EXPLORING THE ‘CRIMINOLOGY OF PLACE’ IN CHICAGO: A MULTI-LEVEL ANALYSIS OF THE SPATIAL VARIATION IN VIOLENT CRIME ACROSS MICRO-PLACES AND NEIGHBORHOODS

by

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ABSTRACT OF THE DISSERTATION

Exploring the ‘Criminology of Place’ in Chicago: A Multi-Level Analysis of the Spatial Variation in Violent Crime Across Micro-Places and Neighborhoods

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Two historically distinct bodies of research evidence have developed in criminology to understand the spatial variability of crime patterns within cities. This study explores the integration of both units of analysis and theories from each literature to enhance our understanding of the spatial variability of violent crime across urban landscapes. Using historical and contemporary data sources from Chicago a multi-level, longitudinal analysis explores both the prospects of integrating key concepts from crime opportunity and social disorganization theories to explain spatial variation in violence and attempt to address some concerns raised about the viability of theory integration in micro-contexts. Both descriptive and inferential statistical analyses were conducted to analyze the spatial variation of violent crime incident reports from 2001 to 2014. This dissertation research focuses on three key questions. The first inquiry is designed to examine whether violent crime is clustered at street segments, neighborhood clusters, and community areas over time in Chicago. While violent crimes incidents were concentrated at all units of analysis in Chicago only patterns at street segments were characterized by developmental stability over the observation period.

The second inquiry attempts to determine the unique contribution of each spatial unit of analysis to description of the total spatial variability of violent crime across Chicago over time. Street segments accounted for the largest share of the total spatial variability confirming that micro-places do indeed account for the most refined description of crime patterns within cities even when accounting for their hierarchical nesting within neighborhoods. The third inquiry examines the role of criminal opportunity measures at the street segments and social disorganization measures at the neighborhood clusters to explaining the spatial variability of violence within and between Chicago neighborhoods. The influence of criminal opportunity was found to vary noticeably between neighborhood clusters indicating the salience of neighborhood effects. Overall, this study suggests a multi-level integration of micro-places and neighborhoods in addition to criminal opportunity and social disorganization theories can offer a more comprehensive understanding of the spatial distribution of crime within cities.

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CHAPTER 1 - INTRODUCTION

For more than three centuries, empirical investigations into the spatial variation of crime have consistently revealed the uneven distribution of criminal events across urban environments (Mayhew 1851; Shaw et al., 1929; Sampson, 2012). The study of crime variation across places represents a distinct departure from traditional criminological scholarship which focuses primarily on why certain individuals commit crime (see Merton, 1938; Becker, 1963; Sampson and Laub, 1993). Over the course of the 20th century, scholars examined the spatial variation of criminal activity using a variety of theoretical perspectives (Shaw and McKay, 1942; Eck and Weisburd, 1995; Agnew, 1999). Most notably, the units of analysis representing "places" have ranged from large areas, such as countries, states, and cities (Krohn, 1976; Blumstein and Rosenfeld, 1998) to medium-sized areas, such as communities and neighborhoods (Shaw et al., 1929; Sampson and Groves, 1989) to very small "micro" places such as specific street block faces and intersections (Pierce, Sparr, and Briggs, 1988; Weisburd et al., 2004). In recent years, neighborhoods and micro-places have emerged as the two predominant units of analysis used to describe crime variation within cities (Sampson, 2013; Weisburd, 2015).

Social disorganization and crime opportunity theories represent two seemingly disparate theoretical explanations commonly applied to explain the variation of crime within cities. In the middle of the 20th century, the influence of opportunity on criminal behavior was considered only on the periphery of mainstream criminological theories (see Sutherland, 1940; Cloward and Ohlin, 1960). However, more recently, crime opportunity theories have been advanced as a key perspective to explain the variation of crime events at micro-places within cities (Eck and Weisburd, 1995; Braga and

Weisburd, 2010). Opportunity perspectives of crime represent an interconnected class of theories which investigate the interaction of rational offenders, targets, and guardians in specific situational contexts (Cohen and Felson, 1979; Clarke, 1983; Brantingham and Brantingham, 1991). Social disorganization theory was developed through the collective scholarship of sociologists at the University of Chicago, commonly referred to as the "Chicago School" (see Farris, 1967; Bulmer, 1984), in the early 20th century as a socio-ecological mechanism for explaining crime variation between neighborhoods (Shaw and McKay, 1942). The theory has been re-conceptualized and expanded substantially in the decades since its initial formulation (Kornhauser, 1978; Kubrin and Weitzer, 2003) and remains a dominant sociological and criminological perspective on the spatial variation of crime across cities.

Contemporary criminological inquires have considered the integration of social disorganization and opportunity theories to enhance understanding of crime variation within cities (Meir and Miethe, 1990; Rice and Smith, 2002; Weisburd, Groff, and Yang, 2012). Micro-places and neighborhoods are inherently hierarchical in composition; this allows the modeling of both units of analysis simultaneously (see Steenbeek and Weisburd, 2016). The integration of theoretical mechanisms can be expressed using a multi-level framework. For instance, Clarke (1995) suggests the structural characteristics of a neighborhood can indirectly influence situational criminal opportunities at the micro-places which comprise them (also see Wilcox and Land, 2015). Recently, Weisburd et al. (2012) tested an alternative model which integrated social disorganization and opportunity measures at street segments and found that both theoretical perspectives had predictive value in identifying chronic crime places relative to place that experience no or very little crime.

This dissertation research explores the spatial distribution of violence in Chicago. Over the past century, research conducted in Chicago has informed much of our scholarly knowledge on the importance of social disorganization and "neighborhood effects" in understanding crime and delinquency (Sampson, 2012). As will be discussed further, Chicago School researchers were among the first to consider the variation of crime and criminal behavior across neighborhoods in cities (Shaw et al., 1929; Shaw and McKay, 1942). Chicago has served as an on-going laboratory for decades of research on the influence of neighborhood effects on violent crime (Zorbaugh, 1929; Sampson and Raudenbush, 1999; Griffiths and Chavez, 2004; Kirk and Papachristos, 2011). Although a growing number of micro-level analyses have been conducted within Chicago recently (see Block and Block, 1995; Block, Galary, and Brice, 2007; St. Jean, 2007; Bernasco and Block, 2009; Barnum et al., 2016), the city has become synonymous in criminology with studies exploring crime variation at the neighborhood level of analysis.

This study has two key components with three primary empirical analyses; the research questions and analytical approach are discussed later in this chapter. The first component of the study investigates the role of spatial aggregation in describing the distribution of violent crime patterns in Chicago. The initial analysis examines the concentration of violent crime at specific street segments over time in Chicago. A broader analysis observes the unique contribution of micro-places in describing the spatial variability of violent crime while hierarchically accounting for larger levels of spatial aggregation at neighborhoods and larger community areas. Second, the study investigates the integration of social disorganization and opportunity theories to improve explanatory analyses of the spatial variability of violent crime patterns in Chicago. This analysis conducts a multi-level test to determine if both classes of theories can be used together to enhance explanation of the spatial variability of violent crimes at micro-places.

The remainder of this introductory chapter provides a brief review of the available theoretical and empirical research on micro-place and neighborhood variation in crime across urban environments. An abbreviated discussion of key issues pertaining to the integration of these divergent units of analysis and theories in place-based criminology is then presented. The chapter concludes with a presentation of this study's main research questions.

Micro-Places and Criminal Opportunity

Technological advances at the turn of the 21st century allowed for the systematic exploration of crime variation at increasingly smaller spatial units of analysis within neighborhoods. Influential city-wide analyses were first conducted in Boston and Minneapolis; both observed spatial concentration of crime at micro-places. Pierce et al. (1988) found over a six year observation period an average of 3.6% of street addresses accounted for approximately 50% of total calls for service in Boston. In Minneapolis, Sherman, Gartin, and Buerger (1989) noted a remarkably similar concentration; 3% of street addresses and intersections accounted for 50% of the total calls for service over a year. These findings suggest the use of smaller spatial units of analysis to describe crime variation within cities has the potential to capture previously unobserved variation.

A growing number of studies have recently examined the longitudinal distribution of crime at micro-places to test whether these high-crime locations represent stable targets for crime prevention (Braga and Weisburd, 2010). Weisburd et al. (2004) observed 14 years of total crime incident reports at street segments in Seattle finding remarkable developmental stability of patterns including even the most criminally active micro-places. In Boston, Braga and colleagues were able to expand upon this analysis through observing the longitudinal concentration and developmental patterns of gun violence (Braga, Papachristos, and Hureau, 2010) and robbery (Braga, Hureau, and Papachristos, 2011) incidents at street segments and intersections over a 29 year observation period. These studies demonstrate that crime is repeatedly concentrated at certain micro-places or "hot spots" of activity over extended periods of time (also see Weisburd, Morris, and Groff, 2009; Curman, Andresen, and Brantingham, 2015) and further suggest that cities should focus their resources on these persistent problem places (see, e.g. Braga, Papachristos, and Hureau, 2014). Additionally, these findings imply theoretical mechanisms used to explain the distribution of crime at micro-places should account for the temporal persistence of patterns.

Opportunity theories, also commonly referred to as environmental criminology, are frequently used to explain the distribution of crime at micro-places within cities. Three complementary opportunity theories have been pursued to facilitate this understanding: rational choice, routine activities, and crime pattern theory (Braga and Weisburd, 2010; Eck and Weisburd, 1995). Each of these opportunity theories is unique in the broader context of criminology because they ignore the motivation of offenders and focus entirely on the emergence of crime events. Rational choice theory posits that crime is the result of a conscious decision-making process and the use of focused situational prevention strategies at micro-places can discourage individuals from offending (Clarke, 1980). This contemporary extension of rational choice theory (see Beccaria, 1764) argues that potential offenders make decisions at various stages before, during, and after the commission of crimes (Clarke, 1983).

Routine activities theory proposes the spatial-temporal intersection of a motivated offender, suitable target, and the lack of a capable guardian creates the prerequisite conditions for a crime event to occur (Cohen and Felson, 1979). Crime prevention efforts should offer a specific form of supervision or guardianship to each of the three elements to reduce crime (Clarke and Eck, 2003). Crime pattern theory is used to explore the movement of offenders and targets in order to explain how their interaction facilitates the occurrence of crime events at micro-places (see Brantingham and Brantingham, 1991). Crime pattern theory presents the optimal framework to investigate how the three components of routine activities intersect in a specific time and place. Collectively, these opportunity theories offer a comprehensive account of the foreground ecological conditions, opposed to social disorganization which addresses predominantly background ecological conditions (see Wilcox and Land, 2015), which can be used to explain the variation of crime at micro-places within cities.

Eck and Weisburd (1995) suggest the applied use of opportunity theories to explain the variation of crime at micro-places should focus on assessments of facilities and site features. Facilities are non-residential, special purpose structures which serve a specific function such as high schools or restaurants. Risky facilities or “crime attractors” can increase levels of crime at micro-places through enhancing the availability of situational opportunities for a crime event to occur (Eck, Clarke, Guerette, 2007). Physical and social site features at micro-places can impact the immediate situational opportunity characteristics of locations. One of the earliest efforts to comprehend the role of these features on crime is Newman's (1972) theory of defensible space. Disorder can also be conceptualized as a physical or social site feature of micro-places which can increase the availability of opportunities for crime events to occur (Braga and Weisburd, 2010; see Wilson and Kelling, 1982).

The distribution of criminal opportunity at micro-places within cities does not exist in an independent or isolated spatial environment; micro-places are nested within specific neighborhood contexts. The compatibility of criminal opportunity and neighborhood effects explanations of crime variation within cities has been discussed with more frequency during the contemporary revitalization of place-based criminology (Stark, 1987; Bursik and Grasmick, 1993). Clarke (1995) proposed a theoretical model which reinforces the preexisting hierarchical relationship between these explanatory mechanisms and suggests both can be successfully integrated to provide a comprehensive account of the spatial variation of crime. While this integration is intuitive it is surprisingly neglected in place-based criminology in favor of integrations of neighborhood effects and individual theories (Wilcox-Rountree, Land, and Meithe, 1994), hierarchical integrations of a single theory (Sampson, 1988), or integrations which extend mechanisms beyond their original theoretical domain (Weisburd et al., 2012).

Weisburd et al. (2012) conducted a city-wide analysis in Seattle which explored the role of criminal opportunity and social disorganization measures in explaining differences between developmental patterns of crime at street segments. Both sets of measures were found to influence differences between patterns with opportunity measures accounting for a proportionally larger share of explained variance. Braga and Clarke (2014) suggest a potential limitation of this study is the extension of social disorganization measures beyond their original theoretical domain, at the neighborhood-level, to a micro-level unit of analysis. While modeling social disorganization at the micro-level does offer advantages, the authors were able to observe within neighborhood variation of measures, it raises additional problems and does not represent the only viable approach to integrate these two theories. This integration is a subject of on-going debate in place-based criminology (see Weisburd, Groff, and Yang, 2014) and represents one of the most promising frontiers to enhance understanding of crime variation within cities.

Neighborhoods and Social Disorganization

European social scientists in the 19th century are credited with conducting the earliest investigations of crime variation within cities (Parent-Duchatelet, 1837; Mayhew, 1851). Scholarship from the Chicago School in the early 20th century created an ideological framework that would influence all subsequent inquiries on the study of crime variation within cities (Weisburd, Bruinsma, and Bernasco, 2009a). Park and Burgess (1925) proposed an urban sociological approach focused on cities as distinct ecological behavior settings. Within cities, Park and Burgess suggested neighborhoods and large clusters of neighborhoods referred to as “zones” represent important spatial units of analysis which retain social and cultural significance in the organization of urban life. Variation of these characteristics between neighborhoods creates a distinct ecological effect associated with individual neighborhoods (i.e. neighborhood effect) which influences the spatial distribution of social outcomes, such as poverty or infant mortality, within cities. Shaw et al. (1929) conducted the first empirical inquiry from the Chicago School focused solely on the variation of crime within a city.

Social disorganization is an ecological explanatory mechanism developed by the Chicago School to explain the variation of crime between neighborhoods. Thomas and Znaniecki (1920) introduced the earliest iteration of social disorganization theory in their research on the assimilation of Polish immigrants in Chicago. Park and Burgess (1925) applied this concept to the study of variation in social outcomes between neighborhoods within cities. Shaw and McKay (1942) offered an operational representation of the theory using population heterogeneity, socio-economic status, and residential mobility as the three primary neighborhood socio-structural characteristics which influence the distribution of delinquency across neighborhoods. Informal mechanisms of social control, expressed also through the aggregate characteristics of neighborhood residents, were theorized to intermediate the influence of socio-structural characteristics on crime.

Neighborhood based inquiry was marginalized in criminology during the middle of the 20th century due to several critiques of the Chicago School (see Whyte, 1943; Robinson, 1950). A resurgence of interest in neighborhoods occurred in the late 20th century due to the partial mitigation of these earlier critiques. Kornhauser (1978) reformulated the previously inadequate definition of social disorganization theory provided by the Chicago School, diminishing the role of culture, which posited a more concise causal model. Kasarda and Janowitz (1974) proposed a systemic model of community networks which enhanced understanding and measurement of neighborhood informal social control. Building on both of these developments, Sampson and Groves

(1989) conducted the first comprehensive test of social disorganization which found some preliminary support for the theory. Neighborhoods and social disorganization returned to the mainstream of criminological scholarship with several influential publications which openly lobbied for and offered new research on the topic (Reiss and Tonry, 1986; Byrne and Sampson, 1986; Bursik, 1988).

The revitalization of research on neighborhood effects continued through the late 20th century and into the 21st century as the result of several promising developments (see Sampson, Morenoff, and Gannon-Rowley, 2002; Kubrin and Weitzer, 2003). For instance, a reconsideration of the role of culture in understanding neighborhood effects has demonstrated the influence of legal cynicism in explaining levels of crime (Kirk and Papachristos, 2011). Neighborhood effects have also been used to elaborate on the relationship between concentrated disadvantage, race, and crime (Krivo and Peterson, 1996; see Wilson, 1987). The well-known Project on Human Development in Chicago Neighborhoods (PHDCN) has contributed to several advances in scholarly knowledge on neighborhood effects through primary and secondary analyses of data collected through the project (Sampson and Raudenbush, 1999; Silver and Miller, 2004; Browning and Jackson, 2013). Sampson (2012) prominently featured PHDCN data in his exhaustive city-wide analysis of Chicago which proposes a blueprint for the next era of research on neighborhoods and crime.

Collective efficacy is a contemporary theoretical innovation in neighborhood-based inquiry that is closely linked with the PHDCN. Collective efficacy proposes a concise reformulation of the mechanisms of neighborhood informal social control which mediate the relationship between socio-structural characteristics of neighborhoods and crime (Sampson, 2006). Collective efficacy is defined as "social cohesion among neighbors combined with their willingness to intervene on the behalf of the common good" (Sampson et al., 1997; p. 918). Sampson and colleagues developed this theoretical construct through analyses of PHDCN data; it is now commonly used in empirical tests of neighborhood effects (e.g., see Kirk and Matsuda, 2011; Wright and Fagan, 2013). Findings within and outside of Chicago have demonstrated that collective efficacy can successfully mediate the relationship between socio-structural characteristics of neighborhoods and crime within cities (Morenoff, Sampson, and Raudenbush, 2001; Sampson and Wikstrom, 2008).

The role of transition in neighborhoods over time is central to social disorganization theory and has important ramifications for criminal justice policy focused on neighborhood dynamics. Temporal instability of neighborhood composition is a root cause of social disorganization (Park and Burgess, 1925; Shaw and McKay, 1942; Bursik, 1986). For example, one of the neighborhood socio-structural characteristics proposed by Shaw and McKay to influence crime is residential mobility (also see Sampson et al., 1997; Kirk and Papachristos, 2011). Neighborhoods with high levels of residential mobility (i.e. instability) were theorized to have high levels of crime. Neighborhood instability is also associated with persistent levels of crime which suggests that policy remedies should be place-based and focus on the contextual influence of these specific neighborhoods (Bursik and Webb, 1982; Hope, 1995; see Harcourt and Ludwig, 2006). Sampson (2011) suggests community-based programs which foster positive connections between adults and youths can be used to stimulate collective efficacy in neighborhoods. Overall, neighborhoods and social disorganization represent a salient unit of analysis and theoretical paradigm to describe, explain, and address through criminal justice policy the variation of crime within cities.

Theoretical Integration

Theoretical integration is one of three ideological approaches used to guide evaluation and development of criminological theories (see Messner, Krohn, and Liska, 1989; Kubrin, Stucky, Krohn, 2009). This method offers a synthesis of two or more theories to enhance comprehension and explanatory assessment of outcomes (Thornberry, 1989). Integration provides an important alternative to the theoretical falsification and theoretical competition approaches. Both of these strategies have been critiqued for producing an overabundance of theories with limited empirical support in criminology; the use of these strategies has not resulted in consistent improvement of the explanation of variance in outcomes over time (Elliot, 1985; Weisburd and Piquero, 2008). Integration of criminological theories can be expressed in a variety of manners across disciplines, levels of analysis, and propositional forms (Bernard and Snipes, 1996). Integration has been used in criminology to connect a wide range of theories (see Braithwaite, 1989; Laub and Sampson, 2003).

Theoretical integration assisted the historic development of both social disorganization and opportunity theories. Shaw and McKay's (1942) formulation of social disorganization theory proposed a variety of mechanisms which today are associated with the social control, cultural, and strain perspectives (see Kornhauser, 1978). Their formulation is generally not viewed as a traditional integration due to its occurrence prior to the establishment of these independent theoretical perspectives (see

Cloward and Ohlin, 1960; Hirschi, 1969).[1] Nevertheless, their contribution demonstrates how the idea of combining mechanisms was explored in the early development of social disorganization theory. Opportunity theories also represent an overt integration of multiple micro-level theories focused on crime events (Clarke and Felson, 1993; Eck and Weisburd, 1995). This integration produced a more comprehensive account of crime variation at micro-places within cities (Braga and Weisburd, 2010). Theoretical falsification and theoretical competition approaches in explaining the variation of crime within cities have produced substantial empirical contributions and established two disparate literatures around these theories; theoretical integration offers a pathway to further advance knowledge on crime variation within cities.

The integration of opportunity theories and social disorganization has been previously considered in place-based criminology to explain variation across multiple outcomes. The contemporary revitalization of neighborhood effects research coincided with the early development of opportunity theories facilitating the discussion of both as a general class of ecological theories (Stark, 1987). There are several forms of integration that can be considered to represent these two theoretical explanations and their corresponding units of analysis. Sampson and Wooldredge (1987) use a multi-level framework which models neighborhood characteristics and individual opportunity measures to explain victimization outcomes. Weisburd et al. (2012) conduct an "up and down" integration of both theories at the street segment level which offers a parsimonious model to explain variation in developmental patterns of crime. Deryol et al. (2016) present a multi-level model with social disorganization measures represented at

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[1] Strain or anomie theory which appeared in two influential iterations (Durkheim, 1897; Merton, 1938) prior to the publication of Shaw and McKay's *Juvenile Delinquency and Urban Areas* in 1942 can be considered a contemporary theory to social disorganization.

the neighborhood-level and opportunity measures at the micro-level to explain crime variation finding preliminary support for this hierarchical integration.

A multi-level, spatial integration between opportunity theories and social disorganization has been proposed as an important approach to generate a fuller comprehension of crime variation within cities (see Miethe and Mier, 1994; Felson, 2006; Wilcox and Land, 2015). Bursik and Grasmick (1993) highlighted the importance in conceptualizing not only the variation between neighborhoods in social disorganization but also the variation of opportunity characteristics within neighborhoods to explain the distribution of crime within cities. Brantingham and Brantingham (1993) proposed an opportunity model which accounts for the influence of broader neighborhood context (i.e. the "environmental backcloth") as one of multiple composite spatial layers to explain crime variation at micro-places. The recent proliferation of hierarchical modeling techniques has provided a feasible strategy to test this integration (see Johnson, 2010a). While this method does not fully eliminate ambiguity between specific concepts in social disorganization and opportunity theories, it does offer a convenient framework to address this issue. A multi-level integration allows for social disorganization at neighborhoods to express the background structural conditions associated with crime variation and opportunity at micro-places to capture the foreground conditions that influence the crime event.

The Study

This dissertation research aims to enhance our understanding of the spatial variation of violent crime in Chicago using a multi-level framework which integrates components of both opportunity theories and social disorganization. In essence, this research seeks to extend our knowledge of the "criminology of place" (see Sherman et al., 1989; Weisburd, 2015) by analyzing the influence of larger levels of spatial aggregation (i.e., neighborhoods and communities) on small units of analysis (i.e., street segments). Research on the influence of spatial aggregation relies heavily on the specification of units of analysis (see Hipp, 2007; Andresen and Malleson, 2011); this study selected units of analysis which are both important to characterizing social life in Chicago and have appeared in previous empirical efforts conducted within the city. The spatial distribution of violent crime incidents was observed at street segments, neighborhood clusters, and community areas in Chicago. Collectively each of these units of analysis represents a micro (i.e. street segments), meso (i.e. neighborhood cluster), and macro (i.e. community areas) level to summarize the internal geography of Chicago. As will be discussed in greater detail in Chapter 4, these three hierarchical units of analysis are spatially nested with minimal boundary overlap issues and this allows for the estimation of multi-level models.

Each of these units of analysis captures spatial domains specified to represent criminal opportunity theories and social disorganization mechanisms. Measures of the street networks accessibility and the distribution of motivated offenders, suitable targets, and guardianship are used to represent criminal opportunity. Structural and intermediating characteristics of neighborhoods are used to represent social disorganization processes. This study uses violent crime incident reports- an aggregate measure of robberies, homicides, and aggravated assaults - recorded by the Chicago Police Department from 2001 to 2014. This section presents the three research questions that were investigated in this study.

Research Question One

Is distributional concentration and developmental stability of violent crime incidents observed at street segments, neighborhood clusters, and community areas in Chicago?

Research on the spatial distribution of crime at micro-places has repeatedly demonstrated that crime incidents are concentrated at specific locations and the trajectories of these places are characterized by developmental stable within cities (Sherman et al. 1989; Weisburd et al., 2004; Wheeler, Worden, and McLean, 2015). While Chicago has served as an observation site for several longitudinal neighborhood-level inquiries (see Bursik and Webb, 1982; Griffiths and Chavez, 2004, Papachristos et al., 2011), an extensive, city-wide longitudinal analyses of violent crime patterns at micro-places in the tradition of the criminology of place has not been conducted there (see Weisburd, 2015). This research question will test if the law of crime concentration, outlined by Weisburd (2015), even applies in a city that is synonymous with neighborhood-based research.[2] Also, the concentration and stability of violent crime incidents is compared to patterns at both neighborhood-level units of analysis to begin to uncover the role of spatial aggregation in description of the spatial distribution of crime.

[2] The law of crime concentration suggests that even across different cities the distributional concentration of crime is anticipated to fall within a fixed range of the cumulative percent of total micro-units (e.g. 50% of crime is found between 3-5% of micro-units; see Pierce et al., 1988). A more detailed discussion is provided in Chapter 2.

This research question is answered through simple descriptive analyses and more sophisticated statistical modeling. Crime maps and summary statistics are used to examine the repeated cross-sectional distribution of violent crime incidents in Chicago. It was anticipated that these simple analyses will illustrate a disproportionately large amount of violent crime incidents accounted for by a small number of street segments, neighborhood clusters, and community areas. Lorenz curves, Gini coefficients, and other descriptive analyses are then used to compare the degree of distributional concentration at street segments, neighborhood clusters, and community areas (see Johnson, 2010b). Group-based trajectory modeling is then used to analyze longitudinal patterns of violence at street segments, neighborhood clusters, and community areas (Weisburd et al., 2004; Griffiths and Chavez, 2004). This statistical technique provides an objective approach to categorizing the large number of units of analysis for each spatial level in Chicago into a small number of distinct trajectory groupings based on the level of violence and developmental growth pattern over the observation period. These developmental trajectories are used to understand the longitudinal concentration of violent crime incidents at the most active street segments in Chicago and to summarize developmental patterns throughout the entire city.

Research Question Two

How much of the total spatial variability of violent crime incidents can be uniquely attributed to street segments, neighborhood clusters, and community areas in Chicago?

Research on the distribution of crime at micro-places in cities suggests these units capture unique spatial variation that cannot be observed when using larger place-based units of analysis to describe the distribution of crime within cities (Sherman et al., 1989;

Groff, Weisburd, and Yang, 2010). The importance of spatial aggregation in place-based criminology is often discussed (see Rengert and Lockwood, 2009) but very few empirical inquires attempt to directly specify the relationship between micro-places and neighborhoods in describing variation in crime patterns within cities (see Andresen and Malleson, 2011). Steenbeek and Weisburd (2016) recently assessed the distinct contributions made by micro, meso, and macro units of analysis to understand crime variations within The Hague, Netherlands. After using multi-level models to capture the preexisting hierarchical relationship between these units of analysis, the authors found that street segments accounted for almost two-thirds of the variation of total crime incidents within the city relative to two different types of neighborhood units of analysis. A similar approach is used to investigate the influence of street segments, neighborhood clusters, and community areas in explaining the spatial variability of violent crime in Chicago.

Multiple analyses are conducted to answer this research question. Descriptive techniques such as crime maps and summary statistics are used to examine the nested spatial distribution of violent crime incident developmental patterns at street segments within neighborhood clusters and community areas in Chicago. Steenbeek and Weisburd's (2016) multi-level statistical analysis is replicated to account simultaneously for the hierarchical relationship between the three units of analysis. Linear mixed models are estimated to observe the unique variance attributed to each of the units of analysis for each year of the 14 year observation period.

Research Question Three

Do opportunity measures at street segments explain differences between levels of violent crime incidents at street segments when accounting for social disorganization measures at neighborhood clusters in Chicago?

The existing empirical evidence on the integration of social disorganization and opportunity theories suggests that combining important concepts from both theoretical perspectives can enhance scholarly understanding of urban crime problems (Meithe and Meir, 1990; Andresen, 2006; Weisburd et al., 2012). However, it is important to note that analyses seeking to blend key concepts from differing theoretical perspectives can be limited by concerns over the appropriate conceptual and operational forms used to represent this integration (Braga and Clarke, 2014; Weisburd et al., 2014). In this study, a multi-level model was specified which recognizes the pre-existing hierarchical relationship of street segments within specific neighborhood clusters in Chicago and takes advantage of covariates representing key constructs from social disorganization and crime opportunity theories.

Criminologists have long suggested that the structural characteristics of neighborhoods influence the extensiveness and types of criminal opportunities that exist at specific places within their geographic boundaries (see Clarke, 1995 for a summary). Unfortunately, very few empirical investigations have been conducted to complement these theoretical expositions (see Bursik and Grasmick, 1993; Wilcox and Land, 2015). This research represents a modest attempt to understand how specific crime opportunity variables influence violence at street segments controlling for the influence of larger risk and protective factors occurring at the neighborhood-level. The analytical model provides a preliminary exploration of a multi-level approach to uncover whether key theoretical concepts occurring simultaneously in nested units of analysis can be used to explain the spatial variability of violent crime in Chicago.

Several analyses are conducted to explore the influence of social disorganization and opportunity measures on violent crime incidents at street segments in Chicago. The independent relationship between neighborhood-level social disorganization and street segment-level opportunity measures to violent crime is tested separately before estimation of a multi-level model. Social disorganization variables are measured using data from the U.S. Census and the Project on Human Development in Chicago Neighborhoods (PHDCN). Opportunity variables are measured using data from the City of Chicago's data portal and the Chicago Police Department. A generalized linear mixed model is then estimated to assess the hierarchical relationship between social disorganization measures at neighborhoods and opportunity measures at street segments to explain the variability in counts of violent crime incidents at street segments. Several variations of models are considered which account for the unique influence of criminal opportunity within different neighborhood contexts. It was anticipated that these analyses would provide a modest but insightful empirical exploration of the utility of a multi-level integration of the two predominant units of analysis and theoretical perspectives in the study of crime variation within cities.

CHAPTER 2 – MICRO-PLACES AND CRIME

This chapter offers a literature review of the available theoretical and empirical contributions that have demonstrated the importance of small places in understanding the distribution of crime events within cities. The study of place in criminology is a divergence from traditional criminological inquiry which primarily focuses on criminality of individuals (Lombroso, 1899; Sutherland, 1947; Gottfredson and Hirschi, 1990). This perspective has dominated the history of criminology with a handful of exceptions (Sellin, 1938; Messner and Rosenfeld, 1994). Early contributions in place-based criminology investigated larger units of analysis such as cities or neighborhoods (Quetelet, 1831; Park and Burgess, 1925). These contributions are reviewed in Chapter 3 to provide a historic appraisal of place-based criminology and also the broader context in cities which micro-units of analysis are nested within.

Contemporary research in criminology still remains focused on individuals despite a growing interesting in place (Eck and Weisburd, 1995; Sampson et al., 2002). For instance, Weisburd (2015) observes that two-thirds of all empirical analyses in the journal *Criminology* from 1990-2014 assessed individuals as the primary unit of analysis. Weisburd and Piquero (2008) examined the explained variance of models in the same journal from 1968-2005 noting stagnation in the improvement of these statistics over time which the authors partially attributed to the limitations of relying on individual-based theories to guide explanation. Scholarship over the past 30 years within place-based criminology has increasingly developed micro-units of analysis as an attractive alternative to individual-based inquires (Sherman et al., 1989; Weisburd et al., 2012). The study of crime at micro-places within the broader context of place-based criminology offers a wide range of units of analysis, a concise theoretical framework, and evidence-based crime prevention strategies to understand the spatial variability of crime within cities. Weisburd (2015) even argues that a turning point in the developmental life course of the entire disincline of criminology (see Laub, 2004) has been reached because of the robustness of inquiry on the criminology of place.

This chapter discusses research on micro-places and crime, alternatively known as the criminology of place or “crime and place”, in four distinct sections. The first section contains a discussion of micro-units of analysis and the issue of spatial aggregation in place-based criminology. The second section offers an overview of research on the distribution of crime within cities at micro-places. The third section provides a review of criminal opportunity theories and how they inform understanding of the spatial variability of crime at micro-places within cities. The fourth and final section highlights how criminal opportunity theories can be applied to understand how specific facilities and site features at micro-places influence the emergence of crime events.

Micro-Places and Spatial Aggregation

Micro-places are a broad class of spatial units of analysis including but not limited to street addresses, intersections, or city blocks (see Eck and Weisburd, 1995). These small spatial units of analysis have been suggested as useful behavioral settings which capture the daily rhythms of urban life (Jacobs, 1961; Appleyard, 1981; Taylor, Gottfredson, and Brower, 1984). They represent vital activity hubs where residents in cities interact with each other throughout the course of their lives (Whyte, 1943). In addition to their social influence these units of analysis, initially considered on the margins of early place-based research (see Mayhew, 1851; Shaw et al., 1929); have become more practically viable due to several contemporary developments. Specifically, the intersection of new geo-spatial analytic software packages, enhanced processing power of personal computers, and accessibility of place-based administrative data has driven this revolution (see Weisburd et al., 2012).

Micro-places are generally conceptualized as spatial units of analysis that comprise larger neighborhoods. The idea that crime variation exists not only *between* neighborhoods but also *within* neighborhoods has been considered in place-based criminology for centuries (Mayhew, 1851; Hawley, 1950; Groff et al., 2010). Throughout the history of place-based criminology scholars have consistently explored smaller units of analysis over time (see Weisburd et al., 2009a). This is important to note for two reasons. First, the viability of research on micro-places and crime is predicated not only on demonstrating the merits of these units of analysis independently but also how they provide a comparative advantage to larger spatial units of analysis. In spatial analyses this issue is known as the "modifiable aerial unit problem" (Ghelke and Biel, 1934; Openshaw, 1983). Second, micro-places represent the lowest possible level of spatial aggregation to investigate crime variation. After exhaustively investigating these units of analysis, since there is no small unit to consider, place-based criminology can begin to fully address the role of spatial aggregation.

Initially, the observation of crime concentration at micro-places was used to demonstrate that inquires in place-based criminology should be shifted to exploring micro-places (Sherman et al., 1989). Recent research on this topic is beginning to demonstrate that micro-places offer a unique description of crime variation compared to larger spatial units of analysis. Street segment to street segment heterogeneity was observed between developmental patterns of total crime incidents in Seattle (Groff et al., 2010). Increasing variation within smaller levels of spatial aggregation was found when assessing total crime patterns in Vancouver (Andresen and Malleson, 2011). A multi-level analysis in The Hague, Netherlands determines that street segments account for the largest share of total spatial variance in crime patterns over a nine year observation period (Steenbeek and Weisburd, 2016). This would suggest studies of urban crime problems focused on neighborhoods miss important micro-spatial variability that can be used to enhance understanding of these problems (Eck and Eck, 2012; Weisburd 2015).

Contemporary place-based research has adopted a "small is better" approach, since micro-level units minimize within group heterogeneity (Oberwittler and Wikstrom, 2009). The specification of units of analysis has received substantial scholarly attention recently in place-based criminology (Hipp, 2007; Weisburd, Bernasco, Bruinsima, 2009b). The presence of spatial homogeneity helps to avoid the incorrect assumption that patterns observed across larger units apply equally to the collection of smaller units which comprise it (Johnson et al., 2009), a problem commonly referred to as the "ecological fallacy" (Robinson, 1950). The use of micro-units has been challenged because they could offer poor representations in a handful of contexts due to certain social processes and human behaviors inherently occurring on a larger spatial scale (Hunter, 1985; Boessen and Hipp, 2015). A focus on micro- or even meso- units may be too narrow, suggesting macro-areas such as neighborhoods are the most important scale of ecology in the study of crime (Hipp and Boessen, 2015; Mears and Bhati, 2006). These issues are further discussed in Chapter 3. Overall, a growing amount of empirical evidence does suggest micro-places offer a more refined description of crime variation within cities compared to larger spatial units of analysis. Continued investigation of the role of spatial aggregation in place-based criminology can provide further nuance to this understanding.

The Distribution of Crime at Micro-Places

While early contributions from place-based criminologists did observe the concentration of crime and delinquency at micro-places within cities (see Shaw and McKay, 1942; Hawley, 1950; Crow and Bull, 1975) comprehensive, city-wide assessments of their spatial distribution did not occur until the late 1980s.[1] This section is divided into overviews of both cross-sectional and longitudinal analyses of the spatial distribution of crime at micro-places within cities. The first section highlights two seminal studies which influenced all subsequent inquires on the subject. The second section offers an overview of recent expansions of these studies which investigate developmental patterns of crime at micro-places within cities.

Cross-Sectional

In their report *The Character of Police Work: Strategic and Tactical Implications*, Glenn Pierce, Susan Spaar, and LeBaron Briggs (1988) provided an exhaustive analysis of the spatial distribution of six years of call for service data (1977-1982) in Boston. Collectively the authors assessed three different micro-units of analysis: street addresses,

[1] For example, Shaw and McKay (1942) essentially conducted a micro-level analysis in the earliest iteration of their study. The authors located juvenile delinquents using their home address (i.e. micro-units) but subsequently aggregated findings to neighborhood-levels.

street blockfaces and street intersections.[2] The last two were combined into a single "street blockface or street intersection" unit of analysis. A neighborhood unit of analysis was additionally considered; operationalized by using Geographic Reporting Areas which the Boston Police Department designed encompassing 6 to 12 city blocks. Over 2,900,000 total calls for service were identified to 703,830 street addresses through the creation of a database using the Boston Police Department's Computer Aided Dispatching (CAD) system. The use of calls for service data as an outcome measure of crime does have limitations (see Klinger and Bridges, 1997) but is still an useful source of administrative data collected by the police (see Braga and Bond, 2008).

Pierce and colleagues observed the mean value of calls for service across all six years.[3] For the first micro-unit of analysis; 3.6% of street addresses requested 50.1% of the total calls for service over the observation period. A larger degree of concentration was observed when focusing on the most active street addresses. 0.22% of street addresses, averaging over 100 calls for service per year, generated 13.1% of the total calls for service in Boston. 56.4% of street addresses were relatively crime free over the observation period averaging less than two calls for service per year. For the second micro-unit of analysis findings were similar; 6.9% of street blockfaces or intersections requested 53.3% of the total calls for service over the observation period. The most active street blockfaces or intersections averaged over 300 calls for service per year, representing 0.25% of the city while requesting 11.1% of the total calls for service per year. 37.6% of these units were relatively crime free over the observation period

[2] A blockface is all of the street addresses on one side of a street between two intersections compared to a street segment which is both sides of a street (i.e. two blockfaces) between two intersections.
[3] The copy of this report used as a reference for this dissertation from the Criminal Justice Library at Rutgers University did not have traditional pagination since it was a reproduction of this document. The following statistics were extracted from Chapter VI Tables I – VIII of the document.

averaging less than two calls for service per year. Concentration of calls for service was found at the neighborhood unit of analysis, 23.4% requested 55.8% of total calls, but was comparatively more diffuse then the two micro-place units. Across disaggregate categories of calls for service an even greater concentration was observed. For example, only 9.4% of street blockfaces or intersections represented 82.6% of the total calls for service for gang disturbances.

Lawrence Sherman, Patrick Gartin, and Michael Buerger (1989) conducted a more nuanced description of the spatial distribution focused on a single year of total calls for service in Minneapolis. The authors analyzed over 323,000 calls for service from December 15, 1985 to December 15, 1986 initially collected using the Minneapolis Police Department's CAD system then transferred weekly to an independent database maintained on a personal computer. The calls for service were identified to approximately 115,000 micro-units of analysis: street addresses and street intersections within the city. Similar to findings in Boston, the spatial distribution of total calls for service were disproportionately concentrated at a small number of micro-places in Minneapolis. 3.3% of street addresses and intersections requested 50.4% of total calls for service.

The most active 5% of these locations in Minneapolis averaged 24 total calls for service for the entire year with one location placing 810 calls. Disaggregate calls for service demonstrated even greater degrees of spatial concentration. All robbery and auto-theft calls for service were concentrated to 2.2% and 2.7% of Minneapolis respectively although against only 3.5% of total locations possible in the city. The authors observe that the overall findings of concentration in calls for service do not follow the expected values from a Poisson probability distribution indicating this concentration is greater than anticipated. A majority of street addresses and intersections within the city requested almost no calls for service. 39.6% of locations did not request a call for service while 41.0% requested only one or two calls. When observing the spatial distribution of total calls for service in Minneapolis the authors also noted variation across all types of neighborhoods. This finding suggests that even within the most dangerous neighborhoods there are micro-places which experience little or no crime.

Collectively the findings from Boston and Minneapolis suggested the spatial distribution of crime at micro-places in cities is disproportionately concentrated. A small number of places within both cities were responsible for a larger number of the total calls for service to each city's police department. In Boston, Pierce and colleagues found lower levels of spatial aggregation appeared to provide the most refined description of crime variation within the city. In Minneapolis, Sherman and colleagues began to outline how these findings could influence crime prevention strategies and criminological theory. They coined the phrases "hot spots" and the "criminology of place" which would become readily adopted by future research on the topic. The impact of the Minneapolis study would eclipse Pierce and colleagues research in Boston despite being published a year later; according to a forward search conducted using Google Scholar as of February 2016, the former is cited over ten times more frequently then the latter.

Since the publication of the Boston and Minneapolis findings, the distributional concentration of crime at micro-places in cities has been repeatedly observed across other units of analysis, outcomes, and jurisdictions (Weisburd and Telep, 2014). Few studies would directly replicate the city-wide methodology used in Boston and Minneapolis;

instead these analyses would be used as descriptive overviews for hot spot policing evaluations conducted within cities. Weisburd, Maher, and Sherman (1992) expanded on previous findings by investigating the city-wide distribution of total calls for service at street segments or blocks in Minneapolis over an entire year. The authors conducted their analysis two years after the original study in the city and observed the most active 2.5% of units in the city accounted for 25.0% of total calls for service (also see Sherman and Weisburd, 1995).

Weisburd and Green (1994) investigated the distribution of drug arrests and calls for service at street segments and intersections over six months in Jersey City. The authors also observed distributional concentration; only 226 of 4,404 (5.1%) street segments and intersections experienced an arrest or call for drug related service (also see Weisburd, and Green, 1995). Investigating hot spots of crime in Jersey City using data two years later found that 6% of all street segments and intersections accounted for between 20-25% of robbery and assault calls for service in addition to incidents (Braga et al., 1999). Concentration of crime was also observed when exploring disaggregate crime trends such as gun crimes (Sherman and Rogan, 1995a) in addition to drug dealing at crack houses (Sherman and Rogan, 1995b) in Kansas City.

Eck, Gersh, and Taylor (2000) analyzed over a year of crime incidents in the Bronx observing distributional concentration but comparatively less than previous studies with 10% of street addresses only accounting for 31.5% of total crime incidents. Weisburd, Telep, and Lawson (2014b) later investigating the distribution across all of New York City finding 5% of street segments accounted for 50% of total crime incidents. Findings on the concentration of crime at micro-places have also been documented in jurisdictions outside of the United States (see Forrester et al., 1990). In Tel Aviv-Jaffa, Israel 4.5% of street segments accounted for 50% of total crime incidents (Weisburd and Amram, 2014). In Vancouver, Canada across three years (1991, 1996, and 2001) and seven crime categories between 0.8-8.1% of street segments accounted for 50% of crime incidents (Andresen and Malleson, 2011).

Longitudinal

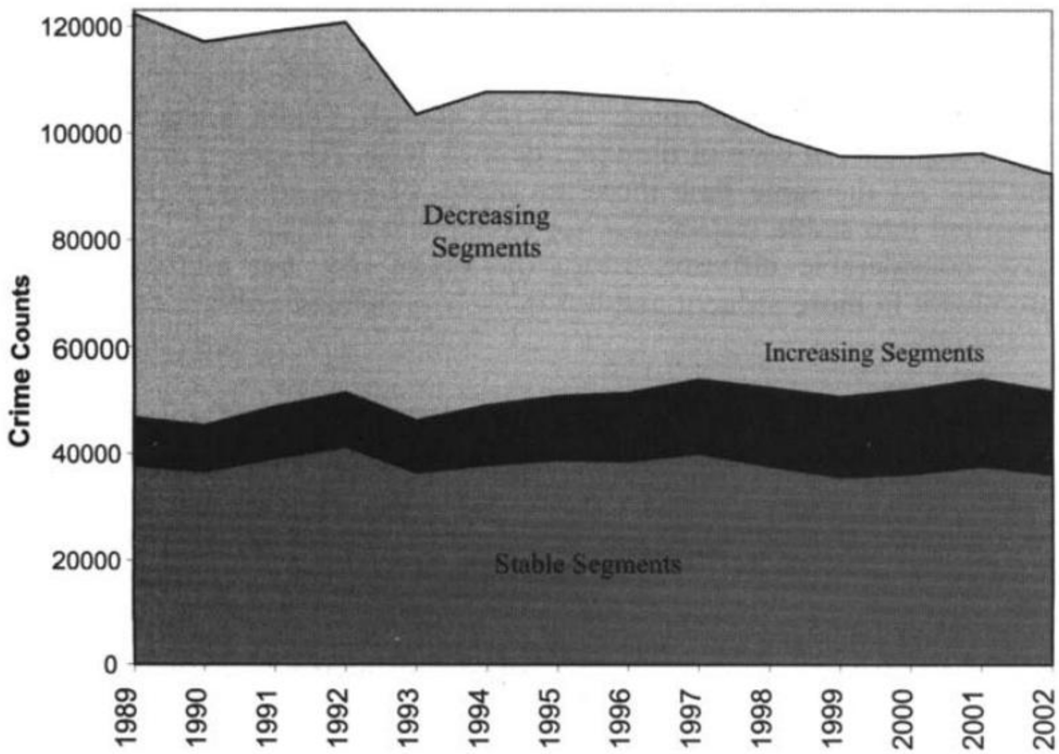
Recent empirical inquiries have started to study developmental patterns of crime patterns at micro-places within cities. While the empirical documentation of the cross-sectional distributional concentration was insightful, uncovering the longitudinal stability or volatility of crime patterns at micro-places within cities has even more important implications for criminal justice policy and criminological theory. Stability of longitudinal patterns offers more support for the use of crime prevention strategies targeting problem places since this stability suggests crime problems are deeply intertwined with places (Braga and Weisburd, 2010). Volatility of patterns indicates the opposite, that crime problems are fleeting at places and strategies targeting these locations are in turn reactive, not proactive responses (see Weisburd and Eck, 2004). For criminological theory, the stability of longitudinal patterns could indicate the root causes of crime problems at places are deeply intertwined with locations (see Clarke, 1980). Volatility could suggest a larger degree of spatial-temporal situational unpredictability of the emergence of crime events at places (see Felson and Steadman, 1983)

Empirical evidence suggests that crime patterns are longitudinally stable at micro-places in cities. Using three years of calls for service data from municipal facilities in Boston, Spelman (1995) observed relative stability of patterns over time. Taylor (1999) also noted stability in patterns of crime incidents at street blocks in Baltimore between two waves of data measured 12 years apart (1982 to 1994). Using repeated cross-sections is a crucial first step in assessing longitudinal patterns but it does not uncover if the same or different micro-places are being captured each year. Weisburd and colleagues (2004) conducted a city-wide analysis of the longitudinal distribution of crimes at micro-places that provided a blueprint, similar to Sherman et al., (1989), for all subsequent inquiries on the topic. The author's geocoded total crime incidents to street segments in Seattle over a 14 year observation period (1989-2002) and then used group-based trajectory modeling (see Nagin, 2010) to characterize developmental patterns city-wide. For each of the 14 years distributional concentration of between 4-5% of street segments accounting for 50% of incidents was observed.

Eighteen distinct developmental trajectories for total crime incidents at street segments were discovered. Of these trajectories, only eight experienced stable growth patterns over the observation period but they accounted for 84% of all street segments in Seattle. Only three trajectory groupings were categorized as having an increasing developmental pattern, these street segments accounted for only 2% of the total number of units in the city. The authors concluded that the seven trajectory groupings which experienced decreasing developmental patterns of crime incidents, which accounted for the remaining 14% of street segments, were the catalysts for driving the city-wide crime reduction that occurred in Seattle during the observation period. Figure 2.1 illustrates the influence of these respective street segments on the city-wide crime trend. Replications in Seattle, Vancouver, and Albany were all able to generally support these results (Weisburd et al., 2012; Curman et al., 2015; Wheeler et al., 2015). These findings suggest that not only are a small number of crime hot spots in cities responsible for a disproportionate amount of crime in a single year but they also drive city-wide crime trends over extended periods of time.

Replications of the Seattle study have also explored the longitudinal distribution of disaggregate categories of crime patterns at micro-places. Juvenile crime incidents at street segments in Seattle were assessed over the same observation period as the original Seattle study (Weisburd, Morris, and Groff, 2009c). The authors find even greater concentration of incidents when investigating this disaggregate crime pattern; only 86 out of the roughly 30,000 street segments in Seattle account for approximately one-third of all juvenile crime incidents. While volatility of developmental patterns of these incidents was observed the most active street segments were overall quite stable. Braga and colleagues (2010) offered a unique expansion of the original Seattle study. Instead of using group-based trajectory modeling to assign developmental patterns, the authors used growth curve regression models to characterize development of gun violence incidents at both street segments and intersections over 29 years (1980-2008) in Boston.

Figure 2.1: Total Crime Incidents in Seattle by Developmental Pattern, 1989-2002



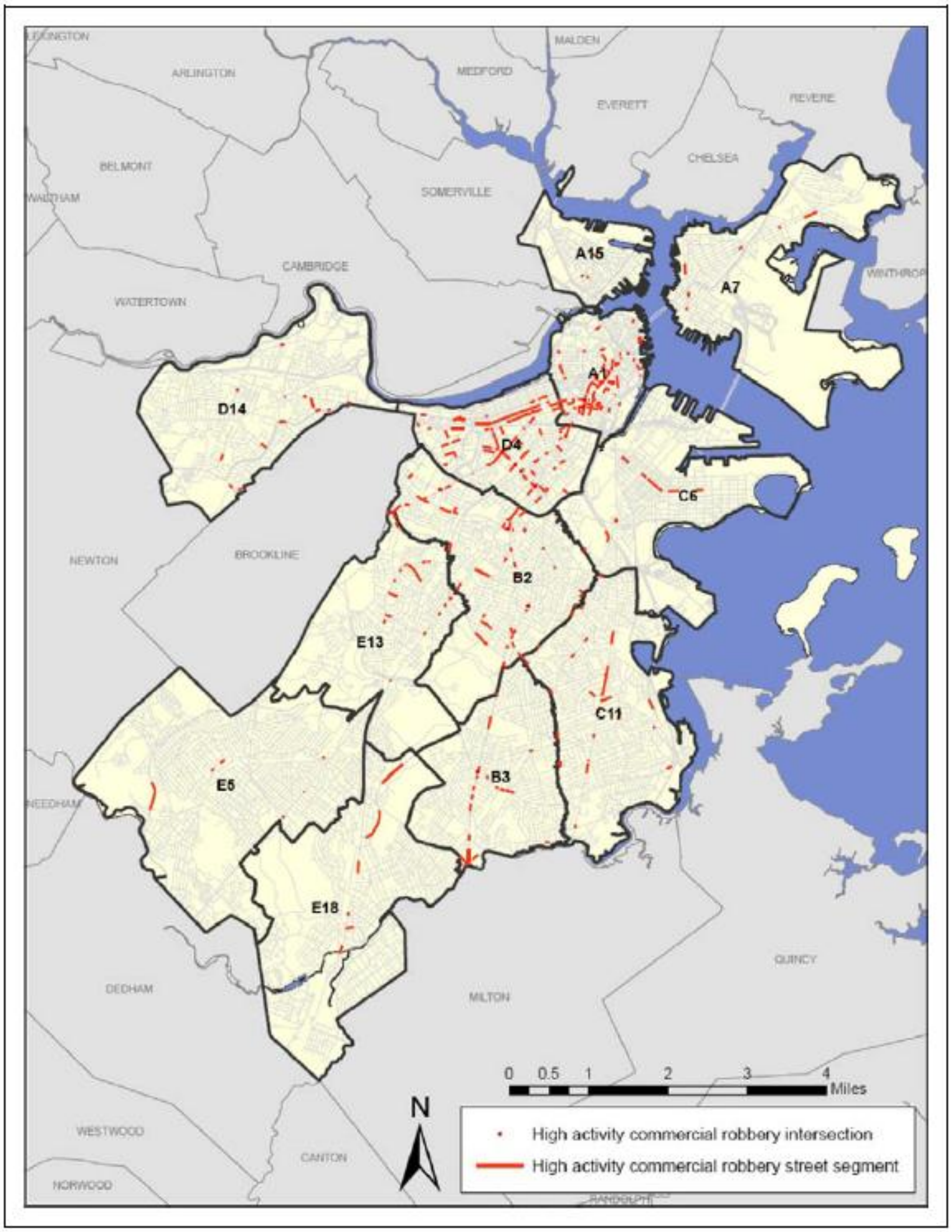
Source: Weisburd et al., 2004

A remarkable level of concentration was found; 4.8% of street segments and intersections experienced 73.9% of gun violence incidents over the observation period. Three developmental groups were assigned to the 11.5% of total units which experienced gun violence: one incident (6.7% of total units, 26.1% of incidents), volatile (2.9% of total units, 52.5% of incidents), and stable (1.9% of total units, 21.3% of incidents). The authors also conducted an additional city-wide analysis in Boston exploring the longitudinal distribution of robbery incidents over the same observation period (Braga et al., 2011). Around 2% of street segments and intersections accounted for 50% of robbery incidents for each year studied while 8.8% of the most active of these units accounted for 68.2% of incidents over the 29 year period in Boston. Such stability of developmental patterns was found that the authors characterized observed trajectories entirely based on levels of incidents (i.e. low, medium, high) instead of growth (i.e. increasing, decreasing, stable). Figure 2.2 illustrates the spatial distribution of street intersections and segments with high levels of commercial robbery incidents over time in Boston. These micro-places are generally concentrated in certain areas although they represent only a handful of micro-places in these locations and are diffused throughout the entire city.

Weisburd (2015) proposes a law of crime concentration at micro-places as a result of the consistency of findings across both cross-sectional and longitudinal research on the distribution of crime within cities (also see Wilcox and Eck, 2011; Weisburd et al., 2012). The concentration of crime at micro-places is suggested to be even greater than the concentration of crime in chronic offenders within cities (Sherman, 1995; see Wolfgang, Figlio, Sellin, 1972). Outside of criminology the concentration of human activity and other outcomes is also frequently observed (see Allport, 1934) and certain disciplines even have corresponding rules which characterize these phenomena (see Pareto, 1909; Lipovetsky, 2009).

The law of crime concentration is constructed on two generalized findings based on research on the distribution of crime at micro-places. First, that the distribution of crime within cities is concentrated a micro-places. Weisburd (2015) even proposes a specific range or "narrow bandwidth of percentages for a defined cumulative proportion of crime" to summarize this concentration (p. 138). Second, a majority of micro-places within cities are characterized by developmental stability of crime patterns. This

Figure 2.2: The Spatial Distribution of Micro-Places with High Concentrations of Commercial Robberies in Boston, 1980-2008



Source: Braga et al., 2011

suggests that regardless of the level of crime at a micro-place (e.g. low, high, etc.) that over time, these places generally experience the same level of crime year to year.[4]

Opportunity Theories

Research on the distribution of crime at micro-places within cities generally applies criminal opportunity theories to explain the spatial variability of patterns between units of analysis (Sherman et al., 1989; Weisburd et al., 2012). The consideration of criminal opportunities in criminological theory is not entirely new (Sutherland, 1940; Cloward and Ohlin, 1960) although contemporary scholarship has established the study of opportunity as a distinct theoretical approach within criminology (Eck and Weisburd, 1995). Opportunity theories are pragmatically focused on crime events and situational influences (i.e. foreground conditions) opposed to other theoretical frameworks (see Agnew, 1985; Gottfredson and Hirschi, 1990) concerned with individual motivation or criminal dispositions (i.e. background conditions). While these theories are not exclusively limited to micro-level analyses (Brantingham and Brantingham, 1991) they provide an ideal theoretical construct to assess the distribution of crime at micro-places within cities. Three complementary criminal opportunity theories are frequently considered together: rational choice, routine activities, and crime pattern theory (Eck and Weisburd, 1995). Broken windows theory, which is not exclusively classified as an opportunity theory, can also be used to understand the spatial distribution of crime at micro-places within cities (Braga and Weisburd, 2010).

[4] The first tenet of the law of concentration is more robust empirically since fewer studies have been conducted on the longitudinal spatial distribution of crime at micro-places within.

Rational Choice

Rational choice theory posits the act of committing a crime is inherently purposive and that an individual's participation in a crime event is the result of a cognitive decision-making process (Cornish and Clarke, 1986). This decision-making process can be limited or bounded to varying degrees of rationality (see Simon, 1972) but is nevertheless still a rational process. Clarke and Cornish (1985) separate the decision-making process into various choices across different stages of involvement. Clarke (1995: p. 10) suggests "a fundamental distinction be made between criminal involvement and crime events"; with the former being "multi-stage and extend over substantial periods of time" and the latter being "frequently shorter processes, utilizing more circumscribed information largely related to immediate circumstances and situations".

Historically, the specification of the earliest iteration of rational choice theory predates the founding of criminology as an academic discipline. Enlightenment scholars Cesare Beccaria (1764) and Jeremy Bentham (1789) proposed that individuals consciously choose to commit crimes and their decision-making process can be influenced by the punishments associated with certain crimes. This scholarship also provided the foundation for deterrence theory in criminology (Nagin, 1975; Apel and Nagin, 2011). Becker (1968) introduced an influential choice model in economics which reinvigorated discourse and contemporary research on the subject throughout the social sciences (see Friedman and Hechter, 1988; Becker, 1993). In his contemporary development of the rational choice perspective in criminology, Clarke (1983) suggested that the decisions made during a crime event were primarily rooted in the offender's assessment of specific criminal opportunities. A critique of rational choice theory is that it does not readily propose a model which is testable since decisions can always be interpreted to an extent as rational (Parson, 1951; Loughran et al., 2016). This critique can be assuaged by offering hypotheses about offender behavior and crime events which opportunity theories explicitly address (Eck and Weisburd, 1995).

Eck and Weisburd (1995; p. 5) suggest “a rational choice perspective provides the basic rationale for defining places as important, since it suggests that offenders will select targets and define means to achieve their goals in a manner that can be explained”. Cornish (1993) views rational choice as a meta-action theory because it specifically outlines how human decisions lead to crime outcomes. Offenders follow a situational progression that can be approximated through crime scripts (Cornish, 1994). This perspective also emphasizes adopting a crime specific prevention focus since scripts are unique for each particular offense (Clarke, 1983). Situational characteristics of locations can influence the available opportunities for crime through encouraging or discouraging actions of individuals at the micro-level (see Clarke and Cornish, 1985). For example, the presence of street lights could decrease the likelihood a potential robbers decides to commit a crime at a location while the presence of a bar on an adjacent street could increase the likelihood (see Roenck and Meir, 1991; Wright and Decker, 1997; Welsh and Farrington, 2008).

The contemporary development of the rational choice perspective as an opportunity theory has also coincided with the emergence of situational crime prevention strategies. Clarke (1980) explicitly uses the former as a tool to ground the latter in. Through the targeting of the situational characteristics of locations, which facilitate the commission of specific crimes, crime control reductions can be achieved (Clarke, 1995).

Evaluations of situational crime prevention strategies suggest they are an effective approach for crime control (Guerette and Bowers, 2009; Clarke, 1997). While the threat of crime displacement, the diversion of crime to other locations or offenses based on the intervention, exists due to these strategies empirical evidence suggests it rarely occurs (Guerette and Bowers, 2009). Instead the presence of its inverse or diffusion of crime control benefits is more often found (Clarke and Weisburd, 1994). Overall, the rational choice perspective contributes to explaining the distribution of crime at micro-places within cities through outlining the link between individual’s actions and place-based characteristics that can be modified to reduce the likelihood of the commission of crime at locations. This suggests the concentration of crime events at micro-places should also coincide with the concentration of place-based characteristics at micro-places which establish these locations as beneficial for individuals to repeatedly commit crimes there (Eck et al., 2007).

Routine Activities

Routine activities theory offers a convenient approach to understand how the interaction of individuals and certain locations results in the emergence of crime events. This theory suggests the spatial-temporal interaction of motivated offenders, suitable targets, and the absence of capable guardians are the prerequisite conditions or “chemistry” for crime events to occur (Cohen and Felson, 1979; see Felson and Eckert, 2015). The theory builds on Hawley’s (1950) investigation of the spatial-temporal intersection of conditions which influenced the distribution of other social outcomes at neighborhoods. Routine activities theory was first introduced with a macro-level spatial analysis - exploring the factors associated with changes in national crime rates- but the theory can be applied across various units of analysis (see Sampson and Wooldredge, 1987; Smith, Glave-Frazee, and Davison, 2000). Cohen and Felson (1979) initially used the theory to explain increases in predatory crime rates during the 1960s and 1970s in the United States. The authors find "the dispersion of activities away from households and families increases the opportunity for crime and thus generates higher crime rates… as a byproduct of changes in such variables as labor force participation and single-adult households" (p. 588). Today, routine activities theory is primarily explored using within city spatial units of analyses (see Rice and Smith, 2002; Weisburd et al., 2012).

The integration of routine activities and rational choice perspectives offers an enhanced comprehension of the situational characteristics at places which influence crime events (Clarke and Felson, 1993). As a result of opportunity theories ignoring offender's motivation entirely this issue is approached through the rational choice perspective. Conceptually, suitable targets are malleable depending on the specific crime category routine activities are used to explain. An important distinction can be found between property crimes and violent crimes because suitable targets switch from being objects, which are more closely associated with places, to people, which are more dynamic spatially. The concept of capable guardians or "guardianship" is used to represent individuals which offer informal social control as opposed to sources of formal social control at place (i.e. police officers). According to Clarke and Felson (1993) "the most likely persons to prevent a crime are not policemen (who seldom are around to discover crimes in the act) but rather neighbors, friends, relatives, bystanders, or the owner of the property targeted" (p. 3). Guardianship as an indicator of informal social control at places can also be used to link routine activities theories to other place-based theories of crime (Braga and Clarke, 2014).

The interaction of these three components of routine activities can be illustrated using the problem analysis triangle (Eck, 1994). More importantly, the problem analysis triangle incorporates a controller for each of the three components of routine activities which can be used to prevent crime (Clarke and Eck, 2007; Eck and Clarke, 2003).[5] Sampson, Eck, and Dunham (2010) have even proposed introducing a third layer of "super controllers" to fortify understanding of techniques for crime control at problem places. Since routine activities proposes the intersection of all three components is necessary for a crime event to occur this perspective suggests crime prevention efforts be focused on disrupting this convergence (Felson, 1987). The routine activities perspective provides a theoretical framework for problem-oriented policing and situational crime prevention strategies which have demonstrated effectiveness in reducing crime through targeting problem places within cities (Guerette and Bowers, 2009; Weisburd et al., 2010).

Over the past thirty years scholarship on routine activities (see Andresen and Farrell, 2015) has diversified to include tests of the theory (Messner and Blau, 1987) , integration with disparate criminological theories (Franklin et al., 2012) and expansions to cyber-space which radically reconsider the concept of "place" (Reyns, 2013). Collectively, scholarship on routine activities theory aids understanding of the distribution of crime at micro-places within cities through providing a framework to

[5] One modification to the problem analysis triangle is exchanging the concept of absence of capable guardian to the broader concept of "place" since the concept of guardianship is expanded on the controller level of the triangle.

begin identifying the specific characteristics of places which influence rational offenders to select them to commit crime.

Crime Pattern Theory

Crime pattern theory investigates the distribution, movement, and interaction of criminal opportunities across time and space (Brantingham and Brantingham, 1991).[6] Crime pattern theory expands upon the contributions of rational choice and routine activities theory through offering a broader understanding of the dynamic nature of criminal opportunities at places. Rational choice theory outlines the decision-making processes of potential offenders. Routine activities theory demonstrates how these motivated, rational offenders interact with suitable targets experiencing no capable guardians at places for crime events to occur at a fixed point in time and space. Crime pattern theory offers an account of *how* each of these three components reached that specific point in time and space. Due to the comprehensive scope of this perspective not only can a wide range of units of analysis be considered but also possible hierarchical relationships between these units (Deryol et al., 2016).

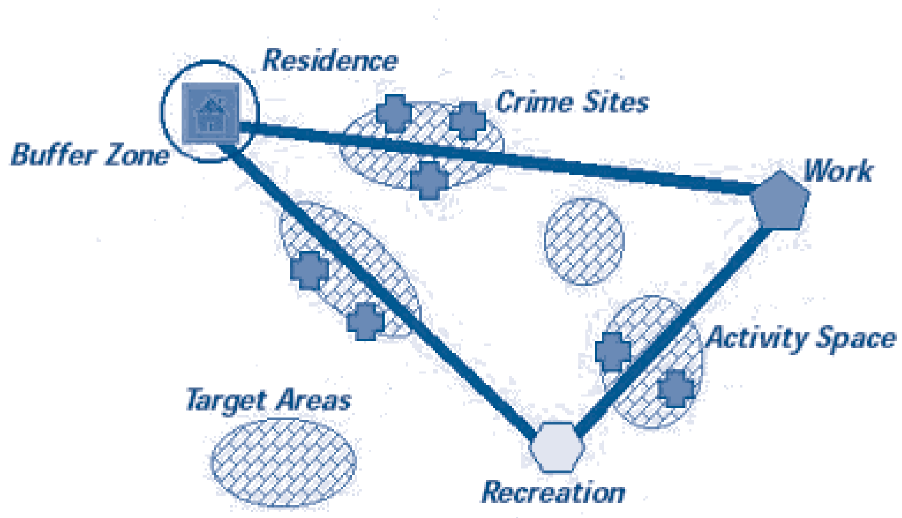
According to crime pattern theory, the relationship between crime and place can be understood through analyzing the spatial (i.e. where it occurred) and temporal (i.e. when it occurred) dimensions of crime events. This perspective can be considered a "lifestyle" theory of crime because it aims to unpack why crime events occur through understanding how crime is a function of everyday life (see Felson and Eckert, 2015).

[6] Crime pattern theory can also be identified as "environmental criminology". The phrase environmental criminology has also even been used interchangeably when describing criminal opportunity theories. This dissertation primarily follows the nomenclature of both Eck and Weisburd (1995) and Braga and Weisburd's (2010) books on the topic.

The offender's journey to crime demonstrates this idea; research suggests that individuals commit crimes in close proximity to their residence (Phillips, 1980; Bernasco, 2010). Figure 2.3 illustrates how an individual's daily routine could influence where they choose to commit crime. Eck and Weisburd (1995: p. 6) provide an insightful explanation of these findings:

> "Just like other, non-offending individuals, offenders move among the spheres of home, school, work, shopping, and recreation. As they conduct their normal legitimate activities, they become aware of criminal opportunities. Thus, criminal opportunities that are not near the areas offenders routinely move through are unlikely to come to their attention. A given offender will be aware of only a subset of the possible targets available. Criminal opportunities found at places that come to the attention of offenders have an increased risk of becoming targets (Brantingham and Brantingham. 1993). While a few offenders may aggressively seek out uncharted areas, most will conduct their searches within the areas they become familiar with through noncriminal activities."

Figure 2.3: The Journey to Crime



Source: Rossmo, 2000;

While the scope of crime pattern theory is much broader compared to the two other opportunity theories discussed in this section, empirical tests of this perspective are conceptually much more focused. Since crime pattern theory is not unified by a singular theory like routine activities empirical tests can explore a wide range of hypotheses within the general framework of this opportunity perspective. This flexibility has resulted in a wide range of studies being conducted using crime pattern theory as the guiding theoretical construct. Tests of crime pattern theory hypotheses can be conceptualized as anything exploring the distribution, movement, and interaction of offenders and targets across time and space on crime. Over only the past few years, for example, analyses have examined the role of the accessibility of streets on burglary incidents (Johnson and Bowers, 2010), the influence of public transit on crime in cities (Groff and Lockwood, 2014), and drug markets as crime attractors at street corners (Taniguichi, Ratcliffe, Taylor, 2011).

Crime pattern theory is influenced by a wide range of theoretical perspectives which does occasionally result in divergent explanations of crime events at locations relative to other opportunity theories (see Brantingham and Brantingham, 1991). For example, a crime pattern theorist views locations as problematic because of various ecological characteristics while a routine activity theorist views certain locations as problematic because of the individuals that are present or absent at a specific place (see Braga and Weisburd, 2010; p. 76). Even when considering these divergences crime pattern theory provides the comprehensive framework to facilitate the integration of routine activities and rational choice theories into cohesive collection of opportunity theories. Critiques of these opportunitytheories do exist (see Clarke and Felson, 1993) but have not hindered their theoretical development due to the conceptual pragmatism which offers readily testable hypotheses (Brantingham and Brantingham, 1984). Crime pattern theory specifically aids understanding of the distribution of crime at micro-places within cities through offering insight to the complex ecological rhythms which cause offenders and targets to repeatedly converge in specific places.

Broken Windows Theory

Broken windows theory does offer an explanation of how opportunities influences the distribution of crime within cities but the theory is not mutually exclusive to only the opportunity theoretical perspective (see Sampson and Raudenbush, 1999; Weisburd et al., 2012). According to Wilson and Kelling (1982), broken windows theory proposes that both social and physical disorder contribute to the fear of residents in locations which in turn forces individuals to relocate from these locations and remaining residents to become isolated. This chain of events attracts potential offenders to the location which increases levels of crime. In other terms, broken windows theory proposes the presence of disorder results in the decrease of social control which in turn increases crime. Wilson and Kelling's formulation also explicitly noted that broken windows theory is concerned with locations in transition or at the "tipping point" of crime problems (see Gladwell, 2000; Steenbeek and Kreis, 2015). Initially broken windows was outlined as occurring at the neighborhood-level but subsequent analyses have extended it to micro-level units of analysis (Hinkle and Weisburd, 2008; Yang, 2010).

Broken windows theory is not the first effort to consider the importance of disorder in understanding urban crime problems (see Wilson, 1968; Zimbardo, 1973).

Wilson and Kelling's publication though has become influential partially because of the concise causal model proposed and how it could impact crime control responses within cities. Research on broken windows theory in the three decades after the theory was proposed can generally be divided into two distinct classes focusing on: testing the causal model (see Skogan, 2015) and crime prevention strategies (see Kelling and Coles, 1996). Empirical evidence on the causal model is mixed. Skogan (1990) offers one of the most readily cited examples of empirical support finding a connection between disorder and crime at neighborhoods across six cities in the United States. St. Jean (2007) and Yang (2010) observed a connection between disorder and violent crimes within neighborhoods at micro-units of analysis. Limited support of the causal relationship between disorder and crime is observed when assessing neighborhoods in Baltimore (Taylor, 2001). Harcourt (2001) critiques Skogan's (1990) analysis and notes that when removing certain outlier cities from the analysis the relationship between disorder and crime disappears. Sampson and Raudenbush (1999) in addition to Harcourt and Ludwig (2006) find little to no relationship between disorder and crime in disparate studies conducted across multiple cities.

Research on the effectiveness of crime prevention strategies which target disorder to reduce crime is also mixed in regards to the research methodology used to evaluate interventions and findings on the effectiveness of these strategies. These crime prevention strategies have countless names (e.g. order maintenance policing, zero tolerance, etc.). Wilson and Kelling (1982) do not explicitly forward a model of broken windows policing (see Kelling and Coles, 1996) but their suggestions are much closer to community-oriented policing strategies (see Skogan and Hartnett, 1997) then the applications which followed. City-wide analyses of broken windows crime prevention strategies in New York City, which became prominently associated with broken windows (see Bratton, 1998), for example have demonstrated no treatment effect (Harcourt and Ludwig, 2006; Greenberg, 2014), a modest treatment effect (Rosenfeld, Fornango, and Rengifo, 2007; Chauhan et al., 2011), and large treatment effects (Kelling and Coles, 2001; Corman and Mocan, 2005).

A systematic review and meta-analysis of experimental evaluations of disorder policing strategies found that interventions which used community or problem solving strategies were effective across evaluations while aggressive enforcement interventions were not (Braga et al., 2015). Even after decades of evaluations on broken windows policing strategies disagreement still exists on the specific mechanisms through which these interventions cause crime reductions (see Apel, 2016; Weisburd et al., 2016). In conclusion, despite the mixed findings on the causal model and associated crime prevention strategies associated with broken widows the “perspective will be around for many more decades to come- its enduring qualities far exceed a smartly coined phrase” (Welsh, Braga, and Bruinsma, 2015; p. 448). Broken windows theory can improve understanding of the distribution of crime at micro-places within cities through highlighting disorder as an important indicator of criminal opportunity at locations.

Understanding the Distribution of Crime Opportunities at Micro-Places

This section discusses the importance of facilities and site features in understanding the distribution of criminal opportunities at micro-places in cities. Eck and Weisburd's (1995) review of research on micro-places and crime classifies studies on the distribution of crime in addition to investigations of facilities and site features as the three primary categories of research on these units of analysis. Research on facilities and site features offers a practical application of the concepts outlined in each of the core opportunity theories previously discussed. For example, systematically observing the distribution of facilities and site features in a city can identify situational characteristics of locations that facilitate the commission of crime (i.e. rational choice), observe the control of locations (i.e. routine activities), and the temporal patterns of activity (i.e. crime pattern theory). Investigating the distribution of these characteristics offers testable hypotheses of the concepts outlined in these theories and bridges the distance between descriptive and explanatory analyses in research on the spatial distribution of crime at micro-place.

Facilities

Facilities in research on micro-places and crime can be defined as: "special purpose structures, operated for specific functions" and "examples of place facilities include high schools, taverns, convenience stores, churches, apartment buildings, and public housing projects" (Braga and Weisburd, 2010: p. 80). Specific facilities can influence the immediate environment of micro-places through either decreasing or increasing the likelihood of a crime event occurring based on the individuals present or characteristics of the location. Crime is also disproportionately concentrated at certain facilities within cities (Eck et al., 2007); these facilities at an increased risk of victimization are known as "risky facilities" or "crime attractors" (Brantingham and Brantingham, 1995; Clarke and Eck, 2007). A brief overview of both the earliest and most contemporary empirical investigations of the influence of facilities on crime at micro-places is conducted next.

Engstad (1975) observed the immediate spatial influence of bars, hotels and shopping centers on multiple crime outcomes finding concentration at certain facilities. Roneck and colleagues conducted several studies exploring the impact of public housing, high schools, and bars on crime in the blocks surrounding these facilities (Roneck and Bell, 1981; Roneck and Meier, 1991). Bars are a frequently studied location with most research suggesting these facilities do have a criminogenic effect on their immediate environment (Block and Block, 1995; Frisbie et al. 1977). Early scholarship on facilities also identified the importance of understanding the interaction between facilities and their accessibility within cities. Duffla (1976) and Nasar (1981) observed facilities with the most crime were located adjacent to major transportation routes in cities.

These early studies were pioneering but suffered from substantial methodological shortcomings in the operational representation of criminal opportunity (see Braga and Weisburd, 2010). Contemporary research on facilities and crime has made substantial progress in this area through more refined analyses, a wider range of data sources, and offering multivariate accounts which control for the presence of other criminal opportunities. Bernasco and Block (2011) investigated the influence of several facilities on robbery incidents in Chicago across three different distances while controlling for social characteristics of these locations finding an effect of a handful of facilities such as gas stations and liquor stores. Bowers (2014) studied the influence of multiple facilities on the number of thefts recorded inside and outside of the facility. The author finds a positive relationship between thefts recorded inside and outside the facility with the level of internal thefts and presence of risky facilities impacting the levels of external thefts.

Groff and Lockwood (2014) focus on the influence of facilities on specific crime outcomes across varying distances from the facility. The authors find facilities have unique effects on specific crime categories but the effects are stable across different distances. Land use at places has repeatedly been a topic of interest across ecological theories in place-based criminology (see Felson and Eckert, 2015). Recently scholars have explored the influence of foreclosures in residential areas on crime which offers a contemporary extension to previous research on abandoned buildings as crime attracting facilities (Spelman, 1993; Felson, 2006). Lacoe and Ellen (2015) find an impact of foreclosures on the distribution of crime at blockfaces which supports previous research conducted using neighborhoods as a unit of analysis (see Baumer, Wolff, and Arnio, 2012; Katz, Wallace, Hedberg, 2013).

Site Features

Site features offer a more detailed description of the physical and social environment of micro-places surrounding facilities. Research on site features addresses the physical and social conditions of locations primarily through the application of guardianship or informal control at micro-places. One of the earliest and most influential contributions to understanding the impact of site features on crime is Newman's (1972) theory of defensible space. Defensible space is a representation of the physical environment of micro-places which can provide individuals with a sense of territoriality based on the ability to observe this area and communicate to potential offenders they are being watched. While Newman's suggestion that public housing complexes with defensible space have less crime has received mixed empirical support (Mayhew, 1979; Mawby, 1977) the concept has become influential in the design of locations (Newman, 1995). This suggests physical and social site features at micro-places can both be used to convey guardianship.

The influence of informal control on reducing crime at place is important to both opportunity theories and social disorganization (Cohen and Felson, 1979; Sampson and Groves, 1989; Weisburd et al., 2014). This concept has been tested in several different ways. Increasing the number of employees focused on place management such as parking attendants and clerks can be used to reduce crime (Clifton, 1987; Laycock and Austin, 1992; LaVigne, 1994). Bartenders and bouncers can reduce the risk of violence by regulating nuisance behavior (Homel and Clark, 1994). Eck (1994) finds drug dealers prefer operating in smaller apartment buildings because of the lack of surveillance from landlords, which installs them as de-factor guardians (see Piza and Sytsma, 2016), at these locations suggesting offenders avoid locations with place managers. Close-circuit televisions (CCTV) are another popular guardianship strategies used by both informal (i.e. place mangers) and formal (i.e. the police) stakeholders in crime control. A systematic review of evaluations on CCTV generally observes the effectiveness of these strategies in crime control (Welsh and Farrington, 2009). Street lights are another strategy conducted by formal stakeholders which influence guardianship at micro-places.

Reviews of research on street lightings impact on crime suggest it’s an effective prevention strategy (Welsh and Farrington, 2008).

Opportunity theories guide understanding of how the formal control of physical and social site features can reduce crime at micro-places. Routine activities generally considers informal controllers as the gatekeepers to reducing crime at place but rational choice advocates the use of situational crime prevention strategies which are more conducive to a crime prevention effort from formal sources of control. The observation of the concentration of crime at micro-places in cities has influenced the proliferation of “hot spots” policing strategies (Braga et al., 2014). These strategies consider traditional deterrence techniques (e.g. saturation patrol) and more opportunities driven responses (e.g. situational crime prevention) to crime problems at micro-places. The use of opportunity measures can also be directly included with analyses of crime hot spots in cities to guide the allocation of police resources (Kennedy, Caplan, and Piza, 2011). Problem-oriented policing and situational crime preventions strategies both attempt to address the physical and social site features of micro-places to drive crime reductions; both strategies have demonstrated effectiveness in crime control (Clarke, 1995; 1997; Weisburd et al., 2010). Focusing on physical and social site features through policing disorder at micro-places has also been observed to be an effective crime control strategy across several evaluations (Braga et al., 2015).

CHAPTER 3 – NEIGHBORHODOS AND CRIME

This chapter provides a literature review of the available theoretical and empirical contributions that have documented the importance of neighborhoods in understanding the distribution of crime within cities.[1] Micro-places are not only spatially nested within neighborhoods but the literature on these units of analysis also exists within the broader context of place-based criminology where neighborhoods have served as the predominant unit of analysis to study crime variation within cities for decades (Shaw and McKay, 1942; Bursik and Grasmick, 1993; Sampson, 2013). The historic development of research on neighborhoods and crime was saddled with several theoretical and methodological obstacles that have been collectively addressed by scholars dedicated to advancing neighborhood-based inquiry (see Kornhauser, 1978; Reiss and Tonry, 1986; Sampson, 2002). The revolutionary contributions of these scholars have assisted in establishing the vitality of neighborhoods as a unit of analysis for empirical examination in all of the social sciences, not just the discipline of criminology (Park and Burgess, 1925; Sampson et al., 2002).

This chapter is divided into four sections. The first section offers a brief overview of the history of research on the distribution of crime at place in the social sciences. European social scientists in the 19th century provided the earliest empirical evidence of the uneven spatial distribution of crime. The second section provides a detailed discussion of the various contributions from the Chicago School. Collectively these scholars constructed the ideological foundation for all subsequent neighborhood-level inquiries and marked the beginning of place-based criminology as a distinct and viable

[1] An argument can be provided that "neighborhoods" and "communities" are different concepts but for the purpose of this study they will be viewed as interchangeable; the former phrase will be used almost exclusively.

sub-discipline in criminology. The third section highlights the contemporary revitalization of research on neighborhoods and crime. While the Chicago School pioneered neighborhood-based inquires several critiques and limitations of their contributions had to be addressed to further advance this research over the second half of the 20th century.

The fourth section briefly documents contemporary developments in neighborhoods and crime research. With the contemporary resurgence of interest in neighborhoods a wave of innovative studies were conducted which continued to expand comprehension of the influence of neighborhood effects on crime. The fifth and final section contains a discussion of how scholarship on neighborhoods and micro-places can be integrated to continue to advance understanding of the distribution of crime within cities. Both perspectives are not in competition. Instead these perspectives are actually complementary and can be integrated to enrich our understanding of the variation of crime across cities. Despite focusing on different units of analysis and theoretical explanations, unique contributions from each literature can be incorporated to help answer the foundational research question which guides both perspectives: why do certain places within cities have more crime than others?

The Origin of Place-Based Criminology

Empirical investigations of the variation of crime at place were first conducted by European social scientists in the 19th century prior to the establishment of criminology as an independent academic discipline. These contributions are influential not only because they provided the earliest empirical documentation of the spatial distribution of crime at place but also because of their immediate recognition of the fundamental issues that would propel research for the next two centuries. Balbi and Guerry (1829) published one of the first cartographic illustrations of the spatial distribution of crime. They used data collected by the French Home Office from 1825-1827 to display the distribution of property and personal crimes at departments, a contemporary analog in the U.S. would be counties, throughout France. This descriptive technique of "crime mapping" would become an indispensable tool for criminologists and criminal justice practitioners to concisely visualize how certain locations experience more crime then others (Weisburd and Lum, 2005; Chainey and Ratcliffe, 2013).

Guerry (1833) elaborated on this study by exploring potential causal mechanisms to explain the distribution of crime at place. He explored the influence of poverty and population density on the variation of crime between departments. This research is the earliest documented exploration of how social causation could be used to explain the variation between levels of crime at places. Other research from Europe in the 19th century would continue to investigate social causation and the relationship between social problems and the spatial distribution of crime (Greg, 1839; Fletcher, 1850). Quetelet (1831) offered a more nuanced explanation of the distribution of crime in Belgium arriving at conclusions that are remarkably similar to contemporary strain and opportunity theories of crime. Eschewing poverty as the singular cause of the spatial distribution of crime Quetelet noted crime develops when the poor and disadvantaged are "surrounded by subjects of temptation and find themselves irritated by the continual view of luxury and of an inequality of fortune" (Queetlet, 1831; p. 38; Weisburd et al., 2012; p. 31).

These European pioneers also began to explore the impact of spatial aggregation on the distribution of crime at place by observing increasingly smaller units of analysis. Parent-Duchatelet (1837) observed variation of crime within departments in France when conducting a longitudinal analysis of five centuries of prostitution data in Paris. Mayhew (1851) even observed the distribution of crime at squares, streets, and buildings (i.e. micro-places) in London. The issue of spatial aggregation was directly addressed by Glyde (1856) arguing that the use of larger spatial units of analysis can mask variation at smaller spatial units nested within them. Neighborhoods as a spatial unit of analysis received little attention from these European scholars (see Parent-Duchatelet, 1837). Research on neighborhoods and crime has its intellectual origins in the United States during the early 20th century but is indebted to the contributions of these European pioneers. Chicago School sociologists would expand on these advances and also create entirely new directions to explore the distribution of crime at place.

The Chicago School

The city of Chicago served as a laboratory and the ideological epicenter for the development of research on neighborhoods and crime. The University of Chicago over three decades was the institutional home for a group of sociologists that advanced theoretical and empirical understanding of the socio-ecological influence of contemporary cities on individual behavior (see Farris, 1967; Bulmer, 1984; Abbott, 1997).[2] These sociologists are now universally referred to as members of the "Chicago School." Collaboration with graduate students played a key role in furthering the

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[2] There is no official start and end dates to this era although historians do offer several ranges. For the purpose of this review the Chicago School will demarcated by three major studies which occurred in 1920, 1925, and 1942. Each will be discussed further in this section.

influence of the Chicago School not only during this era (see Snodgrass, 1976) but also decades later which helped cement the legacy of this scholarship (see Reiss and Tonry, 1986). Studies from the Chicago School explored a wide range of social outcomes, not just crime or criminality (Anderson, 1923; Wirth, 1928).

Within the nascent discipline of criminology early research from the Chicago School, steering the discipline in the direction of a sociological perspective, provided a welcome alternative to other popular theoretical paradigms of the era (Beccaria, 1764; Lombroso, 1899; see Laub and Mattick, 1983). Around roughly the same period of time other sociologists not interested in social ecology from the University of Chicago offered influential writings which also further directed the discipline of criminology towards social explanations of crime (see Sutherland, 1937; Becker, 1963). Assessments of crime variation between neighborhoods by the Chicago School were unique offerings relative to their European predecessors because of the enhanced attention placed on developing a theoretical framework and the improvement of research methodology. The contributions of these European social scientists to the study of crime variation at place would not be ignored (Weisburd et al., 2009a) but within American criminology the Chicago School provided the de-facto starting point for inquiry on not just neighborhoods and crime but also the dawn of place-based criminology.

This section is further divided into four central areas of discussion in order to emphasize the multi-dimensional impact of the Chicago School on studies of the spatial distribution of crime within cities. First, the unique ecological structure of cities and the importance of neighborhoods as units of analysis to understanding social life within cities is discussed. Second, the development of social disorganization as a theoretical mechanism to explain crime variation between neighborhoods is examined. Third, an overview of a seminal study conducted by Clifford Shaw and Henry McKay focused on description and explanation of crime variation between neighborhoods is provided. Fourth, a review of critiques of Chicago School scholarship which led to the marginalization of this research in the middle of the 20th century in criminology is presented.

Neighborhoods

This subsection discusses how the Chicago School pioneered research on the spatial distribution of social outcomes in cities while also establishing neighborhoods as the primary unit of analysis to understand the spatial variation of these outcomes. Robert Park and Ernest Burgess authored a landmark publication titled *The City* in 1925 which provided the ideological basis for the scientific investigation of both cities and neighborhoods as distinct ecological entities. According to Park (1925) “the city is not, in other words, merely a physical mechanisms and an artificial construction. It is involved in the vital processes of the people who compose it; it is a product of nature and particularly human nature” (p. 1; see Park, 1915). Park argued that studying individuals in this ecological context could follow a similar ideological development as related efforts in plant or animal ecology. While European social scientists in the 19th century did observe the distribution of social problems within cities, their analyses did not offer a comprehensive theoretical framework for this focus.

The oeuvre of research provided by the Chicago School promoting the city as an ecological unit of analysis worthy of investigation can be understood as a response to the noteworthy social changes occurring in American cities at the time. At the start of the 20th century in the United States industrialization drove Americans to cities at an increasingly rapid pace (see More, 2000). Chicago epitomized this unparalleled urbanization; the population of the city grew from only 4,000 residents in 1840 to over 1,000,000 in 1890 adding over 500,000 residents each decade from 1890 to 1930 (see Spinney, 2000). Park and Burgess compellingly argued with this historic level of urbanization comes the need to understand the impact of these changes. As the result of this mass migration several "new" phenomena such as crime, poverty, and illiteracy became pressing social problems over a relatively short period of time. Park and Burgess did not focus exclusively on the spatial distribution of crime within cities but instead on the general accumulation of various social problems in urban areas.

Park and Burgess suggest that neighborhoods play a crucial role in the ecological organization of cities. Most of their inferences were directed toward "zones" or clusters of neighborhoods in Chicago. Burgess (1925) created a concentric zone map using empirical evidence to demonstrate how the expansion of the city driven by urbanization can influence the social organization of activities. In this model, five zones existed. The "loop" or "central business district" represented the center zone and the other four zones radiated outward from there. The first zone outside of the loop was titled the "zone in transition" or "zone of deterioration". According to Burgess "in the zone of deterioration encircling the central business section are always to be found the so-called 'slums' and 'badlands' with their submerged regions of poverty, degradation, and disease, and their underworlds of crime and vice" (1925; pp. 54-55). The concentric zone model proposed by Burgess offered a primitive but testable hypothesis about crime variation within cities.

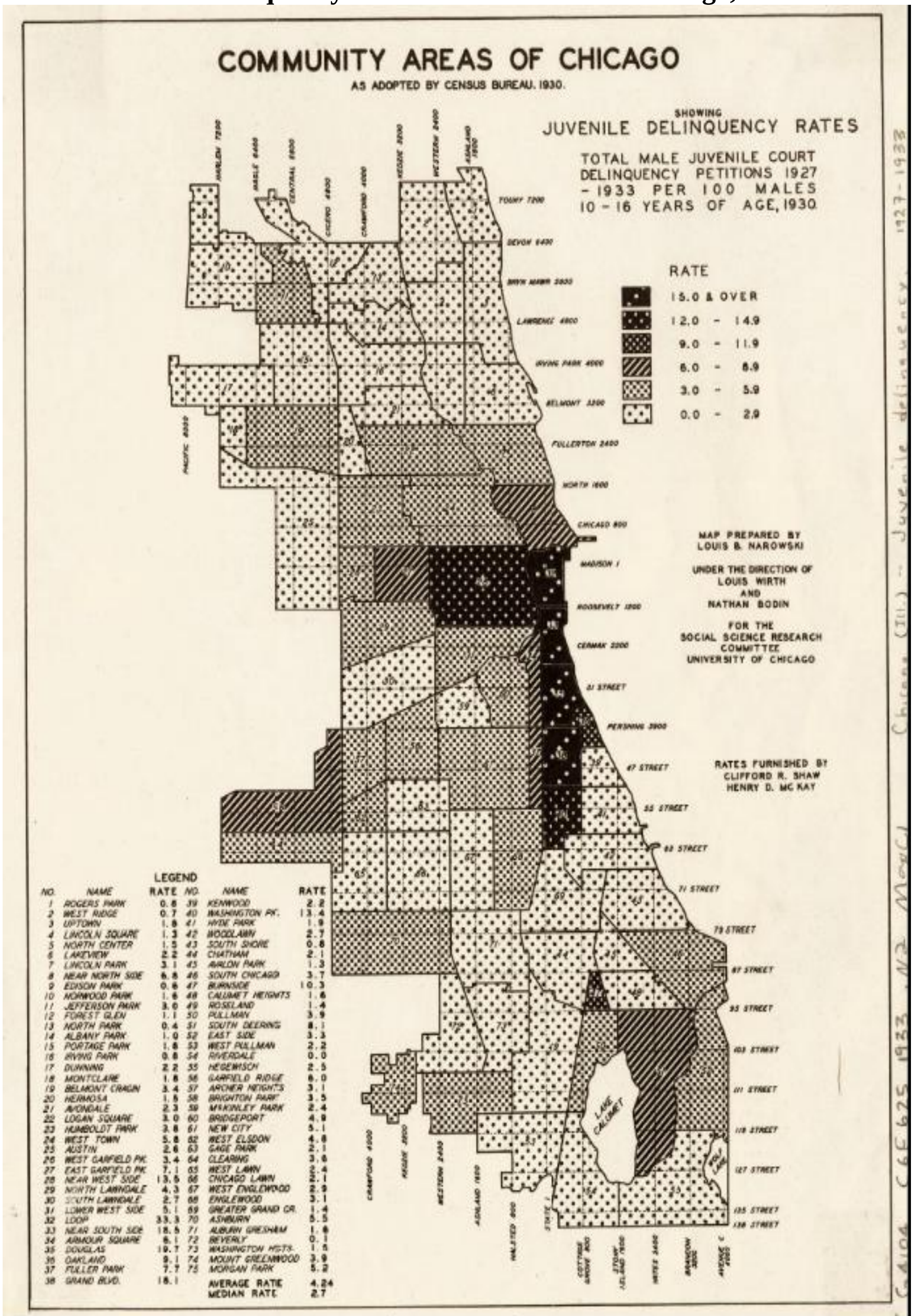
Social problems in the city were theorized to be concentrated in this zone due to the continued expansion of the central business district which resulted in the disorganization of social life in this adjacent group of neighborhoods. Additionally, Burgess theorized that radiating outward from the zone of transition each successive zone would experience lower levels of social problems.

Park and Burgess' discussion of neighborhoods outside of the context of their concentric zone model is minimal. A more nuanced discussion of the nested structure of neighborhoods within zones in Chicago is not provided. Burgess defines neighborhoods as geographical settings which signify "individuals, families, groups, or institutions located upon an area and some or all of the relationships which grow out of this common location" (1925, p. 144). In addition he proposes "the study of social forces in a local area should assume that the neighborhood or the community is the resultant of three main types of determine influences: first, ecological forces; second cultural forces; and third, political forces" (Burgess, 1925, p. 147). Understanding of neighborhoods as a unit of analysis and their relationship to social problems would be expanded throughout the collective works of the Chicago School. For example, Wirth (1928) focused on understanding the cultural and structural organization of an impoverished Jewish neighborhood in Chicago. Zorbaugh (1929) detailed the peculiarity of the spatial co-location in cities of impoverished and affluent neighborhoods in the *Gold Coast and The Slum*. McKenzie (1924) would further elaborate on the ecological conditions of neighborhoods, specially their development and internal structure.

Clifford Shaw and colleagues (1929) contributed the first description of the spatial distribution of crime at neighborhoods in Chicago. Home addresses of a wide range of offenders and juvenile delinquents were identified across four periods of time from 1900-1927 (i.e. 1900-1906, 1917-1923, 1924-1926, 1927). Up to 12,000 different home addresses were plotted and analyzed across several types of crime maps. The author's findings were generally supportive of Burgess' concentric zone model finding the concentration of offenders and delinquents decreased radiating outward from the zone in transition. While not the first inquiry into the spatial distribution of crime within cities this research provided a historically significant effort due to its rigorous methodological approach. Figure 3.1 illustrates the variation between rates of juvenile delinquency at community areas in Chicago from data collected and prepared by Clifford Shaw and colleagues in 1939. The creation of community areas in Chicago will be further discussed in Chapter 4.

Shaw and colleagues research, combined with *The City*, provided the theoretical and methodological blueprint for conducting city-wide analyses. In the decades after the Chicago School, place-based criminology would continue to explore a wide range of units of analysis (see Krohn, 1976; Blumstein and Rosenfeld, 1998) but for the purpose of this dissertation only city-wide analyses are assessed. Clifford Shaw and Henry McKay would later expand on these findings in a 1942 book titled *Juvenile Delinquency and Urban Areas*. This book is discussed in more detail later in this section.

Figure 3.1: Juvenile Delinquency Rates Per 100 Males in Chicago, 1927-1933



Source: Prepared by Narowski (1939) for the University of Chicago's Social Science Research Committee

Social Disorganization

This subsection features a discussion of the early development of social disorganization theory which became the primary theoretical mechanism Chicago School scholars used to explain the spatial variation of crime between neighborhoods. Place-based criminologists have always been interested in more than just illustration and description of crime variation at place. Even the earliest studies in Europe started to explore explanations of crime variation. Research from the Chicago School further investigated the role of social causation that European social scientists first explored to explain the distribution of crime. W.I. Thomas, a patriarch of the Chicago School, is credited with the creation of social disorganization theory (see Janowitz, 1966). According to Thomas and Znaniecki, social disorganization represents "a decrease of the influence of social rules of behavior upon individual members of the group" (1920; p. 20). The concept of social disorganization was created by Thomas when researching Polish immigrants adjustment to life in Chicago neighborhoods. This conceptualization of social disorganization explicitly focuses on the informal mechanisms expressed through social rules which govern behavior of individuals living in neighborhoods. This writing suggested that social forces such as poverty do not directly influence the distribution of social problems in cities.

Park and Burgess (1925) elaborated on social disorganization in *The City* introducing new concepts into its nascent theoretical formulation. Burgess (1925) views social disorganization as an unavoidable consequence of rapid urbanization. Park (1925) discusses the role of informal social control, formal social control, and neighborhood institutions on influencing individual's behavior. He suggested "it is probably the breaking down of local attachments and the weakening of the restraints and inhibitions of the primary group, under the influence of the urban environment, which are largely responsible for the increase of vice and crime in great cities" (1925, p. 25). Collectively, the writings of Thomas, Park, and Burgess informally introduced social disorganization theory. They began to clarify essential concepts of the theory, loosely propose links between these concepts, and finally outline how environments influence individual's behavior. One of the most clearly defined connections was drawn between neighborhood structural characteristics, neighborhood organization, and individual behavior. Other Chicago School sociologists would provide only incremental improvements in clarifying certain concepts or relationships in social disorganization (Blumer, 1937; Wirth, 1940). The earliest iteration of social disorganization theory is undeniably vague but it did provide an introduction to the possibilities of a sociological explanation of the distribution of social outcomes at neighborhoods.

Shaw and McKay (1942) conducted the first test of the influence of neighborhood structural characteristics on the variation of crime between neighborhoods. The authors operationalized neighborhood structural characteristics using variables capturing the socio-economic status, level of residential mobility, and level of population heterogeneity of neighborhoods. Shaw and McKay also offered an expansion of social disorganization theory which integrated concepts that are today associated with cultural deviance and strain theories in criminology. These concepts, in addition to the social organization of neighborhoods, were not represented in their empirical tests. Other scholars from the Chicago School would investigate the relationship between neighborhood social organization and individual behavior using a variety of different methodologies. Shaw and Moore (1931) conducted interviews with delinquents to further understand the social influences on their behavior. Thrasher (1927) studied how the absence of social organization influenced the formation of gangs in Chicago. The next section returns to the research of Shaw and McKay because it represents both the intersection and culmination of various ideological threads proposed during the Chicago School.

Shaw and McKay

Clifford Shaw and Henry McKay's (1942) book *Juvenile Delinquency and Urban Areas* (JDUA) is the Chicago School's most influential offering to the study of crime variation within cities. This seminal publication offers an impressively detailed city-wide descriptive and explanatory analysis of the spatial distribution of juvenile delinquents in Chicago neighborhoods. This analysis also supplemented findings with analyses from five other major metropolitan areas in the United States. Clifford Shaw was one of the first sociologists in the Chicago School to exclusively examine crime outcomes. JDUA is an extension of Shaw and colleagues (1929) previous descriptive research on the spatial distribution of criminal offenders and juvenile delinquents in neighborhoods in Chicago.

The meticulous research methodology applied by Shaw and McKay is exceptional in retrospect and even more impressive when compared to earlier European and Chicago School studies. Shaw and McKay do not use crime incidents or arrest reports to operationalize their crime outcome. Using the residence of juvenile delinquents as an outcome has limitations as a measure of crime or criminality but still captures a historically progressive first step in the use of criminal justice administrative data. Specifically, the home addresses of male delinquents under the age of 17 that were brought before a juvenile court in the city of Chicago were explored in JDUA. The authors explicitly address the limitation of this outcome measure by assessing other categories of individuals including truants, arrestees and repeat offenders.

Shaw and McKay observe the spatial distribution of juvenile delinquents through plotting by hand the individual's residence on a base map of Chicago and then aggregating the number of individuals up to various levels of spatial aggregation. The authors relied primarily upon spatial levels of aggregation defined by the concentric zone map first proposed by Park and Burgess in addition to a map composed of 140 cells covering one-square mile areas of the city. These maps would alternatively be referred to as spot maps, delinquency maps, and radial maps. This operationalization of neighborhoods is quite limited because it almost entirely ignoring the unique spatial boundaries of these areas. It is helpful to note this is not a unique limitation of just JDUA, instead it is a reoccurring issue that would continue to haunt neighborhood-based inquiry for decades afterwards (see Bursik and Grasmick, 1993; Sampson, 2012).

Outcomes were examined across seven year observation periods; 1900-1906, 1917-1923, 1927-1933 were the specific observation periods used in JDUA. The count of juvenile delinquents across the entire observation in a specific neighborhood was collected. Across each of the three observation periods approximately 8,000 total juvenile delinquents were identified. The descriptive analysis generally confirmed Burgess' thesis that crime would be concentrated outside of the central business district and rates would progressively decrease radiating outward from this group of neighborhoods. Shaw and McKay also conducted similar analyses in five other cities to test the external validity of findings in locations which different geographic composition.

These analyses were not as comprehensive as the ones provide in Chicago but they generally supported the findings.

Social disorganization theory was used to begin to explain the distribution of juvenile delinquents in Chicago. Shaw and McKay additionally would explore the comorbidity of crime with other public health outcomes such as infant mortality and tuberculosis. JDUA only investigated the influence of neighborhood structural characteristics on outcomes. These characteristics were measured using variables for population heterogeneity, socio-economic status, and residential mobility collected from the U.S. Census Bureau and other local sources. Basic descriptive analyses including the correlations between variables were used in their analysis.

Shaw and McKay note their findings "indicate a high degree of association between rates of delinquents and other community characteristics when correlations are computed on the basis of values in square-mile areas or similar subdivisions, and a still closer general association by large zones or classes of areas" (1942; p. 169). They also found even in neighborhoods with high population turnover there was a persistently high concentration of juvenile delinquents over time. Shaw and McKay believed this finding suggested a contextual neighborhood effect on individual behavior, opposed to a compositional effect, which does support an ecological explanation of crime. The questionable interpretation of findings would be one of many problems which damaged the influence of JDUA and the Chicago School in the decades immediately after its release.

Critiques

The scholarship of Chicago School sociologists undoubtedly improved upon the efforts of their European predecessors. The major contributions discussed in the three previous subsections would over time become influential but their immediate impact was blunted due to an onslaught of critiques. Place-based explanations of crime and deviance would temporarily recede from the mainstream of criminological research in the middle of the 20^{th} century in favor of individual-based theories (see Reiss and Tonry, 1986; Bursik, 1988). Several critiques of prominent studies from the Chicago School, Shaw and McKay's JDUA in particular, would focus on concerns with the research methodology utilized by these scholars.

In JDUA Shaw and McKay did address the issue of external validity through exploring different observation periods, outcomes, and cities but subsequent domestic and international replications of their study did not consistently support their findings (Morris, 1957; Baldwin and Bottoms, 1976). Using the home addresses of juvenile delinquents was questioned because it assumed that individuals committed crimes in the immediate vicinity of their residences (Lander, 1954). Additionally, Shaw and McKay's use of administrative crime data was criticized because individuals living in lower income neighborhoods were potentially more likely to be arrested and processed in juvenile court (Chilton, 1964). Robinson (1950) offered one of the most frequently cited critiques of the Chicago School which expanded on an idea originally proposed by European social scientists studying crime variation in the 19^{th} century. He argues ecological findings collected from larger units of analysis can offer misleading conclusions about processes potentially occurring at lower levels of spatial aggregation.

The conceptual and operational representation of social disorganization theory in Chicago School analyses was another major target of criticism. Causal mechanisms were referenced (Park and Burgess, 1925; Shaw and McKay, 1942) although never transparently specified to form a unambiguous causal model for social disorganization theory. Bursik (1988) addresses this confusion over the social disorganization causal model with an insightful anecdote about an attempt to clarify the model: "Kobrin's [1971] is the most historically interesting because it was an internal memo at the Institute for Juvenile Research [which had housed the Shaw and McKay research] written while McKay was still employed there. This suggests that Shaw and McKay's model may not have been completely clear even to those people working with them" (p. 526). Certain specifications of the theory would include crime as both a predictor and outcome of social disorganization. This was the result of no universal specification of a causal model across various contributions from the Chicago School and the flawed replications of their scholarship by other researchers (see Faris and Dunham, 1939; Pfohl, 1985). Whyte (1943) even demonstrated that socially disorganized neighborhoods can still retain coherence through the acceptance of alternative norms (also see Suttles, 1968).

The last critique discussed in this subsection would arguably be the most devastating to these early iterations of social disorganization theory. Since no definitive causal model was specified, no test of social disorganization theory was conducted. Shaw and McKay explored only the influence of neighborhood structural characteristics on crime and did not measure the actual informal organization of neighborhoods (see Quinney, 1964). The accumulation of these critiques would ultimately result in the marginalization of research on neighborhoods and crime in the middle of the 20th century in criminology.

Contemporary Resurgence

Research on neighborhoods and crime receded from the mainstream of criminological inquiry in the middle of the 20th century but it did not entirely disappear. Scholars educated within the Chicago School or influenced by this scholarship continued to investigate the relationship between neighborhood ecology and crime (see Hawley, 1950; Suttles, 1972; Reiss and Tonry, 1986). These individuals made concerted efforts to restore the reputation of neighborhood-based research through canonizing Chicago School scholarship even while the discipline of criminology widely regarded these entries as ideological artifacts (Janowitz, 1967; Short, 1969). The resurgence of neighborhoods and crime research occurred over an extended period of time due to the persistence of these scholars.

Kornhauser (1978) published a revelatory investigation into the causal model of social disorganization theory which directly addressed one of the largest obstacles to revitalizing scholarship on neighborhoods and crime. In an exhaustive review of several contemporary criminological theories Kornhauser argued that social disorganization theory provided the most promising sociological construct to explain criminal behavior. She identified Shaw and McKay’s formulation of social disorganization as a mixed model which integrated components of social control and cultural deviance theories. Removing the cultural deviance components, viewing social disorganization as strictly a control theory, provided a more concise specification of a causal model.

According to Kornhauser's reformulation "social disorganization refers to the inability of a community structure to realize the common values of its residents and maintain effective social controls" (Kornhauser, 1978: p. 120; see Sampson and Groves, 1989). This reformulation reinforced the foundational assertion that structural characteristics of neighborhoods (e.g. poverty or residential mobility) do not directly influence levels of crime. The influence of structural characteristics is intermediated by neighborhoods formal and informal organizational structure. This reformulation of Shaw and McKay's conceptualization of social disorganization is also consistent with other scholarship on the theory from the Chicago School. Kornhauser's efforts would help to galvanize the resurgence of scholarship on neighborhoods and crime in criminology (see Cullen et al., 2015).

The early 1980s witnessed a noticeable swell in research on neighborhoods and crime (see Bursik and Webb, 1982; Bursik, 1984; Sampson, 1985). An ecological approach rooted in criminal opportunity was also being developed during this period of time; Chapter 2 offered a review of this literature. With the renewed interest of scholars in ecological inquires several criminologists openly lobbied for a return of the tradition first established during the Chicago School. Reiss and Tonry (1986) edited a collection of ecological themed papers in a volume of *Crime and Justice*. In this collection Reiss (1986) offered an outline for the next generation of ecological research through proposing an integration of neighborhood and individual-level theories. Bryne and Sampson (1986) edited a book on the social ecology of crime which also provided suggestions for the next generation of empirical inquires and reviewed previous contributions. Stark (1987) outlines 30 key propositions of the ecological perspective and Bursik (1988) clarifies several critiques that initially hampered the development of social disorganization theory after the Chicago School. Collectively these publications proposed compelling extensions of the rich ecological tradition established by the Chicago School.

The revitalization of neighborhoods and crime research was primarily focused on enhancing explanatory analyses due to the limits of previous Chicago School contributions. Descriptive analyses of the spatial distribution of crime at neighborhoods were rarely explored as a primary topic of research since concentration was expected (for an exception see Bursik and Webb, 1982). Almost 80 years after Thomas and Znaniecki (1920) introduced the theory the first comprehensive empirical test of social disorganization was finally conducted. Sampson and Groves (1989) used the causal model specified by Kornhauser and were able to finally measure the intermediating neighborhood organizational characteristics. Neighborhood structural characteristics were measured using three categories identified by Shaw and McKay socio-economic status, population heterogeneity, and residential mobility in addition to new measures capturing the level of urbanization and family disruption in neighborhoods (see Sampson, 1987). Intermediating neighborhood organization characteristics were assessed through friendship networks, unsupervised teen groups, and organization participation forming a systemic model.

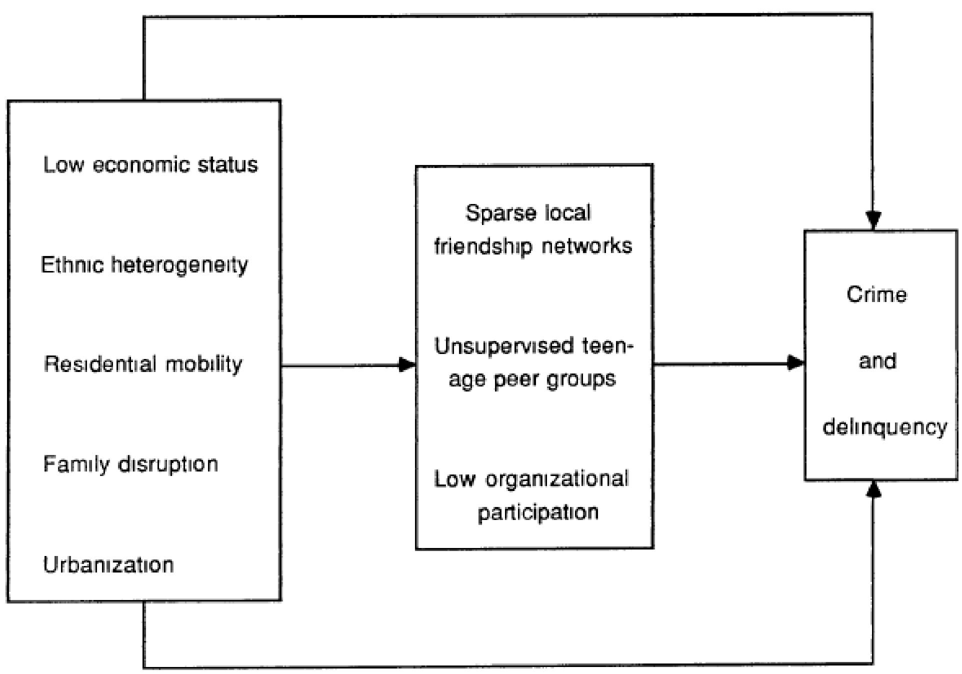
These concepts were referenced indirectly in Chicago School scholarship (see Thrasher, 1927; Park and Burgess, 1925) but were further elaborated through research conducted by Kasarda and Janowitz (1974). According to this systemic model “the local community is viewed as a complex system of friendship and kinship networks and formal and informal associational ties rooted in family life and ongoing socialization processes”

(Sampson and Groves, 1989; p. 777). Data from the 1982 and 1984 British Crime Survey was used for the analysis. Self report measures were assessed for various crime categories of 10,905 individuals aggregated to 238 neighborhoods. Figure 3.2 illustrates the final social disorganization causal model tested by Sampson and Groves.

Findings from their analysis support the causal model of social disorganization: "results from both surveys support the theory and show that between-community variations in social disorganization transmit much of the effect of community structural characteristics on rates of both criminal victimization and criminal offending (Sampson and Groves, 1989; p. 774). Sampson and Groves offered a cautious discussion of their findings noting their analysis "does not constitute a definitive test of social-disorganization theory" only the first empirical results (1989; p. 799). Veysey and Messner (1999) were only able to partially replicate their findings in a re-analysis although another set of authors did offer support using a later wave of data from the British Crime Survey (Lowenkamp, Cullen and Pratt, 2003).

After the publication of Sampson and Groves' successful test of the causal model research on neighborhoods and crime shifted towards further understanding the systemic model of social disorganization. Inquiries would focus on three components of the intermediating mechanisms of neighborhood organization: social networks, formal social control, and informal social control. Social networks are integral to the organizational structure of neighborhoods; these networks can be defined as informal and formal social ties within neighborhoods between individuals, families, peer groups, or other associations (Kasarda and Janowitz, 1974; Berry and Kasarda, 1977). Social networks can be explored in conjunction with informal social control in neighborhoods. Social control is defined as the regulation of human behavior or the "ability of social groups or institutions to make norms or rules effective" (Reiss, 1951; p. 196; Janowitz, 1975). Bursik and Grasmick (1993) present three types of intermediating neighborhoods controls: private, parochial, and public. Variations of control theories have been considered in different theoretical forms at the individual-level over the second half of the 20th century in criminology (see Hirschi, 1969; Gottfredson and Hirschi, 1990).

Figure 3.2: Sampson and Groves' (1989) Systemic Causal Model of Social Disorganization Theory



Source: Sampson and Groves (1989)

Empirical evidence has been generally supportive of the transition to a systemic model of social disorganization in the immediate aftermath of Sampson and Groves' study. Bellair (1997; 2000) found social ties and informal control successfully mediated the influence of neighborhood structural characteristics when observing crime variation between neighborhoods. Elliot and colleagues (1996) found an intermediating relationship between only informal social control and not social ties. Warner and Wilcox-Rountree (1997) found social ties directly reduced levels of crime in neighborhoods but do not intermediate the effect of neighborhood structural characteristics. In a review of the literature on new directions in research on social disorganization theory Kubrin and Weitzer (2003) noted tests of formal social control are less frequent then tests of informal control in the contemporary revitalization of neighborhoods and crime scholarship. Rose and Clear (1998) suggested that an overreliance on formal social control in neighborhoods, such as police patrol or individuals under post-release supervision, can have a negative impact on levels of crime instead of mediating its effect. The underrepresentation of research on the influence of formal social control in neighborhoods on crime could be attributed to the tenuous association at the time of this resurgence on the influence of correctional institutions or the police on crime (see Martinson, 1974; Bayley, 1994).

Over a short period of time research on neighborhoods transitioned from a marginalized subsection of inquiry to a "cottage industry" in both criminology and the social sciences (see Sampson et al., 2002). Substantial scholarly attention was devoted to clarifying conceptual limitations of previous Chicago School entries but in reviews of the contemporary revival of neighborhood based inquires "conceptual fuzziness" still surrounded the application of social disorganization theory (Kubrin et al., 2009; p. 99). Specifically, the opaque formulation related to the use of different terminology for similar theoretical concepts or the overlap between concepts such as informal social control, friendship networks, and social capital (Kubrin and Weitzer, 2003). The advances in scholarship on social disorganization and neighborhoods, which would become jointly referred to as "neighborhood effects", still offset these concerns and paved the way for further investigation of these units of analysis.

New Directions

This section examines multiple contemporary innovations and new directions that have been explored after the return of neighborhoods and crime research to the mainstream of criminological inquiry. A discussion of collective efficacy and the Project on Human Development in Chicago Neighborhoods is provided to demonstrate how the city of Chicago has returned to the forefront of neighborhoods and crime research (see Sampson, 2002). Then a more diverse range of other theoretical and methodological contributions in addition to promising empirical findings are reviewed.

Collective efficacy is defined as "social cohesion among neighbors combined with their willingness to intervene on the behalf of the common good" in neighborhoods (Sampson et al., 1997, p. 918). This concept does not fully eliminate the ambiguity between the various specifications of the intermediating neighborhood organizational characteristics but it does offer a promising attempt to mitigate this problem through combining concepts of informal social control and social networks into one construct (see Kubrin and Weitzer, 2003). Collective efficacy theory has even been considered a unique variation on social disorganization theory as the result of this combination (see Bruinsma et al., 2013). Empirical evidence from Chicago indicates that collective efficacy successfully mediates the influence of neighborhood structural characteristics on violence and disorder (Sampson et al., 1997; Sampson, Morenoff, and Earls, 1999; Morenoff, et al., 2001).

Using meta-analytic techniques, Pratt and Cullen (2005) observe collective efficacy is effective at mediating the influence of neighborhood structural characteristics on crime across multiple studies. International tests of collective efficacy also demonstrate the concept is externally valid outside of the United States (Sampson and Wikstrom, 2008; Mazerolle, Wikes, and McBroom, 2010). Collective efficacy in different ideological iterations has also been explored throughout the social sciences (see Bandura, 1977; Godard, Hoy, and Hoy, 2000). Moving forward, collective efficacy represents one of the most promising conceptualizations of the informal mechanisms occurring at neighborhoods which influence crime variation between neighborhoods (Sampson, 2006, 2012).

The ideological development of collective efficacy, in addition to other contemporary advances in neighborhood effects research, was directly impacted by the Project on Human Development in Chicago Neighborhoods (PHDCN). The PHDCN was a large scale, interdisciplinary study which collected longitudinal data through surveying individuals and conducting systematic social observation of neighborhoods (see Earls and Buka, 1997). Extensive data collection from three waves of over 8,000 individuals and two waves of community surveys in Chicago was gathered from 1994 to 2002 on various public health outcomes including crime (Sampson, 2012). The PHDCN has influenced neighborhoods and crime scholarship primarily from publications of the research team but also through secondary analyses after the data was made publically available. For example, in *Criminology* from 2001-2014 twelve studies have been published that use PHDCN data.[3] This repeated use of PHDCN has returned Chicago to the vanguard of criminological advances in neighborhood-based inquiry. The reestablishment of Chicago as a laboratory for the exploration of neighborhood effects on crime though also can potentially limit advances on this subject by not encouraging the collection of new empirical evidence from other cities since PHDCN data is remarkably rich.

Certain advances in neighborhoods and crime research have been observed through reexamining old concepts. Social disorganization theory was initially constructed to explain variation within cities but extensions to rural areas have found only mixed support for the theory being applicable outside of urban areas (Osgood and Chambers, 2000; Kaylen and Pridemore, 2013). Specific concepts and the pathways between them in the social disorganization causal model have been reassessed in an effort to improve understanding of the model. Peterson and Krivo (2010) have isolated the role of neighborhood racial composition, a structural characteristics of neighborhoods, on crime variation within and between cities. Martinez and colleagues (2010) examined the role of neighborhood immigrant concentration, another structural characteristics, on crime. Warner and colleagues (2015) investigated the role of neighborhood racial composition on the intermediating characteristics of informal social control and social ties.

[3] On the PHDCN website these publications can be searched from this link: http://www.icpsr.umich.edu/icpsrweb/PHDCN/biblio/resources?collection=DATA&journal%5b0%5d=Criminology&paging.startRow=1.

The role of culture in understanding neighborhood effects has also been reconsidered after Kornhauser's influential dismissal of the concept in her reformulation of social disorganization theory (Warner, 2003; Kubrin and Weitzer, 2003). Legal cynicism has become one of the most promising neighborhood cultural mechanisms considered to enhance comprehension of crime variation within cities (Kirk and Papachristos, 2011, 2015). Even the fundamental definition of neighborhoods has been challenged in the era of globalization and increased "placelessness" (Sampson, 2013; Hipp and Besson, 2015). Sampson's (2012) comprehensive analysis in Chicago in *Great American City* offers a compelling blueprint for how neighborhoods can retain their relevance in the 21st century and beyond to explain crime variation within cities.

Contemporary research on neighborhoods and crime has also benefited from technological improvements and a greater emphasis on research methodology. Advances in social network analysis have refined the measurement of social networks as intermediating concepts (see Hipp and Besson, 2015). Improvements in geographic information systems have allowed for closer scholarly attention to be devoted to understanding the spatial effects of adjacent neighborhoods on crime (Morrenoff, et al., 2001). Advances in statistical software packages facilitated the modeling of feedback or recursive effects of concepts in the social disorganization causal model (Markowitz et al., 2001). Longitudinal analyses have been conducted to test temporal propositions from the Chicago School about the role of transition in neighborhoods on crime (Steenbeek and Hipp, 2011). Group-based trajectory modeling has also been used to characterize developmental patterns of violence in neighborhoods over time (Griffiths and Chavez, 2004).

The history of research on neighborhoods and crime presents challenges to summarizing due to the constant reformulation and expansion of social disorganization theory. Bruinsma and colleagues (2013) conducted a perceptive analysis of the changes in social disorganization over the years by identifying and testing six variations of the theory that have been considered over time. Table 3.1 describes the components of these six variations of social disorganization theory. The authors find little improvement in explanations of neighborhood crime variation between models over time. This finding was interpreted by the authors as problematic since it suggests there was little cumulative value added to the theory after decades of critiques, reformulation, and “conceptual fuzziness”. Alternatively, this finding could be interpreted as complementary because it indicates, for better or worse, coherence among the central tenets of the theory and explicitly outlines its limitations. A century of research has indicated that neighborhoods and social disorganization theory do provide a unique contribution to understanding crime variation within cities. Efforts to enhance understanding of the spatial distribution of crime within cities can potentially be improved through the integration with other units of analysis and ecological theories.

Table 3.1: Six Historical Variations of The Social Disorganization Model

Models	Classic model	Shaw and McKay	Sampson 1987	Sampson and Groves 1989	Social capital	Collective efficacy
Concepts						
SES	X	X	X	X	X	
Ethnic heterogeneity	X	X	X	X	X	
Residential mobility	X	X	X	X	X	
Concentrated disadvantage						X
Immigrant concentration						X
Residential stability				X		X
Heterogeneous tolerant value system		X				
Family disruption			X	X		X
Urbanization				X		
Structural density				X		
Local friendship networks				X	X	
Organizational participation				X	X	
Unsupervised peer groups				X	X	
Neighbourhood trust					X	
Collective efficacy						X

Source: Bruinsma et al., 2013

Integration

This final section offers a discussion of the integration of both neighborhood and micro-place units of analysis in addition to social disorganization and opportunity theories. Upon reviewing each of the two predominant literatures used in place-based criminology to understanding the spatial distribution of crime within cities each explicitly addresses the possible benefits of this integration. The section synthesizes discussions of this integration from both literatures to provide a unified ecological overview before transitioning to the next chapter which outlines the research methodology for this study.

An integration of both micro-places and neighborhoods is possible because these units of analysis are spatially aligned. Neighborhoods are composed of micro-places; the latter can be conceptualized as a defined cluster nested in the former. Weisburd et al. (2012) even suggest that micro-places such as street segments can be conceptualized as "micro communities" (p. 45). Wicker's (1987) behavior settings theory constructed around "small-scale social systems whose components include people and inanimate objects" has been used to advocate micro-places as distinct units in organizing city life. Taylor (1997, 1998) raises several arguments why street segments can function as unique behavior settings. He suggests these micro-places are frequented by individuals with patterned behavior that develop social roles and can be informally governed by shared norms of behavior. In addition these units are frequented by behavior patterns that are temporally specific, dynamic, and geographically bounded (see Weisburd et al., 2012; p. 24). There is no universally recognized definition of a neighborhood (Sampson, 2011) but according to Bursik and Grasmick (1993, p. 6) a loose consensus does exist around central descriptive features of these units:

> "First, and most basically, a neighborhood is a small physical area embedded within a larger area which people inhabit dwellings. Thus, it is a geographic and social subset of a larger unit. Second, there is a collective life that emerges from the social networks that have arisen among the residents and the sets of institutional arrangements that overlap these networks. That is, the neighborhood is inhabited by people who perceive themselves to have a common interest in that area and to whom a common life is available. Finally, the neighborhood has some tradition of identify and continuity over time."

Neighborhoods and micro-places do have characteristics that are unique to these units of analysis but overall there is a greater degree of similarity between both representations of place. These units of analysis can be conceptualized as two different levels of spatial aggregation because of these similarities. Each captures a "micro" and "meso" or "macro" patterns of the organization of social life within cities. Recent scholarship in place-based criminology (see Weisburd et al., 2012) has emphasized the importance of specification of units of analysis in addition to the dangers of assuming an ideal level of geography or unit of analysis from the outset of research (Weisburd et al., 2009a; Hipp, 2010; Taylor, 2015). The integration of micro-places and neighborhoods can be both beneficial due to these concerns and practical considering the functionality of multi-level modeling in criminology (Johnson, 2010a). Previous studies on the influence of spatial aggregation have already investigated differences within and between classes (e.g. neighborhood or micro-place) of units of analysis within cities (Hipp, 2007; Andresen and Mallesen, 2011; Steenbek and Weisburd, 2016).

The integration of social disorganization and opportunity theories has been frequently considered in place-based criminology (Miethe and Mier, 1994; Rice and Smith, 2002; Weisburd et al., 2014a; Jones, 2015). The contemporary revitalization of social disorganization theory coincided with the formative development of opportunity theories which lead to several scholars considering both as sub-classes of a broader collection of ecological theories (Reiss, 1986; Stark, 1987). Empirical tests of social disorganization would commonly use routine activities theory to understand the mechanisms of residential stability or informal social control (see Sampson, 1986; Warner and Pierce, 1993). Bursik and Grasmick's (1993) book *Neighborhoods and Crime* contained an entire chapter on how understanding criminal opportunities can improve studies of crime variation at neighborhoods. Crime pattern theory considers the environmental backcloth, which can essentially be viewed as neighborhood structural characteristics, to explain criminal opportunity at place (Brantingham and Brantingham, 1993). Clarke also (1995) provides a model demonstrating how criminal opportunities are embedded in a broader socio-structural context. Wilcox and Land (2015) suggest a model for the integration of social disorganization and criminal opportunity which addresses criminal offending and crime events through two different mechanism of control (also see Felson, 2006). Appendices 1-3 offer illustrations of the three previously mentioned hierarchical conceptual models.

A rich theoretical foundation exists to facilitate the integration of social disorganization and opportunity theories although little empirical evidence exists on the topic. Studies exploring victimization outcomes have integrated social disorganization with individual-level theories of opportunity (Miethe and Meir, 1990). Smith and colleagues (2000) find integrating social disorganization with the routine activities perspective improved the explanation of robberies at face blocks. Rice and Smith (2002) also observe the same when analyzing auto-thefts at face blocks. Weisburd et al. (2012) observe both social disorganization and opportunity measure in Seattle can be used to explain variation between developmental trajectories at street segments. Davies and Johnson (2015) conduct a multi-level integration which found when controlling for neighborhood structural characteristics, the accessibility of street segments still can account for increased risk of burglaries at street segments. Deryol and colleagues (2016) also conducted a hierarchical integration observing a significant influence of both neighborhood structural characteristics and the density of facilities at micro-places on explaining crime incidents at street segments. While the integration of these theories can be operationally problematic (see Braga and Clarke, 2014) the limited empirical evidence on the topic offers promising results suggesting that both theories can be used to explain the spatial distribution of crime within cities.

CHAPTER 4 – RESEARCH METHODS:

CHICAGO AND VIOLENCE

This chapter presents the methodology that was used to answer the research questions proposed in the first chapter. This study draws upon the "blueprint" provided by Weisburd and colleagues (2012) in their city-wide analyses of the longitudinal spatial distribution of total crime incidents at street segments in Seattle. First, the longitudinal distribution of violent crime incidents at micro-places is summarized. Second, the unique contribution of micro-places in describing spatial patterns of violence is comparatively assessed to larger units of spatial aggregation. Third, the influence of social disorganization and opportunity measures on explaining differences between levels of violent crime incidents at street segments is tested. This blueprint divides the study into two distinct sets of analyses focused on the description and explanation of crime patterns in Chicago. Research questions one and two focus on the description of violent crime patterns at place while research question three explores explanations of these patterns. This chapter presents the research setting, dependent variable, and units of analysis that are explored across both sets of analyses.

The first section of this chapter discusses the research setting for the broader study. While the previous chapters highlighted the legacy of Chicago in place-based criminology, this section discusses the city's history and presents the practical benefits of using this location as a research setting. The second section focuses on the dependent variable for this dissertation – violent crime. Chicago's reputation as a particularly violent American city is considered and city-wide violent crime trends are observed. The third section describes the units of analysis that were used in the research. Each unit of analysis represents a micro-, meso-, and macro-level of place that can be intuitively used to characterize the geography of Chicago.

Research Setting

This dissertation research was conducted in Chicago, Illinois. This location was selected because of its legacy in place-based criminology and the vast collection of spatial data available to examine violent crime patterns within the city. As discussed in previous chapters, Chicago is inextricably linked with neighborhood-level inquiry in place-based criminology. The analysis of street segments within Chicago provides a provocative contrast to this tradition and can provide a modest expansion to our understanding of the law of crime concentration at micro-places (see Weisburd, 2015). The City of Chicago maintains an open-source data portal offering an assortment of opportunity measures at micro-places. PHDCN provides another dynamic, publicly available data source that can be used to supplement U.S. Census data for the creation of social disorganization measures at neighborhoods. The remainder of this section provides brief overviews of Chicago's history, economy, culture, and population.

Chicago was permanently settled in the late 18th century by a merchant of African heritage named Jean Baptiste Point du Sable,[1] Chicago was incorporated as a city in 1837 with an estimated population of 4,000 residents. The name "Chicago" is derived from the indigenous residents' title for the river which flows through the city. This river in turn received its name because of the odorous *chicagoua* plants which grew near the river thus forever equating the city, which would receive several other unfortunate

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[1] For more comprehensive histories of Chicago, interested readers should start with the city's website (http://www.cityofchicago.org/city/en/about/history.html.) and then consult more detailed accounts from Miller (1997), Spinney (2000), and Dyja (2013).

nicknames over the years, with an unpleasant aroma. Located on the southwestern shore of Lake Michigan, near the Illinois-Indiana border, the city is naturally divided by the Chicago River which splits the municipality into north, west, and south sides.[2] In a major feat of civil engineering, the flow of the Chicago River was reversed in 1900 away from Lake Michigan to prevent the spread of sanitation related illnesses. The city's geographic proximity to waterways and centralized location within the Midwestern United States established Chicago as a major transportation hub which fueled the historic growth of the city.

Throughout the 19th and early 20th century Chicago epitomized the industrial American metropolis. Urbanization of the city occurred rapidly, as briefly discussed in Chapter 3, with the population growing from approximately 500,000 residents in 1880 to over 3,000,000 in 1930 (Spinney, 2000). Mark Twain famously remarked during the beginning of this population boom in 1883 that "it is hopeless for the occasional visitor to try to keep up with Chicago. She outgrows his prophecies faster than he can make them" (City of Chicago, 2016). Chicago's experiences during this era were similar to other industrialized urban centers in the United States. Jane Addams opened the Hull House in response to the influx of immigrants which served as an exemplar for aiding the assimilation of immigrants to the United States. Upton Sinclair offered an eye-opening depiction in Chicago of this experience and the lax occupational regulations associated with the industrial revolution in his muckraking masterpiece *The Jungle* in 1906.

While Chicago's population growth subsided in the middle of the 20th century, the city's influence on American culture did not. Al Capone kept Chicago in the national

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[2] Today, the distinction between the north and south sides of Chicago is commonly associated as a differentiation between social strata within the city. The north side generally containing wealthier residents and the south side containing more impoverished residents.

spotlight with his violent exploits during the 1930s. The first self-sustaining nuclear chain reaction occurred in the city, secretly under the Chicago Bears stadium in 1942, which helped propel the world towards the nuclear age. America's countercultural movement in the 1960s and 1970s intersected with the city in various ways. A highly publicized riot occurred when individuals protesting the Vietnam War at the 1968 Democratic National Convention were attacked by the Chicago Police. The early 1970s witnessed a meteoric rise in the prominence of Playboy magazine, founded and published in Chicago, as the country was in the middle of a historic sexual revolution. The Sears Tower, today renamed the Willis Tower, was completed in 1973 and stood as the tallest building in North America until 2014. Michael Jordan and the Chicago Bulls dominated American sports in the 1990s winning six NBA championships while cementing "MJ" as one of the most iconic athletics in the history of professional sports. Building a Chicago-based entertainment empire, Oprah Winfrey became the first female African-American billionaire in 2003. The 2008 election of Illinois Senator Barak Obama as President of the United States immediately established him as Chicago's most famous resident while further demonstrating the influence of the "great American city" into the 21st century (see Sampson, 2012).

Today the city of Chicago is a prominent commerce center in the United States. The greater Chicago area contains corporate headquarters for several Fortune 500 companies including Walgreens, United, Boeing, All State, and McDonald's with other large corporations maintaining regional offices within the city (Fortune, 2016). The city also contains multiple universities, professional sports franchises, and airports which provide stability to the local economy. Despite Chicago's unforgiving winters the city is a popular tourist destination in the United States which offers another boost to the economy. Chicago's nickname as the "windy city" was not given to the city because of its climate – instead bestowed because of the city's arrogant politicians in the late 19th century (see Zorn, 2006) - which is ironic because of its proximity to Lake Michigan the city is actually quite windy. From the Magnificent Mile to Millennium Park, Chicago contains several iconic destinations for tourists.

Chicago is also a prominent cultural center in the United States. Chicago contains several museums, historic theaters, and popular music festivals. From Ernest Hemingway to Kanye West, the city has creatively inspired residents that would become prominent cultural figures across generations and mediums. The city of Chicago was an important location in the historic development of jazz, blues, and soul music in the United States during the 20th century with the sounds of influential musicians Joe "King" Oliver, Muddy Waters, and Sam Cooke leading the way. Contemporary American comedy is highly influenced by Chicago's Second City, another mocking nickname of the city, troupe which helped diffuse improvisational comedy to television and film in the 21st century. Notable alumni include Bill Murray, Stephen Colbert, and Steve Carell. While not the only culinary contribution from the city, today Chicago is commonly associated with a distinct style of deep dish pizza.

The U.S. Census Bureau (2016) estimates the population of Chicago was 2,722,389 in 2014. Chicago is still the third most populous city in the United States even though its population has steadily decreased from a historic high of over 3,600,000 in 1950. This reduction is fairly common amongst other Midwestern "rust belt" cities such as Detroit or Cleveland over the same time period (see High, 2003). Overall, Chicago has adjusted much better to this population migration associated with deindustrialization (see Wilson, 1987) then most other cities in the region. Tables 4.1 and 4.2 report demographic characteristics and other select Census information for Chicago over the observation period for this dissertation. For the 2010 U.S. Census the federal government made a host of changes to procedures. The American Communities Survey now produces estimates across ranges of years (i.e. 2010-2014) which coincide with the end of observation period for this study.

Table 4.1 demonstrates that Chicago is comparatively populated by more African-American residents then averaged population results from other large cities in the United States. As of 2014, nine cities in the United States have a population greater than 1,000,000 residents. In 2000 and 2010-2014 Chicago's population was underrepresented in Hispanic residents compared to other large cities. Another major alteration to the Census was the questions residents were asked about race and ethnicity. Due to these changes, comparisons for the white racial category cannot be made across years (see Table 4.1 notes). Table 4.2 reports that compared to averaged results from other large cities in the United States, Chicago is fairly representative in various social and economic indicators. For both Tables 4.1 and 4.2 general stability of these measures in Chicago was observed over time relative to the broader changes occurring across all other larger cities in the United States over the observation period (e.g. % vacant housing and % unemployed increased over time for all cities, Chicago still experienced a proportionally higher level for both measures).

Table 4.1: Racial Composition of Chicago Compared to Other Cities with Population Greater Than 1,000,000 (2000, 2010-2014)

	2000		2010-2014	
	Chicago	Cities 1,000,000 +	Chicago	Cities 1,000,000 +
% White	42.0	53.7	32.2	32.8
% African-American	36.8	17.3	31.5	15.8
% Hispanic	-	-	28.9	38.0
% Asian	4.3	8.5	5.7	10.6
% Other	16.9	20.5	1.7	2.7
Total Population	100.0	100.0	100.0	100.0

Notes: Values for cities 1,000,000 + are averaged across all observations. Hispanic could not be calculated as a mutually exclusive category in 2000 U.S. Census. The measure which captured Hispanic (any race) from 2000 was 26.0% of Chicago's population compared to 33.8% of cities over 1,000,000 residents.

Table 4.2: Select Census Information on Chicago Compared to Other Cities with Population Greater Than 1,000,000 (2000, 2010-2014)

	2000		2010-2014	
	Chicago	Cities 1,000,000+	Chicago	Cities 1,000,000+
% Owner-occ. Housing	40.4	46.7	38.6	42.5
% Renter-occ housing	51.7	47.3	47.8	47.5
% Vacant housing	7.9	6.0	13.6	9.7
% College degree	25.5	26.3	34.9	31.4
% Foreign born	21.7	25.6	20.9	26.7
% Poverty	19.6	17.7	22.7	20.8
% Unemployment	6.2	4.5	8.7	6.6

Notes: Values for cities 1,000,000 + are averaged across all observations. For % College degree includes only individuals 25 years or older while % Unemployed is individuals 16 or older.

Violence in Chicago

"Down here, it's easier to find a gun than it is to find a [expletive] parking spot"

-Chance the Rapper, on violence in Chicago in "Pusha Man/Paranoia" (Bennett, 2013)

This section provides a brief justification for the selection of violent crime as the primary dependent variable for this study which is then followed by a general discussion of violence in Chicago. Violence is a persistent social problem (see Best, 2007) in cities throughout the United States. The city of Chicago and its south side in particular, have gained a reputation as one of the most violent urban areas in the entire country. In 2012, Chicago even briefly overtook New York City, which contains over five million more residents, as the "murder capital" of the United States because Chicago experienced the highest total count of homicide incidents in any city during that calendar year (Wilson, 2013). Recently Chicago has earned another unfortunate nickname of "Chi-raq" because of the city's frequent and headline grabbing outbursts of violence (Daly, 2014; Harrington, 2015). Even President Obama routinely addresses violence in his adopted hometown; "I live on the south side of Chicago, so my house is pretty close to places where shootings take place. Because that's real, we've got to get on top of it" (Pearson, 2015; p. 1).

The legitimacy (see Tyler, 2004) of the Chicago Police Department has also recently been challenged due to its response to violence in the city. In November 2015 footage was released showing a Chicago Police officer shooting a 17 year old named LaQuan McDonald. The controversy surrounding the release of this footage in addition to allegations of the city government and police department delaying the release to minimize damage to these institutions resulted in the Superintendent of the Chicago Police Garry McCarthy being fired (Davey and Smith, 2015). In December 2015, the U.S. Department of Justice announced an investigation of the Chicago Police Departments use of force practices would be conducted.

Chicago's reputation as one of the most violent cities in the United States is questionable when empirical evidence is examined closely. Comparing violent crime rates to cities with a population over 250,000 residents Papachristos (2013a) finds that Chicago had only the 19th highest rate in 2012. Chicago's violent crime rate of 1,045 crimes per 100,000 residents fell substantially below cities like Detroit (2,122), St. Louis (1,776), and Baltimore (1,405) which also maintain reputations as violent American cities. These three cities had the 1st, 3rd, and 6th highest violent crime rates respectively. Papachristos (2014) suggests the perception of Chicago as a violent city is driven by a small number of communities with high levels of crime creating a "crime gap" (also see Weisburd et al., 2004; Braga et al., 2010).

When investigating a different comparison group, the nine other cities with populations over one million in 2014, and longer time series a different story emerges.[3] Using Uniform Crime Report (2016) data, from 1985 to 2002 Chicago's violent crime rate was the highest of the 10 total cities. Between 2002 and 2014 (the years after the crime drop; see Blumstein and Wallman, 2000), Chicago was surpassed by Philadelphia as the most violent of the 10 most populous cities in the United States. Over this period of time, Chicago would alternate with Houston and Dallas for the 2nd and 3rd most violent

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[3] Since Chicago is such an exceptionally large American city it should not be compared to medium sized cities (250,000-999,999 residents). Controlling for the population (i.e. rates per 100,000) does not adequately address *which* cities it should be compared with. Also, for both the Papachristos analysis and the description in this section rape incidents were excluded, all other UCR Part I violent crimes were assessed.

city. While the 1990s-2000s crime drop was experienced in all of these cities, Chicago's reduction was one of the most precipitous with a 50% reduction in violent crime occurring between its high in 1992 and 2001.

This dissertation investigate the spatial distribution of violent crime incidents in Chicago from 2001-2014.[4] Incident reports from the Chicago Police Department were collected from the City of Chicago's publically available data portal.[5] Data collected from the Chicago portal allowed for the precise geocoding of crime incidents. One well-documented limitation to the use of incident reports as a crime outcome measure is this data only captures crimes known and reported to the police (see Black, 1970; Carr et al., 2007). Nevertheless, crime incident reports collected from police departments still provide an insightful measure of crime in cities when the appropriate care is used in understanding the limitation of the data (see Schneider and Wiersema, 1990). Furthermore, incident reports have been frequently used in several contemporary studies on the distribution of crime within cities (see Weisburd, 2015).

A total violent crime measure was created by combining robbery, homicide, and aggravated assault incidents. Sexual assault or rape incidents were excluded because they are frequently underreported and more challenging to associate to locations due to the traumatic nature of the offense (see Allen, 2007). Aggravated assault incidents were not reported by the Chicago Police Department in the data portal. To replicate the UCR measure, these incidents had to be manually identified through sorting the aggravated sub-category for assault and battery incidents individually and then combined into one measure. From 2001-2014 Chicago, experienced 456,060 violent crime incidents which

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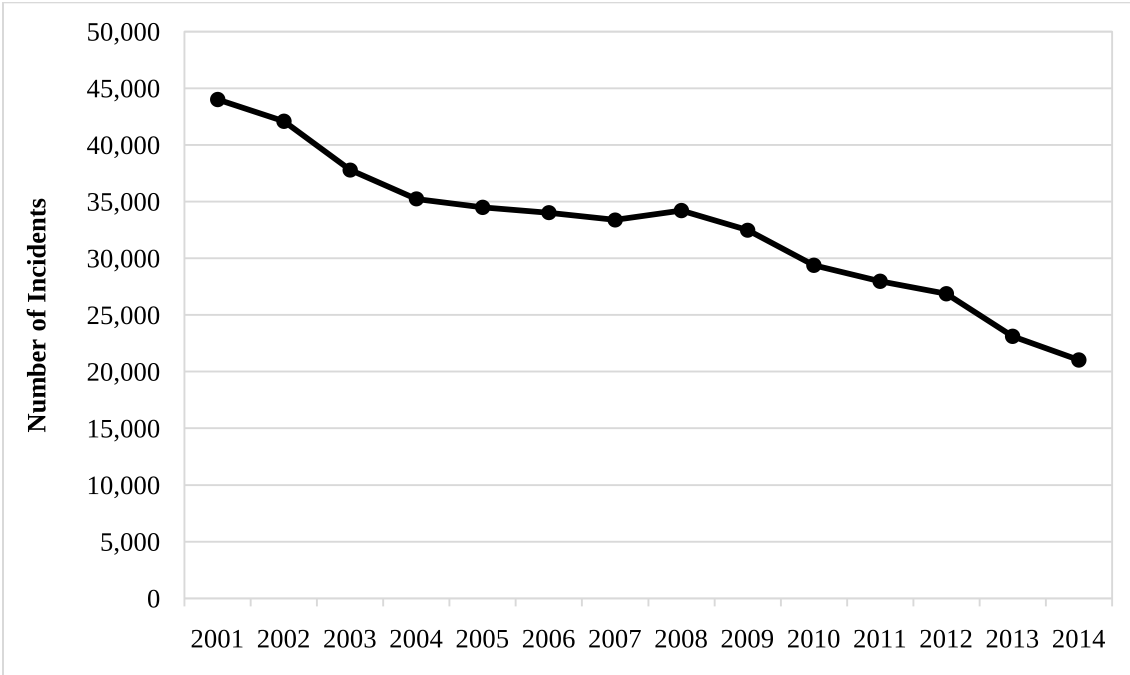
[4] 2001 is the first year that data are readily available online to analyze.
[5] https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-present/ijzp-q8t2.

represented only 8.0% of the total crime incidents recorded by the Chicago Police Department over the 14-year observation period.

Figure 4.1 illustrates the general trend of overall violent crime incidents in Chicago from 2001-2014. During this time period, Chicago experienced a 52.2% reduction in violent crime incidents from a high of 44,001 violent events in 2001 to a low of 21,027 violent events in 2014. There was a steady violent crime decline between 2001 and 2007, with violence increasing briefly in 2008 only to decline sharply again between 2009 and 2014. This general trend is almost identical to the one experienced by total and property crime incidents in Chicago over the same period of time. 51.6% of the total violent crime incidents were aggravated assaults, 46.9% were robberies, and only 1.5% were homicides. These disaggregate trends also followed the general decline observed in total violent crime incidents.[6]

[6] A high of 24,893 aggravated assaults was observed in 2001 with a low of 10,814 in 2013. A high of 18,441 robbery incidents occurred in 2002 with a low of 9,798 in 2014. A high of 667 homicide incidents were observed in 2001 and a low of 415 in 2014.

Figure 4.1: Violent Crime Incidents in Chicago, 2001-2014



Units of Analysis

This section introduces the units of analysis this study used to explore the spatial distribution of violent crime incidents in Chicago. Street segments represent the primary unit of analysis with neighborhood clusters and community areas representing higher levels of spatial aggregation at neighborhoods. Each unit of analysis was selected because of its importance in understanding Chicago's geography. Street segments, alternatively referred to as street block faces, are a frequently considered unit of analysis in studies which describe the distribution of crime at micro-places (Weisburd et al., 2004; Braga et al., 2010; see Weisburd, 2015). Neighborhood clusters and community areas have also been utilized in several analyses of neighborhood effects in criminology (Sampson et al., 1997; Kirk and Papachristos, 2011; Sampson, 2012). Street segments are nested in neighborhood clusters and community areas with minimal issues of boundary overlap since each unit of analysis generally adheres to natural spatial boundaries (i.e. waterways, parks, etc.) and street networks (see Grannis, 1998) in Chicago.

Street Segments

Weisburd et al. (2004) define street segments as "the two block faces on both sides of a street between two intersections" (p. 290). Street segments offer a host of advantages over alternative micro-units of analysis such as street addresses or block groups. These units are large enough to minimize coding errors associated with micro-units such as street addresses but are small enough to avoid unnecessary aggregation which might mask unique micro-level variation in crime patterns (Andresen and Malleson, 2011; Weisburd et al., 2012). Street segments also retain theoretical importance in the organization of social life within cities. Taylor (1997) suggests street segments function as finite and dynamic behavior settings; these ecological units, similar to neighborhoods, are characterized by patterns and roles in individual behavior (see Appleyard, 1981; Taylor et al., 1984). Street segments offer an intuitive description of the geography of cities. For example, people primarily navigate urban areas via street networks or grids through either identifying specific street addresses (e.g. 625 Michigan Ave.) or street segments (e.g. Michigan Ave. between Ohio & Ontario St.), which represent a collection of street addresses.

A street segment map of Chicago was created through modifying a shapefile of the street network obtained from the city's data portal using ArcGIS 10.1. Street intersections were first geo-spatially identified, where two or more streets intersect, to begin the process of converting a street network map to a street segment map. As noted in previous research (Weisburd et al., 2014b) verifying the validity of spatial units raises certain challenges. Specifically, GIS base maps (e.g. street networks) are typically drawn to reflect city zoning patterns and block level address ranges. Previous studies which did not use GIS base maps identified street segments based on address ranges; for instance, the identification of addresses 100-199 as one street segment, addresses 200-299 as another, and so forth (see Taylor, 1997).

Certain street segments in a street network may not be identified as "true street segments" when using GIS. Specifically, certain street segments may be represented by multiple lines. If not corrected, the database would reflect multiple "street segments" where only one street segment existed. To correct these errors, each of the initially identified street units was reviewed within ArcGIS 10.1 (using aerial imagery base maps) to ensure their accuracy, combining separate street segments into single units when necessary. Through this process, the original file of 55,747 street segments was converted to a final dataset comprising 51,650 street segments and over 29,000 street intersections.[7] The mean length of these street segments in Chicago is 426.52 feet (SD = 233.49 feet). All crime incident report data in the Chicago Data Portal corresponds directly to an X-Y coordinate that was located on the actual street rather than the intersection of two or more streets. Therefore, unlike other micro-level analyses that developed "street intersections" as a unit of analysis (e.g. Braga et al., 2010) or excluded crime incidents geocoded to intersections due to double-counting concerns (Weisburd et

[7] The final street segment map was generously provided by Professor Eric Piza at John Jay College of Criminal Justice.

al., 2004), all violent crime incidents with X-Y coordinates were geocoded to street segments. As such, intersections were not included in the current research study.

Interstates, highways, and highway access points represented 2,621of these street segments and were excluded from the analysis because of a myriad of problems.[8] The remaining 49,029 street segments were used to answer research question one. To answer research questions two and three additional street segments had to be excluded because of boundary concerns. 6,400 street segments were excluded because they either shared or crossed a neighborhood cluster or community area boundary in Chicago.[9] These segments would need to be uniquely identifiable to a single neighborhood cluster or community area to be included in the hierarchical models estimated for these research questions. There are an additional 703 street segments that were excluded from the analysis after these locations were identified to Chicago's O'Hare International Airport. These units are frequently excluded in analyses set in Chicago because, while O'Hare does represent a unique ecological context for crime, it cannot be considered a true "neighborhood" (see Sampson et al., 1999; Kirk and Papachristos, 2011). After these exclusions 41,926 street segments remained to answer research questions two and three.

Violent crime incidents were geocoded to locations in Chicago using X-Y coordinates provided with the incident reports (and the event street addresses in the

[8] These units were longer than municipal street segments because they do not intersect with other street segments. While these units can be spatially identified within neighborhood clusters or community areas they are almost exclusively used for transportation between areas. Their presence represents more of an opportunity measures then a spatial domain to understand the distribution of violent crime incidents since few rarely occur on these units. Violent crime incidents occurring on these segments were rare and primarily recorded by the Illinois State Police, which patrols these locations instead of the CPD. As a result, almost all of these incidents did not appear in the Chicago data portal.

[9] Of these units 6,117 street segments were excluded because they shared boundaries (95.6% of 6,400) and only 283 (4.4%) were excluded because they crossed boundaries. These street segments are considered in sensitivity analyses for research question two to test the robustness of findings. Steenbeek and Weisburd (2016) divided the cross-neighborhood segments into two new segments. This analysis does not utilize this strategy because the number of these segments is negligible and this strategy would devalue the street segments as a stand-alone unit of analysis (i.e. favoring neighborhoods over segments).

reports) from the data portal. Incident reports in Chicago's data portal are not attributed to specific addresses but are listed to 100 blocks of addresses. For example, all incidents occurring on the 6600 address block of Halsted Street are recorded as "66XX Halstead Street" in the data portal. While the incident locations are aggregated to the 100 block, the geographic X-Y coordinates for each incident corresponded to a specific address, not a shared center point in the 100 block. Map 1 in Figure 4.2 displays the 38 incidents recorded as "66XX Halstead Street" from 2012- 2014. As illustrated, points fall at unique X-Y coordinates across street segments A and B within the 100 block.

It should be noted that the process by which X-Y coordinates are recorded in Chicago's data portal has been recently modified. Map 2 displays the identical incidents in Map 1 but with new X-Y coordinates that center the incidents on the corresponding street segment within each 100 block. As can be seen, these points are geocoded to several locations at the center of the street segments, rather than the precise street address. Incident reports for Map 1 were accessed in February 2015 while incidents for Map 2 were in May 2016. All incident reports assessed in this study were geocoded using the X-Y coordinates from Map 1 although for the purpose of this analysis both techniques would be appropriate.

Figure 4.2: Geocoding Violent Crime Incidents in Chicago

Some 99.3% of incidents were successfully geocoded to the original 51,650 street segments, well above the 85% suggested by Ratcliffe (2010) to retain observational accuracy of an outcome. This suggests that the total number or "population" of incident reports was not used to answer the research questions. As suggested above, 98.8% of the total violence incidents were used to answer research question one and 78.9% to answer research questions two and three. Geocoded violent crime incidents were spatially joined to the specific street segment identifiable to the precise X-Y location and aggregated to a count for the entire street segment via ArcGIS 10.3. The number of violent crime incidents occurring in a neighborhood cluster or community area was identified by aggregating the counts of all incidents at street segments that are nested within these units.

Neighborhoods

This dissertation used two neighborhood-level units of analysis: neighborhood clusters and community areas. Both of these units of analysis were selected because they capture two distinct levels of neighborhood spatial aggregation; neighborhood clusters as "meso" and community areas at "macro" within the city of Chicago. The ubiquity of PHDCN data in research on crime in Chicago has privileged neighborhood clusters as the key unit of analysis in several recent innovations in neighborhood-based inquiry (Sampson et al., 1997; Kirk and Papchristos, 2011). Beyond their use by scholars and in media accounts, community areas are widely recognized by residents and municipal agencies within the city as the primary neighborhood delineation in Chicago (Sampson 2012)[10]. As considered in the analyses framed by research questions two, neighborhood clusters are nested within larger community areas and, therefore, minimize analytical problems stemming from boundary overlap.

Neighborhood clusters were created by the PHDCN research team (see Earls and Buka, 1997) to explore heterogeneity within community areas without relying exclusively on census tracts (which are a common proxy for neighborhoods; see Bellair, 2000; Sampson et al., 2002; Peterson and Krivo, 2010). Two to three census tracts were combined based on PHDCN research team's knowledge of Chicago's local neighborhoods, major geographic boundaries, and cluster analyses of census data (Sampson, 2012). PHDCN data is publically available but due to its confidentiality a data access proposal must be submitted to the Interuniversity Consortium for Political

[10] The Chicago Tribune maintains a webpage which tracks crime trends in the city using community areas; http://crime.chicagotribune.com/). The city's data portal contains several measures of public health at community areas.

and Social Research (ICPSR).[11] Professor Robert Sampson generously provided the neighborhood cluster boundary shapefile after approval was received from ICPSR (see Earls et al., 2007). Community areas were delineated in the 1920s by Chicago School researchers in conjunction with the city's Department of Public Health (Chicago Fact Book Consortium, 1990). Driven by dissatisfaction with U.S. Census boundaries, these units were created to conform to preexisting natural and social boundaries observed in Chicago (Wirth and Bernert, 1949; Hunter, 1974). The University of Chicago's library maintains an extensive collection of historic maps which document the creation of these units in addition to several other maps from Chicago School studies that collectively demonstrate the importance of neighborhoods in the city of Chicago.[12] A shapefile of community areas was obtained through the Chicago Data Portal.

Chicago has a total geographic expanse of nearly 230 square miles covered by 342 neighborhood clusters and 76 community areas after excluding O'Hare airport. However, the geographic sizes of community areas range from between 0.61 to 13.3 square miles (mean = 3.00 sq. miles), and the geographic sizes of neighborhood clusters range from as small as 0.08 sq. miles to 10.52 sq. miles (mean = 0.67 sq. miles). Community areas averaged some 36,000 residents per area while neighborhood clusters averaged roughly 8,000 residents per cluster. Figure 4.3 illustrates the hierarchical relationship of all three nested units of analysis that were used in this dissertation.

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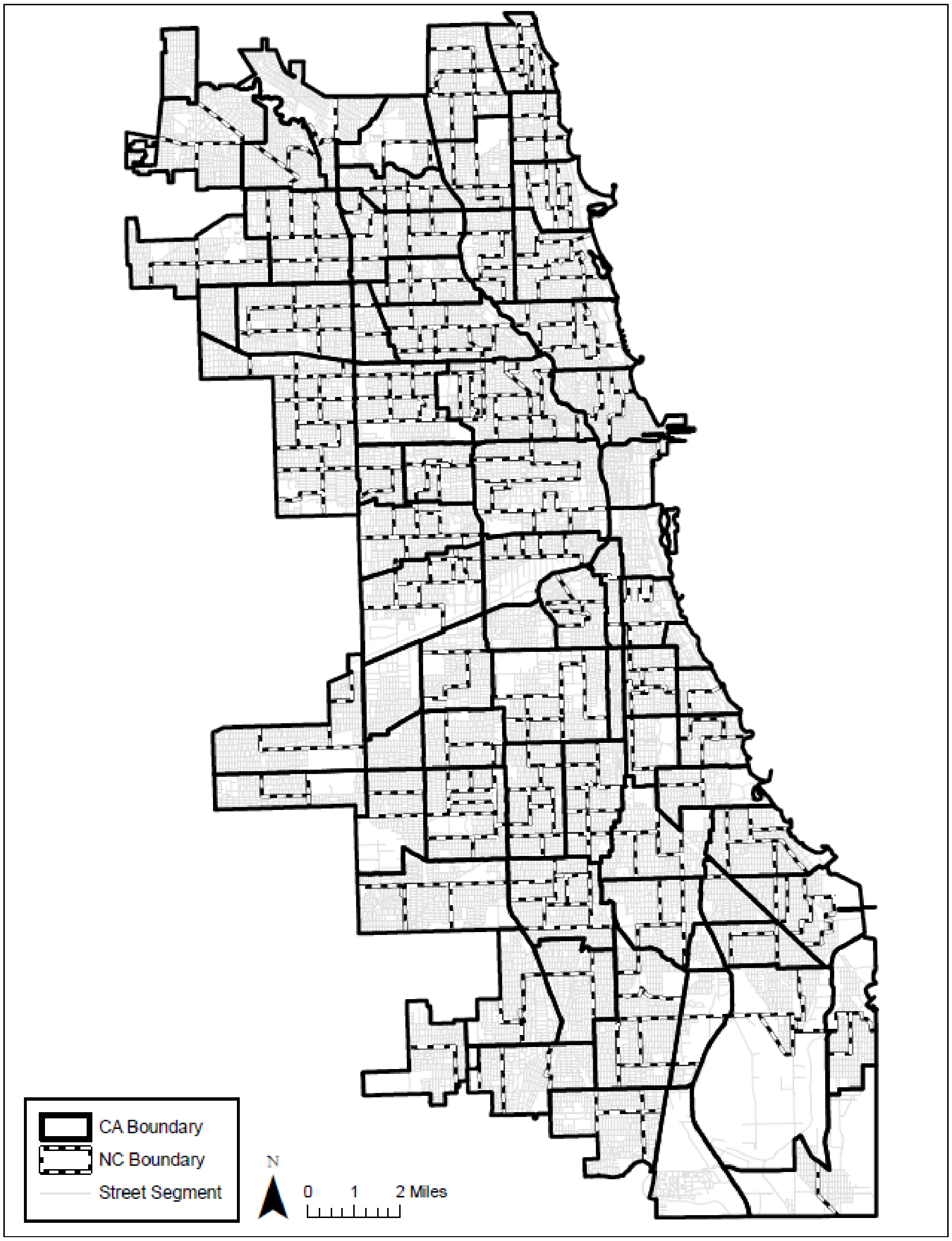
[11] Proposals are submitted at: http://www.icpsr.umich.edu/icpsrweb/PHDCN/.

[12] These "Social Science Research Committee" and "Social Scientist Map Chicago" documents can be viewed on the libraries website; http://www.lib.uchicago.edu/e/collections/maps/chisoc/.

Figure 4.3: Spatial Units Used in the Study; Street Segments Nested Within Neighborhood Clusters (NC) Nested Within Community Areas (CA) in Chicago



Note: On average 122.59 street segments are nested within neighborhood clusters (SD = 87.89, Min. = 9, Max. = 790), 551.66 street segments are nested within community areas (SD = 285.67, Min. = 81, Max. = 1544), and 4.5 neighborhood clusters are nested within community areas (SD = 2.89, Min. = 1, Max. = 15).

CHAPTER 5 – RESEARCH METHODS:

MODELS AND MEASURES

This chapter continues discussion of the methodology that will be used to answer the research questions proposed in the Chapter 1 of this dissertation. The first section reintroduces each of the three research questions to further elaborate upon the analytic techniques that will be used to answer each. The second section provides a detailed examination of the models that will be used to answer the research questions. The third section describes the criminal opportunity and social disorganization measures that will be considered to answer research question three.

Analytic Strategy

Research Question 1

Is distributional concentration and developmental stability of violent crime incidents observed at street segments, neighborhood clusters, and community areas in Chicago?

This research question will be answered by summarizing the distribution of 450,668 violent crime incidents at 49,029 street segments, 342 neighborhood clusters, and 76 community areas over 14 years in Chicago. Crime maps will be used to visualize the distribution of violent crime incidents and demonstrate the distributional concentration. Year to year 50% and 100% concentration values, which are commonly used in crime clustering analyses at micro-places (see Weisburd, 2015), are calculated to observe repeated cross-sectional patterns. Lorenz curves for the entire observation period and select years are plotted to illustrate the comprehensive distributional form without applying arbitrary cutoff thresholds (see Lorenz, 1905; Johnson, 2010b). Gini coefficients will be calculated to begin to provide a standardized method to compare the distribution of violent crime at each unit of analysis (see Johnson, 2010b; Steenbeek and Weisburd, 2016).

Group-based trajectory models (GBTM) will be estimated in Stata 14.1 to characterize developmental patterns of violent crime incidents at street segments and neighborhood clusters from 2001-2014 (see Griffiths and Chavez, 2004; Weisburd et al., 2004; Nagin and Jones, 2013). Due to the small number of community areas in Chicago developmental patterns will not be assessed at these units of analysis. Weisburd and colleagues (2004) used a simple procedure fitting linear intercepts and slopes to the grouped counts of incidents over time in addition to visual inspections of the trajectories to summarize the developmental growth of each identified group.

Research Question 2

How much of the total spatial variability of violent crime incidents can be uniquely attributed to street segments and neighborhoods in Chicago?

This research question will be answered by summarizing the distribution of 359,786 violent incidents at 41,926 street segments nested within 342 neighborhood clusters, in turn nested within 76 community areas in Chicago over 14 years. First, using the developmental patterns identified in research question one an initial overview of the nested distribution of violence at street segments in larger units of spatial aggregation can be captured. Second, Crime maps will be used to visualize if spatial heterogeneity of developmental patterns exists within neighborhood clusters and community areas. Cross-tabulations based on street segment and both neighborhood cluster developmental patterns also can describe the composition of violence patterns within these units and find if spatial homogeneity of patterns is observed within neighborhoods.

These analyses provide an initial account of the role of spatial aggregation in observing the variability of violent crime incidents between units of analysis. However, it is important to recognize that these simple descriptive analyses do not model the hierarchical relationship between these units of analysis simultaneously. This limitation is addressed by estimating a linear mixed model. Using a linear mixed model also provides an alternative method to characterize developmental patterns at place which strengthens the robustness of previous findings using GBTM. A four-level model of observations nested in street segments nested in neighborhood clusters nested in community areas will be estimated with a random effect of time. The variance component of this random effect is then decomposed and calculated for each level or unit of analysis to answer the research question.

Research Question 3

Do opportunity measures at street segments explain differences between levels of violent crime incidents at street segments when accounting for social disorganization measures at neighborhood clusters in Chicago?

This research question will be answered by an explanatory analysis of 56,444 violent crime incidents at 41,926 street segments nested in 342 neighborhood clusters over 3 years (2012-2014) in Chicago. Neighborhood clusters were selected over community areas to represent “neighborhoods” in order to maximize the number of level-2 units of analysis assessed. Limiting this analysis to three years of the observation period was decided for several practical reasons. First, estimating a model that accounts for level-1 and level-2 predictors for 14 years with over 350,000 incidents would present efficiency challenges due to the long amount of time for model estimation. Second, using a 14 year observation period is beneficial for the descriptive analyses because it provides a comprehensive time series to understand the relationship between violence and place in Chicago but it also unfortunately restricts the available data for explanatory analyses.

Predictors would need to be measured prior to 2001 or consistently from 2001-2014. The former was not possible since most available data sources for opportunity measures are not available then (i.e. Chicago data portal) and the latter was not possible because there was a lengthy gap between available social disorganization measures (i.e. PHDCN/2000 to 2010 Census). Third, the explanatory analysis will consider a theoretical integration that already presents challenges without even accounting for the longitudinal structure of the data. To focus on the hierarchical theoretical integration the longitudinal component of the outcome measure will be excluded to refocus the primary analysis. Other explanatory analyses will be conducted to address the longitudinal nature of the dependent variable.

Several analyses will be conducted prior to the estimation of a hierarchical model. These analyses will use descriptive statistics, correlations, and regression models to understand the relationship between opportunity, social disorganization, and violence in Chicago prior to the estimation of an integrated multi-level model. Developmental trajectories identified in the first research question will be used to incorporate the longitudinal nature of the outcome data. The main analysis offers the most comprehensive answer to the research question because it examines the influence of both sets of measures. A generalized linear mixed model will be estimated to explain variation between counts of violent crime incidents at street segments in Chicago. The significance of coefficients for level-1 opportunity measures are compared before and after the introduction of level-2 social disorganization measures to answer the research question. Then models which specify random effects for criminal opportunity variables and cross-level interactions (see Piza et al., 2016) were estimated to determine if these measures influence the level of violence at street segments across different neighborhood contexts. Finally, GBTM is used to summarize developmental patterns of violence and concentrated disadvantage at neighborhood clusters to offer another example of the influence of "neighborhood effects" on criminal opportunity at micro-places. This technique accounts for the hierarchical relationship, spatial lag, and temporal influence of neighborhood effects in a more intuitive manner.

Models

Group-Based Trajectory Modeling

Over the past twelve years, several empirical investigations attempting to expand our understanding of the concentration and stability of crime at places within cities have applied group-based trajectory modeling (GBTM) to characterize developmental patterns (Griffiths and Chavez, 2004; Weisburd et al., 2009c; Yang, 2010). In general, GBTM can be used to describe population differences for an outcome over time (Nagin and Piquero, 2010). This semi-parametric, finite mixture modeling technique identifies a limited number of latent developmental groups within a population assuming an unknown, continuous distribution (Nagin, 2005). Within the observed population each individual case is assigned a posterior probability of membership to each of the identified developmental trajectories before being assigned as belonging to the one with the highest probability. GBTM can be viewed as a technique that descriptively condenses longitudinal into cross-sectional data; the description of patterns over time can be succinctly expressed through the identified trajectory groupings.

Nagin (1993) first used GBTM to observe offending patterns of individuals over the life course (also see Laub, Nagin, and Sampson, 1998; Apel et al., 2007). GBTM has subsequently been diffused to a wide range of other disciplines in the social sciences (see Nagin and Odgers, 2010). This technique can be used to test theoretical typologies but has been suggested to be most effective when used for description of developmental patterns (Nagin and Tremblay, 2005). When applying GBTM, analysts must be aware of the risk for the misclassification of groups or creation of groups that are not real and distinct from each other (Skardhamar, 2010). The concern of the creation of non-distinct groups is an inherent limitation to GBTM; developmental groupings should be interpreted as approximations dependent on fixed temporal observation periods (Eggelston, Laub, and Sampson, 2004; Nagin and Odgers, 2010). Nagin (2005), however, suggests that the risk of misclassification of groups can be reduced through a rigorously-specified grouping procedure.

Griffiths and Chavez (2004) were the first criminologists to apply GBTM to understand developmental crime patterns at neighborhoods, while Weisburd and his colleagues (2004) were the first to apply GBTM to understand developmental crime patterns at street segments. Alternatively, Braga and colleagues (2010) estimated growth curve regression models to observe developmental patterns of gun violence incidents at street segments and intersections in Boston (also see Braga et al., 2011). Curman and colleagues (2015) used k-means clustering to identify developmental patterns of total crime incidents in Vancouver. Both of these studies reached similar conclusions as the first analysis by Weisburd and colleagues (2004) and other analyses using GBTM (Weisburd et al., 2009c; Weisburd et al., 2012; Wheeler et al., 2015). GBTM will be used to answer research question one because it provides a more objective grouping process for the large number of street segments in Chicago then growth curve modeling and distributional outliers did not influence the estimation of the models to warrant the use of k-means clustering techniques (see Curman et al., 2015).

Models will be estimated using the zero inflated Poisson probably distribution. This distribution was selected because the only alternatives in Stata 14.1 are censored normal or logistic which would represent even less appropriate fits for the count outcome data (Jones and Nagin, 2013). The equation for the zero inflated Poisson model that will be estimated:

$$p^j\,(y_{it} = 0) = \propto_t^j + \left(1 - \propto_t^j\right) e^{-\lambda_{jt}},$$

$$p^j\,(y_{it}) = (1 - \propto_t^j)\,\frac{\lambda_{jt}^{y_{it}}\, e^{-\lambda_{jit}}}{y_{it}!} \qquad (y_{it} = 1, 2, \ldots)$$

Estimation will proceed using the approach used by Weisburd et al., (2012) and the classification of groups will be determined using guidelines specified in Nagin (2005). Using this approach, the polynomial type for the model will be tested as intercept, linear, quadratic, and cubic across all groups. The total number of groups will be increased until the lowest Bayesian Information Criteria (BIC) for the model is observed. Additionally, the odds of correct classification and average group posterior probability will be calculated throughout this process using the thresholds proposed in Nagin (2005) for high assignment accuracy of groups to supplement the BIC to determine the optimal model fit (i.e. number of groups).

Linear and Generalized Linear Mixed Models

Linear and generalized linear mixed models will be estimated to answer the second and third research questions. Specifically, a linear mixed model (LMM) will be used to assess the variance attributed to each spatial level of aggregation in research question two and a generalized linear mixed model (GLMM) will be estimated to determine the influence of opportunity measures at street segments and social disorganization measures at neighborhoods in research question three. Both variations of the mixed model will be reviewed.

Multi-level or hierarchical models offer an analytic technique to observe differences in outcomes within and between nested clusters of observations (see Raudenbush and Byrk, 2002). Predictors can be specified at different hierarchical levels. Mixed models are a classification of hierarchical models, alternatively known as HLM, which include both fixed effects and random effects of predictors. Fixed effects influence each of the identified clusters of observations uniformly. Random effects consider a unique relationship for the predictor at each of the identified clusters in addition to the fixed effect. Mixed models allow for a flexible characterization of predictors based on the ability to specify fixed or random effects for each predictor individually (see Rabe-Hesketh and Skrondal, 2012a). The difference between a linear and generalized mixed model is the distributional form of the outcome variable; the linear model assumes a continuous distribution while the generalized linear model a non-normal distribution. The non-normal distribution is assumed to be discretely continuous then connected to the observed response through a link function to the appropriate probability distribution (see Rabe-Hesketh and Skrondal, 2012b).

Hierarchical relationships can be observed in various aspects of contemporary social life. Throughout the sciences these hierarchical modeling techniques have become increasingly applied over the past few decades to model these relationships (Goldstein, 1987a; Gelman and Hill, 2002). Across disciplines, the notation and textual accounts may vary when describing multi-level models but the underlying logic is identical (see Raundebush and Byrk, 2002; Rabe-Hesketh and Skondral, 2012a). In criminology, multi-level models have been utilized more frequently over the past few decades to further understand hierarchical relationships in data (see Sampson and Wooldredge, 1987; Johnson, 2010a; Davies and Johnson, 2015). In place-based criminology, multi-level models have an obvious appeal because of the inherent hierarchical relationship between different place-based units of analysis. Since “place” is a malleable construct the spatial aggregation of place-based units of analysis can be viewed, for example, as similar to a “Matryoshka” or Russian nesting doll. While this study focuses on geographic levels within cities they can easily be conceptualized outside of this context; cities are nested within counties which are nested within states and so on. The use of multi-level models can begin to assess the influence of these levels of spatial aggregation (see Hipp, 2010; Steenbeek and Weisburd, 2015).

Research question two will replicate the methodology used in a recent study which assessed the variance attributed between three spatial levels of aggregation within a city (see Steenbeek and Weisburd, 2015). To determine if estimation of an LMM would be appropriate to replicate this study in Chicago a discussion of the specification procedure for the model will be conducted. Steenbeek and Weisburd (2015) estimated a LMM on a *sample* of street segments in The Hague, Netherlands. The authors conducted a bootstrapping procedure which drew 500 stratified random samples of 25% of street segments per neighborhood; the authors' findings were based on averaged variance estimates across all of the replications. This procedure was used to satisfy an assumption of the random effects model that data assessed will be drawn from a random sample of a population for each level since the data represented the "population" of street segments in The Hague. For this proposed analysis, estimates will be reported from a single model for three key reasons. First, due to the exclusion of certain street segments (i.e. boundary overlap, highways) the remaining street segments represent a sample – albeit a non-random one – of the population of street segments in Chicago which partially satisfies the assumption.[1]

Second, Chicago is much larger than The Hague which creates a computational problem – which was already a concern for Steenbeek and Weisburd (2015). The Hague study assessed 9 years of total crime incidents geocoded to 15,527 street segments nested within 114 neighborhoods nested within 44 districts compared to this proposed study which assesses 14 years of violent crime incidents geocoded to 41,926 street segments nested within 342 neighborhood clusters nested within 76 community areas in Chicago. The bootstrapping procedure was partially employed as a time efficient strategy to reduce the time of model estimation in The Hague study. However, this would likely no longer be the case when the procedure will be applied to Chicago. Third, the other benefits of using the bootstrapping procedure described in Steenbeek and Weisburd (2015, p. 8),

[1] 51,650 street segments were initially identified before excluding 9,724 thus creating a sample of 81.2% of the original population. Even without this consideration, identifying the 51,650 street segments as a "population" is to some degree an arbitrary and rhetorical decision since these data could always be conceptualized to belong to a super-population (see Hartley and Sielken, 1975). In other words, the street segments in Chicago could be argued to be a sample of the street segments in Illinois or the violent crime incidents from 2001-2014 could be argued to be a sample of 14 years from the 179 years Chicago has been incorporated as a city.

such as addressing spatially correlated errors on the street segment level, could be recovered through conducting the procedure as a sensitivity analysis and comparing estimates to a single model which provides a more straightforward analytic approach which includes all street segments.

Model estimation will proceed by first investigating whether the assumptions of the linear model were violated by the distribution of the dependent variable residuals. Three-level hierarchical models (street segments nested in neighborhood clusters nested in community areas) will be estimated using raw violent crime counts and logged violent crime counts for each wave of data.[2] The normality assumption of the dependent variable will be reviewed using residual diagnostic plots to determine which measure is the most appropriate for the LMM. [3] Then Restricted Likelihood Ratio Tests will be used to determine whether the two-, three-, or four-level models best fit the panel data (see Rabe-Hesketh and Skrondal, 2012a).

The logged street segment length will be added as the only covariate in the LMM since shorter street segments inherently allow for fewer crime opportunities relative to

[2]This dependent variable will be constructed by adding one to each observation and then taking the natural logarithm of the values: log (raw violent crime count + 1).

[3] Another approach would be to treat the dependent variable as count data and estimate generalized linear mixed models (GLMMs) that use a log link function and the probability mass function for the Poisson distribution. However, estimating a four-level GLMM model using the Chicago dataset presents a formidable computational challenge. Using Stata 14.1, for example, this model would not converge after running for three days. Additionally, as suggested by Steenbeek and Weisburd (2015), GLMMs are limited by a number of considerations for this kind of analysis that make interpretation of results much more complicated. For instance, while a simulation approach has been proposed as a solution (Browne et al., 2005), a disadvantage of GLMM is that the level-1 variance depends on the expected value and is therefore not reported by the Stata 14.1 software used in our analysis (and most other statistical packages). What is more, it was unlikely that our sampling distributions of the parameters were multivariate normal given the relatively small number of units per level in our models. This problem could be addressed by approximating the confidence intervals around our point estimates via parametric boot- strap methods (Efron, 1979). Fortunately, the log transformation of the violent crime measure yielded satisfactory residual diagnostics which allowed for the continued use of straightforward LMMs parameters were multivariate normal given the relatively small number of units per level in this proposed model. This problem could be addressed by approximating the confidence intervals around the point estimates via parametric boot- strap methods (Efron, 1979). Fortunately, the log transformation of the violent crime measure is anticipated to yield a near normal distribution that allowed the use of straightforward LMMs.

longer street segments (see, e.g., Braga et al., 2010, 2011). Other covariates will not be added since research question two is not interested in explaining crime variability by time-constant or time-varying predictor variables. Again, this investigation is simply interested in estimating the variability of crime across different levels of geographic aggregation. While adding additional co-variates would likely influence the variance proportions, estimating an "empty" model provides an insightful baseline representation of these proportions. This research question will analyze, similar to Steenbeek and Weisburd (2015), the effect of a time trend and divergent time effects for community areas, neighborhood clusters, and street segments will be estimated by allowing coefficients of time to vary randomly at each spatial level. The final model will have *t* measurements nested within street segment *i* nested in neighborhood cluster *j* nested in community area *k*, with correlated random effects, estimated using restricted maximum likelihood in Stata 14.1:

$$Y_{tijk} = \beta_{0tijk} + \beta_{1ijk}\, time_{tijk} + \beta_2 \log(length)_{ijk} + \beta_3 \log(length)^2{}_{ijk}$$

$$\beta_{0tijk} = \beta_0 + f_{0k} + v_{0jk} + u_{0ijk} + \varepsilon_{0tijk}$$

$$\beta_{1ijk} = \beta_1 + f_{1k} + v_{1jk} + u_{1ijk}$$

Inferences on violent crime variation for the three spatial levels will be made based on the proportion of the total variance in violence that can be explained by each geographic level. Since each spatial level allows the effect of time to vary randomly, the variance for each level depends on time. The street segment variance, for instance, is calculated by:

$$var\left(u_{0ijk} + u_{1ijk}\, time_{tijk}\right) = {\sigma_{u0}}^2 + 2\sigma_{u01} time_{tijk} + {\sigma_{u1}}^2 {time_{tijk}}^2$$

with σ_{u01} referring to the covariance between the random effect of street segment and the random slope of time (see Goldstein, 1987b). Equivalent calculations will be used to estimate the variance functions for community areas and neighborhood clusters.

Research question three will estimate a GLMM and will return to observing the probability distribution of violent crime incidents as Poisson (see Piza, 2012) since the decomposition of random effects is not necessary to answer this question. Multiple tests will be conducted to determine the optimal modeling technique to represent the event count data (e.g. zip, negative binomial, etc.). Fixed effects for all level-1 and level-2 predictors with only a random effect to identify level-2 clusters (i.e. random intercept model) will initially be specified. The proposed model will have street segments *i* nested in neighborhood clusters *j*, with *opp1* representing opportunities variables, with *sd1* representing social disorganization variables, and will be estimated in Stata 14.1:

$$\Pr\left(Y_{ij} = y \middle| \mu\right) = \frac{\exp(-\mu)\mu^{y}}{y!}$$

$$Y_{ij} = \beta_{0ij} + \beta_{1j} + \beta_2(opp1)_{ij} + \beta_3(sd1)_j + \beta_4(opp2)_{ij} + \beta_5(sd2)_j \ldots$$

$$\beta_{0ij} = \beta_0 + u_{0j} + \varepsilon_{0ij}$$

$$\beta_{1j} = \beta_1 + u_{1j}$$

Place-Based Theoretical Measures

Two theoretical classes of place-based variables will be used to answer research question three: criminal opportunity measures at street segments and social disorganization measures at neighborhood clusters. This dissertation will use a similar multi-level framework for the theoretical integration recently applied by Davies and Johnson (2015) in addition to Deryol et al. (2016).[4] Opportunity measures will capture the foreground ecological conditions which influence individual's decision-making at small places while the social disorganization measures will represent the background socio-ecological characteristics of the larger areas these small places are nested within. This study does not propose a comprehensive test of the integration between these two theories. Measures of social control in particular were not extensively tested at both levels (see Hunter, 1985) because of ambiguity between theoretical concepts (see Braga and Clarke, 2014) and challenges in collecting this data. Also, most of the variables tested are conceptually linked to opportunity theories instead of social disorganization.

Instead this dissertation tests an exploratory framework that begins to examine the relationship between these two classes of theories while contributing to the paucity of empirical findings on the subject. Since this study proposes an exploratory framework the influence of variables spatial and temporal specification will be assessed by providing several variations of key models. Finally, even within each theoretical class several variations of interpretations between the causal pathway of each variable and violent crime can exist (see Goldstein, 1985). For example, illegal market incidents at street

[4] A critique of the interactions terms used in this article prompted an exchange between the authors (Deryol et al., 2016b) and Reinhart (2016). The analyses conducted in this dissertation adapt the multi-level framework of this article, not their representation of interaction terms which resulted in the aforementioned exchange.

segments could influence the number of violent crimes at these locations by increasing the number of suitable targets *or* motivated offenders. The descriptions of variables that follow will highlight only a handful of the leading theoretical explanations to justify inclusion of the measure.

Opportunity Measures

Table 5.1 provides an overview of the independent variables that will be used to represent criminal opportunity in Chicago. The operational representation of criminal opportunity measures will be organized in two distinct categories of variables: accessibility and routine activities. Each of these categories captures a central component of the opportunity theories discussed in Chapter 2. The presence of these characteristics on street segments influences individual's appraisal of potential criminal opportunities at micro-places. Accessibility is associated with crime pattern theory; individuals observe criminal opportunities throughout the course of their daily routines as they navigate between locations. Violence is the outcome of an interaction between two or more individuals therefore an investigation to explain the variation between incidents at places needs to first account for the concentration and movement of individuals within a city. Accessibility measures will specifically assess the configuration of Chicago's transportation network to understand how individuals traverse the city.

The routine activities category is associated with its namesake theory and the level of situational risk at specific locations; the presence of suitable targets, motivated offenders, and lack of guardianship create the prerequisite conditions for crime events to occur at places. These measures will identify micro-situational factors which can influence the emergence of violence at street segments. Routine activities offers a helpful theoretical construct to operationalize the distribution of criminal opportunity measures within cities (see Weisburd et al., 2012). These three components will be considered together because overlap between these groups, with suitable targets and motivated offenders in particular, is common when studying the situational context of violent crime events (Luckenbill, 1977; Felson and Steadman, 1983; Kennedy, Braga, and Piehl, 2001; Griffiths, Yule, and Gartner, 2011). Together accessibility and routine activities jointly

Table 5.1: Description of Criminal Opportunity Variables

Level-1 Opportunity	Description
Accessibility:	
Length	Length of street segment in feet
Permeability	Street segment is connected to 1-5 other street segments (=0) or 6+ other street segments (=1)
Arterial	Street segment is primary access route throughout the city (0 = No, 1=Yes)
Highway Access	Distance in feet of street segment to closest highway or interstate on/off ramp
Train Station	Distance in feet from street segment to closest train station
Bus Stops	Presence of bus stop within one block of street segment (0 = No, 1=Yes)
Routine Activities:	
Land Use	Presence of active business on street segment (0 = No, 1=Yes)
Facility with Alcohol	Distance in feet of street segment to nearest facility where alcohol can be purchased
Public Housing	Street segment is within one block of a public housing facility (0 = No, 1=Yes)
Gang Territory	Presence of gang turf on street segment (0 = No, 1=Yes)
Illegal Market Incidents	Number of drug, prostitution, and gambling incidents reported on street segment to CPD
Physical Disorder	Factor score of 311 calls for service on street segment: abandoned buildings, abandoned cars, and graffiti removal

Note: Level-1 variables measured at street segments (N = 41,926) begin to unpack how people navigate a city and where violence will concentrate. Both of these categories of measures assume a rational choice model of criminal offending. For the analysis in research question three all opportunity variables will be measured from between 2010-2011. All variables will be collected from the Chicago Data Portal unless noted otherwise. Also, each variable was geocoded using X-Y coordinates in ArcGIS and all geocoding rates were over 95%.

Six variables were collected to measure the accessibility of street segments. [5] All six accessibility variables are time stable (2011-2014) representations of these measures. While it's possible for each measure to be altered by the City of Chicago over the three year observation period this analysis will investigate, the risk of substantial changes is negligible since city's transportation infrastructure is generally stable over short periods of time.[6] *Length* of street segments was observed because longer street segments are more likely to experience a crime event. Longer street segments present an increased raw volume of possible opportunities for crime events to occur. This co-variate is one of the most important control variables to capture when analyzing the distribution of crime at street segments (Braga et al., 2010; 2011; Steenbeek and Weisburd, 2016). Street segment length is a continuous variable measured in feet using ArcGIS 10.3 that will be transformed using the natural logarithm function to approximate a normal distribution of the variable.

[5] These six variables represent a combination of both measure that have been repeatedly utilized across studies to capture street accessibility and are also germane to comprehending the transportation network of the city. This set of variables is not a representation of the best available measures but instead an exhaustive collection of the optimal measures.

[6] The Chicago Transit Authority did make a few minor alterations of bus routes and train lines over this time period. Fortunately, the Chicago Data Portal contains historic data on ridership which allowed for the precise confirmation of the bus routes and train lines that were active between 2011 and 2014. These data will be used in this analysis.

Permeability was explored because street segments that are increasingly connected to Chicago's street network are at an elevated risk of victimization. The number of entry/exit points on street segments can indicate the level of usage within the street network. Recent research on the configuration of street networks has drawn upon the broader study of social networks to find preliminary support for their influence in explaining crime events within cities (see Beavon, Brantingham, Brantingham, 1994; Summers and Johnson, 2016; Papachristos, Hureau, and Braga, 2013). This dichotomous variable measures the number of other street segments connected to a street segment in Chicago's street network divided into two groups (0 = zero to five segments, 1 = six or more).[7] Permeability was calculated in ArcGIS by conducting a spatial join of a duplicate of the Chicago street segment basemap to the original file then counting the number of units it intersects with excluding the original street segment.

Arterial routes were identified because segments central to street networks are more likely to experience a violent crime incident since more individuals use these locations. Research investigating the centrality in addition to the permeability of streets in street networks has found these units are at an increased risk of victimization (Johnson and Bowers, 2010; Davies and Johnson, 2015). This dichotomous variable was created by obtaining the major streets shapefile in Chicago and then conducting a spatial join with the street segments basemap in ArcGIS to identify these thoroughfares.

[7] For example, imagine being in a car that comes to a four way stop at an intersection. The car can proceed in three possible directions (left, right, or straight); therefore on this end of the street segment it is connected to three other segments. Unless the street segment is a dead-end the same calculation occurs on the opposite side. A dichotomous variable was used instead of a continuous measure because the distribution was skewed; almost 90% (37,444 of 41,926) of all street segments in Chicago have 4-6 entry/exit points.

Highway Access was observed because segments closer to these locations are more accessible throughout the broader street network of a city. The influence of the proximity to highways or interstates is not studied often, although the limited empirical evidence suggests a connection to crime (Rengert, Ratcliffe, and Chakravorty, 2005), but this concept is aligned with the logic of understanding the transportation patterns of individuals within cities. This continuous variable is created by using the Network Analyst extension in ArcGIS and calculating the distance in feet between the center-point of each street segment and the center-point of the nearest highway or interstate entry/exit ramp using the street network.[8] Using the street network provides a more authentic representation of the distance opposed to using the Euclidean distance which measured the straight line or "as the crow flies" distance (see Xu and Griffiths, 2016). The natural logarithm of this variable will be created to transforms the distributional form.

Train Station was included in the analysis because street segments closer to train stations are more connected within Chicago's broader transportation network and they represent busy activity hubs which also increases their likelihood of victimization. The proximity to public transportation has been identified as a robust influence on the occurrence of crime events at micro-places (Smith and Clarke, 2000). This continuous variable is created by using the Network Analyst extension in ArcGIS and calculating the distance in feet between the center-point of each street segment and the location of the nearest train station. The natural logarithm of this variable will be calculated to transform the distributional form.

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[8] Center-points of street segments are used for practical reasons because Network Analyst can only calculate distance between two points. Since street segments are on average 428 feet in Chicago the distance between these locations and other places represents only a summary measure. Using this summary measure is aligned with using the aggregate count of incidents occurring at these locations which does not account for their specific location on the street segment.

Bus Stops were analyzed for similar reasons as train stations; these variables were measured separately because they are more common and provide an additional dimension to understanding the transportation network of Chicago which is large enough to merit a distinction between each instead of viewing them collectively as “public transportation”. For example, while there are only 121 train stations in Chicago there are over 10,000 bus stops. This dichotomous variable captures if a street segment is located within a one block buffer (0 = No, 1 = Yes) of a bus stop within Chicago. A one block buffer was selected instead of a continuous distance measure because of the high frequency of stops in Chicago which restricted the variation of distance measures (i.e. most segments are either close or *very* close to bus stops).[9] This measure was created by joining a bus stops shapefile to the street segment basemap then using the proximity tool in ArcGIS to determine if a segment was within a 660 feet (i.e. a city block in Chicago) buffer. Bus stops were calculated opposed to bus routes (see Deryol et al., 2016) because once bus stops were joined to the street segments there was almost no differentiation between segments with bus stops and segments on bus routes. Accounting for the path between bus stops is necessary, as opposed to the routes between train stations, because individuals can exit buses anywhere between these locations on a street network.

Six variables were collected to measure the presence of situational risk on street segments. These variables will have different temporal specifications which provides a contrast to the time stable uniformity of the accessibility variables. *Land Use* was measured to account for the different functions of street segments in urban areas.

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[9] Differentiating between a continuous distance measure and a “distance band” - a dichotomous variable based on falling within or outside of a specified distance threshold (i.e. one block) – is crucial. Both techniques are used in this dissertation. Each variable will be specified as one for a theoretically informed or practical reason then tested, if possible, with the other as a sensitivity analysis (see Xu and Griffiths, 2016).

Different daily rhythms and routines of individuals occur based on the land use of a street segment; commercial, mixed, and residential representing the three main distinctions. This variable is a common control in place-based analyses occurring at all spatial-levels (Taylor and Harrell, 1996; Stucky and Ottensmann, 2009; Weisburd et al., 2012). Observing this variable provides a simple summary of the land use on the street segment instead of beginning to unpack the specific facilities occurring at these locations. This dichotomous variable was created by observing if one or more business licenses were identified to a street segment in 2011 (0 = No, 1 = Yes). Each year will be assessed in the sensitivity analyses although the 2011 measure will be primarily used to answer research question three.

Facility with Alcohol were assessed because street segments within their immediate proximity have an increased risk of victimization due to either the situational impact of alcohol on individual's behavior or the attraction of motivated offenders. The influence of facilities serving alcohol on crime is one of the most exhaustively explored criminal opportunity measures (Roenck and Meir, 1991; Madensen and Eck, 2008; Groff and Lockwood, 2014). This continuous variable was created by calculating the distance in feet between street segment center-points and the closest location that sells alcohol on the premise (e.g. bars, liquor stores, etc.) using Network Analyst in ArcGIS. The locations were identified through sorting classes of liquor licenses under Chicago's business licenses for each year between 2011 and 2014. The natural logarithm of this variable will be calculated to transform the distributional form. Each year will be assessed in the sensitivity analyses although the 2011 measure will be primarily used to answer research question three.

Public Housing was included in the exploratory model because these facilities have been hypothesized as "crime attractors" for violent incidents through offering the interaction of motivated offenders and suitable targets. The relationship between public housing and crime has been studied extensively over the past fifty years with mixed findings on their influence on crime (Newman, 1972; Griffiths and Tita, 2009). This dichotomous variable was created by identifying the addresses of these multi-unit public housing facility locations through the Chicago Housing Authority website and then using aerial basemap imagery to manually draw their boundaries in ArcGIS.[10] Google Street View was then used to supplement this information to determine if these facilities were built prior to 2011. All public housing facilities used in the analysis were confirmed as being built prior to 2011 (i.e. time stable). After this shapefile was created a one block buffer was added to each facility to identify the street segments in the immediate proximity and to minimize error since the boundaries were created manually.

Gang Territory was included because street segments within or adjacent to these areas experience an increased risk of victimization for violent crime incidents. While several potential theoretical pathways exist to understand this relationship, similar to most place-based measures in this study, two of the more prominent are that gangs use organized violence to enforce order at places (i.e. motivated offenders) or violence is the byproduct of retaliation between gangs (i.e. suitable targets). The relationship of gangs to crime within Chicago has been studied across decades (see Thrasher, 1927; Block and Block, 1993) and their influence on the distribution of violence at micro-places has garnered recent scholarly attention (see Curry and Spergel, 1988; Tita and Ridgeway, 2007). A dichotomous variable was created to measure if a street segment falls within or

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[10] http://www.thecha.org/.

partially intersects with gang territory in 2010. The Chicago Police Department conducts an annual audit of gang territory during which they collect gang intelligence from several sources to identify, confirm, and then exhaustively map the spatial boundaries of these areas throughout the entire city (Chicago Crime Commission, 2012; Papachristos et al., 2013). In 2011, despite the gang territory map being reprinted in the city's annual crime report, a local media outlet in Chicago published this map to a wider audience with the permission of the CPD. A shapefile of the gang territory has subsequently been made available to the public which this study used.

Illegal Markets Incidents were observed because these events elevate the risk of victimization at street segments due to these locations attracting both suitable targets and motivated offenders (Goldstein, 1985). Bernasco and Block (2011) found a relationship between the presence of illegal market incidents at micro-places and the number of robberies in Chicago (also see St. Jean, 2007; Taniguichi et al., 2011). A continuous variable was calculated by aggregating the number of drug, prostitution, and gambling incident reports to the CPD into one measure then generating the natural logarithm to transform its distributional form.

Physical Disorder was measured at street segments because locations with increased levels have been hypothesized to experience more violent crime incidents (Wilson and Kelling, 1982). Disorder in place-based criminology has been explored at multiple spatial levels within cities (Sampson and Raudenbush, 1999; Hinkle and Weisburd, 2008); this analysis considers the concept at the micro-level to offer the most refined characterization of its variation between places in Chicago. A continuous variable was calculated by aggregating the total number of 311 calls for service (see

O'Brien and Sampson, 2015) for abandoned cars, abandon buildings, and graffiti removal in 2011 then conducting a factor analysis to create a single variable to capture the underlying concept. Disorder has been commonly associated with guardianship or informal social control at places (see Weisburd et al., 2012), although the use of calls for service also draws upon an entirely different construct in addition, the willingness of residents to report disorder.

Social Disorganization Measures

The operational representation of social disorganization measures will be captured through the use of structural and organizational characteristics of neighborhood clusters. These categories of variables highlight the two central components of social disorganization theory discussed in Chapter 3. Neighborhood structural characteristics in social control models of social disorganization are directly associated with explaining differences in levels of crime between neighborhoods. Organizational characteristics offer informal mitigation of this relationship and regulate the behavior of individuals in these locations. Neighborhood structural measures of social disorganization have been empirically demonstrated to explain crime variation across multiple operational representations of neighborhoods (Sampson, 2012) and between multiple cities for decades (Peterson and Krivo, 2010; Taylor, 2015). Structural measures were collected from the 2010 U.S. Census then values were aggregated from tracts to neighborhood clusters. Values of structural characteristics at tracts were weighted based on the number of street segments within the tract then averaged across the number of tracts identified within the neighborhood cluster.[11] Organizational variables were collected from the PHDCN capturing values measured in 1995. These variables were previously aggregated to the neighborhood cluster by the PHDCN research team.

Two variables were constructed to measure structural characteristics of neighborhoods: concentrated disadvantage and residential instability (see Sampson et al., 1997). [12] Both variables are factor scores. Factor analysis is a common tool in neighborhood-based inquires used to group variables with high correlations that are linked through a latent construct (Harman, 1960; Kubrin et al., 2009). Both variables have been repeatedly used to operationalize neighborhood structural characteristics in Chicago (see Sampson et al., 1997; Morenoff et al., 2001; Kirk and Papachristos, 2011). *Concentrated Disadvantage* is explored because the spatial comorbidity of several social and economic indicators of poverty within cities is robustly associated with several social problems. This continuous variable was created by combining five variables: the percent of individuals below the poverty line, percent of female headed households, percent unemployed, percent younger than 18 years old, and percent African-American within neighborhood clusters. *Residential Instability* is observed because neighborhoods with high population turnover are hypothesized to be associated with lower levels of control and higher levels of crime. This continuous variable was created by combining two variables: the percent of owner occupied houses and the percent of vacant housing.

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[11] Boundary overlap issues – segments on the boundary between two tracts and two neighborhood clusters - were not overly problematic because these locations have already been removed to answer research question two. New boundaries were introduced within neighborhood clusters by including yet another hierarchical spatial unit of analysis. These boundaries do not present major concerns because the overlap between tracts is mitigated by averaging values across these units.

[12] All U.S. Census data used to create the concentrated disadvantage variable (1970-2010) was accessed through the National Historic Geographic Information Systems website (see http://www.nhgis.org; Minnesota Population Center, 2016).

Table 5.2: Description of Social Disorganization Variables

Level-2 Social Disorganization	Description
Structural:	
Concentrated Disadvantage	Factor score: % individuals below poverty line, % female headed households, % unemployed, % under 18, and % African-American
Residential Instability	Factor score: % owner occupied and % vacant housing
Organizational:	
Collective Efficacy	Empirical Bayes: 10 variables measuring social cohesion, trust and informal social control within neighborhoods
Network Ties	Empirical Bayes: 2 variables measuring the number of kinship and friendship ties of individuals to other residents within neighborhoods
Other:	
Spatial Lag	Mean number of violent crime incidents per street segment within neighborhood cluster

Note: Level-2 variables measured at neighborhood clusters (N = 342)

Two variables were constructed to measure organizational characteristics of neighborhoods: collective efficacy and network ties (see Sampson et al., 1997; Silver and Miller, 2004). Both variables are empirical Bayes estimates composed from several measures. Both variables have been repeatedly used to operationalize organizational neighborhood characteristics in Chicago (see Sampson et al., 1997; Morenoff et al., 2001; Kirk and Papachristos, 2011). *Collective Efficacy* was measured because the informal regulation of behavior by neighborhood residents can reduce the likelihood of crime events occurring within these locations. This continuous variable was created by combining 5 measures of social cohesion and trust in addition to 5 measures of informal social control then computing the empirical Bayes estimate. Appendix 4 displays each of the 10 variables used to create this measure. *Network Ties* was observed because the sheer bandwidth of connections between individuals within neighborhoods influences the capacity for collective action in these locations. This continuous variable was created by combining 2 measures reflecting the number of kinship and friendship ties individuals identified within the neighborhood cluster they resided in and they computing an empirical Bayes estimate.

One other neighborhood-level variable will be used in this analysis. This measure is not a social disorganization variable but is still a valuable neighborhood characteristic to account for. *Spatial Lag* is an important covariate because the level of violence in the general area of a neighborhood could increase the number of incidents occurring at street segments nested within them. Research question two will directly address this question and is the primary rationale for measuring the spatial lag at neighborhood clusters instead of alternate micro-units to maintain continuity between analyses in this study. The current availability of GIS software to place-based criminologists and criminal justice practitioners (see Weisburd and Lum, 2005; Chainey and Ratcliffe, 2013) has resulted in this variable becoming a common covariate in spatial analyses (Anselin et al., 2000; Morenoff et al, 2001; see Groff et al., 2010). This continuous variable was calculated by averaging the number of violent crime incidents in 2011 within a neighborhood cluster by the number of segments within the neighborhood cluster.

CHAPTER 6 – RESULTS:

DESCRIPTIVE ANALYSES

This chapter presents the results of the descriptive analyses proposed earlier in this dissertation to answer the first and second research questions. The first section observes the spatial distribution of violent crime incidents at street segments, neighborhood clusters, and community areas in Chicago to determine if distributional concentration of incidents at each of these units of analysis is detected. The second section determines if developmental stability of violent crime incidents is found at these units of analysis over the fourteen year observation period of this study. Both of these sections together will answer the first research question. The third section begins to compare the nested spatial distribution of violent crime incidents at these units of analysis to observe the hierarchical spatial variability of violence patterns within Chicago. The fourth section estimates a linear mixed model to determine the unique contribution of each unit of analysis to describing the spatial variability of violent crime patterns in Chicago. This section will provide an answer to the second research question.

The Spatial Distribution of Violence

Between 2001 and 2014, 75% of the total street segments in Chicago (36,786 of 49,029) experienced one or more violent crime incidents. Figure 6.1 displays the distribution of violent crime incidents at two thresholds – 50% and 100% of incidents – for each year in the observation period; the former value is helpful to describe the most active street segments and the latter summarizes the entire distribution (Weisburd et al., 2004; Braga et al., 2010). Each year, between 5.5% and 7.1% of street segments accounted for 50% of the violent crime incidents in Chicago. Over the entire observation period, only 9.3% of street segments accounted for 50% of incidents. The share of street segments that accounted for 100% of violent crime incidents was less consistent, starting with 36% of street segments in 2001 and decreasing to 23% street segments in 2014. This decreasing trend mirrors the reduction in violent crime incidents occurring city-wide in Chicago over the observation period.

For the 75% of street segments during the 2001-2014 observation period that experienced a violent crime incident, 12.2% experienced one incident, 19.9% experienced two to four incidents, and 32.1% experienced five or more incidents. Figure 6.2 summarizes the distribution of violent crime incidents in three groups for the street segments that experienced one or more incident within each year of the observation period. Year to year, approximately half of the street segments that experienced a violent crime had only one incident occurs at that location. As the total number of street segments city-wide that experienced an incident over the observation period decreased, the proportional contribution of each of the three groups remained relatively constant. The percent of segments with five or more incidents each year also overlaps closely with the percent of segments that account for 50% of incidents in Figure 6.1.

Figure 6.1: Violent Crime Incidents at Street Segments in Chicago, 2001-2014

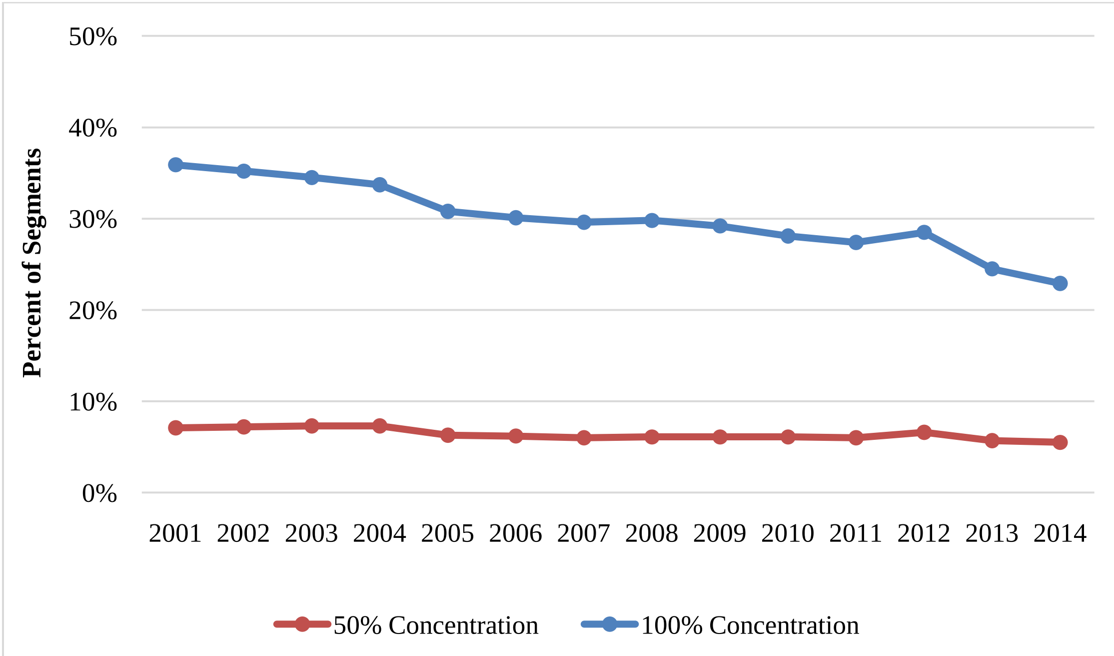


Figure 6.2: The Distribution of Violent Crime Incidents at Street Segments in Chicago, 2001-2014

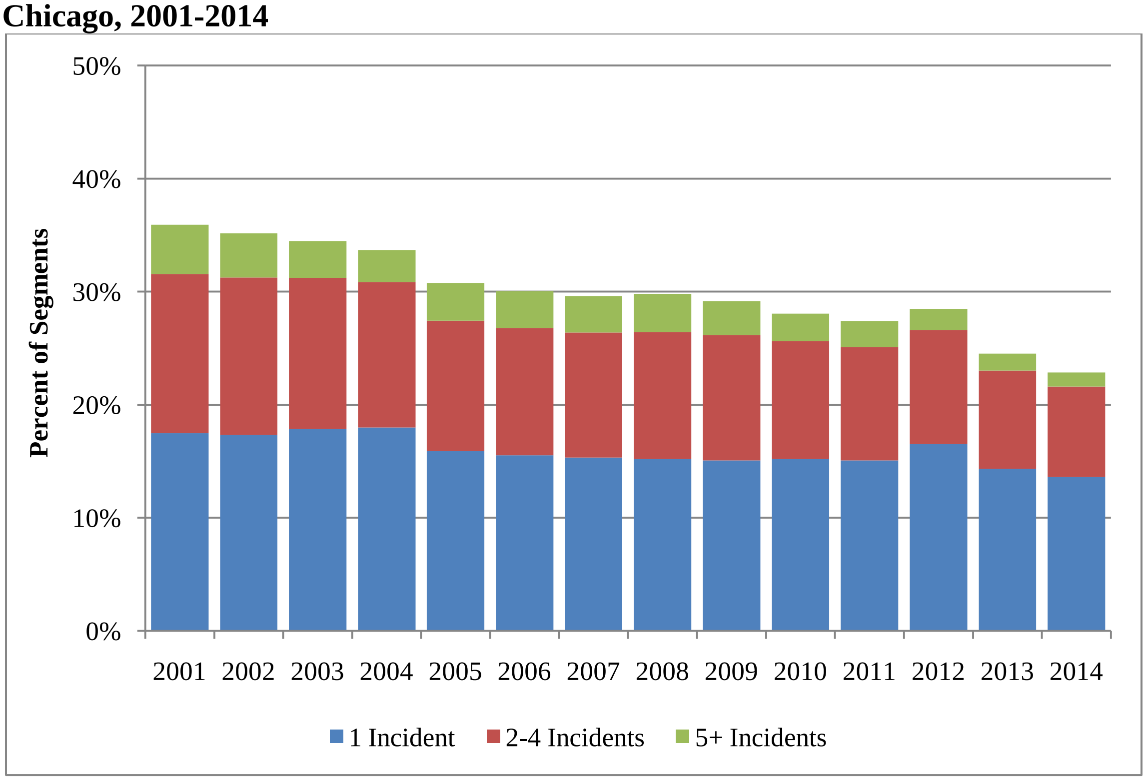
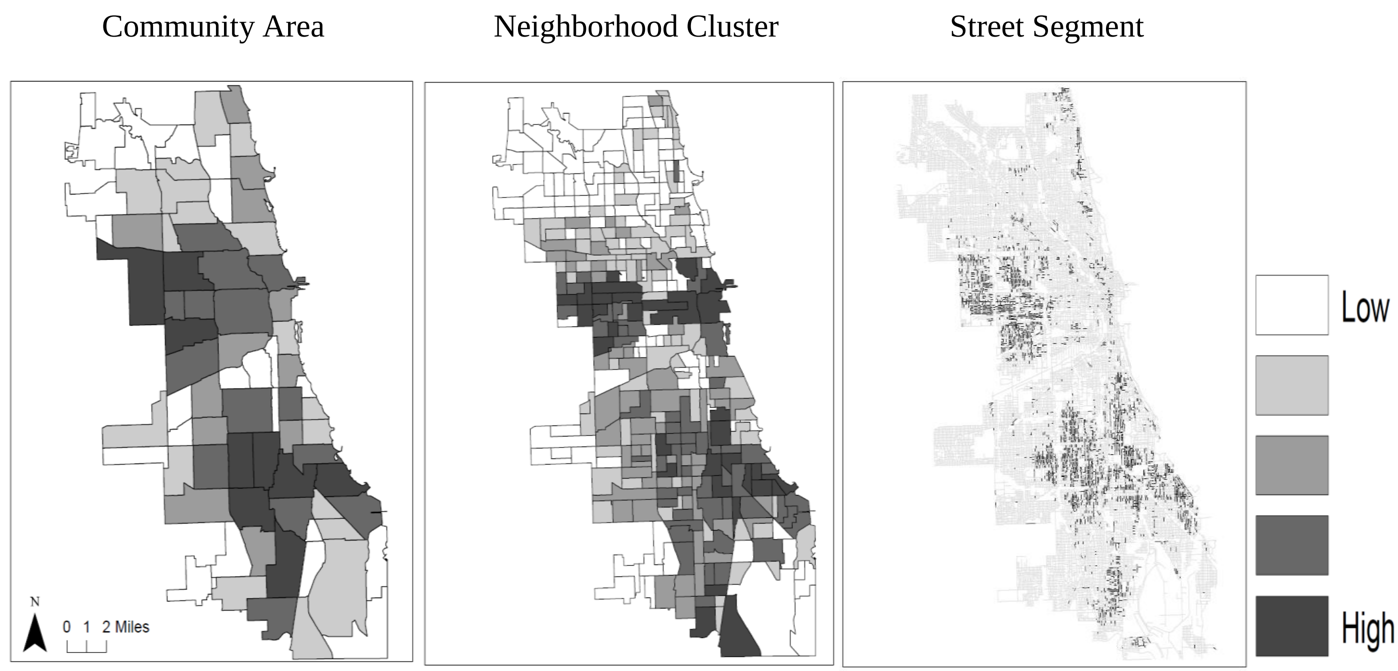


Figure 6.3 illustrates the spatial distribution of violent crime incidents at community areas, neighborhood clusters, and street segments in Chicago. This figure suggests violent crime is disproportionately concentrated on the west and south sides of the city. Appendices 5 and 6 illustrate the spatial distribution at neighborhood clusters and community areas over time indicating that the west and south sides repeatedly are the most violent over the observation period. An additional street segment map was not provided because the large number of units present challenges to offering an ascetically coherent city-wide map. Between 18-23% of neighborhood clusters and community areas account for 50% of violent crime incidents for each year from 2001-2014. The 100% threshold is not useful when investigating both neighborhood-level units because this value is approximately 100% for each year due to the population of these neighborhood clusters (N = 342) and community areas (N = 76) being drastically smaller than street segments (N = 49,029).

Between 2001 and 2014, the average neighborhood cluster experienced 1,052.01 violent crime incidents (SD = 828.67, Min = 55, Max = 4193) and the average community area experienced 4,734.03 incidents (SD = 4,533.34, Min = 95, Max = 23,787). Figures 6.4 and 6.5 summarize the distribution of violent crime incidents over the observation period at each unit of analysis divided into three groups based on the number of incidents. For both units of analysis the group with the least amount of incidents steadily increased from 2001 to 2014. This finding is the inverse of the city-wide violence reduction over the observation period suggesting that this trend does influence the proportional distribution of violent crime incidents at larger spatial units of analysis.

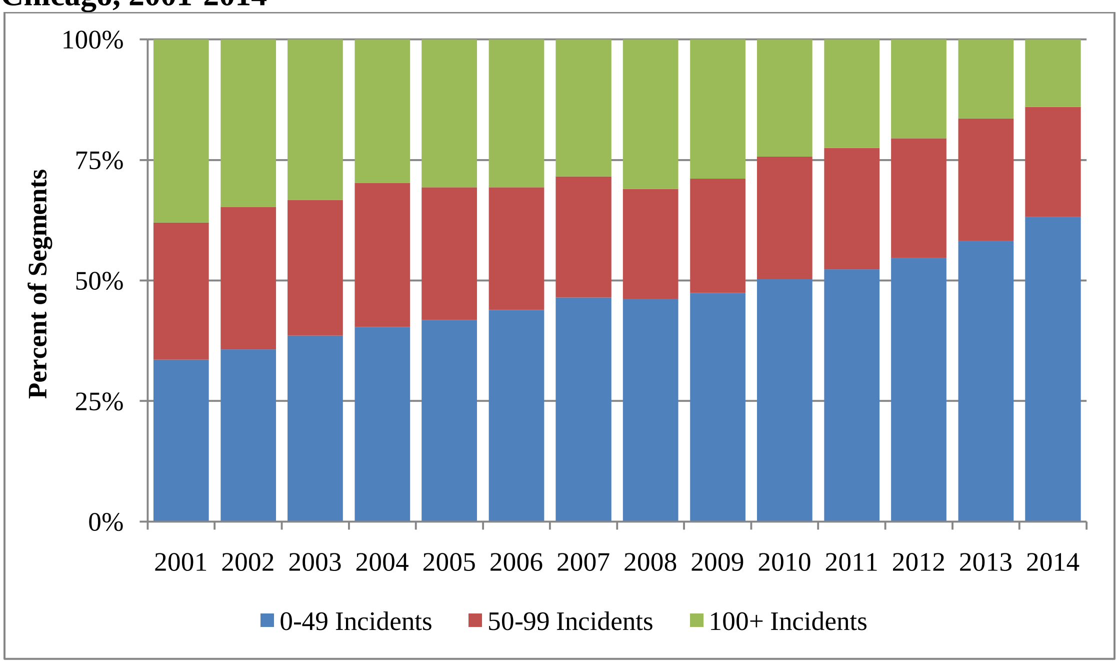
Figure 6.3: The Spatial Distribution of Violent Crime Incidents in Chicago per Unit of Analysis, 2001-2014



Note: Intervals based on Fisher-Jenks algorithm (see Slocum et al., 2005); Community areas and neighborhood clusters were divided into groups of five but street segments were divided into two groups to improve the illustration of these units of analysis.

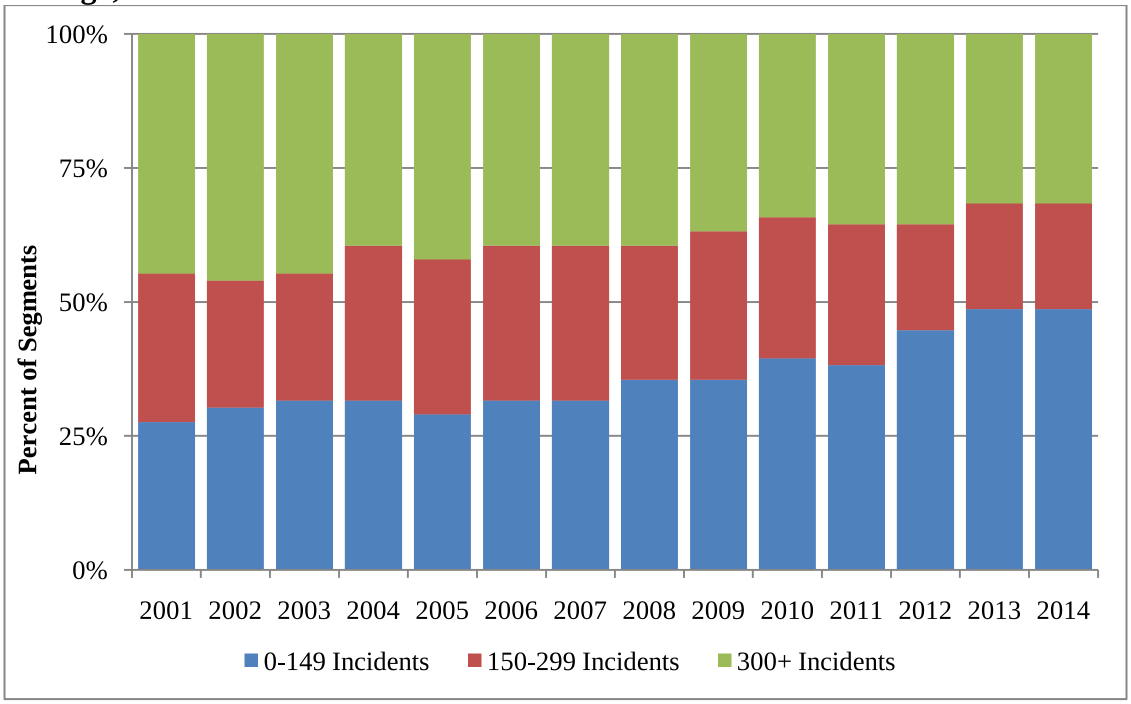
Figure 6.6 presents Lorenz curves for each of the three units of analysis to directly compare the distribution of violent crimes from 2001-2014 at each unit.[1] Violent crime is concentrated at each of the three units of analysis. However, street segments exhibit higher degrees of violent crime concentration relative to neighborhood clusters and community areas. For example, 25% of the cumulative units of analysis accounts for approximately 54% of violent crime incidents at neighborhood clusters, 59% at community areas, and 79% at street segments.

Figure 6.4: The Distribution of Violent Crime Incidents at Neighborhood Clusters in Chicago, 2001-2014



[1] Lorenz curves for each individual year within the observation period offer similar results; street segments display a slight increase in degree of concentration compared to neighborhood clusters and community areas since neighborhood clusters and community already have practically 100% of units having an incident (i.e. can't increase) while street segments only have room to increase over time. Also, Fig. 6.6 displays an inverted Lorenz curve that is best suited to visualize the spatial distribution of crime incidents while Gini coefficients are calculated on Lorenz curves facing the opposite direction. This does not influence the calculation of the Gini coefficient.

Figure 6.5: The Distribution of Violent Crime Incidents at Community Areas in Chicago, 2001-2014



Gini coefficients were used to summarize the degree of violent crime concentration in the Lorenz curves for each wave of data for the three spatial levels. As previously shown by Steenbeek and Weisburd (2016), the Gini coefficient is the ratio of the area that lies between the line of equality and the Lorenz curve over the total area under the line of equality. Figure 6.7 confirms that crime is highly concentrated and moderately increasing over time for street segments with a Gini coefficient of .793 in 2001 which grows to .825 in 2008 and .852 in 2014. The concentration of crime for neighborhood clusters and community areas is still quite substantial (around the 0.4-0.5 mark on a scale of 0-1), although crime is certainly less concentrated on these higher levels of spatial aggregation.

In addition, there is general stability in coefficients across both of these spatial units over the observation period. The Gini coefficient for neighborhood clusters starts at .406 in 2001 and finishes at .446 in 2014 while the coefficient for community areas starts at .484 in 2001 and finishes at .505 in 2014. It is noteworthy that the degree of violent crime concentration at the neighborhood cluster level and the community area level is similar. Indeed, as previously observed by Steenbeek and Weisburd (2016) in The Hague, this pattern could indicate that there is comparatively high within-community area (between-neighborhood cluster) homogeneity in violent crime concentration. This suggests that the neighborhood cluster-level may not explain much about violent crime concentration beyond what was already observed at the higher community area level.

The figures presented in this section confirm findings from several other cities that crime is concentrated across all three units of analysis within Chicago. Violent crimes are highly concentrated at street segments with between 5.5-7.1% of units accounting for 50% of incidents from 2001 to 2014. Neighborhood clusters and community areas also demonstrated concentration of incidents with between 18-23% of units experiencing 50% of violent crimes over the observation period. These findings suggest that violence in Chicago is influenced by a small number of highly active locations regardless of the unit of analysis selected but street segments do reveal a higher degree of distributional concentration.

Figure 6.6: Lorenz Curves for Violent Crime Incidents in Chicago from 2001-2014

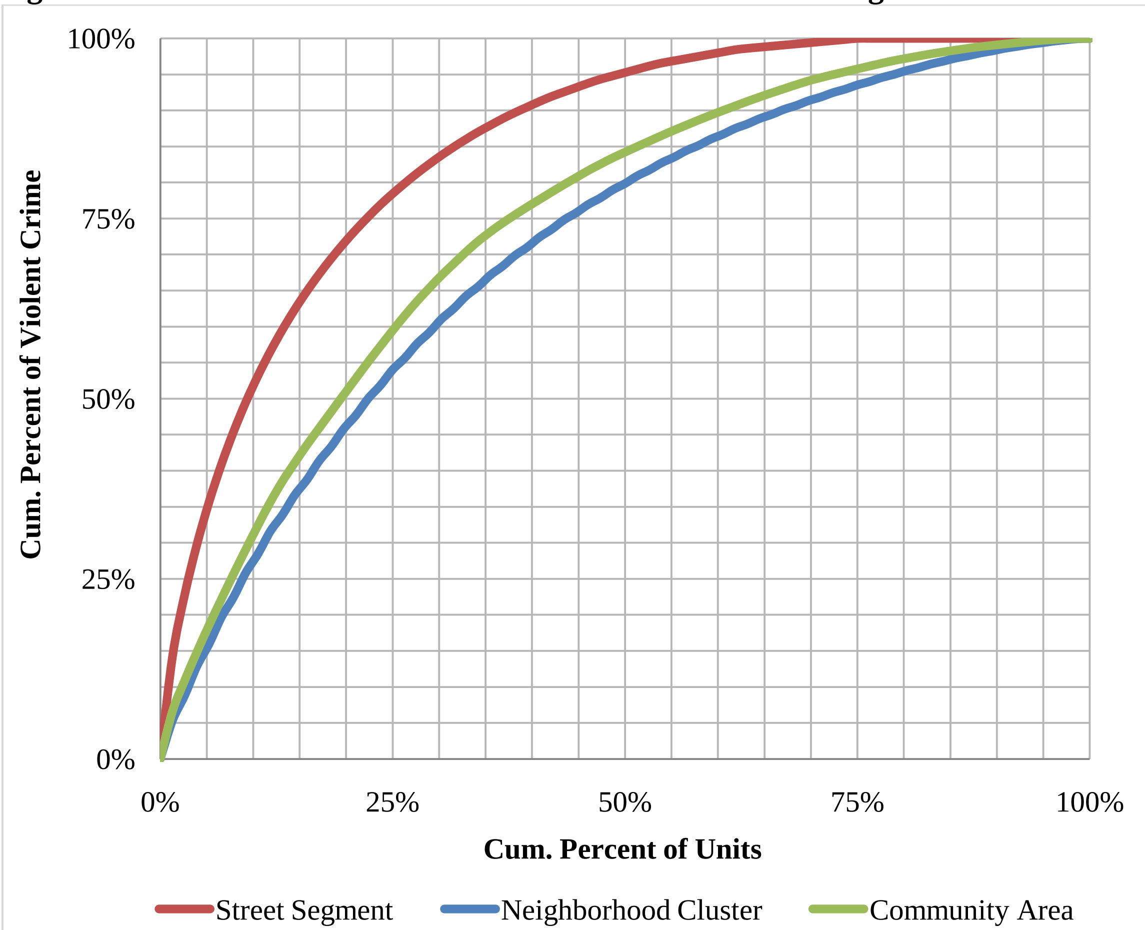
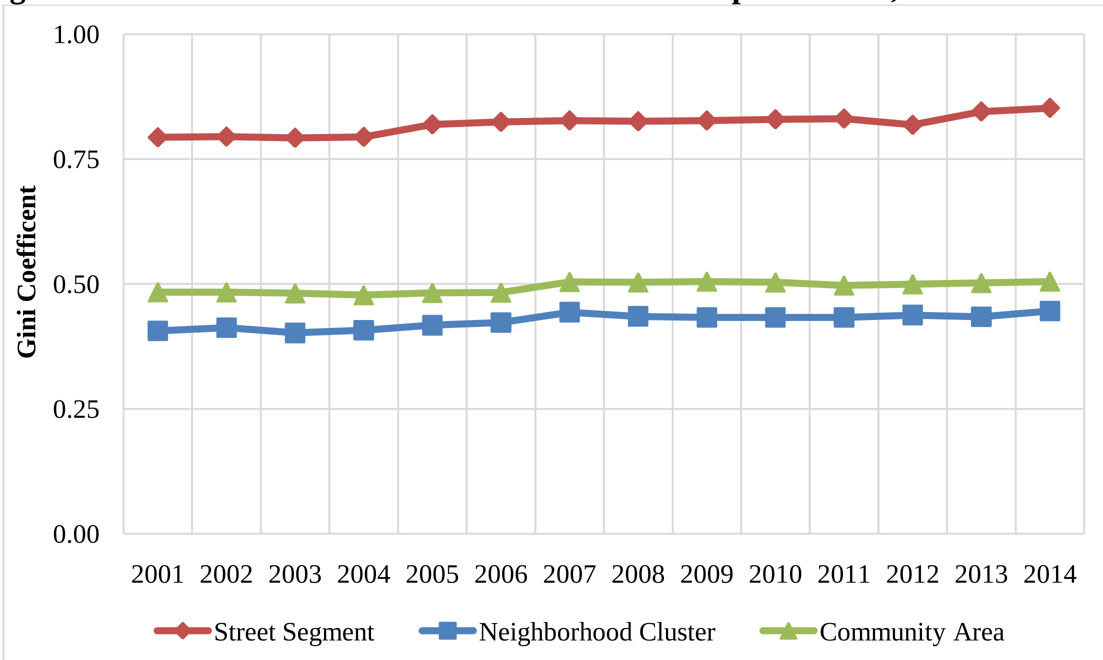


Figure 6.7: Gini Coefficient for Violent Crime for All Spatial Units, 2001-2014



The Stability of Violence

Street Segments

Group-based trajectory modeling (GBTM) was used to determine if developmental stability of the number of violent crime incidents at street segments from 2001-2014 was observed. Model estimation followed procedures outlined by David Weisburd and colleagues (2004) and Daniel Nagin (2005) to ensure the optimal number of developmental groups were assigned to characterize the distribution of incidents over time (also see Weisburd et al., 2012). First, prior to the estimation of models in Stata 14.1 the probability distribution for the model must be specified between censored normal, zero-inflated Poisson, and logistic options. Violent crime incidents are by definition event counts and year to year between 60-80% of street segments did not experience an incident which suggested the zero-inflated Poisson distribution offered the best option. The selection of the probability distribution for GBTM is not guided by a specification test. Since only three options are provided among general classes of linear, binary, and count variables in Stata 14.1 no further tests can be conducted to determine model fit.

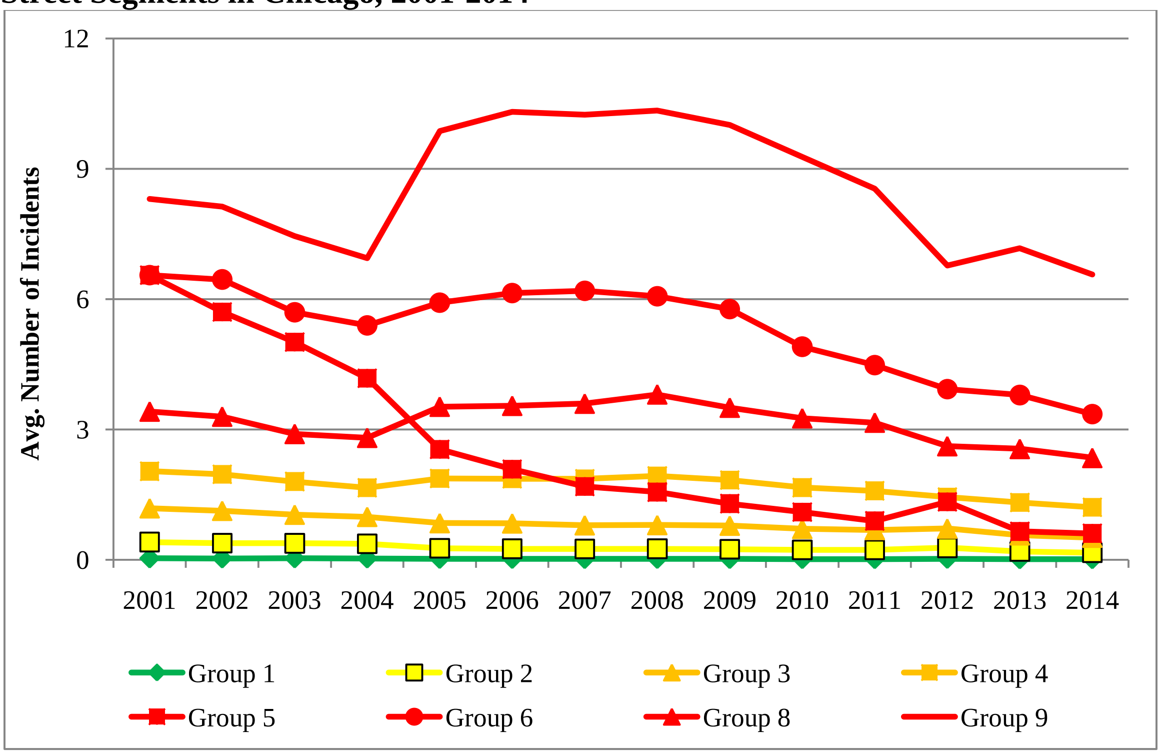
Second, the total number of developmental groups must be identified. Since an exploratory analysis should not assume a fixed number of developmental groups a priori, the number of groups would be determined by the model which best fits the distribution. The number of potential groups started at three and was increased until the lowest possible Bayesian Information Criteria (BIC) was observed which also reported an average within-group posterior probability of membership above 80% for all groups and odds of correct classification (OCC) above 5.00. Third, the polynomial order for each group solution tested must also select between intercept, linear, quadratic, and cubic options to approximate the developmental growth of the variable of interest over time for each group.

For example, a three group, intercept polynomial order model (i.e. 0 0 0) was estimated then the BIC, posterior probabilities, and OCC were recorded in an Excel document. Then a three group, linear polynomial order model (i.e. 1 1 1) was estimated and so on for each of the four polynomial order options and with an increasing number of groups. A nine group, linear polynomial order solution was identified (BIC = 580,991.97) as the optimal model to characterize the distribution of violent crime incidents at street segments in Chicago from 2001-2014. Table 6.1 reports diagnostics from this model and Figure 6.8 illustrates the differences between each identified developmental trajectory of violent crime incidents at street segments.

Table 6.1: Group-Based Trajectory Model Diagnostics

Group	Avg. Posterior Prob.	OCC	Fitted Intercept	Fitted Slope	Avg. Incidents Per Year	New Label
1	0.810	9.67	0.034	-0.023	0.023	Crime Free
2	0.857	29.68	0.401	-0.016	0.279	Low Stable
3	0.851	63.10	1.174	-0.046	0.830	Moderate Stable
4	0.923	20.24	2.092	-0.050	1.718	Moderate Stable
5	0.889	197.25	5.789	-0.437	2.515	High Decreasing
6	0.919	799.06	6.968	-0.218	5.331	High Decreasing
7	0.943	4,119.42	25.213	-1.503	13.942	High Decreasing
8	0.851	433.63	3.550	-0.005	3.166	High Stable
9	0.971	3,3449.28	9.091	-0.070	8.565	High Stable

Figure 6.8: GBTM Defined Developmental Patterns of Violent Crime Incidents at Street Segments in Chicago, 2001-2014



Note: Excludes the outlying Group 7 for easier interpretation of the figure; Group 7 reported 25.6 incidents per segment in 2001 and was steadily reduce to 5.8 incident per segment in 2014

Fourth, developmental groups were relabeled to facilitate the most parsimonious interpretation of the findings. New labels were created based on calculating the fitted intercept and linear slope of each trajectory group over the observation period in Figure 6.8 and then conducting a visual inspection of the trajectories to further intuitively characterize each pattern. The labels were created in two parts; the first addresses the intercept (i.e. low, moderate, high) and the second captures the slope (i.e. decreasing or stable). Groups with intercepts under 0.05 incidents per segment were relabeled as *crime free*, intercepts between 0.06-0.99 as *low*, intercepts between 1.00-2.99 as *moderate*, and intercepts above 3.00 as *high*. Groups with slopes under -0.20 incidents per year relabeled as *decreasing*, slopes from -0.19 to .19 as *stable*, and slopes above .20 as *increasing*.

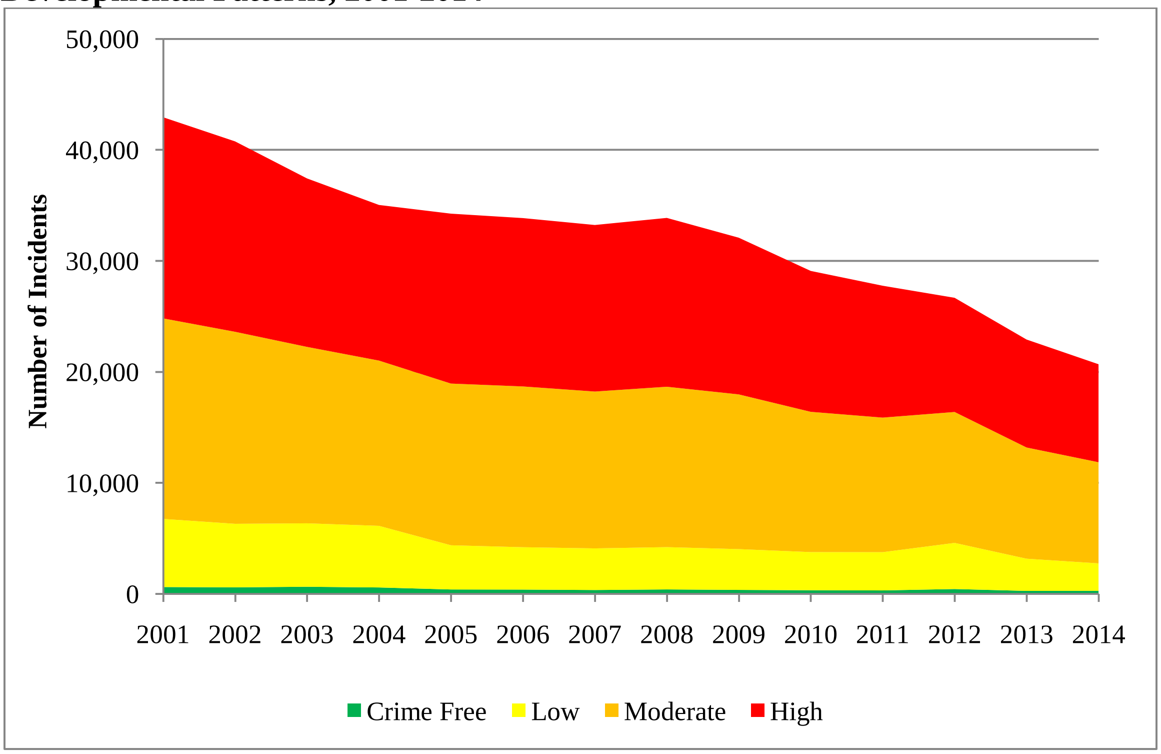
Table 6.2 offers a summary of the contribution of each developmental group to the city-wide level of violent crime incidents over the observation period. Each of the five high crime developmental groups captured a disproportionate percent of violent crime incidents relative to the total number of street segments they represent; together 7.1% of the total street segments yet they accounted for 42.7% of the city-wide violence. Figure 6.9 helps visualize the influence of each of these developmental trajectories collapsed by their group intercept on the city-wide violence trend in Chicago. The high and moderate groups were clearly the most impactful in driving the city-wide violence trend. While only 3 of the 9 groups could be identified as having decreasing patterns using this relabeling procedure, it appears these street segments offer the most direct influence on the city-wide crime reduction while the other locations, all with negative fitted slopes, appear to collectively have a cumulative effect in contributing to the drop.

Table 6.2: The Distribution of Violent Crime Incidents in Chicago by GBTM Defined Developmental Groups, 2001-2014

Group	# Segments	% Segments	# Incidents	% Incidents
CF - 1	18,240	37.2%	5,997	1.3%
LS - 2	14,997	30.6%	58,577	13.0%
MS - 3	8,215	16.8%	95,448	21.2%
MS - 4	4,073	8.3%	97,960	21.7%
HD - 5	623	1.3%	21,934	4.9%
HD - 6	708	1.4%	52,839	11.7%
HD - 7	47	0.1%	9,174	2.0%
HS - 8	1,934	3.9%	85,717	19.0%
HS - 9	192	0.4%	23,022	5.1%
Total	49,029	100.0%	450,668	100.0%

Note: CF = crime free, LS = low stable, MS = moderate stable, HD = high decreasing, HS = high stable; the number identifies the original GBTM defined group

Figure 6.9: Violent Crime Incidents in Chicago by Collapsed GBTM Defined Developmental Patterns, 2001-2014



Neighborhood Clusters

The same procedures used to guide identification of the developmental trajectories of violent crime incidents at street segments were replicated to explore these patterns at neighborhood clusters. The zero-inflated Poisson probability distribution was still selected, despite eliminating all of the 0's from the distribution when exploring neighborhood clusters, because it still offered the best option among the three provided in Stata 14.1 to estimate the model using count data. A five group, intercept polynomial order solution was identified as the optimal model specification (BIC = 32,917.54). Table 6.3 reports the relevant diagnostics and Figure 6.10 displays each of the developmental patterns. All five of the developmental groups identified can be characterized by a similar decreasing pattern over the observation period. This is a noteworthy contrast to the street segment findings where after relabeling only 2.8% of units were identified as having decreasing trends. Due to this consistency between patterns slope and the natural division between intercepts the groups were not relabeled. Their original group number is retained to reflect the increase in the level of crime occurring within the neighborhood (i.e. intercept).

Table 6.3: Group-Based Trajectory Model Diagnostics for Neighborhood Clusters

Group	Avg. Posterior Probability	OCC	Fitted - Intercept	Fitted -Slope	Avg. Incidents Per Year
1	0.999	2487.911	29.654	-1.173	20.860
2	0.999	3325.675	63.505	-2.434	45.238
3	0.999	3874.171	104.670	-3.230	80.440
4	0.999	7539.462	163.650	-5.085	125.517
5	0.999	5205.969	261.560	-8.192	200.121

Figure 6.10: Developmental Patterns of Violent Crime Incidents at Neighborhood Clusters in Chicago Defined by Group-Based Trajectory Models, 2001-2014

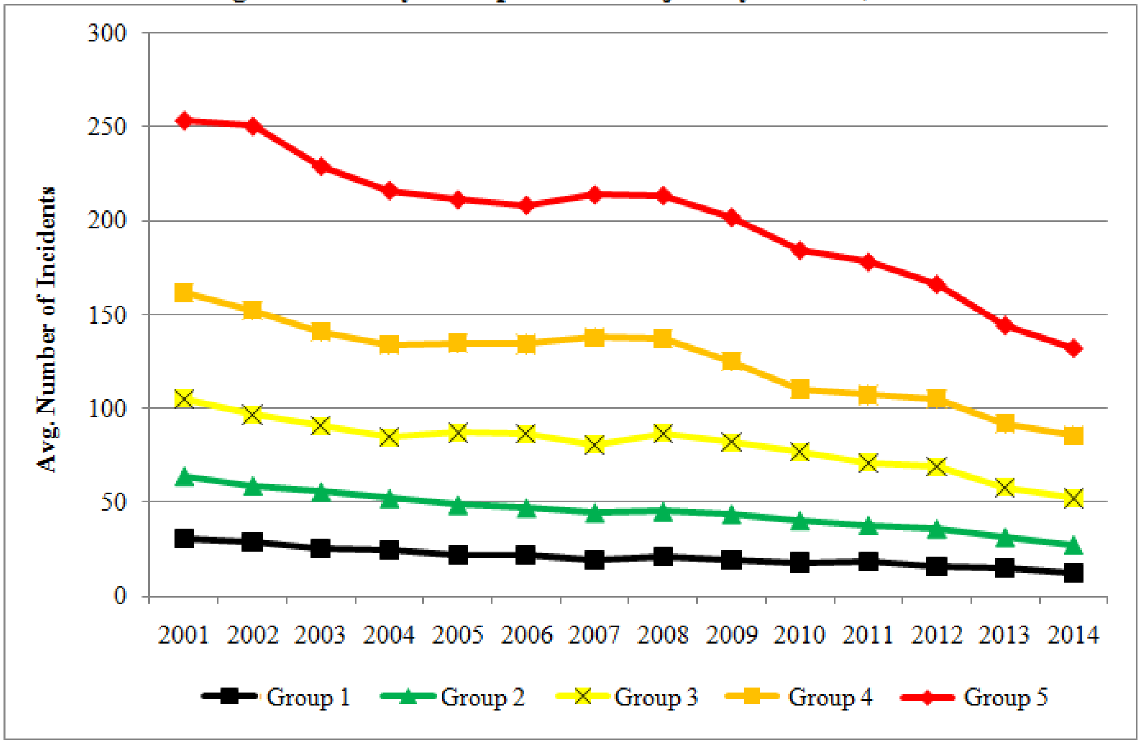


Table 6.4 offers a summary of the contribution of each neighborhood cluster developmental group to the city-wide level of violent crime incidents over the observation period. As the group number increases the neighborhood cluster represents a larger share of the violence in Chicago from 2001-2014 with incidents being the most concentrated in group 5. This group does not appear to influence the city-wide violent crime trend as disproportionately as its high crime street segments counterparts. Unfortunately, developmental patterns could not be assigned to community areas due to the small number of units. BIC values would not improve when changing from two to three group solutions.

Overall, violent crime incidents were characterized by overwhelming developmental stability at street segments but not at neighborhood clusters in Chicago. The differences between these findings will be further discussed in Chapter 8 of this dissertation. The analyses provided in the first section found distributional concentration of violent crime incidents at street segments, neighborhood clusters, and community areas. The analyses in this section also observed developmental stability of patterns at street segment but not at neighborhood clusters. The developmental stability of violent crime incidents at community areas could not be rigorously tested. Crime maps do preliminarily indicate that incidents were concentrated at the same locations on the west and south side of the city over the observation period.

Table 6.4: The Distribution of Violent Crime Incidents in Chicago by GBTM Defined Developmental Groups, 2001-2014

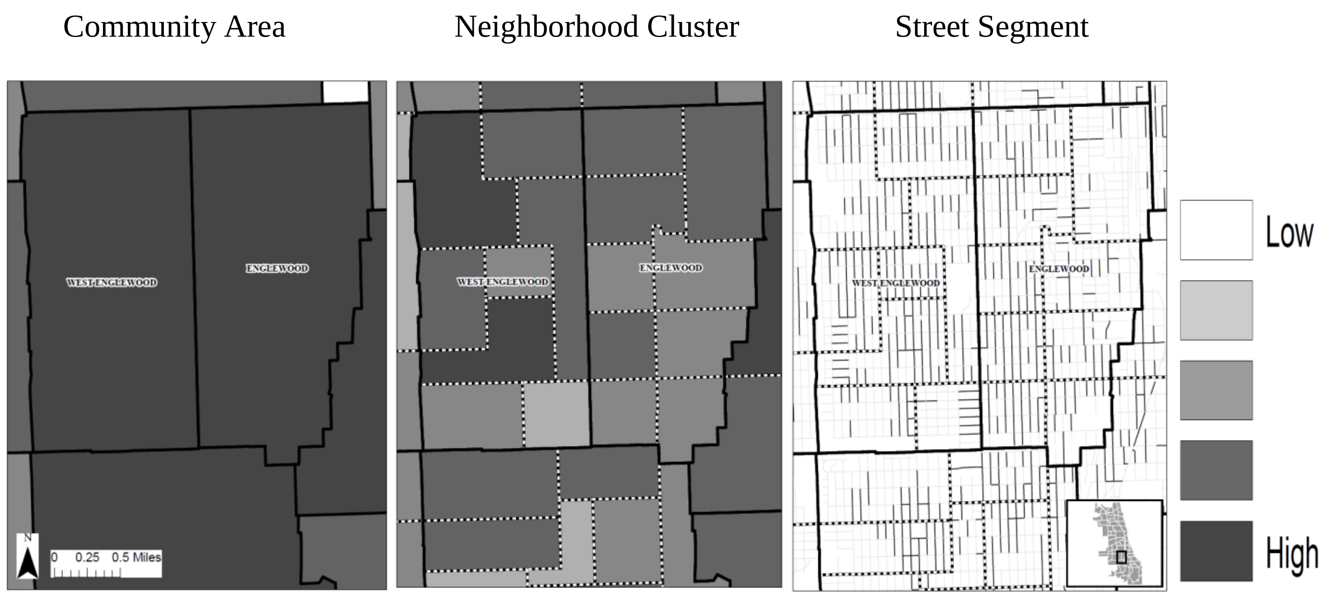
Group	# Neighborhood Clusters	% Neighborhood Clusters	# Incidents	% Incidents
1	96	28.1%	28,036	7.8%
2	92	26.9%	58,266	16.2%
3	60	17.5%	67,570	18.8%
4	55	16.1%	96,648	26.9%
5	39	11.4%	109,266	30.4%
Total	342	100.0%	359,786	100.0%

Nested Patterns of Violence

This section investigates the hierarchical relationship between street segments, neighborhood clusters, and community areas in understanding the total spatial variability of violent crime incidents in Chicago. Figure 6.11 illustrates the nested spatial distribution of violent crime incidents within two high violence community areas on the south side of the city from 2001-2014. This map demonstrates as the level of spatial aggregation is lowered from community areas to neighborhood clusters to street segments a more nuanced description of the spatial variability of violence in Chicago is provided. Exploring the nested spatial distribution of the GBTM defined developmental groups at street segments within neighborhood clusters and community areas can also provide insight into the degree of spatial variability lost when using larger units of analysis.

Figure 6.12 depicts the spatial variability of street segment developmental patterns nested within neighborhood clusters in turn nested within one high violence community area on the west side of Chicago. Neighborhood clusters with low (i.e. group 1), moderate (i.e. group 3), and high (i.e. group 5) levels of violence are highlighted to display variation within the community area. This map reinforces that even high violence community areas are composed of neighborhood clusters and street segments with varying developmental patterns in close spatial proximity. Figure 6.13 illustrates even within the same developmental class (i.e. high), variability exists within community areas on the developmental growth (i.e. stable or decreasing) of patterns at street segments in close spatial proximity while Figure 6.12 displays variation even on a single block.

Figure 6.11: Variability of the Distribution of Violent Crime Incidents per Unit of Analysis in Two Community Areas in South Side of Chicago, 2001-2014



Note: Intervals are based on the Fisher-Jenks algorithm; thick black line = community area boundary, black-white dashed line = neighborhood cluster boundary. Street segments are divided in two groups (i.e. grey = lower end of distribution and black = higher) while community areas and neighborhood clusters are divided into five groups. Appendix 7 offers an expanded view of the street segment map.

In addition, Figure 6.13 denotes while most street segments with high crime patterns are located in certain community areas on the west and south sides of Chicago they can also be found throughout the entire city in community areas with varying levels of violence. Street segments with high stable or decreasing patterns of violence were found nested within 73.1% of total neighborhood clusters and 89.5% of total community areas in Chicago. Table 6.5 offers a cross-tabulation of street segment and neighborhood cluster developmental patterns. Of the 6,400 street segments excluded for resting on the boundary between multiple neighborhood clusters or community areas 27.1% were characterized with crime free developmental patterns, 28.0% low stable, 32.2% moderate stable, and 12.7% high stable or decreasing. Compared to the city-wide composition these street segments on average were marginally more violent. This table suggests as the developmental group of neighborhood clusters increases, high violence street segments are also increasingly likely to be found within these areas while crime free segments are less likely. This also begins to demonstrate how neighborhood effects could influence the spatial distribution of these micro-level patterns.

Each type of developmental patterns at the street segment-level can be found across each developmental group of neighborhood clusters. Even approximately half of the street segments in neighborhood cluster group 5 experience crime free or low patterns over the observation period indicating that even in the most violent areas of Chicago crime is still concentrated at micro-places. Overall, these findings suggest there is both a high degree of spatial variability of developmental patterns within all types of neighborhood clusters but also that there is a possible neighborhood effect on the overall composition of these patterns.

Figure 6.12: The Nested Structure of Developmental Patterns at Street Segments and Neighborhood Clusters within a High Violence Community Area in Chicago

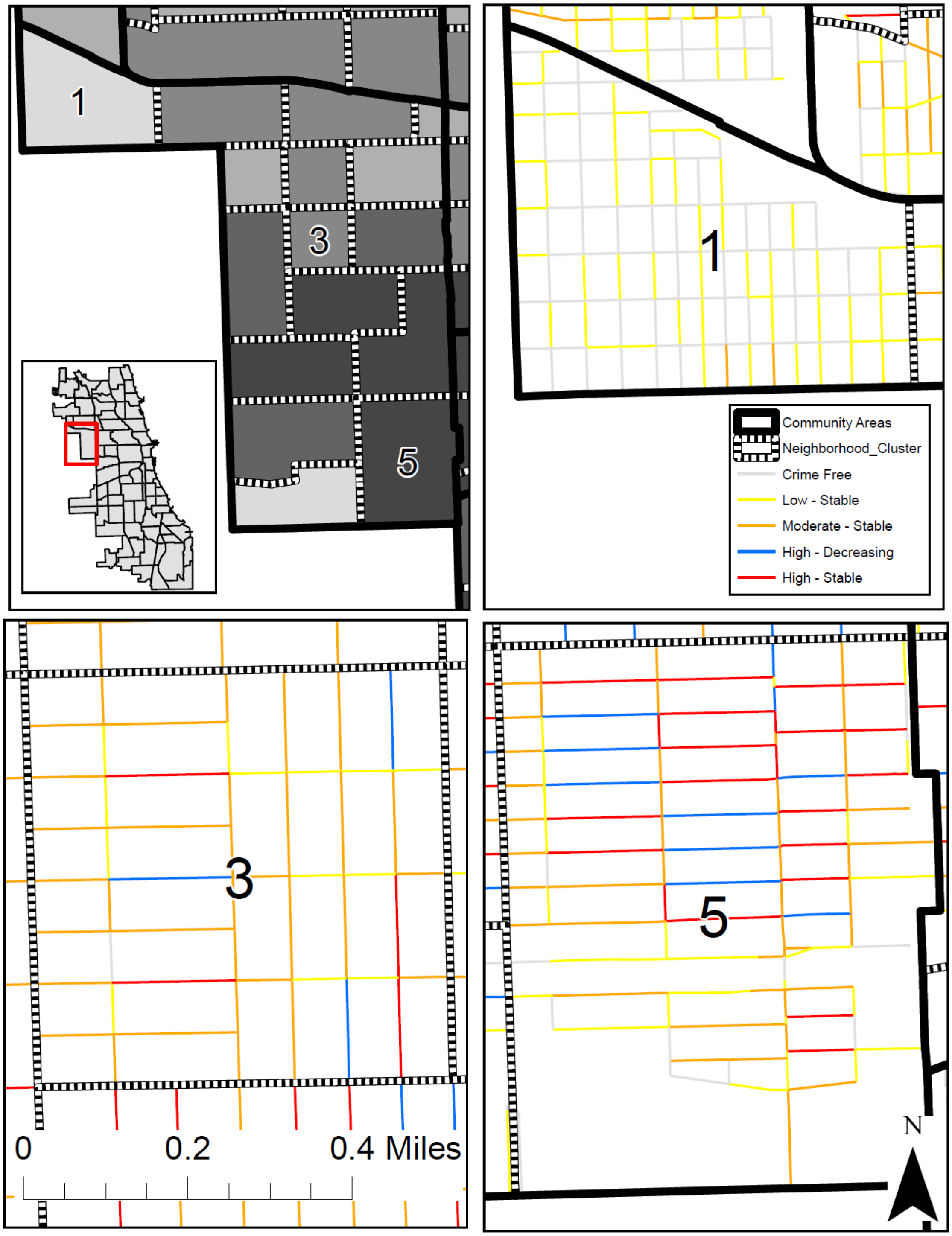


Figure 6.13: The Spatial Distribution of High Violence Street Segments within Community Areas in Chicago

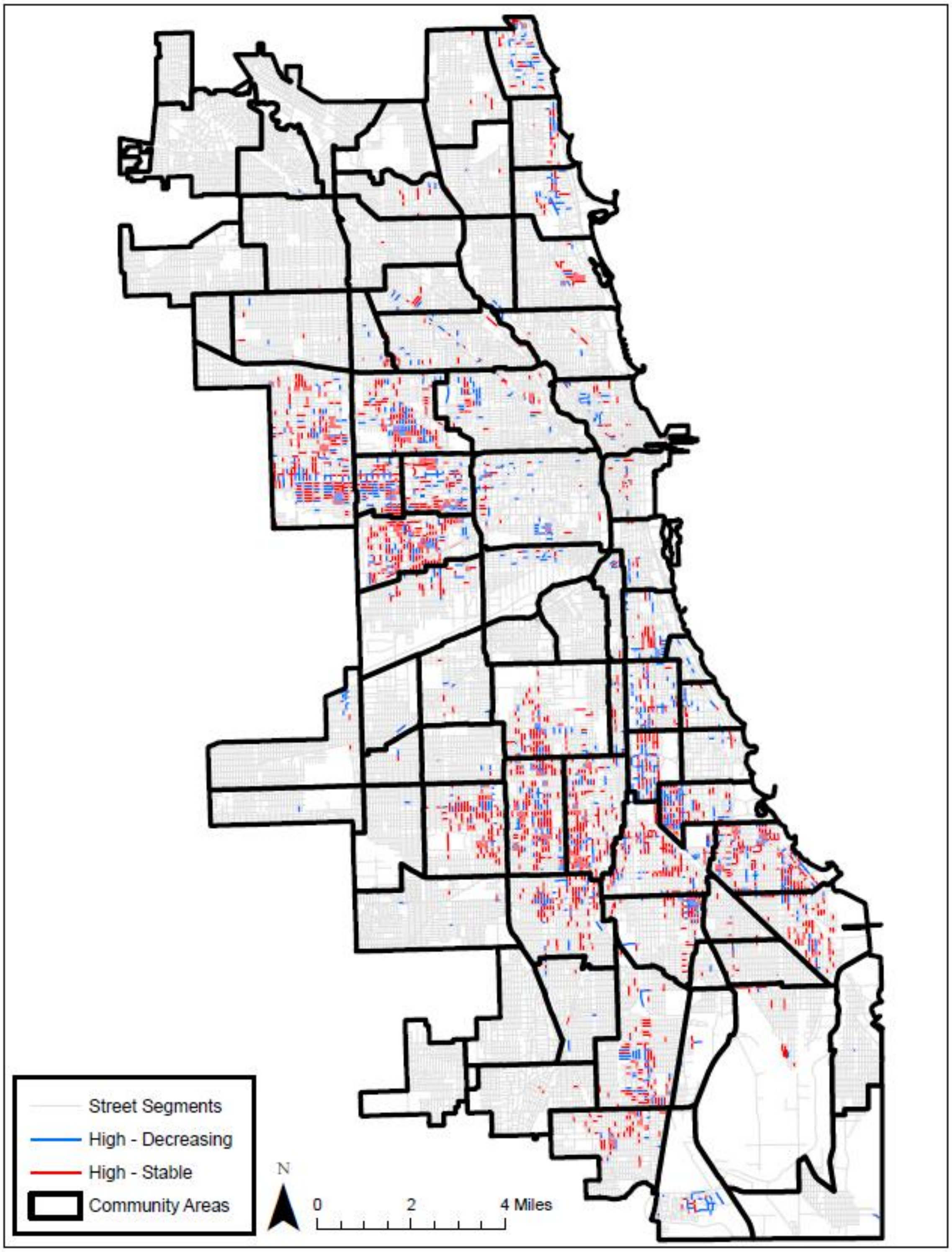


Table 6.5: Cross-Tabulation of Street Segment and Neighborhood Cluster Developmental Patterns for Violent Crime Incidents, 2001-2014

		NC Trajectory				
SS Trajectory	**All**	Grp. 1	Grp. 2	Grp. 3	Grp. 4	Grp. 5
Crime Free	**37.8%**	64.7%	33.6%	26.1%	22.3%	25.0%
Low Stable	**31.4%**	27.3%	38.7%	36.7%	28.0%	26.8%
Moderate Stable	**24.4%**	7.6%	24.6%	31.8%	36.9%	32.5%
High Decreasing	**2.4%**	0.2%	1.4%	1.6%	4.4%	6.1%
High Stable	**4.1%**	0.2%	1.7%	3.8%	8.4%	9.6%
Total	**100.0%**	100.0%	100.0%	100.0%	100.0%	100.0%
N	**41,926**	11,878	8,836	7,432	6,823	6,957

Note: SS = Street segment, NC = Neighborhood Cluster

Linear Mixed Models

This section continues to investigate the hierarchical relationship between street segments, neighborhood clusters, and community areas in describing the total spatial variability of violence in Chicago. Findings from the previous section suggest that street segments offer the most refined description of the spatial variability of violence in Chicago. These analyses are limited because they do not offer a modeling strategy to simultaneously account for the hierarchical relationship of these units. The analysis presented in this section estimated linear mixed models to quantify the amount of crime variation across the different units of analysis over time. Specifically, the panel data analyses involved estimating a four-level model of years nested in street segments nested in neighborhood clusters nested in community areas (see Steenbeek and Weisburd, 2016). A fixed effect of time was added to the longitudinal model to estimate the overall time trend (e.g. a decline in the number of crime events over the fourteen-year period). The slope of time was allowed to vary randomly across street segments (and/or neighborhood clusters and/or community areas) so different patterns of change over time per street segment (or neighborhood cluster or community area) could be captured.

Model estimation proceeded by first investigating whether an assumption of the linear model was violated by the distribution of the dependent variable residuals. Three-level hierarchical models (street segments nested in neighborhood clusters nested in community areas) were estimated using raw violent crime counts and logged violent crime counts for each wave of data. Extreme violations of the normality assumption were detected in reviews of residual diagnostic plots of the raw violent crime counts. However, diagnostic plots of the logged violent crime counts variable yielded only mild normality violations, suggesting it was more appropriate to use this dependent variable in our LMM (see Gelman and Hill, 2007). Restricted Likelihood Ratio Tests were used to determine whether the two-, three-, or four-level models best fit the panel data (see Rabe-Hesketh and Skrondal, 2012). This investigation revealed the best fit was obtained by the four-level model.

The variance functions for the community area, neighborhood cluster, and street segment levels as a function of time are presented in Figure 6.14. The level-1 residual variance for these LMMs captures the "variance of time that can be attributed to time-varying explanations" (Steenbeek and Weisburd, p. 14). This estimate from the final model was observed to be .120. This analysis is only concerned with the spatial variability accounted for by the model (i.e. levels 2-4), not the total variability captured (i.e. levels 1-4). The magnitude of the level-1 variance can provide insightful context to the findings on the spatial variability, this issue is further discussed Appendix 8. The variance in violent crime that can be attributed to the community area and neighborhood cluster levels of analysis does not exhibit substantive nonlinearity and is consistently very small over time. The variance of violent crime at both levels *decreases* over the fourteen-year period, indicating increasing within-neighborhood cluster and within-community area variability in violent crime over time. In contrast, most of the variation in violent crime occurs at the street segment level. The LMM demonstrates a non-linear change in violence variance at the street segment level over time that decreases significantly and then flattens.

Figure 6.15 presents the proportion of total variance attributed to the community area, neighborhood cluster, and street segment spatial levels for each wave of data during the 14-year observation time period. The point estimate for each variance component was used to calculate the proportions shown in Figure 6.15. As each variance represents an estimated parameter in the LMM, there is a 95 % probability that the ±1.96 SD confidence interval around this point estimate captures the true population mean. The reported proportions represent the proportion of variance in violent crime of each spatial unit as compared to the total variance in violent crime attributed to the three spatial units (net the level- 1 residual variance of crime). On average, about 58.7 % of the total variance can be attributed to variation between street segments across the years. Community areas account for about 25.1% on average, while between-neighborhood cluster variance (controlled for street segment and community area level variability) accounts for about 16.2% of the total variance on average. The results also demonstrate an increasing degree of crime concentration at the street segment level over time: from 56.3% in 2001 to 65.3 % in 2014. The proportion of total variance accounted for by the neighborhood cluster-level decreases between from 17.9% to 13.4% while the community area-level variance proportion decreases from 25.9% in 2001 to 21.2% in 2014.

Fig. 6.14: Variance Functions per Spatial Level, 2001-2014

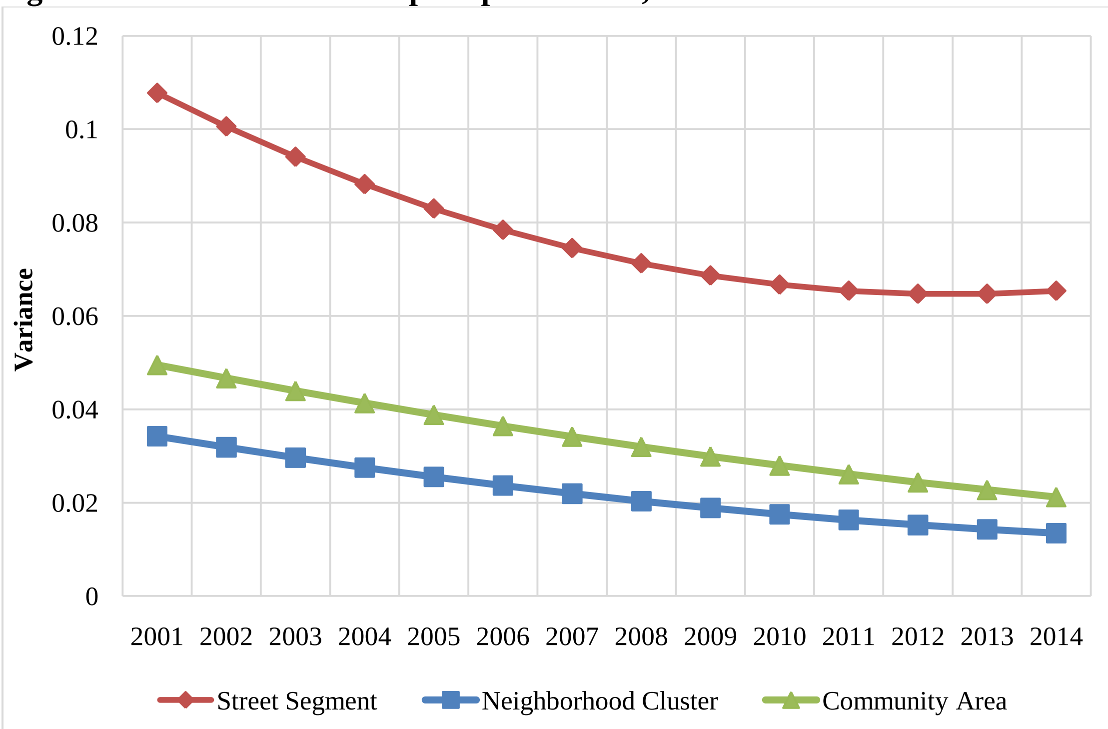
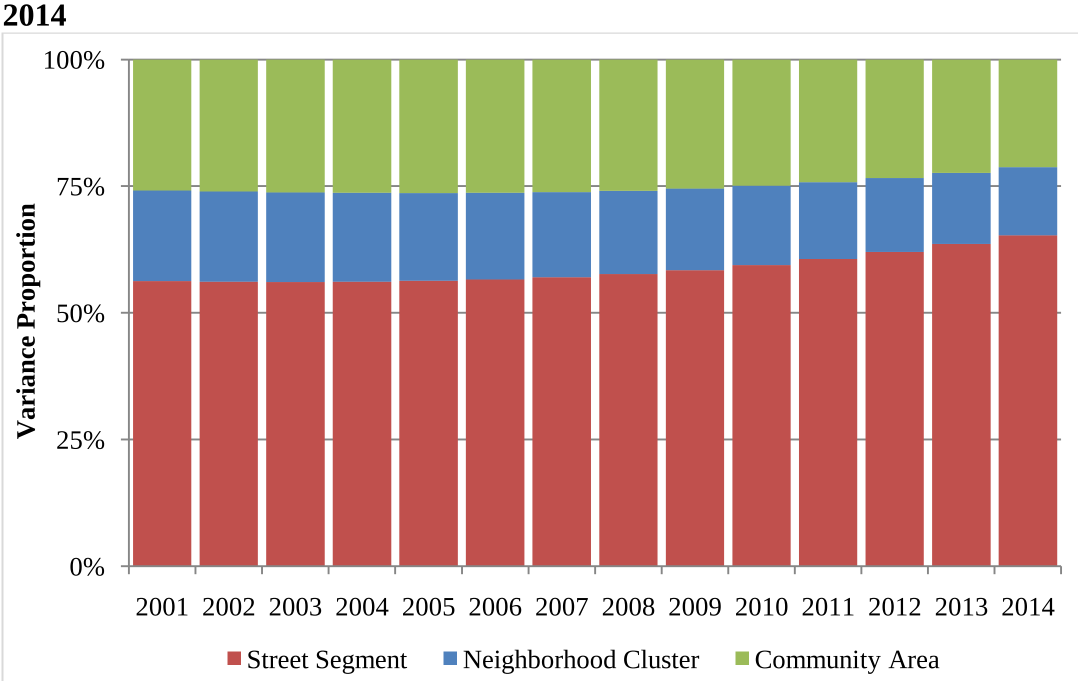


Figure 6.15: The Proportion of Total Variance Attributed to Spatial Levels, 2001-2014



The LMM estimates support the results of the descriptive statistical analyses in demonstrating that the bulk of violence is concentrated at the street segment level. The neighborhood clusters and community areas generate similar but much smaller levels of crime concentration relative to street segments. Confirming the original work of Steenbeek and Weisburd (2016), these findings suggest that some community areas as a whole are more crime-prone than others, but that neighborhoods clusters within the same community area are rather homogeneous with regard to crime (either high or low). Nevertheless, most of the variability in violence occurs on street segments and the proportion of variability in violence attributed to street segments increases over time.

Sensitivity Analyses

Sensitivity analyses were conducted to test the robustness of outcomes presented in this analysis. As described earlier, there were some methodological and analytical differences between this analysis and the work conducted by Steenbeek and Weisburd (2016). How each of these differences may have impacted outcomes is explored. The first assessment applied the bootstrapping procedure conducted in The Hague study to test the robustness of the estimates. This analysis followed the same parameters when conducting the stratified resampling of street segments in Chicago: 25% of segments (n = 10,523) were randomly selected from within all 342 neighborhood clusters – which in turn represent all 76 community areas. Two sets of LMM estimates were observed, averaged variance components across 250 and 500 replications. Results for both sets were almost identical to the findings from the main analysis presented above. Street segments accounted for 57-65% of the total variance proportion with neighborhood clusters and community areas accounting for 13-18% and 21-26% respectively. Over time the variance proportion increased for street segments and decreased for the two neighborhood units of analysis as the number of violent crime incidents decreased in Chicago.

The second assessment included the street segments which were previously excluded because they were spatially located on the boundary of two or more neighborhood clusters or community areas. These 6,400 street segments were randomly assigned to one of the various neighborhood clusters and/or community areas in which they were located. Once again, results were almost identical to findings from the main analysis. Street segments accounted for 56-66% of the variance proportion while neighborhood clusters accounted for 13-19% and community areas 21-25%. The variance proportion for street segments also increased over time while the proportion decreased over time for neighborhood clusters and community areas. The third assessment, also conducted in the Steenbeek and Weisburd sensitivity analysis, removed outliers from our models. Approximately 1% of street segments (N = 365) with the highest number of total violence incidents over the observation period were removed. Results for the variance proportion for each spatial level and their temporal trend were congruent with the main and sensitivity analyses presented thus far (street segments 55-65%, neighborhood clusters 14-19%, and community areas 22-27%).

The fourth assessment disaggregated the general violent crime dependent variable into two specific categories of violence. These analyses revealed a modest increase in the importance of street segments relative to neighborhood clusters and community areas in decomposing the total variance proportion per spatial level in Chicago. For robbery incidents, street segments accounted for 63-69% of the total variance proportion while neighborhood clusters explained 14-16% and community areas explained 18-21%. Since there were not enough homicide incidents to support an individual model, homicides were combined with aggravated assaults in an "assaultive violence" measure. For assaultive violence, 59-68%, 13-17%, and 19-23% of the total variance proportion was accounted for by street segments, neighborhood clusters, and community areas respectively. For both disaggregated violent crime outcomes, the variance proportion increased over time for street segments and decreased for neighborhood clusters and community areas. These findings are also very similar to those of Steenbeek and Weisburd (2016) which observed an increased proportion of the crime variance explained by street segments when they examined disaggregated crime trends.

The fifth assessment included property crimes in the dependent variable. With the inclusion of an additional N=3,920,467 incidents over the study time period, the residual diagnostics for this LMM did not violate the normality assumption for the distribution of residuals. These analyses suggest an increased influence of street segments in comparison to neighborhood clusters and community areas in decomposing the total variance proportion per spatial level. Some 63-73%, 11-16%, and 16-21% of the total variance proportion was attributed to street segments, neighborhood clusters, and community areas respectively with the variance proportion increasing over time for street segments and decreasing for the other two units of analysis.

The sixth assessment added fixed effect covariates to the model to begin to observe how measures of criminal opportunity and social disorganization would influence the share of variability assigned to each unit of analysis. The dichotomous variable measuring if a street segment is an arterial road was included which combined with the control variable for street segment length presents two micro-measures of criminal opportunity variables. Continuous variables for collective efficacy and network ties were included at neighborhood clusters in addition to continuous variables for concentrated disadvantage and residential instability at the community area. 70-80%, 13-17%, and 7-12% of the total variance proportion were attributed to street segments, neighborhood clusters, and community areas respectively.

The seventh assessment added the level-1 variance into the calculation of the variance proportion to determine how much of the total variability captured by the model was accounted for by the spatial units (i.e. levels 2-4) relative to time varying explanations (i.e. level 1). The inclusion of the level-1 variance does not change the relative contribution of the three spatial units to each other but it does reduce their magnitude: around 29-35%, 6-11%, and 10-16% of the total variance proportion were identified to street segments, neighborhood clusters, and community areas over the observation period. Collectively, the spatial variability accounted for between 45-61% of the total variability identified by the model while the time-varying explanations accounted for the other 39-55%. Overall, these sensitivity analyses confirm the estimates generated by our main LMM models are robust to varying methodological and analytical specifications.

CHAPTER 7 – RESULTS:

EXPLANATORY ANALYSES

This chapter presents findings from the explanatory analyses proposed earlier in this dissertation to answer the third research question. The first section conducts a descriptive overview of the study's criminal opportunity measures in Chicago prior to testing their influence on explaining variation in violent crime patterns between street segments. The second section offers a descriptive overview of the study's social disorganization measures prior to testing their influence on explaining variation in violent crime patterns between both street segments and neighborhood clusters. The third section explores the multi-level integration of these two groups of place-based theoretical measures. Several modeling techniques are utilized to determine the role criminal opportunity plays in explaining the spatial distribution of violence while also accounting for the hierarchical influence of social disorganization and the divergent effect of opportunity between neighborhood clusters.

Criminal Opportunity Measures

Table 7.1 displays descriptive statistics for each of the 12 criminal opportunity measures in addition to the primary dependent variable used for the analyses in this chapter. The data that comprises the 12 opportunity predictor variables was measured in 2011; however, the dependent variable is an aggregate count of violent crime incidents at the street segment from 2012-2014. It is important to note the values of the opportunity variables were found to be relatively consistent from 2011-2014 based on correlation tests which observed strong year-to-year associations for each predictor variable. The only exceptions were gang territory which was explicitly mapped only in 2010-2011 and 311 calls for service for physical disorder which showed variation year to year from 2011-2014. For all of the analyses that follow sensitivity analyses were conducted with this variable and reported if noticeable differences changed findings.

The six measures in the *Accessibility* grouping provide a summary of the broader transportation network covering the approximately 230 square miles within Chicago's city limits. The last three years of the fourteen year observation period used in research questions one and two were used as the primary dependent variable to answer research question three. From 2012-2014 the mean number of violent crime incidents at street segments in Chicago was 1.346 while 43.8% of the total street segments experienced at least one incident. 18.1% of street segments experienced only one incident, 17.4% experienced two to four incidents, and 8.3% experienced five or more incidents.

Three of the six *Accessibility* measures are continuous variables delineated in feet while the other three are dichotomous variables.[1] The average street segment in Chicago is 428 feet long. The mean distance of 8,489 feet (i.e. ~ 1.5 miles) of street segments to the nearest highway access point is shorter than the mean distance of 10,699 feet (i.e. ~ 2.0 miles) to train stations. This suggests most street segments in Chicago have relatively easy access to the broader transportation network throughout the entire city. Only 11.4% of street segments are located within one block of a bus stop. 17.6% of street segments are identified as arterial while 46.3% are connected to five or more street segments.[2] This

[1] The natural logarithm was calculated for each of the three continuous variables because of their skewed distribution. The transformed variables are used in all models. The values prior to these transformations are discussed here because they are easier to interpret considering these variables are measured in feet.
[2] This variable captures street segment permeability. The variable was originally measured as continuous but then transformed into a dichotomous variable because of it offered an improved characterization of its skewed distribution relative to calculating its natural logarithm and retaining it as a continuous variable.

indicates to an extent that most street segments are nested within localized pockets away from primary access routes with dense connections between several street segments. Collectively, the *Accessibility* measures begin to sketch a portrait of Chicago as a collection of street segments organized in clusters, most likely grouped by neighborhoods, which are detached but easily accessible to the broader transportation lines within the city.

Table 7.1: Descriptive Statistics of Criminal Opportunity Measures and Dependent Variable

Level-1 (N=41,926)	Mean	SD	Min.	Max.
Dependent Variable:				
Violent Crime Incidents 2012-2014	1.346	2.686	0	67
Accessibility:				
Length*	428	204	7	3,986
Permeability	.463	.499	0	1
Arterial	.176	.381	0	1
Highway Access^*	8,489	5,131	23	27,826
Train Station^*	10,699	9,016	0	52,910
Bus Stop	.114	.318	0	1
Routine Activities:				
Land Use	.299	.458	0	1
Facility with Alcohol^*	2,115	1,870	0	56,546
Public Housing	.032	.176	0	1
Gang Territory	.444	.497	0	1
Illegal Market Incidents*	.760	3.09	0	235
Physical Disorder+	3.21	8.32	0	208

Note: These variable are included in the final models as * = natural logarithm; denotes variable is ^ = distance in feet, + = factor score

The six measures in the *Routine Activities* group provide a summary of characteristics of street segments or facilities on street segments which influence their situational risk of victimization for violent crime incidents. Of the six measures in this group; three are dichotomous variables, two are count variables, and one is a continuous variable. The continuous variable and one of the count variables were transformed using their natural logarithm. See the previous footnote. The 311 calls for service for physical disorder variable – listed in the table as a count variable - will be included as a factor score. 29.9% of street segments in 2011 contained a facility with an active business license indicating the majority of street segments in Chicago are utilized for non-commercial purposes. The average street segment in Chicago is 2,115 feet (~ 0.5 miles) away from the nearest facility where alcohol can be purchased which is much closer than the average distance to train stations or highways for street segments. Only 3.2% of street segments are located within one block of a public housing facility while 44.4% of street segments intersect with gang territory in 2011. The mean number of illegal market incidents reported at street segments was less than one in 2011; 74.6% of street segments did not experience an illegal market incident compared to 73.4% for violent crime incidents. The mean number of physical disorder related 311 calls for service on street segments was 3.21 in 2011; 51.6% of street segments did not report a physical disorder-related call for service.

Table 7.2 reports a correlation matrix created using the twelve criminal opportunity variables. Of the 66 bivariate pairings observed, only 3 correspond with an $r > .300$. Each combination was a pairing between two distance measures. Facilities with alcohol and highway access point reported an $r = .506$, facilities with alcohol and train stations reported an $r = .602$, and train stations with highway access reported an $r = .713$.

Appendix 9 presents multicollinearity diagnostics for all twelve variables. Each variable reported a variance inflation factor (VIF) below 2.6 with a group mean of 1.39 affirming the use of all twelve variables in multivariate regression models should not encounter problems calculating the unique influence of each variable (McClendon, 1994).

Table 7.3 reports estimates from two negative binomial regression models which use the 12 criminal opportunity variables to predict variation in counts of violent crimes at street segments in Chicago. Since over-dispersion was observed in the dependent variable negative binomial regression models provided a better fit than Poisson models for the count data. Even considering this, estimates were consistent between negative binomial, Poisson, and zero-inflated Poisson models. Model 1 illustrates that each of the accessibility measures is a statistically significant predictor of violence. Longer street segments, arterial segments, and segments within one block of bus stops were at an increased risk of victimization even when controlling for the other *Accessibility* covariates. Also, street segments with six or over access points experienced a greater risk of violent victimization relative to segments with five or under access points. As anticipated, street segments further away from train stations experienced lower levels of violence although segments further away from highways were surprisingly associated with higher counts of incidents. For example, the incidence rate ratio (IRR) for this variable indicates, when controlling for the other *Accessibility* variables, each additional logged foot moving away from a highway access ramp street segments are associated with a 71.4% increase in violent crime incidents.

Table 7.2: Criminal Opportunity Variable Bivariate Correlations

	SL	SP	SA	HA	TS	SB	LU	FA	PH	GT	IM	PD
Length (SL)	1											
Permeability (SP)	.193	1										
Arterial (SA)	-.127	-.044	1									
Highway Access (HA)	.168	.153	-.037	1								
Train Station (TS)	.121	.059	-.022	.713	1							
Bus Stops (SB)	.010	.130	.070	-.044	-.165	1						
Land Use (LU)	.180	.075	.136	.025	-.106	.158	1					
Fac. with Alcohol (FA)	.231	.012	-.101	.506	.602	-.191	-.157	1				
Public Housing (PH)	-.043	-.056	.002	-.080	-.064	.031	-.023	.017	1			
Gang Territory (GT)	.091	.129	-.064	.071	.071	.045	-.022	.094	.006	1		
IM Incidents (IM)	.208	.152	.042	.050	-.056	.119	.144	-.012	.014	.256	1	
Physical Disorder (PD)	.265	.128	-.023	.082	.013	.033	.110	.041	-.038	.167	.300	1

Note: N = 41,926; all correlations were calculated using the previously discussed transformation for each variable

The coefficients for each of the six *Accessibility* variables retained statistical significance with the introduction of the *Routine Activities* variables although the size of the coefficient decreased for each. The six *Routine Activities* variables were statistically significant and diagnostic tests indicated their addition improved the overall fit of the model. The coefficient for distance to facilities with alcohol was the only estimate that did not produce the anticipated impact on the dependent variable. Similar to the distance to highway access coefficient, the further street segments were from facilities with alcohol the more likely they were to experience a violent crime incident. Gang territory reported one of the highest IRRs; street segments that intersected with gang territory experienced a 98.8% greater risk of victimization for violent crime compared to street segments that did not intersect with gang territory, controlling for the other opportunity covariates.

Table 7.4 reports estimates from a multinomial logistic regression models which examined the influence of the criminal opportunity measures in differentiating between the previously identified developmental patterns of violent crime incidents at street segments (see Weisburd et al., 2012). The interpretation of findings from these models is limited because of the temporal misalignment between independent and dependent variables; the former measured between 2010 and 2011 while the latter between 2001 and 2014. The general stability of developmental patterns at street segments city-wide does provide a compelling justification to consider these models (see Weisburd et al., 2012). Also, these analyses can provide greater insight into the different contexts in which criminal opportunity variables are useful in understanding violence.

Table 7.3: Negative Binomial Regression Model Estimates on Violent Crime Incidents 2012-2014

	Model 1		Model 2	
	Coeff. (SE)	IRR	Coeff. (SE)	IRR
Accessibility:				
Length	1.226 (.018)***	3.408	0.750 (.017) ***	2.118
Permeability	0.252 (.017) ***	1.287	0.111 (.015) ***	1.117
Arterial	0.351 (.022) ***	1.420	0.195 (.019) ***	1.215
Bus Stop	0.539 (.021) ***	1.714	0.329 (.019) ***	1.390
Train Station	-0.255 (.010) ***	0.775	-0.177 (.009) ***	0.837
Highway Access	0.173 (.013) ***	1.188	0.080 (.011) ***	1.084
Routine Activities:				
Land Use	-		0.434 (.016) ***	1.543
Fac. with Alcohol	-		0.036 (.012)**	1.037
Public Housing	-		0.502 (.038) ***	1.652
Gang Territory	-		0.687 (.015) ***	1.988
IM Incidents	-		0.774 (.011) ***	2.168
Physical Disorder	-		0.131 (.007) ***	1.140
Pseudo R-Square	0.054		0.135	
Dispersion Parameter	1.845		.938	
Log Likelihood	-60,278		-55,122	
BIC	120,642		110,393	

* = p < .05, ** = p < .01, *** = p < .001

Similar to Table 7.3, each of the opportunity measures generally retained their statistical significance and direction of their influence on violence. Across both groups of opportunity variables the coefficients increase in magnitude from Model 1 which contrasts crime free to low stable groups to Model 4 which contrasts crime free to high stable groups with highway access as the only exception. In Models 1 and 2 the coefficient of facilities with alcohol is negative and statistically significant but in Models 3 and 4 they change to positive and not significant. Overall, findings from this section confirm decades of research which successfully uses criminal opportunity to explain variation in the level of crime events at micro-places within cities. Results from Table 7.4 do indicate that criminal opportunity has a different influence when comparing street segments with unique developmental patterns of violence. The largest effect of these variables is found when contrasting crime free and high stable street segments indicating that opportunity operates uniquely across different circumstances.

Table 7.4: Multinomial Logistic Regression Model Estimates on Violent Crime Developmental Patterns at Street Segments from 2001-2014

	Model 1 Coeff. (SE)	Model 2 Coeff. (SE)	Model 3 Coeff. (SE)	Model 4 Coeff. (SE)
Accessibility:				
Length	0.823 (.03)***	1.801 (.04)***	2.336 (.011)***	3.285 (.01) ***
Permeability	0.294 (.03)***	0.400 (.03)***	0.653 (.08)***	0.479 (.07) ***
Arterial	0.076 (.04)*	0.277 (.05)***	0.680 (.09)***	0.524 (.09) ***
Bus Stop	0.486 (.03)***	0.812 (.04)***	1.498 (.13)***	1.179 (.09) ***
Train Station	-0.331 (.02)***	-0.558 (.02)***	-0.760 (.05)***	-0.687 (.04) ***
Highway Access	0.378 (.02)***	0.478 (.02)***	0.399 (.05)***	0.422 (.05) ***
Routine Activities:				
Land Use	0.902 (.03)***	1.349 (.04)***	1.783 (.08)***	1.608 (.07) ***
Fac. with Alcohol	-0.117 (.02)***	-0.067 (.02)**	0.088 (.05)	0.069 (.05)
Public Housing	0.860 (.08)***	1.522 (.09)***	2.935 (.15)***	1.873 (.17) ***
Gang Territory	1.255 (.03)***	2.167 (.04)***	2.579 (.09)***	2.616 (.08) ***
IM Incidents	1.316 (.05)***	2.613 (.06)***	3.789 (.07)***	3.897 (.07) ***
Physical Disorder	0.401 (.03)***	0.680 (.03)***	0.806 (.03)***	0.814 (.03) ***
Groups	Crime Free vs. Low Stable	Crime Free vs. Moderate Stable	Crime Free vs. High Decreasing	Crime Free vs. High Stable
# Segments	29,014	26,070	16,842	17,550

Note: Log Likelihood -39,744, Pseudo R^2 = .268, * = p < .05, ** = p < .01, *** = p < .001

Social Disorganization Measures

Table 7.5 presents descriptive statistics of four social disorganization variables divided into two groups: *Structural* and *Organizational*. While not explicitly a social disorganization variable, the neighborhood-level spatial lag is also included in this table. The two *Structural* measures are continuous variables represented as factor scores and the two *Organizational* measures are also continuous variables captured using Empirical Bayes estimates. The metric of these variables unfortunately does not facilitate intuitive interpretations of results from Table 7.5. Appendix 10 reports the factor loading for the creation of each Structural variable. Appendices 11 and 12 report correlations between three waves of *Structural* variables measured from 1990-2010. These figures illustrate the general stability of concentrated disadvantage and residential instability at neighborhood clusters at the turn of the twenty-first century. This stability justifies to an extent the inclusion of PHDCN variables to measure the *Organizational* neighborhood effect. PHDCN measures of neighborhood characteristics were only gathered city-wide in 1995 and not in subsequent follow-up data collection efforts in the late-1990s and early 2000s. Due to the stability of several other neighborhood characteristics over time in Chicago, the previously demonstrated influence of these *Organizational* measures on crime in Chicago, and importance to the social disorganization model these variables were included in the exploratory analyses presented in this chapter (Sampson, 2012, Sampson et al., 1997; Kurbin and Weitzer, 2003). The implications of this model specification decision will be considered in the final chapter of the dissertation.

Table 7.6 presents a correlation matrix of the four social disorganization variables. Three of the 6 pairings of variables reported moderate correlations.

Residential instability and collective efficacy were highly correlated (r = -.753) despite the 15 year gap between collection of measures. This suggests that neighborhood clusters with high levels of collective efficacy in 1995 later experience low levels of residential instability in 2010. Multicollinearity diagnostics in Appendix 13 report VIF's below 2.18. This finding reduces concern that the moderate correlations between social disorganization measures impacts interpretation of these variables in subsequent regression models.

Table 7.7 presents estimates from a negative binomial regression model testing the multivariate impact of the social disorganization measures on explaining the variation of violent crime incidents between neighborhood clusters. The variable for spatial lag was not included in either model because it was created entirely for the purpose of the hierarchical models and is not an appropriate fit within the context of a single-level, neighborhood cluster model since it measures essentially what this model predicts (i.e. neighborhood-level crime) using a different metric. Coefficients for all four variables were statistically significant across both models ($p<.001$).

Table 7.5: Descriptive Statistics of Social Disorganization Measures

Level-2 (N =342)	Mean	SD	Min	Max
Structural:				
Concentrated Disadvantage+	0	1	-1.704	2.426
Residential Instability+	0	1	-2.168	5.670
Organizational:				
Collective Efficacy^	3.612	.279	2.884	4.413
Network Ties^	3.138	.213	2.682	4.16
Other:				
Spatial Lag	.685	.554	.003	2.47

Note: These variable represent: + = is or will be factor score, ^ = empirical Bayes

Negative coefficients for the *Organizational* variables in Model 2 indicate, even controlling for the influence of *Structural* characteristics, increases in these variables correspond with decreases in the count of violent crime incidents for neighborhood clusters. The introduction of the *Organizational* variables in Model 2 reduced the size of the coefficient for residential instability noticeably but not for concentrated disadvantaged. Despite the statistical significance of the *Organizational* variables their addition only marginally improves the overall model fit between Model 1 and 2.

Tables 7.8 and 7.9 explore the cross-level influence of social disorganization measures on the developmental patterns of violent crime incidents at street segments in Chicago. Table 7.8 observes the effect of concentrated disadvantage noting as the level of violence increases at street segments these locations are less likely to be found nested within neighborhood clusters with the lowest level of concentrated disadvantage (i.e. quartile 1). The inverse is also detected; as the level of violence increases street segments were more likely to be nested within neighborhood clusters with the highest levels of concentrated disadvantage (i.e. quartile 4).

A majority of street segments with crime free patterns were found in neighborhood clusters with below average levels of concentrated disadvantage, 76% in quartiles 1 and 2, but this in turn also suggests that a sizable number of crime free segments are still found in neighborhood clusters with above average levels. Again, the same is true with the inverse, 89.2% of high stable patterns were found in neighborhood clusters with above average levels of concentrated disadvantage. Table 7.9 presents the

Table 7.6: Social Disorganization Variable Bivariate Correlations

Level-2 (N = 342)	CD	RI	CE	NT	
Concentrated Disadvantage	1				
Residential Instability	.540	1			
Collective Efficacy	-.526	-.753	1		
Network Ties	.005	-.178	.356	1	
Spatial Lag	.649	.589	-.592	-.224	1

cross-level distribution of street segment developmental patterns nested within neighborhood clusters sorted on levels of collective efficacy. A similar relationship emerges; street segments with crime free developmental patterns were located primarily in neighborhood clusters with high levels of collective efficacy while segments with high stable patterns were nested within neighborhood clusters with low levels of collective efficacy.

Despite the temporal mismatch of variables Tables 7.8 and 7.9 illustrate both a “neighborhood” effect in the spatial distribution of street segment developmental patterns throughout Chicago but also important granular variation at the micro-level. Street segments with high stable patterns were still found in neighborhood clusters with high collective efficacy and low concentrated disadvantage while segments with crime free patterns were still located in neighborhood clusters with low levels of collective efficacy and high levels of concentrated disadvantage (for general discussion see Sherman et al., 1989; Weisburd et al., 2012). These findings offer further support for a multi-level integration of criminal opportunity and social disorganization theories to enhance understanding of the spatial distribution of violence within cities.

Table 7.7: Results from Negative Binomial Regression on Violent Crime Incidents at Neighborhood Clusters 2012-2014

	Model 1		Model 2	
	Coeff. (SE)	IRR	Coeff. (SE)	IRR
Structural:				
Concentrated Disadvantage	.397 (.037)***	1.488	.394 (.036)***	1.483
Residential Instability	.488 (.043)***	1.628	.283 (.051)***	1.327
Organizational:				
Collective Efficacy	-		-.846 (.178)***	.429
Kin/Friendship Ties	-		-.626 (.150)***	.535
Pseudo R^2	.071		.084	
Dispersion Parameter	.329		.282	
Log Likelihood	-1,944		-1,915	
BIC	3,912		3,866	

Note: Count of street segments in neighborhood cluster set as exposure; * = p < .05, ** = p < .01, *** = p < .001

Table 7.8: Percent of Street Segment Developmental Patterns (2001-2014) Sorted by Neighborhood Cluster-Level of Concentrated Disadvantage in 2010

	Concentrated Disadvantage				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Total
Crime Free	49.7%	26.3%	15.3%	8.6%	100%
Low Stable	29.4%	30.7%	24.3%	15.6%	100%
Moderate Stable	13.6%	20.7%	32.9%	32.8%	100%
High Decreasing	5.4%	11.7%	23.2%	59.7%	100%
High Stable	4.7%	6.4%	24.8%	64.2%	100%

N = 41,926 street segments nested in 342 neighborhood clusters.

Table 7.9: Percent of Street Segment Developmental Patterns (2001-2014) Sorted by Neighborhood Cluster-Level of Collective Efficacy in 1995

	Collective Efficacy				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Total
Crime Free	8.9%	10.8%	23.4%	57.0%	100%
Low Stable	14.4%	19.2%	30.8%	35.6%	100%
Moderate Stable	27.4%	28.3%	28.2%	16.1%	100%
High Decreasing	51.2%	31.9%	13.5%	3.4%	100%
High Stable	41.9%	35.1%	18.4%	4.6%	100%

N = 41,926 street segments nested in 342 neighborhood clusters

Theoretical Integration

This section uses several modeling approaches to determine the influence of a hierarchical integration of social disorganization and criminal opportunity theories on explaining the variation of violent crime at street segments in Chicago. First, a generalized linear mixed model was estimated to provide a baseline representation of the multi-level effect of each set of criminal opportunity variables while controlling for social disorganization variables at neighborhood clusters. This model can be alternatively be considered as a random-intercept model. A random-intercept model accounted only for variance in constants between neighborhood clusters. For the purpose of this analysis, this implies that street segments across different neighborhood clusters experience inherently different levels of violence. This model also assumes criminal opportunity variables influence the count of violent crime incidents in a uniform manner across all neighborhood clusters (i.e. a fixed effect).

Second, additional random effects and cross-level interactions were tested to further uncover how these two theories operate in a hierarchical context. Both of these techniques can determine if the effect of criminal opportunity variables differs between different neighborhood clusters. Third, the influence of criminal opportunity within specific neighborhood clusters is tested using GBTM to characterize unique neighborhood ecological conditions then by comparing estimates of negative binomial regression models to determine the differential effect of opportunity on violence in unique ecological contexts. This approach offers a creative attempt to model the foreground and background influence of each theory while also presenting the most theoretically grounded characterization of the data which accounts for its longitudinal and hierarchical form in a parsimonious manner.

Table 7.10 displays estimates from four generalized linear mixed models which integrate social disorganization and criminal opportunity measures. Overall, these models indicate that when accounting for the multi-level clustering of street segments in neighborhood clusters and the preliminary introduction of social disorganization variables, measures from both theoretical classes still retain statistical significance while offering a better model fit to explain the variation of violent crime incidents at street segments in Chicago. BIC is a helpful tool to begin to determine superior model fit. Likelihood ratio tests also concluded that each successive model was an improved fit over the previous. These tests are conducted for models nested within each other; each change from Model 1 to Model 2 and so on was associated with a $p < .001$. All but one variable was statistically significant across each of the four models. This even includes neighborhood cluster variables of collective efficacy and network ties in Model 3 which were measured 15 years prior to the dependent variable. However, when the spatial lag covariate was introduced, the coefficient for collective efficacy did not retain its statistical significance between Models 3 and 4. The coefficient for each of the social disorganization variables was noticeably reduced, although with the exception of collective efficacy each retained their statistical significance. The size of the coefficients and their statistical significance for both groups of opportunity measures remain stable across Models 3 and 4 when introducing the level-2 social disorganization measures. The opportunity variable measuring distance to facilities with alcohol reported negative coefficients across models which is different from the single-level models presented earlier in this chapter but fitting with the previously anticipated direction of its effect.

Table 7.11 offers estimates of additional generalized linear mixed models with random effects specified for four criminal opportunity variables. The specification of a random effect indicates this level-1 variable, in addition to its fixed effect across all neighborhood clusters, can have a differential effect between neighborhood clusters. Due to computational limitations, random effects could only be specified for one criminal opportunity variable at a time. Generalized linear mixed models with only two random effects would not converge after running for over 12 hours. Four variables were selected: two *Accessibility* measures and two *Routine Activities* measures. These variables were selected because they were characteristics of street segments that were likely to be observed across all types of neighborhood clusters. For example, gang territory and public housing would not be optimal variables to select because they were generally only observed across a smaller number of neighborhood clusters.

Since the statistical significance of a random effect is not calculated similar to coefficients in a regression model, likelihood ratio tests were conducted to determine if a model with the additional random effect offered a better fit to relative to one without it.

For each of the four models in Table 7.12 the random effect model offered an improved fit at the *p* < .05-level indicating variation of the influence of these criminal opportunity variables between neighborhood clusters. The statistical significance of the fixed effect for each variable remained the same across all models when included as a random effect and no substantial reductions of coefficients were noticed.

Table 7.10: Generalized Linear Mixed Model Estimates

Fixed Effect	Model 1 Coeff. (SE)	Model 2 Coeff. (SE)	Model 3 Coeff. (SE)	Model 4 Coeff. (SE)
Length	1.189 (.017) ***	0.893 (.017) ***	0.896 (.017) ***	0.894 (.017)***
Permeability	0.164 (.015) ***	0.089 (.014) ***	0.090 (.014) ***	0.088 (.014) ***
Arterial	0.513 (.019) ***	0.259 (.018) ***	0.261 (.018) ***	0.262 (.018) ***
Highway Access	0.346 (.019) ***	0.288 (.019) ***	0.262 (.018) ***	0.204 (.019) ***
Train Stop	-0.327 (.019) ***	-0.166 (.018) ***	-0.137 (.017) ***	-0.125 (.017) ***
Bus Stops	0.374 (.020) ***	0.204 (.019) ***	0.203 (.019) ***	0.247 (.018) ***
Land Use	-	0.437 (.015) ***	0.445 (.015) ***	0.446 (.015) ***
Fac. with Alco.	-	-0.159 (.015) ***	-0.163 (.015) ***	-0.162 (.015) ***
Public Housing	-	0.272 (.046) ***	0.246 (.045) ***	0.267 (.045) ***
Gang Territory	-	0.279 (.020) ***	0.259 (.019) ***	0.257 (.019) ***
IM Incidents	-	0.519 (.011) ***	0.509 (.011) ***	0.505 (.011) ***
Physical Disorder		0.106 (.006) ***	0.105 (.006) ***	0.105 (.006) ***
Concentrated Dis.	-	-	0.356 (.031) ***	0.258 (.033) ***
Residential Instb.	-	-	0.225 (.039) ***	0.174 (.038) ***
Collective Eff.	-	-	-0.308 (.147)*	-0.222 (.139)
Network Ties	-	-	-0.458 (.125) ***	-0.325 (.120)**
Spatial Lag	-	-	-	0.379 (.061) ***
Random Effect	**Var.**	**Var.**	**Var.**	**Var.**
Constant	.891	.534	.172	.153
BIC	109,612	104,843	104,539	104,513

Note: N = 41,926 street segments, N = 342 neighborhood clusters* = p < .05, ** = p < .01, *** = p < .001

Table 7.11: Generalized Linear Mixed Model Estimates with Additional Random Effects

Fixed Effect	Model 1 Coeff. (SE)	Model 2 Coeff. (SE)	Model 3 Coeff. (SE)	Model 4 Coeff. (SE)
Length	0.890 (.017)***	0.895 (.017) ***	0.895 (.017) ***	0.892 (.017) ***
Permeability	0.088 (.014) ***	0.089 (.014) ***	0.089 (.014) ***	0.089 (.014) ***
Arterial	0.262 (.018) ***	0.262 (.018) ***	0.262 (.018) ***	0.261 (.018) ***
Highway Access	0.203 (.019) ***	0.203 (.019) ***	0.203 (.019) ***	0.205 (.019) ***
Train Station	-0.124 (.017) ***	-0.133 (.018) ***	-0.133 (.018) ***	-0.122 (.017) ***
Bus Stops	0.246 (.018) ***	0.253 (.018) ***	0.253 (.018) ***	0.243 (.018) ***
Land Use	0.446 (.015) ***	0.445 (.015) ***	0.445 (.015) ***	0.445 (.015) ***
Fac. with Alco.	-0.161 (.015) ***	-0.162 (.015) ***	-0.162 (.015) ***	-0.159 (.015) ***
Public Housing	0.268 (.045) ***	0.261 (.045) ***	0.261 (.045) ***	0.271 (.045) ***
Gang Territory	0.256 (.019) ***	0.255 (.019) ***	0.255 (.019) ***	0.255 (.019) ***
IM Incidents	0.505 (.011) ***	0.505 (.011) ***	0.505 (.011) ***	0.508 (.011) ***
Physical Disorder	0.105 (.006) ***	0.105 (.006) ***	0.105 (.006) ***	0.113 (.008) ***
Concentrated Dis.	0.249 (.034) ***	0.233 (.035) ***	0.233 (.035) ***	0.258 (.033) ***
Residential Instb.	0.186 (.039) ***	0.184 (.039) ***	0.184 (.039) ***	0.175 (.038) ***
Collective Eff.	-0.221 (.141)	-0.172 (.142)	-0.172 (.142)	-0.209 (.139)
Network Ties	-0.307 (.121)*	-0.335 (.122)**	-0.335 (.122)**	-0.348 (.120)**
Spatial Lag	0.377 (.062) ***	0.403 (.062) ***	0.403 (.062) ***	0.389 (.061) ***
Random Effect	**Var.**	**Var.**	**Var.**	**Var.**
Constant	.113	.113	.110	.152
Segment Length	.001	-	-	-
Train Station	-	.001	-	-
Alcohol	-	-	.001	-
Phys. Disorder	-	-	-	.004
BIC	104,519	104,519	104,514	104,489

***= p < .001, **= p <.01, *=p <.05

Table 7.12 presents estimates from four models that specified cross-level interactions for each of the social disorganization measures to understand how criminal opportunity functions differently between neighborhood clusters. The cross-level interaction between a level-1 opportunity variable and level-2 social disorganization variable determines the additive effect of these variables while controlling for other covariates and the hierarchical clustering (i.e. the random intercept model). While the specification of random effects in the previous analysis determined certain criminal opportunity variables operate differently between neighborhood clusters, these models further elaborate upon the specific contexts through which this happens.

The purpose of this analysis is not to inspect a comprehensive list of every possible combination for a potential cross-level interaction. Opportunity variables selected to interact with the social disorganization variables were based upon, with Model 1 being an exception, two variables which measured similar constructs. For example, collective efficacy and physical disorder both capture the broader theoretical construct of informal social control. The purpose of this analysis is to offer a simple demonstration of how opportunity variables influence violence in different ways between neighborhood clusters.

For example, Model 1 specifies a cross-level interaction of distance to facilities with alcohol and concentrated disadvantage suggesting the former influences violence differently between neighborhood clusters based directly on the influence of the latter. The cross-level interaction term in Model 1 was reported to be statistically significant indicating that indeed the influence of facilities with alcohol does change between neighborhood clusters with different levels of concentrated disadvantage. To further clarify, the effect of spatial proximity to a liquor store is not the same in an impoverished part of Chicago such as the south side relative to a more affluent area such as the north side. Models 1-4 all offer support for cross-level interactions and again each model offered an improved fit using likelihood ratio tests to models that did not add an interaction term.

Table 7.12: Generalized Linear Mixed Model Estimates with Cross-Level Interactions

Fixed Effect	Model 1 Coeff. (SE)	Model 2 Coeff. (SE)	Model 3 Coeff. (SE)	Model 4 Coeff. (SE)
Length	0.903 (.017)***	0.896 (.017)***	0.894 (.017)***	0.894 (.017)***
Permeability	0.088 (.014)***	0.089 (.014)***	0.088 (.014)***	0.088 (.014)***
Arterial	0.262 (.018)***	0.254 (.018)***	0.261 (.018)***	0.262 (.018)***
Highway Access	0.206 (.019)***	0.199 (.019)***	0.203 (.019)***	0.203 (.019)***
Train Stop	-0.126 (.017)***	-0.122 (.017)***	-0.124 (.017)***	-0.124 (.017)***
Bus Stops	0.238 (.018)***	0.245 (.018)***	0.246 (.018)***	0.247 (.018)***
Land Use	0.442 (.015)***	0.446 (.015)***	0.445 (.015)***	0.446 (.015)***
Facility w/ Alco.	-0.170 (.015)***	-0.161 (.015)***	-0.161 (.015)***	-0.162 (.015)***
Public Housing	0.256 (.045)***	0.265 (.045)***	0.264 (.045)***	0.268 (.045)***
Gang Territory	0.255 (.019)***	0.254 (.019)***	0.256 (.019)***	-0.656 (.295)*
IM Incidents	0.506 (.011)***	0.543 (.012)***	0.507 (.011)***	0.505 (.011)***
Physical Disorder	0.101 (.006)***	0.105 (.006)***	-0.216 (.082)**	0.105 (.006)***
Concentrated Dis.	-0.360 (.073)***	0.256 (.032)***	0.256 (.033)***	0.262 (.033)***
Residential Instb.	0.162 (.037)***	0.209 (.037)***	0.173 (.038)***	0.167 (.038)***
Collective Eff.	-0.225 (.137)+	-0.197 (.136)	-0.240 (.139)+	-0.222 (.138)
Network Ties	-0.305 (.117)**	-0.310 (.117)**	-0.320 (.119)**	-0.485 (.129)***
Spatial Lag	0.381 (.060)***	0.391 (.059)***	0.381 (.061)***	0.383 (.006)***
Concentrated Dis. x Alcohol	0.085 (.009)***	-	-	-
Residential Instb. x IM Incidents	-	-0.089 (.012) ***	-	-
Collective Eff. x Physical Disorder	-	-	0.090 (.023) ***	-
Network Ties x Gang Territory	-	-	-	0.290 (.094)**
Random Effect	**Var.**	**Var.**	**Var.**	**Var.**
Constant	.147	.144	.151	.150
BIC	104,433	104,468	104,508	104,514

***= p < .001, **= p <.01, *=p <.05, + = p <.10

The final analysis in this dissertation investigates the influence of criminal opportunity measures *within* specific neighborhood cluster contexts. The previous analyses in this section identify variation in the effect of criminal opportunity *between* neighborhood clusters while accounting for the hierarchical influence of social disorganization measures. First, developmental groups identifying divergent patterns of violent crime at neighborhood clusters from 2001-2011 were estimated with GBTM. Second, developmental groups summarize unique patterns of concentrated disadvantage over 40 years at neighborhood clusters were also estimated with GBTM. These neighborhood cluster developmental groups characterize the environmental backcloth or background ecological conditions theorized to impact the influence of criminal opportunity variables (see Brantingham and Brantingham, 1993). This representation explicitly equates the environmental backcloth with social disorganization theory. Since previous analyses in this section provided temporal incongruity when specifying a more comprehensive social disorganization model (i.e. structural and organizational measures) this analysis focused on only two measures from this model but provides more detailed attention to the temporal relationship.

This approach presents an alternative to just controlling for social disorganization measures at level-2, conducted earlier in this analysis (also see Deryol et al., 2016), because it begins to address the longstanding temporal characteristics of neighborhoods. In addition, this approach captures the pre-existing hierarchical relationship of micro-places and neighborhoods while also providing a theoretically informed representation of the integration of the two ecological theories associated with these units of analysis. While the temporal limitations were primarily a result of the data used in this analysis, specifically the gap between when social disorganization and opportunity variables were measured, attention to this component agrees with Taylor's (2015) assertion that place-based analysis need to focus greater attention to temporal specification to increase their validity. In addition, if the ecological background influences of crime at place are considered a partial explanation of accounting for the "motivated offender" they should be measured prior to when the crime occurred since they would be more prescient to the early-stage life course development of individuals residing in these neighborhoods (see Clarke, 1995).

The use of a developmental pattern of violence is a pragmatic way to capture the spatial lag variable in this analysis. Traditionally, spatial lag variables are measured using a within-neighborhood micro-place measure but due to this dissertation focusing on three spatial units of analysis it became more practical to use a pre-existing unit (i.e. measure the spatial lag at neighborhood clusters instead of introducing a fourth unit of analysis). Assessing concentrated disadvantage over 40 years provided a method to capture longstanding patterns of poverty within neighborhood clusters. Since neighborhood characteristics are often stable over extended periods of time this measure offered a tool to demonstrate this while also showing how deeply engrained certain ecological conditions are at neighborhoods (Sampson, 2012).

Estimation of developmental groups followed the same procedures outlined in Chapter 6. Appendices 14-15 report the mean value for each opportunity measure between neighborhood trajectory groupings for both violence and concentrated disadvantage. The distribution of opportunity variables differs noticeably between neighborhood clusters. The importance of this will be highlighted in Chapter 8.

Appendix 16 provides a cross-tabulation of group assignment for their developmental patterns. A five group, cubic polynomial solution (BIC = 21,416.50) was identified as the optimal fit for developmental patterns of violent crime incidents at neighborhood clusters from 2001-2011. Instead of using the previously identified developmental patterns of violence at neighborhood clusters representing 2001-2014, new models were estimated in order to avoid overlap with measurement of the dependent variable. These developmental groups demonstrate the broader ecological effect of violence on examining the influence of criminal opportunity on violence at micro-places. Appendix 17 presents a plot of the developmental groups and Appendix 18 offers descriptive statistics on group membership. The groups are ordered from least to most violent; similar to the 2001-2014 neighborhood cluster patterns each group is characterized by moderate declines in the number of incidents.

A five group, cubic polynomial solution (BIC =1,367.47) was also identified as the optimal fit for developmental patterns of concentrated disadvantage at neighborhood clusters from 1970-2010. Developmental groups were created using 5 waves of data; each wave corresponded with a decennial U.S. Census. Each developmental group captures the broader ecological effect of neighborhood structural characteristics on examining the influence of criminal opportunity on violence at micro-places. Appendix 19 presents a plot of the developmental groups and Appendix 20 offers descriptive statistics on the group membership. The five developmental groups were characterized as: low stable, moderate decreasing, moderate increasing, high stable, and high decreasing.

Table 7.13 presents estimates from five negative binomial regression models. Models 1-5 report estimates of the influence of criminal opportunity variables on explaining variation in counts of violent crime incidents (2012-2014) across specific neighborhood cluster developmental groups of violence. Each of the five developmental groups represents a unique sub-sample of all street segments in Chicago (i.e. segments in Model 1 + Model 2… = 41,926). Table 7.3 earlier in this chapter illustrated how each opportunity variable is a statistically significance predictor of violence at street segments when observing the city-wide population of nested street segments. This analysis provides a more detailed examination of these findings by reporting differences between neighborhood clusters. The differences between models reflects the unique effect of opportunity variables within certain neighborhood cluster environments.

Eight of twelve opportunity variables retained the same direction of their effect and statistical significance across all models. Within this group of variables several interesting patterns emerged when comparing IRRs. The largest IRR for most variables was observed in Model 1 indicating an increased impact of criminal opportunity in explaining violence in low crime neighborhoods. For example, street segments within a one block buffer of a bus stop in high violence neighborhood clusters are 28.2% more likely to experience a violent crime incident relative to street segments that are not (see Model 5). In low violence neighborhood clusters (i.e. Model 1), street segments within a one block buffer of a bus stop are 79.5% more likely to experience a violent crime incident relative to street segments that are not.

Physical disorder is the only variable that maintain relative consistency in their IRRs between models. The IRR for both gang territory and illegal market incidents variables decrease from Model 1 to 4 only to increase moderately in Model 5. The train station variable experiences a similar pattern but occurring in a different direction. Highway access and public housing are the only two variables which lose statistical significance in a single neighborhood cluster context but retain statistical significance across the other four. Public housing loses statistical significance in Model 4 while highway access does in Model 1. Facilities with alcohol do not retain statistical significance across Models 3-5. The average difference in the percent reduction of the IRR for opportunity variables between Model 1 and Model 5 is 53.9%. This difference is reduced to 19.7% when excluding the public housing variable which exhibits an outlier in the size of its difference of over 430%.

Table 7.13: Negative Binomial Regression Model Sorted by Neighborhood Cluster Developmental Trajectory on Violent Crime Incidents in Chicago, 2012-2014

	Model 1	Model 2	Model 3	Model 4	Model 5
	IRR (SE)	IRR (SE)	IRR (SE)	IRR (SE)	IRR (SE)
Accessibility:					
Length	2.542 (.202) ***	2.211 (.08) ***	2.272 (.086) ***	2.440 (.076) ***	2.332 (.076) ***
Permeability	1.137 (.072)*	1.102 (.036)**	0.996 (.031)	1.137 (.029)***	1.049 (.030)
Arterial	1.408 (.112) ***	1.155 (.048)**	1.190 (.050) ***	1.184 (.041) ***	1.242 (.046) ***
Highway Access	1.007 (.053)	1.211 (.028) ***	1.180 (.027) ***	1.069 (.021)**	1.204 (.027) ***
Train Station	0.779 (.033) ***	0.832 (.017) ***	0.839 (.018) ***	0.932 (.017) ***	0.951 (.016)**
Bus Stops	1.795 (.143) ***	1.387 (.058) ***	1.317 (.050) ***	1.209 (.041) ***	1.282 (.050) ***
Routine Activities:					
Land Use	2.074 (.138) ***	1.658 (.055) ***	1.500 (.051) ***	1.395 (.039) ***	1.500 (.047) ***
Fac. with Alco.	0.791 (.043) ***	0.925 (.022)**	0.970 (.026)	0.974 (.022)	0.975 (.024)
Public Housing	5.510 (1.28) ***	2.440 (.256) ***	1.409 (.107) ***	1.113 (.080)	1.206 (.070)**
Gang Territory	2.005 (.189) ***	1.465 (.048) ***	1.319 (.044) ***	1.257 (.038) ***	1.559 (.050) ***
IM Incidents	2.448 (.219) ***	2.089 (.071) ***	1.960 (.051) ***	1.847 (.034) ***	1.777 (.031) ***
Physical Disorder	1.137 (.042) ***	1.199 (.020) ***	1.128 (.016) ***	1.103 (.011) ***	1.087 (.013) ***
NC Traj. Group	1	2	3	4	5
# of Street Segments	7,239	11,325	7,390	8,860	7,112
Pseudo R^2	.131	.108	.112	.117	.135
BIC	7,691	23,147	21,246	30,110	25,033

Table 7.14 presents estimates from five negative binomial regression models. Models 1-5 report estimates of the influence of criminal opportunity variables on explaining variation in counts of violent crime incidents (2012-2014) across specific neighborhood cluster concentrated disadvantage developmental groups. 7 of the 12 criminal opportunity variables retained statistical significance across all models. IRR's for each opportunity variable did vary noticeably between models in a different manner than the neighborhood violence models. *Accessibility* variables permeability, arterial, and highway access were 3 of the measures which did not retain statistical significance across each model. All 3 variables did not have an influence on explaining variation of violent crime incidents at street segments in neighborhood clusters with high decreasing developmental patterns of concentrated disadvantage. IRR's were relatively consistent for length and bus stop variables across neighborhood contexts. While the train station variable retained statistical significance between neighborhoods a noticeable change of the IRR's was found. For example, every logged foot further away from a train station in a neighborhood cluster with low stable levels of concentrated disadvantage (i.e. Model 1) corresponds with a 29.4% reduction in violent crime incidents. Every logged foot further away from a train station in a neighborhood cluster with high decreasing levels of concentrated disadvantage (i.e. Model 5) is associated with an 18.3% increase in violent crime incidents.

Routine Activities variables facility with alcohol and public housing did not retain statistical significance across each model. The variable facilities with alcohol presents an interesting elaboration on the findings from Table 7.12 which noted a cross-level interaction between this variable and concentrated disadvantage. Findings from these analyses would suggest that since this variable was statistically significant in only neighborhood clusters with low stable and moderate increasing patterns potentially this effect could be driven by these two specific types of neighborhoods. Physical disorder and gang territory are the only variables with general consistency of IRR's is found across neighborhood clusters from this category. The IRR for land use is much larger in neighborhood clusters with low stable developmental patterns which indicate that the presence of commercial land use in these locations relative to locations without commercial land use has a greater impact on explaining variation in violence at street segments than across all other types of neighborhoods. A 101.7% difference is noted in these neighborhoods while a 43.3% difference is observed in high stable neighborhoods. Moderate differences were found between neighborhood clusters in regards to the effect of illegal market incidents. The increase of each logged illegal market incident was associated with a 64.7% increase in violent crime incidents at street segments in high stable neighborhood clusters and 112% increase in high decreasing neighborhood clusters.

Overall, the findings from these analyses confirm that a neighborhood effect does influence to an extent the predictive power of criminal opportunity variables at micro-places. The effect does not primarily influence the statistical significance of a majority of criminal opportunity variables yet it does have a noticeable influence on the magnitude of their IRR in predicting variation in violent crime incidents. Most criminal opportunity variables have their largest impact in neighborhoods with lower levels of violence (i.e. groups 1-2) suggesting neighborhood effects matter less in those situations and more in neighborhoods with higher levels of violence. The inverse is partially confirmed by the findings from the concentrated disadvantage models. The smallest effect of opportunity was generally observed in neighborhood clusters with moderate increasing or high stable patterns of concentrated disadvantage. Similar to the findings from Table 7.12, a cross-level influence does appear to exist between certain criminal opportunity variables nested within specific environmental contexts.

The findings from these analyses generally correspond with the results of the linear mixed model in research question 2. This analysis indicated that street segments accounted for the largest share of the total spatial variability of violence in Chicago but neighborhood context still retained importance in understanding the variability of crime patterns. These analyses demonstrated that both criminal opportunity at micro-places and social disorganization at neighborhood clusters offered unique contributions to explaining variation in the count of violent crime incidents at street segments in Chicago. Comparatively, the influence of criminal opportunity does appear to be marginally larger considering that although the effect of these variables differed between neighborhoods they primarily retained their statistical significance across most neighborhood contexts.

Table 7.14: Negative Binomial Regression Models Sorted by Neighborhood Cluster Developmental Trajectory of Concentrated Disadvantage in Chicago, 1970-2010

	Model 1	Model 2	Model 3	Model 4	Model 5
	IRR (SE)	IRR (SE)	IRR (SE)	IRR (SE)	IRR (SE)
Accessibility:					
Length	2.166 (.06)***	2.257 (.01)***	2.551 (.08)***	2.423 (.09)***	2.143 (.17)***
Permeability	1.132 (.03)***	1.201 (.05)***	1.070 (.03)**	1.094 (.03)**	0.940 (.09)
Arterial	1.217 (.04)***	1.387 (.07)***	1.150 (.04)***	1.243 (.05)***	0.972 (.10)
Highway Access	1.293 (.02)***	1.219 (.03)***	1.103 (.02)***	1.072 (.03)**	1.029 (.07)
Train Station	0.706 (.01) ***	0.935 (.02)**	0.960 (.02)*	0.867 (.02)***	1.183 (.06)**
Bus Stops	1.498 (.05)***	1.335 (.07)***	1.206 (.04)***	1.191 (.05)***	1.363 (.13)**
Routine Activities:					
Land Use	2.017 (.05)***	1.479 (.06)***	1.434 (.04)***	1.433 (.05)***	1.352 (.13)**
Fac. with Alco.	0.924 (.02)***	0.949 (.03)	0.897 (.02)***	1.043 (.03)	0.951 (.06)
Public Housing	2.205 (.03)***	1.437 (.14)***	1.184 (.13)	1.068 (.08)	0.969 (.08)
Gang Territory	1.530 (.04)***	1.203 (.05)***	1.219 (.04)***	1.363 (.05)***	1.387 (.11)***
IM Incidents	2.154 (.06)***	1.864 (.06)***	1.755 (.03)***	1.647 (.03)***	2.120 (.12)***
Physical Disorder	1.149 (.02)***	1.182 (.02)***	1.087 (.01)***	1.088 (.01)***	1.122 (.06)*
NC Traj. Group	Low Stable	Mod. Decreasing	Mod. Increasing	High Stable	High Decreasing
# of Street Segments	22,445	5,331	7,535	5,238	1,377
Pseudo R^2	.124	.126	.123	.117	.105
BIC	40,755	14,102	27,304	20,420	4,426

Table 7.15 summarizes findings from the models estimated across different neighborhood clusters based on their level of violence (i.e. Table 7.13) and concentrated disadvantage (i.e. Table 7.14). Length and physical disorder are the only two variables to return relatively consistent findings across both sets of models. Both of these variables though were observed to have random effects earlier in this chapter indicating their influence also varies to an extent between neighborhoods. Each of the 10 other variables either lost statistical significance across a model or experienced large differences in the effect of the variable between models. The findings from opportunity variables were determined to be consistent if the IRR varied less than +/- 50% between models. Since this decision is ostensibly qualitative a conservative threshold was used. Even the variables that were deemed as having "consistent" findings between models experienced upwards of +/- 40% differences between IRR's.

To restate, each of the 12 variables were either continuous or dichotomous measures. A +/- 50% difference for a continuous variable captures a rather larger difference between the effect of variables. The findings from these analyses go behind a cursory examination of only *p*-values for opportunity variables city-wide, which due to the large size of Chicago could be overly biased towards indicating statistical significance of findings. The multi-level models earlier in this chapter demonstrated the influence of opportunity city-wide but these analyses provide a more detailed examination. Whether the difference in the influence of opportunity between neighborhoods is a function of just the distribution of opportunity in certain locations or the actual influence of these characteristics findings from this chapter indicate criminal opportunity operates differently between neighborhoods within Chicago.

Table 7.15: Summary of Findings from Criminal Opportunity Models Between Neighborhood Clusters Developmental Groups

Variable	Violence	Concentrated Disadvantage
Accessibility:		
Length	✓	✓
Permeability	X	X
Arterial	✓	X
Highway Access	X	X
Train Station	✓	X
Bus Stops	X	✓
Routine Activities:		
Land Use	X	X
Fac. with Alco.	X	X
Public Housing	X	X
Gang Territory	X	✓
IM Incidents	X	X
Physical Disorder	✓	✓

Note: ✓ = effect and statistical significance of variable is consistent between models, X = variable does not retain statistical significance, effect, or direction of effect between models

CHAPTER 8 – CONCLUSION

A foundational goal of research on the 'criminology of place' is to demonstrate that micro-places offer an enhanced description of crime variation within cities compared to larger units of spatial aggregation (Eck and Weisburd, 1995; Weisburd et al., 2009a; 2012). Almost thirty years after the introduction of this phrase into the criminological lexicon (see Sherman et al., 1989), an ever-growing collection of empirical evidence indicates that crime is concentrated at micro-places within cities (Weisburd, 2015). While the documentation of crime concentration at micro-places does suggest these units of analysis offer a more refined spatial domain for the description of crime variability, only a handful of studies have directly compared their unique contribution relative to other alternative place-based units of analysis, such as neighborhoods, within cities (Andresen and Malleson, 2011; Steenbeek and Weisburd, 2016). Crime opportunity theories are the most commonly applied theoretical perspectives to explain crime variation at small places (Eck and Weisburd, 1995; Braga and Weisburd, 2010). These theories generally examine how situational characteristics of places facilitate the spatial-temporal interaction of offenders, targets, and the absence of guardians in ways that result in the emergence of crime events (Clarke, 1983; Cohen and Felson, 1979; Brantingham and Brantingham, 1991).

Throughout most of the twentieth century, neighborhoods and social disorganization were the predominant unit of analysis and theoretical mechanism used to understand variation of crime patterns within cities (Park and Burgess, 1925; Shaw and McKay, 1942; Reiss and Tonry, 1986). Today neighborhoods still provide an irreplaceable spatial domain to characterize meso- and macro-patterns of social activity in urban areas. Sampson (2013) argues even in the era of globalization "neighborhood contexts are important determinants of the quantity and quality of human behavior… differentiation by neighborhood is not only everywhere to be seen… it has durable properties with effects that span a wide variety of social phenomena" (p. 4). While social disorganization theory has to an extent evolved into a broader class of mechanisms generally summarized as "neighborhood effects," Sampson suggests even further expansion into a "family of neighborhood effects across multiple units of analysis, outcomes, and time scales" (p. 4). This proposed reconfiguration of the key theoretical mechanism associated with the influence of neighborhoods on crime provides further justification to consider integration with other ecological-based theories (also see Sampson, 2012).

The integration of units of analysis and theoretical mechanisms across the two leading ecological approaches can improve our understanding of crime variation within cities in several ways.[1] Micro-places are inherently nested within neighborhoods and this multi-level relationship can be operationally represented using hierarchical models (see Steenbeek and Weisburd, 2016). This presents a variation of certain place-based research conducted in the late 1980s and early 1990s which explored the multi-level relationship between individuals and neighborhoods (Miethe and Meir, 1990; Wilcox et al., 1994). A hierarchical integration of spatial units of analysis can identify the unique contribution of

[1] Over the past five years both Robert Sampson and David Weisburd, two of the leading proponents of these ecological orientations, have offered major statements on the vitality of these approaches. Both scholars released insightful books with city-wide analyses documenting the benefits of their respective approaches (see Sampson, 2012; Weisburd et al., 2012) and also offered compelling Presidential addresses to the American Society of Criminology to reinforce these arguments (see Sampson, 2013; Weisburd, 2015). In their works, issues of theoretical reconfiguration and integration are salient considerations in both ecological orientations to crime variability across urban settings.

micro-places and neighborhoods to description of the variability of crime patterns while answering a foundational question in research on the criminology of place. The use of a hierarchical integration can also provide a framework to begin to address the contribution of both theoretical mechanisms to explaining observed spatial variability in crime. The integration of theoretical mechanisms presents several challenges because of the ambiguity between certain related concepts from each class of theory (see Braga and Clarke, 2014; Weisburd et al., 2014). Despite these obstacles this integration framework presents a path to advance ecological-based inquiry on crime variation within cities that is grounded in rich theoretical consideration (Clarke, 1995; Taylor, 2015) and a small but promising foundation of empirical support (Davies and Johnson, 2015; Deryol et al., 2016).

This dissertation research explored crucial issues related to the integration of both units of analysis and theoretical mechanisms from these two complementary ecological orientations. The spatial distribution of violent crime incidents was observed at both micro-places and neighborhoods to determine if concentration and stability of patterns were found in Chicago from 2001 to 2014. A replication of Steenbeek and Weisburd's (2016) multi-level analysis used a hierarchical model to directly test the unique contribution of the spatial units of analysis to the description of crime variability. Both criminal opportunity and social disorganization measures at each of these hierarchical levels were examined to determine if each retained predictive power in explaining crime variation while accounting for the other. The differential effect of criminal opportunity at micro-places between and within neighborhoods was also examined. The city of Chicago is a renowned laboratory for place-based analyses in the social sciences (see Park, 1916;

Shaw et al., 1929; Sampson et al., 1997). Due to the legacy of neighborhood-based inquiry in the city and the burgeoning number of micro-level studies conducted there more recently, Chicago was the ideal candidate for a city to consider theoretical and empirical integration. The availability of several important sources of spatial data, including PHDCN and the city's data portal, also provided a practical advantage to conduct the study in Chicago.

This chapter concludes the dissertation with a comprehensive discussion of the findings from the analyses conducted to answer the research questions in the previous two chapters. After summarizing these findings, a broader conversation of their implications for criminological theory and criminal justice policy is then presented. The first section of this chapter presents definitive answers to the study's research questions based on the analyses conducted in Chapters 6 & 7. The second section assesses the theoretical implications of these results and how they can further advance place-based criminological theory to understand the spatial distribution of crime in cities. The third section highlights how the findings can be used to improve the response of criminal justice policy to urban crime problems. The fourth section focuses on the limitations of this dissertation research, specifically the issues that arose from the theoretical integration. The fifth section outlines how future research can continue to build upon the findings of this dissertation in order to further develop the multi-level integration documented in this study.

Summary of Research Findings

Research Question One

Is distributional concentration and developmental stability of violent crime incidents observed at street segments, neighborhood clusters, and community areas in Chicago?

The analyses conducted in this dissertation found violent crime incidents are concentrated at each of these three units of analysis in Chicago. From 2001 to 2014 between 5-7% of street segments accounted for 50% of violent crime incidents while between 18-23% of neighborhood clusters and community areas accounted for 50% of incidents. Each year over the study's observation period almost every neighborhood cluster and community area experienced one or more violent crime incidents while between only 23-36% of street segments experienced one or more incidents. The findings of this dissertation support one of the core tenets of crime and place research that regardless of the unit of analysis assessed crime is concentrated at places (Shaw and McKay, 1942; Sherman et al., 1989, Weisburd et al., 2012). The dissertation findings also begin to demonstrate how the use of micro-places can offer a more detailed comprehension of the spatial distribution of crime within cities relative to neighborhoods. The greatest concentration of incidents was observed at street segments in Chicago.

The concentration of violence at street segments in Chicago does appear to be less pronounced compared to other larger cities in the United States. Weisburd (2015) finds across five large cities in the United States (e.g. +300,000 population) between 4-6% of street segments captured 50% of *total* crime incidents in these locations. The observation of 50% of *violent* crime incidents captured by 5-7% of street segments indicates an even larger number of locations would likely represent total crime incidents for this 50% threshold since these events occur much more frequently in cities. For example, in

Seattle over 14 years (1989-2002) 77.5% of street segments experienced a total crime incident while in Chicago over 14 years (2001-2014) 75% experienced a violent crime. In Boston over 29 years (1980-2008) 47.5% of street segments and intersections had a robbery incident occur at that location while in Chicago over 14 years 64.9% of street segments had a robbery incident occur.

Street segments in Chicago were characterized by overwhelmingly stable developmental patterns of violent crime incidents starting in 2001 and ending in 2014. Over 97% of street segments were identified as having consistency in the number of incidents occurring at these locations throughout each year of the observation period using GBTM. This finding indicates persistence in the influence of the same violence hot-spots in the city year-in and year-out. Seven percent of these high violence locations represented forty-two percent of the violent crime incidents from 2001-2014. The city-wide reduction of over 50% of incidents was heavily influenced by the 3% of street segments that were characterized as having decreasing developmental patterns of violence.

Neighborhood clusters were not characterized by developmental stability of violence patterns over time; instead each of these locations was identified as having a moderately decreasing pattern.[2] Since the proportion of the decrease was similar across all neighborhood cluster developmental groups the locations that were "low crime" (i.e. group 1) and "high crime" (i.e. group 5) in 2001 remained the same each year until 2014. While this differs from street segments both of these units of analysis were summarized by homogeneity in the description of violence patterns over time (i.e. almost all locations

[2] To restate, developmental patterns of violence at community areas were not assessed with GBTM because there were not enough units of analysis. Preliminary evidence does support the general finding of stability in patterns across community areas over time.

had one type of pattern whether stable or decreasing). Griffiths and Chavez (2004) found three developmental patterns of homicide incidents at census tracts in Chicago from 1980-1995. The highest activity group (i.e. 6% of tracts) did follow a similar development pattern to the city-wide homicide trend over the observation period. The moderate activity group (i.e. 40% of tracts) approximated the trend and the low activity group (i.e. 54% of tracts) did not because these tracts experienced such a low number of incidents. This study is the only other neighborhood-level analysis of crime trajectories using GBTM. Since it is difficult to compare findings to this study because of the different crime trends and units of analysis more research is clearly necessary to observe variation in developmental growth of crime patterns at neighborhoods.

The observation of uniform developmental stability observed at street segments and uniform developmental decreases at neighborhood clusters offers two seemingly divergent portraits of how to understand crime patterns within cities. When using street segments the city-wide reduction in violence can be considered as being influenced by a handful of locations in addition to small, unobservable reductions in incidents at these micro-places that do not become noticeable until each of the patterns are aggregated to the neighborhood-level.[3] When using neighborhood clusters the city-wide reduction was evenly distributed across each of the developmental groups which were characterized by decreasing developmental patterns of incidents. The reduction in incidents from 2001 to 2014 across each of the five groups was relatively consistent ranging between 47-58%. The city-wide reduction in violent crime incidents was 52.2%.

[3] A reexamination of the fitted slopes for each of the street segment developmental groups labeled as "stable" revealed these locations were not even close to the threshold specified by Weisburd et al. (2004) for labeling as decreasing patterns. This indicates the problem is much more complex than simply modifying the labeling procedure.

The neighborhood cluster patterns appear to closely follow the decreasing city-wide violence trend over the observation period. When further examined the divergent developmental patterns of these units of analysis do offer a coherent narrative. The reduction in the number of violent crimes in Chicago over 14 years was primarily a manifestation of decreases occurring across the entire city at these micro- and meso-units of analysis. This is observable at neighborhood clusters since all units were characterized by decreasing developmental patterns but not at street segments with the exception of a few locations which experienced inordinately high reductions in incidents. The spatial disaggregation of the units of analysis down to the micro-level resulted in the city-wide reduction of incidents to become unobservable. Braga and colleagues (2011) in Boston found all developmental groups of robbery incidents at street units did capture the city-wide reduction in incidents over the period of their study. Weisburd and colleagues (2004) found greater variability in developmental patterns of total crime incidents at street segments in Seattle over a period of non-linear growth in the city's crime trend (e.g. increased briefly, then decreased from 1989-2002).[4] The comparison of street segment to neighborhood cluster developmental patterns provides an important tool to continue to demonstrate how spatial aggregation influences the description of crime patterns in cities.

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[4] The differences in findings between the Seattle and Boston analysis could be the byproduct of using different statistical techniques to modeling longitudinal patterns of crime at place (i.e. GBTM vs. growth curve).

Research Question Two

How much of the total spatial variability of violent crime incidents can be uniquely attributed to street segments, neighborhood clusters, and community areas in Chicago?

The analyses conducted in this dissertation found several important observations about the hierarchical nesting of violence patterns at micro-places within neighborhoods. General developmental homogeneity of violent crime patterns at street segments was observed in low crime neighborhood clusters while developmental heterogeneity of street segment patterns was noted within high violence neighborhood clusters. In the lowest violence neighborhood clusters 64.7% of street segments experienced crime free patterns, 34.9% low or moderate stable, and finally less than 1% had high crime patterns. A majority of micro-places in these neighborhood clusters are summarized by a single developmental pattern. In the highest violence neighborhood clusters a more balanced composition of all developmental patterns was observed: 25.0% were crime free, 26.8% low stable, 32.5% moderate stable, and 15.7% high stable or decreasing.

While violence is concentrated at micro-places in Chicago there also appears to be spatial diffusion of high violence patterns at street segments throughout the city. Street segments with high stable or decreasing patterns of violence were found nested within 73.1% of neighborhood clusters and 89.5% of community areas in Chicago suggesting the "hot spots" were not just isolated in the west and south sides of the city (see Sherman et al., 1989; Weisburd et al., 2012). Observing the nested patterns of developmental trajectories also reinforced an organizing principle from the criminology of place that smaller units of analysis capture a degree of spatial variability in crime patterns that is undoubtedly missed when using larger units of analysis (Groff et al., 2010; Andresen and Malleson, 2011).

Using a similar research methodology this dissertation was able to successfully replicate Steenbeek and Weisburd's (2016) findings on the spatial variability of crime patterns in Chicago. In The Hague, Netherlands where these authors conducted their study, the "micro" unit of analysis captured 58-69% of the total spatial variability from 2001-2009, the "meso" unit of analysis 5-7%, and the "macro" 24-38%. In Chicago, the micro-unit of analysis represented 56-65% of the total spatial variability from 2001-2014, the meso-unit of analysis 13-18%, and the macro-unit of analysis 21-26%. While the values at meso- and macro-units are mildly different in Chicago, the general observation that micro-units account for more spatial variability is confirmed. This modest divergence in findings could be the result of the different sizes of these units of analysis in Chicago relative to The Hague. At the only spatial level where the same unit of analysis was used (i.e. micro-level = street segments), the findings were almost identical.

In Chicago and The Hague the total spatial variability accounted for by micro-units of analysis increased over time. These findings support the recent scholarly focus on micro-units of analysis because they offer the most refined description of the spatial variability of crime patterns within cities. Neighborhoods, specifically the macro-representation of these units of analysis, still retain importance in description of the spatial variability of crime patterns in cities. These units of analysis can potentially be re-conceptualized as domains to consider the clustering of hot-spots or micro-patterns of crime. Based on the findings from this dissertation, multi-level analyses should be considered to begin to explain the spatial variability of crime patterns within cities. The available empirical evidence confirms that a noticeable contribution comes from both micro-places and neighborhoods.

Research Question Three

Do opportunity measures at street segments explain differences between levels of violent crime incidents at street segments when accounting for social disorganization measures at neighborhood clusters in Chicago?

The analyses conducted in this dissertation provided several demonstrations of a strong connection between criminal opportunity at street segments and social disorganization at neighborhoods in explaining patterns of violence in Chicago. A bivariate link was found between neighborhood levels of concentrated disadvantage and collective efficacy to violence patterns at street segments. Increases in the level of concentrated disadvantage at neighborhood clusters coincided with decreases in the number of street segments with crime free patterns nested in these locations. Decreases in the level of collective efficacy at neighborhood clusters were connected to increases in the number of street segments with high stable patterns nested in these locations.

Criminal opportunity measures were identified as statistically significant predictors to explain variation in the count of violent crime incidents at street segments from 2012-2014 even while accounting for the hierarchical influence of social disorganization and neighborhood clustering. Each of the 12 criminal opportunity variables offered a statistically significant fixed effect across multiple generalized linear mixed models. Four of the five social disorganization variables yielded statistically significant predictors of violence across each model. Collective efficacy was the only social disorganization variable to not retain statistical significance across all models. It is important to note here again the collective efficacy and network ties variables were collected 15 years earlier than the dependent variable. As such, it was noteworthy to observe the partial influence of the collective efficacy variable and significant influence of the network ties variable to predict violence at street segments in a much later time period. The inclusion of a neighborhood cluster spatial lag coincided with the collective efficacy measure losing its statistical significance. No a priori theoretical rationale exists to understand why this happened. The most likely explanation is the size of the fixed effect for collective efficacy variable, which was only marginally significance at a *p*-value of <.05, was reduced enough by the inclusion of the robust spatial lag measure to influence the *p*-value. These analyses provided an answer to the research question but several additional analyses were conducted to examine other germane issues pertaining to this integration.

Additional random effects and cross-level interactions were explored in separate models to determine if criminal opportunity variables functioned differently depending on the neighborhood cluster they were nested within. Both sets of models confirmed that a handful of criminal opportunity variables – such as physical disorder, train stations, and facilities with alcohol – do indeed have a disparate influence on violence at street segments depending on the neighborhood cluster they are nested within. Group-based trajectory models were estimated to offer a more theoretically grounded representation of neighborhood effects to determine their influence on criminal opportunity at micro-places. This analysis uncovered the statistical significance of criminal opportunity predictors of violence at street segments generally did not change between classes of neighborhoods but instead the magnitude of their effect did fluctuate noticeably. Criminal opportunity variables exhibited their largest influence on explaining variation between levels of violence at street segments in neighborhood clusters with low levels of violence and concentrated disadvantage.[5]

The findings from these analyses offered more clarity to the results of the hierarchical model estimated in research question two. While the size of the contribution of each set of measures cannot be compared in a similar capacity to the question three analysis, the robustness of the statistical significance of opportunity predictors across neighborhood clusters could indicate a potentially larger contribution of these variables relative to social disorganization measures in explaining crime variation in Chicago. The key finding of the hierarchical analysis in research question two is the importance of both units of analysis but also a larger contribution by street segments. These results express a comparable idea, both theories offer helpful explanations but a potentially larger contribution is provided by criminal opportunity theories. Proceeding with caution is crucial here because a more extensive and nuanced set of measures was used to capture opportunity variables relative to social disorganization variables. This discussion is continued in the limitations section of this chapter. Overall, the analyses in this dissertation do confirm both social disorganization and criminal opportunity theories are essential to understanding the spatial distribution of crime within cities. Using both can offer an enhanced understanding of crime variability within cities.

Theoretical Implications

This dissertation research focused on the integration of two units of analysis and the two theoretical mechanisms commonly associated with these spatial units to

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[5] A similar finding was also observed in an analysis in Chapter 7 which noted criminal opportunity variables offered the greatest influence when comparing crime free to high violence street segments opposed to comparing crime free to low violence segments.

understand the variability of violence in Chicago. The observation of unique spatial variability captured at both micro-places and neighborhoods provides clear support for the continued use of multi-level models to explain crime patterns within cities. A false dichotomy is created when place-based scholars seemingly must select between micro-places or neighborhoods as the primary unit of analysis to study. Micro-places are associated with the largest share of the total spatial variability, providing partial support for the idea that "small is better" in descriptive place-based criminology analyses (see Oberwittler and Wikstrom, 2009). Crucial insight can still be gained from understanding how patterns of crime at micro-places are clustered within neighborhoods.[6] The exploration of theoretical mechanisms linked with both spatial levels can facilitate a more comprehensive explanation of crime variability within cities.

The next generation of empirical inquiries on the spatial variability of crime within cities should seek to both identify and differentiate links between theoretical processes operating at different geographic levels. A central point made by neighborhood effects research is that geographic social aggregations have meaning – there are processes, structures, institutions, cultures, and networks that powerfully shape social outcomes in larger areas. Institutions, for example, can be physically located on a single

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[6] Recently, both micro- and neighborhood-based analyses have used a "spatial lag" measure to provide a statistical control for the influence of the dependent variable at bordering spatial areas on the unit of analysis of interest (see Morenoff et al., 2001; Weisburd et al., 2012). These measures are routinely identified as statistically significant predictors of the dependent variable at the unit of analysis of interest. Research question two can be interpreted as presenting general confirmation of this idea by identifying unique spatial variability across different levels of spatial aggregation in Chicago. Spatial lag variables are limited because they are quasi-hierarchical representations of place. These measures are problematic because they represent an inelegant amalgam of the unit of analysis; this process creates a new spatial unit that often ignores the organization of even larger spatial boundaries within cities. For example, if the analyses in this research used a spatial lag for neighborhood clusters (i.e. all bordering neighborhood clusters) it would likely not adhere to community area boundaries. Using a multi-level framework can provide greater insight on the influence of spatial lag measures because more attention is focused on specification of the units of analysis where this variable is measured (e.g. in this dissertation, neighborhood clusters captured the spatial lag for street segments).

street segment but their influence on social outcomes can extend to much larger geographic areas. Hunter (1985) suggested three levels of informal social control within neighborhoods. The private level of control was grounded in intimate primary groups such as family and friends. The parochial level referred to relationships among neighbors and was rooted in broader local networks and institutions such as businesses, schools and churches. The public level focused on the ability of the community to secure goods and services from sources outside the neighborhood such as city and police departments. Hunter (1985) argued that effective control in neighborhoods requires agents at all three levels to work together. Inadequate social control at any level could influence criminal behavior at specific places within neighborhoods.

Further empirical tests should be pursued to understand the criminological theories that could explain crime variation at each level of analysis and provide additional guidance on how varying theories could be integrated given the multi-level nature of crime concentration patterns. The influence of street segments in explaining the spatial variation of violence in Chicago while controlling for the neighborhood effect of social disorganization suggests that criminologists should pursue a multi-level integration to develop a more comprehensive understanding of the ecology of places in cities (see Brantingham and Brantingham, 1993; Meier and Miethe, 1994; Deryol et al., 2016). Community structures give rise to criminal opportunities at specific places within particular communities (Clarke, 1995) suggesting an inherently multi-level theoretical structure to ecological explanations of crime (see Wilcox and Land, 2015). Even before discussing the influence of criminal opportunity variables on crime between neighborhoods it is imperative to first highlight how these locations influence the underlying distribution of opportunity.

The findings of this dissertation demonstrate a noticeable relationship between neighborhood context and the distribution of opportunity variables. As suggested by Eck et al. (2007), not only does crime concentrate at places within cities but criminal opportunity does as well. In Chicago, only 6.2% of street segments in low violence neighborhood clusters were claimed as gang territory while 52.8% of street segments in high violence neighborhood clusters were either partially or completely located in gang territory. This relationship is not surprising although this difference would not be accounted for without the use of a multi-level framework to consider this theoretical integration. This provides an intuitive indication of how these two theories are linked; neighborhoods influence the distribution of crime opportunities (see Clarke, 1995).

Social disorganization and opportunity theories partially overlap in their treatment of social control as a key element in crime occurrences. In addition, Rice and Smith (2002) show how combining routine activity and social disorganization theories greatly improves the predictive power of spatial analyses to explain variations in auto theft incidents at block faces in a mid-sized southeastern U.S. city. In their examination of crime at street segments over a 16-year period in Seattle, Weisburd et al. (2012) build upon these studies not only to refine and strengthen the previous observations, but to propose an explanation for the observed crime concentrations, which integrates concepts from social disorganization and opportunity theories of crime. By comparing persistently hot street segments with very low / no crime street segments, they found that variables supporting both opportunity and social disorganization theories of crime were associated with chronic high crime streets.

However, the proper domain to apply key theoretical concepts to understand variation of crime across and within neighborhoods still needs to be unraveled through ongoing empirical research. For instance, Weisburd et al. (2012) suggest that the level of "collective efficacy" on a street segment was associated with the amount of crime that occurs on that street segment. Braga and Clarke (2014) recently questioned whether the community-level concept of collective efficacy could adequately explain why a particular crime spot is persistently hot over time. They suggested that opportunity theory concepts such as guardianship best characterized levels of informal social control at street segments. Sampson (2013) also cautioned that smaller units, such as hot spots, are not necessarily better than larger units in understanding neighborhood social processes and figuring out how to mobilize collective efficacy. Sampson (2013) observes that micro places and conventional neighborhoods are nested within larger communities that are recognized or named by residents, external housing buyers, institutional actors such as real estate agents, and administrative agencies such as the police. Whether collective efficacy is best understood at the community level, street segment level, or both remains an open empirical question. Nevertheless, it is time for criminologists to begin developing some much needed new knowledge on how different theoretical perspectives may or may not fit across different levels of analysis in place-based crime research.

Even without fully resolving these issues there are clear steps forward for research that can be offered. The concept of the "environmental backcloth" has been used by micro and opportunity-based analyses to represent "the broader and complex physical, cultural, and social features of the area in which a location is situated" (Deryol et al., 2016, p.306; Brantingham and Brantingham, 1993; Wilcox and Eck, 2011). Brantingham and Brantingham's (1993, 1999) establishment of this concept is important for this integration because it provides a conceptualization to consider how larger scale ecological effects influence criminal opportunity. A limitation of the operational representation of the environmental backcloth is that an atheoretical collection of measures are commonly used to measure this concept (see Johnson et al., 2009; Deryol et al., 2016; Mallesen and Andresen, 2016).

A relatively straightforward solution to this problem would be to use a social disorganization or neighborhood effects models to provide both a theoretically coherent collection of measures and also further assist the integration of these two theories. This is the guiding logic of the framework used for this dissertations theoretical integration. In contrast to Taylor's (2015) proposal of a new, integrated ecological model to link social disorganization and opportunity concepts this approach combines two pre-existing components that already fit together remarkably well. Equating the environmental backcloth with a social disorganization model also embraces Hunter's (1985) formulation of multiple levels of control. This suggests place-based scholars would not have to differentiate between guardianship and collective efficacy as the optimal representation of informal social control since both can coexist on different spatial levels. The former being a more specific mechanism of control at small places and the latter a general mechanism of control over larger places.

The variation of the effect of crime opportunity variables between neighborhoods should also be further explored. This dissertation found noticeable differences in the size of the effect, not the statistical significance, of criminal opportunity variables between developmental groups of neighborhood clusters. For example, street segments with commercial facilities on these locations (i.e. “land use” variable) were observed to be more violent in neighborhood clusters with low stable developmental patterns of concentrated disadvantage compared to neighborhood clusters with high stable developmental patterns.

Several possible explanations exist to understand this finding. Routine activities theory provides a helpful tool to consider these explanations (also see Clarke, 1995). The distribution of criminal opportunity is potentially more plentiful and even across neighborhoods with high violence/concentrated disadvantage resulting in more locations where the three prerequisite conditions for crime can intersect. This in turn could marginally reduce the effect of these locations since more micro-places nested in these neighborhoods are influenced by the situational risk presented by these opportunities. The opposite would be true for the distribution of opportunity in low violence/concentrated disadvantage neighborhoods explaining why micro-situational risk of opportunity matters more (i.e. less opportunity/more concentration = greater influence at these places). Clearly much more research and detailed theoretical consideration can be provided to understand this relationship.

Crime opportunity theories posit that certain locations are criminogenic not because of one characteristic but the intersection of several which creates the conditions for crime to emerge (Cohen and Felson, 1979). For instance, all bars are not risky facilities. A bar becomes a risky facility because of several other characteristics (e.g. no bouncer, no lighting in parking lot, etc.). The modeling of opportunity theories could benefit by going beyond the simple, multivariate statistical control for these other characteristics and begin to explore the interaction and differences of influence across neighborhood contexts. The findings of this dissertation suggest this is necessary because important variation in the effect of opportunity is observed above and beyond the simple multivariate statistical control of these other characteristics.

Neighborhood conditions play a vital role in understanding the distribution of criminal opportunity and substantial insight could be lost by not accounting for the influence of these characteristics in the appropriate manner. Even simply controlling for neighborhood characteristics at level-2 is a helpful albeit still limited approach to address this variation (see Davies and Johnson, 2015; Deryol et al., 2016). Returning to the example, a bar is not just a risky facility because of several micro-opportunity characteristics but also because of the neighborhood or “environmental backcloth” of where it is located (e.g. attitudes towards violence, collective efficacy, etc.). While these ideas are not new within place-based criminology (see Brantingham and Brantingham, 1993), they have not been as rigorously tested as these theoretical considerations would truly warrant.

Policy Implications

There are several recommendations for criminal justice policy that can be presented based on the findings of this dissertation research. Criminal justice policymakers have increasingly considered place-based crime prevention strategies over the past decade because of promising empirical evidence demonstrating their effectiveness in reducing crime in urban areas (see Braga and Weisburd, 2010). Braga and colleagues (2014) find hot spots policing strategies are effective across several evaluations in reducing crime at small locations within cities. The concentration and stability of violent crime incidents at street segments in Chicago suggests focusing on these persistent problem areas can provide far reaching crime control benefits (Weisburd et al., 2012). The observation that street segments also accounted for the largest share of the total spatial variability identified in Chicago across 14 years further reinforces the salience of micro-places in responding to crime patterns in cities.

Focusing crime prevention strategies on high activity micro-places is a crucial first step to enhancing crime reduction efforts within cities although selecting the specific crime control response to these locations is of equal importance (see Groff et al., 2015). The significance of criminal opportunity variables in explaining variation in the number of violent crimes at street segments indicates these responses should address the underlying situational characteristics of these locations. Problem-oriented policing and situational crime prevention are two of the most empirically robust crime prevention strategies used to directly target these characteristics of small places to reduce the occurrence of crime events (Clarke, 1997; Guerette and Bowers, 2009; Weisburd et al., 2010). Both of these approaches present alternatives to simplistic increased enforcement responses, such as saturation patrol, at hot spots which have been linked to crime reductions but do not provide the most comprehensive solutions to addressing persistent problems at places (Braga and Weisburd, 2010; for further discussion also see Nagin, Solow, and Lum, 2015).

Problem-oriented policing addresses the underlying causes of crime events at small places through systematically developing responses to target these causes. The

SARA model offers a device police officers can use that has been readily adopted across several evaluations (Weisburd and Eck, 2004; Weisburd et al., 2010). The model suggest officers on patrol scan, analyze, respond, and assess (i.e. SARA) crime problems to develop appropriate solutions to reducing the conditions which lead to crime at these locations (Eck and Spelman, 1987). Situational crime prevention is a complementary strategy to problem-oriented policing that can be used by a broader range of stakeholders interested in crime control at micro-places (Clarke, 1985; 1997; Guerette and Bowers, 2009).

Situational crime prevention is linked with routine activities theory by emphasizing that guardianship of places does not have to be provided strictly by formal sources of social control (i.e. the police). Instead guardianship is presented by informal agents of social control that can already be found at small places such as landlords at apartments or clerks at stores. For example, Mazerolle and colleagues (1998) found these "place mangers" in Oakland, CA had a significant effect on reducing the amount of drug and disorder problems on street blocks. The criminal justice policy recommendation to focus on crime hot spots and use interventions which address root causes of the emergence of crime at these places has been discussed in detail alongside the development of the criminology of place (Eck and Weisburd, 1995; Braga and Weisburd, 2010; Weisburd et al., 2016).

One of the larger contributions of this dissertation research is documenting the role of neighborhoods and variation in the influence of criminal opportunity between these locations in understanding crime patterns within cities. Both neighborhood clusters and community areas captured a modest share of the total spatial variability of violent crime patterns in Chicago. Social disorganization and neighborhood effects also played an integral role in influencing the effect of criminal opportunity predictors between disparate neighborhood contexts. The policy implications of these finding are worth discussion and offer a small caveat to the recent proliferation of hot-spots policing strategies. Crime prevention strategies should also consider interventions that emphasize community building and stimulate citizen involvement (see Braga and Weisburd, 2010). A myopic focus on hot-spots and the situational characteristics which foster the emergence of crime at these locations ignores the broader neighborhood context in which these events occur. The findings of this dissertation suggest both neighborhoods and social disorganization still play a key part in description and explanation of crime patterns in urban areas. Several crime prevention strategies do offer either responses or foundational ideas that can be applied to begin to address these larger scale social conditions within cities.

Community-based crime preventions strategies emphasize investment in the physical and social infrastructure of neighborhoods in addition to establishing a shared set of values among residents (Bursik and Grasmick, 1993; Kahan and Meares, 1998; Braga and Weisburd, 2010). This model of crime prevention is founded on the idea that neighborhood residents and police departments are co-producers of public safety (Taylor, 2001). The contemporary development of collective efficacy theory has informed how neighborhood residents can exert influence over levels of crime in neighborhoods (Sampson et al., 1997; Sampson, 2006). Sampson (2011) discusses several ways to bolster collective efficacy within communities including: supervision of youth leisure time activities, monitoring street corners in high crime areas, staggering school closing times, parent involvement in after-school/nighttime youth programs, and mentoring. Community residents can also be involved prior to and during the implementation of crime preventions strategies to offer their input on the effect of these interventions on their community (see McGarrell et al., 2001). There are several other approaches that can be used to strengthen police-community relationships through stimulating citizen involvement (see Rosenbaum, 1994; Kennedy et al., 2001; Meares and Brown-Corkran, 2007).

Community-oriented policing is one of the most widely advocated and discussed innovations in policing during the late 20th century (Greene and Mastrofski, 1988; Skogan, 2006; Gill et al., 2014). These approaches emphasize tactics such as foot patrol, decentralization, and engagement of citizens to begin to repair law enforcements relationship with communities (Skogan, 2006a). Crime can be reduced in communities using these strategies through the stimulation of citizen involvement which enhances informal social control at these locations in addition to the adoption of problem-solving partnerships with residents. Evaluations of community-oriented policing indicate problem-solving strategies are associated with the largest crime reductions which further reinforces the recommendation that targeting criminal opportunities in communities can control crime (Braga and Weisburd, 2010). Less empirical evidence exists on the effectiveness of community engagement strategies but these techniques do represent a promising approach to building collective efficacy in communities.

A systematic review of the available program evaluation evidence suggests that community-oriented policing strategies do not uniformly reduce crime although they do appear to provide a consistent positive influence on citizen’s perceptions of police legitimacy (Gill et al., 2014). Community-oriented policing has already been implemented in Chicago with reductions in crime and fear of crime in disadvantaged neighborhoods reported (Skogan and Hartnett, 1997). The diffusion of community-oriented policing practices over the past few decades to police departments nationally has been characterized by the shallow adoption of these principles (Mastrofski, 2006; Sparrow, 2016). Regardless of the success of these strategies adoption the fundamental ideology of community-oriented policing still positions it as one of the most well suited crime prevention strategies to begin to address certain key neighborhood conditions which facilitate criminogenic environments.

Due to the recent number of high profile cases in which police officers across the country have killed unarmed minority citizens the legitimacy and procedural fairness of policing practices is one of the most controversial topics in contemporary public discourse on criminal justice reform. Neighborhood constructs such as legal cynicism provide well established measures to capture these attitudes of large groups of residents within cities (see Kirk and Papachristos, 2011, 2015). Neighborhood or community-based crime prevention strategies, despite mixed evidence of their effect on crime, can undoubtedly provide much needed support to enhancing these attitudes towards the police. These approaches can present a small but necessary first step to facilitate conditions that enable the rebuilding of communities in disadvantaged urban areas through demonstrating the support of the criminal justice system and social service providers to this mission (see Braga, 2015; Kennedy, 2011).

Social networks provide another neighborhood-level concept that can be used by criminal justice practitioners to address the broader ecological conditions of crime at places within cities. Social ties are integral to comprehending the informal organization of communities (Kasarda and Janowitz, 1974) and serve as a key intermediating mechanism of structural characteristics in contemporary models of social disorganization (Sampson and Groves, 1989). Social networks have even recently been applied to understand how group ties can increase exposure to violence in cities (Papachristos et al., 2015). Focused deterrence strategies offer a template to understand how targeting the social networks of individuals and groups that are responsible for disproportionate amounts of crime within cities can be effectively leveraged for crime control purposes (Kennedy et al., 2001; Braga and Weisburd, 2012; Braga, Apel, and Welsh, 2013).

These strategies help demonstrate how micro and neighborhood conditions are linked and can be targeted with city resources to reduce crime in urban areas. For example, gang territory can cover small or large areas within cities (i.e. micro-places and/or neighborhoods) but the organization of the group's social network can provide insight into the influence of certain individuals and how potential conflicts with other groups can arise across these spatial boundaries. The effectiveness of crime prevention strategies can potentially be improved by focusing not only on place but also on how the disruption of the social networks of gangs and fostering of residents social ties that interact with these places can be used to reduce crime within cities. The role of social networks has been well documented in theoretical discussion of crime and place but more research needs to occur to understand how crime prevention strategies can address these networks to reduce crime.

Limitations

Like other studies, this dissertation research has some limitations that pertain to the availability of data in Chicago.[7] Due to these limitations, this study was explicitly designed as an exploratory investigation of a multi-level integration of units of analysis and theories from the two predominant literatures considered to understand the spatial distribution of crime within cities. Both units of analysis could be successfully integrated but unfortunately a full test of the integration of the two theories could not be conducted. This informed the decision to label the study as exploratory instead of a fully specified test of multi-level integration. Both operational representations of social disorganization and criminal opportunity theories faced challenges because of the selection of available variables to investigate. Social disorganization variables in particular were the most influenced by data availability concerns.

In order to specify a complete social disorganization model both structural and organizational neighborhood characteristics were required. Structural characteristics are primarily measured by the U.S. Census and as a result, much easier to collect. Organizational characteristics must be gathered independently which creates several data challenges. Instead of ignoring this essential component of the social disorganization model (see Shaw and McKay, 1942; Robinson, 1950) PHDCN measures were used to measure neighborhood organizational characteristics. As previously discussed, this raised several temporal issues due to the collection of these variables 15 years earlier than the primary dependent variable for research question three. Thankfully, supplemental analyses were able to confirm one of the key assumptions of social disorganization theory

[7] Several other minor limitations were addressed throughout discussions of the research methodology in Chapters 4 & 5. These limitations are not returned to for further discussion in this section.

that neighborhood characteristics are generally stable over extended periods of time (see Bursik and Webb, 1982; Bursik and Grasmick, 1993; Sampson, 2012).

This partially mitigates the inherent limitations of using a variable measured 15 years prior to the other neighborhood-level characteristics since it can be assumed values are relatively consistent over time. However, observed stability of neighborhood characteristics does not fully mitigate this limitation because it still presents a concerning temporal misalignment between the structural and organization neighborhood characteristics. Several other empirically robust neighborhood measures such as immigrant concentration and legal cynicism were not included in this analysis due to their role being currently redefined in social disorganization models (Martinez et al., 2010; Kirk and Papachristos, 2015). Immigrant concentration in particular was also excluded because the U.S. Census has recently altered how data is collected for several questions that are instrumental to creating this factor score which made it difficult to compare values over time.[8]

Using structural and organizational characteristics offered the most parsimonious neighborhood model. The omission of these additional variables and the temporal mismatch of the variables that were included resulted in the limited social disorganization model used in research question three. Several different conceptual representations of social disorganization theory and neighborhood effects are considered across studies which suggests that striving to use a single, definitive model is impossible because one does not exist (Sampson, 2013; Brunsima et al., 2013). No unified model of criminal opportunity theories exists either suggesting this issue impacts other ecological

[8] These differences were discussed in Chapter 4.

orientations as well (Brantingham and Brantingham, 1991; Eck and Weisburd, 1995; Hipp, 2016).

The criminal opportunity model presented in research question three was more comprehensive and included a larger number of total variables. Still several other opportunity variables were not included that could have improved the quality of this analysis. Since this dissertation research used secondary data a handful of variables could not be accessed. Certain key variables could have possibly been collected through a partnership with the Chicago Police Department. The residences of arrestees (i.e. motivated offender) and locations of CCTV's (i.e. guardianship) are two examples of variables that could likely have been obtained by a researcher with a closer relationship to the CPD. These limitations could have strengthened the *Routine Activities* category of opportunity variables.

Since a city-wide analysis was conducted this also limited the number of variables that could be considered. Certain place-based analyses are forced to make a decision regarding whether a more nuanced set of measures is collected for a smaller number of places (e.g. Grossman, 2016) or a comparatively less nuanced set of measures is used for a city-wide analysis of a much greater number of places (e.g. Weisburd et al., 2012). This dissertation's primary theoretical goal was to explore the relationship of criminal opportunity measures generally between neighborhoods across Chicago; as such, certain salient variables could not be investigated in much depth. For instance, contemporary research on criminal opportunity often will probe the influence of highly specific facilities or place characteristics on crime events (Griffiths and Tita, 2009; Groff and Lockwood, 2014; Piza et al., 2016). This dissertation instead considered general categories such as “land use” or “facilities with alcohol”. The available empirical evidence suggests that opportunity characteristics within these sub-categories of broad conceptual variables would likely influence crime variation if tested.

Future Research

Future research should attempt to address the limitations of this study by specifying a more detailed and comprehensive multi-level integration of the two core ecological theories examined here. Ruth Kornhauser’s (1978) *Social Sources of Delinquency* revitalized neighborhoods and crime research because it reformulated the social disorganization model (see Cullen et al., 2015). The integration of social disorganization and opportunity theories cannot proceed without directly addressing the remaining conceptual and operational issues that obscure their consideration together as a single ecological theory (see Stark, 1987; Braga and Clarke, 2014; Weisburd et al., 2014). While it is unrealistic to forecast that a single book or study on this topic would carry the influence of *Social Sources of Delinquency*, a similar detailed investigation should be conducted. Most of the theoretical support for this integration is discussed only in literature reviews of journal articles or book chapters. Kornhauser meticulously deconstructed several theories while highlighting their key assumptions and limitations throughout an entire book. A similar effort could help to clarify the important issues that remain for this integration. Ralph Taylor’s 2015 *Community Criminology* undertakes such a project. His book exhaustively outlines an ecological model which considers multiple levels of spatial aggregation and theoretical integration.

Today, several types of studies can be conducted to offer further empirical support to this integration and also assist in resolving key issues. The law of crime concentration can continue to be tested in different jurisdictions to reinforce its strength (Weisburd, 2015; see Braga et al. 2017). The influence of different units of analysis in description and explanation of the spatial variability of crime patterns at places can continue to be tested. Steenbeek and Weisburd's (2016) study provided a template to conduct these descriptive analyses. A similar research methodology can be applied to different spatial levels or units of analysis to continue to explore the role of spatial aggregation (see O'Brien and Winship, 2016). Hipp's (2007) study on the influence of ecological predictors at different spatial levels can also provide a guide to determine the optimal representation of certain measures in this integration. Johnson and Bowers (2015) in addition to Deryol et al., (2016) offer examples to further test the multi-level integration of these two theories. The analyses provided in this dissertation to capture the effect of opportunity between neighborhoods also can be expanded upon to continue to advance understanding of how these variables operate in different neighborhood contexts.

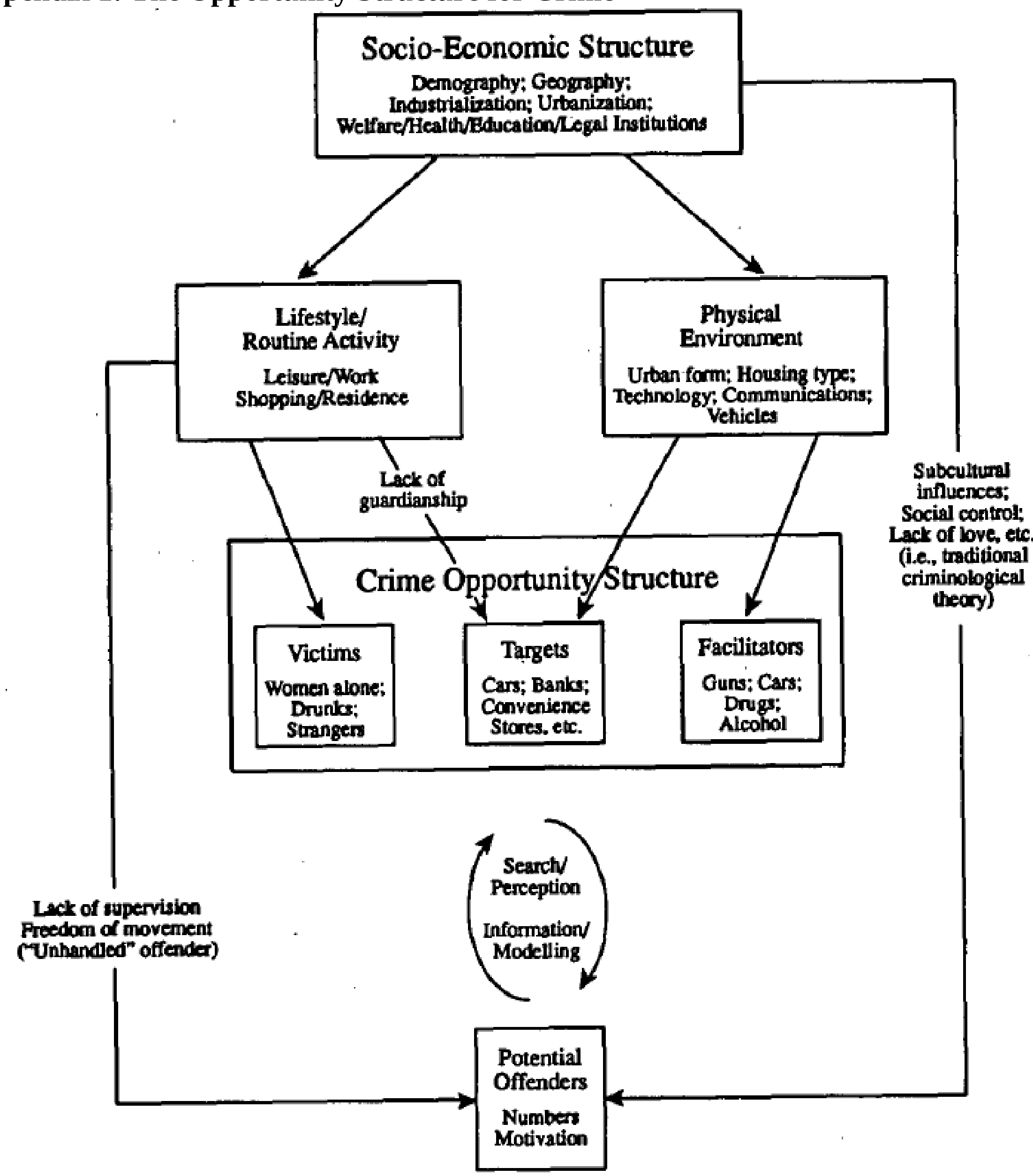
Thomas Kuhn (1962) noted that the potential for shifting paradigms in science rested, in part, on the ability of a specific scientific sub-community to gather human resources to act as a vanguard for a new way of thinking or doing science. Revolutionary ideas and new theoretical perspectives cannot move forward if converts are not drawn to the cause. As suggested by Laub (2004), the "life course" of criminology can be characterized by specific turning points that change how the field understands and responds to crime. Weisburd (2015) argues that it is time for another turning point in criminology and points to a relatively small but growing sub-community of scholars researching the criminology of place as showing great promise for advancing criminology as a science and improving its relevance for policy. This dissertation, highlighting the importance of micro places in understanding crime variation across Chicago – the Mecca of neighborhood effects research, strongly supports his call for more scholars to study the criminology of place and theoretical integration of ecological theories.

Conclusion

Over the past century two predominant ecological orientations have emerged to understand crime variation within cities. While preliminary efforts have been made to integrate concepts from each research tradition more empirical evidence needs to be collected on this subject. In response this dissertation observed the concentration, stability, and total spatial variability of violent crime incidents at three nested spatial units of analysis in Chicago. The integration of criminal opportunity variables at micro-places and social disorganization variables at neighborhoods was then conducted to determine if each theory can together advance explanation of the spatial distribution of violence in Chicago.

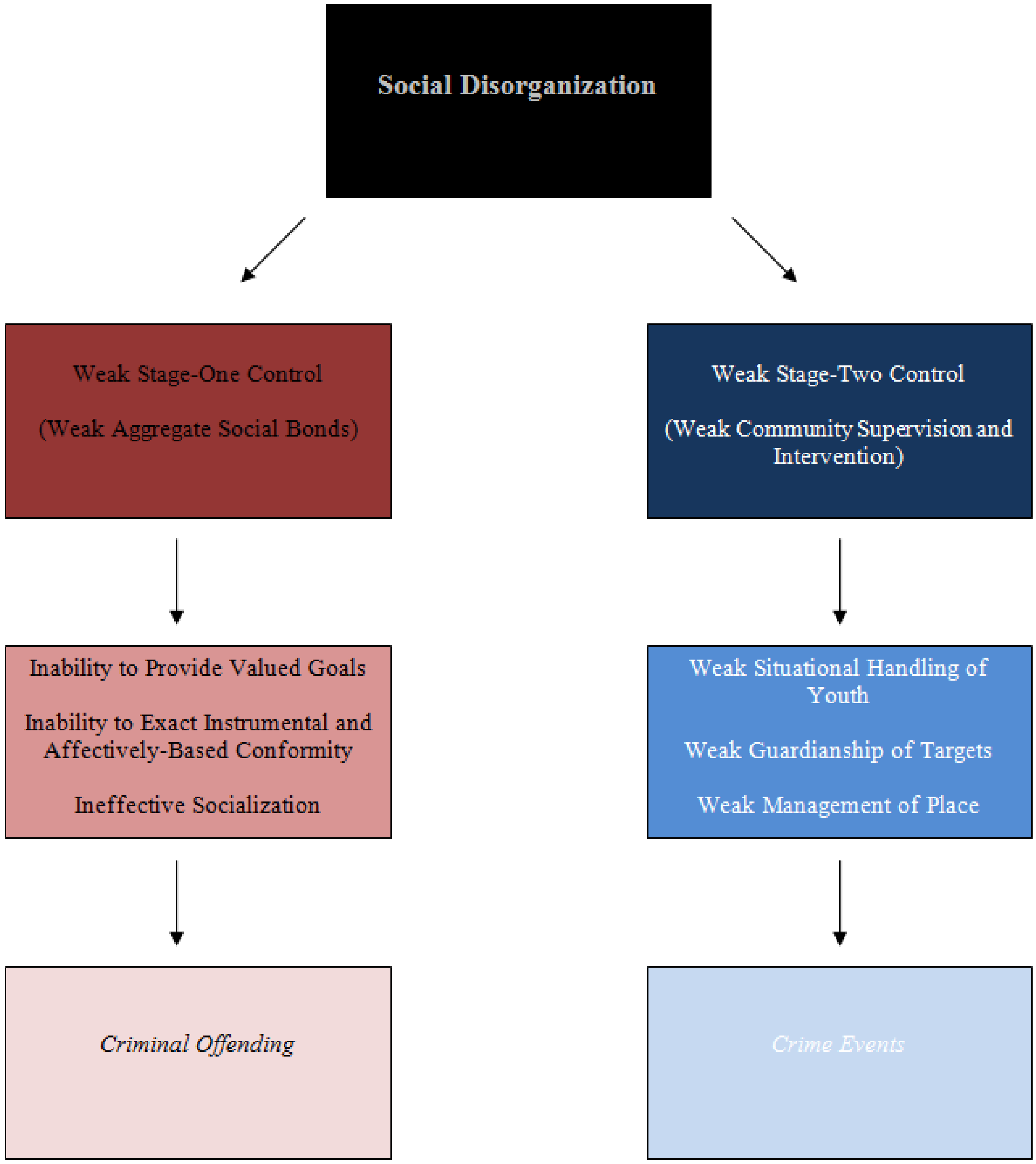
The findings from this dissertation research indicated a multi-level integration of these theories can indeed enhance understanding of crime variation within cities. While street segments accounted for the largest share of the total spatial variability in violence patterns, neighborhood clusters and community areas still represented a noticeable share of variability. The neighborhood effect of social disorganization also demonstrated an influence on criminal opportunity measures influence across different neighborhood contexts. Criminal opportunity measures exerted a more robust influence in predicting variations in violent crime at street segments in neighborhoods with low levels of social disorganization. In addition to the benefits for criminological theory these findings also have important implications for criminal justice policy. Crime prevention strategies should not ignore neighborhood context and focus strictly on controlling crime at hot spots using increased enforcement strategies. Instead, they should consider strategies which target criminal opportunity structures that span across micro-places and techniques which stimulate community building across broader spatial dimensions within cities.

Appendix 1: The Opportunity Structure for Crime



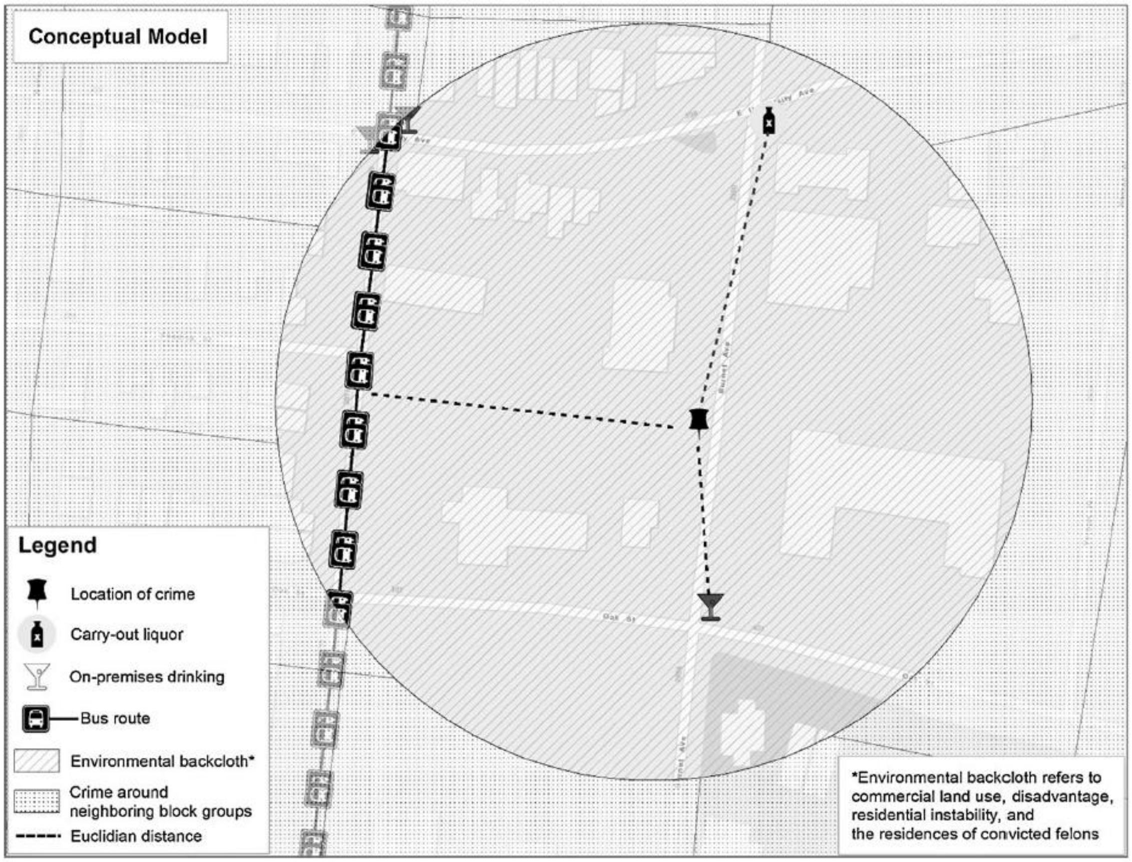
Source: Clarke, 1995

Appendix 2: Social Disorganization Theory of Criminal Offending and Crime Events



Source: adapted from Wilcox and Land, 2015; the authors cite *Crime and Everyday Life* (Felson and Eckert, 2015) as key reference in composing this model.

Appendix 3: Deryol et al.'s Multi-Level Conceptual Model of Brantingham and Brantingham's Theory of Crime Locations

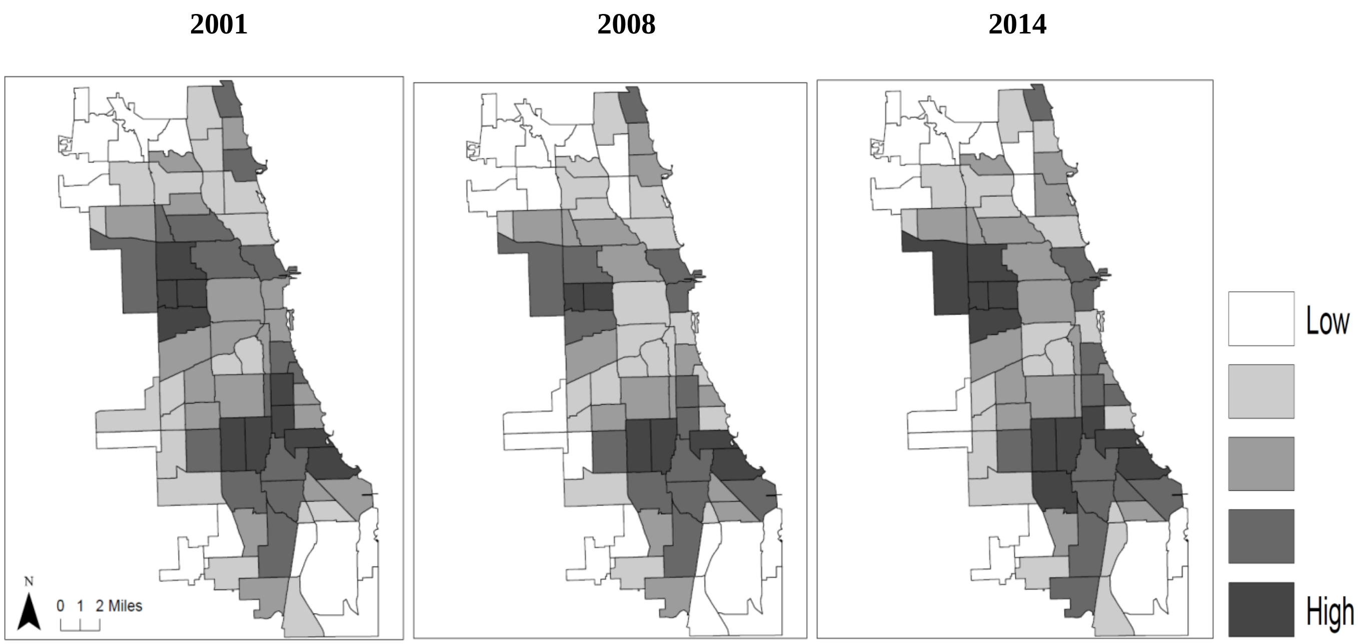


Source: Deryol et al., 2016; influenced by Brantingham and Brantingham (1993)

Appendix 4 PHDCN Measures Used to Create Collective Efficacy

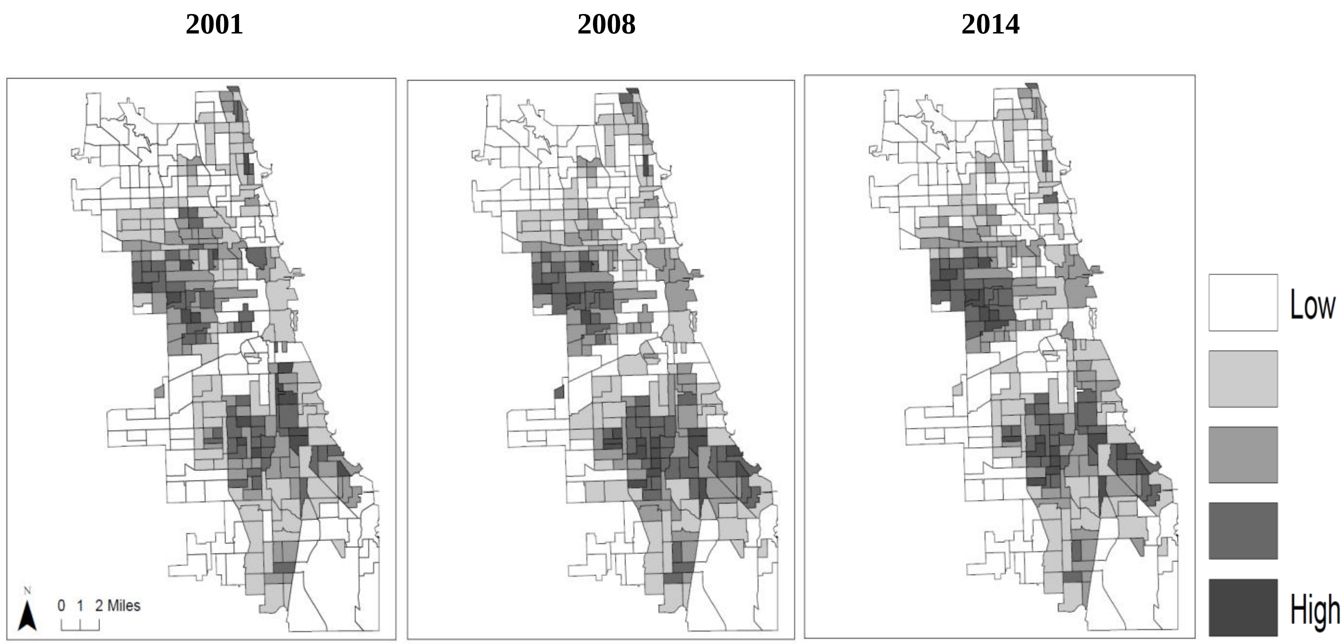
Variable #	Question
	Informal Social Control
1	Neighbors would intervene if children skip school and hang out on street corner
2	Neighborhoods would intervene if children spray-paint graffiti on a local building
3	People in the neighborhood would scold child if they disrespect adult
4	Neighbors would break up a fight in front of your house
5	Neighbors would organize to keep closest fire station open if it were to be closed down by city because of budget cuts
	Social Cohesion and Trust
6	How strongly do you feel this is a close-knit neighborhood
7	People in neighborhood are willing to help their neighbors
8	People in neighborhood generally don’t get along with each other
9	People in neighborhood don’t share same values
10	People in neighborhood can’t be trusted

Appendix 5. Violent Crime Rates (Count per Sq. Mile) in Chicago per Community Area (2001, 2008, 2014)



Note: Intervals are based on the Fisher-Jenks algorithm (Slocum et al., 2005); divided into five groups

Appendix 6. Violent Crime Rates (Count per Sq. Mile) in Chicago per Neighborhood Cluster (2001, 2008, 2014)



Note: Intervals are based on the Fisher-Jenks algorithm; divided into five groups

Appendix 7 The Distribution of Violent Crime Incidents at Street Segments Nested in Neighborhood Clusters Nested within Two Community Areas on the South Side of Chicago, 2001-2014

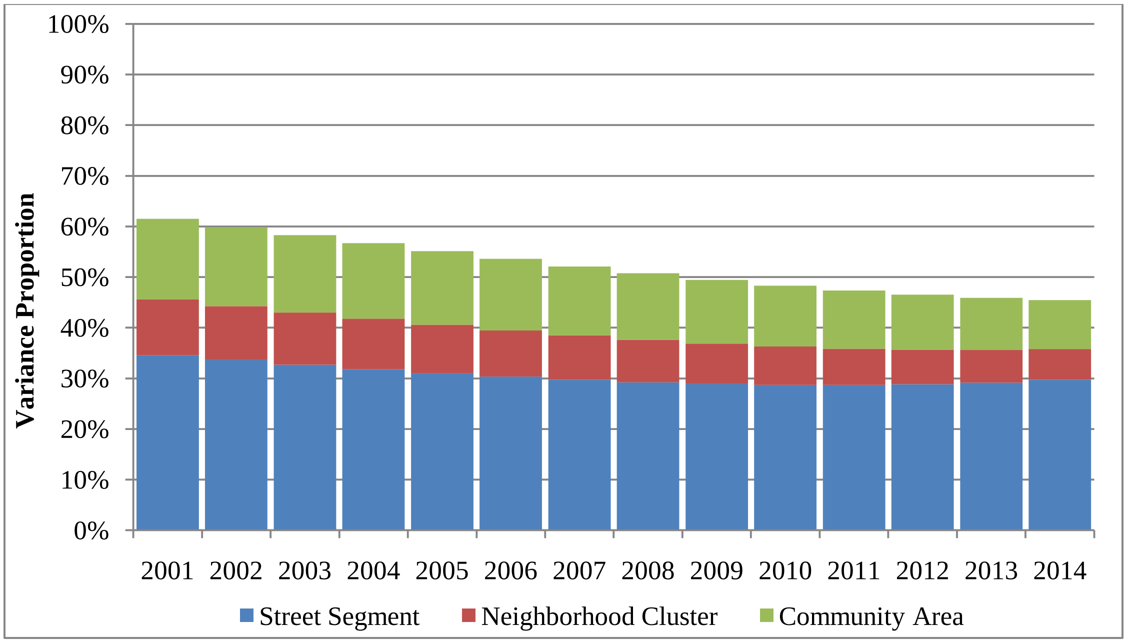
Note: Intervals based on Fisher-Jenks algorithm

Appendix 8 Comparing the Total Spatial Variability to the Total Variability

This dissertation is focused on the variance parameters of the hierarchical levels that were associated with the three spatial units of analysis; street segments (i.e. level-2), neighborhood clusters (i.e. level-3), and community areas (i.e. level-4). The remaining level-1 variance accounted for by the model can be attributed to time-varying explanations. Since this research interest rested entirely in the spatial variability (i.e. levels 2-4) opposed to the total variability (i.e. levels 1-4) accounted for by the model this topic was not explored in more detail.

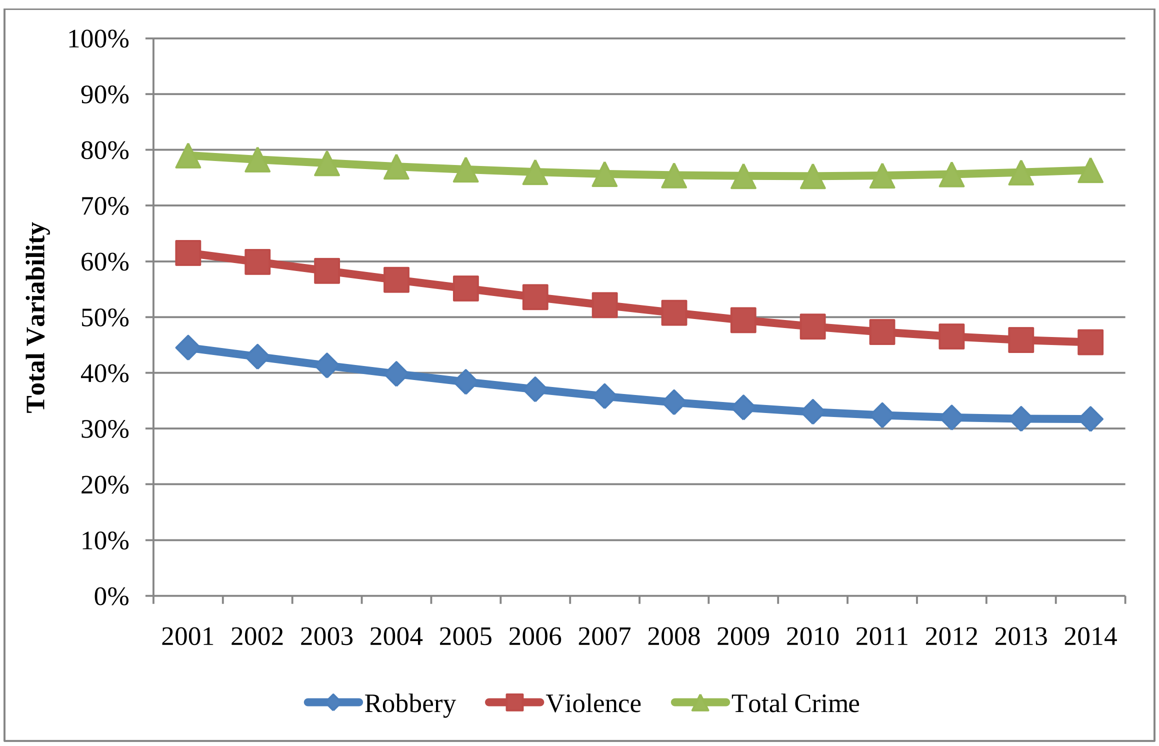
If the level-1 variance is large it does provide an interesting caveat to the findings since focusing on just the spatial variability may mask a potentially more compelling finding if it is only a small share of the total variability accounted for by the model. The level-1 variance can be added into the calculation of the total variance proportion to answer this question. This does not change the relationship between the proportional share accounted for by the three spatial units of analysis. The first figure below offers a demonstration of the new variance proportion for the final model used in this dissertation (also discussed in the *Sensitivity Analyses* section). To provide additional context to these findings similar calculations were provided for three supplementary models that were estimated for the sensitivity analyses. The second figure presents these results from the final model (i.e. violence) and models which used robbery and total crime as the dependent variable.

Total Variance Proportion for Violent Crime Including Level-1 Variance



,

Spatial Variability per Year for Three Dependent Variables



In both figures the unobserved variability is accounted for by level-1 variance. This variance is a moderate size. Large enough to notice but not quite large enough to undermine the findings because the spatial variability results were based on such a small share of the total variability. This issue was discussed with Wouter Steenbeek in regards to his findings with David Weisburd in The Hague. Their findings were similar to the results from the total crime measure, hovering around 75% of total variability accounted for by the spatial levels. The inconsistency of this across models though and the clear desire this dissertation to explore just the spatial variability resulted in this issue not being discussed in any further detail. Again, this study explicitly focused on the contributions of our units of analysis relative to the total *spatial* variability. Not the spatial compared to total variability. While this finding is definitely interesting it was beyond the scope of further discussion in this dissertation.

Appendix 9. Collinearity Diagnostics for Criminal Opportunity Variables

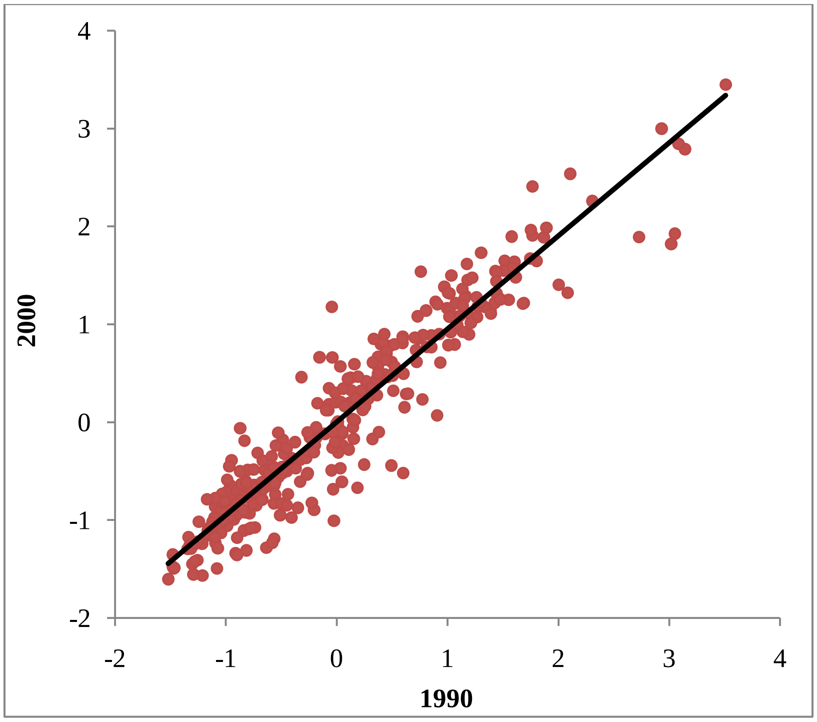
Variable	VIF	$\sqrt{VIF}$	Tolerance	R^2
Train Station	2.52	1.59	0.397	0.603
Highway Access	2.21	1.49	0.452	0.548
Fac. with Alcohol	1.77	1.33	0.565	0.435
Length	1.25	1.12	0.800	0.200
IM Incidents	1.22	1.10	0.820	0.180
Physical Disorder	1.17	1.08	0.855	0.145
Land Use	1.15	1.07	0.870	0.130
Gang Territory	1.11	1.05	0.901	0.099
Bus Stops	1.09	1.04	0.917	0.083
Permeability	1.07	1.03	0.935	0.065
Arterial	1.06	1.03	0.943	0.057
Public Housing	1.02	1.01	0.980	0.020

Mean VIF = 1.39

Appendix 10. Factor Loading for Social Disorganization Measures

Variable	Factor Loading	Uniqueness
Concentrated Disadvantage:		
% Under 18	0.6615	0.5624
% Black	0.8745	0.2353
% Female Headed Households	0.9577	0.0829
% Unemployed	0.9215	0.1508
% Below Poverty Line	0.8611	0.2585
Residential Instability:		
% Units Vacant	0.869	0.2448
% Units Rented	0.869	0.2448

Appendix 11 Persistence and Change in Levels of Concentrated Disadvantage in Neighborhood Clusters from 1990 to 2000



Note: R = .904, p < .001

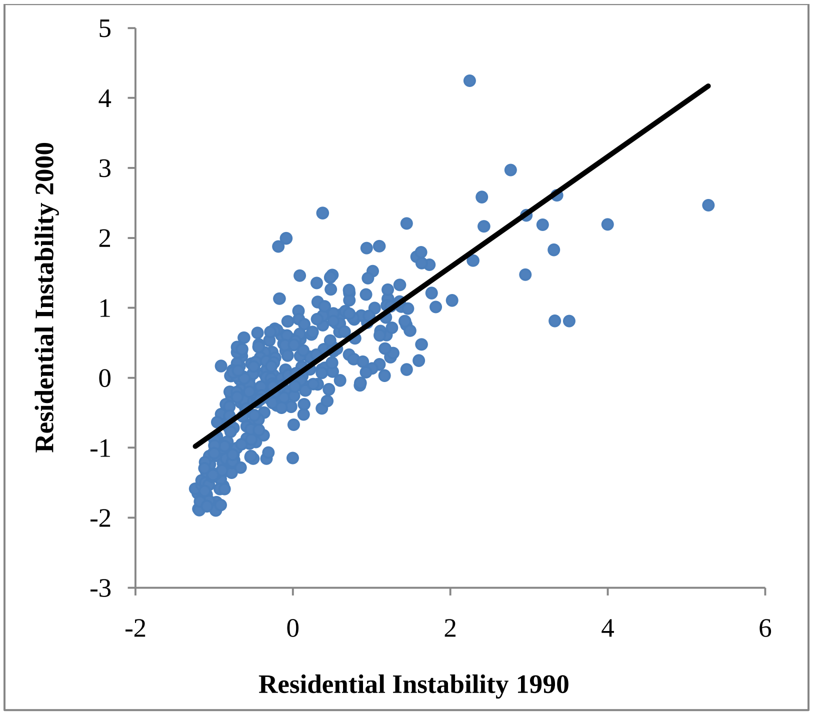
Concentrated Disadvantage Correlations

	1990	2000	2010
1990	1		
2000	.951	1	
2010	.813	.900	1

Cross-Tabulation, 1990 and 2010 Concentrated Disadvantaged by Quartile

	2010 Quartile				
1990 Quartile	1	2	3	4	Total
1	**76.7%**	22.1%	1.2%	0.0%	100%
2	22.4%	**64.7%**	12.9%	0.0%	100%
3	1.2%	14.1%	**74.1%**	10.6%	100%
4	0.0%	0.0%	11.6%	**88.4%**	100%
Total	100%	100%	100%	100%	

Appendix 12 Persistence and Change in Levels of Residential Instability in Neighborhood Clusters from 1990 to 2000



Note: R = .624, p < .001

Residential Instability Correlations

	1990	2000	2010
1990	1		
2000	.790	1	
2010	.718	.778	1

Cross-Tabulation, 1990 and 2010 Residential Instability by Quartile

	2010 Quartile				
1990 Quartile	1	2	3	4	Total
1	**89.7%**	9.2%	0.0%	1.1%	100%
2	4.7%	**49.4**	34.1%	31.8%	100%
3	3.5%	28.2%	**36.5%**	31.8%	100%
4	1.2%	14.1%	29.4%	**55.3%**	100%
Total	100%	100%	100%	100%	

Appendix 13 Collinearity Diagnostics for Social Disorganization Variables

Variable	VIF	$\sqrt{\text{VIF}}$	Tolerance	R^2
Collective Efficacy	2.88	1.70	.347	0.653
Residential Instability	2.59	1.61	.387	0.613
Spatial Lag	2.16	1.47	.462	0.538
Concentrated Disadvantage	2.01	1.42	.497	0.503
Network Ties	1.27	1.13	.789	0.211

Mean VIF = 2.18

Appendix 14 Mean Value for Opportunity Variables Between Neighborhood Clusters Violence Trajectory Group

		Neighborhood Trajectory Group				
Variable	All	1	2	3	4	5
Violence 12-14	1.346	0.248	0.714	1.412	2.093	2.469
Accessibility:						
Length	5.916	5.932	5.923	5.954	5.930	5.834
Permeability	0.462	0.397	0.447	0.438	0.518	0.508
Arterial	0.175	0.174	0.179	0.167	0.173	0.182
Train Station	8.855	9.322	8.808	8.988	8.793	8.395
Highway Access	8.788	9.028	8.813	8.891	8.786	8.400
Bus Stop	0.746	0.640	0.748	0.733	0.787	0.816
Routine Activities:						
Land Use	0.299	0.246	0.347	0.288	0.278	0.312
Fac. with Alcohol	7.405	7.540	7.293	7.491	7.479	7.266
Public Housing	0.032	0.007	0.016	0.046	0.032	0.067
Gang Territory	0.444	0.062	0.318	0.603	0.717	0.528
IM Incidents	0.284	0.051	0.154	0.308	0.431	0.522
Physical Disorder	0.004	-0.185	-0.061	0.041	0.169	0.060
# of Segments	41,926	7,272	11,330	7,352	8,860	7,112

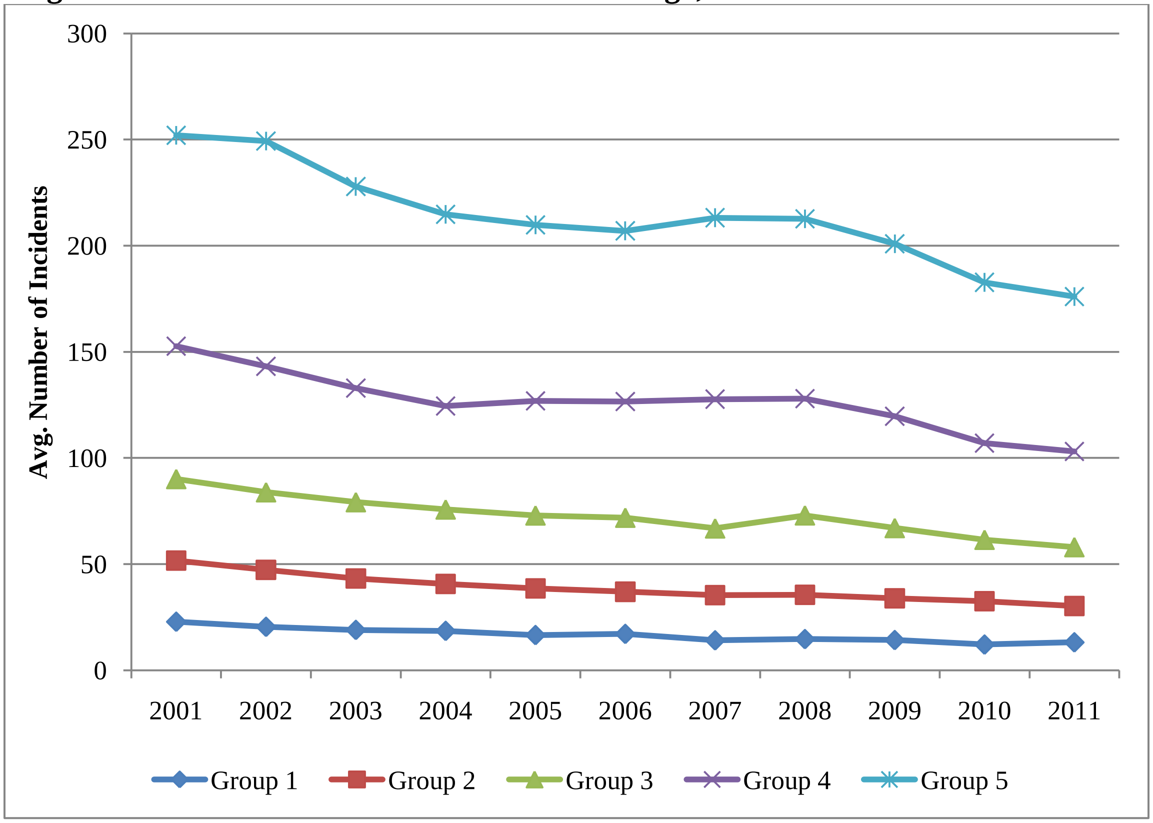
Appendix 15 Mean Value for Opportunity Variables Between Neighborhood Clusters Concentrated Disadvantage Trajectory Group

		Neighborhood Trajectory Group				
Variable	All	LS	MD	MI	HS	HD
Violence 12-14	1.346	0.610	1.218	2.442	2.924	1.838
Accessibility:						
Length	5.916	5.913	5.864	5.998	5.904	5.797
Permeability	0.462	0.445	0.432	0.544	0.501	0.287
Arterial	0.175	0.188	0.182	0.131	0.184	0.163
Bus Stop	0.746	0.723	0.791	0.706	0.858	0.762
Train Station	8.855	8.877	8.498	8.975	8.540	8.414
Highway Access	8.788	8.909	8.547	9.359	8.322	8.460
Routine Activities:						
Land Use	0.299	0.319	0.382	0.235	0.242	0.224
Fac. with Alcohol	7.405	7.340	7.285	7.619	7.484	7.477
Public Housing	0.032	0.005	0.035	0.015	0.048	0.484
Gang Territory	0.444	0.233	0.534	0.835	0.713	0.392
IM Incidents	0.284	0.129	0.247	0.526	0.621	0.370
Physical Disorder	0.004	-0.108	0.046	0.231	0.188	-0.261
# of Segments	41,926	22,445	5,331	7,535	5,238	1,377

Appendix 16 Cross-Tabulation of Neighborhood Cluster Violence (2001-2011) By Concentrated Disadvantage (1970-2010) Developmental Patterns

	Concentrated Disadvantage				
Neighborhood Cluster Violence	Low Stable	Moderate Decreasing	Moderate Increasing	High Stable	High Decreasing
1	30.3%	11.8%	1.4%	2.0%	7.7%
2	48.4%	35.3%	13.5%	2.0%	15.4%
3	14.8%	35.3%	24.3%	14.3%	30.8%
4	4.5%	17.6%	41.9%	40.8%	23.1%
5	1.9%	0.0%	18.9%	40.8%	23.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

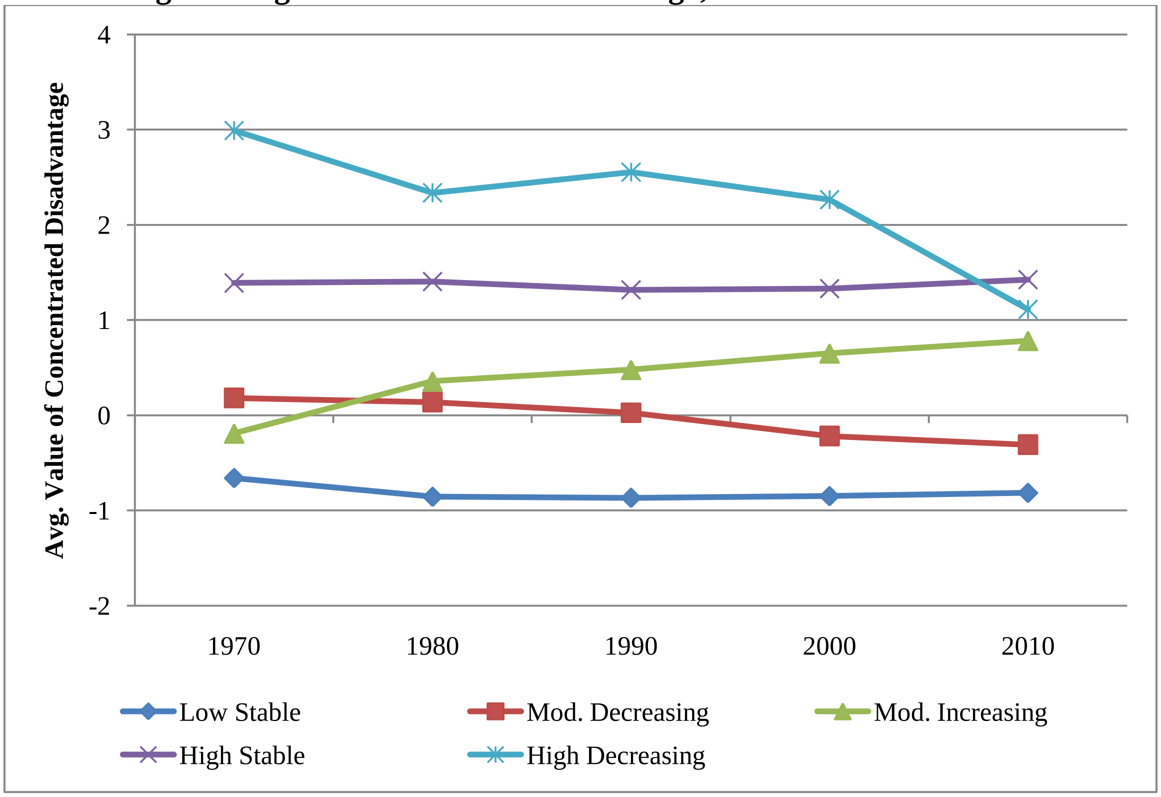
Appendix 17 GBTM Defined Developmental Patterns of Violent Crime Incidents at Neighborhood Clusters with Covariates in Chicago, 2001-2011



Appendix 18 The Distribution of Violent Crime Incidents in Chicago by GBTM Defined Developmental Groups, 2001-2011

Group	# Neighborhood Clusters	% Neighborhood Clusters	# Incidents	% Incidents
1	55	16.1%	10,048	3.3%
2	106	31.0%	45,173	14.9%
3	71	20.8%	56,819	18.7%
4	70	20.5%	97,449	32.1%
5	40	11.7%	93,853	30.9%
Total	342	100.0%	303,342	100.0%

Appendix 19. GBTM Defined Developmental Patterns of Concentrated Disadvantage at Neighborhood Clusters in Chicago, 1970-2010



Appendix 20. GBTM Defined Developmental Patterns of Concentrated Disadvantage at Neighborhood Clusters in Chicago, 1970-2010

Group	# Neighborhood Clusters	% Neighborhood Clusters
Low Stable	155	45.3%
Moderate Decreasing	51	14.9%
Moderate Increasing	74	21.6%
High Stable	49	14.3%
High Decreasing	13	3.8%
Total	342	100.0%

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