliffe, 2005, p. 117). Spatial regression is a method designed specifically for quantitative data that is spatial in nature (Chainey and Ratcliffe, 2005; Mitchell, 2005). Spatial data are different from other types of data in that its geographic origin will be incorporated into the analysis. This type of analysis seeks to establish what effect the geography of an area has on the relationship between the data, based on the proximity of data points or polygons to each other. This type of analysis utilizes the spatial component of the data and, in so doing, recognizes the importance of including the human context and the effects of the environment on the patterning of crime events. Spatial analysis is recognized as a crucial tool in crime analysis and sees increasing popularity within the profession (Chainey and Ratcliffe, 2005; Gwinn et al., 2008; Boba, 2009; Hill and Paynich, 2014).

In addition to spatial regression, analyses were conducted using descriptive statistics, Pearson's Correlations, and tests of spatial autocorrelation. These analyses served to thoroughly investigate the relationships between variables, identify the location of high-crime areas and determine the significant socio-economic factors of that area. Using a variety of methodologies that build in complexity demonstrates how results may vary depending on the level of analysis employed and thus illustrates the possible implications that exist when choosing an analytical approach and drawing conclusions from the results.

4.1. Hypotheses

The purpose of this thesis is to explore the relationship between criminal events, land use types, and socio-economic variables with theoretical support from the established criminological theories of social disorganization and routine activity. As demonstrated in previous chapters, a strong body of literature exists that has tested similar concepts and methodology. Specifically, the work of Kinney et al. (2008) and Andresen (2006) can be looked to as similar studies in the descriptive and spatial analysis of crime occurrences in the Metro Vancouver Region.

The primary alternate hypothesis of this research is that there exists a spatial relationship between residential break and enter, commercial break and enter, and theft of motor vehicle with the land use designations found within the census tracts of Surrey, BC. The primary null hypothesis is, therefore, that no spatial relationship exists between these variables. The secondary alternate hypothesis is that there exists a relationship between residential break and enter, commercial break and enter, and theft of motor vehicle with the socio-economic variables found within the census tracts of Surrey, BC, that represent the criminological theories of social disorganization and routine activities. The secondary null hypothesis is, therefore, that no spatial relationship exists between these variables. Overall, given these hypotheses, it is predicted that crime will demonstrate a spatial dependency with not only the built environment of the region but also the socio-economic profile of its residents.

H₁=A spatial relationship exists between crime and land use in Surrey, BC census tracts

H₀=No spatial relationship exists between crime and land use in Surrey, BC census tracts

H₂= A spatial relationship exists between crime and the socio-economic variables associated with routine activity theory and social disorganization theory in Surrey, BC census tracts

H₀= No spatial relationship exists between crime and the socio-economic variables associated with routine activity theory and social disorganization theory in Surrey, BC census tracts

4.2. Data

All of the data used in this research were publicly available and collected by third-party agencies. In all analyses, the dependent variables were the three types of crime: residential break and enter, commercial break and enter, or theft of motor vehicle. As well, in all analyses, the independent variables were six aggregated land use categories and 13 socio-economic variables chosen from the Statistics Canada's 2006 Census of Population. These census variables served as proxy measures for the criminological theories of routine activity theory and social disorganization theory, which provided the theoretical basis of the hypotheses.

All data and analyses pertain to the city of Surrey. In using an entire city as the sample size, data with a range of distribution was available for analysis. This allowed for a holistic view of criminal event patterning across the landscape and demonstrated the variation possible not just within a city but also within a single policing jurisdiction. The units of analysis for the city were census tracts. Of Surrey's 78 census tracts, 76 had available data and were used in all of the analyses. Each census tract had at least one neighbour, and there were no islands. The census tracts were structured as polygon data and were compatible with the spatial analytical methodology chosen.

In order to protect the identity of the people and places involved in the criminal events, the crime data was aggregated to the census tract level. Similarly, the land use and census data was also aggregated to this level for compatible and anonymized analyses. No individual data or incident details were used in these analyses, and no specific person or place can be identified through these analyses or results.

4.2.1. Crime

Crime occurrence data from the year 2006 for the city of Surrey, BC, was used as the dependent variables in all analyses. This data was publicly accessible through the Surrey RCMP's website and was aggregated by a third-party to the census tract level for analysis¹. Occurrence counts for three crime types were available: commercial break and enter, residential break and enter, and theft of motor vehicle. As defined by

¹ Data made available on the Surrey RCMP website came directly from PRIME and may differ from official Statistics Canada publications that use data validated at the end of the year.

the *Criminal Code* of Canada, the offence of break and enter refers to the act of breaking and entering a place that may be a dwelling or other building with the intent to commit an indictable offence (*Criminal Code*, 1985, s 348). Theft of motor vehicle is defined as the unlawful taking or stealing of a motor vehicle or vessel (*Criminal Code*, 2010, s. 3).

In addition to the occurrence counts, a rate was calculated for each crime type to act as a standardized measure of crime levels across the census tracts. For each census tract, the rate of commercial break and enter was calculated per 1,000 non-residential land use plots. The rate of residential break and enter was calculated per 1,000 residential land use plots. The rate of theft of motor vehicle was calculated per 1,000 people, based on each census tract's population for the year 2006 as reported in the Census of Population. When performing the spatial analyses, two different models were run for each analysis to test the difference in results found between using count data or standardized data. The first model used the count of crime types as the dependent variables, and the second model used the rate of crime types as the dependent variables. Each model was used in each type of analysis.

4.2.2. Land Use

Land use data from the British Columbian Assessment Authority (BCAA) were acquired with permission through the Institute for Canadian Urban Research Studies (ICURS) at Simon Fraser University. These data were available at the census tract level and provided a count of land use plots within each census tract. The aggregation of this data did not account for the relative size of the plots or the number of addresses within a plot or buildings on a plot. The BCAA classified land use by six categories: residential, farm, commercial, industrial, transportation/communication/utility, and civic/institutional/recreational (see Table 4.1.) (BC Assessment Authority, 2014). Each of the six BCAA land use categories was represented in the city of Surrey, and all were able to be used as independent variables in all analyses. Counts for each of these categories were also converted into a percentage of the total land use by census tract to act as a standardized measure of land use composition across the census tracts.

Within these six land use categories, there were a total of 210 possible subcategories, of which 148 were seen in the data. The land use subcategories most frequently found in Surrey demonstrated what crime attractors or generators were

present in the city overall and within each census tract specifically that could be influencing rate patterns (see Table 4.1.). All subcategories were aggregated to their general category level for analysis. Due to the number of census tracts that had zero counts for some of the subcategories, they were not able to be used separately in analyses.

Of the original sample size of 113,127 land use plots, 112,819 were able to be mapped to a census tract using ArcGIS 10.1. This is a hit rate of 99.73%, which met accepted industry standard for geocoding, and therefore the analysis proceeded (Gwinn et al., 2008; Boba, 2009). Unmapped land use was due to either absent address data or nonspecific address information that could not be associated with census tracts. Of the 308 unmapped land use designations, railways, telephone, docks/wharves and marinas, industrial vacant, and commercial, institutional, recreational vacant were the most dominant types (unmapped data was excluded from Table 4.1.).

Table 4.1. BCAA land use categories and most frequent subcategories in Surrey, BC

Category Type	# Land Plots	# of Sub-categories	Top 5 Subcategories by Frequency
Residential	103,114	26	Single family dwelling Row housing - single unit ownership Strata-lot residence (condominium) Single family dwelling with basement suite Vacant residential less than 2 acres
Farm	1,147	17	Other Beef Mixed Vegetable & truck Grain & forage
Commercial	5,072	42	Commercial strata-lot Store(S) and service – commercial Storage & warehousing – closed Vacant
Industrial	710	34	Office building (primary use) Industrial – vacant Metal fabricating industries Miscellaneous & (industrial other) Transportation equipment industry (including aircraft) Furniture & fixtures industry
Transportation, Communication, & Utility	180	11	Electrical power systems (including non-utility) Gas distribution systems Railway Telephone
Civic, Institutional, & Recreational	2,596	18	Telecommunications (other than telephone) Civic, institutional & recreational – vacant Parks & playing fields Schools & universities, college, & technical Churches & bible schools Recreational & cultural building (includes curling)

4.2.3. Census of Population

The Census of Population is the national survey of Canadian citizens administered by Statistics Canada (Statistics Canada, 2007a). It is conducted every five years and serves as the primary source of demographic statistics for the country. Through this process, basic questions were asked of the entire population; however, more detailed questions were asked of 20% of the population through a long-form survey (Statistics Canada, 2007a). Statistics Canada uses a weighting model to extrapolate for the population as a whole. All census data was made publicly available

for download and analysis through the Statistics Canada website (Statistics Canada, 2007a).

Based on the criminological theories of routine activities and social disorganization, 13 variables were selected or calculated from the 2006 Census. These variables became the independent variables in all analyses. Three of these variables served the double function of representing both criminological theories, though for different reasons, but they only appear once in each analysis. Thus, in total, eight variables represented each theory. These socio-economic variables acted as proxy measures for behaviours and characteristics believed to impact the occurrence of crime according to routine activity theory and social disorganization theory (Cohen & Felson, 1979; Shaw & McKay, 1969). The Census variables used to reflect these theories were chosen to be the best representation possible of each concept, and while it was not possible to measure every premise of these theories directly or specifically, these variables were the closest proxy available in a standardized and publicly available data set. These same variables were used previously in the work of Andresen (2006) in a spatial analysis of Vancouver, BC. In repeating their use here, it served to create a study that not only is comparable to previous research but also is easily replicable across the country using the Census of Population.

The variables chosen to represent routine activity theory were: total population, population density (km²), number of occupied private dwellings, average family income (\$), average dwelling value (\$), rental residences (%), unemployment rate, and population aged 15-29 (%)(see Table 4.2). The variables for total population, number of occupied private dwellings, average family income (\$), average dwelling value (\$), and unemployment rate were measures taken directly by the Census of Population. The variables for population density (km²), rental residences (%), and population aged 15-29 (%) were calculated from measures available in the Census.

The variables chosen to represent social disorganization theory were: recent immigration 2001-2006 (%), college graduates (%), single parents (%), population change (%), standard error of average family income (\$), average family income (\$), rental residences (%), and unemployment rate (see Table 4.2). The variables for unemployment rate, average family income (\$), standard error of average family income (\$), and population change 2001-2006 (%) were taken directly by the Census of

Population. The variables for recent immigration 2001-2006 (%), college graduates (%), single-parent families (%), and rental residences (%) were calculated from measures available in the Census.

Table 4.2. Definition of independent variables from Census of Population

Theoretical Application	Variable	Definition
Routine activity theory	total population	census weighted estimation of total population count of census tract (CT)
Routine activity theory	population density (km ²)	calculated: total population/ total km ² area of CT
Routine activity theory	number of occupied private dwellings	census count of each separate dwelling 20% sample ex. house, apartment unit, or separate suite
Routine activity theory	population aged 15-29 (%)	calculated: male age 15 to 29 years + female age 15 to 29 years/total population*100
Routine activity theory	average dwelling value (\$)	census count of average value of owner-occupied private non-farm non-reserve dwellings
Routine activity theory & Social disorganization theory	average family income (\$)	census count of average family income before taxes
Routine activity theory & Social disorganization theory	rental residences (%)	calculated: number of occupied private dwellings by housing tenure 20% sample-rented/ number of occupied private dwellings by housing tenure 20% sample*100
Routine activity theory & Social disorganization theory	unemployment rate	census variable based on the population 15 years and over by labour force activity - 20% sample
Social disorganization theory	recent immigration (%)	calculated: total immigrant population by period of immigration 2001-2006 - 20% sample/total population of CT*100
Social disorganization theory	college graduates (%)	calculated: population aged 15 or over with a university certificate, diploma, or degree/total population of CT *100
Social disorganization theory	single parents (%)	calculated: number of census families in private households - 20% sample data, total lone parent families by sex of parent and number of children/total population of CT *100
Social disorganization theory	population change (%)	total CT population percent change, 2001-2006
Social disorganization theory	standard error of average family income (\$)	standard error taken of average family income

4.3. Analyses

A series of increasingly complex analyses were performed on the data in order to form a thorough evaluation of its relational properties. First, descriptive statistics were performed to explore the distribution of the data. Second, Pearson's Correlations were performed to assess linear relationships in the data. Finally, GeoDa and GeoDa Space software were used to test for spatial autocorrelation and to conduct spatial regression analyses. Two models were used throughout the analyses: the first model used crime type counts as the dependent variables with land use counts and census variables as the independent variables, and the second model used crime type rates as the dependent variables with land use category percentages and census variables as the independent variables².

GeoDa and GeoDa Space software were publicly available for download and use through the developer's website at the University of Chicago GeoDa Center for Geospatial Analysis and Computation (University of Chicago, 2017). GeoDa was designed for spatial analyses, including spatial regression, and was chosen for use in these analyses because of its compatibility with polygon data.

4.3.1. Descriptive Statistics

Descriptive statistics were calculated for the three crime types, the land use categories, and the census variables. These calculations included: total count, average, median, min, max, and standard deviation. The purpose of this was to assess the properties and distribution of the data.

4.3.2. Pearson's Correlations

Pearson's Correlation tests were performed to look for linear relationships in the data. Pearson's Correlations performed with the dependent variables checked for linear relationships within the crime types. Pearson's Correlations between the independent variables checked for any perfect, or near perfect, correlations that would indicate the presence of multiple variables that were measuring the same phenomena, particularly within the census data. Separate analyses were conducted using the census variables

² Models were also attempted that used count data as dependent variables with land use percent as independent variables and as well with rates as dependent variables with land use counts as independent variables, but these models returned anomalous results and were excluded from further analysis. The results of these analyses are not presented in this thesis.

with land use counts and the census variables with land use percentages to reflect the two models used throughout the analyses. Pearson's Correlations were also conducted for each of the two model types in full, with the crime types, to test for non-spatial relationships between all the variables. These tests were conducted to add another level of analysis and understanding to the data. It is important to explore these results and compare them to those found in the spatial analyses.

4.3.3. Spatial Autocorrelation

Spatial autocorrelation is the geographically based correlation of a variable with itself. When applied to crime data, this type of spatial association refers to when the occurrence of a crime type clusters in geographic areas and correlates significantly with the occurrence of the same crime type in its neighbouring geographic areas (Arizona State University, n.d.; Spatial Structures in the Social Sciences, n.d.; Hill and Paynich, 2014). Using a global spatial autocorrelation test, the presence of positive spatial autocorrelation indicates that high-crime areas are geographically near other high-crime areas or that low-crime areas are geographically near other low-crime areas, the presence of negative spatial autocorrelation indicates that high-crime areas are geographically near low-crime areas or vice versa, and the absence of spatial autocorrelation indicates that there is no significant clustering of high or low values relative to their neighbours.

Using GeoDa to check for spatial autocorrelation, the test of Univariate Moran's I was chosen because of its compatibility with polygon data and its recommended use by crime analysis manuals (Chainey and Ratcliffe, 2005; Mitchell, 2005; Gorr and Kurland, 2012; Hill and Paynich, 2014). Moran's I assesses the difference between each value of the variable and its mean. As a covariance test, it is similar to a Pearson's Correlation coefficient but applicable to the spatial relationship of the data. The significance of the Moran's I score was determined using 999 randomized permutations with a pseudo p-level of 0.001 (Spatial Structures in the Social Sciences, n.d.; Anselin, 2003; Anselin, 2005). As a global statistic, Moran's I results are a simple detection or rejection of the phenomena of spatial autocorrelation in the entire region of study (Kosfeld, n.d.; Spatial Structures in the Social Sciences, n.d.; Chainey and Ratcliffe, 2005; MIT Libraries, 2013). Moran's I analyses were also conducted separately for the crime variables to

assess for spatial autocorrelation of each crime occurrence. This served to further the analytical understanding of the crime patterns found in this region.

4.3.4. Local Indicator of Spatial Association

Global spatial autocorrelation assumes homogeneity in the distribution of variables across the area of study and gives only a summary statistic of the entire region (Hill and Paynich, 2014). As such, while the global Moran's I test reveals the presence or absence of spatial autocorrelation in the study region, it does not provide the specific geographic location of these clusters within the global space. To achieve this, using GeoDa, a Local Indicator of Spatial Association (LISA) was performed to give a clear visual of the spatial relationship and arrangement of crime concentrations by census tract.

A LISA test analyzes each polygon based on its spatial relationship to its shared-border neighbours (Anselin, 1995). This analysis and visualization of the data uses a 0-1 contiguity to identify crime hot spots and cold spots (Anselin, 1995). These hot and cold spots, or areas of high-crime and areas of low-crime, exist in a non-stationary spatial state; that is, spatial dependency may vary with location. Including this test expands the analyses to show which census tracts in Surrey have spatially significant clusters of crime occurrences. The results of the LISA tests will be presented as aerial unit cluster maps showing high-crime and low-crime areas by census tract for crime types that have a statistically significant relationship with their neighbouring census tracts.

4.3.5. Spatial Regression

While the identification and mapping of clustered crime occurrences is an important step in understanding crime patterns, in crime analysis, it is important not only to be able to geographically label crime clusters but also to discuss their social or structural context, and this is where spatial regression analyses are used (Hill and Paynich, 2014). To conduct the spatial regression analyses, a shape file containing all the dependent and independent variables was imported to the GeoDa software. A spatial weights file was then created to account for the geographic relationship of census tracts, and the spatial weights variable was added to the attribute table using a First

Order Queens Contiguity as the contiguity-based matrix. This method recognized neighbour-type relationship between polygons that share boundaries and/or corners (Arizona State University, n.d.). This method was chosen because census tracts are not isolated geographic entities, people may flow in and out of different census tracts without being aware of their transition. As such it was important to consider all possible neighbouring census tracts to account for this real-world relationship.

Similar to the other analyses of this research, two different types of models were assessed for spatial effects. The first model analyzed crime counts with land use counts and census variables, and the second model analyzed crime rates with percentage of land use and census variables. A separate analysis was run for each crime type and model resulting in a total of six analyses. This approach was used not only to assess the spatial relationships of the data but also to allow for the comparison of results between model types³.

The first analysis for each model was an Ordinary Least Squares (OLS) regression. This analysis returned diagnostics for spatial dependency, heteroscedasticity, spatial autocorrelation, and multicollinearity. These initial results served to direct further analyses. The results of the tests for spatial dependency revealed whether a spatial lag, spatial error, or OLS model was the most appropriate for the data. If heteroscedasticity was present, then the chosen analysis was moved in to GeoDa Space because this software was specifically designed to account for such a relationship whereas GeoDa was not. If no heteroscedasticity was present then the model continued in GeoDa. Spatial autocorrelation was noted to be either significant or nonsignificant.

4.4. Conclusions

Using methodology appropriate to the data types, statistical analyses were conducted to explore the relationships between crime, land use, and socio-economic variables in the city of Surrey, BC. These analyses of increasingly complexity

³ Models were also attempted that used count data as dependent variables with land use percent as independent variables and as well with rates as dependent variables with land use counts as independent variables but these models returned anomalous results and were excluded from further analysis or interpretation. The results of these analyses are not presented in this thesis.

demonstrated the various relationships these data have to each other and culminated in an assessment of their spatial relationship. Each stage of this methodology advanced the understanding of this data and the study region. In using multiple types of analyses, a full exploration of the data was possible, as well as a comparison between results that shows what sort of conclusion would be drawn from each method in isolation. The results of the analyses will be presented in the next chapter.

Chapter 5.

Results

5.1. Introduction

The following chapter presents the results from the analyses that were conducted to determine what relationships exist between the dependent and independent variables chosen for this research. Beginning with simple descriptive statistics and advancing to spatial regression, these increasing levels of analyses revealed many different connections between the data and provide a broad understanding of the study area and its criminal event patterning.

5.2. Descriptive Statistics

The descriptive statistics performed on both the independent and dependent variables showed their spread and distribution across the study region. This provided a general description of the data and revealed non-inferential connections within the data that gave context to the statistical analyses to follow.

5.2.1. Crime

Descriptive statistics were calculated for each crime type by count (see Table 5.1) and by rate (see Table 5.2.). The most frequent crime occurrence was theft of motor vehicle, followed by residential break and enter then commercial break and enter. All census tracts experienced theft of motor vehicle and residential break and enters; however, eight (11%) did not experience any commercial break and enters. Of these eight census tracts, four had no commercial land use, and the other four had between just one and three plots designated as commercial, which was below the average found across census tracts of 15.

Standard deviation results by count indicated that residential break and enter was the least variable crime type across the city, followed by commercial break and enter and theft of motor vehicle (see Table 5.1.). However, when the standard deviation

for the rate of each crime type was calculated, these standardized results showed that theft of motor vehicle was the least variable crime type, followed by residential break and enter and commercial break and enter. Additionally, commercial break and enter was revealed as the most geographically concentrated crime. Three census tracts accounted for the top 25% of commercial break and enters, which represents just 4% of all the census tracts; comparatively, the top 25% of residential break and enters and theft of motor vehicle were each spread out over nine census tracts, which represents 12% of all the census tracts in the study region.

Table 5.1. Descriptive statistics for counts of crime types

Statistic	Commercial Break and Enter	Residential Break and Enter	Theft of Motor Vehicle
Total	1,175	2,374	3,669
Average	15	31	48
Median	7	30	44
Min	0	3	5
Max	124	97	142
Standard Deviation	21.7	19.2	28.4

Table 5.2. Descriptive statistics for rates of crime types

Statistic	Commercial Break and Enter	Residential Break and Enter	Theft of Motor Vehicle
Rate	144.73	24.71	10.14
Median	104.13	23.30	8.71
Min	0.00	4.80	2.06
Max	610.17	59.45	37.95
Standard Deviation	132.26	13.03	6.14

Furthermore, some census tracts that had a high number of one crime type also had a high number of another crime type. In these comparisons, crime counts and crime rates revealed different patterns. The census tract with the highest count of theft of motor vehicle also had the second-highest count of commercial break and enters, and the census tract with the second-highest count of theft of motor vehicle had the second-highest count of residential break and enters. These results demonstrate that when crime is high in an area, it may not be just one type but rather multiple types of crime may be pronounced in the same area. Only one similar relationship was seen when looking at the top three census tracts by crime rate. In this case, it was observed that the census tract with the third-highest rate of theft of motor vehicle also had the highest rate of residential break and enters. This relationship is the type that prompts further inquiry in the similarities between these census tracts relating to land use or socio-

demographic profile that could be linking these phenomena. To test for the significance of these findings, these relationships were explored further through Pearson's Correlation analyses.

5.2.2. Land Use

Descriptive statistics were calculated for each land use category by count (see Table 5.3.) and by percentage (see Table 5.4.). The majority of land use plots in Surrey were residential, and the standard deviation further showed this to be the most dispersed of the land use types. Residential and civic, institutional, and recreational were the only two categories that were found in all census tracts.

Table 5.3. Descriptive statistics for counts of land use

Statistic	Residential	Farm	Commercial	Industrial	Transportation, Communication, & Utility	Civic, Institutional, & Recreational
Total	103,114	1,147	5,072	710	180	2,596
Average	1,356.8	15.1	66.7	9.3	2.4	34.2
Median	1,222	0	16	0	1	27
Min	253	0	0	0	0	6
Max	3,338	403	780	311	23	170
Standard Deviation	658.2	63.2	135.6	38.1	4.7	28.1

Table 5.4. Descriptive statistics for percentages of land use

Statistic	Residential	Farm	Commercial	Industrial	Transportation, Communication, & Utility	Civic, Institutional, & Recreational
Percentage	91.40	1.02	4.50	0.63	0.16	2.30
Average	91.22	1.00	4.48	0.63	0.16	2.51
Median	95.4	0	1.142	0	0.047	2.059
Min	33.68	0	0	0	0	0.439
Max	99.26	28.72	42.51	14.88	1.518	10.09
Standard Deviation	11.80	3.83	8.61	2.26	0.29	1.88

5.2.3. Census of Population

Descriptive statistics were calculated for each census variable that had been chosen to represent the criminological theories of routine activity theory (see Tables

5.5.) and social disorganization theory (see Table 5.6.). These results show the distribution and spread of these variables within the population of the study area.

Table 5.5. Descriptive statistics for variables of routine activity theory

Statistic	Total Population	Population Density (km ²)	Number of Occupied Private Dwellings	Average Family Income (\$)	Average Dwelling Value (\$)	Rental Residences (%)	Unemployment Rate	Population Aged 15-29 (%)
Total	379,303	2,408.8	126,620	n/a	n/a	n/a	n/a	n/a
Average	4,987.2		1,666.1	82,685.9	456,202.9	23	5.5	20.3
Median	5,134.5	1817.2	1662.5	75,619.5	422,736.5	20.6	5.4	20.8
Min	1008	1068.9	315	41771	162,255	2.2	1.3	12
Max	8729	9256.1	3555	157,756	924,341	69.2	9.3	24.4
Standard Deviation	1978.7	1593.8	771.2	21,950.8	155,602.2	13.3	1.8	2.6

Table 5.6. Descriptive statistics for variables of social disorganization theory

Statistic	Recent Immigration (%)	College Graduates (%)	Single Parents (%)	Population Change (%)	Standard Error of Average Family Income (\$)	Average Family Income(\$)	Rental Residences (%)	Unemployment Rate
Total	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	6.9	16.9	4	29.8	3,830.3	82,685.9	23	5.5
Median	6.4	15.7	3.8	6.5	2,809.5	75,619.5	20.6	5.4
Min	0.6	6.2	1	6.8	1,469	41771	2.2	1.3
Max	21.3	31.9	8.3	896.4	11,654	157,756	69.2	9.3
Standard Deviation	4.2	5.4	1.3	108.3	2,353	21,950.8	13.3	1.8

5.3. Pearson's Correlations

Pearson's Correlation tests were performed to check for linear relationship between the variables used in the analyses of this research. This also served to determine the continued presence and possible significance of the non-inferential relationships seen in the descriptive statistics. Pearson's Correlations were run separately on the independent variables and crime type counts and rates then on each full model of the analyses.

5.3.1. Land Use and Census of Population

The results of the Pearson's Correlations measured the linear dependence between the independent variables. Separate analyses were conducted using the independent variables for model I: census variables and land use counts (see Tables 5.7.) and for model II: census variables and land use percentages (see Tables 5.8.). When the census variables and land use counts were compared, no perfect correlations were found, and when the census variables and land use percentages were compared, again, no perfect correlations were found. As such, no variables needed to be eliminated from the model. The purpose of this test was to determine if any perfect correlations existed in the independent variables.

Table 5.7. Pearson's Correlation results for all theoretical variables and counts of land use

X ₁	1																		
X ₂	-.851**	1																	
X ₃	.920**	-.762**	1																
X ₄	-.095	.166	-.121	1															
X ₅	-.266*	.374**	-.324**	.845**	1														
X ₆	.165	-.240*	.207	-.712**	-.547**	1													
X ₇	.218	-.301**	.130	-.596**	-.549**	.593**	1												
X ₈	-.154	.056	-.381**	-.314**	-.159	.222	.337**	1											
X ₉	.114	-.168	.008	-.588**	-.461**	.667**	.602**	.448**	1										
X ₁₀	.055	.020	.102	.678**	.527**	-.480**	-.471**	-.250*	-.199	1									
X ₁₁	-.449**	.557**	-.397**	.820**	.810**	-.504**	-.556**	-.231*	-.431**	.608**	1								
X ₁₂	.242*	-.276*	.355**	-.728**	-.724**	.704**	.408**	.060	.412**	-.411**	-.579**	1							
X ₁₃	-.080	.002	-.113	.210	.113	-.250*	-.192	-.114	-.022	.142	.092	-.227	1						
X ₁₄	.805**	-.658**	.885**	.108	-.157	-.138	-.028	-.485**	-.273*	.197	-.230*	.110	-.039	1					
X ₁₅	-.044	.021	-.035	.292*	.490**	-.130	-.294**	-.120	-.243	.091	.202	-.251*	.022	-.028	1				
X ₁₆	.009	-.011	.013	-.188	-.138	.215	.125	-.022	.172	-.182	-.098	.031	-.093	-.021	.039	1			
X ₁₇	-.132	.117	-.105	-.029	.077	.072	.020	-.038	-.028	-.166	.101	-.051	-.055	-.101	.147	.509**	1		
X ₁₈	.018	-.083	.027	-.121	-.003	.180	.008	-.051	-.060	-.242*	-.078	.058	-.093	.020	.265*	.345**	.558**	1	
X ₁₉	.163	-.165	.166	.311**	.311**	-.189	-.182	-.065	-.347**	.126	.150	-.241*	-.088	.272*	.266*	.079	.545**	.472**	1
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₈	X ₁₉

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

X₁ Population 2006; **X₂** Population Density (km²); **X₃** # of Dwellings; **X₄** Average Family Income (\$); **X₅** Average Dwelling Value (\$); **X₆** % of Rental Residences; **X₇** Unemployment Rate; **X₈** % of Population Aged 15-29; **X₉** % Recent Immigration (2001-2006); **X₁₀** % of College Graduates; **X₁₁** SE of Average Family Income (\$); **X₁₂** % Single-Parent Families; **X₁₃** % Population Change (2001-2006); **X₁₄** Residential Total; **X₁₅** Farm Total; **X₁₆** Commercial Total; **X₁₇** Industrial Total; **X₁₈** Transportation/Communication/Utility Total; **X₁₉** Civic/Institutional/Recreational Total

Table 5.8. Pearson's Correlation results for all theoretical variables and percentages of land use

X ₁	1																			
X ₂	-.851**	1																		
X ₃	.920**	-.762**	1																	
X ₄	-.095	.166	-.121	1																
X ₅	-.266*	.374**	-.324**	.845**	1															
X ₆	.165	-.240*	.207	-.712**	-.547**	1														
X ₇	.218	-.301**	.130	-.596**	-.549**	.593**	1													
X ₈	-.154	.056	-.381**	-.314**	-.159	.222	.337**	1												
X ₉	.114	-.168	.008	-.588**	-.461**	.667**	.620**	.448**	1											
X ₁₀	.055	.020	.102	.678**	.527**	-.480**	-.471**	-.250*	-.199	1										
X ₁₁	-.449**	.557**	-.397**	.820**	.810**	-.504**	-.556**	-.231*	-.431**	.608**	1									
X ₁₂	.242*	-.276*	.355**	-.728**	-.724**	.704**	.408**	.060	.412**	-.411**	-.579**	1								
X ₁₃	-.080	.002	-.113	.210	.113	-.250*	-.192	-.114	-.022	.142	.092	-.227*	1							
X ₁₄	.268*	-.288*	.256*	-.013	-.208	-.101	.066	.003	-.014	.190	-.165	.127	.085	1						
X ₁₅	-.139	.123	-.127	.321**	.519**	-.149	-.327**	-.090	-.251*	.093	.268*	-.288*	.045	-.474**	1					
X ₁₆	-.156	.175	-.152	-.188	-.082	.238*	.115	.007	.204	-.263*	-.026	.044	-.101	-.883**	.102	1				
X ₁₇	-.240*	.307**	-.204	.023	.172	.046	-.036	-.055	-.065	-.189	.208	-.057	-.059	-.775**	.216	.615**	1			
X ₁₈	-.117	.075	-.106	-.136	.025	.196	-.008	-.032	-.039	-.285*	-.022	.057	-.100	-.482**	.246*	.337**	.450**	1		
X ₁₉	-.378**	.373**	-.388**	.285*	.415**	-.238*	-.232*	.205	-.256*	.096	.362**	-.353**	-.076	-.259*	.176	-.039	.335**	.286*	1	
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₈	X ₁₉	

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

X₁ Population 2006; X₂ Population Density (km²); X₃ # of Dwellings; X₄ Average Family Income (\$); X₅ Average Dwelling Value (\$); X₆ % of Rental Residences; X₇ Unemployment Rate; X₈ % of Population Aged 15-29; X₉ % Recent Immigration (2001-2006); X₁₀ % of College Graduates; X₁₁ SE of Average Family Income (\$); X₁₂ % Single-Parent Families; X₁₃ % Population Change (2001-2006); X₁₄ Residential Total; X₁₅ Farm Total; X₁₆ Commercial Total; X₁₇ Industrial Total; X₁₈ Transportation/Communication/Utility Total; X₁₉ Civic/Institutional/Recreational Total

5.3.2. Crime

Pearson's Correlation results showed the degree of linear relation between the dependent variables. Separate analyses were conducted comparing just the dependent variables using both the crime count (see Table 5.9.) and crime rate data (see Table 5.10.). No perfect correlations were found in any of the analyses, and as such, no changes were made to the models.

Significant positive correlations were found between commercial break and enter count and theft of motor vehicle count ($r = .558$, $N = 76$, $p = 0.1$), and between residential break and enter count and theft of motor vehicle count ($r = .614$, $N = 76$, $p = 0.1$). However, no significant correlation was found between the counts for commercial break and enter and residential break and enter. When comparing the crime rates, all possible relationships showed significant positive linear dependence, though the strength of these findings was low. As with the crime count comparison, the relationship between rates of residential break and enter and theft of motor vehicle was the strongest ($r = .456$, $N = 76$, $p = 0.1$).

Table 5.9. Pearson's Correlation results for counts of property crime occurrences

Crime Type	Commercial Break and Enter	Residential Break and Enter	Theft of Motor Vehicle
Commercial Break and Enter	1		
Residential Break and Enter	0.197	1	
Theft of Motor Vehicle	.558**	.614**	1

** Correlation is significant at the 0.1 level

Table 5.10. Pearson's Correlation results for rates of property crime occurrences

Crime Type	Commercial Break and Enter	Residential Break and Enter	Theft of Motor Vehicle
Commercial Break and Enter	1		
Residential Break and Enter	.248*	1	
Theft of Motor Vehicle	.286*	.456**	1

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

5.3.3. Model I

Results of Pearson's Correlations show the degree of linear dependence found in Model I. Separate analyses were conducted for commercial break and enter count (see Table 5.11.), residential break and enter count (see Table 5.12.), and theft of motor vehicle count (see Table 5.13.). No perfect correlations were found in any of the analyses, and as such, no changes were made to the model.

The results from the commercial break and enter count analysis showed only one significant correlation among the census variables. In relation to both routine activity theory and social disorganization theory, percent rental residences had a low positive correlation ($r = .276$, $N = 76$, $p = 0.05$). No other theoretically supportive variables were significant in this analysis. However, three positive correlations were found with the land use counts: commercial total ($r = .843$, $N = 76$, $p = 0.1$), industrial total ($r = .630$, $N = 76$, $p = 0.1$), and transportation, communication, utilities total ($r = .393$, $N = 76$, $p = 0.1$). Overall, the greatest correlation was found between commercial break and enter and total commercial land use.

Table 5.11. Significant Pearson's Correlation results for commercial break and enter count, land use counts, and all theoretical variables

Variable	Pearson's Correlation
Percent Rental Residences	.276*
Commercial Total	.843**
Industrial Total	.630**
Transportation, Communication, Utilities Total	.393**

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

The results from the residential break and enter count analysis showed many significant correlations with the census variables relating to both routine activity theory and social disorganization theory. One significant correlation was also found between the residential break and enter and total residential land use ($r = .446$, $N = 76$, $p = 0.1$). Overall, the greatest positive correlation was found between residential break and enter and number of dwellings ($r = .572$, $N = 76$, $p = 0.1$), and the greatest negative correlation was found with population density ($r = -.491$, $N = 76$, $p = 0.1$).

Table 5.12. Significant Pearson's Correlation results for residential break and enter counts, land use counts, and all theoretical variables

Variable	Pearson's Correlation
Population 2006	.535**
Population Density	-.491**
Number of Dwellings	.572**
Average Dwelling Value	-.424**
Average Family Income	-.372**
Percent Rental Residences	.381**
Percent College Graduates	-.247*
SE of Average Family Income	-.461**
Percent Single Parent Families	.486**
Residential Total	.446**

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

The results from the theft of motor vehicle count analysis showed many significant correlations, both positive and negative, relating to both routine activity theory and social disorganization theory. With the census variables, the greatest positive correlation was found with percent rental residences ($r = .670$, $N = 76$, $p = 0.1$), and the greatest negative correlation was with average family income ($r = -.546$, $N = 76$, $p = 0.1$). Theft of motor vehicle also correlated significantly with three of the land use variables. Here, the greatest positive correlation was with total commercial land use ($r = .454$, $N = 76$, $p = 0.1$).

Table 5.13. Significant Pearson's Correlation results for theft of motor vehicle, land use counts, and all theoretical variables

Variable	Pearson's Correlation
Population 2006	.503**
Population Density	-.479**
Number of Dwellings	.558**
Average Dwelling Value	-.543**
Average Family Income	-.546**
Percent Rental Residences	.670**
Unemployment Rate	.412**
Percent Recent Immigration	.448**
Percent College Graduates	-.274*
Percent Single Parent Families	.597**
SE of Average Family Income	-.510**
Residential Total	.315**
Commercial Total	.454**
Industrial Total	.381**
Transportation, Communication, Utilities Total	.361**

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

5.3.4. Model II

Results of Pearson's Correlations show the degree of linear dependence found in Model II. Separate analyses were conducted for commercial break and enter rate (see Table 5.14.), residential break and enter rate (see Table 5.15.), and theft of motor vehicle rate (see Table 5.16.). No perfect correlations were found in any of the analyses, and as such, no changes were made to the model.

The results for commercial break and enter rates revealed many significant correlations, both positive and negative, relating to both routine activity theory and social disorganization theory. For the census variables, the greatest positive correlation was with percent single parent families ($r = .635$, $N = 76$, $p = 0.1$), and the greatest negative correlation was found with average dwelling value ($r = -.422$, $N = 76$, $p = 0.1$). Commercial break and enter rates only correlated significantly with one land use variable: civic, institutional, and recreational percent ($r = -.456$, $N = 76$, $p = 0.1$).

Table 5.14. Significant Pearson's Correlation results for commercial break and enter, percent of land use, and all theoretical variables

Variable	Pearson's Correlation
Population Density	-.253*
Number of Dwellings	.289*
Average Family Income	-.405**
Average Dwelling Value	-.422**
Percent Rental Residences	.486**
Unemployment Rate	.305**
Percent Recent Immigration	.324**
SE of Average Family Income	-.326**
Percent Single Parent Families	.635**
Civic, Institutional, Recreational Percent	-.456**

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

The results for residential break and enter rates also demonstrated many significant correlations, both positive and negative, relating to both routine activity theory and social disorganization theory. For the census variables, the greatest positive correlation was with percent rental residences ($r = .546$, $N = 76$, $p = 0.1$), and the greatest negative correlation was found with average family income ($r = -.484$, $N = 76$, $p = 0.1$). Residential break and enter rates only correlated significantly with one land use variable: commercial percent ($r = .229$, $N = 76$, $p = 0.1$).

Table 5.15. Significant Pearson's Correlation results for residential break and enter, percent of land use, and all theoretical variables

Variable	Pearson's Correlation
Average Family Income	-.484**
Average Dwelling Value	-.347**
Percent Rental Residences	.546**
Percent Recent Immigration	.332**
Percent College Graduates	-.444**
SE of Average Family Income	-.304**
Percent Single Parent Families	.459**
Commercial Percent	.229*

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

The results for theft of motor vehicle rates also showed a mix of both positive and negative significant correlations relating to both routine activity theory and social disorganization theory. Similarly to that the results found with residential break and enter, for theft of motor vehicle rates, the greatest positive correlation was with percent rental residences ($r = .531$, $N = 76$, $p = 0.1$), and the greatest negative correlation was also found with average family income ($r = -.442$, $N = 76$, $p = 0.1$). Theft of motor vehicle rates however correlated significantly with four land use variables. The greatest positive correlation with land use was found with industrial percent ($r = .729$, $N = 76$, $p = 0.1$), and the greatest negative correlation was with residential percent ($r = -.651$, $N = 76$, $p = 0.1$).

Table 5.16. Significant Pearson's Correlation results for theft of motor vehicle, percent of land use, and all theoretical variables.

Variable	Pearson's Correlation
Average Family Income	-.442**
Average Dwelling Value	-.286*
Percent Rental Residences	.531**
Unemployment Rate	.260*
Percent Recent Immigration	.306**
Percent College Graduates	-.433**
Percent Single Parent Families	.410**
Residential Percent	-.651**
Commercial Percent	.649**
Industrial Percent	.729**
Transportation, Communication, Utilities Percent	.485**

** Correlation is significant at the 0.1 level

* Correlation is significant at the 0.05 level

5.4. Spatial Autocorrelation of Crime

Using a univariate Moran's I, half of the crime variables returned pseudo p-values that were significant at the 999 permutation alpha level of 0.001. Residential break and enter count ($I = 0.217$), theft of motor vehicle count ($I = 0.312$), and residential break and enter rate ($I = 0.307$) were all significant for positive spatial autocorrelation. Commercial break and enter count, commercial break and enter rate, and theft of motor vehicle rate were not significant for spatial autocorrelation.

5.5. Local Indicators of Spatial Association

Tests for Local Indicators of Spatial Association (LISA) were performed on the three crime variables that were significant for positive spatial autocorrelation according to their global Moran's I results: residential break and enter count, residential break and enter rate, and theft of motor vehicle count. These LISA results show crime concentrations in each census tract as they relate to neighbouring census tracts, and they also illustrate specifically where these census tracts are located in the study region of Surrey, BC.

The results for residential break and enter count revealed primarily areas of high-high and low-low crime clusters (see Figure 5.1.). In northwestern Surrey, several high-high census tracts were significant, and in the northeastern area of Surrey, census tracts with low-low crime counts were dominant.

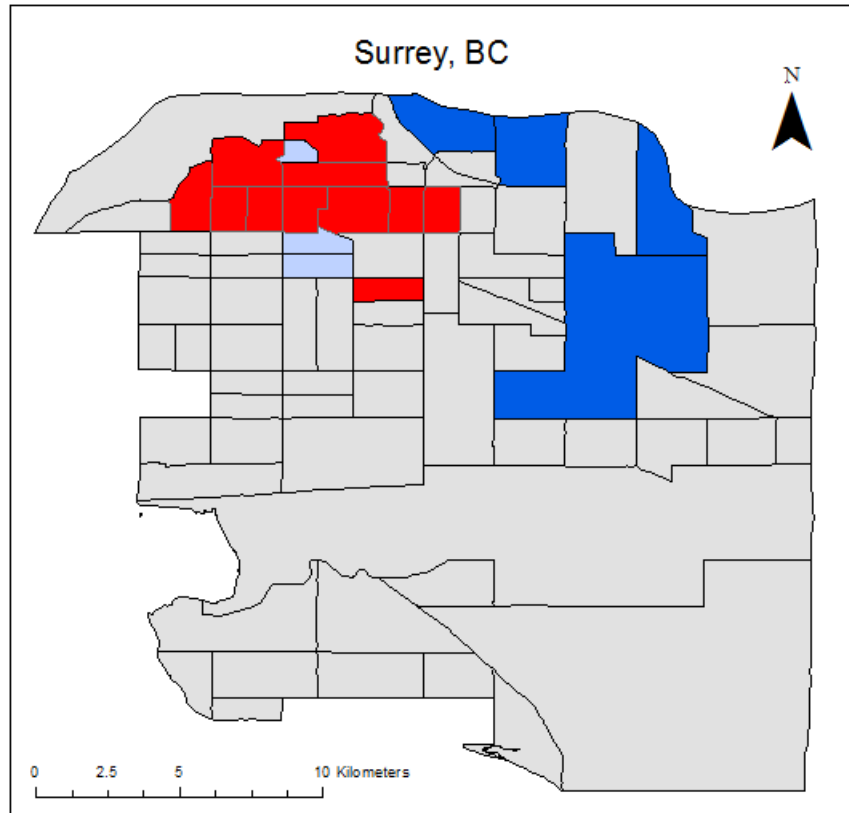


Figure 5.1. Results for Local Indicators of Spatial Association analysis of counts of residential break enters

Note: Dark Red = High-High (11), Light Red = High-Low (0), Dark Blue = Low-Low (4), Light Blue = Low-High (3), White = Not Significant (58)

The results for residential break and enter rate showed a greater mix of clustering than was seen using the court variable (see Figure 5.2.). Again though, in northwestern Surrey, several high-high census tracts were significant, and in the northeastern area of Surrey, census tracts with low-low crime rates were seen. Additional clustering of low-low crime rates were present in southwestern Surrey, as well as a single large census tract with a high-low rating.

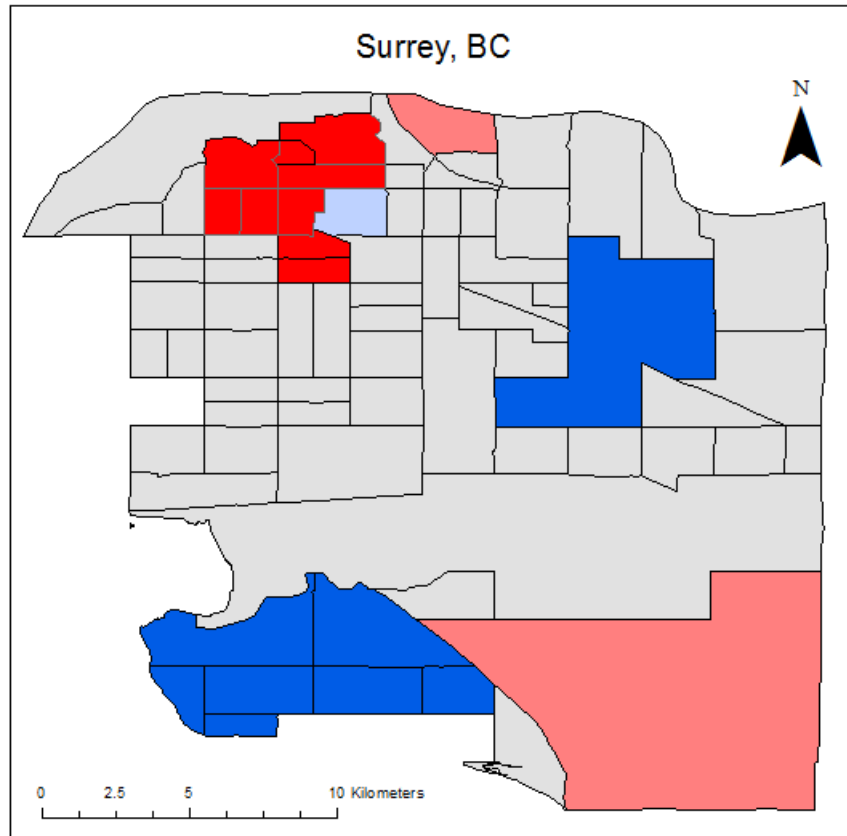


Figure 5.2. Results for Local Indicators of Spatial Association analysis of rates of residential break and enters

Note: Dark Red = High-High (9), Light Red = High-Low (2), Dark Blue = Low-Low (8), Light Blue = Low-High (1), White = Not Significant (56)

The results for theft of motor vehicle count were most similar to those for residential break and enter count (see Figure 5.3.). As with both residential break and enter count and rate, in northwestern Surrey, a large area of high-high census tracts were significant, but in the northeastern area of Surrey, a much larger area of census tracts with low-low crime rates was seen. Additionally, this analysis showed more clustering of low-high census tracts than other analyses. Theft of motor vehicle has more significant census tracts than the other two LISA analyses.

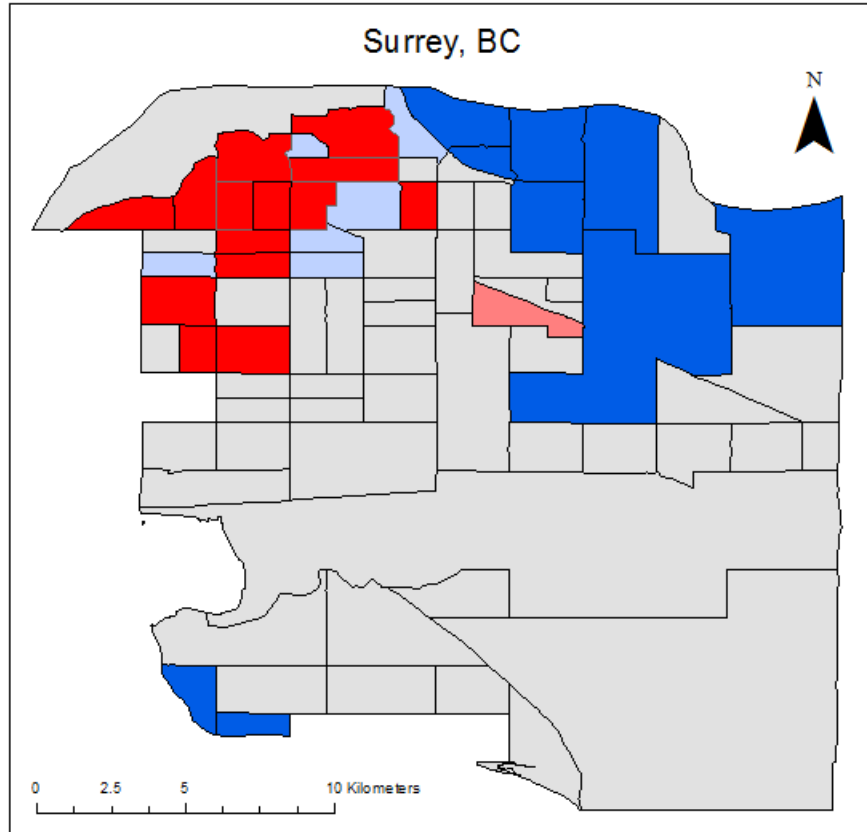


Figure 5.3. Results for Local Indicators of Spatial Association analysis of counts of theft of motor vehicle

Note: Dark Red = High-High (14), Light Red = High-Low (1), Dark Blue = Low-Low (9), Light Blue = Low-High (6), White = Not Significant (46)

Overall, for all three analyses, the results of the LISA analysis showed high-high census tracts in northwestern Surrey and low-low census tracts in northeastern Surrey. Additional low-low census tracts and high-low census tracts were significant in some crime types.

5.6. Spatial Regression Model I

The results for the spatial regression analyses of model I demonstrate the spatial correlations between the counts of commercial break and enters, residential break and enters, and theft of motor vehicle and the counts of land use and socio-economic census variables that represent the criminological theories of routine activity theory and social disorganization theory.

5.6.1. Commercial Break and Enter

The first analysis of model I used commercial break and enter count as the dependent variable with land use counts and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial Ordinary Least Squares (OLS) regression. This analysis was significant for heteroscedasticity using the Breusch-Pagan test, $p < .01$, but returned no significant tests for either spatial dependency or spatial autocorrelation. Given that the analysis showed no spatial dependency, a spatial analysis was no longer needed, and a classic OLS was performed. To account for the presence of heteroscedasticity, this analysis was moved to GeoDa Space, and the White Standard Errors results of the classic OLS were accepted.

The classic OLS regression performed in GeoDa Space returned an r^2 of .84 and five statistically significant relationships. Using an alpha level of $>.05$, the largest positive correlation was with percent single parent families ($r^2(0.84) = 5.23$, $p = .0047$). Commercial break and enter also correlated positively with total commercial land use ($r^2(0.84) = .115$, $p = .0019$), total farm land use ($r^2(0.84) = .033$, $p = .0247$), and total industrial land use ($r^2(0.84) = .169$, $p = .0090$). Using an Alpha level of $>.1$, commercial break and enter negatively correlated with total residential land use ($r^2(0.84) = -.0084$, $p = .0859$).

As no spatial dependency was detected in this analysis, the primary null hypothesis of no relationship of spatial dependency existing between commercial break and enter count and land use failed to be rejected, and the secondary null hypothesis of no relationship of spatial dependency existing between commercial break and enter count and the variables for routine activity theory and social disorganization theory also failed to be rejected. Additionally, as only one of the census variables chosen to represent these theories returned a significant result in this analysis, support for a non-spatial correlation between of these theories and commercial break and enter count is low. However, given the significant relationship seen with three of the six land use types, there is moderate support for the non-spatial correlation between commercial break and enter count and the built environment.

5.6.2. Residential Break and Enter

The second analysis of model I used residential break and enter count as the dependent variable with land use count and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial OLS regression. This analysis was significant for heteroscedasticity using the Breusch-Pagan test, $p = .0406$, and returned a significant result for the Lagrange Multiplier (lag) test for spatial dependency, as well as having a significant Moran's I indicating the presence of spatial autocorrelation. Given the presences of heteroscedasticity, this analysis was moved to GeoDa Space, and the White Standard Errors results of a spatial lag test were accepted.

The spatial lag regression performed in GeoDa Space returned a pseudo r^2 of .59 and five statistically significant relationships. Using the alpha level of $>.05$, residential break and enter count had a positive dependency with percentage of population change ($r^2(0.59) = .033$, $p = .0000$) and a negative dependency with percent recent immigration ($r^2(0.59) = -1.52$, $p = .0299$). Using the alpha level of $>.1$, residential break and enter count had a positive dependency with population aged 15-19 ($r^2(0.59) = 1.55$, $p = .0611$), percent single families ($r^2(0.59) = 3.886$, $p = .10$), and total commercial land use ($r^2(0.59) = .018$, $p = .0991$). As spatial dependency was detected in this analysis, the primary null hypothesis of no relationship of spatial dependency existing between residential break and enter count and land use was rejected, and the secondary null hypothesis of no relationship of spatial dependency existing between residential break and enter count and the variables for routine activity theory and social disorganization theory was also rejected.

5.6.3. Theft of Motor Vehicle

The last analysis of model I used theft of motor vehicle count as the dependent variable with land use count and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial OLS regression. This analysis was not significant for heteroscedasticity using the Breusch-Pagan test ($p = .5257$), and returned no significant tests for spatial dependency, but the Moran's I error for spatial autocorrelation was significant ($p = .0319$). Given the lack of heteroscedasticity and spatial dependency, the final analysis was a classic OLS run

using GeoDa. This analysis GeoDa returned an r^2 of .86 and three statistically significant relationships. Using the alpha value of $>.05$, theft of motor vehicle was positively correlated with percent rental residences ($r^2(0.86) = .828$, $p = .0075$), total commercial land use ($r^2(0.86) = .032$, $p = .0255$), and total industrial land use ($r^2(0.86) = .277$, $p = .0001$).

As no spatial dependency was detected in this analysis, the primary null hypothesis of no relationship of spatial dependency existing between theft of motor vehicle count and land use failed to be rejected, and the secondary null hypothesis of no relationship of spatial dependency existing between theft of motor vehicle count and the variables for routine activity theory and social disorganization theory also failed to be rejected. Additionally, as only one of the census variables chosen to represent these theories returned a significant result in this analysis, support for a non-spatial correlation between these theories and theft of motor vehicle count is low. However, given the significant relationship seen with two of the six land use types, there is moderate support for a non-spatial correlation between theft of motor vehicle count and the built environment.

5.7. Spatial Regression Model II

The results for the spatial regression of Model II demonstrate the spatial correlations between the rates of commercial break and enters, residential break and enters, and theft of motor vehicle with the percentage of each land use categories and socio- economic census variables that represent the criminological theories of routine activity theory and social disorganization theory.

5.7.1. Commercial Break and Enter

The first analysis of model II used commercial break and enter rate as the dependent variable with land use percent and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial OLS regression. This analysis was significant for heteroscedasticity but returned no significant results for the tests for spatial dependency or spatial autocorrelation. Given that the analysis showed no spatial dependency, a spatial analysis was no longer needed, and a classic OLS was performed. To account for the presence of

heteroscedasticity, this analysis was moved to GeoDa Space, and the White Standard Errors results of the classic OLS were accepted. This analysis returned an r^2 of .55 and just one statistically significant relationship. Using the alpha value of $>.05$, commercial break and enter rates were positively correlated with percent single family residences ($r^2(0.55) = 54.97$, $p = .0017$). No land use percent variables showed significant correlations with commercial break and enter rates.

As no spatial dependency was detected in this analysis, the primary null hypothesis of no relationship of spatial dependency existing between commercial break and enter rate and land use failed to be rejected, and the secondary null hypothesis of no relationship of spatial dependency existing between commercial break and enter rate and the variables for routine activity theory and social disorganization theory also failed to be rejected. Additionally, as only one of the census variables chosen to represent these theories returned a significant result in this analysis, support for a non-spatial dependency between these theories and commercial break and enter rate is low. Furthermore, given that no land use variables returned significant results, there is no support for the non-spatial dependency of commercial break and enter rate with the land use designations.

5.7.2. Residential Break and Enter

The second analysis of model II used residential break and enter rate as the dependent variable with land use percent and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial OLS regression. This analysis was not significant for heteroscedasticity but returned a significant result for the Lagrange Multiplier (lag) test for spatial dependency as well as having a significant Moran's I indicating the presence of spatial autocorrelation. Given the lack of heteroscedasticity, the final analysis was a spatial lag was run using GeoDa.

The spatial lag performed in GeoDa returned a pseudo r^2 of .52 and five statistically significant relationships. Using the alpha value of $>.05$, residential break and enter rate had a positive dependency with percent rental residences ($r^2(0.52) = .44$, $p = .0243$) and a negative dependency with unemployment rate ($r^2(0.52) = -1.935$, $p = .0389$). Using the alpha value of $>.1$, positive significant dependencies were found with percent single family ($r^2(0.52) = 2.73$, $p = .0909$) and percent population change ($r^2(0.52)$

= .02, $p = .0539$) and a negative dependency with SE average family income ($r^2(0.52) = -.0015$, $p = .0908$). No land use percent variables showed spatial dependency with residential break and enter rate.

As spatial dependency was detected in this analysis, based on the variables that returned significant results, the secondary null hypothesis of no relationship of spatial dependency existing between residential break and enter rate and the variables for routine activity theory and social disorganization theory was rejected. However, as no land use variables returned a statistically significant result, the primary null hypothesis of no relationship of spatial dependency existing between residential break and enter rate and land use failed to be rejected.

5.7.3. Theft of Motor Vehicle

The final analysis of model II used theft of motor vehicle rate as the dependent variable with land use percent and all of the census variables as the independent variables. In GeoDa, the first analysis performed was a spatial OLS regression. This analysis was not significant for heteroscedasticity and returned a significant result for the Lagrange Multiplier (error) test for spatial dependency, as well as having a significant Moran's I indicating the presence of spatial autocorrelation. Given the lack of heteroscedasticity, the final analysis was a spatial error was run using GeoDa.

The spatial error performed in GeoDa returned an pseudo r^2 of .90 and three statistically significant relationships. Using the alpha value of $>.05$, theft of motor vehicle rate had a positive dependency with percent single family ($r^2(0.90) = .727$, $p = .0329$) and a negative dependency with average dwelling value ($r^2(0.90) = -1.023 e^{-005}$, $p = .0331$). Using the alpha value of $>.1$, a positive dependency was also found with percent rental residences ($r^2(0.90) = .079$, $p = .0666$). Again, no land use percent variables showed significant relationship with residential break and enter rate.

As spatial dependency was detected in this analysis, based on the variables that returned significant results, the secondary null hypothesis of no relationship of spatial dependency existing between theft of motor vehicle rate and the variables for routine activity theory and social disorganization theory was rejected. However, as no land use variables returned a statistically significant result, the primary null hypothesis of no

relationship of spatial dependency existing between theft of motor vehicle rate and land use failed to be rejected.

5.8. Conclusions

The results of these analyses demonstrated the presence of relationships within the data through the use of descriptive statistics and Pearson's Correlations; however, the results of the spatial regression analyses failed to reject the primary and secondary null hypotheses of this research in half of the analyses. In the first model, the spatial analysis results failed to reject both the primary and secondary null hypotheses of spatial dependency for both commercial break and enter count and theft of motor vehicle count. However, the first model also rejected both the primary and secondary null hypotheses of spatial dependency for residential break and enter count. In the second model, the spatial analysis results failed to reject both the primary and secondary null hypotheses of spatial dependency for commercial break and enter rate. As well, in the second model, the spatial analysis results failed to reject the primary null hypotheses for both residential break and enter rate and theft of motor vehicle rate. However, the second model also rejected the secondary null hypothesis for both residential break and enter rate and theft of motor vehicle rate.

Residential break and enter was the only crime type that rejected the null hypotheses for spatial dependency with routine activity theory and social disorganization theory in both models. Residential break and enter count was the only count crime type to fail to reject the primary hypothesis of spatial dependency with land use, and theft of motor vehicle rate was the only other crime type to reject the secondary hypothesis for spatial dependency the routine activity theory and social disorganization theory. Commercial break and enters failed to reject the both the null hypotheses in both models. Overall, support for spatial dependency with land use was found for only one crime type, and for two crime types, support was found for spatial dependence with the census variables that represented the criminological theories routine activity theory and social disorganization theory. These results will be the focus of the following chapter.

Chapter 6.

Discussion

Three analyses rejected at least one of the null hypotheses of spatial dependency: count of residential break and enter, rate of residential break and enter, and rate of theft of motor vehicle. These results will be the focus of this chapter. While the primary and secondary null hypothesis failed to be rejected in half of the spatial regression analyses, the preliminary and correlational tests still yielded results of interest that will be discussed briefly.

6.1. Commercial Break and Enter

6.1.1. Descriptive Analyses

Commercial land use was not found in all of the study area's census tracts, and thusly commercial break and enters could not be found in each census tract either. Commercial break and enter was found in 89% of the census tracts and was the least numerous of the crime types in the study region. This low frequency and dispersion may have impacted the spatial autocorrelation analysis and contributed to the results that failed to reject the null hypothesis. However, three census tracts, or 4% of census tracts, accounted for 25% of all of the commercial break and enters, which indicates a spatial concentration of this crime type, if not a spatial dependency.

The results of a Pearson's Correlation using just the dependent variables demonstrated a significant positive correlation between the count of commercial break and enter and the count of theft of motor vehicle, while no significant correlation was found with count of residential break and enter. This correlation with theft of motor vehicle is explainable by the fact that commercial areas frequently include parking lots for people to park their cars in while shopping and thus unattended vehicles can be expected to concentrate in commercial areas. A lack of correlation with the count of residential break and enter indicates that there is either no significant overlap in land use in the census tracts of the study region or the residences found in mixed-use land use areas are not suitable targets for residential break and enter. However, a low positive

correlation was found between the rate of commercial break and enter and both the rate of theft of motor vehicle and residential break and enter. This result differs from that using count data and suggests that commercial break and enters do correlate with residential break and enters. This indicates that census tracts with high rates of commercial break and enter also have high rates of residential break and enters and may indicate that the study region has break and enter hot spots. This comparison of results based on count versus rate illustrates that when a variable is standardized, relationships may be revealed.

The Pearson's correlation between the count of commercial break and enter and a count of independent variables showed only one low positive significant correlation with one of the census variables: percent rental residences. Using social disorganization theory, this is explainable such that as the number of rental residences increase, so do commercial break and enters due to an increase in social disorganization in a community that creates an atmosphere conducive to delinquency (Shaw & McKay, 1969). Routine activity theory also supports this finding by explaining that as rental residences increase, so do commercial break and enters because the frequent turnover of residence decreases the guardianship in a community (Cohen & Felson, 1979). Both weak and strong significant positive correlations were also found with different land use designations that contain commercial businesses: Commercial, Industrial, and Transportation, Communication, Utilities. This finding indicates that as the number of these types of land use plots increase in a census tract, as will commercial break and enters.

The Pearson's Correlation between the rate of commercial break and enter with the percent of land use and the census variables returned a greater number of significant relationships for the socio-economic variables than did the similar analysis that used count data; however, fewer significant correlations were seen for the land use variables. Civic, institutional, recreational had a significant negative correlation with commercial break and enter. This land use designation contains mainly vacant lots, parks, and schools and not other businesses. This finding indicates that as the number of parks and schools increase in a census tract, the rate of commercial break and enters will decrease. Looking at the socio-economic variables, more support was seen for social disorganization theory with positive correlations with percent rental residences, unemployment rate, percent recent immigration, and percent single parents and

negative correlations with the average family income and the standard error of average family income. Together, these results suggest that as social disorganization increases in the study region so do commercial break and enters. Further relationships were revealed for routine activity theory as well; however, these results give a mix of support and refutation for this theory. Support for routine activity theory is seen in the positive correlation with the number of occupied private dwellings as an indicator of increased suitable targets, percent rental residences as an indicator of decreased guardianship and increased suitable targets, and unemployment rate as an indicator of increased motivated offenders (Cohen & Felson, 1979; Andresen, 2006). However, a negative correlation with population density is contrary to the expected positive correlation that would indicate an increase in suitable targets (Cohen & Felson, 1979; Andresen, 2006). It may be that in this study region a decreased population density is more representative of decreased guardianship and not an increase in suitable targets. Additionally, the negative correlations with both average dwelling value and average family income are also contradictory to the expected positive correlation that would indicate an increase in suitable targets (Cohen & Felson, 1979; Andresen, 2006). It may be that in this study region commercial break and enter better correlates with lower income areas as an indicator of the presence of more motivated offenders targeting businesses within their neighbourhood awareness space or an indicator of the presence of businesses that may be easier to break in to and that, while they don't offer high value targets, have items that are easier to steal and pawn, resell, or use by the offenders.

These preliminary analyses revealed a greater number of non-spatial correlations between the rate of commercial break and enter and the socio-economic independent variables than when analyzing the count of commercial break and enter. Overall, support was seen for the application of both social disorganization and routine activity theory; however, evidence was also seen for the refutation of routine activity theory. These contrary results suggest the need for further analysis and the consideration that the socio-economic environment in which this theory was created does not strictly apply to the study region. It may be, as each city is unique in its socio-economic makeup, that a different interpretation of results is needed when applying these theories to this study region or that other factors are acting to mediate between these theories and the pattern of crime occurrences.

6.1.2. Spatial Regression

Neither the count nor rate of commercial break and enter was found to have spatial autocorrelation with land use or the socio-economic variables of the study region. These results suggest that the spatial distribution of land use is a poor predictor of the location of commercial break and enters in this area. As well, these results suggest that the spatial distribution of the variables that represent the criminological theories of routine activity theory and social disorganization theory are also a poor predictor of the location of commercial break and enter. These results are also contrary to those found by other researchers (Andresen, 2006). Andresen (2006), who used an aggregate break and enter variable and the same socio-economic variables as this research, found 64.5 percent of the variation in break and enters were explained by social disorganization theory and routine activity theory.

6.2. Residential Break and Enter

6.2.1. Descriptive Analyses

Residential land use was found in all of the study area's census tracts, and residential break and enter was also found in each census tract. Residential break and enter was the second most numerous of the crime types in the study region. The count of residential break and enter was the least dispersed of the crime types, and the rate was the second least dispersed. This relatively high frequency coupled with a low dispersion may have impacted the spatial autocorrelation analysis and assisted in the results that rejected the null hypothesis. Additionally, nine census tracts, or 12% of census tracts, accounted for 25% of all of the residential break and enters which indicates a spatial concentration of this crime type if not a spatial dependency.

The results of a Pearson's Correlation using just the dependent variables demonstrated a significant positive correlation between the count of residential break and enter and the count of theft of motor vehicle, while no significant correlation was found with count of commercial break and enter. The correlation with theft of motor vehicle is explainable by the fact that residential areas include driveways or parking lots for people to park their cars near where they live, and thus unattended vehicles can be expected to concentrate in residential areas. A lack of correlation with the count of

commercial break and enter indicates that there is either no significant overlap in land use in the census tracts of the study region or the residences found in mixed-use land use areas are not suitable targets for commercial break and enter. However, a low positive correlation was found between the rate of residential break and enter and both the rate of theft of motor vehicle and commercial break and enter. This result differs from that using count data and suggests that commercial break and enters do correlate with residential break and enters. This indicates that census tracts with high rates of residential break and enters also have high rates of commercial break and enters and may indicate that the study region has break and enter hot spots. This comparison of results based on count versus rate illustrates that when a variable is standardized, relationships may be revealed.

The Pearson's Correlation between the count of residential break and enters and a count of independent variables showed only one moderately positive significant correlation with one of the land use variables: residential total. This finding indicates that as the number of residential land use plots increase per census tract, as will the number of residential break and enters. Correlation results for the socio-economic independent variables revealed several significant relationships. Support for social disorganization theory was seen in the positive correlation with percent rental residences and percent single parents as measures of increased family disruption and an unstable population (Shaw & McKay, 1969; Andresen, 2006). Additional support for this theory was evident in the negative correlation with percent college graduates and average family income as measures of socio-economic deprivation (Shaw & McKay, 1969; Andresen, 2006). However, the standard error of average family income returned a negative result, which is contrary to the expected positive relationship to social disorganization theory as a measure of economic deprivation (Shaw & McKay, 1969; Andresen, 2006). Support for routine activity theory was seen by the positive correlation with total population and number of occupied private dwellings as measures of increased suitable targets and with percent rental residences as a measure of decreased guardianship (Cohen & Felson, 1979; Andresen, 2006). However, the negative correlation found for population density, as found with commercial break and enter, is contrary to the expected theoretical outcome as a measure of suitable targets. Here again, it may be that a decrease in population density is a better measure of decreased guardianship within this study region as opposed to an indicator of number of targets. Additional contrary findings for

routine activity theory were again seen in the negative correlations with both average dwelling value and average family income. Similar to commercial break and enters, these results indicate that, instead of increasing with the relative wealth of the study region, break and enters increase with the relative lack of wealth. It may be that in this study region residential break and enter better correlates with lower income areas as an indicator of the presence of more motivated offenders targeting residences within their neighbourhood awareness space. It is possible that while a lower-income residence may offer targets of relatively lower value, these residences may be easier to break into and such items may be easier to resell or pawn.

The Pearson's Correlation between rate of residential break and enter, the percent of land use, and the census variables returned fewer significant relationships for the socio-economic variables than did the similar analysis that used count data, and only one significant correlation was seen with the land use variables. The total commercial land use had a low significant positive correlation with residential break and enters. This result is not as counterintuitive as it may first appear. Commercial and residential units often share not only the same census tract but also the same building. As well, the correlation of these two crime types may speak to a generalized level of delinquency in the study region and point to a property crime hot spot. In support of social disorganization theory, here again, there is a positive correlation with percent rental residences and percent single parents as measures of increased family disruption and an unstable population (Shaw & McKay, 1969; Andresen, 2006). In this analysis, there was also a significant positive correlation with percent recent immigration, which is another measure of population turnover as an indicator of social disorganization. Additional support for this theory was evident in the negative correlation with percent college graduates and average family income as measures of socio-economic deprivation (Shaw & McKay, 1969; Andresen, 2006). However, the standard error of average family income again returned a negative result, which is contrary to the expected positive relationship to social disorganization theory as a measure of economic deprivation (Shaw & McKay, 1969; Andresen, 2006). Support for routine activity theory was only seen by the positive correlation with percent rental residences as a measure of decreased guardianship (Cohen & Felson, 1979; Andresen, 2006). The negative correlation found for both average dwelling value and average family income is again contrary to the expected results for routine activity theory. As previously stated, there

may be additional factors at work in this study region that, while they do not fit with either of the theoretical explanations used here, may explain this finding and provide further insight into what mediating factors are specific to this study region and its crime rate.

6.2.2. Spatial Autocorrelation and Local Indicators of Spatial Association

Both the count and the rate of residential break and enter were significant for positive spatial autocorrelation. These findings indicate that residential break and enters are clustered together in space. The results of the Local Indicator of Spatial Association (LISA) revealed where in the study region this crime type was clustered and pointed to both high and low-crime areas for the count residential break and enters and the rate of residential break and enters. For both the count and rate variables, high-crime clusters were identified in the Whalley/Central City neighbourhood of Surrey. This finding suggests that there is a hot spot of residential break and enters in this neighbourhood. Low-crime clusters were seen for both the count and rate of residential break and enter in the Guildford neighbourhood, and an additional low-crime cluster was identified in South Surrey for the rate of residential break and enter. These areas represent clusters of census tracts that have lower occurrences of residential break and enter.

6.2.3. Spatial Regression

The spatial lag regression analysis for the count of residential break and enter found that 59 percent of the variation in the count of residential break and enter could be explained by the land use of the region in combination with social disorganization theory and routine activity theory. A significant negative spatial dependency with percent recent immigration and a significant positive dependency with percent single parents were found in support of the application of social disorganization theory. As well, total population and percent population aged 15-29 had significant positive spatial dependency in support of routine activity theory. Additionally, the total commercial land use also had a significant positive dependency with residential break and enter. These results indicate that as these variables change within the census tracts of the study region, they will have the greatest predictive effect on the number of residential break and enter.

The spatial lag regression analysis for the rate of residential break and enter found that 52 percent of the variation in the rate of residential break and enter could be explained by the combination with social disorganization theory and routine activity theory. In this analysis, no significant results were returned for any of the land use variables. This suggests that the occurrence of residential break and enters is not spatially dependent on the land use of the study region and land use cannot significantly predict the rate of residential break and enters. Significant positive spatial dependencies with percent rental residences, percent single parents, and percent population change were found in support of the application of social disorganization theory. As well, unemployment rate and the standard error of average family Income had significant negative dependencies in support of social disorganization theory. The significant positive dependency with percent rental residences and significant negative dependency with unemployment rate were also in support of the application of routine activity theory. These results indicate that as these variables change within the census tracts of the study region, they will have the greatest predictive effect on the rate of residential break and enter.

These results have similarities overall to those found by other researchers who conducted related analyses (Andresen, 2006). Andresen (2006), who used an aggregate break and enter variable based on calls-for-service data and the same socio-economic variables as presented here, found 64.5 percent of the variation in break and enters was explained by social disorganization theory and routine activity theory.

6.3. Theft of Motor Vehicle

6.3.1. Descriptive Analyses

Theft of motor vehicle was the most abundant of the three crime types and was found in all of the study area's census tracts. By count, theft of motor vehicle was the most dispersed of the crime types, but by rate, it was the least dispersed. This relatively high frequency coupled with variation in its spread may have impacted the spatial autocorrelation analysis and contributed to the mixed results that rejected the null hypothesis in some analysis but failed to reject it in others. Additionally, nine census tracts, or 12% of census tracts, accounted for 25% of all of the theft of motor vehicle, which indicates a spatial concentration of this crime type if not a spatial dependency.

The results of a Pearson's Correlation using just the dependent variables demonstrated a positive significant correlation between the count of theft of motor vehicle and both the count of residential break and enter and the count of commercial break and enter. These correlations with residential break and enter and commercial break and enter are explainable by the fact that both residential and commercial areas may contain parking lots that may be targeted by offenders. Similar results were seen in the Pearson's Correlation using the rates of the dependent variables; however, the results showed lower significant positive correlations for both the rate of residential break and enter and the rate of commercial break and enter. This comparison of results based on count versus calculated rate variables, unlike in the other analysis, may indicate that the denominator used to calculate the rate for theft of motor vehicle was not the most applicable variable to use.

The Pearson's Correlation between the count of theft of motor vehicle and those of the independent variables showed four moderately significant positive correlations with the land use variables: residential, commercial, industrial, and transportation, communication, utilities. This finding supports the understanding that theft of motor vehicle is more widespread than other crime types because vehicles can be found on all possible land use types. The correlations with residential and commercial land use types are clearly seen as related to where vehicles spend most of their time; however, of interest is the positive correlations with industrial and transportation, communication, utilities land uses. The study region has a number of industrial areas such as ports and rails yards as well as several transportation hubs, including large parking lots for mass transit stations. As such, these land uses would commonly attract workers and commuters who would potentially leave their vehicles unattended for long periods of time. Correlation results for the socio-economic independent variables revealed several significant relationships. Support for social disorganization theory was seen in the positive correlation with percent rental residences and percent recent immigration as measures of an unstable population and with percent single parents as a measure of increased family disruption (Shaw & McKay, 1969; Andresen, 2006). Additional support for this theory was evident in the negative correlation with percent college graduates and average family income and the positive correlation with the unemployment rate all as measures of socio-economic deprivation (Shaw & McKay, 1969; Andresen, 2006). However, the average family income and the standard error of average family income

both showed negative correlations, which is contrary to the expected positive relationship to social disorganization theory as measures of economic deprivation (Shaw & McKay, 1969; Andresen, 2006). Support for routine activity theory was seen by the positive correlation with total population and number of occupied private dwellings as measures of increased suitable targets, with percent rental residences as a measure of decreased guardianship, and with the unemployment rate as a measure of increase in motivated offenders (Cohen & Felson, 1979; Andresen, 2006). However, the negative correlation returned for population density, as found as well with both commercial break and enter and residential break and enter, is contrary to the expected theoretical outcome as a measure of suitable targets. Here, it may be that a decrease in population density is a better measure of decreased guardianship within this study region as opposed to an indicator of number of targets. Additional contrary findings for routine activity theory were again seen in the negative correlations with both average dwelling value and average family income. Similar to commercial break and enter and residential break and enter, these results may indicate that instead of theft of motor vehicle increasing with the relative wealth of the study region, they increase with the relative lack of wealth as a reflection of the ease of stealing older less valuable vehicles. As with population density, this finding may also suggest a lack of guardianship rather than a decrease in suitable targets.

The Pearson's Correlation between the rate of theft of motor vehicle and the percent of the independent variables overall returned fewer significant correlations. The findings for land use were similar except for the correlation with residential land use, which was negative in this analysis. This could be a function of the type of residential land use that is increasing in the study region. For example, it may be harder to steal vehicles from secure underground parking garages of newer condos or apartment buildings; whereas, vehicles may be easier targets when parked over night outside a residence in an open driveway or carport. Otherwise, commercial, industrial, and transportation, communication, and utilities land uses all returned significant positive correlations as in the previous analysis. As with the Pearson's Correlation using counts of theft of motor vehicle, support for social disorganization theory was seen in the positive correlation with percent rental residences and percent recent immigration as measures of an unstable population and with percent single parents as a measure of increased family disruption (Shaw & McKay, 1969; Andresen, 2006). Additional support

for this theory was evident in the negative correlation with percent college graduates and average family income and the positive correlation with the unemployment rate all as measures of socio-economic deprivation (Shaw & McKay, 1969; Andresen, 2006). However, average family income had a negative correlation, which is contrary to the expected positive relationship to social disorganization theory as a measure of economic deprivation (Shaw & McKay, 1969; Andresen, 2006). Support for routine activity theory was not seen in this analysis using total population, number of occupied private dwellings, but there were significant positive correlations with percent rental residences as a measure of decreased guardianship and the unemployment rate as a measure of increase in motivated offenders (Cohen & Felson, 1979; Andresen, 2006). Contrary findings for routine activity theory were again seen in the negative correlations with both average dwelling value and average family income. As previously stated, this may reflect an increased suitability of targets or possibly decreased guardianship.

6.3.2. Spatial Autocorrelation and Local Indicators of Spatial Association

The count of theft of motor vehicle was significant for positive spatial autocorrelation. This finding indicates that theft of motor vehicle occurrences are clustered together in space. The results of the Local Indicator of Spatial Association (LISA) revealed where in the study region this crime type was clustered and pointed to both high and low-crime areas for the count theft of motor vehicle. Similar to the findings of residential break and enters, high-crime clusters were identified in the Whalley/Central City neighbourhood of Surrey. Here, though, the high-crime cluster was larger and included several pockets of low clusters of theft of motor vehicle amongst the high clusters of census tracts. This finding suggests while theft of motor vehicle is widespread in this neighbourhood with several high-crime census tracts spatially clustered together, that there may be specific factors that have led to the occurrence of low-crime areas spatial clustered with high-crime areas. Similar again to the results for residential break and enter, a large low-crime cluster was seen for theft of motor vehicle counts in the Guildford neighbourhood, and an additional small low-crime cluster was identified in South Surrey.

6.3.3. Spatial Regression

The classic OLS regression analysis for the count of theft of motor vehicle found that 86 percent of the variation in the count of theft of motor vehicle could be explained by the land use of the region in combination with social disorganization theory and routine activity theory. A significant positive correlation with percent rental residences was found in support of the application of both social disorganization theory and routine activity theory. Additionally, total commercial land use and total industrial land use also had significant positive correlations with the count of theft of motor vehicle. These results indicate that as these variables change within the census tracts of the study region, they will have the greatest predictive effect on the number of theft of motor vehicles.

The spatial error regression analysis for the rate of theft of motor vehicle found that 90 percent of the variation in the rate of theft of motor vehicle could be explained by the combination of social disorganization theory and routine activity theory. In this analysis, no significant results were returned for any of the land use variables. This suggests that theft of motor vehicle is not spatially dependent on the land use of the study region. A positive spatial dependency with both percent rental residences and percent single parents were found in support of social disorganization theory. As well, a significant positive dependency with percent rental residences and a significant negative dependency with average dwelling value were found in support of the application of routine activity theory. These results indicate that as these variables change within the census tracts of the study region, they will have the greatest predictive effect on the rate of theft of motor vehicles.

Andresen (2006), who used a theft of motor vehicle variable based on calls-for-service data and the same socio-economic variables as presented here, found 52.5 percent of the variation in theft of motor vehicle was explained by social disorganization theory and routine activity theory. However, Andresen's analysis returned a greater number of significant relationships with the variables of theoretical importance than did the present research.

6.4. Conclusions

This study set out to investigate the spatial relationship between residential break and enter, commercial break and enter, and theft of motor vehicle and the land use designations within the census tracts of Surrey, BC, along with variables of theoretical support from social disorganization theory and routine activity theory. Results demonstrated that no spatially dependent relationship exists in this study region between commercial break and enter and either land use or these spatial criminology theories. However, residential break and enter was found to have a relationship with both land use and the supporting theories. Social disorganization theory's variables of ethnic heterogeneity, family disruption, population turnover, and economic deprivation were all seen to have a spatial dependent relationship with residential break and enter. As well, routine activity theory's variables relating to the number of potential targets and potential offenders were also seen to have a spatial dependent relationship with residential break and enter. Under this theory, no variable that was originally designed to measure guardianship showed a relationship with residential break and enter. Additionally, few variables of land use were shown to have a predictive spatial relationship with residential break and enter. Only total commercial land use was shown to have a relationship. Overall, moderate support was found for the spatial dependency of residential break and enter with routine activity theory and social disorganization theory, and low support was found for the spatial dependency of residential break and enter with the built environment of this region.

Theft of motor vehicle was also found to have a spatial dependency with both land use and the supporting criminological theories. Social disorganization theory's variables of economic deprivation and family disruption were shown to have a spatial relationship with theft of motor vehicle. Under this theory, no variable that was originally designed to measure ethnic heterogeneity or population turnover showed a relationship. As well, routine activity theory's variables relating solely to the number of targets were seen to have a spatial relationship with theft of motor vehicle. Additionally, few variables of land use were shown to have a predictive spatial relationship with theft of motor vehicle. Only total commercial land use and total industrial land use were shown to have a spatial dependency with theft of motor vehicle. Overall, moderate support was found for the spatial dependency of theft of motor vehicle with routine activity theory and social

disorganization theory, and low support was found for the spatial dependency of theft of motor vehicle with the built environment of this region.

The use of spatial analytics allowed for not only an in depth understanding of where crime is occurring and the significance of its concentration relative to surrounding geographic areas but also an assessment of which structural and theoretical variables have a spatially dependent relationship with each crime type. The results found using these analyses can over time have implications for police, policy makers, and community planners when considering how a city is growing and changing.

Chapter 7.

Research Limitations

Analyses were constrained by the aggregation of the data to the census tract level. In particular, the BCAA land use data was limiting in that it did not reflect the location of land uses relative to each other within a census tract, and thus analyses pertaining to relationships of proximity between land use types was not possible. Land use counts also only represented the zoning of a land use plot and did not account for the number of addresses within a plot. Similarly, the crime occurrence counts available as aggregated to the census tract level prohibited linking specific crime types to specific land use types directly. While this level of aggregation is important and encouraged so as to maintain the anonymity of victims and offenders, it also limits the results. As well, any future studies that wish to be comparable would require the use of detachment level crime data as Statistics Canada no longer releases counts for subcategories of break and enters.

Chapter 8. Future Research Directions

Future research opportunities exist in this study region related to the exploration of correlations and spatial crime patterns. While the data used in this thesis was aggregated to the census tract level, it would be of interest to explore a street-level analysis or disaggregated point data of specific types of residential and commercial buildings to look for more detailed relationships between crime and land use. Similarly, a street-level analysis utilizing the socio-economic variables of social disorganization theory and routine activity theory could also be explored to assist in narrowing down the specific areas most affected by these factors.

Additionally, a longitudinal data analysis would serve to explore any changes in crime patterns experienced in this region over time. Specifically, the city of Surrey constitutes a large portion of the Metro Vancouver Region and is currently experiencing a substantial degree of development, as are other cities in this area. Understanding this area's crime patterns would benefit policing in the surrounding areas as well the city's own police force as the city continues to grow and change.

As well, based on the mixed results seen for the theoretical variables in the Pearson's Correlation results, it may be of interest to explore the enduring application of both social disorganization theory and routine activity theory in the current social and economic times generally and specifically in the study region. These theories were both developed several decades ago based on the socio-economic conditions and changes of the times. Much has changed since then. It may be relevant to explore whether or not the socio-economic variables proposed by these criminological theories are still best predictors to use. It may be that additional mediating factors now act on crime rates in society.

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