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Activity Nodes, Pathways, and Edges: Examining Physical Environments, Structural Characteristics and Crime Patterns in Street Segments

Author

Kim, Young-An

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Activity Nodes, Pathways, and Edges: Examining Physical Environments, Structural Characteristics and Crime Patterns in Street Segments

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for the degree of

DOCTOR OF PHILOSOPHY

in Criminology, Law and Society

by

Young-An Kim

Dissertation Committee:
Professor John R. Hipp, Chair
Professor Charis E. Kubrin
Professor Richard McCleary
Professor George E. Tita
Associate Professor Jae Hong Kim

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CURRICULUM VITAE

YOUNG-AN KIM

Department of Criminology, Law & Society
University of California–Irvine
2340 Social Ecology II
Irvine, CA 92697-7080
youngank@uci.edu

EDUCATION

Ph.D. in Criminology, Law & Society 2018
University of California–Irvine
Dissertation: "Activity Nodes, Pathways, and Edges: Examining Physical Environments, Structural Characteristics and Crime Patterns in Street Segments"
Committee: John R. Hipp, Charis E. Kubrin, Richard McCleary, George E. Tita, Jae Hong Kim

M.A. in Sociology 2013
University of Texas at El Paso

B.A. in Sociology 2010
University of Seoul

AREAS OF INTEREST

Neighborhoods and crime, Criminology of place, Community context of crime, Crime patterns in street segments, Urban land use and crime, Units of analysis, Geo-spatial analysis, Street network, Sociology of health, Urban sociology, Structural Equation Modeling (SEM), Quantitative research methods

ACADEMIC PUBLICATIONS

Hipp, John R., James C. Wo, and **Young-An Kim** (2017). "Studying Neighborhood Crime Across Different Macro Spatial Scales: The Case of Robbery in 4 Cities" *Social Science Research*. Online: http://www.sciencedirect.com/science/article/pii/S0049089X16307931

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UNDER REVIEW

Kane, Kevin and **Young-An Kim**. "Big Data as Individual Data: How can Parcels and Establishments Improve the Measurement of Proximity in Cities?" *Environment and Planning B*, *Revise and Resubmit.*

Hipp, John R. and **Young-An Kim**. "Explaining the Temporal Dimensions of Robbery: Differences across Measures of the Physical and Social Environment" *Journal of Research in Crime and Delinquency*, *Revise and Resubmit.*

Kim, Young-An and John R. Hipp. "Street Egohood: A New Perspective of Measuring Neighborhood
Based on Street Network Configurations" *Under Review*.

Kubrin, Charis E., **Young-An Kim**, and John R Hipp, "Institutional Completeness and Crime Rates in Immigrant Neighborhoods" *Under Review*.

Kim, Jae Hong, Kevin Kane, **Young-An Kim**, and John R. Hipp. "Business Churning and

Neighborhood Stability: Is there a link?" *Under Review.*

Hipp, John R., **Young-An Kim**, and James C. Wo. "Micro-scale, macro-scale, and temporal scale: Comparing the relative importance for robbery risk in New York City" *Under Review*.

Hipp, John R., **Young-An Kim**, and Kevin Kane. "The Effect of the Physical Environment on Crime Rates: Capturing Housing Age and Housing Type at Varying Spatial Scales" *Under Review*.

WORK IN PROGRESS

Kim, Young-An and John R. Hipp "A Longitudinal Analysis on the Level of Business Activity, Disorder, and Crime in Street Segments in New York City" *In progress*.

FELLOWSHIPS, AWARDS, AND HONORS

Dean's Dissertation Writing Fellowship ($12,000) — Fall 2017
School of Social Ecology
University of California, Irvine

Outstanding Student Paper Award — 2016
Korean Society of Criminology in America (KOSCA)

Summer Research Grant ($6,000) — 2015, 2016, 2017
Criminology, Law and Society
University of California, Irvine

Newkirk Fellowship ($4,000) — Fall 2013
School of Social Ecology
University of California, Irvine

Outstanding Master's Thesis Award ($500) — 2013
Graduate School
University of Texas at El Paso

Departmental Honor — 2013
Department of Sociology
University of Texas at El Paso

Global Korea Scholarship ($62,000) — 2011-2013
Ministry of Education
Republic of Korea

Seoul Mayor's Scholarship ($1,500) — 2005
University of Seoul

RESEARCH EXPERIENCES

Graduate Student Researcher 2013-Present
Irvine Laboratory for the Study of Space and Crime (ILSSC)
University of California, Irvine

Graduate Student Researcher 2015-Present
Metropolitan Futures Initiative (MFI)
University of California, Irvine

Research Assistant 2012-2013
Computer Science Cyber-Share Lab
University of Texas at El Paso

Research Assistant 2012-2013
Laboratory for Environmental Justice
University of Texas at El Paso

TEACHING EXPERIENCES

Teaching Assistantships
Crime Measurement (undergraduate course) Spring 2018
Criminology, Law & Society
University of California, Irvine

Crime Hotspot (undergraduate course) Winter 2018
Criminology, Law & Society
University of California, Irvine

Introduction to Criminology, Law and Society (undergraduate course) Winter 2014
Criminology, Law & Society
University of California, Irvine

Community Context of Crime (undergraduate course) Spring 2014
Criminology, Law & Society
University of California, Irvine

Statistical Social Survey Lab Fall 2010
Sociology
University of Seoul (South Korea)
Teaching basic statistics and SPSS to undergraduate students

Guest Lectures
"Environmental and Situational Theories" in Macro Criminology Spring 2015, 2016
(Graduate course; Instructor: Charis E. Kubrin)
Criminology, Law & Society
University of California, Irvine

"Social Disorganization Theory" in Crime Hotspot Winter 2018

(Undergraduate course; Instructor: Richard McCleary)
Criminology, Law & Society
University of California, Irvine

ACADEMIC PRESENTATIONS

Hipp, John R. and **Young-An Kim**, *Explaining the Temporal Dimensions of Robbery: Differences across Measures of the Physical and Social Environment*. Annual meeting of Western Society of Criminology, 2018, Long Beach, CA.

Kim, Young-An, *Pathways: Examining the Crime Patterns by Street Network Configurations*. Paper presented at annual meeting of American Society of Criminology, 2017, Philadelphia, PA.

Pedraza, Kevin, Christopher Jay Bates, John R. Hipp, Charis E. Kubirn, **Young-An Kim**, *Open Government Data and Public Criminology*. Annual meeting of American Society of Criminology, 2017, Philadelphia, PA.

Kim, Young-An, *Roundtable: Contextual Effects? Spatial Dependence? Spatial Regressions? Where We Are and Where We Go*, Invited and participated as a discussant at the annual meeting of American Society of Criminology, 2017, Philadelphia, PA.

Kim, Young-An and John R. Hipp, *Physical boundaries and City boundaries: Consequences for Crime Patterns on Street Segments?* Paper presented at the annual meeting of American Society of Criminology, 2016, New Orleans, LA.

Kubrin, Charis E., John R. Hipp, and **Young-An Kim**, *Different than the Sum of its Parts: Examining the Unique Impacts of Immigrant Groups on Neighborhood Crime Rates*, Paper presented at the annual meeting of American Society of Criminology, 2016, New Orleans, LA.

Kim, Young-An, *Roundtable: GIS/Spatial Data Analysis in Criminal Justice Research and Practices*, Invited and participated as a discussant at the annual meeting of American Society of Criminology, 2016, New Orleans, LA.

Hipp, John R. and **Young-An Kim**, *Estimating the presence of offenders, guardians, and targets at street segments: Consequences for crime at various times of day*, Paper presented at the annual meeting of American Association of Geographers, 2016, San Francisco, CA.

Kim, Young-An, *Imputing Structural Characteristics in Segments: Is the pain worth the gain?* Paper presented at the annual meeting of American Society of Criminology, 2015, Washington, DC.

Wo, James C., John R. Hipp, and **Young-An Kim**, *Land Use and Neighborhood Robbery: A Spatial Examination across Four cities*, Paper presented at the annual meeting of American Society of Criminology, 2015, Washington, DC.

Kim, Young-An, Charis E. Kubrin, and John R. Hipp, *Dissecting the relationship between* *immigrants and neighborhood crime: Immigrant subgroups matter?* Paper presented at the annual meeting of the American Society of Criminology, 2014, San Francisco, CA.

Wo, James C., and **Young-An Kim,** *Crime hot spots in Anaheim: Land use, Intensity, and temporal change.* Paper presented at the annual meeting of the American Society of Criminology, 2014, San Francisco, CA.

McDonald, Yolanda J, Sara E. Grineski, Timothy W. Collins, and **Young-An Kim**. *A scalable climate health justice assessment model (oral), Environment Section: Sub-section Climate Change through the Lens of Health Equity and Emergency Response*, Paper presented at the annual meeting of the American Public Health Association Annual Conference, 2014, New Orleans, LA.

Grineski, Sara E., Timothy W. Collins and **Young-An Kim**, *Effects of individual-level acculturation and neighborhood ethnic enclaves on children's respiratory health*, Paper presented at the meeting of the Association of American Geographers 2014, Tampa, FL.

McDonald, Yolanda J., Sara E. Grineski, Timothy W. Collins, and **Young-An Kim,** *A scalable m odel for assessing incidence, treatment costs, and socio-spatial disparities for diseases with well-documented climate change linkages*. Paper presented at the meeting of the Association of American Geographers 2014, Tampa, FL.

McDonald, Yolanda J., Sara E. Grineski, Timothy W. Collins, and **Young-An Kim,** *The incidence of diseases associated with climate change in Texas, 2008-2010: An examination of economic impacts and socio-spatial disparities.* Paper presented at the meeting of 25th International Symposium in Medical/Health Geography 2013, East Lansing, MI.

Kim, Young-An, and Gang Lee, *Level of students' delinquency as a measure of victimization and academic learning environments in Korea and USA: Employing hierarchical linear m odeling.* Paper presented at the meeting of the Southwestern Social Science Association 2013, New Orleans, LA.

Kim, Young-An, Sara E. Grineski, and Timothy W. Collins, *Deprivation and the Hispanic health paradox: Neighborhood effects on children's wheezing in El Paso, TX*. Paper presented at the meeting of the Southwestern Social Science Association 2013, New Orleans, LA.

Kim, Young-An, Sara E. Grineski, and Timothy W. Collins, *Neighborhood context and the Hispanic health paradox: differential effects of immigrant density on children's wheezing by poverty, nativity and medical history.* Paper presented at the meeting of the Association of American Geographers 2013, Los Angeles, CA.

Kim, Young-An, and Gang Lee, *School Violence and Academic Learning Environments in South Korea and Japan: Utilizing the International Educational Database of the Trends in International Mathematics and Science Study 2007.* Paper presented at the meeting of the American Society of Criminology 2012, Chicago, IL.

PROFESSIONAL AFFILIATIONS

American Society of Criminology (ASC)
Association of American Geographers (AAG)
Korea Academy of Government-Supported Scholars (KAGS)
Korean Society of Criminology in America (KOSCA)

PROFESSIONAL SKILLS

Statistical Analysis
- Stata, Hierarchical Linear Modeling (HLM), SAS, SPSS, Excel

Geographic Information Systems (GIS)
- ArcGIS, ArcPy (Python scripting), GeoDa, Quantum GIS

Other Programming Languages
- Autoit

ABSTRACT OF THE DISSERTATION

Activity Nodes, Pathways, and Edges: Examining Physical Environments, Structural Characteristics and Crime Patterns in Street Segments

By

Young-An Kim

Doctor of Philosophy in Criminology, Law and Society

University of California, Irvine, 2018

Professor John R. Hipp, Chair

The dissertation examined how land uses, street network connectivity, and physical boundaries in urban settings dictate the activity patterns of persons; and thus influence spatial crime patterns. Although existing studies successfully theorized and revealed the effects of the physical environment on crime, less attention has been paid to distinguishing the specific characteristics of the physical environment that may be most important for understanding the location of crime. Drawing on the literature on crime pattern theory and the geometry of crime, the dissertation specifically focuses on the question of what characteristics of physical environments determine why some areas seem to have more crime. Thus, my dissertation draws a comprehensive picture by accounting for the effects of physical environments and structural characteristics on crime patterns in street segments informed by routine activities theory, crime pattern theory, environmental criminology, and social disorganization theory.

In the first chapter of my dissertation, I explore how different land use characteristics conceptualized as activity nodes are related to the levels of both violent and property crime in street segments. These land use characteristics include: (1) type of business, (2) number of

employees (as a proxy measure of the magnitude of people moving in-and-out), (3) local ownership status (e.g., whether a business is owned and run by a local entrepreneur or a non-local franchise company), and (4) age of business (e.g., number of years since a business facility has established and started operating). The next chapter focuses on the street network configurations, conceptualized as pathways, and examines their relationship with violent and property crime in street segments. In this chapter, I propose an application of the theoretical and methodological concepts of complex network topology to street network systems utilizing several conceptions of centrality: Reach and Betweenness. The final chapter of my dissertation – edges, incorporates measures of nearness of street segments to spatial boundaries. This chapter of my dissertation tests how spatial crime patterns in street segments are affected by different types of spatial boundaries, nearness to them, and the level of land use classification difference at the street segment level.

CHAPTER 1. DISSERTATION INTRODUCTION

Why do some areas in cities have more crime than others? What is it about certain areas that consistently breed high crime rates? How are these patterns temporally different? These are the central questions that motivate the dissertation research. Theories of criminal opportunities have argued that different physical environments create different criminal opportunities (the mixture of motivated offenders, potential victims, and presence or absence of capable guardians) and consequently, the amount of crime (Bernasco & Block, 2011; Brantingham & Brantingham, 1993a; Brantingham & Brantingham, 1995; Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993b; Taylor & Gottfredson, 1986; R. Taylor, Koons, Kurtz, Greene, & Perkins, 1995). Particularly, Brantingham & Brantingham (1993, 1995) specify the concept of criminal opportunities in places as part of crime pattern theory. Specifically, the Brantinghams classify these physical environments into three spatial geometric notions: (1) activity nodes, (2) pathways, and (3) edges.

Activity nodes are the places where people spend their time and develop their routinized activities. Activity nodes are important factors because they are the determinants of the number and type of people who are familiar with the locations. Some activity nodes (e.g., shopping centers, malls, schools, hotels, etc.), according to the Brantinghams, are seen to be *crime generators* because they draw a large number of people into the places that increases the probability of the co-location of the motivated offenders and suitable targets at the same time. Other types of facilities (e.g., drug markets, half-way houses, bars, etc.) are considered to be crime attractors because they have reputations for criminal opportunities, and therefore will attract offenders to them. A characteristic of crime attractors is that “they provide motivated offenders many attractive and weakly guarded victims or targets” (Bernasco & Block, 2011:35).

Pathways are the street network system and road structure that connect one activity node to another so that people move from one place to another. Empirical studies have found that the structure of the street network plays important role in shaping spatial distribution of crime in places (Beavon, Brantingham, & Brantingham, 1994; Bevis & Nutter, 1977; Davies & Johnson, 2015; Hillier, 1996; Johnson & Bowers, 2010).

Edges are the spatial boundaries where noticeable changes are observed (Brantingham & Brantingham, 1993a). For example, locations next to rivers or parks are seen to be edges given that they can be very pronounced physical boundaries. In an urban setting, transit systems such as major roads, interstate highways, or railroads act as paths, but also as edges. Interstate highways can serve as pronounced borders that are only crossable at occasional locations. Locations where different land use zones adjoin are seen to be edges. Indeed, empirical studies have tested whether places near edges actually have more crime (Brantingham & Brantingham, 1978; Brantingham & Brantingham, 1975; Brantingham, Brantingham, Vajihollahi, & Wuschke, 2009; Song, Andresen, Brantingham, & Spicer, 2015).

Another body of studies looking at the spatial patterns of crime have identified the relationships between structural characteristics (i.e., poverty, residential instability, racial heterogeneity, economic inequality, etc.) of street segments and crime; and these studies usually employ social disorganization theory as the theoretical frame. Although scholars of criminology of place have somewhat neglected the importance of the structural characteristics in empirical studies, there are several theoretical and empirical reasons to consider them as important factors to understanding crime patterns at the street segment level. First, theoretically, street segments are seen to be small scale social communities (behavior settings) where people know each other, get familiar with others' routines, develop and share their own norms on street segments

(Wicker, 1987; Taylor, 1997). Therefore, street segments can be seen as communities that contain the structural characteristics of communities presented in social disorganization theory. Thus, Weisburd et al. (2012:45) stated that “if the street segment can be seen as a type of ‘micro community,’ then social disorganization theory would seem to have direct relevance to the understanding of the criminology of place.” This implies that it is necessary to test the effects of structural characteristics on crime at street segment level along with the measures of physical environments (i.e., activity nodes, pathways, and edges).

Although the existing studies successfully theorized and revealed the effects of physical environments on crime, less attention has been paid to distinguishing the specific characteristics of them, and how the spatial crime patterns can vary by them. Moreover, many studies frequently focus solely on a single type of physical environment, which ignores the effects of other types of physical environments and social environments (structural characteristics). This dissertation examines the associations between various types of physical environments and spatial crime patterns using a large sample of street segments in about 130 cities in the Southern California region, while accounting for the effects of structural characteristics (i.e., level of poverty, residential stability, and ethnic/racial compositions).

The dissertation attempts to draw a comprehensive picture of physical environments, social environments, and spatial crime patterns in street segments informed by routine activities theory, crime pattern theory, environmental criminology, and social disorganization theory. To do so, in the dissertation, I propose and create theoretically and methodologically refined alternative measures of the physical environment (conceptually based on activity nodes, pathways, and edges) by employing advanced GIS techniques, and empirically estimating the effects of the physical environment on crime in street segments using quantitative research techniques. Moreover, the dissertation not only involves testing for the direct effects that the measures of various physical environments have on crime; but equally importantly, it examines how such effects may operate differently depending on the level of socioeconomic status in the area.

<<<Figure 1-1 is about here>>>

Figure 1-1 is a road map of the dissertation. As presented, there are three main components: (1) Crime in place, (2) physical environments, and (3) social environments. Therefore, the dissertation examines spatial patterns of crime by looking at how the two different types of environments can affect crime in place. Physical environments are theorized as activity nodes, pathways, and edges based on crime pattern theory, while social environments are operationalized as social-structural characteristics of place based on social disorganization theory. As mentioned, the dissertation explores how physical environments and social environments are interactively working together in explaining crime pattern in place by testing interaction effects.

The dissertation is comprised of one theoretical chapter discussing existing research and three main analytic chapters. In chapter 2, I begin the dissertation by focusing on the theoretical background of the research. Specifically, I discuss theories of criminal opportunities and crime pattern theory in relation to the development of geometry of crime (activity nodes, pathways, and edges). Then, I discuss the theoretical importance of considering structural characteristics of street segments in understanding spatial patterns of crime drawing from social disorganization theory. Subsequently, I suggest studying the interaction effects between criminal opportunities and socioeconomic status. Finally, I close the chapter with a discussion of why the street segment is an appropriate unit of analysis in studying of physical environments, socio-structural characteristics, and crime in place.

In each of the subsequent analytic chapters 3, 4, and 5, I recognize the considerable achievement of the existing literature in studying physical and social environments and crime in places, yet there still remains room for theoretical and methodological improvement. Therefore, I propose alternative measures of each geometric notion of physical environments to the ones previously employed, and empirically test their effects on crime by taking advantage of advanced GIS and statistical methods.

Specifically, in the first analytic chapter of the dissertation (chapter 3), I explore how different business characteristics conceptualized as *activity nodes* are related to the levels of both violent and property crime in street segments. These characteristics include: (1) type of business, (2) number of employees (as a proxy measure of the magnitude of people moving in-and-out), (3) local ownership status (e.g., whether a business is owned and run by a local entrepreneur or a non-local franchise company), and (4) age of business (e.g., number of years since a business facility has established and started operating). These characteristics are important in understanding crime because they shape the number and type of people routinely visiting the place, and the quantity and quality of social interactions among them.

The next analytic chapter (chapter 4) focuses on the street network configurations, conceptualized as *pathways*, and examines their relationship with violent and property crime in street segments. In this chapter, I propose an application of the theoretical and methodological concepts of complex network topology to street network systems utilizing several conceptions of centrality: *Reach* and *Betweenness*. A key additional feature is that I refine these measures by assigning higher weighting on the journey to known centers of activity nodes. This innovative conceptualization and measures of pathways allow me to view the importance of overall street network configuration on crime in street segments.

The final analytic chapter (chapter 5) – *edges*, incorporates measures of nearness of street segments to various spatial boundaries (i.e., highways, parks, and rivers). This chapter theoretically and methodologically improves Kim & Hipp (2017) by using distance based on the street network rather than straight-line distance. Arguably, street-network distances are more relevant to real-life environments because they account for the street geography and certain physical barriers; consequently they are more predictive of physical activity than straight-line distance. Also, given the definition of a street segment (both sides of a street between two intersections), the difference of land use between one side and the other of a street segment may act as a boundary. This chapter of the dissertation tests how spatial crime patterns in street segments are affected by different types of spatial boundaries, nearness to them, and the level of land use classification difference at the street segment level.

<<<Figure 1-2 is about here>>>

In sum, the primary aims of this dissertation are as follows: (1) this dissertation will empirically test the effects of the physical environments theorized as *activity nodes*, *pathways*, and *edges* on crime in street segments while controlling for measures of structural characteristics of areas; (2) to do so, the dissertation proposes theoretically and methodologically refined alternative measures of physical environments (conceptualized as activity nodes, pathways, and edges) by employing advanced Geographic Information System (GIS) techniques; and (3) the dissertation discusses theoretical expectations for the interaction effects between the measures of physical environments and socioeconomic status in street segments that seem to be especially important to the literature of crime and place; and expects that some of these will be empirically supported.

Chapter 1 Figures

Figure 1-1. Dissertation Roadmap

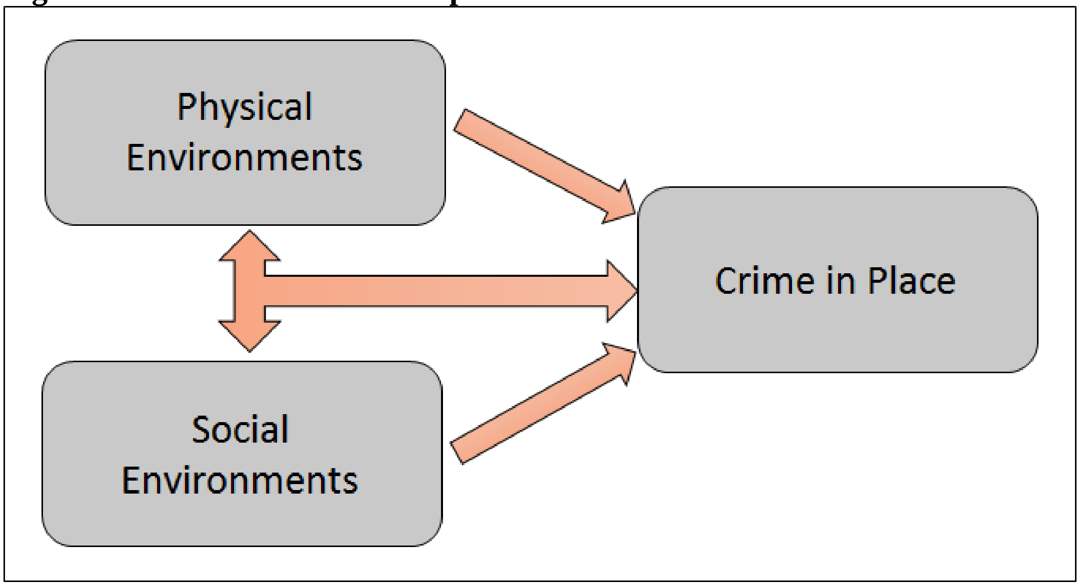
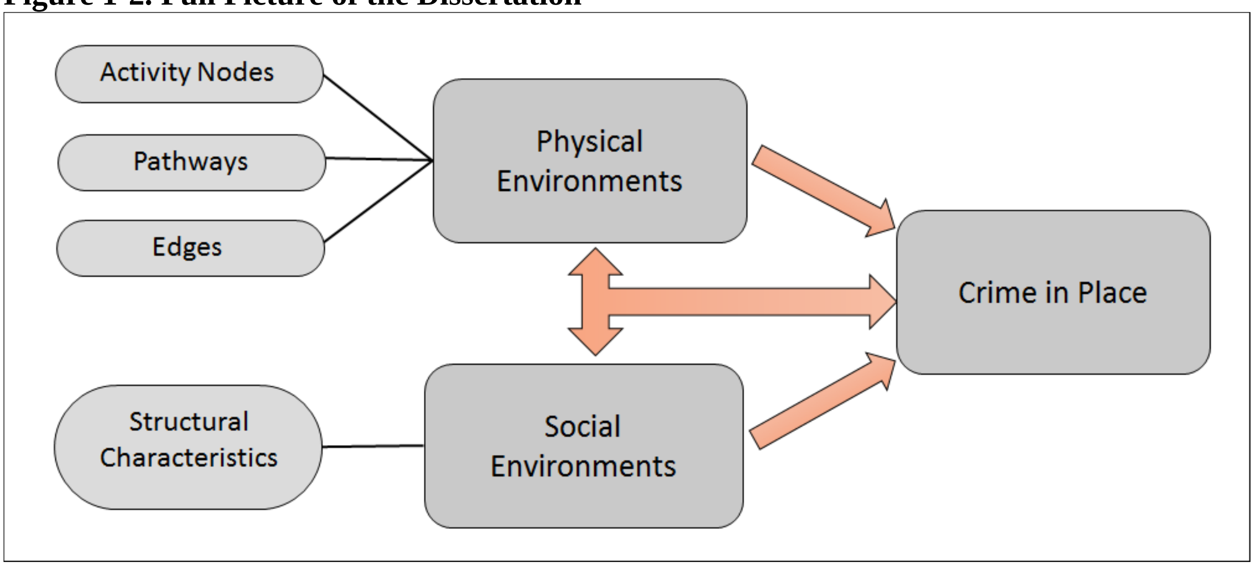


Figure 1-2. Full Picture of the Dissertation



CHAPTER 2. RESEARCH CONTEXT

Contextualizing Physical Environment and Crime in Place

In this chapter, I describe the theoretical backgrounds of physical environment and crime in place based on theories of criminal opportunities. A body of studies emphasize the importance of criminal opportunities at places (Block & Block, 1995; Brantingham & Brantingham, 1993, 1995; Eck et al., 2000; Eck & Weisburd, 1995; Weisburd et al., 2006). This literature suggests that different physical environments create different criminal opportunities – the convergence of motivated offenders, potential victims, and the presence or absence of capable guardians (Cohen & Felson, 1979; Felson, 1987; Felson & Boba, 2010). A primary inquiry of this perspective is why some types of situational and contextual factors increase or decrease the level of crime. Specifically, the theories argue that a process leading an offender to commit a crime is not random nor unpredictable. This process begins with an offender who has sufficient criminal motivation and knowledge to search and act upon available criminal opportunities within activity areas and associated awareness spaces (Brantingham & Brantingham, 1993b). These criminal opportunities may be found in non-criminal pedestrian activities or a specific search for suitable targets.

The identification of criminal opportunities is a multistep decision process within some general environment. This process includes several levels of perception and learning about the surrounding environment. During this process, people develop images of physical and social environments around them. These images are formed by the characteristics of the surrounding environments. These images, perception of objects within a complex environment, are called *templates* (Brantingham & Brantingham, 1978). A template is a holistic image of physical and social environments, based on which an offender identifies what/whom should be considered as suitable targets in specific space and time.

Neither motivated offenders nor opportunities for crime are evenly distributed in space and time. That is, criminal opportunities can vary by characteristics of places and targets, locations of targets, travel patterns of potential offenders and victims, times of day, days of week, or months of year. This is because physical, social, and cultural environments surrounding the motivated offender, potential victim, and capable guardian are not spatially and temporally static but dynamic. Therefore, "crimes are patterned; decisions to commit crimes are patterned; and the process of committing a crime is patterned" (Brantingham & Brantingham, 1993b:264).

Crime Pattern Theory

Crime pattern theory is derived from multiple theoretical frameworks of criminal opportunities which argue that crime is not randomly distributed but concentrated at certain places. The theory argues that crime patterns are formed by routinized social, cultural, and economic activities over time, and spatially constructed by social and physical environments (Brantingham & Brantingham, 1984, 1993b, 1995). Brantingham & Brantingham (1993b) suggested four elements to explain criminal behavior and crime patterns: (1) the actual process of commission of crime (*event process*); (2) offenders' readiness or willingness to commit a crime (*readiness/willingness*); (3) the general crime templates and activity backcloth (*activity backcloth*); and (4) the interactions of all three elements.

Event process is a series of decisions or choices that lead to the commission of crime. Potential offenders see a situation during the search process of opportunities to find a good place and time for crime. Prior to actual actions (commission of crime), decisions or choices are made in the process of search for criminal opportunities. Occurrence of the crime event also depends on the existence of motivated offenders with a sufficient *readiness/willingness* to commit a crime. Moreover, crime pattern theory explains patterns of crime in conjunction with the *activity backcloth*. Activity backcloth is a set of physical and structural surroundings. Understanding the activity backcloth is important because the other two abovementioned elements of crime pattern (event process and readiness/willingness) are largely shaped by the offender's knowledge of the activity backcloth. Therefore, "crime is an event that is best viewed as an action that occurs within a situation at a site on a non-static backcloth… [and it] is a product of varying initial conditions under which the decision processes leading to criminal events unfold" (Brantingham & Brantingham, 1993b:266).

The activity backcloth is formed by daily pedestrian routine activities. People (including motivated offenders) develop routinized activity patterns and spend most of their time in non-criminal routine activities. These routine activities interact with the physical environmental characteristics to shape the patterns of crime. Specifically, routine activities shape one's activity space where people develop their awareness space. The awareness space is spatially and temporally limited because people know only a limited area around their activity space. During the event process, the awareness space shapes the search area of potential offenders who assess whether the locations and time are more (less) suitable for committing crime. Once potential offenders see and perceive criminal opportunities (suitable targets, places, and time), they are motivated with readiness/willingness to offend. Thus, willingness/readiness is not independent of the knowledge of the surroundings within a spatially and temporally limited awareness space. In sum, the theory posits that the primary importance in understanding crime is the interactive nature of the link between the decision making process evaluating criminal opportunities and offenders' readiness/willingness to commit a crime arrayed on activity backcloth. Brantingham & Brantingham (1993b, 1995) conceptualized the *activity backcloth* as the spatial geometric notions: (1) *activity nodes*, (2) *pathways,* and (3) *edges*. In the following section, I provide a discussion of each of them.

<<< Figure 2-1 is about here >>>

Geometry of Crime

Activity Nodes

Brantingham & Brantingham (1984, 1995) describe how individuals' behavior interacts with the surrounding environment, *activity backcloth,* to produce different patterns of opportunities for crime. Specifically, they suggested that busier places would have more opportunities for crime resulting from more inflow of people, which leads to higher probability of having more potential offenders and victims present. Brantingham & Brantingham (1995) argue that crime patterns can be understood through examination of the different land uses that identify *activity nodes* (p.64). Specifically, certain types of business facilities (e.g., shopping centers, malls, schools, hotels, etc.) are seen to be *crime generators* that draw large number of people into places, some of whom may be potential offenders or victims. Other types of facilities are classified as crime attractors because of their reputations for criminal opportunities. Unlike crime generators, crime attractors do not necessarily bring large number of people into the places, but because of their functions, motivated offenders find the place attractive for criminal activities. One characteristic of crime attractors is that they provide motivated offenders many attractive and weakly guarded victims or targets (Bernasco & Block, 2011:35).

A number of papers have studied activity nodes and consistently found their crime enhancing effects (Bernasco & Block, 2011; Block & Block, 1995; Kubrin & Hipp, 2014; Kubrin, Squires, Graves, & Ousey, 2011; McCord, Ratcliffe, Garcia, & Taylor, 2007). These studies typically measure activity nodes as certain types of business facilities in locations such as bars, liquor stores, or restaurants. For example, in a block-level study of robberies in Chicago, Bernasco & Block (2011) tested whether various types of business facilities that are expected to attract criminals and generate crime increase the amount of crime in blocks. Crime attractors and generators used in the study included a wide array of facilities such as bars, clubs, restaurants, food stands, barbers, beauty salons, liquor stores, grocers, etc. The authors found that blocks that have crime attractors and generators not only have increased numbers of robberies within the blocks but also spread their crime risk to adjacent blocks. Additionally, Kubirn et al. (2010) and Kubrin & Hipp (2014) examined the impact of types of fringe lenders on neighborhood crime rates. Findings of both studies revealed that the presence of fringe banks in neighborhoods is related to higher levels of crime.

Although these studies theorized and revealed the criminogenic effects of businesses at places, another body of studies argue that business facilities at places potentially contribute to lower crime rates because they would enhance the opportunities of having social interactions and ties among residents resulting in high level of informal social control (Carr, 1992; Carr, Francis, Rivlin, & Stone, 1992; Oldenburg, 1999). Carr et al. (1992:45) refers to them as public spaces that “afford casual encounters in the course of daily life that can bind people together and give their lives meaning and power,” while Oldenburg (1999:16) refers to them as third places “that host the regular, voluntary, informal, and happily anticipated gatherings of individuals beyond the realms of home and work” thus have more guardians at places.

Third places include businesses such as restaurants, bars, coffee shops, cafes, ice cream parlors, pizza parlors, etc. In relation to crime, empirical studies have found that third places generally provide crime reducing effects in neighborhood (Papachristos, Smith, Scherer, & Fugiero, 2011; Wo, 2014). For example, in a recent longitudinal study, Papachristos et al. (2011) showed that third places have crime reducing effects. Specifically, the authors found that the presence of coffee shops is related to lower homicide rates in Chicago neighborhoods. Wo (2014) constructed an index of third places by combining the number of employees of coffee shops, cafes, bagel and doughnut shops, pizza parlors, ice cream paroles, diners, and snack and beverage shops. He hypothesized and found that neighborhoods with more third place employees have lower crime rates. In sum, based on the theorization and the findings of previous empirical studies, this dissertation views the concept of activity nodes as a primary type of physical environment in understanding the spatial crime patterns.

Pathways

Crime pattern theory argues that offenders decide to commit crime during the course of their routinized activities. Specifically, it suggests that offenders form awareness spaces through routine activities, and they are most likely to offend when they find suitable opportunities for crime. The street network is a fundamental factor that determines an offender's cognitive perception and knowledge about the environment and thus the opportunities for crime. This is because (1) awareness spaces are formed by travel patterns in regular daily activities, thus the paths by which offenders regularly take affect their awareness of potential victims; (2) crime generators and attractors are located on the street network; and (3) offenders have to move to or from one place to another to offend via the street network system. In all cases, the routes that offenders take are constrained by the shape of street network. Therefore, Brantingham & Brantingham (1993a:17) stated that “the physical structure of the road network itself seems to influence how far crime spreads from major pathways.”

Moreover, the configuration of street network plays an important role in shaping of non-criminal pedestrian activities which may affect (in) formal social control and guardianship. This is because the number and type of people at a given time and place can be largely determined by street networks and routes that they take to travel from one place to another. However, the theoretical context of the street network and crime is more complicated. On one hand, it is plausible to think that more pedestrian activities along the street network are associated with lower crime risks due to higher level of natural surveillance. In contrast, areas with fewer people passing by via street network are accountable for greater amount of crime compared to those with more pedestrian activities as there would be lower informal surveillance and natural policing from eyes on the street in the area (Jacobs, 1961).

On the other hand, areas with more transient pedestrian activities would have more criminal opportunities given that they have more people visiting the place including potential offenders and targets at the same time and place. Also the areas would have less territoriality, which may reduce the territorial protection and natural surveillance. Newman (1972) contended that the more territorial subdivision exists, the better residents can recognize which persons do (not) belong in the area. This is because increased territoriality reduces the ambiguity on who is responsible for the surveillance of the area. For example, in the study of streets and crime in Saint Louis, Missouri, Newman and Franck (1980) empirically tested the effects of private streets (blocked off at the one end not to allow through traffic) on crime, and found that the private streets have lower violent and property crime in general. This implies that more crime is expected on the streets used more frequently.

Based on the complicated theorizations, a body of studies empirically examined the relationship between street network configuration and crime, and found that more accessible streets have more crime (Ackerman & Rossmo, 2015; Beavon et al., 1994; Bevis & Nutter, 1977; Davies & Johnson, 2015; Hillier, 1996; Johnson & Bowers, 2010). Bevis & Nutter (1977) is probably the earliest work of street network design and crime. In a study of isolated streets, network density, and burglary in Minneapolis, the authors hypothesized that houses and apartments along less accessible streets will not be burglarized as much as the ones along more accessible streets. Utilizing a measure of accessibility of streets at the tract level (a beta measure derived from graph theory – total number of street segments divided by the total number of intersection nodes within area), they found support for the hypothesis that there exists a positive association between accessibility of streets in a tract and the burglary rate even after controlling for measures of structural characteristics.

White (1990) also examined the effects of permeability on burglary rates in 86 neighborhoods in Norfolk, Virginia in 1987. He found that more accessible areas have higher risk of burglary after controlling for various other relevant factors. In this study, permeability was defined as the number of access streets from major roads (arterial streets) to the neighborhoods. A similar pattern is observed in a study employing smaller spatial units (street segment). In Ridge Meadows, Canada, Beavon et al. (1994) measured street accessibility as the number of other segments with which it shared an intersection node, while a hierarchical road classification system was used to measure traffic flow. They found that both road network complexity and traffic flow in each segment were associated with lower levels of property crime.

In a more recent study of permeability and burglary risk, Johnson & Bowers (2010) also observed the same pattern that burglary risk is lower on cul-de-sacs, and major roads and the streets connected to them have higher burglary rates.

Another body of studies employed a method known as space syntax (Hillier, 2004). Space syntax is mathematical approach to quantify the characteristics of the street network (Summers & Johnson, 2016) and measures how each street segment connects to every other (Johnson & Bowers, 2010). Three space syntax measures are most frequently employed: (1) integration, (2) connectivity, and (3) choice. *Integration* measures accessibility or closeness centrality that indicates how close a street segment is to all other surrounding segments within a given distance threshold. It is defined as the inverse of cumulative distance required to reach from that street segment to all other segments that fall within the search radius along the shortest paths. *Connectivity* measures is the number of street segments connected to a street segment. *Choice* is defined as the fraction of shortest paths between pairs of other street segments in the network that pass by a street segment. Several studies of space syntax empirically tested the effects of street network on crime and their findings are mixed. While some studies found that streets with higher integration, connectivity, and betweeness have higher risk of robbery and violent crime (Baran et al. 2006; 2007), other studies found that less accessible streets have more crime when controlling for the length of street segments. In sum, based on the theorization and the findings of previous empirical studies, the dissertation sees the concept of pathways (street network configurations) as an important type of physical environment in understanding spatial crime patterns.

Edges

The Brantinghams consider the importance of *edges* defined as the physical boundaries where noticeable changes are observed as one type of activity backcloth. For example, locations next to rivers can be edges given that rivers can be a very pronounced boundary. Likewise, regional or local parks have edges. Transit systems such as major roads, interstate highways, or railroads themselves can constitute edges. Finally, edges can be considered in terms of different cognitive images with diverse land use on either face of a street where different land use zones adjoin. Areas around (or contiguous) edges often have high crime rates. Brantingham & Brantingham (1993a) argued that many of the crimes that occurred at high-activity locations such as commercial stores, bars, or sporting arenas occur at the edges of them. This is because: (1) there exists more anonymity and less surveillance, and thus strangers can access the edges more easily; and (2) the formation of social ties among residents can be limited across physical boundaries. In terms of the first point, because edges may contain mixes of land use and physical features of crime generators and attractors, strangers are more easily and frequently accepted than interior areas where strong territorial boundaries are set. In regards to the second point, a neighborhood containing a long stretch of an edge can be bisected into separate areas. In such neighborhoods, residents may have difficulty establishing social ties with those on the other side, which decreases the level of neighboring, attachment, and cohesiveness. Indeed, Hipp, Corcoran, Wickes, and Li (2014) found that the neighborhoods where edges (particularly highways and rivers) are present have lower level of cohesion and informal social control and therefore fewer guardians, which are known to have crime reducing effects in neighborhoods.

In spite of the theoretical importance of edges in understanding crime, relatively less attention has been paid to whether areas near edges actually have more crime (Brantingham & Brantingham, 1978; Brantingham & Brantingham, 1975; Brantingham et al., 2009; Song et al., 2015). Brantingham & Brantingham (1975; 1978) tested and found that street segments in the border area of a neighborhood have higher burglary rates than those located in the interior of the neighborhood. Brantingham et al. (2009) defined edges as locations where land use classifications changed from one to other types. They employed a “fuzzy topology algorithm” to measure the amount of land use difference and changes at the street block level and found that the burglary levels on the borders are about three times higher than in the interior of neighborhoods. In a recent study, Song et al. (2015) empirically tested levels of criminal victimization on edges and confirmed that criminal victimization rates were 2–3 times higher on an edge compared to elsewhere, although this effect decreased very quickly moving away (about 40 meters) from these locations. In a recent study in the Southern California area, Kim & Hipp (2017) also found that that street segments near physical boundaries such as highways, rivers and park boundaries often have more crime. Interestingly, the measure of less visible edges (city administrative boundaries) also showed a significant positive relationship with crime. In sum, based on the theorization and the findings of previous empirical studies, the dissertation considers the concept of edges (spatial boundaries) as one primary type of physical environment in understanding the spatial crime patterns.

Contextualizing Social Environment and Crime in Place

So far, I have theorized the physical environment part of the dissertation by discussing the importance of criminal opportunities provided by the *activity backcloths* – conceptualized as *activity nodes, pathways,* and *edges*. However, another body of research suggests that the social environment operationalized as the structural characteristics of places (i.e., poverty, ethnic heterogeneity, and residential mobility) contains important factors that affect the amount of crime. These studies usually employ social disorganization theory as the theoretical frame. The theory argues that certain structural characteristics of neighborhoods impede the formation of social cohesion and common values among residents, and lower levels of informal social control, thereby decreasing the ability to supervise and intervene (Bursik, 1988; Bursik & Grasmick, 1993; Morenoff, Sampson, & Raudenbush, 2001; Sampson & Groves, 1989; Sampson, Raudenbush, & Earls, 1997).

According to the theory, neighborhoods with high levels of economic disadvantage, residential instability, and racial/ethnic heterogeneity are likely to have more offenders and crime. (Shaw & McKay, 1942). Specifically, such structural factors impede the sharing of common values and trust among residents, thus decreasing the ability to maintain informal social control – ability to regulate community itself (Bursik, 1988; Bursik & Grasmick, 1993; Kubrin, 2003). Therefore, informal social control in the form of informal surveillance, communication, supervision, and intervention is thought to be the key mechanism intervening between social disorganization and crime.

Although numerous studies of social disorganization theory have tested the relationships between various structural characteristics and crime, less attention has been paid to the theoretical importance of the geographical aggregation employed, especially at the level of micro places. However, it is necessary to test the effects of various structural characteristics on crime at the level of micro places such as street segments for several reasons. First, as previous studies have suggested, the causal mechanisms of structural characteristics vary in spatial scale (Hipp, 2007; Taylor, 2015). That is, structural characteristics differ in their effects based on the level of aggregation employed. For example, Hipp (2007) found that effects of racial/ethnic heterogeneity and economic resources can differ in their effects by the geographical level of aggregation.

Second, social disorganization theory is also applicable to understanding crime patterns at micro places. Barker (1963) coined the term "behavior setting" as a pattern of behavior and social environment to explain the relationship between people's behavior in a particular situation and the structural characteristics. Wicker (1987) viewed street segments as small scale social communities (behavior settings) where people know each other, get familiar with others' routines, develop and share their own norms on street segments. Moreover, street segments are as temporally dynamic as other geographic units as people constantly move in and out and land use keeps changing (Taylor, 1997). Therefore, street segments can be seen as locations that contain the characteristics of communities presented in social disorganization theory. Thus, "if the street segment can be seen as a type of 'micro community,' then social disorganization theory would seem to have direct relevance to the understanding of the criminology of place" (Weisburd et al., 2012:45). Scholars of criminology of place, however, have generally neglected the importance of social disorganization theory in empirical studies. A rare exception was a study attempting to collect proxy data in street segments for several social disorganization constructs (Weisburd et al., 2012). Indeed, in a recent empirical study, using imputation methods to apportion the Census block data to measure the structural characteristics of street segments, Kim (2016) confirmed that the structural characteristics of street segments operate as crucial settings for crime. Therefore, it is necessary to account for the effects of characteristics of social disorganization when studying crime at the street segment level. In sum, the dissertation considers social environment in understanding spatial patterns of crime in place based on social disorganization theory.

Working Together? Moderating Effects between Physical and Social Environments

The effects of physical environments on crime may be moderated by social environment of the place. Theories of criminal opportunities posit the presence of motivated offenders, potential victims, and capable guardians at the same place and time as a function of criminal opportunities, whereas social disorganization theory sees crime as a product of structural characteristics (i.e., concentrated disadvantage). This dissertation proposes that although each type of environment contributes to explaining crime in places, the criminal opportunities provided by physical environment (activity backcloth – conceptualized as activity nodes, pathways, and edges) may be contingent on social environment (i.e., socioeconomic status of places).

Socioeconomic status should have significant main effects on crime because it may provide hints to offenders about the general accessibility to and relative attractiveness of places for commission of crime. However, socioeconomic status of place may moderate the effects of certain physical environments. For example, the effect of living in a high disadvantaged areas may be so strong that variations in routine activity patterns of motivated offenders and potential victims constructed by activity nodes, pathways, and edges may not be impactful to the risk of crime in places. Or, in contrast, a potential trend is that socioeconomic disadvantage may strengthen the crime enhancing effects of certain physical environments. For example, high disadvantaged areas are likely to face challenges facilitating cohesion, trust, organizational participation, and social ties between residents, which may heighten the crime enhancing effects of certain physical environments in the areas.

Indeed, some empirical studies have found significant potential interactions between physical environments and socioeconomic status. For example, in a street segment level study, Smith et al. (2000) found that the effects of specific types of business facilities such as hotels/motels, bars, restaurants, and gas stations on street robbery are moderated by socioeconomic status measured as the number of single parent households. Specifically, on street segments with a motel/hotel, each additional single-parent household has an approximate 24% increase in the number of street robberies and where bars, restaurants, and gas stations are found on the same street segments with single-parent households, street robbery is more likely. Similarly, Rice & Smith (2002) tested interaction effects between the number of certain types of businesses (bars, restaurants, and gas stations) and building values in street segments (as a proxy measure of economic status), and found that low building values result in increased auto theft, but more so if buildings are located on face blocks with these features of businesses.

In terms of interactions between the structural characteristics and pathways, although it was not directly about crime, Vaughan (2005) examined how street connectivity, income, and poverty are related. He found that street connectivity can be a significant factor influencing the spatial distribution of poverty. Specifically, higher-class streets tend to have much more direct accessibility (in terms of directional reach) than lower-class streets (See also Carpenter & Peponis, 2010; Vaughan et al., 2005; and Vaughan, 2007).

When it comes to edges, Brantingham & Brantingham (1993a) suggested that since areas by spatial edges may contain structural characteristics that brings about less informal social control in communities, there can be less surveillance by stable residents who are committed to keep their community safe. These considerations suggest that the characteristics of edges may interact with the structural characteristics of places to shape human activity and thus moderate crime patterns. Therefore, this dissertation considers possible interactions between physical environments measured as activity nodes, pathways, edges and social environments in terms of socioeconomic status of places.

Street Segment as a Unit of Analysis

The unit of analysis of this dissertation is street segment, a type of small unit. A street segment is defined as both sides of a street between two intersections. Using small units such as street segment warrants both theoretical and methodological merits. Theoretically, small units are preferred because they better measure the physical and social environments. Residents' behaviors are affected by physical and social surroundings only when they can perceive these environments with their senses; and these environments are arguably small. Small units of analysis are methodologically better because small units are less likely to be heterogeneous in their environmental conditions, but more homogenous; thus, at lower risk of ecological fallacy. Therefore, it is fair to assume that smaller units are less vulnerable to the risk of the aggregation bias.

Studies of crime and place employing small units of analysis emphasized the importance of micro places. Eck and Weisburd (1995) define micro places as specific locations within the larger social environments of communities. The definitions of these places vary: buildings or addresses, block faces, or street segments. A body of literature finds that crime is not randomly distributed but rather spatially concentrated at these "micro" places regardless of the unit of analysis used (Eck et al., 2000; Eck & Weisburd, 1995; Sherman, Gartin, & Buerger, 1989; Sherman & Weisburd, 1995; Taylor, 1997; Taylor & Gottfredson, 1986). Indeed, a number of studies argued that small units of analysis are both theoretically and methodologically preferred (Groff, Weisburd, & Yang, 2010; Oberwittler & Wikstrom, 2009; van Wilselm, 2009; Weisburd, Groff, & Yang, 2012). For example, in a study comparing the aggregate level reliability of survey by different levels of aggregation, Oberwittler & Wikstrom (2009) found that there is a general tendency for weaker and subtle effects to disappear when analyzed at a higher level of aggregation. They explained this result that this may be because aggregating small units waters down the degree of spatial homogeneity. Moreover, they suggested that lower levels of aggregation produce more nuanced and complex findings.

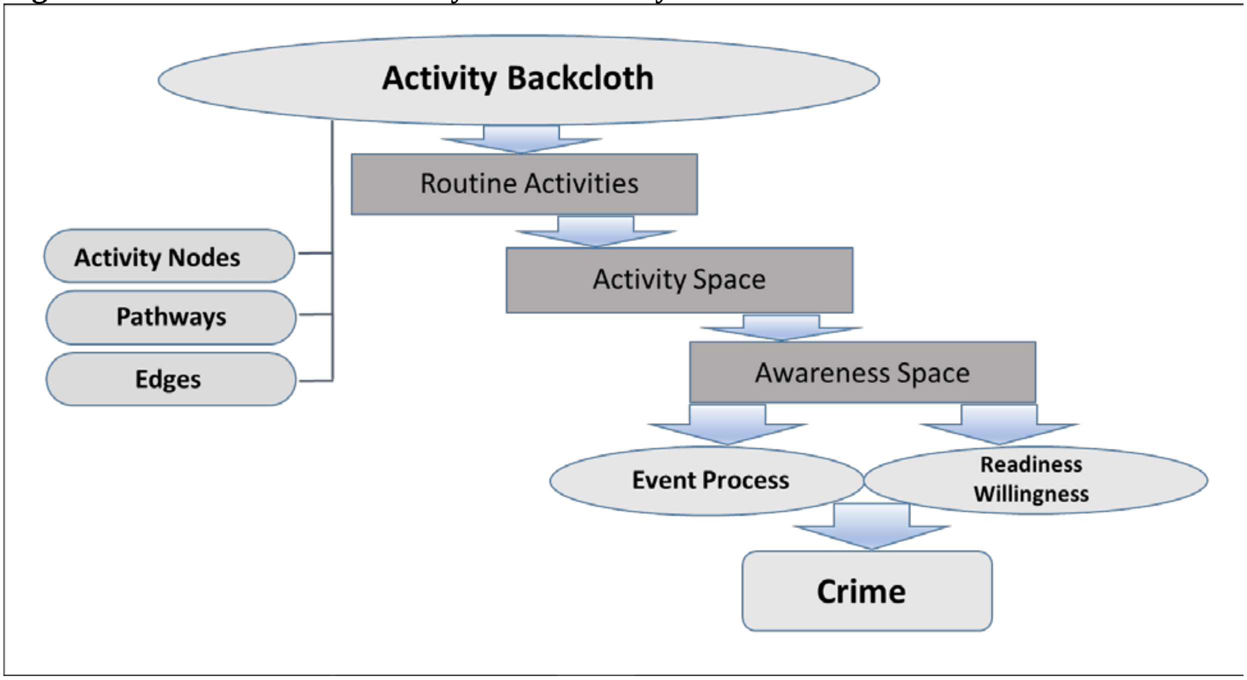
The street segment is one of the most frequently employed small units of analysis. Previous studies revealed a spatial concentration of crime at street segments (Groff & LaVigne, 2001; Groff et al., 2010; Weisburd, Bushway, Lum, & Yang, 2004; Weisburd et al., 2012) and the patterns of crime concentration are stable over time. Additionally, these studies found that there is substantial street-to-street variability of crime levels, which may not be observable in studies using larger units of analysis (Weisburd et al., 2012; Groff et al., 2010). These findings suggest that within an area, crime patterns across street segments are spatially heterogeneous; thus crime patterns of individual street segments can be completely distinct from their adjacent streets.

Importantly, Weisburd et al. (2012) hypothesized and found that there is substantial variability of opportunities for crime and structural characteristics across street segments. Specifically, they found strong evidence of spatial heterogeneity of criminal opportunities (i.e., business related crime generators and attractors) and social disorganization (i.e., residential property values, land use, racial heterogeneity, and physical disorder) at the street segment level. They suggest that studies at larger geographic units might not properly capture the effects of criminal opportunities and structural characteristics of places.

Moreover, some studies have suggested that theories of criminal opportunities are more applicable to micro places. Sherman et al. (1989:31) defined the precise geographic place for understanding crime as "a fixed physical environment that can be seen completely and simultaneously, at least on its surface, by one's naked eyes." Brantingham & Brantingham (1984, 1993a) also suggested that crime pattern theory is more plausibly theorized and empirically tested at the micro place level. As stated above, the Brantinghams argued that routine activities physically shape residents' awareness space from which they can develop their activity space. The awareness space is spatially and temporally restricted because of limited area around their activity space. Therefore, it is more plausible to study criminal opportunities and structural characteristics at micro places such as street segments.

Chapter 2 Figures

Figure 2-1. Crime Pattern Theory and Geometry of Crime



CHAPTER 3. ACTIVITY NODES

Introduction

A number of studies have examined the association between the presence of various types of business facilities and crime, and found that business facilities operate as activity nodes – crime generators and attractors. The types of businesses include schools, restaurants, malls, hotels, and check-cashing stores. Although the existing studies successfully theorized and revealed the protective/adverse effects of business facilities on crime at places, less attention has been paid to distinguishing the specific characteristics of businesses, and how the spatial patterns of crime can vary by them. These characteristics include: (1) type of business, (2) number of employees, (3) local ownership status (whether it is owned and run by a local entrepreneur or a non-local franchise company), and (4) age of business (number of years since a business facility has established and started operating). These characteristics are important in understanding crime because they are the factors in shaping of the number and type of people routinely visiting the place, and the quantity and quality of social interactions among them; yet, they have been not comprehensively tested in the existing literature. In the subsequent section, I discuss each one of these characteristics of activity nodes.

First, type of business is one of the key factors in understanding the crime pattern in place. Criminal opportunities and the probability of whether a motivated offender actually commits a crime differ based on the sites and situations surrounding the offenders. Studies suggest that the number and type of business facilities can create different criminal opportunities in place. Some previous research has studied the number and type of business in place and constantly found the adverse effect on crime (Bernasco & Block, 2011; Block & Block, 1995; Kubrin & Hipp, 2014; Kubrin, Squires, Graves, & Ousey, 2011; McCord, Ratcliffe, Garcia, &

Taylor, 2007). These studies typically measure activity nodes as certain types of business facilities in locations such as bars, liquor stores, or restaurants. In contrast, other scholars have argued that the number and type of businesses in place may have protective effects in that they can help to formulate social ties that are necessary for informal social control, thus engender social organization or collective efficacy among residents (Beyerlein & Hipp, 2005; Morenoff et al., 2001; Pattillo, 1998; Papachristos et al. 2011; Peterson et al., 2000; Sampson & Groves, 1989; Slocum et al., 2013; Wilson, 1987).

Second, the number of business employees is another important factor. Larger business facilities are likely to have more customers visiting. Places with higher magnitude of people moving in-and-out would have higher criminal opportunities because of higher probability of the convergence of potential offenders and targets at the same time and place. While it is not easy to quantify the number of people visiting a business facility, the number of employees can be used as a proxy measure. Also, other studies theorized that the number of business employees matters not only because it can be a proxy measure of potential inflow of people visiting the place but because employees may act as capable guardians in place. Jacobs (1961) suggested that shopkeepers can play an active role that can prevent neighborhood problems. She stated that "store keepers and other small businessmen are typically strong proponents of peace and order themselves; they hate broken windows and holdups; they hate having customers made nervous about safety" (Jacobs, 1961, p.37). Also, Clarke (1992) studied how business employees can regulate others' behaviors. He argued that business employees can play even more important roles than local residents for keeping the neighborhood safe during working hours. Felson (2002) also suggested that employees can be the most important controllers of places in particular settings. Eck & Weisburd (1995) emphasized the role of a 'place manager' who is professionally responsible for the surveillance of a place such as a security guard or a store clerk. In sum, these studies implied that there would be lower risk of crime if there are more active business employees in place.

However, an alternative hypothesis could be that when the number of business employees is sufficiently large, there would be so-called “free riding effect” that employees would less likely to act as capable guardians as they let someone else do. This suggests that the relationship between the number of employees and crime in place may be non-linear (Steenbeek et al., 2011). Jacobs also recognized the possible curvilinear effect of the number of employees on crime as she stated that “[business employees] are great street watchers and sidewalk guardians *if present in sufficient numbers*” (1961, p.37).

Third, the local ownership status whether a business is run and owned by local entrepreneurs or by larger corporations is also important to consider, yet rarely tested in previous studies. Since local businesses are more locally patronized by customers, they may feel more familiarity but less anonymity when visiting the place. Such businesses are more likely to operate as locus of social activities and interactions, which may enhance the level of informal social control among the residents. In contrast, non-local businesses can simply act as *crime generators* that just draw a large number of random anonymous people into the place; thus provide more criminal opportunities. Although it is theorized that different local ownership status of a business may have dissimilar effects on crime, they are not necessarily mutually exclusive. That is, locally owned businesses sometimes can act as crime attractors or crime generators, while non-local businesses can also be a potential locus of social interactions, networks, and ties for the residents. Then, the necessary next step is empirically testing whether the local ownership status of the business actually matters in understanding crime in street segments.

Finally, age of business (i.e., number of years since establishment) is also another important factor. Business facilities can undergo potential changes over time, which brings about changes in surrounding landscape. Such environmental changes, in turn, may have consequences for either enhancing or reducing crime in place. Specifically, business facilities are likely to experience changes in terms of the type and number of customers visiting, the number of employees, financial status, or the locations over time. Therefore, recognition of the temporal dynamic aspects of business facilities is important for understanding how they can affect spatial patterns of crime.

Wo, Hipp, & Boessen (2016) theorized temporally dynamic aspects of voluntary organizations (e.g., youth development, vocational, recreational, crime prevention organizations, etc.) on neighborhood crime. They argued that although the existing literature suggested crime reducing effects of voluntary organizations, certainly, they will not last forever and would not reduce crime rates all the way down to zero. Although Wo et al. (2016)'s work was about voluntary organizations and neighborhood crime, the theorization of temporal dynamics of organizations can be applicable to understand the relationship between business facilities and crime in place.

In sum, although a number of studies have tested associations between activity nodes and crime in place, less attention has been paid to the various characteristics of businesses such as type of business, number of employees, local ownership status, and age of business, and how the patterns of crime in place can vary by them. Yet, theoretical and empirical evidence suggests that such factors matter in understanding spatial patterns of crime. Therefore, this chapter of the dissertation attempt to test whether there exist distinct effects of businesses on crime by the characteristics suggested above. Additionally, as theorized in Chapter 2, the effect of physical environments in terms of activity nodes can be moderated by the socioeconomic status of place. Indeed, empirical studies suggest potential interactions between measures of activity nodes and socioeconomic status of place (Smith et al., 2000; Rice & Smith, 2002). Therefore, this chapter of the dissertation estimates a series of interaction terms that pair together measures of activity nodes and a measure of economic status in street segments.

Data and Methods

Independent Variables

The unit of analysis of the current study is the street segment (both sides of a street between two intersections). About 300,000 street segments in about 200 cities across the Southern California area (Counties of Los Angeles, Orange, San Diego, Imperial, Riverside, San Bernardino, and Ventura) are included. To measure various characteristics of business facilities in places, this chapter utilized the Reference USA business establishment data in 2010. The data include a wealth of information such as addresses, types of businesses by North American Industry Classification System (NAICS) 6-digit code, the number of employees, year of establishment, the business revenues, and etc. In order to properly obtain the information of businesses in street segments, I geocoded addresses of businesses to latitude–longitude point locations using ArcGIS 10.2 and then aggregated to street segments.

Using the Reference USA data, I created various measures of activity nodes to capture the characteristics of businesses as discussed above. First, to capture various types of businesses, I use NAICS codes to create a typology of 10 types of consumer-facing businesses: “Drinking

Business" (Beer, Wine, and Liquor Stores and Drinking places), "Retail Business" (Apparel Retailing, General Merchandise Retailing, Home Products Retailing, Personal Products Retailing, and Specialty Retailing), "School Business" (Elementary and Secondary Schools and Other Learning Institutions), "Service Business" (Auto Services, Child Care Services, Gas Stations, Laundry, Hair Care Services, Other Personal Services, and Repair Services), "Finance Business" (Deposit-taking Institutions and Personal Financial) "Restaurants" (Full-Service Restaurants and Limited-Service Food and Beverage), "Health Business" (Healthcare Provider Offices, Hospitals, and Medical Laboratories), "Amenities" (Movie Theaters and Recreational Facilities and Instruction), "Organizations" (Religious Organizations and Social Service Organizations), and "Stores" (Convenience Stores, Drug Stores, Groceries, and Specialty Food). This typology follows Kane, Hipp, & Kim (2016), which categorized NAICS codes based on whether businesses are interregional or intraregional. For more information on the 10 types of business categories, please see Appendix Table A3.1 which contains the detailed information of which business types are linked to which NAICS codes.

Second, to measure the number of employees of the 10 types of businesses in street segments, I used the information of the number of employees provided by the Reference USA data. The total number of business facilities and employees of a business type is aggregated at the street segment level. Next, to properly identify whether business facilities are owned and run by local entrepreneurs or larger corporations, I considered three different attributes in the Reference USA data: (1) whether a business facility is a franchise or not; (2) whether a facility is a headquarter, branch, or neither; and (3) if a facility is publicly traded company, branch of publicly traded company, or private company.

The third attribute is based on an assumption that most local businesses tend not to be publicly traded. Combining these three criteria together, a business facility is identified as locally owned and run, if it is (1) not categorized as a franchise, (2) neither a headquarter nor a branch, and (3) a private company; otherwise, it is treated to be franchise owned and run. Then, the total number of local or non-local businesses of each of the 10 business types is aggregated at the street segment level. Finally the age of each and all 10 types of consumer facing business facilities are calculated as the establishment year of a facility subtracted from the current data year. For example, if the data year is 2010 and the year established is 1997, the age of this facility is 13 years. Then, the average of each of the 10 business type of consumer facing businesses is computed at the street segment level.

To measure structural characteristics of street segments, data collected at the street segment level is preferred, yet such data are hard to obtain. Alternatively, in a recent study, Kim (2016) proposed two unique methods for imputing existing Census data at the block level to street segments: Simple Average (SA) and Segment Weighted Average (SWA). The results confirmed that the two imputation methods are generally valid compared to data actually collected at the street segment level, and thus the simpler method (SA) is effectively preferred. Therefore, I employ the SA method to impute the 2010 Census block data to street segments to measure structural characteristics. A typical street segment is associated with two contiguous blocks (Block A and B in Figure 1). The SA method calculates the average values of these two blocks to apportion the data of the blocks to the street segment, which takes following form:

$$SA = \frac{\sum_{j=1}^{J} V_j}{J} \qquad (3\text{-}1)$$

where J is the number of contiguous blocks associated with a given street segments, V_j is value of Census data of block j. To test the effects of structural characteristics of street segments, the current study includes Census indicators of the three structural determinants of social disorganization. First, I constructed a *concentrated disadvantage index*, which is a factor score computed after a factor analysis of four measures: (1) percent at or below 125% of the poverty level; (2) percent single-parent households; (3) average household income; and (4) percent with at least a bachelor's degree. The last two measures had reversed loadings in the factor score. Second, to measure *residential stability*, this study utilizes the percent home owners. The present study controls for the presence of racial/ethnic minorities in street segments as the percent African-American and the percent Latino/Hispanic. To capture the level of *racial/ethnic heterogeneity*, a Herfindahl index based on five racial/ethnic groups (white, African-American, Latino, Asian, and other races) was computed, which takes the following form:

$$H = 1 - \sum_{j=1}^{J} G_j^2 \qquad (2\text{-}2)$$

where G_j indicates the proportion of the population of racial/ethnic group *j* out of *J* groups. Besides the variables included above, this study also accounted for the percent *occupied units* to measure vacancies.

Dependent Variables

The dependent variables of this chapter are the number of incidents of violent crime (aggravated assault, robbery, and homicide) and property crime (burglary, larceny, and motor vehicle theft). The crime data for this study come from the Southern California Crime Study (SCCS). These are from official crime data. Police agencies of cities reported incident crime data with geographic information such as addresses or 100 blocks. SCCS classified crime events into violent crime and property crime. Crime events were geocoded for each city separately to latitude–longitude point locations using ArcGIS 10.2, and subsequently aggregated to street segments. In the current study (and the subsequent analytic Chapters 4-5), I used the average of violent and property crime incident data in 2010, 2011, and 2012 at the street segment level.

Some prior studies have not included crime incidents that occurred at intersections for the following reasons: (1) Since the events at intersections could be considered part of any one of the participating street segments, there is no clear method for assigning them to one or another; and (2) incident reports at intersections differed dramatically from those at street segments (Weisburd et al. 2012; Weisburd et al. 2014; Groff et al. 2010). However, if characteristics of crime at intersections (about one percent in the data) are not different from those at street segments, excluding them might introduce a systematic bias. Therefore, instead of simply dropping all the crime incidents at intersections, I evenly assigned them to contiguous street segments (Kim, 2016). For example, if a crime incident occurred on a typical intersection where two roads cross, each of four segments is given 0.25 of a crime incident.

Analytic Strategy

Since the dependent variables of the current study are counts of crime events (violent and property crime), their distributions are not likely to be normally distributed. Accordingly, negative binomial regression, which effectively deals with over-dispersion, is used in the current study (Osgood, 2000). It is likely that segments have different levels of exposure to risk to crime. Therefore, I included (logged) population as an exposure term in all models and the coefficient is constrained to equal 1. The inclusion of the exposure term effectively translates the outcomes to crime rates. I also employ a fixed-effects modeling strategy by including dichotomous variable of each city, which allows me to test changes of crime *within* a particular city rather than *across* cities.

Research has emphasized the spatial dependence of neighborhoods in relation to the distribution of crime (Anselin et al., 2000; Cohen and Tita 1999). To account for potential spatial autocorrelation, the current study includes spatially lagged independent variables for the measures of the structural characteristics. Including spatially lagged independent variables in the models is a conventional and valid way to account for spatial effects if theoretically justified. Anselin (2002:251) stated that it "does not require specialized estimation methods and ordinary least squares remains unbiased." Florax & Folmer (1992) argued that omission of spatially lagged independent variables is an important cause for spatially correlated residuals. They empirically tested and revealed that the spatially dependent residuals can be remedied by incorporating the omitted spatially lagged predictor variables into the model. Many studies in the field address spatial dependence by including spatially lagged exogenous variables (Anselin, 2003; Bernasco & Block, 2011; Elffers, 2003; Haberman & Ratcliffe, 2015; Kubrin & Hipp, 2014; Morenoff, 2003; Sampson, Morenoff, & Earls, 1999; Wo, 2014; Wo et al., 2016). I follow the lead of these previous studies by including spatially lagged independent variables to account for spatial effects.

The current study created spatially lagged measures of structural characteristics based on an inverse distance function with a cutoff at 0.25 mile around the street segment (beyond which the areas have a value of zero in the *W* matrix). The resulting spatial weights matrix (*W*) is row standardized. This matrix is multiplied by the matrix of values in the blocks for the variables of interests. As the 0.25 mile buffers of a street segment and the contiguous blocks are geographically very proximate, it is plausible to suspect that the spatially lagged independent variables of blocks and segments are highly correlated. Effectively, I used the SA method to construct the spatially lagged independent variables at the segment level. In other words, the average values of the block level data were apportioned at the street segment level using the average of the buffer measures of blocks contiguous to the street segment.

This study estimates a series of models in which the effects of characteristics of business facilities abovementioned are tested while controlling for the effects of structural characteristic measures. The general form of these models is

$$E(y) = exp(\alpha + \beta_2 x + \beta_3 z + \beta_4 wz + \beta_5 j) \qquad (2\text{-}3)$$

where *y* is the dependent variable to be explained (the number of violent or property crime events in that year), α is an intercept, *x* represents a matrix of various business measures in the models, *z* is a matrix of the structural characteristic variables, *wz* is a matrix of the spatially lagged structural characteristic measures, and *j* is a matrix of the dummy variables for cities. Specifically, Model 1 (EST column in Tables 3.2 and 3.3) includes the number of the 10 consumer facing types of business establishments in street segments, while in Model 2 (EMP column), the number of employees of businesses substitutes the number of business establishments. Note that the measures included in Model 1 and 2 have no distinction between local and non-local businesses.

Compared to Model 1, Model 3 (LOC column) tests whether the distinction of local and non-local business matters in terms of crime. To do this, Model 3 includes the number of the 10 types of *local* businesses establishments identified using the method discussed above. Note that only the number of establishments of local businesses are included in Model 3. Model 4 (AGE column) testes the effects of ages of the various types of business establishments (no distinction between local and non-local in this model). Finally, in order to see if there exist interaction effects between the number of various types of business facilities and socioeconomic status of street segments, I estimated a set of models including the measures in Models 1-4 with the interaction terms with the concentrated disadvantage index, respectively (Tables 3.4 and 3.5). To capture possible non-linear relationships, squared and cubic terms are included for the primary business measures included in the models. Table 3.1 presents the summary statistics for the dependent and independent variables used in the analyses.

<<< Table 3.1 about here >>>

Results

Main Effect Models

The complete set of coefficient estimates from the main effect models are shown in Tables 3.2 and 3.3. I have plotted the predicted values of violent and property crime in Appendix Figures A3.1-80. The x-axis represents the values of business measures included in the models ranging from 1st to 95th percentile of the distribution, while the y-axis is for the predicted rates of violent or property crime. First, I begin with the findings of the number of business establishments (EST). Figures 3.1 and 3.2 indicate the effect of the number of retail business establishment. As shown, the general pattern is crime-enhancing for violent and property crime. Specifically, one additional increase in the number of retailers results in about an 8 percent increase in the violent crime rate and a 15 percent increase in the property crime rate. This means that street segments with more retail businesses would have higher risk of violent and property crime, in general. Likewise, as the number of health related businesses increase, risks of violent and property crime increase (Figure 3.3).

<<< Tables 3.2-3 about here >>>

<<< Figures 3.1-2 about here >>>

Interestingly, I observe that some types of businesses have non-linear relationships (inverted U-shape) with the risk of violent and property crime. At low levels, increase in schools, financial businesses, restaurants, amenities, organizations, and stores initially lead to a corresponding increase in violent and property crime rate. However, beyond a threshold, these businesses begin to exert negative effects on the risk of crime. For example, as shown in Figures 3.4 and 3.5, as the number of restaurants increases up to a threshold 5, violent (property) crime rate increases about 95 (92) percent; yet the pattern turns to be crime-reducing after the threshold that violent (property) crime decreases about 30 (35) percent as it increases up to 10. The results confirm that the amount of crime in place largely depends on the various types of businesses.

<<< Figures 3.3-5 about here >>>

Next, I turn to the findings of the number of business employees (EMP). I observe that the number of business employees is positively associated with violent and property crime, regardless of the types of businesses. For example, according to Figures 3.6-7, every twenty additional number of retail business employees lead to about 5-10 percent increase in violent crime and 10-15 percent increase in property crime in street segments. Although I hypothesized a non-linear relationship between the number of business employees and crime, I find less evidence to support the hypothesis in the current study. This implies that the measures of business employees operationalized as proxy of the magnitude of people moving in-and-out, may capture the criminal opportunities rather than the level of guardianship in place.

<<< Figures 3.6-7 about here >>>

Turning to the findings of the local ownership status of business (LOC), I see that the general patterns are similar to the results not considering the local ownership status (EST

Model). For instance, street segments with more local retail businesses would have higher risk of violent and property crime, similar to the findings of the EST described above. However, I see some distinct patterns for a few local business types that have curve-linear relationships with crime. For instance, similar to the EST results, increase in the number of local restaurants, services, and stores initially lead to increase in the risk of violent and property crime; yet beyond a threshold, the pattern turns to crime-reducing. For a comparison, I plotted the predicted rates of violent and property crime from the EST and LOC models together in Figures 3.8-15. Importantly, I observe that although the general patterns of LOC look similar to the EST, the crime reducing part of the curvilinear pattern is more pronounced in the LOC than the EST. That is, the inflection point (or the threshold point) where the patterns turn to be crime-reducing is at lower in the LOC compared to the EST (Figures 3.8-15). For instance, as shown in Figures 3.8 and 3.9, locally owned school/learning businesses have about 23 percent and 33 percent lower violent and property crime compared to the EST on average. Likewise, local restaurants have about 10 percent lower risk of violent and property crime compared to the measure of restaurants in street segments not considering local ownership status. This may suggest that the local ownership status may strengthen the crime-reducing part of the effect for the businesses that have curve-linear relationships with violent and property crime in street segments.

<<< Figures 3.8-15 about here >>>

Next, I turn to the results of age of business. I theorized that potential changes that a business facility can experience over time may be an important factor in understanding crime pattern in place. I find that the measures of business age have curve-linear relationships (inverted U-shape) with violent and property crime, regardless of the types of businesses. At low level, increase in business age leads to increase in the risk of violent and property crime. After about 6-

8 years, however, as the businesses get older, street segments have lower risk of violent and property crime. For example, as shown in Figures 3.16 and 3.17, as the age of restaurants increases up to 6 years, violent (property) crime rate increases about 113 (133) percent; yet the pattern turns to be crime-reducing that violent (property) crime decreases about 60 (62) percent from 6 to 10 years of the ages of restaurants. The results suggest that although certain types of businesses have crime enhancing effects, such effects will not last forever but have temporarily dynamic patterns for crime patterns in place.

<<< Figures 3.16-17 about here >>>

Now let me briefly describe the findings of the control variables in the models. The concentrated disadvantage index shows positive and statistically significant effect on violent crime while it indicates a negative relationship with the risk of property crime. Percent occupied units and percent homeowners have negative relationships with all types of crime, while percent Afro-Americans in street segments has a positive relationship with crime. These findings of controls for structural characteristics are consistent with the findings of previous studies. However, the racial/ethnic heterogeneity measure has the statistically significant negative coefficients. This finding is consistent with previous studies of spatial patterns of crime and structural characteristics at the street segment level (Kim, 2016; Kim & Hipp, 2017; Rice & Smith, 2002; Smith et al., 2000).

Moderating Effect Models

I next assessed whether the social environment, measured in the concentrated disadvantage index, moderates the relationship between the various characteristics of business and crime. For each form of moderation, there is a model using violent crime as the outcome, and a model using property crime as the outcome. Tables 3.4 and 3.5 show the interaction terms consisting of the business measures and the concentrated disadvantage index. To visually discern patterns of moderation, I have graphed the predicted values of crime in Appendix Figures A81-160 according to the coefficient results of the interaction term and the main effects at varying levels of the concentrated disadvantage index (Low = -1 SD, Med = mean, and High = +1 SD).

<<< Tables 3.4-5 about here >>>

First, I describe the interactions between the number of business establishments (EST) and concentrated disadvantage. I observed general patterns as follows with few exceptions: (1) street segments with higher level of concentrated disadvantage generally have higher risk of violent crime but lower risk of property crime; (2) the relationships between the number of business measures and violent (property) crime are more (less) pronounced in high disadvantaged areas; and thus (3) the effect of the number of business establishments on violent (property) crime matters more (less) in high disadvantaged areas, in general.

For example, Figure 3.18 indicates the effect of the number of retail businesses in street segments on violent crime at different levels of disadvantage. As presented, the risk of violent crime in high disadvantaged segments are higher than the others. This means that disadvantaged areas have higher risk of violent crime, regardless of the patterns of the number of retail businesses in the areas. Moreover, the slope for high disadvantaged areas is steeper than the others. For example, the crime-enhancing effect of the number of retail business establishments for violent crime in high disadvantaged areas is about 30 percent larger than better-off areas. This means that the relationship between the number of retail businesses and violent crime is more pronounced in the disadvantaged street segments. However, the pattern looks different for property crime. For example, better-off areas generally have more property crime (about 22 percent more on average) than worse-off areas given that the “high” line is lowest in Figure 3.19. This may be because there would be more suitable targets for property crime in better-off areas than high disadvantaged areas; thus potential offenders might perceive more criminal opportunities and find the places more attractive for committing property crime.

<<< Figures 3.18-19 about here >>>

I also observed a few exceptions not following the abovementioned general patterns. For instance, Figure 3.20 reveals the association between the number of school/learning businesses in street segments at different levels of disadvantage. As shown, the relationship quite varies across different levels of socioeconomic status of street segments. For example, in high disadvantaged areas, as the number of school-learning businesses increases, violent crime increases initially; yet the pattern turns to crime-reducing as it reaches and passes a threshold point. In contrast, in better-off street segments, the pattern is quite flat as it increases further. This pattern is similar in the property crime model (Figure 3.21).

<<< Figures 3.20-21 about here >>>

Next, I turn to the moderating effects between the number of business employees and the socioeconomic status of place (EMP). I generally find that the crime enhancing effect of the number of employees on violent crime is more pronounced in high disadvantaged areas. For example, as presented in Figure 3.22, the slope of the number of retail business employees in worse-off areas is steeper than the others. That is, socioeconomic disadvantage strengthens the crime-enhancing effect of retail business employees on violent crime in street segments. For property crime, although the interaction coefficients are statistically significant, there is less evidence that high disadvantaged segments will have higher property crime given that the gap between the three lines (which show low, medium, and high disadvantaged areas) is quite narrow (i.e., Figure 3.23). A few exceptions are the plots for financial businesses and amenities that widen after a threshold point (Figures A3.135 and 138).

I next turn to the business measures considering the local ownership status (LOC). The relationship between the number of local businesses and crime is moderated by socioeconomic status of a street segment; and the pattern seems similar to the EST results. For example, the curve-linear (inverted U-shape) relationships between the number of local drink, retail, service businesses, amenities, social organizations, and stores and violent crime on a street segment are more pronounced in high disadvantage areas (Figures A3.101-110). However, some businesses have different patterns for crime as the socioeconomic status changes. For instance, the number of local restaurants have a curve-linear (inverted U-shape) relationship with violent and property crime in high disadvantaged street segments, whereas there is a crime-enhancing effect in low disadvantaged areas (Figures 3.24-25).

Also, I observe that increase in the number of local health service providers results in elevated risk of violent crime in high disadvantaged areas, while they have a crime-reducing effect in low disadvantaged areas (Figure A3.107). When looking at the findings of the interaction between local businesses and disadvantage for property crime, I found that better-off areas generally have more property crime than the worse-off areas given that the “high” line is lowest in the figures (Figures A3.141-150). Finally, pertaining to the temporal patterns for the measures of businesses (age of business), there are up-and-downs of risk of violent and property crime in street segments as businesses get older, and this pattern is more pronounced in high disadvantaged areas for violent crime (i.e., Figure 3.26 for stores) and low disadvantaged areas for property crime (i.e., Figure 3.27 for stores) given the wider gaps between the lines.

Discussion

This chapter of the dissertation focused on the physical environment conceptualized as *activity nodes* where people spend most of their time and develop daily routine activities, and crime in place. The current study considers various characteristics of activity nodes by examining types of businesses, number of employees, local ownership status of business, and age of business in street segments in the Southern California region. The results indicate that spatial patterns of violent and property crime are largely determined by the various characteristics of activity nodes. Specifically, the first set of models including the number of 10 types of consumer facing businesses in street segment suggests that there are different spatial crime patterns by different types of businesses in place. I observed that some businesses in street segments have curve-linear relationships with violent and property crime (i.e., service providers, financial business, restaurants, amenities, and stores), while others have crime-enhancing effects (i.e., health care providers, drink, retail, and voluntary organizations). The mixed findings are consistent with previous studies. For example, Bernasco & Block (2011) found that crime generators and crime attractors are associated with higher risk of robbery. In contrast, Stucky & Ottensmann (2009) found that some nonresidential land uses are associated with higher violent crime, whereas others are associated with lower violent crime. Also, Browning et al. (2010) found a curvilinear association between commercial land use and both homicide and aggravated assault.

These mixed findings may be because of different functional patterns of potential offenders, targets and capable guardians in a place driven by different types of businesses. The number and type of people visiting the place can be largely determined by the number and types of businesses in a given area. This is because different types of businesses may provide different products and services to customers, and thus create different environmental features of onsite locations and surrounding areas. For example, the number of financial businesses can increase criminal opportunities because of more presence of suitable targets with cash. However, they usually have physical features of surveillance such as CCTVs, thereby leading to lower risk of crime as the number of them continue to increases. Also, social disorganization theory perspective implies that these businesses can increase neighborhood control through the provision of loans, mortgages, and financial relief services, which may lead to lower risk of crime.

People who drink in bars or at liquor stores are more likely to be in situations where masculine posturing is commonplace (Parker & Rebhun, 1995; Pridemore & Grubesic, 2013). Also, customers of these businesses tend to carry cash, which makes them more vulnerable to motivated offenders. Thus, there would be more criminal opportunities in the areas with more drinking businesses. In contrast, restaurants, stores, and amenities show curve-linear patterns due to different reasons. These businesses initially have crime-enhancing effects but after a threshold, the patterns turn to be crime-reducing. This may be because although restaurants, stores, and amenities may initially increase the probability of the convergence of potential offender and targets at the same time and place, there would be higher level of natural surveillance from eyes on the streets dampening the crime enhancing effects to be crime-reducing as the number of the businesses increases.

Although prior studies generally found that high and middle schools contribute to increased risk of crime at the block group level (Gouvis-Roman, 2004; Murray & Swatt, 2010; Roncek & Faggiani, 1985; Roncek & Lobosco, 1983; Wilcox et al., 2005), the current study found a curve-linear relationship between the number of schools and crime in street segments.

This finding is possibly due to the measure of school business employed in the current study, which includes vocational training schools, technical schools, automobile driving schools, and fine arts schools along with the regular elementary, middle, and high schools. These learning businesses and schools might initially bring population inflow into the areas including potential offenders and targets. However, the learning institutions usually have capable guardians or intimate handlers such as teachers who actually take care of the students and are engaged with them for training, and parents waiting outside and watching over. Consequently, as the number of these various schools increases further, there might be higher level of guardianship which reduces the risk of crime in place.

The finding that organizations have crime-enhancing effect is inconsistent with expectations and findings of some earlier studies (Beyerlein & Hipp, 2005; Lee, 2008; Peterson et al., 2000; Putnam, 2000; Rosenfeld, Messner, & Baumer, 2001). However, Wo (2014) also observed that civic and social organizations have no crime-reducing impact. He suggested a few possible explanations: (1) the organizations may affect residents' perception of crime in neighborhood, but fail to reduce the actual risk of crime; and (2) some organizations attract people with criminal history due to the purposes of organizations.

The results of the current study do not necessarily mean that the organizations are fundamentally criminogenic. Alternatively, Wo et al. (2016) found that many of organizations have the temporally delayed impacts between the placement of an organization and a neighborhood subsequently experiencing a reduction in crime. This is somewhat consistent with the result of age of organization discussed later. The speculation for each pattern by each type of business goes beyond the scope of the current cross-sectional study. Yet the findings suggest that researchers explicitly need to consider physical types of businesses to understand spatial patterns of crime.

I observed that healthcare providers (i.e., hospitals) in street segments have crime-enhancing effects. This is consistent with previous studies that have seen hospitals as a well-known example of risky facilities whose products, services and operations produce opportunities for various crimes (Sherman et al. 1989; Eck, Clarke, & Guerette, 2007). Smith (1987) surveyed over 1,000 hospital employees on their experiences of criminal victimization in and around the hospital and found that there were high levels of crime involving motor vehicles and personal theft. However, Sherman et al. (1989) suggested that high crime risk in places with hospitals may be due to a problem of over-reporting because hospitals are the facilities where crime victims may go in the aftermath of a crime. It is still unclear why street segments with more healthcare providers and hospitals have more crime than others. Future research may want to delve more deeply to see what factors make hospitals and the surrounding areas more criminogenic. Finally, the number of retail business has a crime-enhancing effect on violent and property crime. This is somewhat expected and consistent with previous studies that found various measures of retail and commercial businesses are associated with higher crime rates (Bernasco & Block, 2011; Smith et al., 2000).

The number of employees of 10 types of consumer facing businesses in street segment has a crime-enhancing effect regardless of the types of business. Although some previous studies theorized business employees in place as capable guardians or place managers, the current study finds less evidence of such argument but rather confirms that the number of business employees may quantify the inflow of people visiting a given area including potential offenders and targets; thereby, areas with higher magnitude of people moving in-and-out would have more criminal opportunities. However, this does not necessarily mean that the place managers or employees are incapable of mitigating crime in street segments. The employee measures used in the current study are the sheer counts which may not capture the specific process how a business employee actually intervenes to prevent crime. Madensen & Eck (2008) argued that the place management decision is very crucial to occurrence of crime in areas where a business establishment (e.g., bar) is located. They found that place managers (i.e., business employees and owners) can create an environment to reduce violence in place through business related choices and decisions. For instance, they found that managers and employees of bars in Cincinnati prevent violence by employing various strategies such as using bouncers, training servers to limit patron over-intoxication, posting rules of conduct, and chaining a large dog behind the bar. Thus, it is plausible to believe that there might be more specific process in what context a business employee actually plays a role as a capable guardian. Indeed, Madensen (2007) developed a more general theory of place management which may influence the types and probability of crime and disorder in place. Future research should focus more on the specific mechanism between business employees, their management of place, and crime in place.

The general patterns of local ownership status of business (LOC) are similar to the findings of the first set of models including the number of 10 types of consumer facing businesses. However, few types of businesses showed that the local business establishments generally lower the levels of violent and property crime in street segments. This result partly supports the hypothesis that areas with more local businesses would have lower risk of crime. This may be because owners and employees of local businesses tend to know the area more and spend more time locally, and thus have more opportunities to intervene to prevent crime and disorder. Also, customers of local businesses tend to be more local and know and care more about the business firms and the onsite location and surrounding areas. Therefore, there would be a higher level of guardianship and informal social control, which leads to relatively lower risk of crime. This is also consistent with previous studies focused on the relationship between local business owners, employees, and crime in neighborhood (Steenbeek & Schutjens, 2014).

However, except for few business types, I found less evidence that the local businesses have a different effect compared to the models not considering the local ownership status. The measures of local businesses employed in the current study can be further refined by considering other business characteristics. For example, distances from homes of local residents to businesses can be incorporated given that local residents are more likely to visit business establishments closer to their homes. Moreover, local businesses tend to be quite small with fewer employees, and are run by the owner him/herself, only one employee besides the business owner, or just a few more employees. Considering these characteristics specifically when measuring local businesses may be a better way to capture the local ownership status of businesses and their effects on crime given that it better incorporates the actual relationship between local business facilities, owners, employees, and residents.

The final key finding of the current study is that there is a curve-linear relationship between the age of businesses and crime in street segments (AGE). Specifically, when looking at the effect of the number of business facilities by age, I observed that there is a crime-enhancing pattern in 2-4 years since a business facility has established and started operating. However, the pattern peaks at 6-8 years and becomes crime-reducing as business facilities grow older. One possible explanation for this finding is that younger business facilities may initially increase the foot traffic, which leads to more criminal opportunities in the area. However, as they grow older, business customers visiting the areas tend to be more local, have closer personal relationships with the owners and employees. These customers may care more about the safety of the areas where the businesses are located in because the businesses would comprise a decent portion of their daily routine activities. Moreover, owners and employees of older businesses generally have worked longer in the same place; thus, they are more familiar with the areas and the surroundings, and know better how to manage and intervene to keep the area safe.

Finally, the results of the moderating effects suggest that business characteristics in street segments can increase or decrease crime, but their effects depend on the socioeconomic context, which is consistent with the findings of prior studies (Browning et al., 2010; Rice & Smith, 2002; Smith et al., 2000; Stucky & Ottensmann, 2009). For example, high disadvantaged areas are generally at higher risk of violent crime. Specifically, the relationships between the various measures of activity nodes and violent crime are more pronounced in high disadvantaged street segments. This is consistent with the hypothesis that socioeconomic disadvantage may strengthen the effects of certain activity nodes in street segments. In contrast, better-off areas are generally at higher risk of property crime, and the relationships are more apparent in low disadvantaged areas. This is because there may be more potential targets for property crime in better-off areas than the disadvantaged. These moderating effects suggest that previous studies focusing solely on either social or physical environment tell an incomplete story of the spatial patterns of crime. Therefore, researchers should take into consideration both business characteristics (physical environment) and socioeconomic status of the place (social environment), and how they interactively work together to produce opportunities for crime in place.

In spite of the contributions, I acknowledge some limitations to the current study. First, although the current study utilizes 10 categories of consumer facing businesses, there still remains room to refine them to distinguish more specific types within the 10 categories. Future research needs to examine more closely the extent to which more fine-grained categories of businesses increase or decrease violent and property crime. Another limitation is that the current study could not directly examine the specific mechanism via informal social control, incivilities, or criminal opportunities between activity nodes, structural characteristics and crime. Future research should fully explore the roles of physical and social environment in understanding crime by incorporating measurements of the key intervening variables. Finally, this study is conducted in the context of Sothern California region. Although I believe that the effects of business characteristics examined in the current study will remain similar in other study area contexts, future research may want to analyze the spatial crime patterns by the various business characteristics and socioeconomic status of place in other cities to assess the generalizability of the findings of the current study.

In sum, I found that various business characteristics affect the risk of violent and property crime in street segments, and such effects vary depending on the level of socioeconomic status in place. The results of the current study suggest that it is necessary to include the physical environment in terms of the business characteristics and the social environment as the structural characteristics of place into models to develop a more comprehensive explanation for crime in place.

Chapter 3 Tables

Table 3.1. Summary Statistics

Variable	N	Mean	S.D.	Min	Max
Outcomes					
3 year average violent crime	326452	0.13	0.52	0	44.33
3 year average property crime	326452	0.59	2.27	0	315
Number of Business Establishments (EST)					
Drink Business	326452	0.01	0.10	0	4
Retail Business	326452	0.09	0.92	0	160
School Business	326452	0.02	0.16	0	8
Service Business	326452	0.13	0.75	0	33
Finance Business	326452	0.03	0.33	0	43
Restaurants	326452	0.06	0.46	0	30
Health Business	326452	0.16	3.76	0	961
Amenities	326452	0.04	0.43	0	86
Organizations	326452	0.03	0.24	0	11
Stores	326452	0.01	0.11	0	7
Number of Business Employees (EMP)					
Drink Business	326452	0.04	0.95	0	204
Retail Business	326452	0.65	12.27	0	2611
School Business	326452	0.80	12.76	0	3266
Service Business	326452	0.61	13.46	0	7017
Finance Business	326452	0.20	4.98	0	1105
Restaurants	326452	0.75	8.16	0	1315
Health Business	326452	0.91	28.89	0	8026.5
Amenities	326452	0.10	2.97	0	700
Organizations	326452	0.37	11.09	0	4000
Stores	326452	0.34	5.72	0	1500
Number of Local Business Establishments (LOC)					
Drink Business	326452	0.01	0.10	0	4
Retail Business	326452	0.08	0.66	0	82
School Business	326452	0.01	0.10	0	8
Service Business	326452	0.12	0.70	0	31
Finance Business	326452	0.02	0.20	0	21
Restaurants	326452	0.04	0.34	0	29
Health Business	326452	0.07	1.56	0	380
Amenities	326452	0.01	0.09	0	5
Organizations	326452	0.03	0.39	0	86
Stores	326452	0.02	0.19	0	11
Age of Business Establishments (AGE)					
Drink Business	326452	0.03	0.58	0	26
Retail Business	326452	0.13	1.11	0	26

School Business	326452	0.13	1.49	0	26
Service Business	326452	0.28	1.68	0	26
Finance Business	326452	0.04	0.63	0	26
Restaurants	326452	0.10	0.99	0	26
Health Business	326452	0.09	0.90	0	26
Amenities	326452	0.02	0.45	0	26
Organizations	326452	0.19	1.74	0	26
Stores	326452	0.06	0.74	0	26
Structural Characteristics					
Concentrated disadvantage	326452	-1.77	8.78	-15	15
Racial/ethnic heterogeneity	326452	0.44	0.17	0	0.79
% Home owners	326452	68.74	26.55	0	100
% Black	326452	5.56	11.39	0	100
% Latino	326452	34.86	28.04	0	100
% Occupied units	326452	94.03	8.39	0.40	100
% Age 15-29	326452	19.97	8.20	0	100
Spatially lagged (.25 mile)					
Concentrated disadvantage	326452	-1.25	8.03	-15	15
Racial/ethnic heterogeneity	326452	0.47	0.16	0	0.77
% Home owners	326452	65.32	24.76	0	100
% Black	326452	5.53	10.21	0	100
% Latino	326452	36.18	27.15	0	100
% Occupied units	326452	93.94	7.19	1.42	100
% Age 15-29	326452	20.63	7.01	0	100

Table 3.2. Estimated Models (Violent Crime)

	Violent Crime							
	EST		EMP		LOC		AGE	
Drinking Business	0.5329	**	0.1079	**	0.6010	**	0.2712	**
	8.0737		39.1237		8.9573		27.7358	
Retail Business	0.0839	**	0.0066	**	0.1165	**	0.1650	**
	30.3208		30.2749		31.7059		38.9270	
School Business	0.2351	**	0.0038	**	0.2091	**	0.0684	**
	11.0465		23.9985		6.8533		10.8523	
Service Business	0.1723	**	0.0101	**	0.1952	**	0.1262	**
	44.0566		33.1969		47.2930		39.5393	
Finance Business	0.0507	**	0.0094	**	0.0822	**	0.1313	**
	7.5428		15.4106		6.9926		17.8652	
Restaurants	0.2845	**	0.0172	**	0.3007	**	0.2747	**
	45.3069		62.4160		39.0005		54.0445	
Health Business	0.0028	**	0.0010	**	0.0034	†	0.1063	**
	3.8948		9.2710		1.8653		21.1753	
Amenities	0.2025	**	0.0056	**	0.2163	**	0.1364	**
	6.0527		6.2744		4.3924		11.4462	
Organizations	0.0989	**	0.0031	**	0.0883	**	0.0905	**
	21.1998		12.3268		15.0284		19.2136	
Stores	0.4146	**	0.0113	**	0.3681	**	0.1957	**
	31.2673		24.4590		23.8151		31.4073	
Drink Business (sq)	-0.1098		-0.0018	**	-0.1577	*	-0.0284	**
	-1.3978		-26.5853		-1.9728		-20.4662	
Retail Business (sq)	-0.0017	**	0.0000	**	-0.0041	**	-0.0194	**
	-20.0049		-25.1805		-16.0268		-30.5445	
School Business (sq)	-0.0728	**	0.0000	**	-0.1234	**	-0.0055	**
	-4.2168		-7.6352		-4.9688		-6.9262	
Service Business (sq)	-0.0202	**	0.0000	**	-0.0230	**	-0.0131	**
	-30.9219		-22.7326		-31.7423		-28.6597	
Finance Business (sq)	-0.0081	**	0.0000	**	-0.0209	**	-0.0147	**
	-8.1420		-13.6375		-5.7333		-13.2927	
Restaurants (sq)	-0.0341	**	-0.0001	**	-0.0416	**	-0.0292	**
	-28.0232		-42.6034		-22.5334		-38.5456	
Health Business (sq)	0.0000	**	0.0000	**	0.0001	**	-0.0117	**
	5.1721		-4.8077		4.3721		-15.3648	
Amenities (sq)	-0.1229	**	0.0000	**	-0.0923	†	-0.0139	**
	-4.4592		-6.5840		-1.9172		-8.3492	
Organizations (sq)	-0.0039	**	0.0000	**	-0.0031	**	-0.0093	**
	-11.5575		-7.9788		-8.1637		-15.4833	
Stores (sq)	-0.1384	**	-0.0001	**	-0.1274	**	-0.0205	**

	-19.1439		-21.2234		-14.3371		-21.9527	
Drink Business (cu)	0.0014		0.0000	**	0.0094		0.0007	**
	0.0705		22.0370		0.4777		17.6524	
Retail Business (cu)	0.0000	**	0.0000	**	0.0000	**	0.0005	**
	16.3553		22.3497		9.9533		26.3405	
School Business (cu)	0.0054	*	0.0000	**	0.0121	**	0.0001	**
	2.0469		5.5557		3.5824		5.5694	
Service Business (cu)	0.0005	**	0.0000	**	0.0006	**	0.0003	**
	22.7643		21.3140		23.3068		24.3715	
Finance Business (cu)	0.0002	**	0.0000	**	0.0007	**	0.0004	**
	6.3147		12.0766		3.8071		11.0925	
Restaurants (cu)	0.0009	**	0.0000	**	0.0011	**	0.0008	**
	19.5586		35.4906		15.8331		32.2495	
Health Business (cu)	0.0000	**	0.0000	**	0.0000	**	0.0003	**
	-4.6808		3.2658		-3.9601		12.5767	
Amenities (cu)	0.0132	**	0.0000	**	0.0070		0.0004	**
	3.1070		5.8554		0.7626		6.9270	
Organizations (cu)	0.0000	**	0.0000	**	0.0000	**	0.0002	**
	8.4143		5.6673		5.2816		13.8621	
Stores (cu)	0.0111	**	0.0000	**	0.0104	**	0.0005	**
	14.4113		20.6403		11.1878		17.9200	
Structural Characteristics								
Concentrated disadvantage	0.0007	*	0.0007	*	0.0009	**	0.0008	**
	2.4700		2.3762		2.9736		2.6023	
Racial/ethnic heterogeneity	-0.3480	**	-0.3664	**	-0.3507	**	-0.3555	**
	-31.5664		-32.8566		-31.6209		-32.0372	
% Home owners	-0.0024	**	-0.0030	**	-0.0026	**	-0.0025	**
	-30.7407		-37.9024		-32.4106		-31.7011	
% Black	0.0041	**	0.0042	**	0.0042	**	0.0043	**
	17.1536		17.5101		17.6111		18.0915	
% Latino	0.0013	**	0.0014	**	0.0013	**	0.0014	**
	11.1044		11.9019		10.9772		11.1961	
% Occupied units	-0.0025	**	-0.0026	**	-0.0026	**	-0.0026	**
	-12.4584		-12.7188		-12.7773		-12.9314	
% Age 15-29	0.0001		0.0000		0.0001		0.0001	
	0.4017		0.0355		0.5081		0.4395	
Spatial lags (.25 mile)								
Concentrated disadvantage	0.0024	**	0.0025	**	0.0026	**	0.0024	**
	5.9119		6.1641		6.2688		5.8084	
Racial/ethnic heterogeneity	0.0549	**	0.0681	**	0.0624	**	0.0713	**
	4.3847		5.3734		4.9552		5.6530	
% Home owners	-0.0016	**	-0.0018	**	-0.0016	**	-0.0016	**
	-16.2817		-18.1989		-16.2864		-16.1166	

% Black	0.0059	**	0.0058	**	0.0057	**	0.0055	**
	21.1029		20.5087		20.4245		19.7681	
% Latino	0.0022	**	0.0022	**	0.0021	**	0.0020	**
	15.4985		15.3539		14.9897		13.9373	
% Occupied units	-0.0016	**	-0.0015	**	-0.0016	**	-0.0018	**
	-6.0305		-5.4680		-5.8377		-6.5849	
% Age 15-29	0.0005	*	0.0001		0.0005	*	0.0007	**
	2.1090		0.3823		2.0079		2.7299	
Intercept	-5.9928	**	-5.9107	**	-5.9732	**	-5.9632	**
	-177.8850		-173.5144		-176.2754		-175.8604	
N	326452		326452		326452		326452	
Pseudo-R sq	0.2569		0.2397		0.2482		0.2470	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects are included but not reported in the tables

Table 3.3. Estimated Models (Property Crime)

	Property Crime							
	EST		EMP		LOC		AGE	
Drink Business	0.5520	**	0.0900	**	0.5923	**	0.1823	**
	4.8974		19.1989		5.1787		10.9313	
Retail Business	0.1444	**	0.0123	**	0.2178	**	0.2951	**
	30.5603		33.2584		34.7754		40.8394	
School Business	0.5486	**	0.0074	**	0.5282	**	0.1490	**
	15.0939		27.6699		10.1561		13.8570	
Service Business	0.3203	**	0.0219	**	0.3501	**	0.2326	**
	47.9524		42.2626		49.7676		42.7330	
Finance Business	0.1321	**	0.0178	**	0.2070	**	0.2390	**
	11.4977		17.1917		10.3247		19.0757	
Restaurants	0.2857	**	0.0208	**	0.3164	**	0.3039	**
	26.6401		44.4077		24.0800		35.0633	
Health Business	0.0073	**	0.0024	**	0.0238	**	0.2456	**
	5.8580		13.6484		7.5985		28.6810	
Amenities	0.5640	**	0.0165	**	0.4278	**	0.2904	**
	9.8721		10.8612		5.0964		14.2954	
Organizations	0.1737	**	0.0055	**	0.1649	**	0.1432	**
	21.8089		12.7425		16.4654		17.8387	
Stores	0.3908	**	0.0132	**	0.3141	**	0.1548	**
	17.2572		16.8023		11.9208		14.5691	
Drink Business (sq)	-0.3151	*	-0.0014	**	-0.3241	*	-0.0180	**
	-2.3485		-12.3437		-2.3791		-7.6005	
Retail Business (sq)	-0.0029	**	0.0000	**	-0.0097	**	-0.0336	**
	-19.6173		-26.1952		-22.1908		-31.0006	
School Business (sq)	-0.1892	**	0.0000	**	-0.2873	**	-0.0113	**
	-6.4200		-11.9066		-6.7834		-8.3457	
Service Business (sq)	-0.0332	**	0.0000	**	-0.0365	**	-0.0255	**
	-29.7276		-25.5207		-29.6251		-32.7809	
Finance Business (sq)	-0.0157	**	-0.0001	**	-0.0506	**	-0.0254	**
	-9.2008		-14.2706		-8.1627		-13.4358	
Restaurants (sq)	-0.0358	**	-0.0001	**	-0.0464	**	-0.0320	**
	-17.1893		-30.0623		-14.7319		-24.7696	
Health Business (sq)	0.0000		0.0000	**	-0.0001		-0.0261	**
	-1.2630		-9.7676		-1.6024		-19.9989	
Amenities (sq)	-0.2787	**	-0.0001	**	-0.1625	*	-0.0322	**
	-5.9189		-8.3336		-1.9801		-11.3043	
Organizations (sq)	-0.0080	**	0.0000	**	-0.0074	**	-0.0141	**
	-13.8648		-10.1676		-11.5469		-13.7185	
Stores (sq)	-0.1598	**	-0.0001	**	-0.1567	**	-0.0163	**

	-12.9410		-13.3324		-10.3476		-10.2118	
Drink Business (cu)	0.0509		0.0000	**	0.0498		0.0005	**
	1.5390		10.0861		1.4858		6.4384	
Retail Business (cu)	0.0000	**	0.0000	**	0.0001	**	0.0009	**
	15.2627		22.5055		16.5819		26.4143	
School Business (cu)	0.0178	**	0.0000	**	0.0316	**	0.0002	**
	3.9719		9.7311		5.4969		6.4318	
Service Business (cu)	0.0008	**	0.0000	**	0.0009	**	0.0007	**
	20.3057		23.5093		20.4495		28.2470	
Finance Business (cu)	0.0004	**	0.0000	**	0.0023	**	0.0007	**
	8.4117		13.1185		7.3014		10.9778	
Restaurants (cu)	0.0009	**	0.0000	**	0.0013	**	0.0008	**
	12.3831		25.5018		10.6823		20.7179	
Health Business (cu)	0.0000		0.0000	**	0.0000		0.0007	**
	-0.2127		8.1947		-0.1414		16.1925	
Amenities (cu)	0.0303	**	0.0000	**	0.0164		0.0009	**
	4.1685		7.6072		1.0484		9.8630	
Organizations (cu)	0.0001	**	0.0000	**	0.0001	**	0.0003	**
	10.7370		8.4690		8.9540		11.9579	
Stores (cu)	0.0130	**	0.0000	**	0.0134	**	0.0004	**
	9.9297		12.8155		8.4056		8.5080	
Structural Characteristics								
Concentrated disadvantage	-0.0016	**	-0.0017	**	-0.0014	**	-0.0016	**
	-3.2994		-3.3823		-2.8052		-3.2041	
Racial/ethnic heterogeneity	-0.7735	**	-0.7966	**	-0.7768	**	-0.7840	**
	-41.0798		-42.0357		-41.0910		-41.4386	
% Home owners	-0.0027	**	-0.0035	**	-0.0029	**	-0.0029	**
	-20.0374		-26.1276		-21.5040		-21.1247	
% Black	0.0051	**	0.0052	**	0.0052	**	0.0055	**
	12.4982		12.7018		12.8073		13.3373	
% Latino	0.0007	**	0.0008	**	0.0007	**	0.0008	**
	3.4471		4.0466		3.4477		3.6386	
% Occupied units	-0.0026	**	-0.0027	**	-0.0027	**	-0.0027	**
	-7.5429		-7.7555		-7.8232		-7.9877	
% Age 15-29	0.0018	**	0.0017	**	0.0018	**	0.0018	**
	5.4130		4.9918		5.3888		5.3649	
Spatial lags (.25 mile)								
Concentrated disadvantage	0.0002		0.0003		0.0005		0.0002	
	0.2703		0.3950		0.6521		0.2345	
Racial/ethnic heterogeneity	0.4256	**	0.4422	**	0.4349	**	0.4483	**
	19.8949		20.5419		20.2508		20.8588	
% Home owners	-0.0057	**	-0.0060	**	-0.0057	**	-0.0057	**
	-34.9665		-36.7431		-34.8428		-34.5522	

% Black	0.0019	**	0.0018	**	0.0017	**	0.0014	**
	3.9545		3.8668		3.5840		2.9507	
% Latino	0.0006	*	0.0006	*	0.0005	†	0.0002	
	2.2917		2.2904		1.9071		1.0030	
% Occupied units	-0.0043	**	-0.0041	**	-0.0043	**	-0.0046	**
	-9.4571		-8.7983		-9.2769		-9.9501	
% Age 15-29	0.0052	**	0.0047	**	0.0052	**	0.0055	**
	12.1865		10.7508		12.0150		12.8147	
Intercept	-5.2169	**	-5.1082	**	-5.1894	**	-5.1752	**
	-90.6701		-88.2319		-89.8407		-89.5172	
N	326452		326452		326452		326452	
Pseudo-R sq	0.1123		0.1019		0.1060		0.1045	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects are included but not reported in the tables

Table 3.4. Interaction Models (Violent Crime)

	Drink Business								Retail Business							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.4677	**	0.0941	**	0.5240	**	0.2350	**	0.0621	**	0.0051	**	0.0878	**	0.1256	**
	6.2903		28.3384		6.9284		21.3222		21.8529		22.4921		23.2663		29.5896	
Business (sq)	-0.1337		-0.0019	**	-0.1729	†	-0.0253	**	-0.0012	**	0.0000	**	-0.0028	**	-0.0152	**
	-1.5051		-16.8790		-1.9136		-16.2069		-12.3506		-19.9023		-10.0683		-23.8965	
Business (cu)	0.0154		0.0000	**	0.0228		0.0007	**	0.0000	**	0.0000	**	0.0000	**	0.0004	**
	0.7062		12.5624		1.0309		14.0231		10.5313		18.3111		4.1224		20.7948	
Concentrated disadvantage	0.0005	†	0.0004		0.0006	*	0.0006	*	0.0002		0.0004		0.0003		0.0003	
	1.7953		1.5266		2.2635		1.9685		0.8010		1.3867		1.1714		0.9240	
Interaction	0.0122		0.0024	**	0.0152	†	0.0022	†	0.0041	**	0.0002	**	0.0055	**	0.0061	**
	1.3784		7.2087		1.6851		1.8818		14.2941		9.0512		14.6068		14.1626	
Interaction (sq)	-0.0056		0.0000	*	-0.0111		-0.0001		-0.0002	**	0.0000	**	-0.0005	**	-0.0008	**
	-0.5034		-2.1793		-0.9757		-0.8933		-11.4493		-7.5476		-11.8008		-11.5756	
Interaction (cu)	0.0021		0.0000		0.0036		0.0000		0.0000	**	0.0000	**	0.0000	**	0.0000	**
	0.6962		-1.6180		1.1816		0.6346		9.5575		5.0628		10.6657		9.8093	
Intercept	-6.1219	**	-6.0944	**	-6.1179	**	-6.1162	**	-6.1206	**	-6.0945	**	-6.1170	**	-6.1156	**
	-182.4519		-180.3076		-181.5347		-181.2992		-182.4561		-180.2971		-181.5590		-181.3379	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.4. Continued

	School Business								Service Business							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.1902	**	0.0039	**	0.1146	**	0.0642	**	0.1127	**	0.0092	**	0.1324	**	0.0846	**
	8.2034		19.2069		3.2095		10.2168		27.9231		23.4626		31.2237		25.6593	
Business (sq)	-0.0375	†	0.0000	**	-0.0343		-0.0050	**	-0.0135	**	0.0000	**	-0.0159	**	-0.0090	**
	-1.8568		-5.0997		-1.0146		-6.3515		-20.2529		-11.5684		-21.7459		-19.2498	
Business (cu)	-0.0006		0.0000	**	-0.0053		0.0001	**	0.0003	**	0.0000	**	0.0004	**	0.0002	**
	-0.1832		4.5031		-0.8168		5.0197		15.0505		8.9988		16.2967		16.7467	
Concentrated disadvantage	0.0004		0.0005		0.0006	*	0.0005	†	-0.0002		0.0001		0.0000		0.0000	
	1.4468		1.5883		2.2257		1.7211		-0.7481		0.5097		0.0762		0.0530	
Interaction	0.0121	**	0.0001	**	0.0034		0.0035	**	0.0082	**	0.0005	**	0.0075	**	0.0052	**
	4.3671		5.7709		0.7511		4.9514		20.6408		13.4291		17.9450		15.5986	
Interaction (sq)	-0.0010		0.0000		0.0081	†	-0.0003	**	-0.0010	**	0.0000	*	-0.0010	**	-0.0005	**
	-0.3973		-0.6260		1.7889		-3.1643		-14.2753		2.3538		-11.9364		-11.0619	
Interaction (cu)	-0.0005		0.0000		-0.0022	*	0.0000	*	0.0000	**	0.0000	**	0.0000	**	0.0000	**
	-1.0890		-0.4768		-2.4875		2.4676		12.0256		-7.5528		10.1880		8.9614	
Intercept	-6.1248	**	-6.0958	**	-6.1194	**	-6.1181	**	-6.1256	**	-6.0972	**	-6.1212	**	-6.1199	**
	-182.560		-180.330		-181.583		-181.368		-182.691		-180.468		-181.732		-181.495	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.4. Continued

	Finance Business								Restaurants							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.0448	**	0.0078	**	0.0448	**	0.0926	**	0.2128	**	0.0158	**	0.2261	**	0.2227	**
	6.1800		12.7847		3.7500		12.5733		33.0340		52.3858		25.3468		41.8602	
Business (sq)	-0.0123	**	0.0000	**	-0.0135	**	-0.0106	**	-0.0238	**	-0.0001	**	-0.0318	**	-0.0244	**
	-8.4841		-10.5776		-3.4065		-9.4323		-19.2740		-35.3008		-12.0846		-30.8780	
Business (cu)	0.0005	**	0.0000	**	0.0005	*	0.0003	**	0.0006	**	0.0000	**	0.0010	**	0.0006	**
	7.4236		9.1210		1.9718		7.9480		12.9432		27.2144		6.3933		26.0044	
Concentrated disadvantage	0.0003		0.0003		0.0006	†	0.0004		0.0002		0.0002		0.0004		0.0004	
	1.0889		1.1350		1.9599		1.5322		0.6526		0.5808		1.5245		1.5218	
Interaction	0.0116	**	0.0009	**	0.0120	**	0.0075	**	0.0089	**	0.0006	**	0.0094	**	0.0030	**
	14.5173		14.1667		8.8691		9.7958		14.1143		20.5221		9.4525		5.5556	
Interaction (sq)	-0.0020	**	0.0000	**	-0.0026	**	-0.0009	**	-0.0013	**	0.0000	**	-0.0016	**	-0.0003	**
	-10.1452		-10.5193		-4.9342		-7.4863		-9.3165		-19.5904		-4.1610		-3.5312	
Interaction (cu)	0.0001	**	0.0000	**	0.0001	**	0.0000	**	0.0000	**	0.0000	**	0.0000		0.0000	**
	8.0356		8.8465		3.2815		6.3919		6.6635		18.2389		-0.0931		2.8222	
Intercept	-6.1223	**	-6.0938	**	-6.1184	**	-6.1171	**	-6.1189	**	-6.0935	**	-6.1152	**	-6.1150	**
	-182.5135		-180.3095		-181.5661		-181.3521		-182.4124		-180.376		-181.490		-181.271	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.4. Continued

	Health Business								Amenities							
	EST		**EMP**		**LOC**		**AGE**		**EST**		**EMP**		**LOC**		**AGE**	
Business	0.0046	**	0.0003	*	0.0082	**	0.0752	**	0.1611	**	0.0066	**	0.1923	**	0.1332	**
	5.9831		2.2295		4.3334		14.9816		4.5561		6.6624		3.9279		11.0430	
Business (sq)	0.0000	**	0.0000	**	0.0002	**	-0.0084	**	-0.0836	**	0.0000	**	-0.0842	†	-0.0142	**
	7.8789		4.3664		7.3727		-10.9531		-2.7374		-5.5343		-1.7566		-8.1622	
Business (cu)	0.0000	**	0.0000	**	0.0000	**	0.0002	**	0.0069		0.0000	**	0.0074		0.0004	**
	-7.5560		-6.0817		-7.0087		8.9919		1.3673		3.7343		0.8129		6.9189	
Concentrated disadvantage	0.0004		0.0004		0.0006	*	0.0004		0.0005	†	0.0005	†	0.0007	*	0.0005	†
	1.5678		1.3356		1.9622		1.3026		1.7480		1.6624		2.2700		1.8481	
Interaction	0.0009	**	0.0002	**	0.0020	**	0.0050	**	0.0114	**	0.0007	**	0.0182	**	0.0096	**
	10.8283		12.1398		10.8739		9.6749		3.2519		5.8243		3.3857		7.5940	
Interaction (sq)	0.0000	**	0.0000	**	0.0000	**	-0.0006	**	-0.0013		0.0000	**	-0.0092	†	-0.0011	**
	-9.2942		-9.8116		-9.5322		-7.1492		-0.4465		-4.0744		-1.7148		-6.3125	
Interaction (cu)	0.0000	**	0.0000	**	0.0000	**	0.0000	**	-0.0002		0.0000	**	0.0011		0.0000	**
	8.2921		8.1857		8.2096		5.8214		-0.5035		3.0526		1.0754		5.6687	
Intercept	-6.1233	**	-6.0960	**	-6.1190	**	-6.1166	**	-6.1215	**	-6.0938	**	-6.1182	**	-6.1152	**
	-182.5166		-180.3573		-181.5907		-181.3395		-182.4445		-180.259		-181.543		-181.280	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.4. Continued

	Organizations								Stores							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.0839	**	0.0026	**	0.0820	**	0.0678	**	0.2815	**	0.0056	**	0.2413	**	0.1471	**
	16.7255		8.7913		13.1282		13.8070		19.0824		9.7318		13.0624		20.7853	
Business (sq)	-0.0047	**	0.0000	**	-0.0043	**	-0.0069	**	-0.0931	**	0.0000		-0.0846	**	-0.0165	**
	-11.6727		-5.7645		-9.5857		-11.0721		-11.4705		-1.5320		-7.2392		-15.5157	
Business (cu)	0.0001	**	0.0000	**	0.0000	**	0.0002	**	0.0076	**	0.0000	**	0.0074	**	0.0004	**
	10.7698		4.9052		8.5213		9.8928		8.5492		-6.7663		5.2043		12.7831	
Concentrated disadvantage	0.0003		0.0004		0.0005	†	0.0004		0.0003		0.0003		0.0005	†	0.0004	
	0.9029		1.4652		1.8346		1.3536		0.9722		1.0269		1.7743		1.5591	
Interaction	0.0087	**	0.0003	**	0.0080	**	0.0050	**	0.0191	**	0.0011	**	0.0180	**	0.0044	**
	16.4359		9.2866		12.3431		9.6995		12.5603		13.4077		9.5001		6.3502	
Interaction (sq)	-0.0008	**	0.0000	*	-0.0007	**	-0.0005	**	-0.0065	**	0.0000	**	-0.0064	**	-0.0003	**
	-12.3411		-2.2666		-9.8952		-7.4627		-7.3070		-9.8666		-5.0817		-2.8478	
Interaction (cu)	0.0000	**	0.0000		0.0000	**	0.0000	**	0.0005	**	0.0000	**	0.0004	**	0.0000	†
	11.8417		-1.6202		9.9186		6.4595		4.6216		8.7895		2.8078		1.7613	
Intercept	-6.1256	**	-6.0953	**	-6.1195	**	-6.1184	**	-6.1222	**	-6.0948	**	-6.1175	**	-6.1160	**
	-182.6359		-180.3312		-181.6241		-181.3980		-182.520		-180.352		-181.554		-181.320	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.5. Interaction Models (Property Crime)

	Drink Business				Retail Business			
	EST	EMP	LOC	AGE	EST	EMP	LOC	AGE
Business	0.7489 **	0.0861 **	0.7867 **	0.1835 **	0.1262 **	0.0106 **	0.1915 **	0.2520 **
	5.8826	15.1775	6.0785	9.7385	25.9347	27.3986	29.6503	34.7131
Business (sq)	-0.5407 **	-0.0017 **	-0.5450 **	-0.0176 **	-0.0025 **	0.0000 **	-0.0090 **	-0.0290 **
	-3.5541	-9.0187	-3.5243	-6.5876	-15.7330	-21.9944	-18.6019	-26.6392
Business (cu)	0.1046 **	0.0000 **	0.1031 **	0.0004 **	0.0000 **	0.0000 **	0.0001 **	0.0008 **
	2.8026	6.6608	2.7267	5.3353	12.2696	18.9054	14.6013	22.7481
Concentrated disadvantage	-0.0018 **	-0.0020 **	-0.0016 **	-0.0019 **	-0.0016 **	-0.0021 **	-0.0012 *	-0.0017 **
	-3.6987	-4.0907	-3.1992	-3.8344	-3.2268	-4.1856	-2.4851	-3.3771
Interaction	-0.0300 *	-0.0013 *	-0.0284 †	-0.0060 **	-0.0031 **	0.0000	-0.0063 **	-0.0038 **
	-1.9726	-2.2593	-1.8336	-2.9816	-6.4259	0.1012	-9.6380	-5.1537
Interaction (sq)	0.0127	0.0001 **	0.0079	0.0005 †	0.0001 *	0.0000	0.0004 **	0.0003 **
	0.6677	2.7957	0.4068	1.6923	2.2336	0.5790	5.7615	3.0380
Interaction (cu)	0.0020	0.0000 **	0.0034	0.0000	0.0000 †	0.0000 *	0.0000 **	0.0000 *
	0.3999	-3.2519	0.6574	-1.0440	-1.8461	-2.4261	-3.9608	-2.3348
Intercept	-5.3816 **	-5.3439 **	-5.3721 **	-5.3773 **	-5.3825 **	-5.3436 **	-5.3737 **	-5.3768 **
	-93.670	-92.600	-93.160	-93.215	-93.689	-92.597	-93.197	-93.211
N	326412	326412	326412	326412	326412	326412	326412	326412

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.5. Continued

	School Business								Service Business							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.5564	**	0.0096	**	0.5303	**	0.1620	**	0.2796	**	0.0244	**	0.3068	**	0.2036	**
	14.0113		28.1269		8.6830		15.0870		40.4150		36.3168		42.2547		36.0969	
Business (sq)	-0.1543	**	0.0000	**	-0.2701	**	-0.0121	**	-0.0287	**	-0.0001	**	-0.0317	**	-0.0228	**
	-4.4603		-12.0453		-4.6629		-8.9712		-25.1700		-18.7546		-25.3350		-28.3614	
Business (cu)	0.0091		0.0000	**	0.0288	**	0.0003	**	0.0007	**	0.0000	**	0.0008	**	0.0006	**
	1.5239		10.8867		2.5987		6.8848		17.0421		14.6304		17.3775		24.6749	
Concentrated disadvantage	-0.0019	**	-0.0020	**	-0.0017	**	-0.0020	**	-0.0016	**	-0.0020	**	-0.0013	**	-0.0017	**
	-3.9771		-4.1061		-3.4511		-4.0138		-3.1713		-4.1641		-2.6269		-3.3623	
Interaction	-0.0022		-0.0001	**	-0.0024		-0.0005		-0.0037	**	-0.0002	**	-0.0049	**	-0.0028	**
	-0.4682		-3.7862		-0.3017		-0.3862		-5.5228		-3.0606		-6.8733		-4.9252	
Interaction (sq)	0.0044		0.0000	**	0.0009		0.0001		0.0004	**	0.0000	**	0.0007	**	0.0003	**
	1.0248		5.9180		0.1111		0.5763		3.4272		12.7628		4.8224		3.8159	
Interaction (cu)	-0.0012		0.0000	**	-0.0001		0.0000		0.0000	†	0.0000	**	0.0000	**	0.0000	**
	-1.6037		-6.3909		-0.0978		-0.6097		-1.6530		-13.8080		-2.8744		-3.3394	
Intercept	-5.3815	**	-5.3430	**	-5.3715	**	-5.3769	**	-5.3802	**	-5.3444	**	-5.3702	**	-5.3751	**
	-93.661		-92.589		-93.143		-93.205		-93.644		-92.638		-93.129		-93.177	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.5. Continued

	Finance Business								Restaurants							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.1362	**	0.0166	**	0.1925	**	0.2099	**	0.2589		0.0193		0.3287		0.2898	
	10.9758		16.0055		9.4160		16.6648		23.4674		37.6388		21.5358		31.8580	
Business (sq)	-0.0180	**	-0.0001	**	-0.0361	**	-0.0221	**	-0.0311	**	-0.0001	**	-0.0608	**	-0.0315	**
	-7.2427		-13.1119		-5.3378		-11.4861		-14.7565		-23.0511		-13.5094		-23.3223	
Business (cu)	0.0005	**	0.0000	**	0.0008	†	0.0006	**	0.0008	**	0.0000	**	0.0027	**	0.0008	**
	4.3875		12.0735		1.7792		9.2377		10.5773		16.4675		10.0005		19.7614	
Concentrated disadvantage	-0.0019	**	-0.0021	**	-0.0016	**	-0.0019	**	-0.0017	**	-0.0022	**	-0.0014	**	-0.0016	**
	-3.8346		-4.3067		-3.2023		-3.9122		-3.4926		-4.4187		-2.8833		-3.2700	
Interaction	0.0005		0.0003	**	-0.0109	**	-0.0023	†	-0.0048	**	0.0003	**	-0.0110	**	-0.0077	**
	0.3946		2.8746		-4.6838		-1.7677		-4.4450		5.2733		-6.4544		-8.4450	
Interaction (sq)	-0.0007	*	0.0000	**	0.0031	**	0.0003		0.0008	**	0.0000	**	0.0037	**	0.0009	**
	-2.1377		-2.8143		3.3893		1.6419		3.1346		-7.0284		5.6506		6.8128	
Interaction (cu)	0.0000	†	0.0000	*	-0.0002	**	0.0000		0.0000	*	0.0000	**	-0.0004	**	0.0000	**
	1.7310		2.4405		-3.5508		-1.4518		-2.3374		7.5625		-6.5505		-6.1835	
Intercept	-5.3815	**	-5.3435	**	-5.3715	**	-5.3767	**	-5.3832		-5.3444		-5.3748		-5.3798	
	-93.665		-92.593		-93.148		-93.203		-93.692	**	-92.613	**	-93.210	**	-93.267	**
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.5. Continued

	Health Business								Amenities							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.0093	**	0.0027	**	0.0271	**	0.2301	**	0.5549	**	0.0213	**	0.4337	**	0.2861	**
	7.0893		12.9052		8.3264		26.7927		9.1645		12.4988		5.1773		13.8685	
Business (sq)	0.0000	*	0.0000	**	-0.0001	*	-0.0243	**	-0.2676	**	-0.0001	**	-0.1770	*	-0.0314	**
	-2.3538		-7.2673		-2.3174		-18.6298		-5.1150		-9.9810		-2.1585		-10.5256	
Business (cu)	0.0000		0.0000	**	0.0000		0.0006	**	0.0286	**	0.0000	**	0.0203		0.0008	**
	1.2070		4.5931		1.0685		15.0607		3.3006		9.4725		1.2945		8.7991	
Concentrated disadvantage	-0.0019	**	-0.0021	**	-0.0017	**	-0.0018	**	-0.0019	**	-0.0021	**	-0.0017	**	-0.0020	**
	-3.9732		-4.2335		-3.4595		-3.6782		-3.8735		-4.1880		-3.4039		-4.0193	
Interaction	0.0001		0.0000		-0.0002		-0.0030	**	-0.0062		-0.0002		0.0141		0.0023	
	0.3775		0.6349		-0.5407		-3.4712		-1.0329		-1.0579		1.5341		1.0778	
Interaction (sq)	0.0000		0.0000		0.0000		0.0003	*	0.0029		0.0000	**	-0.0185	*	-0.0003	
	0.6990		1.2991		1.3271		2.3035		0.5743		3.3090		-2.0151		-0.8680	
Interaction (cu)	0.0000		0.0000	†	0.0000		0.0000	†	-0.0003		0.0000	**	0.0030	†	0.0000	
	-1.2412		-1.8590		-1.5697		-1.6786		-0.4161		-4.6446		1.6576		0.5981	
Intercept	-5.3816	**	-5.3442	**	-5.3717	**	-5.3767	**	-5.3816	**	-5.3444	**	-5.3715	**	-5.3764	**
	-93.668		-92.605		-93.148		-93.205		-93.663		-92.612		-93.146		-93.197	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 3.5. Continued

	Organizations								Stores							
	EST		EMP		LOC		AGE		EST		EMP		LOC		AGE	
Business	0.1953		0.0064		0.1798		0.1507		0.3899		0.0114		0.3468		0.1798	
	22.7340		12.7175		16.8073		17.9510		15.4316		11.5512		10.9693		14.8554	
Business (sq)	-0.0101	**	0.0000	**	-0.0092	**	-0.0146	**	-0.1484	**	-0.0001	**	-0.1450	**	-0.0196	**
	-14.6776		-8.2714		-11.9675		-13.6937		-10.6731		-6.4538		-7.2541		-10.7840	
Business (cu)	0.0001	**	0.0000	**	0.0001	**	0.0004	**	0.0124	**	0.0000		0.0122	**	0.0005	**
	11.5384		6.1674		9.4182		11.8967		8.0777		0.9874		5.0100		8.8023	
Concentrated disadvantage	-0.0018	**	-0.0021	**	-0.0017	**	-0.0019	**	-0.0016	**	-0.0021	**	-0.0014	**	-0.0017	**
	-3.7149		-4.1807		-3.3896		-3.8200		-3.3460		-4.2236		-2.8722		-3.5324	
Interaction	-0.0022	*	0.0000		-0.0014		-0.0025	**	-0.0098	**	0.0000		-0.0151	**	-0.0101	**
	-2.4018		-0.2102		-1.2491		-2.8674		-3.7741		-0.0815		-4.6665		-8.5148	
Interaction (sq)	-0.0001		0.0000	**	0.0000		0.0003	**	0.0012		0.0000		0.0019		0.0012	**
	-0.4659		2.7303		-0.2185		2.5880		0.7867		0.4093		0.8682		6.6657	
Interaction (cu)	0.0000	*	0.0000	**	0.0000		0.0000	*	-0.0001		0.0000		-0.0001		0.0000	**
	2.1829		-3.8162		1.6045		-2.4293		-0.7640		0.1885		-0.4142		-5.3507	
Intercept	-5.3814	**	-5.3445	**	-5.3722	**	-5.3763	**	-5.3810	**	-5.3435	**	-5.3728	**	-5.3776	**
	-93.663		-92.611		-93.159		-93.195		-93.664		-92.594		-93.182		-93.231	
N	326412		326412		326412		326412		326412		326412		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Chapter 3 Figures

Figure 3.1. Number of Retail Businesses and Violent Crime in Street Segments

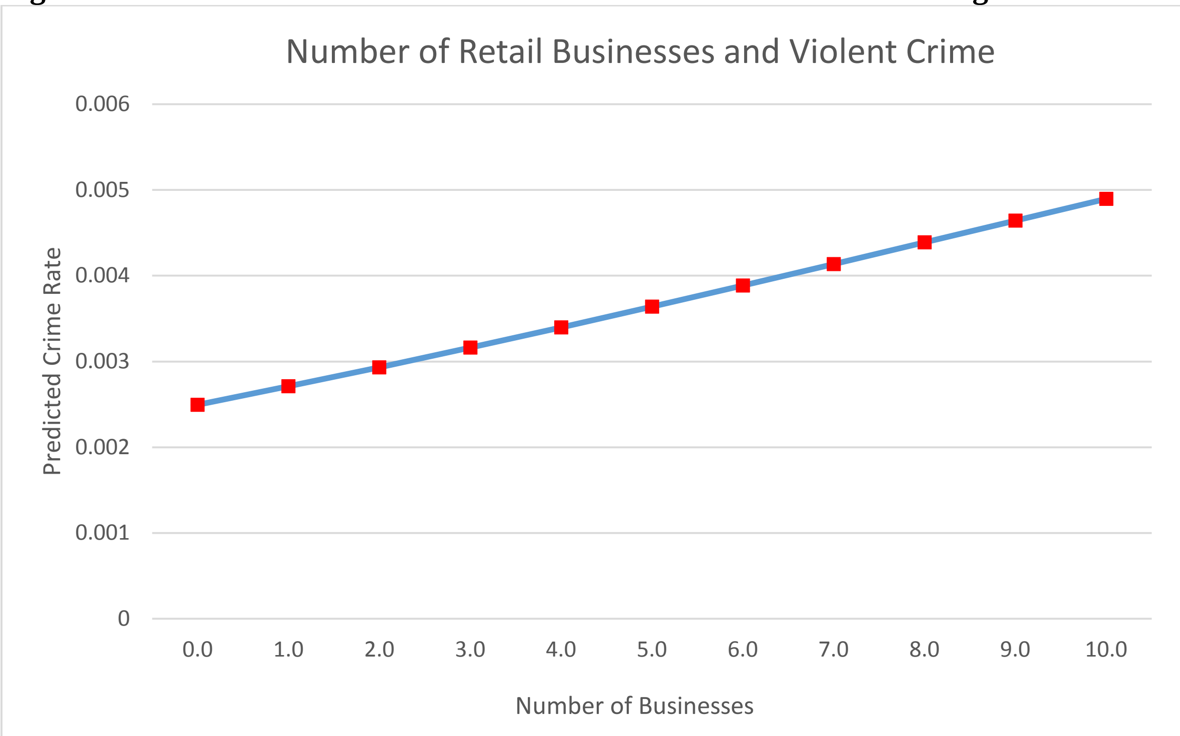


Figure 3.2. Number of Retail Businesses and Property Crime in Street Segments

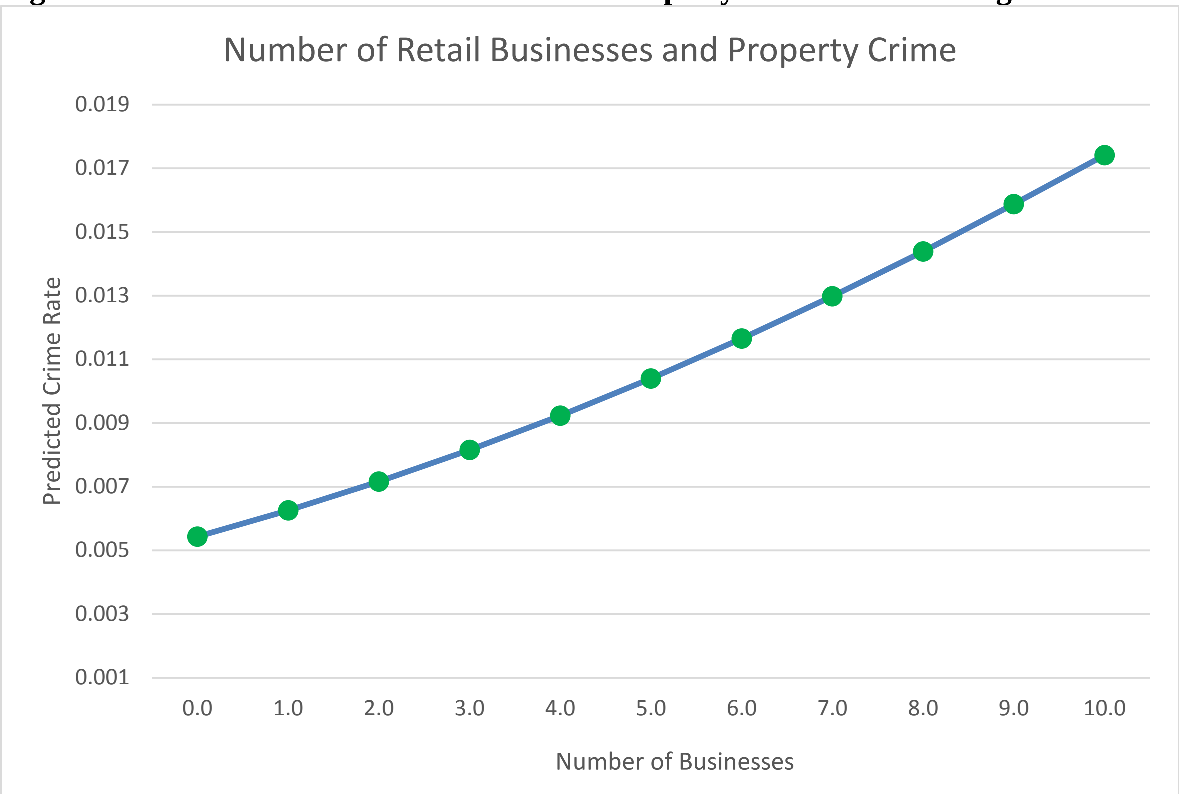


Figure 3.3. Number of Health Businesses and Violent Crime in Street Segments

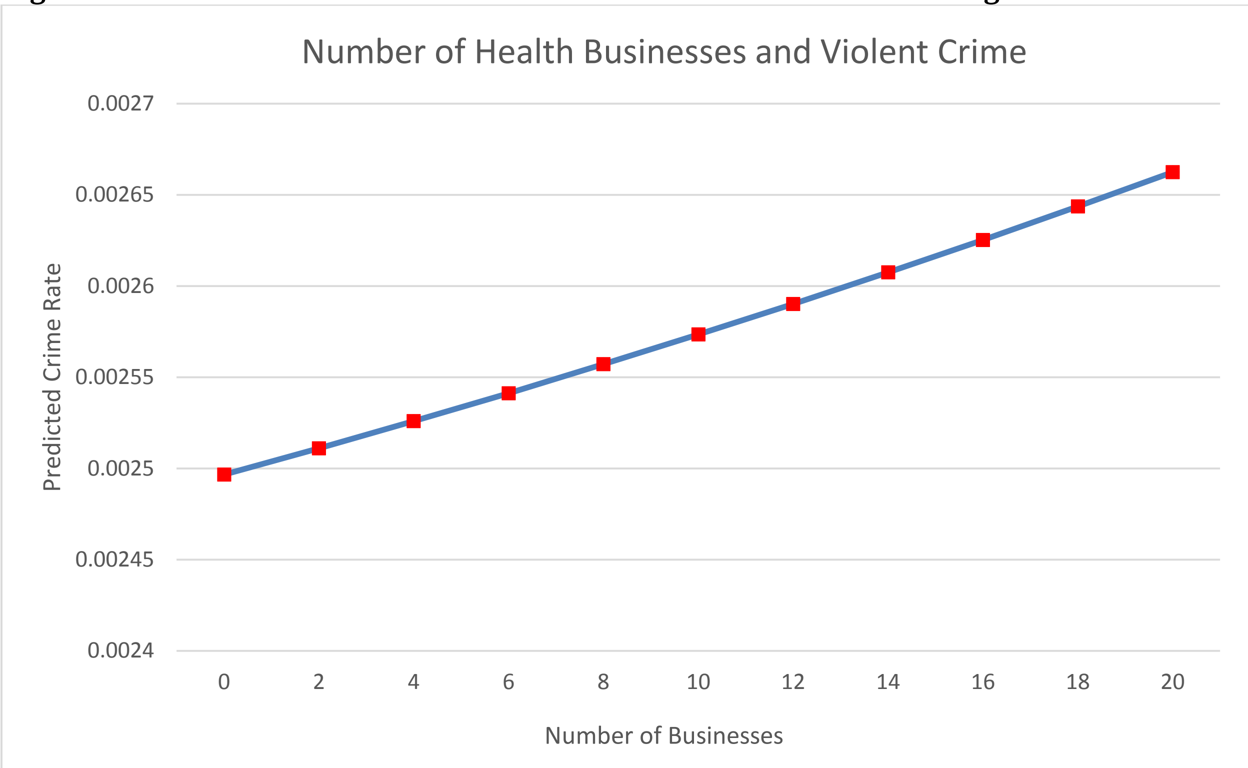


Figure 3.4. Number of Restaurants and Violent Crime in Street Segments

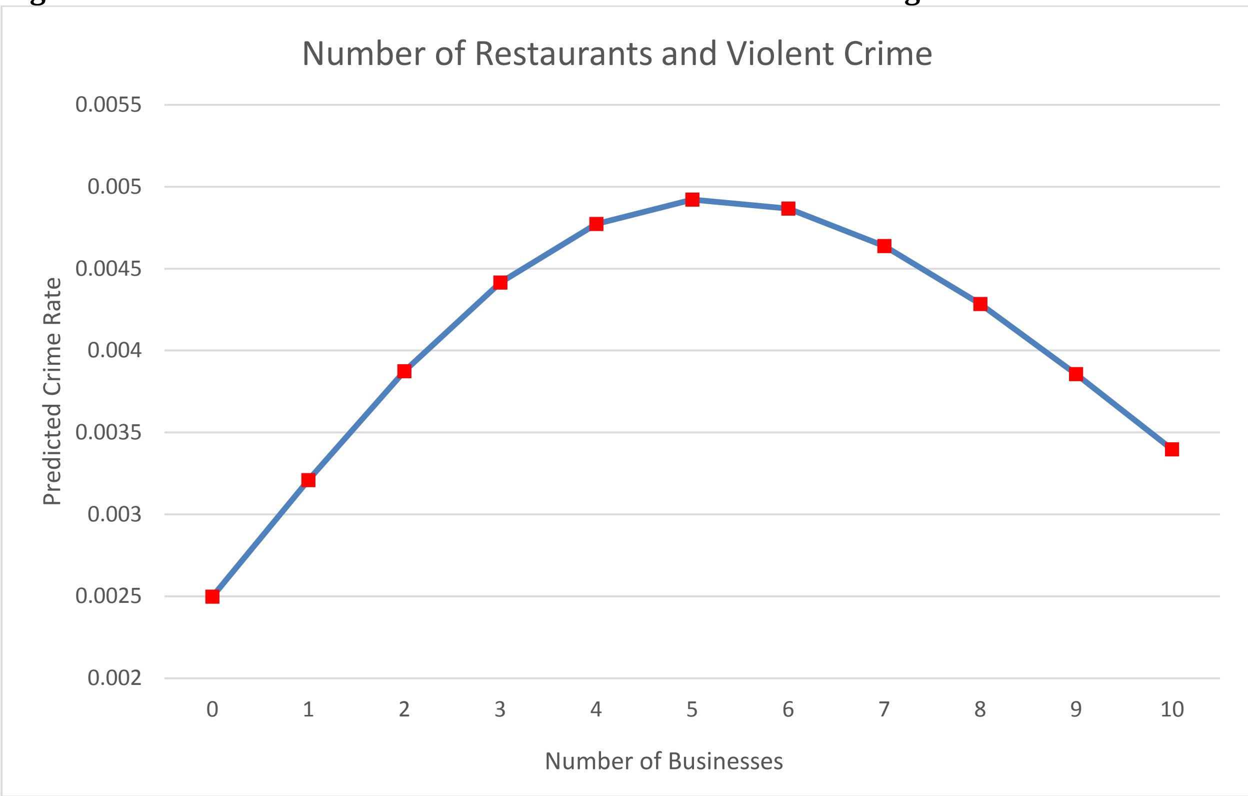


Figure 3.5. Number of Restaurants and Property Crime in Street Segments

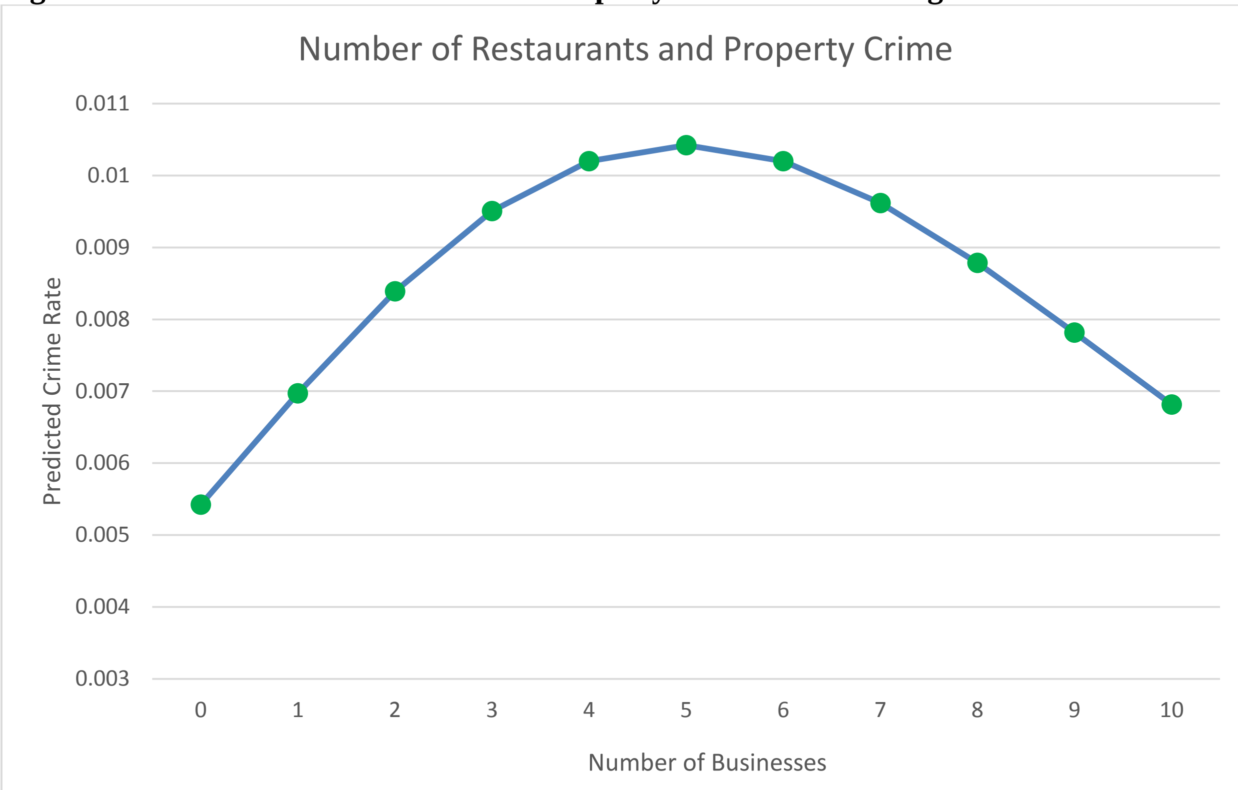


Figure 3.6. Number of Retail Employees and Violent Crime in Street Segments

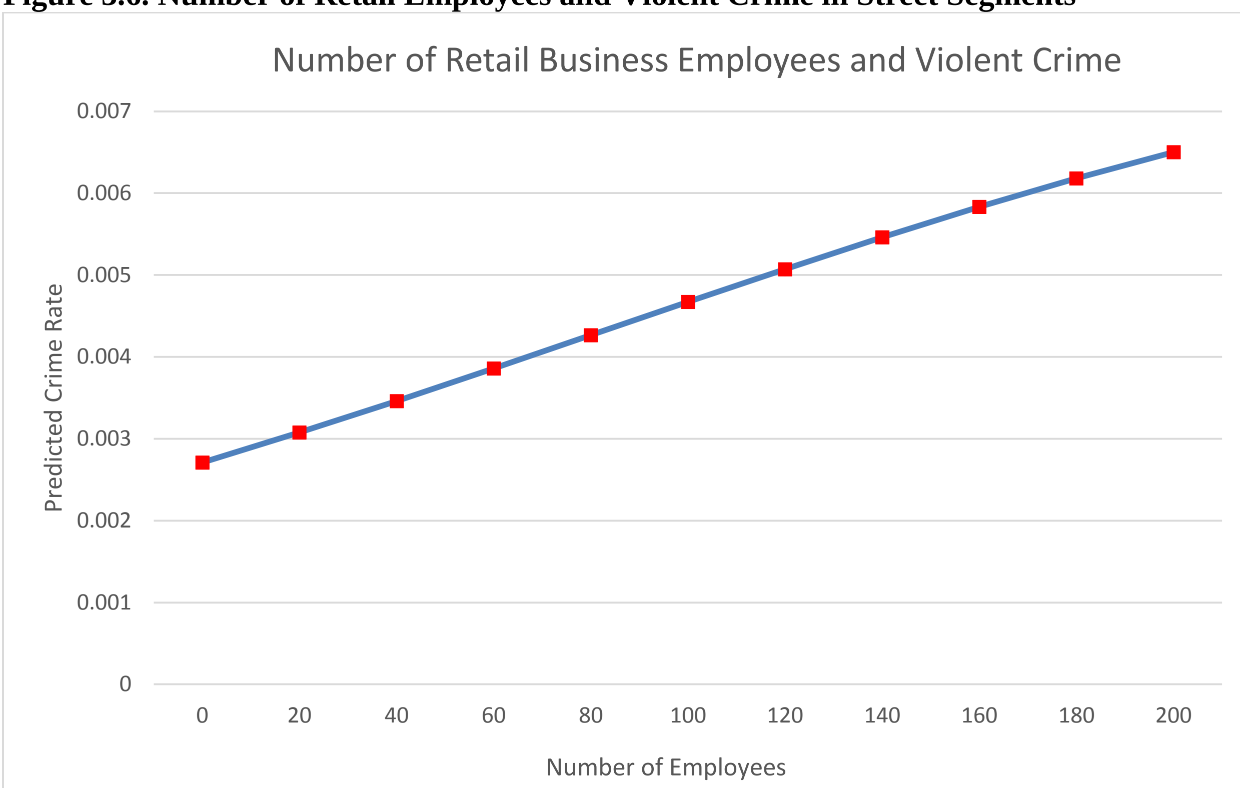


Figure 3.7. Number of Retail Employees and Property Crime in Street Segments

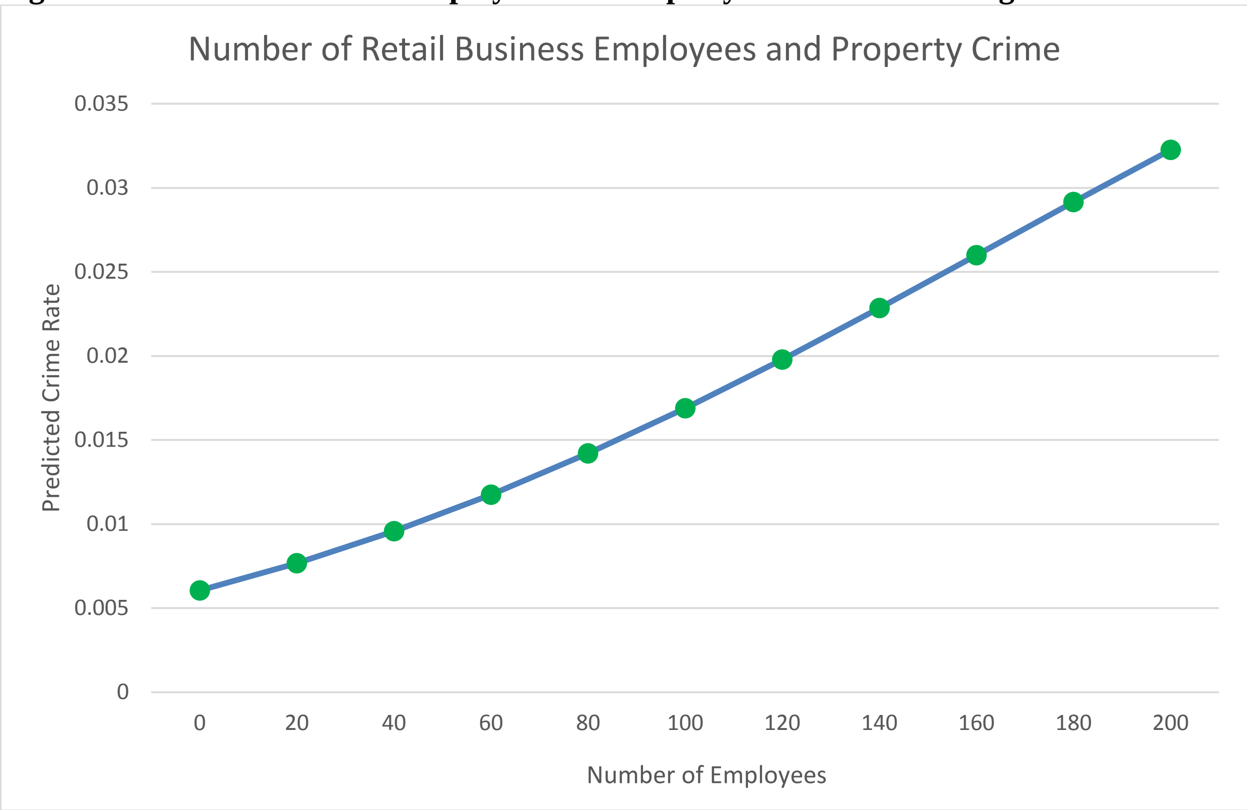


Figure 3.8. EST vs. LOC School Businesses and Violent Crime

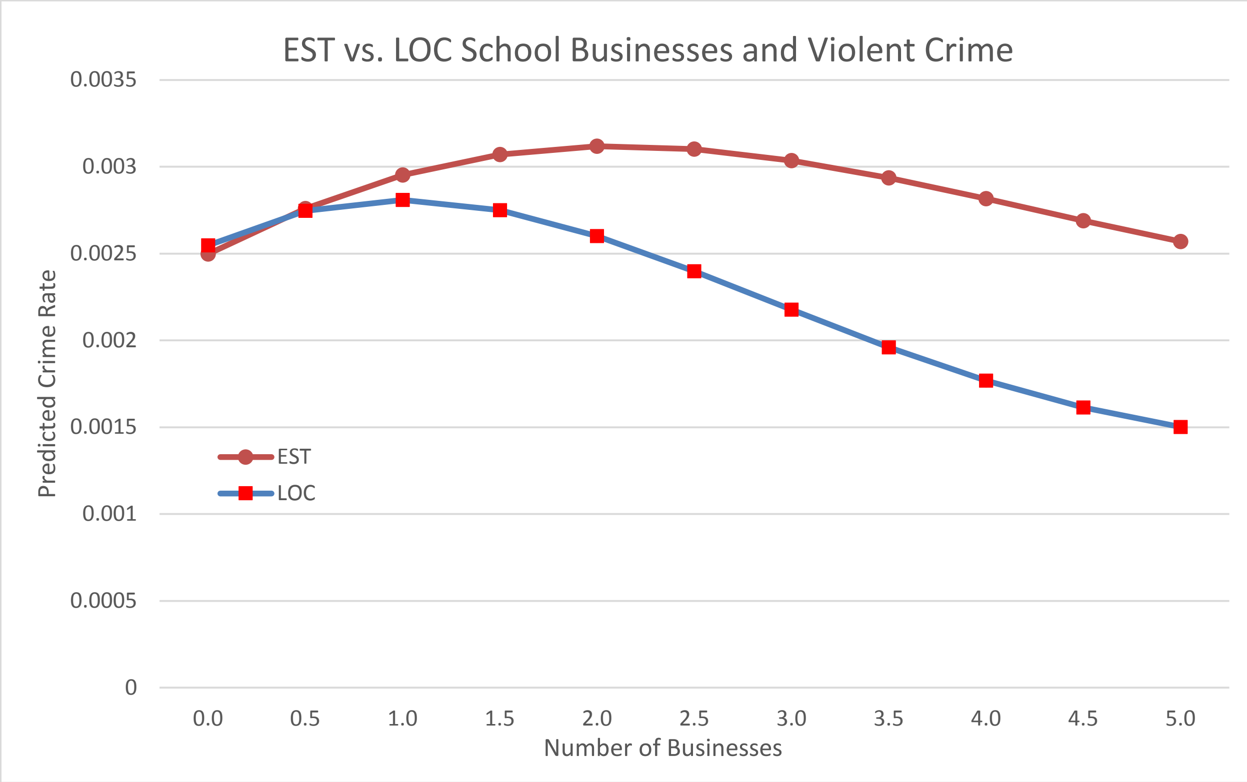


Figure 3.9. EST vs. LOC School Businesses and Property Crime

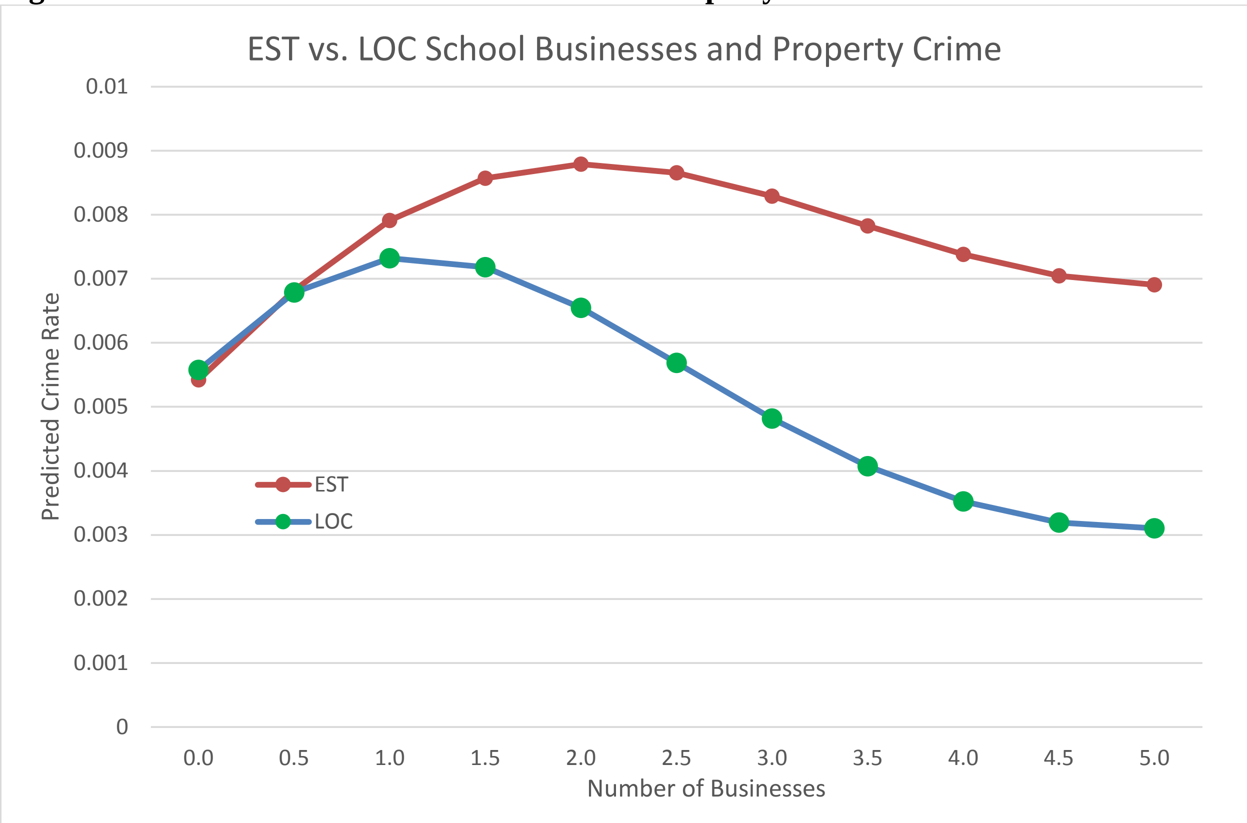


Figure 3.10. EST vs. LOC Finance Businesses and Violent Crime

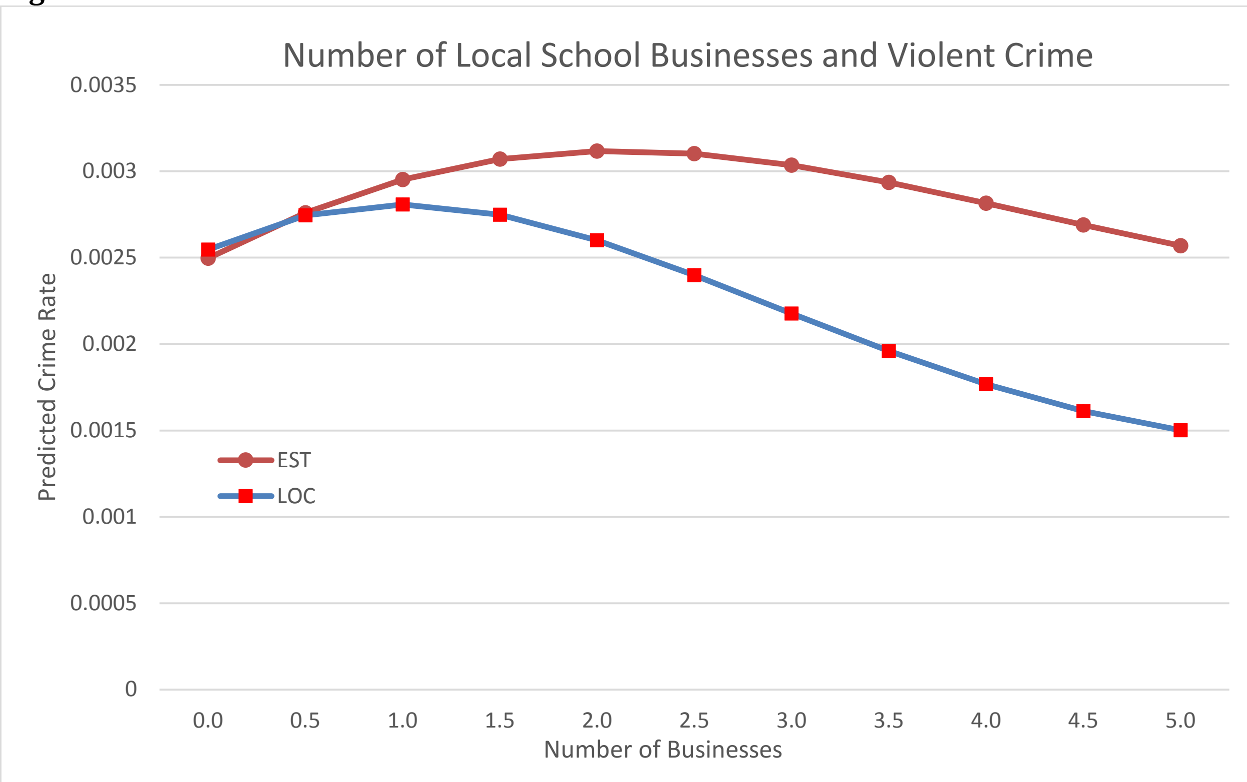


Figure 3.11. EST vs. LOC Finance Businesses and Property Crime

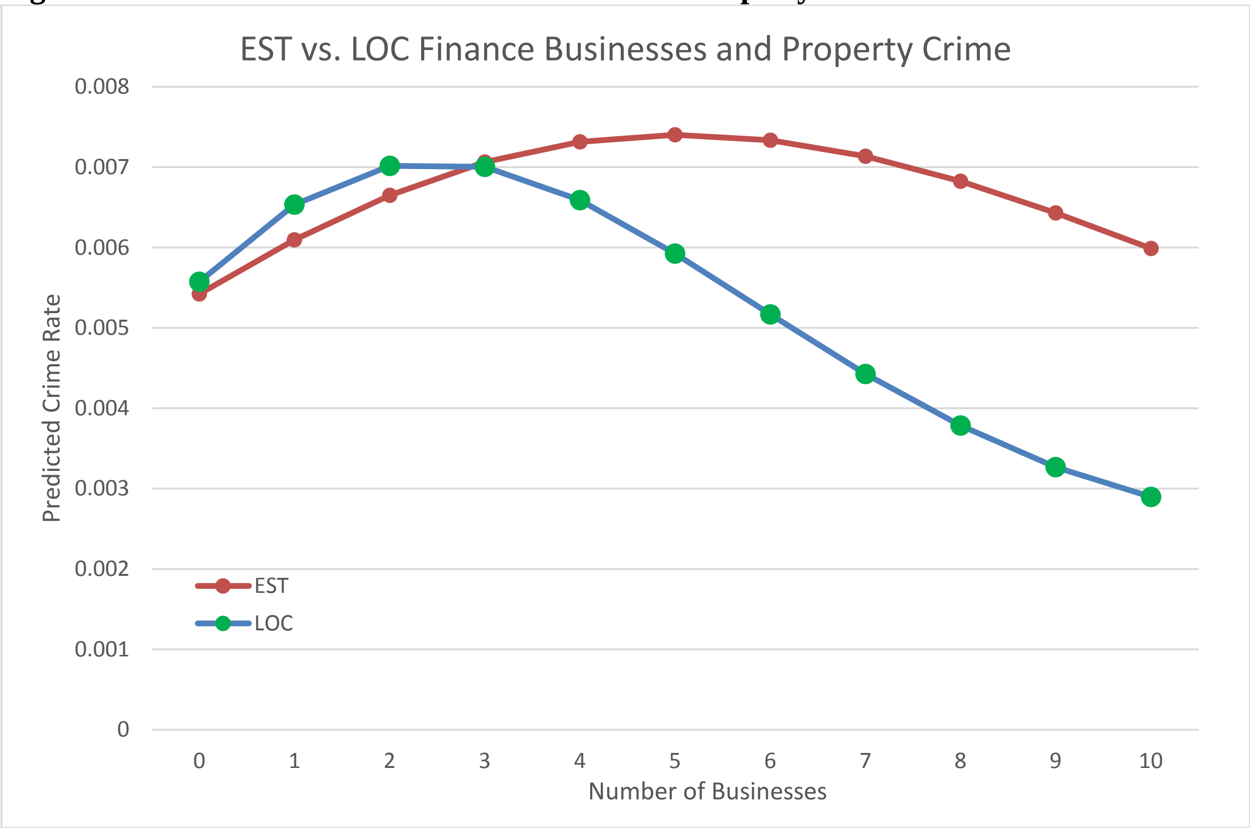


Figure 3.12. EST vs. LOC Restaurants and Violent Crime

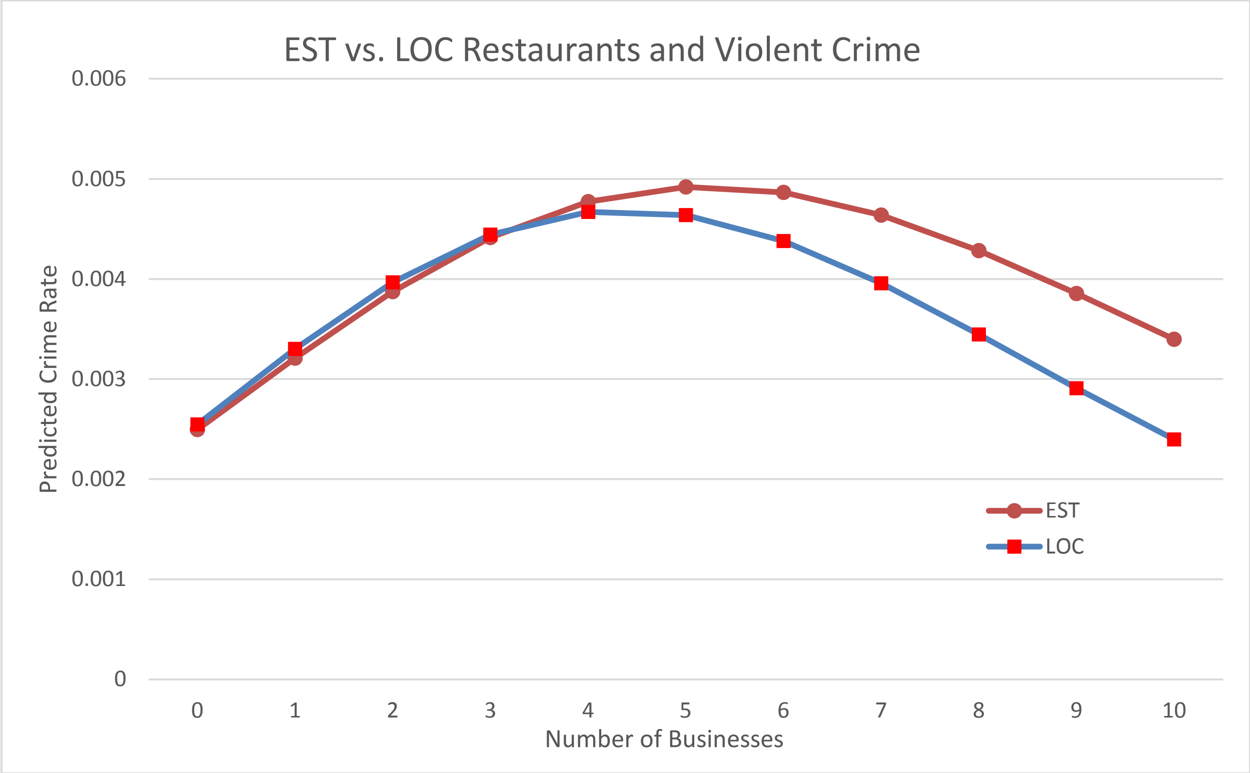


Figure 3.13. EST vs. LOC Restaurants and Property Crime

Figure 3.14. EST vs. LOC Stores and Violent Crime

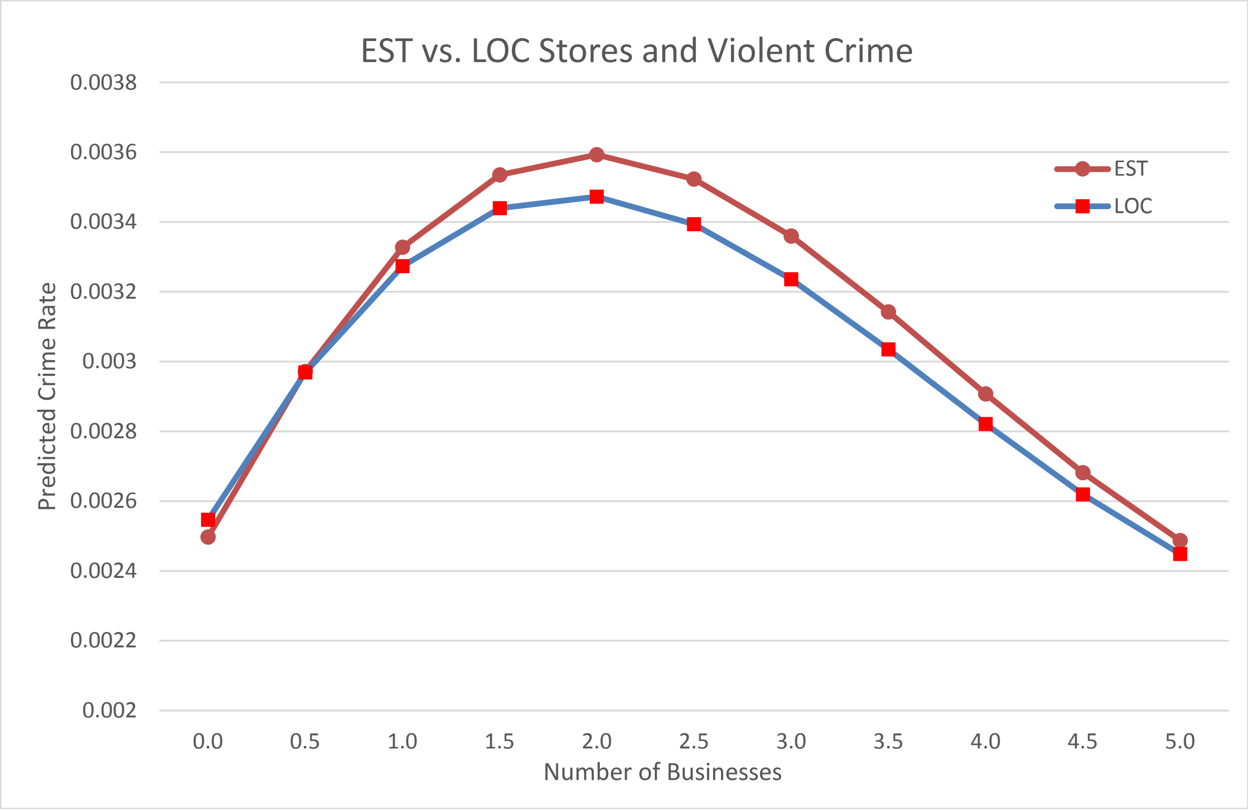


Figure 3.15. EST vs. LOC Stores and Property Crime

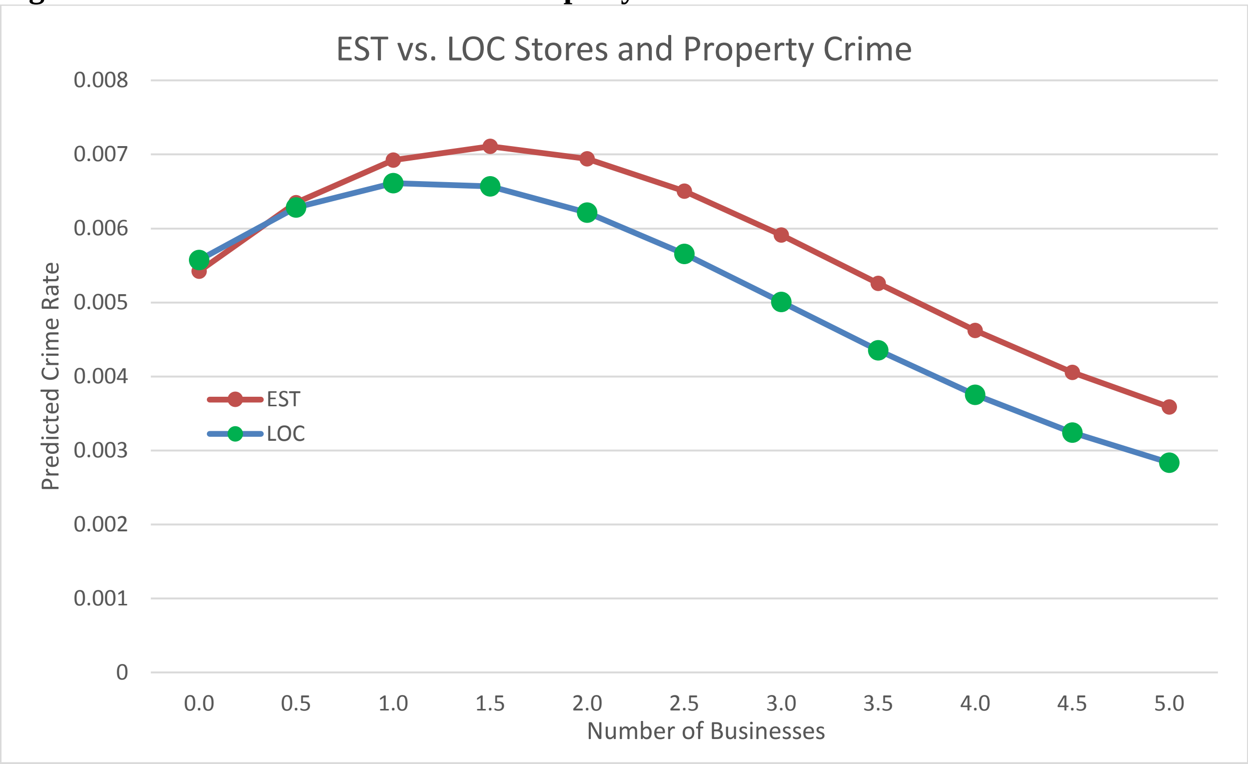


Figure 3.16. Age of Restaurants and Violent Crime

Figure 3.17. Age of Restaurants and Property Crime

Figure 3.18. Interaction: Number of Retail Businesses and Disadvantage (Violent Crime)

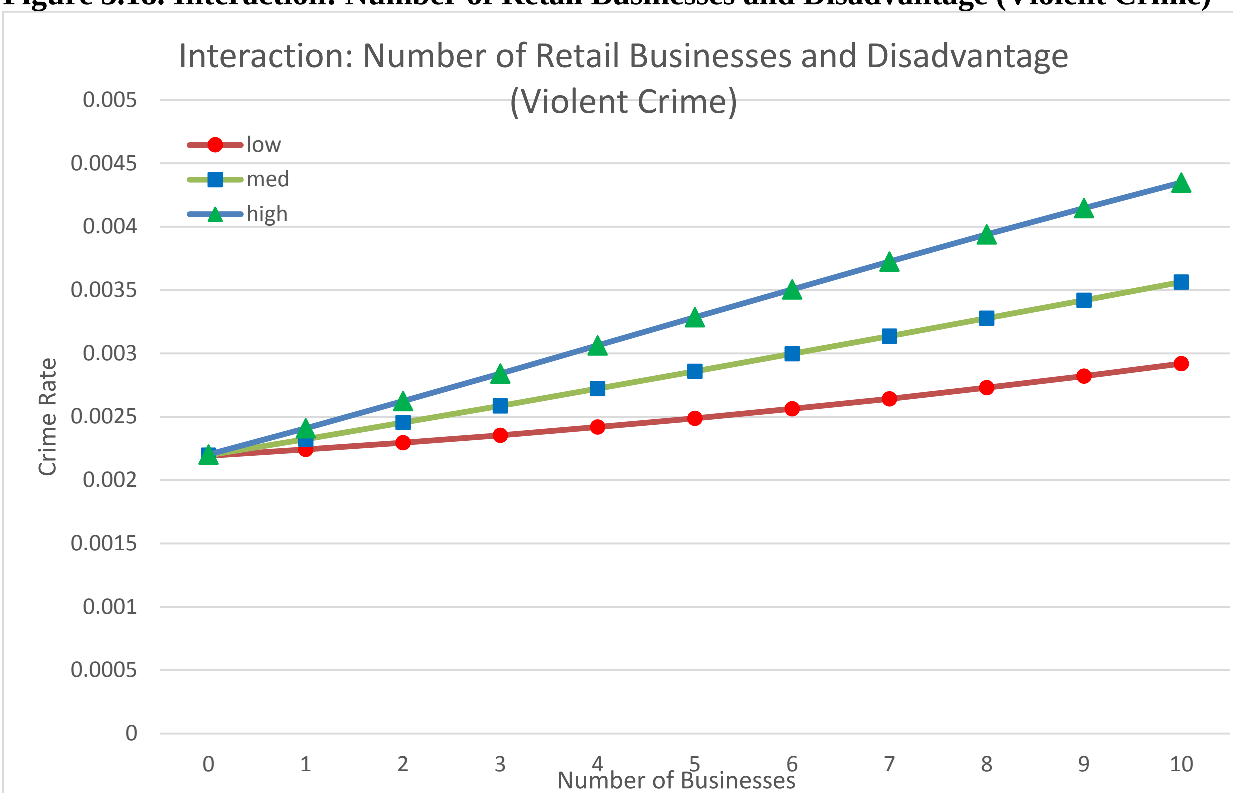


Figure 3.19. Interaction: Number of Retail Businesses and Disadvantage (Property Crime)

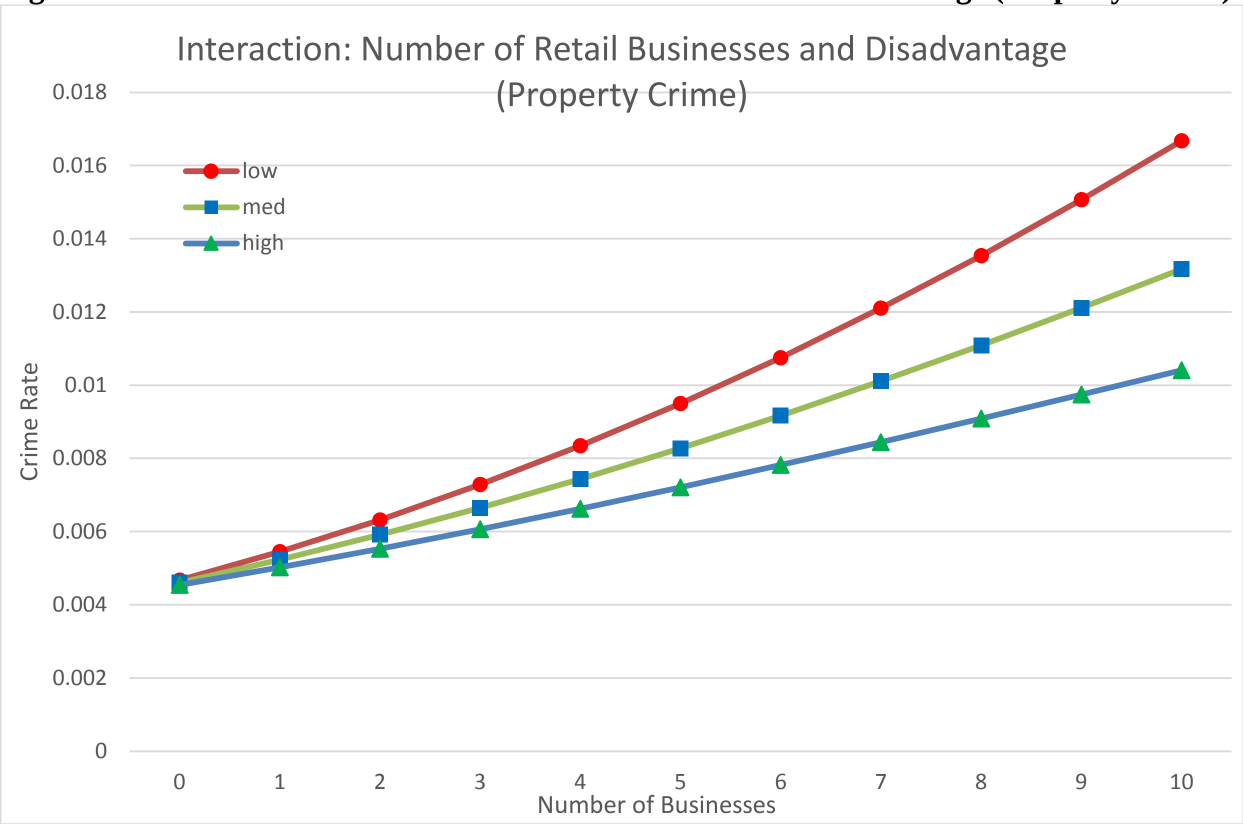


Figure 3.20. Interaction: Number of School Businesses and Disadvantage (Violent Crime)

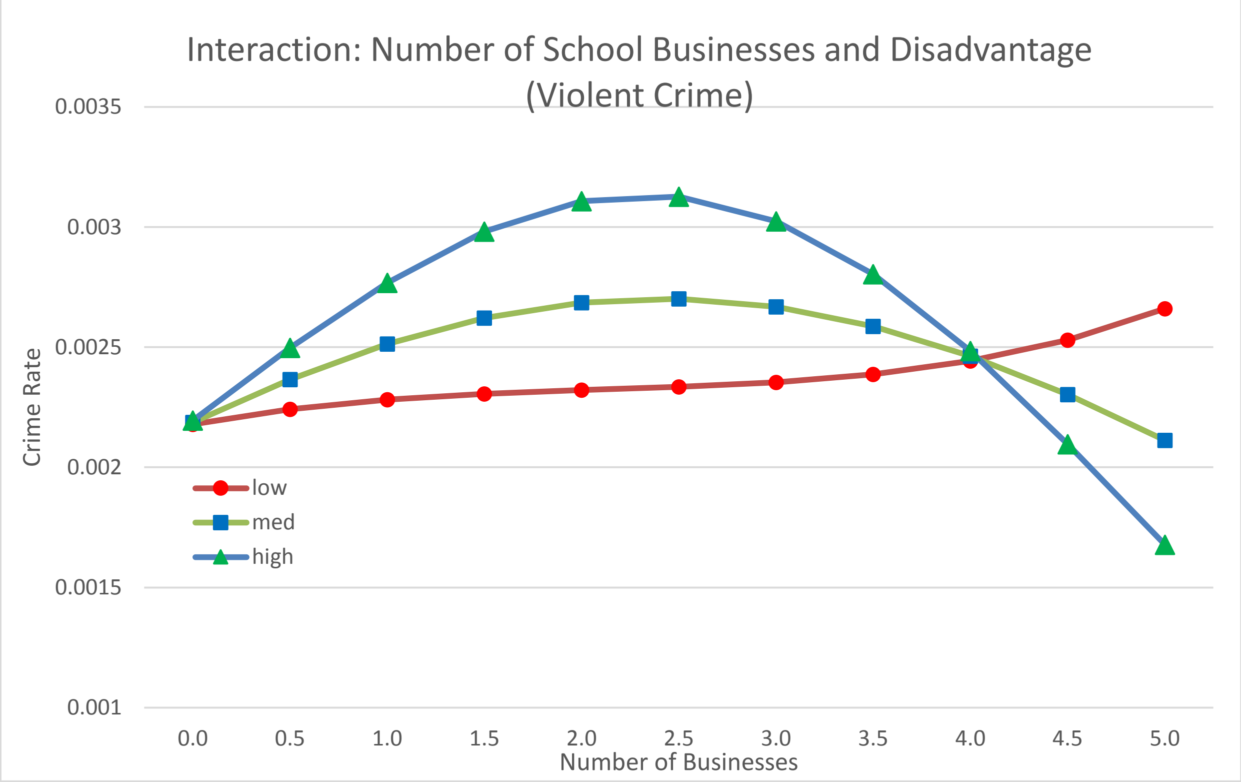


Figure 3.21. Interaction: Number of School Businesses and Disadvantage (Property Crime)

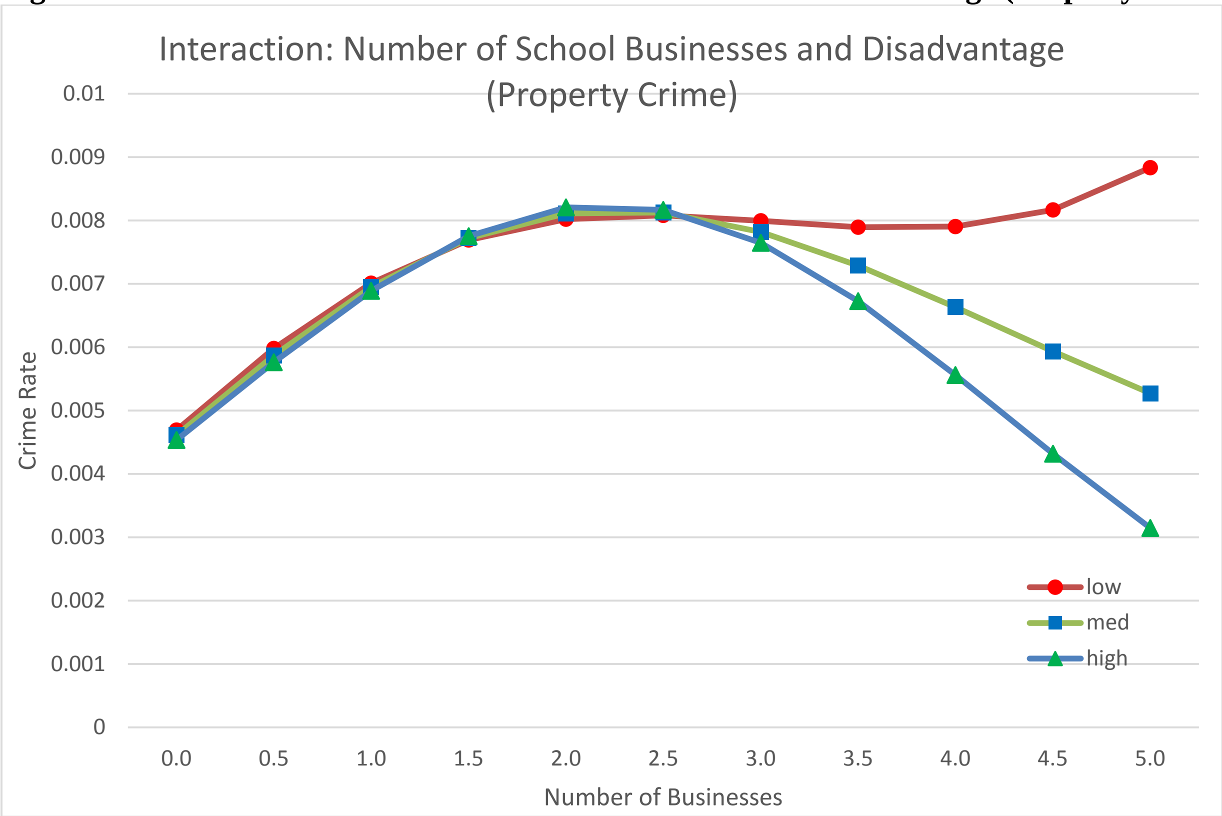


Figure 3.22. Interaction: Retail Business Employees and Disadvantage (Violent Crime)

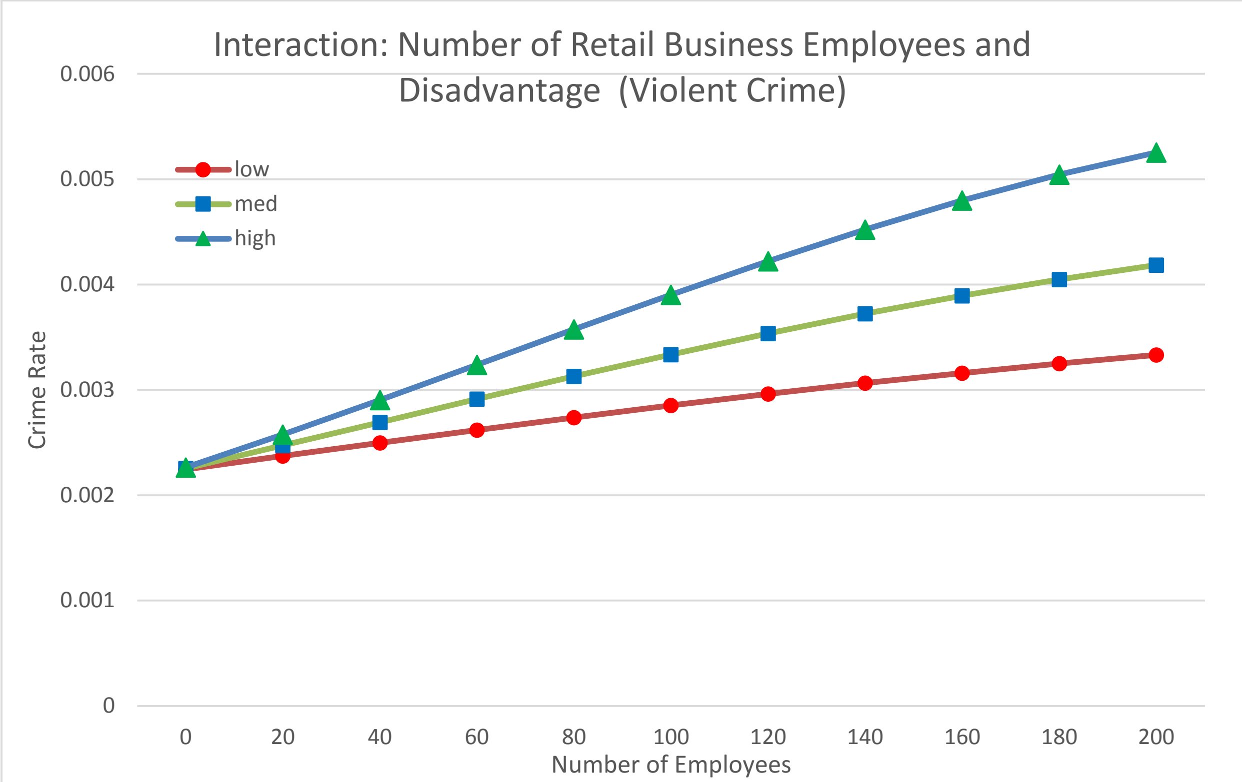


Figure 3.23. Interaction: Retail Business Employees and Disadvantage (Property Crime)

Figure 3.24. Interaction: Local Restaurants and Disadvantage (Violent Crime)

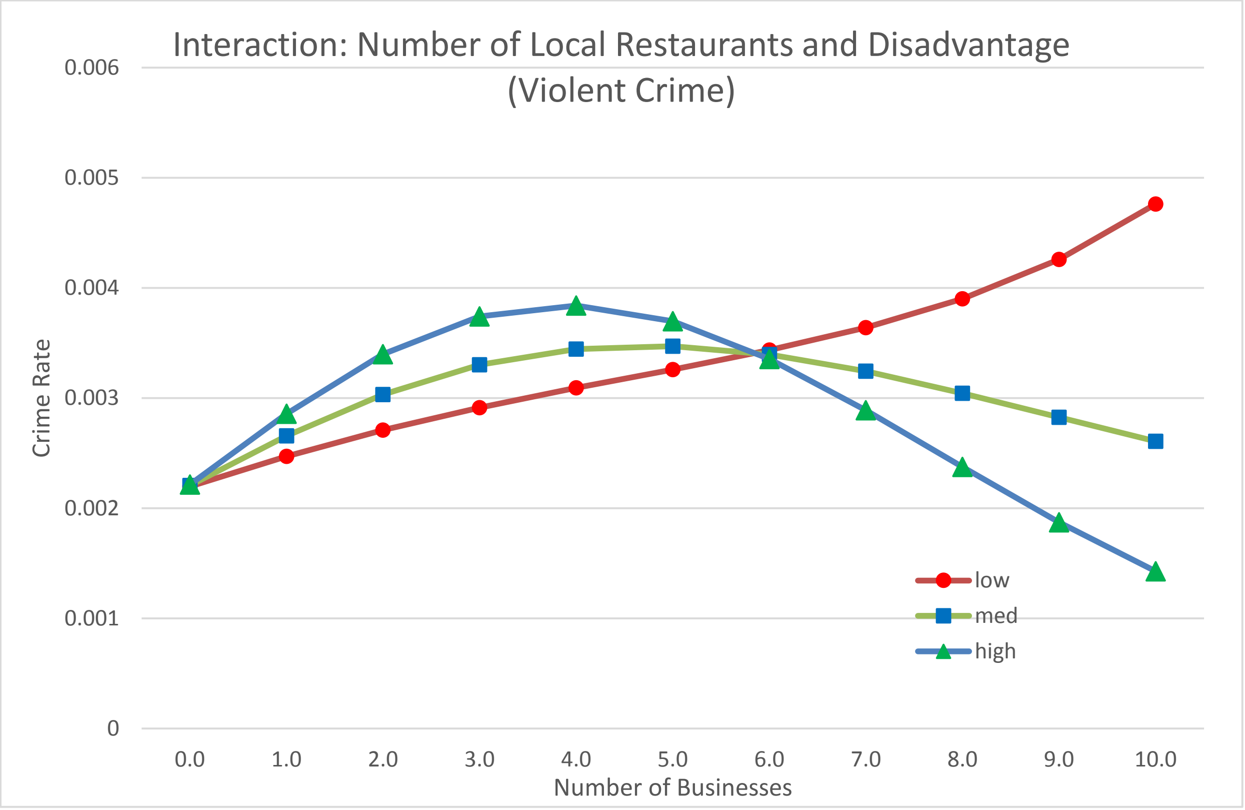


Figure 3.25. Interaction: Local Restaurants and Disadvantage (Property Crime)

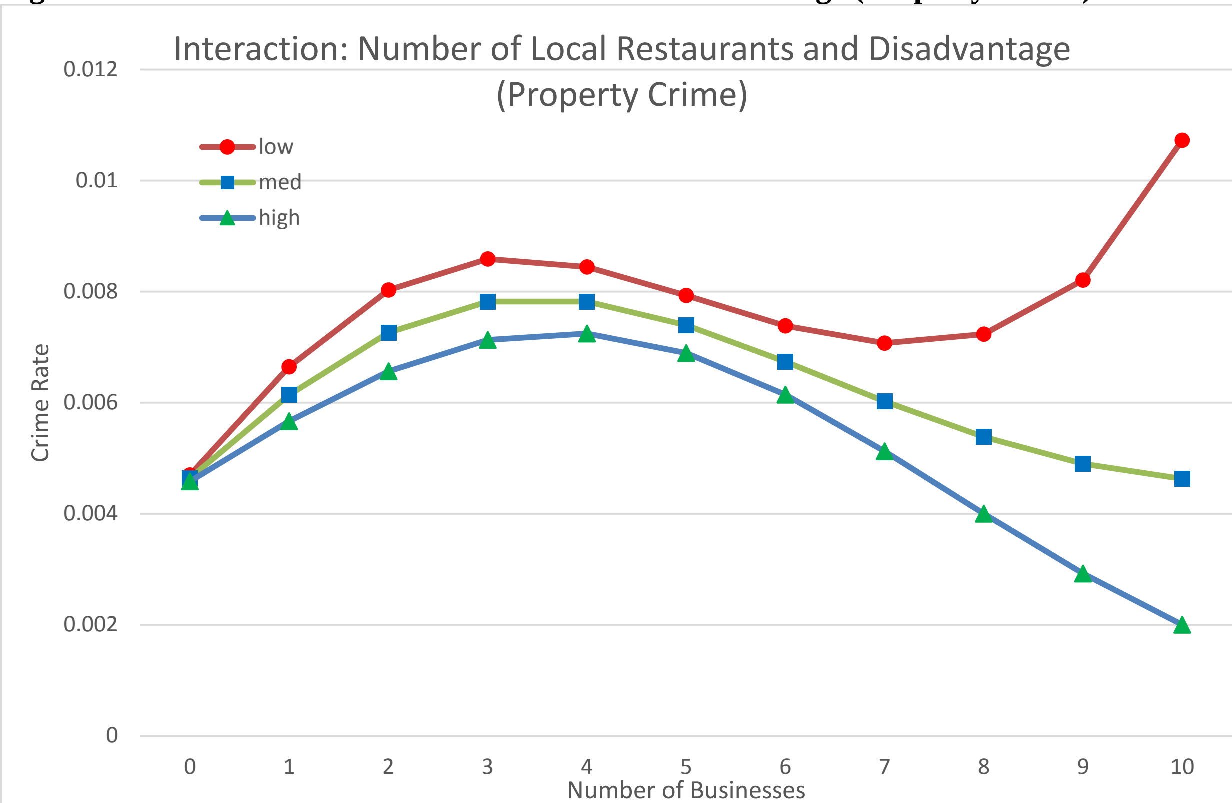


Figure 3.26. Interaction: Age of Stores and Disadvantage (Violent Crime)

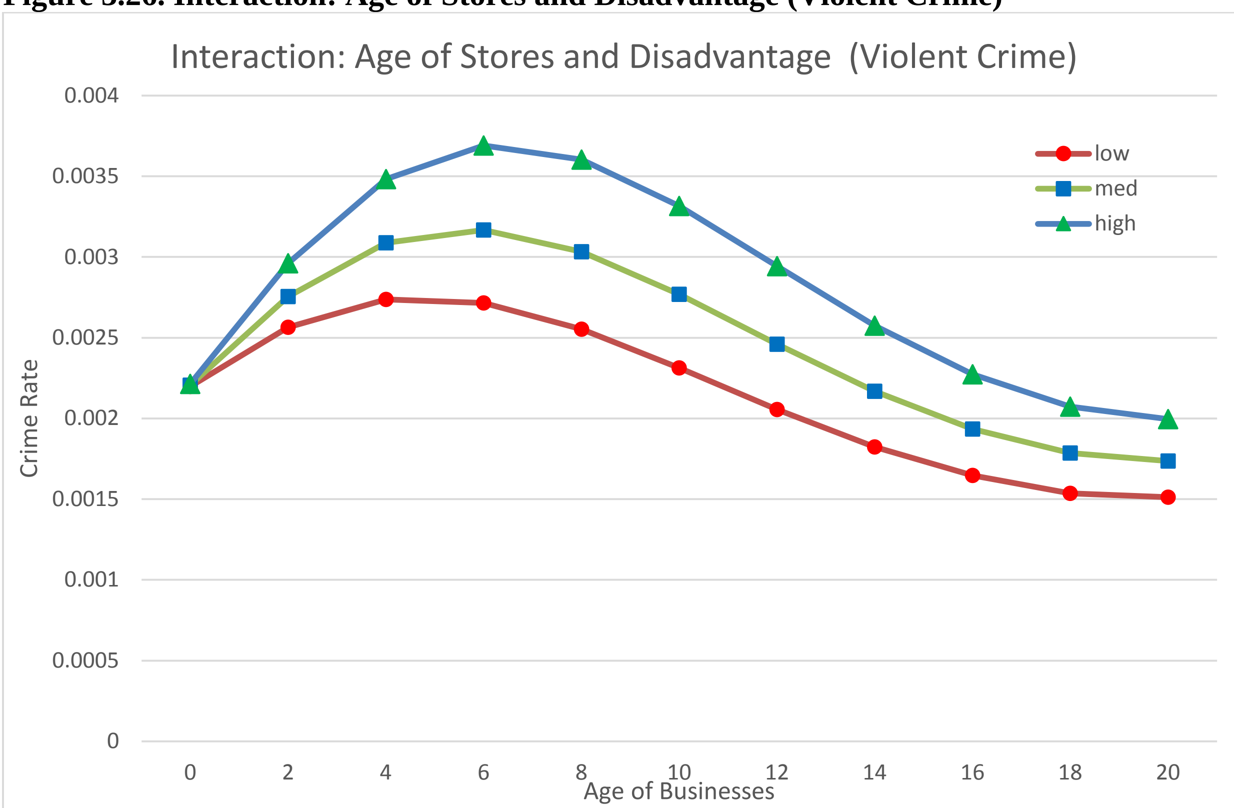
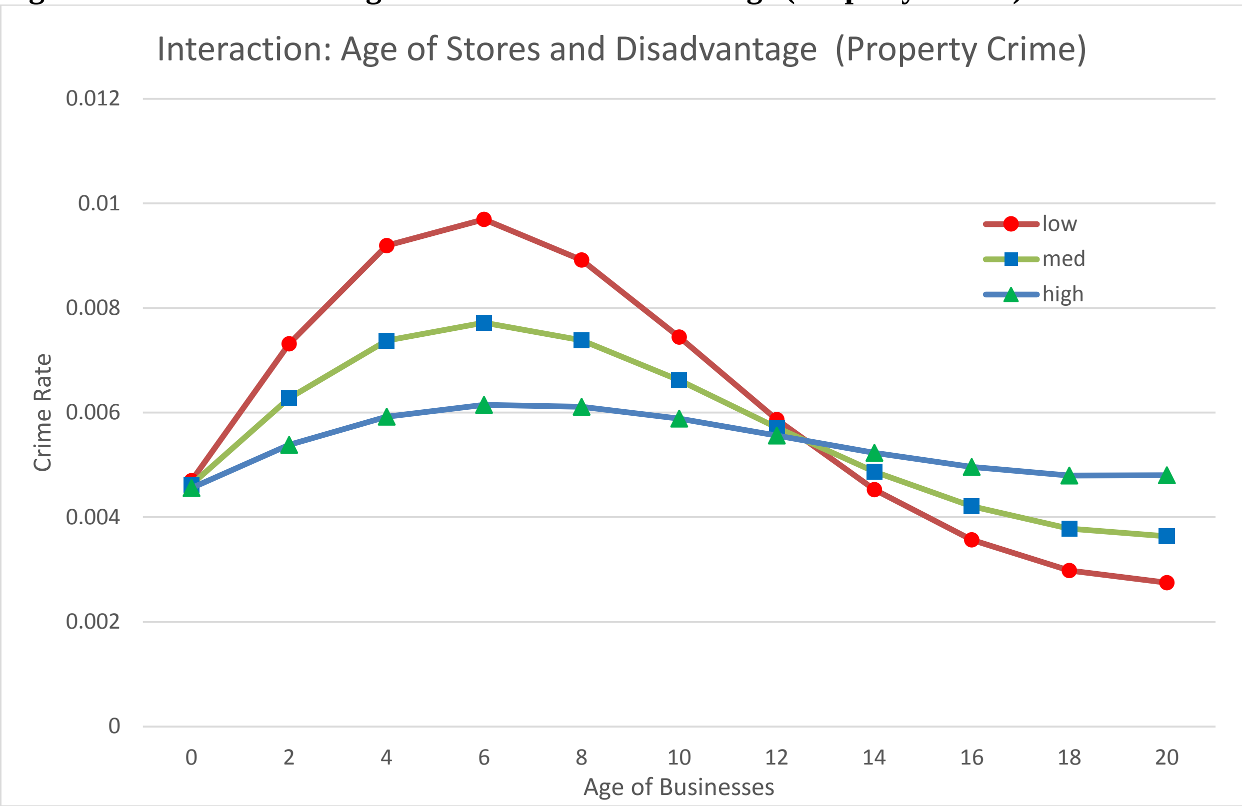


Figure 3.27. Interaction: Age of Stores and Disadvantage (Property Crime)



CHAPTER 4. PATHWAYS

Introduction

Pathways (street network configurations) are crucial elements of physical environments, along which travel can occur. This chapter of the dissertation looks at how physical environments in terms of the street network configuration, and social environments operationalized as structural characteristics, explain the risk of crime in street segments. The current study theorizes that the street network configurations can affect the risk of crime in place because the street network can determine the number and type of people at a given time and place, thus affecting criminal opportunities and level of guardianship in place. Specifically, (1) the pathways offenders take are constrained by the street network configuration, which affects their awareness space and perception of potential targets; (2) criminogenic activity nodes are located along the street network; and finally (3) the street network configuration can influence the patterns of routine activities of people who might provide natural and potential guardianship in place. In the subsequent section, I explain why these three points matter in understanding spatial patterns of crime.

Street Network Configurations and Crime: Potential Offenders and Targets

The first point is about the street network configuration and crime in terms of offenders' decision making process. Rational choice theory and situational crime prevention literature posit that offenders consider the maximized benefits and minimized cost of offending, and thus where to offend. If the effort to commit crime is increased by longer travel distances to get to where to offend, offenders would perceive fewer criminal opportunities. Therefore, the shortest distances that offenders must travel to offend are preferred. This is consistent with the tendency in the journey to crime literature which finds that offenders have a tendency to commit offenses that are closest to their residence based on a distance decay function (Brantingham & Brantingham, 1984; Evans & Herbert, 1989; Rengert, Piquero & Jones, 1999; Van Koppen & De Keijser, 1997). Although the Euclidean distance measures employed in the journey to crime studies can be good proxy estimates for the cost of travel, they ignore the real-life geography of street network configurations that might have direct impact on the travel pathways offenders take. The street network configuration is important for understanding offenders' movement patterns because it can determine not only the distance to where to offend but also how quick and easy it is to travel from one activity node to another.

All in all, distance to where to offend and the configuration of the street network are related to offenders' familiarity with the places. The Brantinghams (1993) identified several elements to explain spatial crime patterns in terms of familiarity with the places (*awareness space* in their term). First, offenders (just as non-criminal pedestrians) develop their routine activities in daily life. These routine activities shape one's activity space, the spatial territory where these routine activities are played out. Based on the activity space, offenders develop their own 'awareness space' which is a familiarized space of routine activities. Places easier to access along the street network will be more familiar to offenders because they are more likely to be traveled by passers-by including offenders.

Regarding the second point, the street network configuration can largely determine the number and type of people coming into the place including potential offenders and targets because criminogenic activity nodes are located along the street network. The Brantinghams (1984, 1995) suggest that there are more criminal opportunities in busier places due to greater inflow of people, and thus higher probability of potential offenders and targets present. They view the types of facilities in places as the important factors in shaping the number and type of people who are familiar with that place. Certain types of facilities (e.g., shopping centers, malls, schools, hotels, etc.) are seen to be crime generators because they draw a large number of people, some of whom may be potential offenders (Brantingham & Brantingham, 1995). By attracting more people to a place, crime generators facilitate an increase of the number of potential offenders, as well as potential victims. Other facilities (e.g., drug markets, half-way houses, bars, etc.) are classified as crime attractors because they have reputations for criminal opportunities. Crime attractors are places that do not necessarily bring together large groups of people at the same time, but their function makes them well suited for motivated offenders to find attractive and weakly guarded targets. Accordingly, we can expect more inflow of passing-by movement in a given area, thus more criminal opportunities in the place, if there are more crime generators or attractors in travel destinations along the street network.

Street Network Configurations and Crime: Level of Guardianship in Place

The third point is about the street network configuration and crime pertaining to guardianship in place. Street network configuration is important because it determines the daily routine activities of people who possibly provide potential guardianship in place. Jane Jacobs (1961) argued that high population density and mixed land use would draw high volumes of passing-by movement. Such areas tend to have more “eyes on the streets” and “natural surveillance” from traveling foot traffic on the streets. Therefore, busier areas with more residential and local business activities would have lower risk of crime and disorder due to increased levels of natural monitoring. Additionally, according to Jacobs (1961), busier streets would encourage the public social interaction between regulars of the streets such as residents, business owners, and employees. Consequently, active streets will have a web of public respect and trust formed over time from many brief public sidewalk contacts (Jacobs 1961:56). The argument of Jacobs on social interactions, mutual trust, and level of guardianship on the streets is similar to theorizing of informal social control and collective efficacy (Sampson and Raudenbush 1999; Sampson, Raudenbush, and Earls 1997).

In contrast, other scholars suggest that populated areas with high number of passers-by would suffer due to many strangers from outside the neighborhood (Newman, 1972; Taylor, 1997). As the number of unfamiliar outsiders on the streets who might not know and care much about the area increases, ambiguity on who is responsible for the surveillance of the areas increases too. Then, the risk of crime and disorder on the streets elevates. According to Newman's (1972) defensible space argument, in an area with a high level of territoriality people form clear segregation between public and private spaces. Potential offenders perceive the areas less attractive for offending because it is more apparent who belongs to the area or not.

In sum, the theoretical context provided by Jacobs and Newman implies a possible curvilinear relationship between the potential number of passers-by on the streets and the risk of crime in place. Thus, I hypothesize that at low levels, street segments with more passers-by would get higher risk of crime due to the combined effect of reduced territoriality, guardianship, and more inflow of people into the place, which may lead to higher probability of convergence of potential offenders and targets at the same time and place; yet beyond a threshold, street activities produced by more passers-by would have crime-reducing effects due to higher level of natural surveillance from eyes on the street.

Application of Centrality to Measure Potential Movements

To test the proposed hypothesis, this chapter of the dissertation utilizes the theoretical and methodological concepts of complex network topology of street network systems. The study of complex network topology is a field of scientific research that studies the connection and interaction between components in real-world networks such as a street network. One important measure, *centrality*, is a fundamental concept of network topological analysis (Lin & Ban, 2013). Indicators of centrality identify the most important vertices or nodes (street segments for the current study) within a network system (i.e., street network). A body of network studies suggest several distinct conceptions of centrality such as *Reach* and *Betweenness* (Freeman, 1977, 1979). Note that the current study utilizes the general network concepts of *Reach* and *Betweenness centrality* in a specific context of the street network.

Reach centrality indicates the number of other street segments to which a given segment is adjacent via the street network. It measures how well a given segment is connected to other segments through the street network by counting the number of segments each street segment can reach within a given search radius (e.g., quarter mile) via the street network. Therefore, it is the most straightforward index of connectivity to quantify the level of connectivity of a given segment to others, which may capture the amount of potential traffic and population passing through the segment. Connectivity is an important factor in studying crime risk at place given that it reflects how the street network configuration affects pedestrian and vehicular movements. Indeed, prior studies found that connectivity via the street network is associated with crime risk (Beavon et al., 1994; Johnson & Bowers, 2010).

Betweenness centrality indicates the potential traffic passing along a given street segment within a search radius on the street network. Thus, it captures how frequently individual segments are used during journeys from one to others through the network along the shortest path (Freeman, 1977, 1979). As discussed in Chapter 2, some studies argued that segments with higher potential usage (higher betweenness) would have lower crime risk due to higher natural surveillance from more pedestrian activities, whereas other studies posit that segments with more transient activities would have less territoriality, which may reduce the territorial protection, and hence result in more crime in place. Therefore, it is necessary to empirically test whether crime risk is higher on street segments with higher potential usage.

Some previous studies have empirically tested the relationship between centrality indicators and crime at the street segment level, and found that they can be significant predictors of crime. For example, in a recent study conducted in London, United Kingdom (UK), Summers & Johnson (2016) examined the associations between levels of connectivity (equivalent to reach centrality), integration, and choice (betweenness) and the level of violent crimes such as (attempted) homicide, (attempted) aggravated assault, sexual assault, and robbery. The results showed that higher levels of connectivity and betweenness were associated with the greater odds of risk of violent crime. Also, in a study of the spatial distribution of residential burglary and the configuration of a street network in Birmingham, UK, Davies & Johnson (2015) suggested that betweenness can be a more objective measure compared to categorical classifications of streets as previously employed. Their results showed that the level of burglary is higher on streets with higher betweenness values, which is consistent with their hypothesis based on crime pattern theory, implying higher criminal opportunities and thus risk of crime for streets with more usage. Along with the betweenness measure, they also included a measure of straightness and found that more linear streets generally have lower risk of burglary victimization.

Although these studies successfully examined the association between the physical configuration of the street network and crime in place, one possible additional refinement on the measures is considering to what extent the effects of the physical configuration of the street network on crime is confounded by the criminal opportunities introduced by the characteristics of "where people are from and go" in each travel when computing the betweenness centrality (i.e., population, number of business of employees, etc.). Including the characteristics of where people from and go in the calculations of the measures of the street network configuration is theoretically and methodologically more appealing for the following reasons.

First, theoretically, Brantingham & Brantingham (1993a) recognized the role of pathways in relation to activity nodes present in places that "the search process [of motivated offenders] used to find a suitable target is not random, but seems to involve looking for targets near the criminal's usual *travel paths* between *major routine activity nodes*…" (p.5). Indeed, some empirical studies support this argument. For example, in a study of offenders' homes and offence locations, Iwanski et al. (2012) examined whether offenders committed crime while in the process of a longer journey. They found that the paths offenders take are biased towards *crime attractors* such as major shopping centers. Therefore, some origins and destinations (where people are from and go) might account for more travel journeys passing through a given street segment via the street network due to their characteristics of land uses and the size of the residential population (Frith et al. 2017).

Methodologically, the unweighted configuration of street network elements can bring about potential bias because it assumes that all street segments in the network have the same characteristics. For instance, a street segment with more visitors for retail business facilities will be treated equally as segments with more residential land uses. Thus, by not considering specific characteristics of the street segments, an unweighted configuration of the street network limits the analyses to the geometric properties of the street network only. Therefore, the role of pathways should be understood in relation to the characteristics of places (street segments) by assigning higher weighting to the measures of pathways based on the characteristics of places. Specifically, these weights include: (1) residential population living in where people are from and go given that a segment with more residents tends to have more pedestrian and vehicular movement along the street network; and (2) residential population living in where people are from and the number of business employees in where people go given an assumption that larger business facilities tend to have more employees, and thus more customers visiting the focal street segment.

In sum, previous studies have emphasized the importance of pathways and tested their associations with the patterns of crime at place. Although these studies developed the measures of pathways, there still remains theoretical and methodological room for further refinement. The current study attempts to do so by introducing theoretical concepts and measures of network topology of street network systems. Moreover, to incorporate the important characteristics of where people from and go, the current study assigns higher weighting on the journey to or from known centers of activity nodes. Therefore, the primary research questions of this chapter are as follows: (1) whether physical environments theorized as *pathways* (street network configuration) have significant effects on crime in places; and (2) whether these effects vary by residential and business characteristics in "where people are from and go" in each travel route that can be taken within a given area. Additionally, as theorized in chapter 2, the analyses estimate a series of interaction terms that pair together measures of pathways and the socioeconomic status of street segments.

Data and Methods

The unit of analysis in this chapter is the street segment. The dependent variables of this chapter are the number of violent and property crime incidents. The crime data come from the Southern California Crime Study (SCCS) as described in Chapter 3. I used the average of violent and property crime incident data in 2010, 2011, and 2012 at the street segment level. To measure the configuration of the street network at the street segment level, this study employs 2 types of centrality measures as discussed above (*Reach* and *Betweenness*). To calculate these measures, first, I built a street network dataset using 2010 ESRI Street Map data. Then, the centroids of street segments on the street network are used to construct the centrality measures using the Urban Network Analysis (UNA) toolbox for ArcGIS 10.2 developed by the City Form Lab at Massachusetts Institute of Technology (MIT). Street segments near the boundary of the study area may inherently have less movement if the street network data are limited to the study area boundary. To avoid this, I drew 5 mile buffers and included the street network and street segments within the buffer boundary.

To consider residential characteristics of where people are from and go, I utilized residential population in street segments from 2010 US Census data at the block level imputed into street segments. I employed the SA imputation method proposed by Kim (2016) described in the previous chapter. To consider business characteristics of where people go, I employed the typology of 10 consumer-facing businesses using the Reference USA data in 2010 as described in previous chapter. Addresses of business facilities are geocoded to latitude and longitude points using ArcGIS 10.2 and then aggregated to the street segment level based on their geographic proximity to get information on the number of the 10 types of consumer facing business employees in street segments. The detailed information on construction of the four centrality measures is described below. Once the centrality measures are created, I examined the associations between them and crime while controlling for the structural characteristics in street segments.

Reach Centrality

Reach centrality measures how many other segments can be reached from a given street segment on a street network within a specified search radius. Therefore, the reach matrix characterizes the number of particular destinations that can be reached from any locations in a city within a given access radius. The mathematical specification of the *Reach* measure used here takes following form:

$$Reach_i^r = \{\, j \in N - \{i\}: d[i,j] \leq r \,\} \qquad (3\text{-}1)$$

where, $Reach_i^r$ indicates the total number of other reachable street segments at the shortest path from a given street segment i on a street network N within search radius r (quarter or one mile). $d\ [i, j]$ denotes the shortest path distance between i nodes and j in the street network N. This mathematical equation defines distances from a segment i to another segment j as less or same as the search radius r. $\{i\}$ is the cardinality of the set i, which means the number of elements of the set. For example, the set A = {3, 6, 9, 11} contains 4 elements, and therefore A has a cardinality of 4.

Betweenness Centrality

The betweenness centrality index estimates how often a street segment is in-between other locations. It estimates the likely paths of trips, and tells us which street segments are passed most often along the way. Thus, the betweenness centrality quantifies the potential of passers-by at different segments on the network; or in other words, an estimate of the use of a given segment by traffic passing through the network as a measure of how frequently a segment is used in a network (Freeman, 1977). Betweenness of a given segment *i* is defined as the number of shortest routes between pairs of other segments in the street network passing by segment *i*, which takes following form:

$$Betweenness_i^r = \sum_{j \in N-\{i\}: d[i,j] \leq r} \frac{n_{jk}[i]}{n_{jk}} \qquad (3\text{-}2)$$

where $Betweenness_i^r$ is the betweenness of segment *i* within search radius *r*, n_{jk} depicts the total number of shortest routes between segment j and *k*, while $n_{jk}[i]$ represents the number of shortest routes from segment *j* to *k* that pass by segment *i*.

For the betweenness measure, as abovementioned, input weights can be introduced to account for meaningful characteristics of origin *i* (where people are from) and destination *j* (where people go). Giving weights of origin *i* and destination *j* assigns more importance to the routes taken while traveling from segment i to$j$. This chapter of the dissertation considers the importance of the activity nodes in where people are from and go when calculating the betweenness centrality measure, especially residential population in where people are from and go and the number of employees of 10 types of consumer facing businesses in where people go. Therefore, betweenness centrality has three sets of measures: 1) unweighted betweenness centrality measure, 2) betweenness centrality measures of segment *i* considering residential population in segment *j* and *k* which captures the potential of passing-by population going to a segment *k* from *j* through *i*; 3) betweenness centrality measures of segment *i* considering residential population in segment *j* and the number of business employees in segment *k* which captures the potential movement going to segment *k* from *j* through *i*. For 3), considering the weights of the number of employees of 10 business types used in previous chapter. The equation of the weighted betweenness measure for segment *i* is presented below:

$$Betweenness_i^r = \sum_{j \in N-\{i\}:d[i,j] \leq r} \frac{n_{jk}[i]\; w_j\; w_k}{n_{jk}\; \sum w_{jk}} \qquad (3\text{-}3)$$

where w_j represents the origin's weight (where people are from), w_k is the destination weights (where people go), and $\sum w_{jk}$ is the total weights of all possible origin-destination (*j*-*k*) pairs within the given search radius from the focal street segment *i*. The weighted betweenness equation is from Frith et al. (2017). This approach effectively assumes that routes of origins and destinations with more population or business employees would have more usage, thus receive higher weightings.

To account for the effects of the social environment (socio-structural characteristics), I included the list of Census measures imputed in street segments as described in the previous chapter. To do this, the *SA* imputation method aforementioned is employed to apportion the Census block data to street segments. Specifically, I constructed a *concentrated disadvantage index*, which is a factor score computed after a factor analysis of four measures: (1) percent at or below 125% of the poverty level; (2) percent single-parent households; (3) average household income; and (4) percent with at least a bachelor's degree. The last two measures had reversed loadings in the factor score. To measure *residential stability*, this study utilizes the percent home owners. The present study controls for the presence of racial/ethnic minorities in street segments as the percent African-American and the percent Latino/Hispanic. To capture the level of *racial/ethnic heterogeneity*, a Herfindahl index based on five racial/ethnic groups (white, African-American, Latino, Asian, and other races) was computed. Besides the variables included above, this study also used the percent *occupied units* to measure vacancies.

Search Radii – Local Pedestrian vs. Non-local Vehicular Movements

This study uses quarter and one mile as search radii when calculating centrality measures for the following reason. By restricting the length of the trip to short distances of quarter mile, the first approach specifically considers those segments that are likely to be journeys through the network within relatively shorter distance (local trips), which makes the metrics of centrality measures indicators of mostly local pedestrian movements rather than those requiring usage of vehicles. Relatively short trips may be perceived as the “local area” where a person might feel more responsible for the surveillance of the area. Also, this kind of short distance trip is more likely to be walked by local people. Therefore, using quarter mile more directly identifies local movements made by people actually living or having routine activities and awareness space in the area (Hiller, 1996; Davies & Johnson, 2015).

On the other hand, I consider non-local vehicular movements by extending the length of journeys to one mile via the street network. People taking such longer distance trip are more likely to be non-local taking vehicles and only passing through the area. Therefore, they might not know and care much about the area, and feel less responsible for the surveillance of the area. A few prior studies found that local (pedestrian) movement can bring about very distinct crime patterns in place compared to non-local (vehicular) movements. For example, Davies & Johnson (2014) and Frith, Johnson, & Fry (2017) found that local pedestrian traffic decreases crime risk whereas the non-local vehicular traffic was positively associated with crime in street segments.

Analytic strategy

This study estimates a series of models in which the effects of the physical environments in terms of the street network configuration measured as the centrality indices (reach and betweenness) are included in the models, while accounting for the effects of socio-structural characteristics. I estimated sets of negative binomial regression models with city fixed effects and spatially lagged measures of the structural characteristics. The general form of these models are:

$$E(y) = exp(\alpha + \beta_2 lnx + \beta_3 z + \beta_4 wz + \beta_5 j) \qquad (3\text{-}4)$$

where y is the dependent variable to be explained (the count of crime incidents in that year), α is an intercept, *lnx* represents logarithm of each centrality measure included in each model, one at a time, *z* is a matrix of the structural characteristic variables, *wz* is a matrix of the spatially lagged structural characteristic measures, and *j* is a matrix of the dummy variables for cities for city-fixed effects to control for the average differences across cities in any observable or unobservable predictors. I included block population as the exposure variable, effectively making the outcomes interpretable as rates.

Specifically, Models 1-2 include each centrality measure of reach and unweighted betweenness, respectively. Models 3-13 include the measures of betweenness weighted by population and the number of employees by 10 business types, respectively. To see how the physical environment of street network configuration and the social environment in terms of socio-economic status interactively working together, I estimated a set of models including the measures in Models 1-13 with the interaction terms with the concentrated disadvantage index, respectively. To capture possible non-linear relationships, squared and cubic terms are included for the primary measures included in the models. Table 4.1 presents the summary statistics for the dependent and independent variables used in the analyses. Also, correlations between the centrality measures are reported in Table 4.2.

<<< Tables 4.1 and 4.2 about here >>>

Results

Figure 4.1 is a map of Los Angeles City with street segments colored according to the level of local betweenness. Red streets are the areas with more potential passing-by usages via the street network—higher betweenness, while the blue streets indicate the areas with lower level of betweenness. As shown, there is some variation in terms of how frequent streets are used along the physical configurations of street network. Also, I see that larger streets in the city of Los Angeles have higher betweeness, which makes sense given that the larger streets would have more potential usage based on the street network.

<<< Figure 4.1 about here >>>

Main Effect Models

I begin with the findings of the estimated models. I first display the results from the main effect models. The complete set of coefficient estimates from the main effect models are shown in Tables 4.3-4.6. Yet, it is inherently challenging to discern patterns from traditional regression tables. Consequently, I have plotted the predicted values of violent and property crime in Appendix Figures A4.1-52. The x-axis represents the values of centrality measures ranging from 1^{st} to 95^{th} percentile of the distribution, while y-axis is the predicted violent or property crime rate.

<<< Tables 4.3-4.6 about here >>>

For example, Figures 4.2 and 4.3 show the effects of local reach centrality which captures the level of connectivity via the street network within a relatively smaller area (quarter mile search radius) on violent and property crime. I found that although crime initially increases as the level of connectivity (reach) increases, the general pattern is crime-reducing for both violent and property crime. For example, every 100 percent increase in the reach index leads to about 19 percent decrease in violent crime rate, on average. This means that better connected street segments along the street network within relatively smaller areas would have lower risk of violent and property crime, in general. Likewise, the pattern of reach centrality is crime-reducing when employing a larger search radius (Appendix Figures A4.27 and 40).

<<< Figures 4.2 and 4.3 about here >>>

Next, I turn to the findings of the betweenness centrality measures. For example, Figures 4.4 and 4.5 describe the effects of unweighted local betweenness centrality (potential local pedestrian movements passing by a given street segment based solely on the physical geography of street network) on violent and property crime. For both violent and property crime, as the level of local betweenness increases, crime is initially elevated, yet the pattern peaks and down turns as the local betweenness enhances further. This means that street segments with more potential usage via the street network have higher risk of crime at first, but as they are more frequently used, they have lower risk of crime. Likewise, non-local betweenness (one mile radius) has a curve-linear (inverted U-shape) relationship with property crime, whereas violent crime increases and levels off as non-local betweenness increases further (Appendix Figures A4.28 and 41).

<<< Figures 4.4 and 4.5 about here >>>

Turning to the results of the weighted betweenness centrality measures considering the residential population of where people are from and go, I observed inverted U-shape patterns regardless of search radii and crime types. For example, Figures 4.6 and 4.7 describe the effects of the betweenness considering the residential population in where people are from and go, which captures the number of potential passers-by coming through a given street segment along the street network. At low levels, increasing in the number of potential passers-by via the street network leads to a corresponding increase in violent and property crime. Beyond a threshold (around the median of the distribution), betweenness begins to show a negative effect on the violent and property crime risk. For instance, every 100 percent increase in betweenness results in about 32 percent increase in property crime on average up to the threshold point. However, after the threshold, property crime decreases about 18 percent on average for every 100 percent increase in the betweenness. This means that street segments with more passers-by would initially have higher risk of violent and property crime but this pattern turns to be crime-reducing as it reaches and passes a certain threshold. The pattern remains stable when employing larger search radius to capture non-local vehicular passing-by movements.

<<< Figures 4.6 and 4.7 about here >>>

Weighted Betweenness Results

Next, I describe the findings of the weighted betweenness considering residential population in where people from and the number of employees of various types of business in where people go as the businesses would draw more customers, thus increase the number of potential passers-by coming through a given street segment. For example, the results of betweenness weighted by the number of retail employees show non-linear relationships (inverted

U-shape) with the risk of violent and property crime in street segment (Figures 4.8 and 4.9). At lower centrality levels, street segments with more potential passers-by along the street network “to get to retail areas” have higher risk of violent and property crime; but the pattern turns to be crime reducing as the number of potential passers-by continue to increase. For example, each 145 percent (about one log of the betweenness) increase in betweenness results in about 18 and 21 percent initial increase in violent and property crime. Yet the pattern changes to be crime-reducing after a threshold (three log increases of betweenness): each 145 percent increase in betweenness leads to about 7 and 14 percent decrease in the risk of violent and property crime. This pattern is similar when looking at the findings of betweenness weighted by other types of business employees in where people go (Appendix Figures A4.1-26) and a one mile search radius (Appendix Figures A4.31 and 44).

<<< Figures 4.8 and 4.9 about here >>>

Now let me briefly describe the findings of the control variables in the models. The concentrated disadvantage index shows a positive and statistically significant effect on violent crime while it indicates a negative and non-significant relationship with the risk of property crime. Percent occupied units and percent homeowners have significant and negative relationships with both types of crime, while percent African-Americans in street segments has positive relationships. These findings of control variables for structural characteristics are consistent with the findings of previous studies. However, the racial/ethnic heterogeneity measure has statistically significant negative coefficients. This finding is surprising given that it is opposite to what social disorganization theory posits. However, this finding is consistent with previous studies of spatial patterns of crime and structural characteristics at the street segment level (Smith et al., 2000; Kim, 2016; Kim & Hipp, 2017).[1] Regarding the measures of land use characteristics, segments with more retail land use and industrial land use have higher risk of violent and property crime. Segments with more residential land use have generally negative effects on violent and property crime. One possible explanation is that residential population are more likely to operate as eyes on the street so that the areas with more residential land use have higher level of natural surveillance; thus lower risk of crime.

Moderating Effects: Street Network Configurations, Socioeconomic Status, and Crime in Place

In this section, I discuss the effects of centrality measures on the risk of crime in street segments, moderated by socioeconomic status of the place measured by the concentrated disadvantage index. For each test of moderation, there is a model using violent crime as the outcome, and a model using property crime as the outcome. The main effect models showed that the reach and betweenness indexes have curvilinear effects (inverted U-shape) on the rates of violent and property crimes, irrespective of the different search radii. Tables 4.7-10 show statistically significant interaction terms consisting of centrality measures and socioeconomic status. Yet, it is challenging to discern patterns of moderation from a regression table. Consequently, I have graphed the predicted values of crime in Appendix Figures A4.53-104 according to the coefficient results of the interaction term and the main effects at varying levels of the concentrated disadvantage index (Low = -1 SD, Med = mean, and High = +1 SD).

<<< Tables 4.7-4.10 about here >>>

When looking at the effects of the local (1/4 mile search radius) and non-local (1 mile search radius) centrality measures on violent and property crime at different levels of

[1] Please refer to Kim (2016) for a detailed explanation on why racial/ethnic heterogeneity in street segments may function in a different way compared to other larger spatial units of neighborhood.

disadvantage, I observed some general patterns as follows with few exceptions: (1) high disadvantaged areas generally have higher risk of crime; and (2) the curve-linear relationships between centrality measures and crime are more pronounced in high disadvantaged areas; thus (3) the levels of reach and betweenness matter more in high disadvantaged street segments than better-off areas, in general. For example, Figure 4.10 captures the effect of local betweenness centrality considering residential population in where people from and go at different levels of concentrated disadvantage. As presented, the risk of violent crime in high disadvantaged segments is higher than the others. This means that disadvantaged areas tend to have higher risk of violent crime regardless of the patterns of potential passers-by in the areas.

Figure 4.11 shows the effect of local betweenness weighted by residential population in where people are from and the number of retail employees in where people go on property crime risk. As shown, the graph amplitude for high disadvantaged areas is larger than the other two lines. This means that the curve-linear relationship between the local betweenness index and the risk of property crime seems more pronounced in disadvantaged street segments, so the non-linear effect matters more in disadvantaged areas than better-off areas.

I also observed a few exceptions not following the abovementioned description of general patterns. For instance, Figures 4.12 reveals the association between the (non-)local betweenness considering residential population in where people are from and the number of retail employees in where people go and violent crime in street segments. As shown, the relationship varies across different levels of socioeconomic status. In high disadvantaged areas, as non-local betweenness increases, violent crime increases initially; yet the pattern changed to be crime-reducing as it passes a threshold point. In better-off street segments, in contrast, non-local betweenness has a crime-enhancing effect only. Therefore, for high disadvantaged street segments, more potential passers-by to get to retail areas along the street network would initially enhance the level of violent crime in the areas but eventually turn to be crime-reducing pattern, whereas for better-off areas, those potential passing-by movements only have a crime-enhancing effect for violent crime. Likewise, I observed similar patterns for the local and non-local betweenness measures weighted by residential population in where people are from and the number of service business employees in where people go for the risk of violent crime in street segments.

Discussion

This chapter examined the impact of physical environment theorized as pathways in terms of the street network configuration on violent and property crime in street segments in the Southern California area. While scholars have theorized how the street network configuration (pathways) can be important for understanding the location of crime, the empirical relationship between the street network and crime is relatively under-researched compared with other features of the environment. This chapter employed measures of pathways based on the street network configuration and found that the street network configuration is important for understanding the spatial patterns of crime in street segments.

First, the current study finds a curve-linear relationship between the potential passers-by along the street network and crime in street segments. Specifically, street segments with more potential passers-by would initially have higher risk of crime, yet the pattern turns to crime-reducing after reaching a certain threshold,. One possible explanation for this finding is that the crime enhancing pattern at lower level of potential usages of a street segment via the street network may result from higher probability of convergence of potential offenders and targets at the same time and place due to more inflow of people coming in-and-out. However, beyond a threshold, more street activities produced by more passers-by on the street bring about crime-reducing effects due to higher level of natural surveillance from eyes on the street.

These findings support the theoretical proposition based on the work of Jacob's eyes on the street and Newman's defensible space. According to Jacobs (1961) street activities from residents and business owners (natural proprietors in her term) increase the level of natural surveillance and effective informal social control. However, it is necessary to emphasize that the number of eyes on the street provided by street activities should be sufficiently high to bring about effective control on the streets. Otherwise, increases in the number of potential passers-by may only increase the prevalence of crime by reducing the level of territoriality, and potentially provide more criminal opportunities in the area. The current study empirically tested these perspectives on the role of potential passers-by along the street network. Findings from the models confirmed the expectations for both violent and property crime.

In order to see the importance of the activity nodes in understanding the effects of pathways on crime, the current study considers residential population in where people are from and go, and the business characteristics in where people go by incorporating the number of employees of 10 types of consumer facing business in the destinations when computing the betweenness measures. One important implication is that the pathways offenders take may be biased towards various activity nodes. So the findings suggest that the search process of motivated offenders to find a suitable target might not be just random over the space, but near the travel pathways between major routine activity nodes. This is also consistent with the findings of previous studies that the streets near busier areas are at higher risk of crime (Angel, 1968; Wilcox, 1973).

The current study theorized that local pedestrian traffic would decrease the risk of crime, whereas non-local vehicular traffic is positively associated with crime in street segments. To empirically test this, I computed the centrality measures using different search radii: a quarter mile search radius for local pedestrian traffic and one mile for non-local vehicular traffic. Unlike previous studies, I found less evidence of the distinction between the local (pedestrian) and non-local (vehicular) movements. This may be because of the context of the study area. The Southern California region is laced by over 500 miles of freeways, and people are more likely to drive to get to destinations. Sothern Californian urban and suburban planning typically assumes that every adult has access to a car. Such characteristics of the study area may lead to less evidence of distinctive effects between the measures of local pedestrian and non-local vehicular movements.

The results of moderating effects suggest that the spatial patterns of crime can vary by the levels of socioeconomic status of the place. For example, high disadvantaged areas are generally at higher risk of crime, and the curve-linear relationship between the street network configurations and crime is more pronounced in high disadvantaged street segments. Specifically, high disadvantaged areas generally have more crime notwithstanding the level of reach and betweenness, in general. This finding is consistent with previous studies that high disadvantaged areas are at higher risk of crime due to lack of resources and informal social control to keep the communities safe. Disadvantaged areas tend to have relatively lower level of informal social control, which may strengthen the crime-enhancing part of the curve-linear relationship between the street network configurations and crime. Additionally, for the crime-reducing part of the curve-linear relationship, disadvantaged areas have relatively less resources to prevent crime other than natural surveillance. Thus, the physical presence of eyes on the street matters more in high disadvantaged areas than the better-off areas.

I acknowledge some limitations to the current study. First, although I laid out some possible explanations for the relationships observed in the current study, testing the mechanisms explaining how the level of potential passers-by via the street network reduces or enhances the amount of crime in street segments is beyond the scope of the current study. Specifically, one remaining question is whether the observed pattern is associated with the characteristics of offenders, of the areas, or both. Future research may want to study more the precise residential locations of offenders, where crime occurs, and movements of offenders to more accurately analyze the relationship between the movement patterns of offenders along the street network, their awareness space, and crime in place.

Second, it is possible that the observed patterns in the current study may temporally dynamic, yet the current study was unable to account for the temporal effects in the models. In a shorter term, the patterns can vary by different times of the day and days of the week. It is plausible to think that population inflow driven by business characteristics in the destinations are time dependent because business facilities have different hours of operation. Also, in a longer term, street network layouts can be newly constructed, expanded, or disappear due to construction and changes in planning policy. Therefore, future studies will want to (1) take times of the day and days of the week into consideration when studying movement patterns of people via the street network; and (2) employ longitudinal data to see how the changes in the street network configuration over time impact changes in crime in place.

Third, the strategy used here assumes that people travel between different locations through the street network by taking the shortest routes. However, people may not always take the shortest distance because of physical barriers (i.e., roads under construction) or social barriers (i.e., spatial segregation). Although people generally try to find and take the shortest distance from one location to another, future research might improve the current project by more appropriately incorporating physical and social barriers between the origins and destinations.

Another challenge with studying the relationships between the physical environment and crime is the possibility of endogeneity. It is likely that the travel routes of people take can be affected by the level of crime in place. If a traveler already knows that a given area is a so-called crime hotspot, then one will likely avoid passing through the area even though it is the shortest distance to get to a destination. If so, an implication is that a non-recursive model design may be more accurate to find the reciprocal effect between pathways and crime. Therefore, future studies will want to utilize data to capture how crime at previous time point brings about changes in travel patterns of potential offenders and targets at current time point. Such work can reveal the complexity of the structure of street network, the routine activities, and crime in place.

In conclusion, this study has highlighted that there is an important relationship of the physical environment in terms of the street network configuration and crime in street segments. The results reinforce the findings of prior research that physical configuration of the street network can affect crime. The findings also highlighted that the effects of the street network configuration can be strengthened by accounting for the socioeconomic status of the place. I believe that empirically examining the spatial patterns of crime accounting for the physical and social environment is a fruitful direction for future research that will better reveal the processes of crime in place. The strategy of applying the theoretical and methodological insights of social network topology to the street network can be a useful one as criminologists continue exploring the street network configuration and crime in place.

Chapter 4 Tables

Table 4.1. Summary Statistics

	N	Mean	S.D.	Min	Max
Outcomes					
3 year average violent crime	326452	0.14	0.55	0	36.33
3 year average property crime	326452	0.61	2.35	0	325.67
Pathway measures (Logged)					
Local measures (0.25 mile radius)					
Reach	326443	2.73	0.95	-4.61	5.43
Betweenness					
Unweighted	326443	0.98	3.67	-4.61	8.11
Weighted by population	326443	4.44	5.88	-4.61	13.77
Weighted by employees of drink	326443	-4.35	1.33	-4.61	7.96
Weighted by employees of retail	326443	-3.55	2.67	-4.61	10.13
Weighted by employees of school	326443	-4.03	2.21	-4.61	10.29
Weighted by employees of service	326443	-3.19	3.03	-4.61	8.97
Weighted by employees of finance	326443	-4.09	1.91	-4.61	9.84
Weighted by employees of restaurant	326443	-3.78	2.56	-4.61	9.75
Weighted by employees of health	326443	-3.85	2.40	-4.61	9.73
Weighted by employees of amenity	326443	-4.40	1.23	-4.61	8.75
Weighted by employees of organizations	326443	-3.74	2.44	-4.61	9.75
Weighted by employees of stores	326443	-3.95	2.17	-4.61	9.38
Non-local measures (1 mile radius)					
Reach	326443	5.38	0.78	-4.61	7.15
Betweenness					
Unweighted	326443	4.75	4.84	-4.61	11.68
Weighted by population	326443	8.65	6.79	-4.61	17.62
Weighted by employees of drink	326443	-3.76	2.88	-4.61	13.14
Weighted by employees of retail	326443	-2.14	4.85	-4.61	14.19
Weighted by employees of school	326443	-3.01	4.23	-4.61	14.71

Weighted by employees of service	326443	-1.57	5.26	-4.61	13.31
Weighted by employees of finance	326443	-3.14	3.86	-4.61	14.26
Weighted by employees of restaurant	326443	-2.57	4.71	-4.61	14.28
Weighted by employees of health	326443	-2.71	4.48	-4.61	14.51
Weighted by employees of amenity	326443	-3.79	2.89	-4.61	12.98
Weighted by employees of organizations	326443	-2.53	4.50	-4.61	14.45
Weighted by employees of stores	326443	-2.86	4.24	-4.61	13.80
Structural Characteristics					
Concentrated disadvantage	326452	-1.77	8.78	-15	15
Racial/ethnic heterogeneity	326452	0.44	0.17	0	0.79253
% Home owners	326452	68.74	26.55	0	100
% Black	326452	5.56	11.39	0	100
% Latino	326452	34.86	28.04	0	100
% Occupied units	326452	94.03	8.39	0.40	100
% Age 15-29	326452	19.97	8.20	0	100
Land use 2008					
% Industrial land use	326412	0.02	0.09	0	1
% Office land use	326412	0.02	0.09	0	1
% Residential land use	326412	0.73	0.28	0	1
% Retail land use	326412	0.04	0.12	0	1
Spatial lags (.25 mile)					
Concentrated disadvantage	326452	-1.25	8.03	-15	15
Racial/ethnic heterogeneity	326452	0.47	0.16	0	0.77
% Home owners	326452	65.32	24.76	0	100
% Black	326452	5.53	10.21	0	100
% Latino	326452	36.18	27.15	0	100
% Occupied units	326452	93.94	7.19	1.42	100
% Age 15-29	326452	20.63	7.01	0	100

Table 4.2. Correlations between Centrality Measures

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Local Reach																									
2	Local Betweenness	0.5198																								
3	Weighted by population	0.4828	0.9832																							
4	Weighted by employees of drink	0.1064	0.129	0.1185																						
5	Weighted by employees of retail	0.1769	0.2577	0.2432	0.3776																					
6	Weighted by employees of school	0.1006	0.1611	0.1616	0.1352	0.2065																				
7	Weighted by employees of service	0.2063	0.3019	0.2904	0.3908	0.5644	0.2564																			
8	Weighted by employees of finance	0.1179	0.1696	0.1609	0.3307	0.4692	0.2044	0.4682																		
9	Weighted by employees of restaurant	0.1603	0.2104	0.196	0.4614	0.5897	0.2187	0.603	0.537																	
10	Weighted by employees of health	0.1426	0.2018	0.192	0.3313	0.4831	0.2228	0.4996	0.5253	0.5399																
11	Weighted by employees of amenity	0.07	0.1048	0.0988	0.2375	0.3031	0.1471	0.2932	0.3032	0.3466	0.3099															
12	Weighted by employees of organizations	0.162	0.2273	0.2206	0.2612	0.3834	0.274	0.434	0.3623	0.3903	0.4056	0.2301														
13	Weighted by employees of stores	0.1419	0.1926	0.1866	0.3711	0.5121	0.1972	0.52	0.4583	0.5967	0.4643	0.2745	0.3617													
14	Non-Local Reach	0.6669	0.3717	0.3442	0.1369	0.2219	0.139	0.2641	0.1583	0.2133	0.1868	0.0918	0.2179	0.1967												
15	Non-Local Betweenness	0.3633	0.8117	0.8072	0.1281	0.2463	0.1645	0.291	0.1702	0.2099	0.1992	0.1059	0.2239	0.1949	0.381											
16	Weighted by population	0.3273	0.7913	0.8108	0.1114	0.2205	0.1528	0.2649	0.1512	0.1842	0.1782	0.0932	0.2045	0.1765	0.3412	0.9869										
17	Weighted by employees of drink	0.0909	0.0911	0.0816	0.7037	0.3646	0.1457	0.3903	0.3314	0.4406	0.3419	0.2208	0.2723	0.3681	0.1757	0.1799	0.1618									
18	Weighted by employees of retail	0.1081	0.1537	0.145	0.3171	0.7954	0.1884	0.4894	0.3989	0.4997	0.4178	0.2514	0.3375	0.4372	0.2284	0.2966	0.2751	0.5204								
19	Weighted by employees of school	0.0708	0.0979	0.098	0.175	0.2417	0.7298	0.2886	0.2429	0.2707	0.2681	0.165	0.279	0.2463	0.171	0.2221	0.2099	0.379	0.4151							
20	Weighted by employees of service	0.128	0.1825	0.177	0.3233	0.4689	0.2231	0.8243	0.3927	0.5048	0.4234	0.2446	0.3719	0.439	0.2661	0.3385	0.3178	0.5073	0.6532	0.4368						
21	Weighted by employees of finance	0.0711	0.0934	0.089	0.2831	0.3946	0.1814	0.4117	0.7345	0.4588	0.445	0.2512	0.3135	0.3932	0.177	0.2234	0.2074	0.5252	0.6092	0.448	0.5894					
22	Weighted by employees of restaurant	0.1034	0.1232	0.1135	0.3708	0.4804	0.1941	0.509	0.4403	0.7704	0.4551	0.2807	0.3414	0.4887	0.224	0.259	0.2372	0.601	0.6914	0.451	0.687	0.682				
23	Weighted by employees of health	0.0875	0.1162	0.1103	0.2855	0.4088	0.1947	0.4354	0.4328	0.4662	0.77	0.2584	0.3428	0.3992	0.1991	0.2488	0.2314	0.5097	0.6125	0.4497	0.6073	0.6676	0.6777			
24	Weighted by employees of amenity	0.0332	0.051	0.0478	0.2212	0.2841	0.1416	0.2899	0.2953	0.3343	0.3124	0.6382	0.2254	0.2698	0.1138	0.1621	0.1504	0.4439	0.471	0.3868	0.4478	0.5229	0.5342	0.5116		
25	Weighted by employees of organizations	0.1088	0.1408	0.1372	0.2488	0.3548	0.2458	0.4065	0.3348	0.3762	0.3744	0.212	0.7925	0.3476	0.2321	0.2748	0.2576	0.4437	0.5255	0.4646	0.5516	0.528	0.5499	0.5474	0.4245	
26	Weighted by employees of stores	0.0953	0.1131	0.1095	0.3184	0.4346	0.1847	0.4583	0.3934	0.5062	0.4099	0.2348	0.3283	0.7501	0.2158	0.2477	0.2311	0.5591	0.6469	0.4437	0.6374	0.6389	0.7295	0.6306	0.493	0.5369

Table 4.3. Estimated Models of Local Centrality Measures (1/4 mile Search Radius) for Violent Crime

Local Pathway measures (Logged)					
Reach					
Reach	-0.4627 **				
	-21.4040				
Reach (sq)	0.0057 **				
	3.0084				
Reach (cu)	0.0194 **				
	16.1627				
Betweenness (Weighted by)					
Unweighted		-0.1119 **			
		-9.0067			
Unweighted (sq)		-0.0369 **			
		-27.7242			
Unweighted (cu)		0.0025 **			
		4.1079			
population			0.1190 **		
			41.5935		
population (sq)			-0.0702 **		
			-29.0665		
population (cu)			0.0025 **		
			12.4512		
Employees of drink				-0.1756 **	
				-12.9223	
Employees of drink (sq)				-0.0367 **	
				-20.8520	
Employees of drink (cu)				0.0106 **	
				17.4012	
Employees of retail					-0.0625 **
					-7.7889
Employees of retail (sq)					-0.0280 **
					-21.5915
Employees of retail (cu)					0.0042 **

					12.4973		
Employees of school						-0.0384 **	
						-3.2127	
Employees of school (sq)						-0.0367 **	
						-16.7427	
Employees of school (cu)						0.0030 **	
						6.1064	
Employees of service							-0.0831 **
							-9.4887
Employees of service (sq)							-0.0317 **
							-24.3551
Employees of service (cu)							0.0050 **
							12.9407
Structural Characteristics							
Concentrated disadvantage	0.0044 **	0.0043 **	0.0065 **	0.0046 **	0.0046 **	0.0043 **	0.0043 **
	3.0025	2.9214	4.5563	3.1299	3.1546	2.9233	2.9292
Racial/ethnic heterogeneity	-1.7578 **	-1.8793 **	-1.2448 **	-1.7508 **	-1.7275 **	-1.7532 **	-1.7141 **
	-30.0330	-32.0844	-22.3956	-30.1165	-29.6907	-30.1258	-29.5154
% Home owners	-0.0027 **	-0.0028 **	-0.0054 **	-0.0025 **	-0.0025 **	-0.0030 **	-0.0025 **
	-7.0223	-7.3803	-14.8623	-6.5456	-6.5393	-7.8415	-6.6745
% Black	0.0095 **	0.0092 **	0.0078 **	0.0087 **	0.0090 **	0.0085 **	0.0085 **
	10.2328	9.9538	9.0004	9.4403	9.7332	9.2327	9.2237
% Latino	0.0031 **	0.0025 **	0.0038 **	0.0025 **	0.0027 **	0.0025 **	0.0026 **
	4.8835	3.8156	6.3149	3.8520	4.2200	3.9544	4.1193
% Occupied units	-0.0146 **	-0.0152 **	-0.0116 **	-0.0145 **	-0.0148 **	-0.0146 **	-0.0146 **
	-15.1112	-15.5937	-12.8896	-14.9771	-15.3207	-15.0921	-15.1869
% Age 15-29	-0.0001	0.0004	0.0013	0.0000	0.0003	0.0004	0.0000
	-0.0954	0.4258	1.4015	-0.0359	0.3012	0.3688	0.0461
Land use							
% Industrial land use	0.4294 **	0.4167 **	-0.0110	0.4660 **	0.3537 **	0.4674 **	0.3766 **
	7.3396	7.0670	-0.1953	7.9994	6.0459	7.9969	6.4539
% Office land use	0.0002	-0.0657	0.0774	-0.1139	-0.0793	-0.0886	-0.0948
	0.0031	-0.9224	1.1656	-1.6204	-1.1323	-1.2601	-1.3554
% Residential land use	-0.2922 **	-0.3018 **	-0.2679 **	-0.3606 **	-0.3804 **	-0.3457 **	-0.3964 **

	-11.1487	-11.5911	-10.7311	-14.0074	-14.7750	-13.3704	-15.3965
% Retail land use	3.1385 **	3.1899 **	2.5699 **	2.7850 **	2.8242 **	2.9862 **	2.8899 **
	80.3955	81.9116	69.4960	70.3058	70.3082	76.6962	72.2364
Spatial lags (.25 mile)							
Concentrated disadvantage	0.0260 **	0.0217 **	0.0219 **	0.0235 **	0.0242 **	0.0244 **	0.0243 **
	11.7157	9.7515	10.1126	10.5562	10.8614	10.9822	10.9209
Racial/ethnic heterogeneity	1.1953 **	1.1759 **	0.8288 **	1.0943 **	1.0919 **	1.0869 **	1.0684 **
	17.9053	17.5781	12.9950	16.4406	16.3922	16.3012	16.0692
% Home owners	-0.0091 **	-0.0098 **	-0.0093 **	-0.0087 **	-0.0083 **	-0.0086 **	-0.0082 **
	-19.1482	-20.7052	-20.4383	-18.4571	-17.4286	-18.1255	-17.2389
% Black	0.0198 **	0.0208 **	0.0191 **	0.0210 **	0.0203 **	0.0209 **	0.0203 **
	18.6486	19.5496	19.0148	19.8518	19.2354	19.7188	19.2448
% Latino	0.0104 **	0.0111 **	0.0098 **	0.0107 **	0.0101 **	0.0107 **	0.0099 **
	13.2842	14.1769	13.1726	13.7228	12.9849	13.6719	12.6793
% Occupied units	-0.0207 **	-0.0238 **	-0.0221 **	-0.0220 **	-0.0227 **	-0.0230 **	-0.0228 **
	-14.0544	-16.1489	-15.8956	-14.8941	-15.3902	-15.5494	-15.4392
% Age 15-29	0.0067 **	0.0070 **	0.0058 **	0.0077 **	0.0079 **	0.0073 **	0.0081 **
	5.2069	5.4662	4.8001	5.9600	6.1905	5.6551	6.3164
Intercept	-3.3371 **	-2.7938 **	-1.7145 **	-2.5992 **	-2.8449 **	-2.5755 **	-2.7941 **
	-11.5136	-9.6716	-5.9353	-8.9794	-9.8600	-8.8497	-9.6799
N	326403	326403	326403	326403	326403	326403	326403
Pseudo R-sq	0.2480	0.2513	0.2794	0.2503	0.2496	0.2482	0.2500

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 4.3. Continued

Betweenness (Weighted by)					
Employees of finance	-0.1219 **				
	-10.6735				
Employees of finance (sq)	-0.0404 **				
	-24.2148				
Employees of finance (cu)	0.0065 **				
	12.9930				
Employees of restaurant		-0.0349 **			
		-4.0198			
Employees of restaurant (sq)		-0.0323 **			
		-18.9559			
Employees of restaurant (cu)		0.0041 **			
		11.1918			
Employees of health			-0.0769 **		
			-8.4302		
Employees of health (sq)			-0.0431 **		
			-25.3460		
Employees of health (cu)			0.0046 **		
			12.1451		
Employees of amenity				-0.1322 **	
				-7.5758	
Employees of amenity (sq)				-0.0423 **	
				-18.0538	
Employees of amenity (cu)				0.0074 **	
				9.7082	
Employees of organizations					-0.1055 **
					-11.6508
Employees of organizations (sq)					-0.0394 **
					-28.2678
Employees of organizations (cu)					0.0053 **

					13.5117	
Employees of stores						-0.0972 **
						-9.7278
Employees of stores (sq)						-0.0410 **
						-27.9864
Employees of stores (cu)						0.0059 **
						13.5119
Structural Characteristics						
Concentrated disadvantage	0.0046 **	0.0046 **	0.0050 **	0.0042 **	0.0047 **	0.0047 **
	3.1512	3.1639	3.3717	2.8702	3.2162	3.2122
Racial/ethnic heterogeneity	-1.7462 **	-1.7244 **	-1.7272 **	-1.7679 **	-1.7306 **	-1.7158 **
	-29.9974	-29.6409	-29.7077	-30.3620	-29.7967	-29.5444
% Home owners	-0.0027 **	-0.0021 **	-0.0027 **	-0.0029 **	-0.0026 **	-0.0022 **
	-7.0912	-5.6072	-6.9952	-7.6460	-6.8141	-5.8508
% Black	0.0084 **	0.0088 **	0.0085 **	0.0085 **	0.0087 **	0.0083 **
	9.0591	9.5646	9.2413	9.2203	9.4746	9.0397
% Latino	0.0026 **	0.0027 **	0.0026 **	0.0025 **	0.0027 **	0.0023 **
	4.1022	4.1279	3.9821	3.8197	4.2500	3.5162
% Occupied units	-0.0152 **	-0.0145 **	-0.0147 **	-0.0148 **	-0.0145 **	-0.0146 **
	-15.7138	-15.0793	-15.3055	-15.3728	-15.0100	-15.1458
% Age 15-29	0.0001	0.0001	-0.0001	-0.0003	-0.0001	0.0005
	0.1010	0.1034	-0.0679	-0.2743	-0.0583	0.4721
Land use						
% Industrial land use	0.4758 **	0.4321 **	0.4469 **	0.4404 **	0.4606 **	0.4181 **
	8.1557	7.4088	7.6483	7.5453	7.9090	7.1659
% Office land use	-0.1422 *	-0.1546 *	-0.1021	-0.0862	-0.0487	-0.1011
	-2.0117	-2.1964	-1.4514	-1.2277	-0.6981	-1.4445
% Residential land use	-0.3534 **	-0.3643 **	-0.3677 **	-0.3540 **	-0.3707 **	-0.3774 **
	-13.7145	-14.1678	-14.2825	-13.7270	-14.4000	-14.6931
% Retail land use	2.8402 **	2.6434 **	2.8486 **	2.9477 **	2.9380 **	2.7828 **
	71.2202	65.0713	71.9001	75.4112	75.7371	70.2992
Spatial lags (.25 mile)						

Concentrated disadvantage	0.0240	**	0.0248	**	0.0248	**	0.0246	**	0.0229	**	0.0228	**
	10.8055		11.1792		11.1575		11.0737		10.3169		10.2775	
Racial/ethnic heterogeneity	1.1070	**	1.0875	**	1.0739	**	1.0865	**	1.0952	**	1.0988	**
	16.6102		16.3369		16.1419		16.2981		16.4709		16.5363	
% Home owners	-0.0085	**	-0.0081	**	-0.0082	**	-0.0086	**	-0.0087	**	-0.0084	**
	-17.9494		-17.0505		-17.3241		-18.2117		-18.3881		-17.8403	
% Black	0.0214	**	0.0207	**	0.0211	**	0.0213	**	0.0200	**	0.0209	**
	20.2162		19.6091		19.9845		20.1464		18.9324		19.8445	
% Latino	0.0105	**	0.0101	**	0.0107	**	0.0110	**	0.0100	**	0.0101	**
	13.4262		12.9211		13.7671		14.1302		12.8572		12.9763	
% Occupied units	-0.0232	**	-0.0222	**	-0.0233	**	-0.0228	**	-0.0232	**	-0.0230	**
	-15.7188		-15.0387		-15.8173		-15.4596		-15.7916		-15.6892	
% Age 15-29	0.0076	**	0.0080	**	0.0078	**	0.0074	**	0.0072	**	0.0078	**
	5.9486		6.2330		6.0885		5.7897		5.6430		6.0917	
Intercept	-2.5027	**	-2.7606	**	-2.4821	**	-2.4433	**	-2.6092	**	-2.5666	**
	-8.6471		-9.5407		-8.5753		-8.3945		-9.0414		-8.8863	
N	326403		326403		326403		326403		326403		326403	
Pseudo R-sq	0.2493		0.2514		0.2500		0.2480		0.2499		0.2517	

*** $p < .01$(two-tail test), * $p < .05$ (two-tail test), † $p < .05$ (one-tail test)*

T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.4. Estimated Models of Local Centrality Measures (1/4 mile Search Radius) for Property Crime

Local Pathway measures (Logged)					
Reach					
Reach	-0.6104 **				
	-46.2868				
Reach (sq)	-0.0135 **				
	-11.2393				
Reach (cu)	0.0193 **				
	26.5486				
Betweenness (Weighted by)					
Unweighted		-0.1933 **			
		-26.1250			
Unweighted (sq)		-0.0534 **			
		-63.3671			
Unweighted (cu)		0.0040 **			
		11.0506			
Population			0.1139 **		
			64.8167		
Population (sq)			-0.0709 **		
			-49.8667		
Population (cu)			0.0022 **		
			17.8649		
Employees of drink				-0.2863 **	
				-22.4536	
Employees of drink (sq)				-0.0461 **	
				-28.9337	
Employees of drink (cu)				0.0125 **	
				21.4262	
Employees of retail					-0.1702 **
					-26.0796
Employees of retail (sq)					-0.0393 **
					-40.5303
Employees of retail (cu)					0.0072 **

					26.3025		
Employees of school						-0.0449 **	
						-4.9343	
Employees of school (sq)						-0.0375 **	
						-22.4656	
Employees of school (cu)						0.0026 **	
						6.9566	
Employees of service							-0.1723 **
							-25.7264
Employees of service (sq)							-0.0458 **
							-48.8244
Employees of service (cu)							0.0069 **
							23.3815
Structural Characteristics							
Concentrated disadvantage	-0.0002	-0.0009	0.0013	-0.0001	-0.0003	-0.0005	-0.0005
	-0.2083	-0.9459	1.5560	-0.1611	-0.3307	-0.5403	-0.5452
Racial/ethnic heterogeneity	-2.1884 **	-2.2789 **	-1.4127 **	-2.0984 **	-2.0671 **	-2.1030 **	-2.0460 **
	-59.1349	-61.6889	-40.8236	-56.8905	-56.1416	-57.0376	-55.7286
% Home owners	-0.0021 **	-0.0024 **	-0.0054 **	-0.0022 **	-0.0022 **	-0.0023 **	-0.0025 **
	-8.4652	-9.8327	-23.5195	-8.9529	-9.0749	-9.3057	-10.3162
% Black	0.0059 **	0.0060 **	0.0045 **	0.0050 **	0.0055 **	0.0049 **	0.0054 **
	8.2551	8.3009	6.6980	6.9589	7.5541	6.8092	7.4936
% Latino	-0.0027 **	-0.0028 **	-0.0011 **	-0.0027 **	-0.0025 **	-0.0027 **	-0.0025 **
	-6.7220	-7.0843	-3.0668	-6.8610	-6.4074	-6.8511	-6.3266
% Occupied units	-0.0055 **	-0.0067 **	-0.0042 **	-0.0063 **	-0.0063 **	-0.0062 **	-0.0060 **
	-8.2747	-10.2008	-6.9087	-9.6228	-9.5874	-9.4728	-9.1183
% Age 15-29	0.0040 **	0.0049 **	0.0058 **	0.0048 **	0.0048 **	0.0047 **	0.0048 **
	6.4499	7.9323	10.2592	7.7959	7.8581	7.6752	7.9179
Land use							
% Industrial land use	1.5336 **	1.5069 **	0.9063 **	1.5638 **	1.5481 **	1.5519 **	1.5105 **
	36.9942	36.6411	23.8602	37.8391	37.5936	37.4886	36.8523
% Office land use	0.6768 **	0.6040 **	0.5661 **	0.4891 **	0.5018 **	0.4475 **	0.5077 **
	14.9744	13.2881	13.6916	10.9120	11.2206	9.9992	11.3909

% Residential land use	0.1951	**	0.0318	†	0.0137		-0.1320	**	-0.1490	**	-0.1358	**	-0.1543	**
	11.3129		1.8934		0.8690		-7.9437		-8.9790		-8.1539		-9.3183	
% Retail land use	3.4829	**	3.3902	**	2.6010	**	3.1654	**	3.2404	**	3.1760	**	3.3221	**
	115.1410		112.6443		93.0829		103.0880		103.8668		104.9582		107.1533	
Spatial lags (.25 mile)														
Concentrated disadvantage	0.0130	**	0.0098	**	0.0083	**	0.0129	**	0.0129	**	0.0138	**	0.0126	**
	9.7018		7.3175		6.6375		9.6852		9.6948		10.3421		9.4563	
Racial/ethnic heterogeneity	1.5377	**	1.5126	**	1.0359	**	1.3754	**	1.3657	**	1.3830	**	1.3545	**
	36.8614		36.3406		26.6173		33.0152		32.8403		33.2148		32.6752	
% Home owners	-0.0098	**	-0.0100	**	-0.0085	**	-0.0081	**	-0.0078	**	-0.0079	**	-0.0079	**
	-31.5767		-32.5969		-29.776		-26.4612		-25.5625		-25.8883		-25.8561	
% Black	0.0028	**	0.0033	**	0.0034	**	0.0030	**	0.0025	**	0.0030	**	0.0024	**
	3.3712		3.9852		4.3801		3.5477		2.9566		3.5836		2.9183	
% Latino	0.0003		0.0002		0.0004		-0.0011	*	-0.0012	**	-0.0008	†	-0.0014	**
	0.5719		0.5010		0.8507		-2.2490		-2.6144		-1.7409		-2.9731	
% Occupied units	-0.0140	**	-0.0176	**	-0.0143	**	-0.0151	**	-0.0155	**	-0.0154	**	-0.0159	**
	-15.1246		-19.2289		-16.8413		-16.3970		-16.8750		-16.7503		-17.3425	
% Age 15-29	0.0115	**	0.0116	**	0.0092	**	0.0118	**	0.0116	**	0.0114	**	0.0111	**
	13.7697		13.7995		11.9979		14.1143		13.9935		13.6233		13.4417	
Intercept	-3.5302	**	-2.8376	**	-2.0163	**	-2.9863	**	-3.0900	**	-2.9985	**	-2.9607	**
	-19.9785		-16.4760		-11.908		-17.1957		-17.9289		-17.1789		-17.1924	
N	326403		326403		326403		326403		326403		326403		326403	
Pseudo R-sq	0.1200		0.1269		0.1627		0.1130		0.1141		0.1132		0.1154	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.
City fixed effects are included but not reported in the tables

Table 4.4. Continued

Betweenness (Weighted by)						
Employees of finance	-0.1982 **					
	-19.9526					
Employees of finance (sq)	-0.0523 **					
	-39.6308					
Employees of finance (cu)	0.0084 **					
	18.9263					
Employees of restaurant		-0.0906 **				
		-12.6404				
Employees of restaurant (sq)		-0.0435 **				
		-30.9595				
Employees of restaurant (cu)		0.0049 **				
		16.4485				
Employees of health			-0.1391 **			
			-19.3820			
Employees of health (sq)			-0.0513 **			
			-39.7408			
Employees of health (cu)			0.0062 **			
			20.9498			
Employees of amenity				-0.2270 **		
				-15.5934		
Employees of amenity (sq)				-0.0538 **		
				-29.8612		
Employees of amenity (cu)				0.0103 **		
				15.6615		
Employees of organizations					-0.1762 **	
					-22.8125	
Employees of organizations (sq)					-0.0494 **	
					-44.9315	
Employees of organizations (cu)					0.0066 **	
					19.3517	
Employees of stores						-0.1906 **
						-22.3776

Employees of stores (sq)						-0.0522 **
						-42.3645
Employees of stores (cu)						0.0079 **
						21.4219
Structural Characteristics						
Concentrated disadvantage	-0.0002	-0.0002	0.0003	0.0001	0.0001	0.0001
	-0.2135	-0.2134	0.3665	0.1534	0.1129	0.1458
Racial/ethnic heterogeneity	-2.0938 **	-2.0802 **	-2.0751 **	-2.1089 **	-2.0799 **	-2.0682 **
	-56.8494	-56.5438	-56.4327	-57.2039	-56.6154	-56.2433
% Home owners	-0.0023 **	-0.0021 **	-0.0022 **	-0.0023 **	-0.0023 **	-0.0021 **
	-9.3515	-8.4150	-9.0950	-9.1977	-9.4260	-8.6188
% Black	0.0052 **	0.0053 **	0.0053 **	0.0048 **	0.0053 **	0.0050 **
	7.1198	7.3656	7.3922	6.5698	7.3956	6.9447
% Latino	-0.0025 **	-0.0027 **	-0.0027 **	-0.0030 **	-0.0026 **	-0.0029 **
	-6.4530	-6.8202	-6.8757	-7.6667	-6.6604	-7.3396
% Occupied units	-0.0064 **	-0.0061 **	-0.0062 **	-0.0065 **	-0.0062 **	-0.0063 **
	-9.7582	-9.3596	-9.4459	-9.9094	-9.3665	-9.5333
% Age 15-29	0.0047 **	0.0048 **	0.0047 **	0.0043 **	0.0045 **	0.0047 **
	7.6074	7.8631	7.6722	6.9428	7.3543	7.7304
Land use						
% Industrial land use	1.5588 **	1.5110 **	1.5303 **	1.5545 **	1.5252 **	1.5404 **
	37.7622	36.6654	37.1107	37.6243	37.0811	37.4818
% Office land use	0.4586 **	0.4713 **	0.4887 **	0.4602 **	0.5177 **	0.4719 **
	10.2339	10.5527	10.9239	10.2738	11.6275	10.5698
% Residential land use	-0.1329 **	-0.1362 **	-0.1457 **	-0.1315 **	-0.1519 **	-0.1346 **
	-8.0196	-8.2206	-8.7940	-7.9188	-9.1698	-8.1337
% Retail land use	3.1007 **	3.0744 **	3.1131 **	3.1339 **	3.1908 **	3.1343 **
	100.4958	98.0182	101.4038	102.8584	105.7859	101.6295
Spatial lags (.25 mile)						
Concentrated disadvantage	0.0130 **	0.0129 **	0.0132 **	0.0133 **	0.0128 **	0.0125 **
	9.7278	9.6900	9.9254	9.9646	9.6068	9.3875
Racial/ethnic heterogeneity	1.3841 **	1.3685 **	1.3760 **	1.3790 **	1.3866 **	1.3833 **
	33.2793	32.9341	33.1417	33.1302	33.3978	33.3114
% Home owners	-0.0079 **	-0.0077 **	-0.0077 **	-0.0080 **	-0.0081 **	-0.0079 **
	-25.7494	-25.0540	-25.2088	-26.0599	-26.5348	-26.0139

% Black	0.0030 **	0.0027 **	0.0029 **	0.0034 **	0.0025 **	0.0027 **
	3.6160	3.1837	3.4180	4.0710	3.0355	3.2334
% Latino	-0.0010 *	-0.0012 **	-0.0007	-0.0005	-0.0012 *	-0.0012 *
	-2.2366	-2.6318	-1.5179	-1.0070	-2.5048	-2.4943
% Occupied units	-0.0155 **	-0.0157 **	-0.0155 **	-0.0151 **	-0.0156 **	-0.0158 **
	-16.8453	-17.1342	-16.8522	-16.4270	-16.9894	-17.2644
% Age 15-29	0.0112 **	0.0119 **	0.0111 **	0.0115 **	0.0110 **	0.0114 **
	13.4491	14.2931	13.3014	13.7766	13.2607	13.7351
Intercept	-2.7990 **	-2.8932 **	-2.8020 **	-2.7294 **	-2.9231 **	-2.8212 **
	-16.1728	-16.6670	-16.1921	-15.6351	-16.9446	-16.3135
N	326403	326403	326403	326403	326403	326403
	0.1143	0.1141	0.1147	0.1133	0.1148	0.1146

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.
City fixed effects are included but not reported in the tables

Table 4.5. Estimated Models of Non-Local Centrality Measures (1 mile Search Radius) for Violent crime

Non-Local Pathway measures (Logged)												
Reach												
Reach	-0.1649	**										
	-5.9961											
Reach (sq)	0.0264	**										
	3.3507											
Reach (cu)	0.0079	**										
	6.7165											
Betweenness (weighted by)			0.0936	**								
Unweighted			22.7817									
			-0.0214	**								
Unweighted (sq)			-10.8027									
			0.0012	**								
Unweighted (cu)			6.0843									
					0.2141	**						
Population					58.0367							
					-0.0181	**						
Population (sq)					-10.9249							
					-0.0001							
Population (cu)					-0.6512							
							0.0190	**				
Employees of drink							4.2326					
							-0.0593	**				
Employees of drink (sq)							-32.3666					
							0.0048	**				
Employees of drink (cu)							23.8622					
									0.0762	**		
Employees of retail									33.0566			
									-0.0282	**		
Employees of retail (sq)									-18.4354			
									0.0017	**		
Employees of retail (cu)									13.4699			
											0.0939	**
Employees of school											33.7771	
											-0.0399	**
Employees of school (sq)											-22.0295	
											0.0021	**

Employees of school (cu)											13.8939			
													0.0841	**
Employees of service													32.9772	
													-0.0266	**
Employees of service (sq)													-15.9514	
													0.0016	**
Employees of service (cu)													10.6874	
Structural Characteristics	0.0037	*	0.0047	**	0.0070	**	0.0052	**	0.0047	**	0.0049	**	0.0041	**
Concentrated disadvantage	2.5333		3.1855		4.8274		3.5523		3.1719		3.3489		2.7841	
	-1.5721	**	-1.5618	**	-1.1504	**	-1.6323	**	-1.6719	**	-1.6835	**	-1.6904	**
Racial/ethnic heterogeneity	-27.0781		-26.7204		-20.2662		-28.2717		-28.8233		-29.1170		-29.2381	
	-0.0017	**	-0.0029	**	-0.0056	**	-0.0018	**	-0.0014	**	-0.0023	**	-0.0011	**
% Home owners	-4.5560		-7.4373		-14.9792		-4.6638		-3.5665		-6.0073		-2.8581	
	0.0068	**	0.0084	**	0.0086	**	0.0093	**	0.0091	**	0.0090	**	0.0090	**
% Black	7.4527		9.1265		9.7087		10.2410		9.9852		9.8481		9.8056	
	0.0024	**	0.0029	**	0.0040	**	0.0027	**	0.0027	**	0.0028	**	0.0024	**
% Latino	3.7900		4.5395		6.3921		4.2592		4.1817		4.4421		3.7233	
	-0.0148	**	-0.0146	**	-0.0124	**	-0.0139	**	-0.0142	**	-0.0142	**	-0.0141	**
% Occupied units	-15.4752		-15.1768		-13.4518		-14.5067		-14.8441		-14.8525		-14.6813	
	0.0000		-0.0003		0.0002		-0.0002		0.0001		0.0001		-0.0004	
% Age 15-29	0.0441		-0.2616		0.1683		-0.2405		0.1079		0.1468		-0.4498	
Land use	0.4901	**	0.3914	**	0.0702		0.3944	**	0.0987	†	0.4885	**	0.1972	**
% Industrial land use	8.5426		6.7606		1.2486		6.7933		1.6843		8.3980		3.3790	
	-0.0673		-0.1023		-0.0121		-0.2426	**	-0.2633	**	-0.1330	†	-0.2625	**
% Office land use	-0.9786		-1.4808		-0.1850		-3.4494		-3.7126		-1.8930		-3.7216	
	-0.5938	**	-0.4636	**	-0.4587	**	-0.3483	**	-0.3590	**	-0.2786	**	-0.3845	**
% Residential land use	-22.8508		-17.9985		-18.4012		-13.6179		-13.9746		-10.7805		-14.9922	
	2.7412	**	2.9547	**	2.6793	**	2.4976	**	2.4177	**	2.7769	**	2.4449	**
% Retail land use	71.0224		77.1698		72.6360		63.5682		60.7688		71.3608		61.9450	
Spatial lags (.25 mile)														
Concentrated disadvantage	0.0256	**	0.0239	**	0.0255	**	0.0220	**	0.0248	**	0.0240	**	0.0243	**
	11.4070		10.6498		11.5692		9.9321		11.1578		10.7961		10.9284	
Racial/ethnic heterogeneity	0.8411	**	0.9830	**	0.8217	**	0.9561	**	1.0509	**	1.0047	**	1.0333	**
	12.5643		14.6900		12.6682		14.4773		15.8286		15.1458		15.5951	
% Home owners	-0.0058	**	-0.0082	**	-0.0074	**	-0.0082	**	-0.0069	**	-0.0076	**	-0.0069	**
	-12.1365		-17.1291		-15.7748		-17.3620		-14.5219		-16.1372		-14.5407	

% Black	0.0195	**	0.0203	**	0.0184	**	0.0201	**	0.0205	**	0.0201	**	0.0194	**
	18.5250		19.2337		18.1086		19.2934		19.5702		19.1007		18.4910	
% Latino	0.0079	**	0.0097	**	0.0089	**	0.0101	**	0.0101	**	0.0107	**	0.0097	**
	10.1248		12.3492		11.7677		13.0220		12.9986		13.6986		12.5285	
% Occupied units	-0.0197	**	-0.0220	**	-0.0199	**	-0.0217	**	-0.0225	**	-0.0237	**	-0.0220	**
	-13.2091		-14.9675		-14.0556		-14.8731		-15.4637		-16.1518		-15.0396	
% Age 15-29	0.0086	**	0.0066	**	0.0051	**	0.0080	**	0.0082	**	0.0068	**	0.0084	**
	6.5829		5.1496		4.1302		6.2645		6.4458		5.3280		6.5610	
Intercept	-4.1365	**	-3.4378	**	-3.9702	**	-2.0357	**	-2.8116	**	-2.2161	**	-2.9170	**
	-13.4252		-11.8912		-13.7658		-7.0363		-9.7329		-7.6186		-10.0672	
N	326403		326403		326403		326403		326403		326403		326403	
Pseudo R-sq	0.2560		0.2573		0.2717		0.2610		0.2624		0.2590		0.2641	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 4.5. Continued

Non-Local Pathway measures (Logged)						
Employees of finance	0.0778 **					
	22.4295					
Employees of finance (sq)	-0.0402 **					
	-21.6635					
Employees of finance (cu)	0.0024 **					
	13.5539					
Employees of restaurant		0.0997 **				
		42.6311				
Employees of restaurant (sq)		-0.0323 **				
		-17.5215				
Employees of restaurant (cu)		0.0018 **				
		12.3608				
Employees of health			0.1009 **			
			41.7193			
Employees of health (sq)			-0.0330 **			
			-19.3786			
Employees of health (cu)			0.0016 **			
			11.4700			
Employees of amenity				0.0534 **		
				10.7865		
Employees of amenity (sq)				-0.0456 **		
				-21.5554		
Employees of amenity (cu)				0.0031 **		
				13.8997		
Employees of organizations					0.0796 **	
					29.3957	
Employees of organizations (sq)					-0.0418 **	
					-26.4717	
Employees of organizations (cu)					0.0024 **	
					16.7383	
Employees of stores						0.0885 **
						31.8206
Employees of stores (sq)						-0.0411 **
						-24.0121
Employees of stores (cu)						0.0024 **

											16.1365	
Structural Characteristics												
Concentrated disadvantage	0.0049	**	0.0048	**	0.0056	**	0.0047	**	0.0046	**	0.0046	**
	3.3495		3.2875		3.7996		3.2181		3.1194		3.1447	
Racial/ethnic heterogeneity	-1.6709	**	-1.6826	**	-1.6434	**	-1.7122	**	-1.6197	**	-1.6283	**
	-28.7961		-29.0180		-28.3166		-29.4904		-28.0797		-28.1805	
% Home owners	-0.0019	**	-0.0010	*	-0.0018	**	-0.0023	**	-0.0016	**	-0.0010	**
	-4.9375		-2.5458		-4.6643		-6.0497		-4.2729		-2.6456	
% Black	0.0083	**	0.0092	**	0.0089	**	0.0090	**	0.0089	**	0.0089	**
	9.0575		10.0156		9.6400		9.7680		9.7327		9.7966	
% Latino	0.0028	**	0.0026	**	0.0028	**	0.0027	**	0.0029	**	0.0022	**
	4.4127		4.0910		4.4172		4.2232		4.5753		3.4081	
% Occupied units	-0.0146	**	-0.0139	**	-0.0140	**	-0.0148	**	-0.0139	**	-0.0138	**
	-15.2713		-14.5063		-14.6729		-15.3908		-14.6046		-14.4294	
% Age 15-29	0.0003		-0.0002		-0.0002		-0.0001		-0.0004		0.0001	
	0.2756		-0.2506		-0.2017		-0.0780		-0.4414		0.1420	
Land use												
% Industrial land use	0.4259	**	0.3104	**	0.3682	**	0.4121	**	0.4208	**	0.2827	**
	7.3231		5.3162		6.2915		7.0797		7.2511		4.8572	
% Office land use	-0.3418	**	-0.3566	**	-0.3420	**	-0.1764	*	-0.1441	*	-0.2505	**
	-4.7787		-4.9980		-4.7799		-2.5063		-2.0616		-3.5545	
% Residential land use	-0.3290	**	-0.3396	**	-0.3341	**	-0.3467	**	-0.3245	**	-0.3603	**
	-12.8053		-13.2370		-13.0045		-13.4914		-12.6475		-14.0685	
% Retail land use	2.5046	**	2.2549	**	2.5320	**	2.7050	**	2.6932	**	2.4310	**
	63.2594		56.1794		64.2460		69.0997		70.0105		61.9126	
Spatial lags (.25 mile)												
Concentrated disadvantage	0.0243	**	0.0243	**	0.0255	**	0.0242	**	0.0210	**	0.0207	**
	10.9315		10.9433		11.4528		10.8756		9.4475		9.3590	
Racial/ethnic heterogeneity	1.0505	**	1.0577	**	1.0214	**	1.0222	**	1.0379	**	1.0506	**
	15.8118		15.9278		15.3892		15.3854		15.7080		15.8969	
% Home owners	-0.0075	**	-0.0070	**	-0.0069	**	-0.0081	**	-0.0078	**	-0.0075	**
	-15.7643		-14.7642		-14.5849		-17.2037		-16.4796		-15.9498	
% Black	0.0218	**	0.0209	**	0.0215	**	0.0211	**	0.0189	**	0.0205	**
	20.7258		19.8898		20.4119		20.0594		18.0509		19.5861	
% Latino	0.0105	**	0.0103	**	0.0110	**	0.0113	**	0.0099	**	0.0099	**
	13.4585		13.2314		14.1583		14.4604		12.7278		12.7590	
% Occupied units	-0.0246	**	-0.0224	**	-0.0235	**	-0.0224	**	-0.0221	**	-0.0225	**
	-16.8103		-15.3781		-16.0997		-15.2643		-15.2068		-15.4723	
% Age 15-29	0.0073	**	0.0075	**	0.0074	**	0.0073	**	0.0067	**	0.0077	**

	5.7471		5.8869		5.8008		5.7341		5.2509		6.0394	
Intercept	-2.1618	**	-2.6772	**	-2.4636	**	-2.1200	**	-2.3460	**	-2.4665	**
	-7.4439		-9.2204		-8.4844		-7.2773		-8.1203		-8.5082	
N	326403		326403		326403		326403		326403		326403	
	0.2605		0.2652		0.2610		0.2557		0.2629		0.2656	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 4.6. Estimated Models of Non-Local Centrality Measures (1 mile Search Radius) for Property crime

Non-Local Pathway measures (Logged)						
Reach						
Reach	-0.1601 **					
	-10.1598					
Reach (sq)	-0.0105 *					
	-2.5540					
Reach (cu)	0.0080 **					
	12.6429					
Betweenness (weighted by)						
Unweighted		0.1139 **				
		45.2041				
Unweighted (sq)		-0.0203 **				
		-17.8985				
Unweighted (cu)		0.0000				
		0.2086				
Population			0.2404 **			
			119.8702			
Population (sq)			-0.0292 **			
			-29.6650			
Population (cu)			0.0002 **			
			4.5584			
Employees of drink				-0.0024		
				-0.5936		
Employees of drink (sq)				-0.0779 **		
				-52.1595		
Employees of drink (cu)				0.0059 **		
				33.5222		
Employees of retail					0.0628 **	
					34.2743	
Employees of retail (sq)					-0.0436 **	
					-40.6611	
Employees of retail (cu)					0.0029 **	
					30.1954	
Employees of school						0.0962 **
						44.6959
Employees of school (sq)						-0.0574 **
						-43.7890

Employees of school (cu)						0.0032 **	
						28.3483	
Employees of service							0.0791 **
							40.9858
Employees of service (sq)							-0.0449 **
							-40.0965
Employees of service (cu)							0.0026
Structural Characteristics							
Concentrated disadvantage	-0.0005	-0.0001	0.0027 **	0.0005	-0.0004	-0.0006	-0.0009
	-0.5978	-0.1482	3.0987	0.5633	-0.4791	-0.7109	-0.9987
Racial/ethnic heterogeneity	-2.0193 **	-1.9813 **	-1.2590 **	-1.9195 **	-2.0001 **	-2.0010 **	-1.9707 **
	-54.8803	-54.0906	-36.0904	-52.5206	-54.9114	-54.8889	-54.3819
% Home owners	-0.0016 **	-0.0023 **	-0.0053 **	-0.0015 **	-0.0010 **	-0.0016 **	-0.0009 **
	-6.6862	-9.6136	-22.8729	-6.2510	-3.9542	-6.4825	-3.8861
% Black	0.0039 **	0.0054 **	0.0049 **	0.0049 **	0.0053 **	0.0053 **	0.0053 **
	5.4500	7.6098	7.2971	6.9014	7.4779	7.4298	7.5870
% Latino	-0.0028 **	-0.0028 **	-0.0015 **	-0.0027 **	-0.0027 **	-0.0028 **	-0.0027 **
	-7.1478	-7.1786	-3.9883	-6.7854	-6.8964	-7.2257	-7.0966
% Occupied units	-0.0068 **	-0.0064 **	-0.0044 **	-0.0058 **	-0.0062 **	-0.0061 **	-0.0059 **
	-10.3612	-9.7375	-7.1412	-8.8394	-9.5273	-9.3175	-9.1610
% Age 15-29	0.0049 **	0.0048 **	0.0058 **	0.0050 **	0.0043 **	0.0040 **	0.0042 **
	8.0764	7.9415	10.1617	8.3342	7.1808	6.6687	7.0885
Land use							
% Industrial land use	1.6181 **	1.4222 **	0.8420 **	1.4817 **	1.2163 **	1.5373 **	1.2731 **
	39.1756	34.8595	21.9435	36.4127	29.9505	37.8614	31.6443
% Office land use	0.4720 **	0.3984 **	0.3548 **	0.3402 **	0.3660 **	0.3207 **	0.4018 **
	10.5737	9.0387	8.7024	7.6823	8.2617	7.2460	9.1242
% Residential land use	-0.2903 **	-0.1976 **	-0.1979 **	-0.0810 **	-0.0822 **	-0.0332 *	-0.0816 **
	-17.1776	-11.9693	-12.6215	-4.9478	-5.0241	-2.0159	-5.0041
% Retail land use	3.0774 **	3.2096 **	2.7153 **	2.7422 **	2.6004 **	2.8190 **	2.6909 **
	101.8802	107.8388	96.7434	90.7365	85.4032	94.6638	89.6563
Spatial lags (.25 mile)							
Concentrated disadvantage	0.0144 **	0.0125 **	0.0122 **	0.0115 **	0.0139 **	0.0135 **	0.0132 **
	10.7834	9.4230	9.6806	8.7305	10.5545	10.2743	10.0947
Racial/ethnic heterogeneity	1.2775 **	1.3411 **	0.9525 **	1.2255 **	1.3504 **	1.2918 **	1.3163 **
	30.6935	32.4528	24.3358	29.7660	32.8892	31.4355	32.1960
% Home owners	-0.0058 **	-0.0083 **	-0.0075 **	-0.0075 **	-0.0063 **	-0.0070 **	-0.0064 **
	-18.9633	-27.3701	-26.1840	-24.9909	-20.8717	-23.2293	-21.1738

% Black	0.0020	*	0.0027	**	0.0025	**	0.0033	**	0.0033	**	0.0031	**	0.0023	**
	2.3395		3.3101		3.2438		4.0754		4.0833		3.8211		2.8712	
% Latino	-0.0023	**	-0.0006		-0.0004		-0.0009	*	-0.0003		0.0001		-0.0008	†
	-4.8713		-1.3365		-0.9625		-2.0296		-0.7012		0.1952		-1.7517	
% Occupied units	-0.0150	**	-0.0140	**	-0.0102	**	-0.0146	**	-0.0148	**	-0.0167	**	-0.0146	**
	-16.3049		-15.4435		-11.8627		-16.1938		-16.3301		-18.4315		-16.2098	
% Age 15-29	0.0120	**	0.0100	**	0.0075	**	0.0105	**	0.0110	**	0.0096	**	0.0104	**
	14.4540		12.1231		9.7595		12.8215		13.4653		11.7277		12.8933	
Intercept	-3.7024	**	-3.7502	**	-4.0129	**	-1.9298	**	-2.7833	**	-2.0484	**	-2.7770	**
	-20.6577		-21.7817		-23.5919		-11.1376		-16.1626		-11.7685		-16.1405	
N	326403		326403		326403		326403		326403		326403		326403	
Pseudo R-sq	0.1149		0.1226		0.1488		0.1232		0.1263		0.1255		0.1281	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 4.6. Continued

Non-Local Pathway measures (Logged)						
Employees of finance	0.0670 **					
	23.9690					
Employees of finance (sq)	-0.0644 **					
	-47.3033					
Employees of finance (cu)	0.0042 **					
	30.8926					
Employees of restaurant		0.1124 **				
		59.4631				
Employees of restaurant (sq)		-0.0592 **				
		-42.1214				
Employees of restaurant (cu)		0.0033 **				
		29.3402				
Employees of health			0.0969 **			
			52.3330			
Employees of health (sq)			-0.0541 **			
			-45.2736			
Employees of health (cu)			0.0030 **			
			30.3886			
Employees of amenity				0.0337 **		
				8.6527		
Employees of amenity (sq)				-0.0683 **		
				-44.6447		
Employees of amenity (cu)				0.0049 **		
				28.8563		
Employees of organizations					0.0617 **	
					27.1608	
Employees of organizations (sq)					-0.0650 **	
					-54.9631	
Employees of organizations (cu)					0.0040 **	
					35.4156	
Employees of stores						0.0716 **
						31.0518
Employees of stores (sq)						-0.0678 **
						-52.7547
Employees of stores (cu)						0.0043 **
						36.4563

Structural Characteristics												
Concentrated disadvantage	-0.0002		-0.0002		0.0002		0.0011		0.0001		-0.0001	
	-0.2645		-0.1736		0.2195		1.2194		0.0568		-0.0985	
Racial/ethnic heterogeneity	-1.9695	**	-1.9606	**	-1.9423	**	-2.0175	**	-1.8830	**	-1.9066	**
	-54.1772		-54.0591		-53.4152		-55.2083		-51.9257		-52.5237	
% Home owners	-0.0011	**	-0.0007	**	-0.0011	**	-0.0013	**	-0.0010	**	-0.0008	**
	-4.6462		-2.9679		-4.6302		-5.3067		-4.2683		-3.1836	
% Black	0.0045	**	0.0055	**	0.0055	**	0.0049	**	0.0056	**	0.0053	**
	6.4075		7.8267		7.8264		6.8742		7.8919		7.5228	
% Latino	-0.0026	**	-0.0027	**	-0.0023	**	-0.0031	**	-0.0022	**	-0.0027	**
	-6.8355		-6.9046		-5.8874		-7.8554		-5.5918		-6.9899	
% Occupied units	-0.0068	**	-0.0058	**	-0.0059	**	-0.0062	**	-0.0063	**	-0.0057	**
	-10.3988		-8.9254		-9.0823		-9.4616		-9.7643		-8.7882	
% Age 15-29	0.0046	**	0.0041	**	0.0044	**	0.0048	**	0.0038	**	0.0044	**
	7.6838		6.7731		7.3588		7.8513		6.3796		7.3397	
Land use												
% Industrial land use	1.4301	**	1.3100	**	1.3892	**	1.5056	**	1.4387	**	1.3224	**
	35.4061		32.3173		34.2777		36.9842		35.6526		32.7156	
% Office land use	0.2599	**	0.3157	**	0.2871	**	0.3652	**	0.4251	**	0.3640	**
	5.8661		7.1414		6.4608		8.2344		9.6525		8.2583	
% Residential land use	-0.0368	*	-0.0318	†	-0.0618	**	-0.0659	**	-0.0484	**	-0.0444	**
	-2.2545		-1.9489		-3.7774		-4.0119		-2.9633		-2.7243	
% Retail land use	2.5310	**	2.3992	**	2.5986	**	2.7545	**	2.8008	**	2.5684	**
	83.9310		78.9952		86.4388		92.0077		94.9821		85.6480	
Spatial lags (.25 mile)												
Concentrated disadvantage	0.0132	**	0.0124	**	0.0142	**	0.0120	**	0.0114	**	0.0120	**
	10.0482		9.4915		10.8508		9.0728		8.7365		9.1449	
Racial/ethnic heterogeneity	1.2852	**	1.3163	**	1.3162	**	1.2463	**	1.3051	**	1.3143	**
	31.3799		32.2092		32.1596		30.2723		31.9038		32.1613	
% Home owners	-0.0068	**	-0.0065	**	-0.0063	**	-0.0077	**	-0.0072	**	-0.0070	**
	-22.7155		-21.7221		-20.9919		-25.3510		-23.8473		-23.4527	
% Black	0.0045	**	0.0035	**	0.0039	**	0.0040	**	0.0016	*	0.0029	**
	5.5000		4.2759		4.7170		4.8148		1.9694		3.5548	
% Latino	-0.0002		-0.0004		0.0002		0.0004		-0.0010	*	-0.0012	*
	-0.3471		-0.8021		0.4298		0.8771		-2.0978		-2.5558	
% Occupied units	-0.0172	**	-0.0144	**	-0.0147	**	-0.0148	**	-0.0145	**	-0.0151	**
	-19.0246		-15.9969		-16.1811		-16.2402		-15.9941		-16.6633	
% Age 15-29	0.0103	**	0.0103	**	0.0094	**	0.0106	**	0.0101	**	0.0095	**
	12.6545		12.6434		11.5241		12.9281		12.3259		11.7339	

Intercept	-1.8608	**	-2.2982	**	-2.3809	**	-1.9754	**	-2.1018	**	-2.1222	**
	-10.6998		-13.1917		-13.8021		-11.3553		-12.2153		-12.1392	
N	326403		326403		326403		326403		326403		326403	
Pseudo R-sq	0.1286		0.1293		0.1279		0.1236		0.1283		0.1285	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 4.7. Interaction Models (Local) for Violent Crime

	Reach	Betweenness (Weighted by)					
		No weight	Population	Emp Drink	Emp Retail	Emp School	Emp Service
Local Centrality	-0.4523 **	-0.1180 **	0.1214 **	-0.1426 **	-0.0072	-0.0182	-0.0243 *
	-20.4358	-9.6340	35.1153	-8.8327	-0.7452	-1.3548	-2.3480
Local Centrality (sq)	0.0105 **	-0.0383 **	-0.0770 **	-0.0467 **	-0.0230 **	-0.0386 **	-0.0263 **
	5.2039	-26.2737	-28.7946	-21.1026	-14.0830	-16.1828	-16.0428
Local Centrality (cu)	0.0194 **	0.0030 **	0.0030 **	0.0103 **	0.0029 **	0.0030 **	0.0034 **
	15.9040	5.0662	12.8148	14.7619	7.3847	5.3771	7.7940
*Interaction	-0.0053 *	-0.0070 **	0.0002	-0.0049 **	-0.0071 **	-0.0010	-0.0069 **
	-2.4500	-5.9003	0.5346	-3.0480	-7.6247	-0.7493	-6.8513
*Interaction (sq)	-0.0010 **	-0.0007 **	-0.0019 **	0.0012 **	-0.0007 **	0.0008 **	-0.0006 **
	-4.8618	-4.5816	-7.1815	5.3825	-4.0988	3.2417	-3.8784
*Interaction (cu)	0.0001	0.0004 **	0.0001 **	0.0000	0.0001 **	-0.0001	0.0001 **
	0.6745	7.0164	5.6751	0.4427	3.3150	-1.4468	3.0103
Concentrated disadvantage	0.0260 **	0.0116 **	0.0453 **	0.0338 **	0.0077 *	0.0222 **	0.0096 **
	5.7963	3.5411	6.5707	8.5032	2.4199	4.4443	2.9102
Intercept	-3.3537 **	-2.7722 **	-1.5839 **	-2.3397 **	-2.9346 **	-2.4572 **	-2.8660 **
	-11.5576	-9.5940	-5.4677	-8.0499	-10.1378	-8.4282	-9.8988
N	326403	326403	326403	326403	326403	326403	326403

Table 4.7. Continued

	Betweenness (Weighted by)					
	Emp Finance	Emp Restaurant	Emp Health	Emp Amenity	Emp Orgs	Emp Stores
Local Centrality	-0.0933 **	0.0076	-0.0474 **	-0.1388 **	-0.1050 **	-0.0555 **
	-7.0490	0.7577	-4.3434	-7.5648	-8.8982	-4.4064
Local Centrality (sq)	-0.0445 **	-0.0352 **	-0.0428 **	-0.0492 **	-0.0426 **	-0.0454 **
	-22.3473	-16.1006	-21.7678	-19.7773	-23.5062	-22.7773
Local Centrality (cu)	0.0062 **	0.0035 **	0.0042 **	0.0082 **	0.0063 **	0.0054 **
	10.9475	8.5247	9.3967	10.3315	12.4589	10.0799
*Interaction	-0.0041 **	-0.0050 **	-0.0039 **	0.0007	0.0005	-0.0046 **

	-3.0809	-5.1962	-3.5797	0.3794	0.4571	-3.7986
*Interaction (sq)	0.0006 **	0.0004 †	0.0002	0.0013 **	0.0006 **	0.0006 **
	3.0073	1.8484	0.9944	4.9085	3.4188	3.2764
*Interaction (cu)	0.0000	0.0000	0.0000	-0.0002 *	-0.0002 **	0.0000
	0.1368	0.4563	0.4830	-2.0905	-3.3374	0.3104
Concentrated disadvantage	0.0197 **	0.0134 **	0.0084 *	0.0338 **	0.0150 **	0.0184 **
	5.1270	3.1294	2.1214	7.1375	4.3171	4.9579
Intercept	-2.3695 **	-2.7209 **	-2.4710 **	-2.2871 **	-2.4772 **	-2.4310 **
	-8.1626	-9.3424	-8.5161	-7.8480	-8.5570	-8.3719
N	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.8. Interaction Models (Local) for Property Crime

	Reach	Betweenness (Weighted by): No weight	Population	Emp Drink	Emp Retail	Emp School	Emp Service
Local Centrality	-0.6927 **	-0.1757 **	0.1136 **	-0.2618 **	-0.1473 **	-0.0337 **	-0.1424 **
	-47.7726	-22.9212	63.8766	-19.1299	-22.0713	-3.6416	-21.0009
Local Centrality (sq)	-0.0177 **	-0.0519 **	-0.0703 **	-0.0510 **	-0.0372 **	-0.0367 **	-0.0429 **
	-13.7736	-60.8752	-49.1877	-29.2316	-37.7366	-21.8141	-44.8033
Local Centrality (cu)	0.0233 **	0.0031 **	0.0021 **	0.0118 **	0.0066 **	0.0024 **	0.0059 **
	29.1968	8.1890	17.4084	19.2029	23.3824	6.1762	20.0206
*Interaction	-0.0254 **	-0.0001	-0.0012 **	-0.0088 **	-0.0078 **	-0.0030 **	-0.0082 **
	-17.5806	-0.1162	-5.9297	-6.0992	-11.3348	-2.8924	-11.6218
*Interaction (sq)	-0.0027 **	-0.0002 †	0.0002	0.0007 **	-0.0007 **	0.0001	-0.0008 **
	-19.2719	-1.7365	1.1345	4.0387	-6.4418	0.7651	-7.2871
*Interaction (cu)	0.0010 **	-0.0001 **	0.0000	0.0002 **	0.0002 **	0.0000	0.0002 **
	12.6427	-2.9618	-0.3248	3.5079	6.6148	0.9226	7.2306
Concentrated disadvantage	0.0665 **	0.0004	0.0016	0.0312 **	0.0023	0.0117 **	0.0059 **
	22.9947	0.2084	-0.4014	-9.5316	1.1261	-3.1729	2.8047
Intercept	-3.3242 **	-2.8692 **	-2.0343 **	-2.8616 **	-3.1436 **	-2.9696 **	-2.9977 **
	-18.7150	-16.6492	-12.0087	-16.4344	-18.2355	-17.0108	-17.4106
N	326403	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.8. Continued

	Betweenness (Weighted by)					
	Emp Finance	Emp Restaurant	Emp Health	Emp Amenity	Emp Orgs	Emp Stores
Local Centrality	-0.1867 **	-0.0698 **	-0.1266 **	-0.2334 **	-0.1743 **	-0.1566 **
	-18.5035	-9.4557	-17.2991	-16.1678	-21.1856	-17.0552
Local Centrality (sq)	-0.0529 **	-0.0448 **	-0.0495 **	-0.0556 **	-0.0494 **	-0.0533 **
	-39.1293	-29.8134	-38.0436	-30.9485	-42.6817	-38.4662
Local Centrality (cu)	0.0082 **	0.0045 **	0.0059 **	0.0106 **	0.0070 **	0.0071 **
	18.1312	14.7386	19.5660	16.2502	19.2682	17.9734
*Interaction	-0.0036 **	-0.0080 **	-0.0042 **	0.0024	-0.0003	-0.0083 **
	-3.4691	-10.6173	-5.1658	1.5575	-0.3425	-8.7133
*Interaction (sq)	0.0002	-0.0002	-0.0004 *	0.0014 **	0.0004 **	0.0002
	1.5837	-1.0748	-2.5111	6.9373	3.1176	1.1050
*Interaction (cu)	0.0000	0.0002 **	0.0001 *	-0.0002 **	-0.0001 **	0.0002 **
	0.5452	5.4698	2.0647	-2.8008	-3.2031	5.0270
Concentrated disadvantage	0.0158 **	0.0103 **	0.0011	0.0348 **	0.0172 **	0.0160 **
	-5.7399	-3.3017	-0.4027	-9.6994	-7.1901	-5.8034
Intercept	-2.7560 **	-2.8761 **	-2.8285 **	-2.7037 **	-2.8642 **	-2.7745 **
	-15.9195	-16.5216	-16.3445	-15.4922	-16.5939	-15.9956
N	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.9. Interaction Models (Non-Local) for Violent Crime

	Reach	Betweenness (Weighted by)					
		No weight	Population	Emp Drink	Emp Retail	Emp School	Emp Service
Non-Local Centrality	-0.2446 **	0.0765 **	0.2103 **	0.0631 **	0.0951 **	0.1071 **	0.0977 **
	-8.9665	17.3666	53.7428	12.4025	35.3913	32.2742	33.0815
Non-Local Centrality (sq)	0.0083	-0.0219 **	-0.0164 **	-0.0535 **	-0.0187 **	-0.0393 **	-0.0206 **
	1.0786	-10.5058	-8.6196	-25.0139	-10.4806	-19.0396	-10.7809
Non-Local Centrality (cu)	0.0118 **	0.0017 **	-0.0002	0.0040 **	0.0010 **	0.0020 **	0.0011 **
	10.1333	7.7072	-1.5436	17.6073	6.9486	11.6901	6.8972
*Interaction	0.0093 **	0.0033 **	0.0010 *	-0.0060 **	-0.0029 **	-0.0024 **	-0.0021 **
	3.4476	7.2356	2.4575	-11.7050	-10.6714	-7.1433	-6.9266
*Interaction (sq)	0.0001	-0.0003	-0.0002	-0.0007 **	-0.0014 **	0.0002	-0.0006 **
	0.1662	-1.1317	-1.1880	-3.0561	-7.5751	0.8787	-3.1356
*Interaction (cu)	-0.0003 **	-0.0001 *	0.0000	0.0001 **	0.0001 **	0.0000	0.0000 *
	-3.0344	-2.2032	1.2401	4.2797	6.4314	-0.4599	2.1382
Concentrated disadvantage	0.0133	0.0178 **	0.0075	0.0112 *	0.0441 **	-0.0032	0.0271 **
	0.8290	3.1835	1.0745	2.1921	9.2293	-0.5660	5.2013
Intercept	-3.8277 **	-3.3938 **	-4.0117 **	-2.1314 **	-3.1015 **	-2.1877 **	-3.0827 **
	-12.4888	-11.7402	-13.8521	-7.3371	-10.6875	-7.4978	-10.5980
N	326403	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.9. Continued

	Betweenness (Weighted by)					
	Emp Finance	Emp Restaurant	Emp Health	Emp Amenity	Emp Orgs	Emp Stores
Centrality	0.1021 **	0.1245 **	0.1146 **	0.0716 **	0.0887 **	0.1156 **
	25.3589	46.3233	40.2735	13.5064	25.6383	33.3531
Centrality (sq)	-0.0364 **	-0.0317 **	-0.0286 **	-0.0466 **	-0.0421 **	-0.0374 **
	-16.9857	-14.8328	-14.7266	-20.4481	-22.3537	-17.8327
Centrality (cu)	0.0020 **	0.0016 **	0.0013 **	0.0030 **	0.0025 **	0.0020 **
	9.7592	9.9171	8.1063	12.6436	14.3033	10.9259
*Interaction	-0.0038 **	-0.0036 **	-0.0025 **	-0.0034 **	-0.0016 **	-0.0037 **
	-9.1814	-13.3837	-8.7387	-5.8419	-4.5737	-10.8306
*Interaction (sq)	-0.0004 †	0.0003	-0.0006 **	0.0002	0.0003 †	-0.0002
	-1.6609	1.6082	-3.1587	0.9702	1.6572	-0.7893
*Interaction (cu)	0.0000 *	0.0000	0.0000 **	0.0000	0.0000 †	0.0000
	2.0471	-0.8435	2.7117	0.2077	-1.8284	1.4392
Concentrated disadvantage	0.0103 †	-0.0035	0.0229 **	-0.0095 †	-0.0018	0.0079
	1.8683	-0.5933	4.2705	-1.6776	-0.3695	1.4672
Intercept	-2.2432 **	-2.7965 **	-2.6132 **	-2.0908 **	-2.2997 **	-2.5329 **
	-7.6912	-9.5756	-8.9643	-7.1605	-7.9350	-8.6890
N	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.10. Interaction Models (Non-Local) for Property Crime

		Betweenness (Weighted by)					
	Reach	No weight	Population	Emp Drink	Emp Retail	Emp School	Emp Service
Non-Local Centrality	-0.2272 **	0.1143 **	0.2462 **	0.0154 **	0.0637 **	0.0960 **	0.0796 **
	-13.7846	45.1506	120.7253	3.6492	34.1618	43.0487	40.5499
Non-Local Centrality (sq)	-0.0437 **	-0.0217 **	-0.0302 **	-0.0734 **	-0.0426 **	-0.0566 **	-0.0437 **
	-9.8727	-18.8092	-29.9841	-47.2826	-39.4225	-42.3243	-38.7303
Non-Local Centrality (cu)	0.0122 **	0.0002	0.0003 **	0.0054 **	0.0028 **	0.0031 **	0.0026 **
	18.2523	1.3459	5.0825	29.5259	29.4841	27.3047	24.9534
*Interaction	0.0074 **	0.0045 **	0.0034 **	-0.0050 **	-0.0009 **	-0.0003	-0.0006 **
	4.4419	16.2966	15.3025	-11.2637	-4.2612	-1.1912	-2.9801
*Interaction (sq)	-0.0029 **	0.0001	-0.0009 **	-0.0012 **	-0.0011 **	-0.0007 **	-0.0009 **
	-6.3931	0.4408	-8.1030	-7.4304	-9.0888	-5.0193	-6.8034
*Interaction (cu)	-0.0001	-0.0001 **	0.0000 **	0.0001 **	0.0001 **	0.0000 **	0.0000 **
	-1.5154	-6.3871	6.7959	6.8544	6.2512	3.6189	4.2972
Concentrated disadvantage	0.0658 **	0.0026	0.0253 **	0.0208 **	0.0290 **	0.0190 **	0.0243 **
	7.5016	0.8052	6.6522	5.4717	9.5939	5.0434	7.4784
Intercept	-3.0654 **	-3.6744 **	-3.9554 **	-2.0058 **	-2.8128 **	-2.0488 **	-2.7813 **
	-16.8273	-21.3333	-23.2103	-11.5676	-16.3310	-11.7665	-16.1647
N	326403	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*
T-values below coefficient estimates.
City fixed effects and other controls are included but not reported in the tables

Table 4.10. Continued

	Betweenness (Weighted by)					
	Emp Finance	Emp Restaurant	Emp Health	Emp Amenity	Emp Orgs	Emp Stores
Centrality	0.0672 **	0.1163 **	0.0953 **	0.0349 **	0.0594 **	0.0793 **
	23.7157	60.1614	50.4731	8.9821	24.5018	32.5645
Centrality (sq)	-0.0636 **	-0.0579 **	-0.0543 **	-0.0681 **	-0.0647 **	-0.0652 **
	-46.3205	-40.7296	-45.0707	-44.4354	-53.2684	-49.4718
Centrality (cu)	0.0042 **	0.0032 **	0.0031 **	0.0049 **	0.0041 **	0.0041 **
	30.4536	28.0259	30.7510	28.6427	34.6358	33.3518
*Interaction	0.0002	-0.0015 **	0.0005 *	-0.0012 **	-0.0003	-0.0021 **
	0.6334	-7.3316	2.4980	-2.8782	-1.0156	-7.9779
*Interaction (sq)	-0.0003 *	0.0003 †	-0.0007 **	0.0000	-0.0002	-0.0002 †
	-1.9685	1.7917	-5.4254	-0.2874	-1.4026	-1.6488
*Interaction (cu)	0.0000	0.0000	0.0000 *	0.0000	0.0000	0.0000 †
	-0.4526	-1.5937	2.3074	0.7779	-0.5945	1.7536
Concentrated disadvantage	0.0088 *	0.0085 *	0.0229 **	0.0008	0.0060 †	0.0033
	2.4328	2.0785	6.4913	0.2075	1.8140	0.8948
Intercept	-1.8644 **	-2.3576 **	-2.3526 **	-1.9845 **	-2.0828 **	-2.1638 **
	-10.7206	-13.5146	-13.6335	-11.4060	-12.1012	-12.3630
N	326403	326403	326403	326403	326403	326403

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Chapter 4 Figures

Figure 4.1. Non-Local Betweenness in the City of Los Angeles

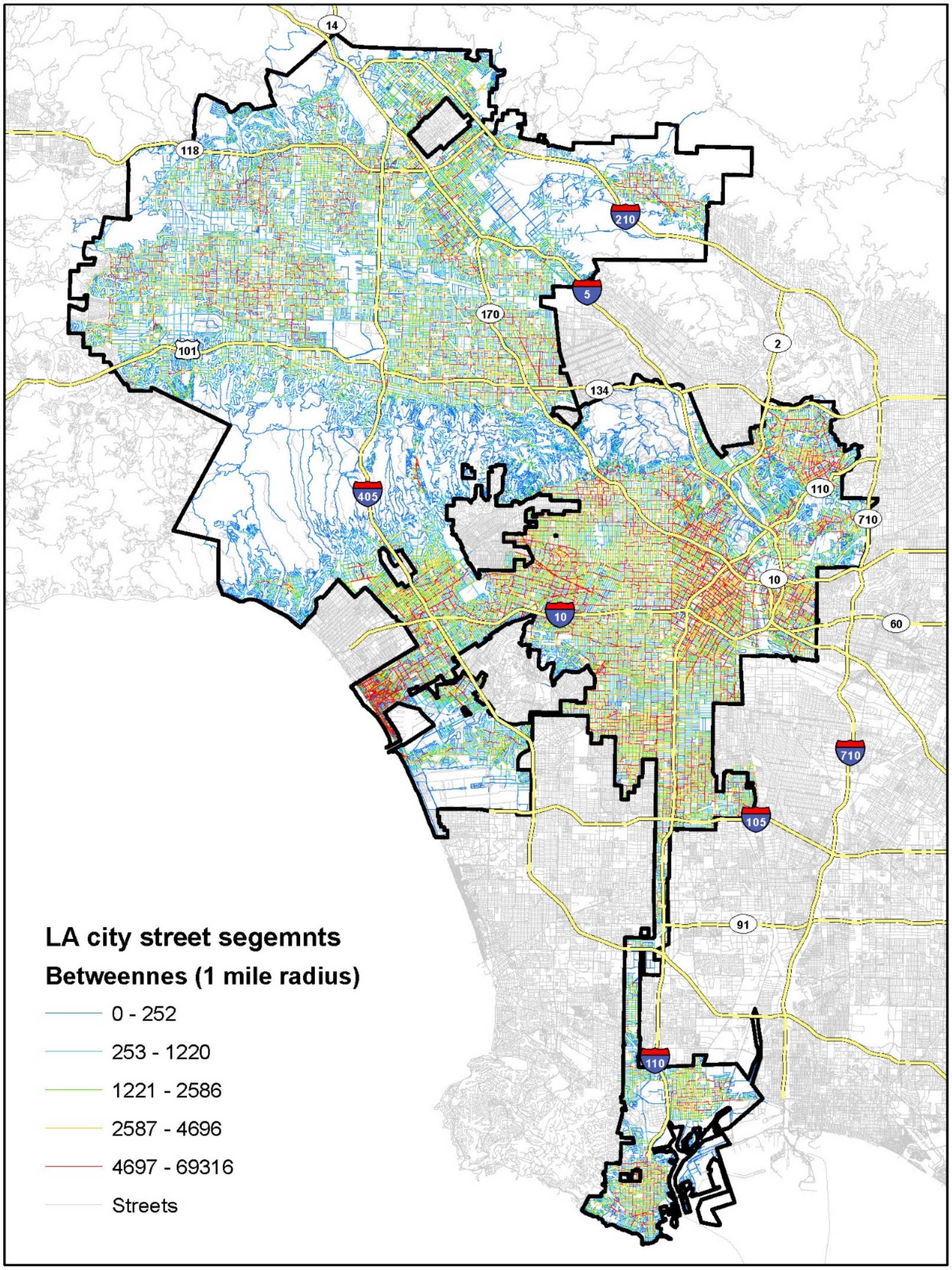


Figure 4.2. Local Reach and Violent Crime in Street Segments

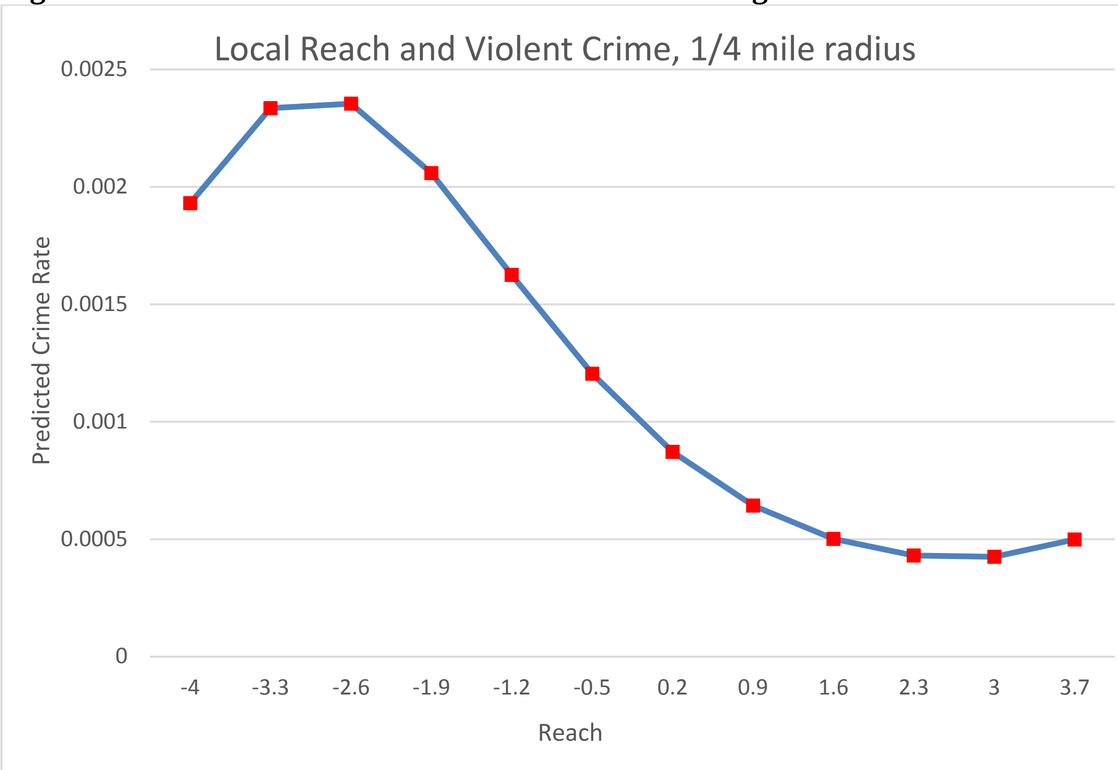


Figure 4.3. Local Reach and Property Crime in Street Segments

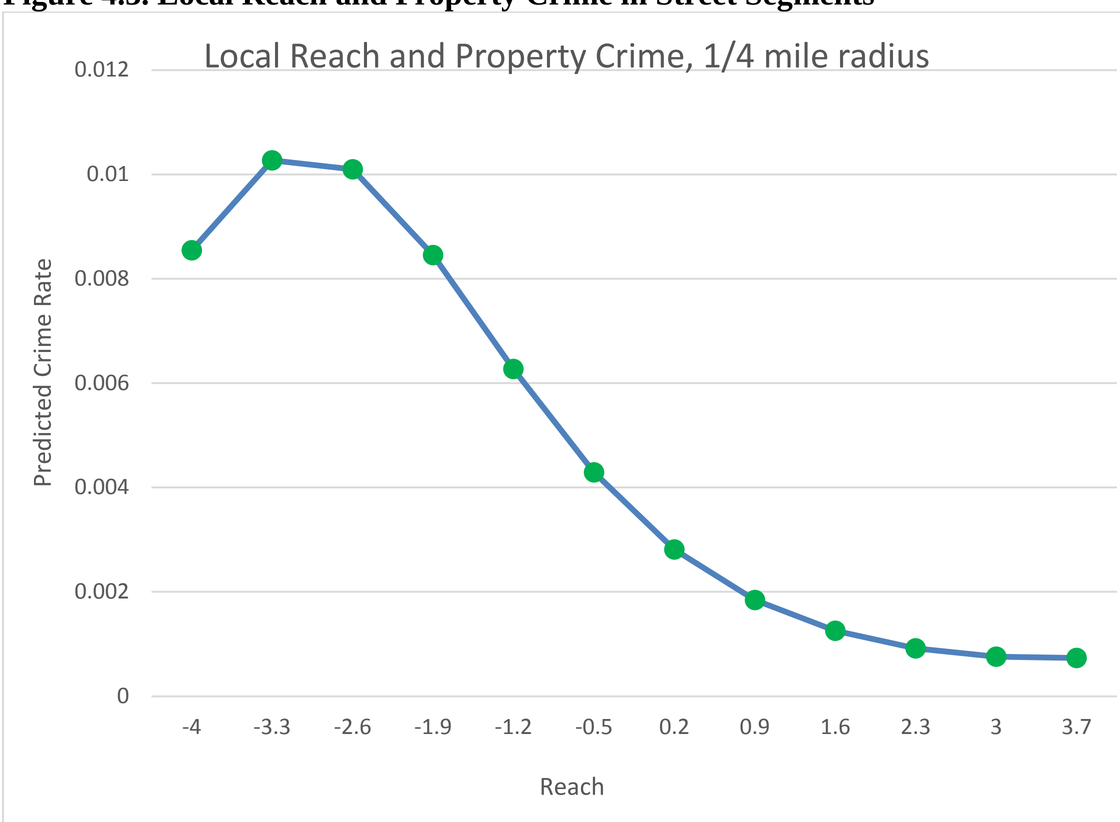


Figure 4.4. Local Betweenness (Unweighted) and Violent Crime in Street Segments

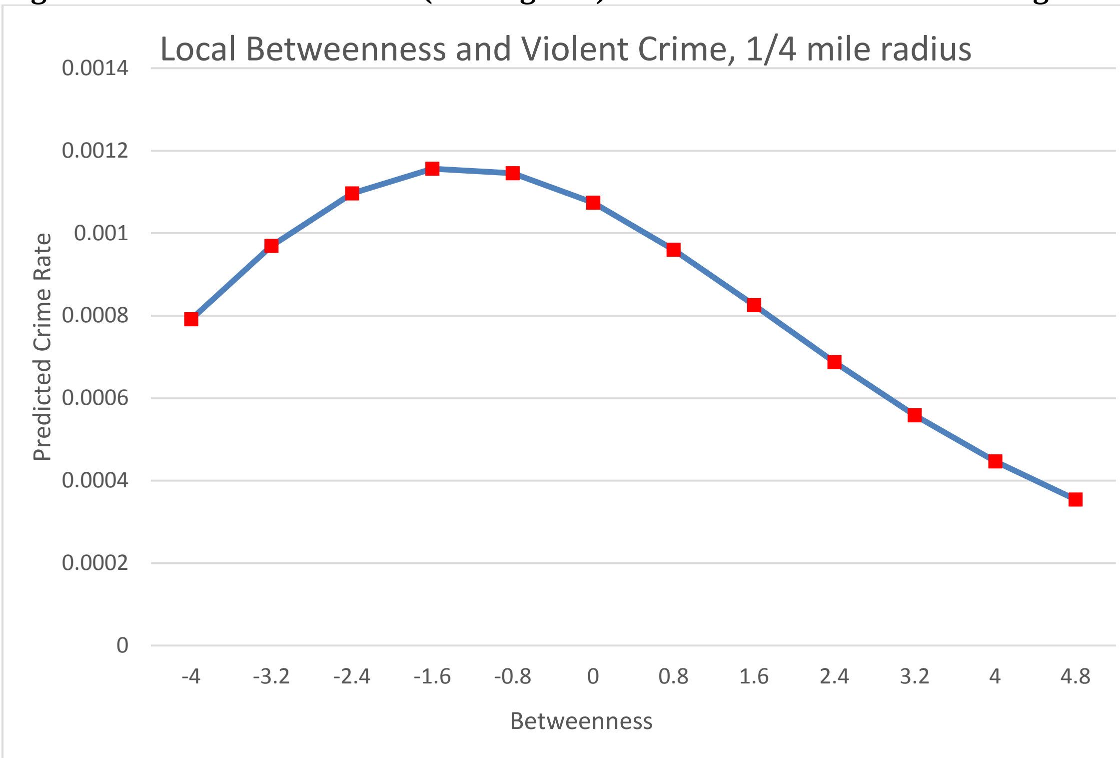


Figure 4.5. Local Betweenness (Unweighted) and Property Crime in Street Segments

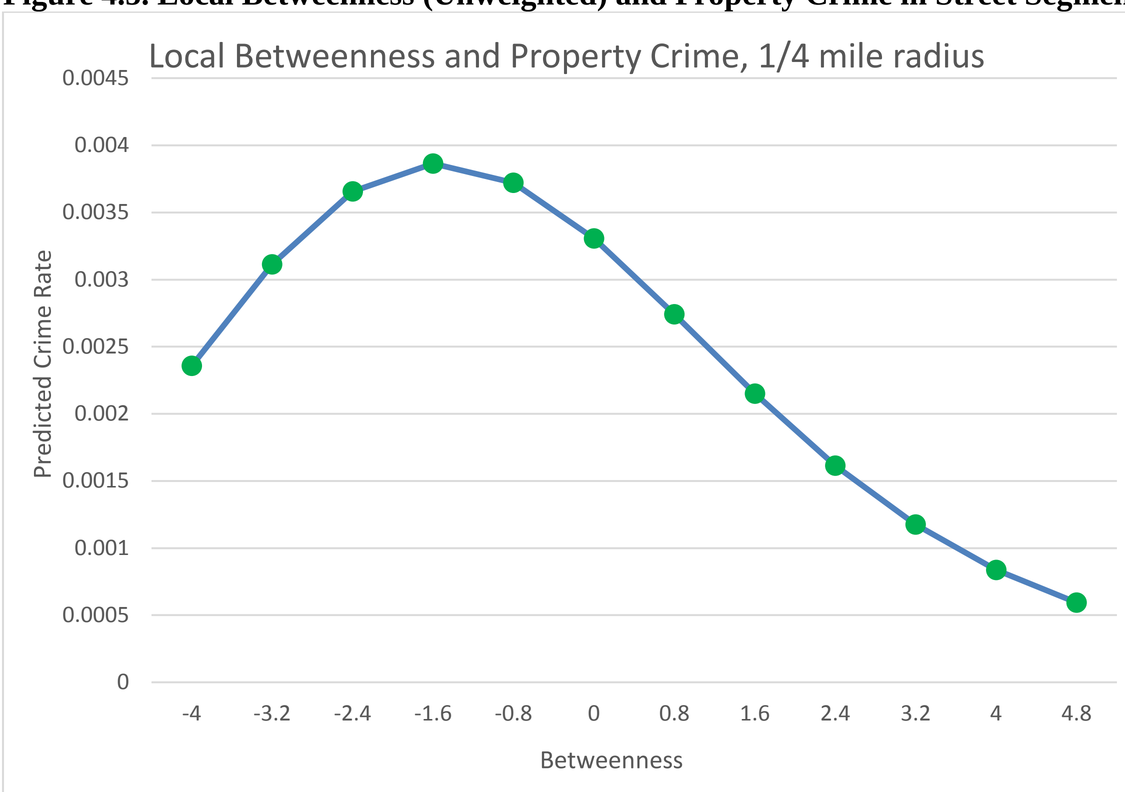


Figure 4.6. Local Betweenness (Population Weighted) and Violent Crime

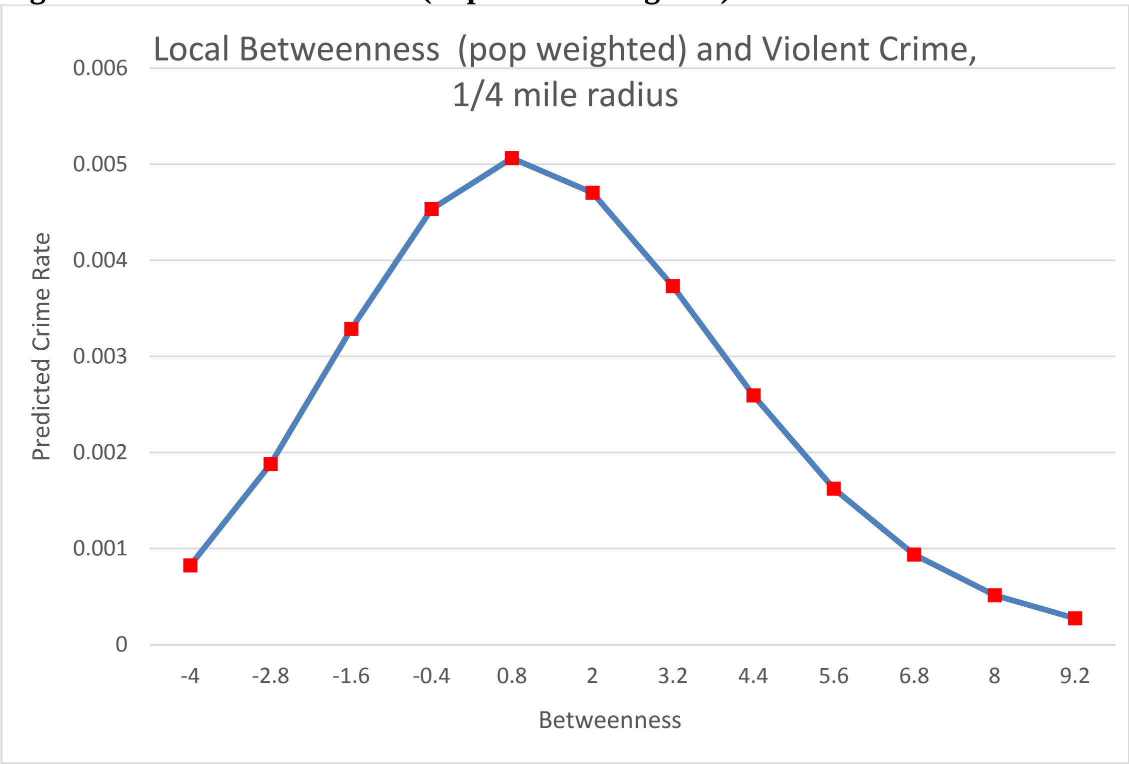


Figure 4.7. Local Betweenness (Population Weighted) and Property Crime

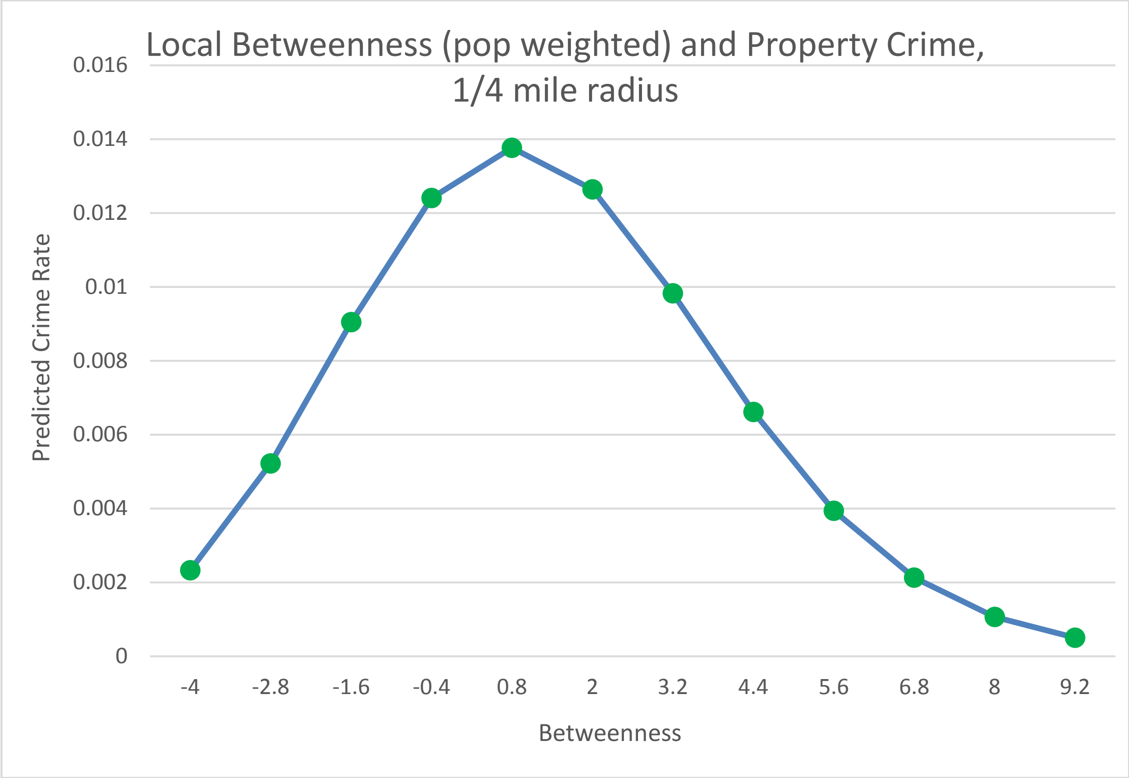


Figure 4.8. Local Betweenness (Population & Retail Employee Weighted) and Violent Crime

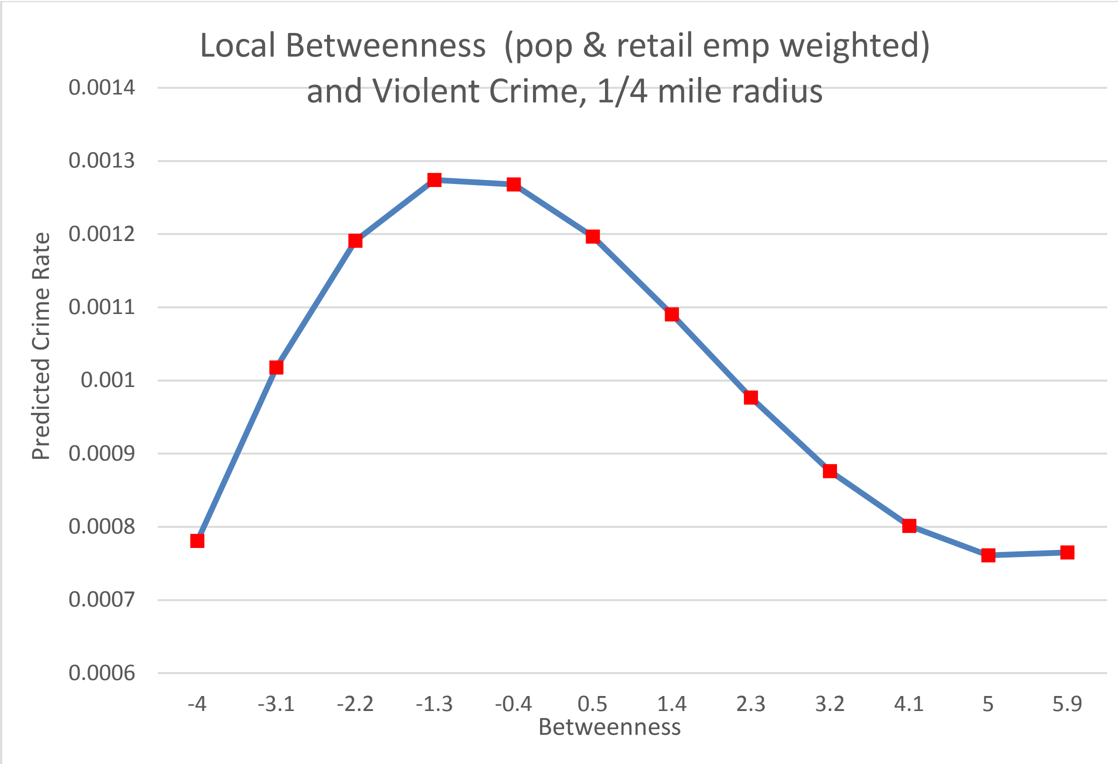


Figure 4.9. Local Betweenness (Population & Retail Employee Weighted) and Property Crime

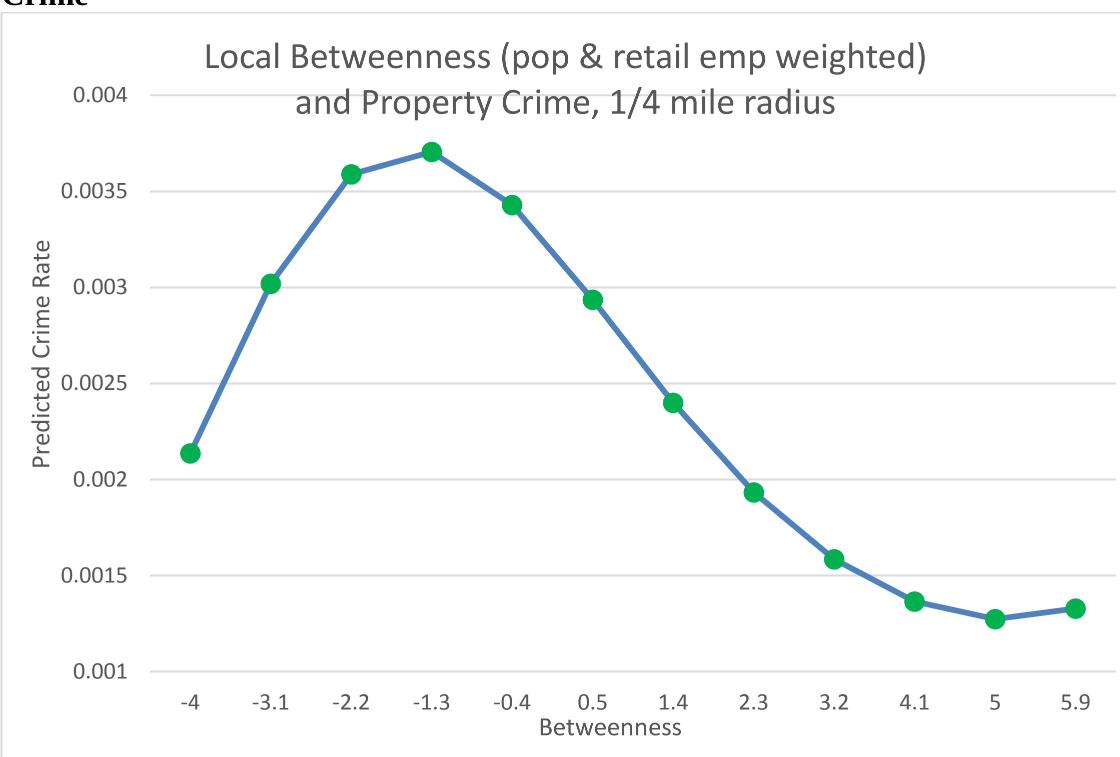


Figure 4.10. Interaction: Local Betweenness (Population Weighted) and Disadvantage for Violent Crime

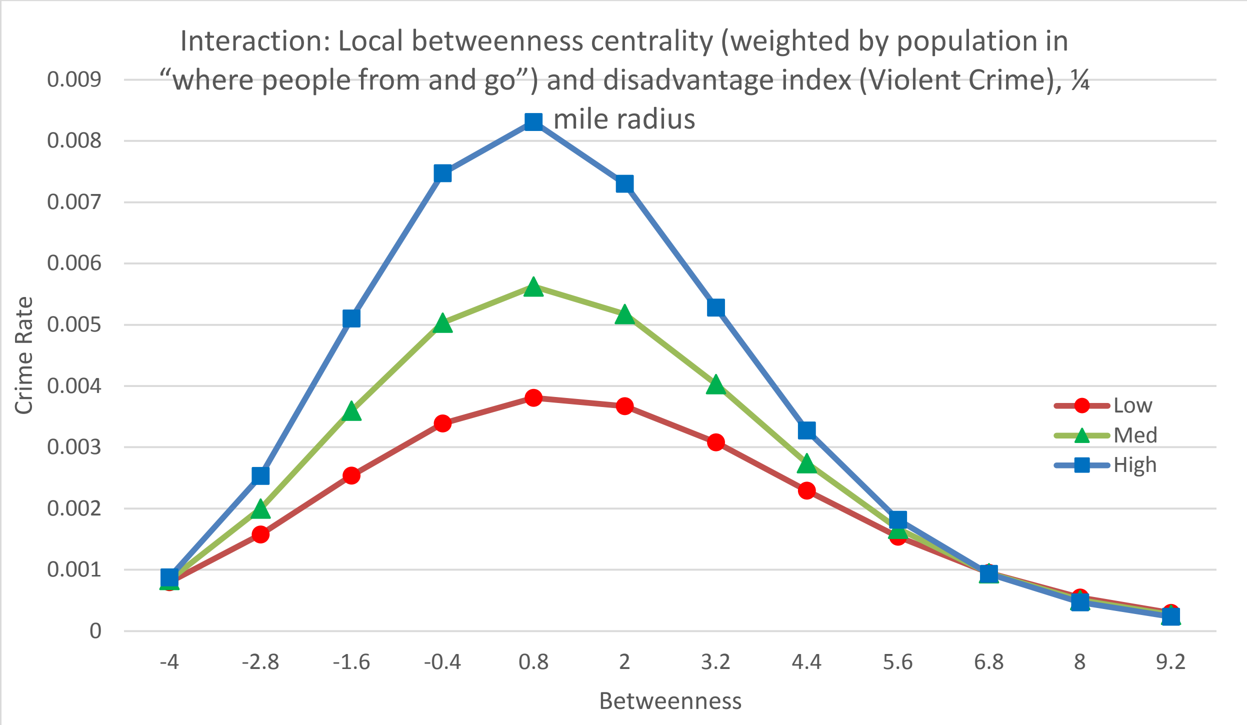


Figure 4.11. Interaction: Local Betweenness (Population & Retail Employee Weighted) and Disadvantage for Property Crime

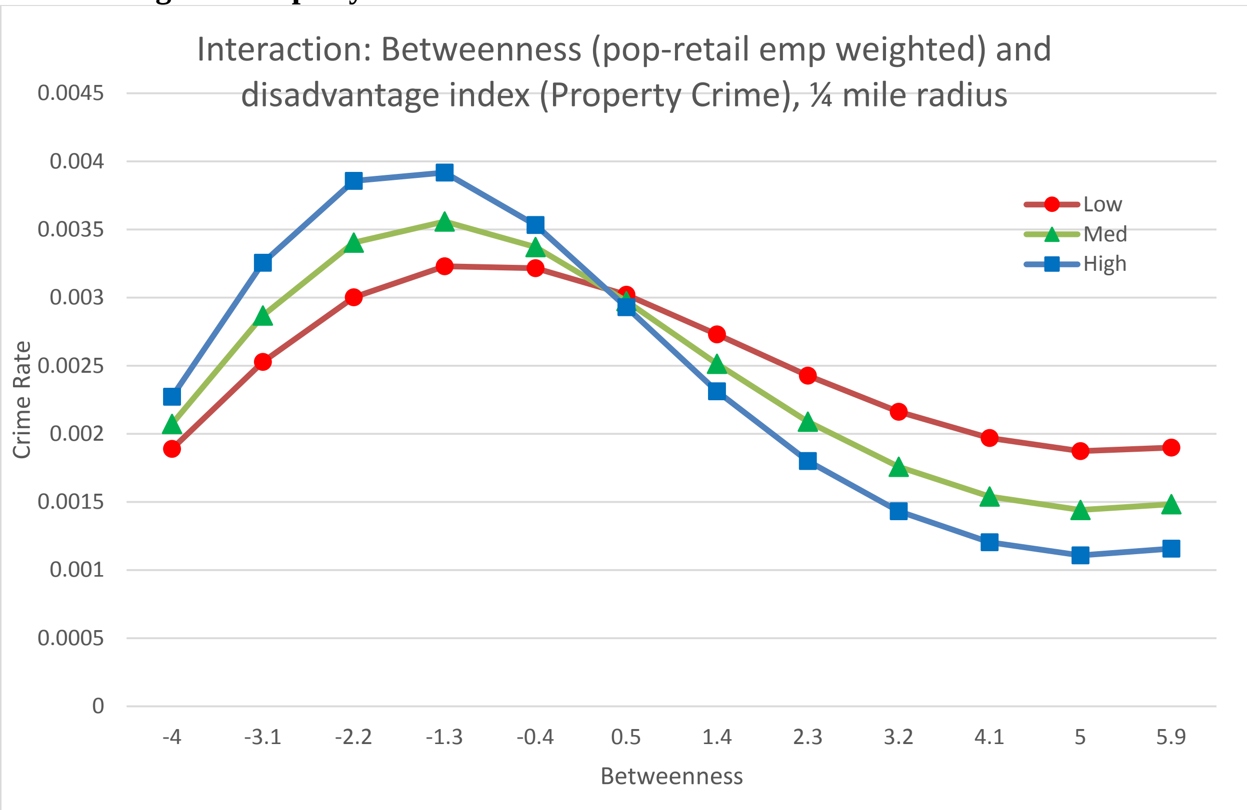
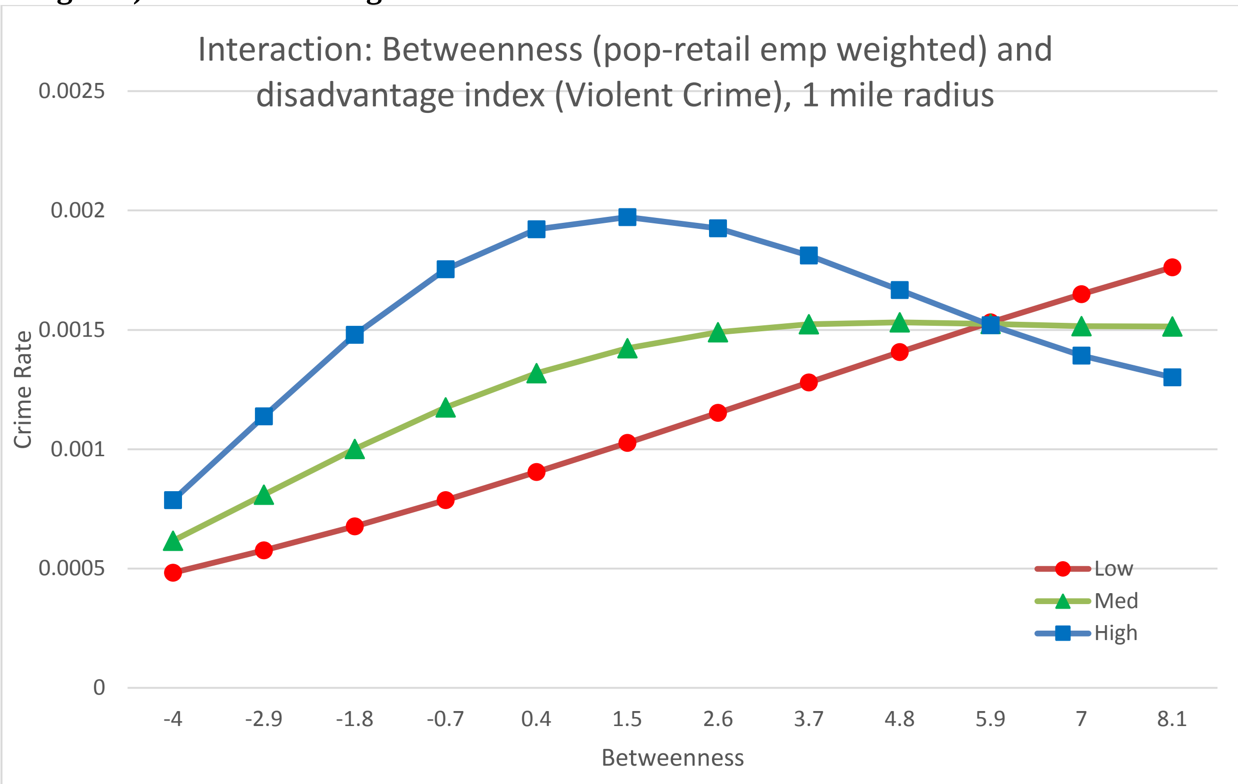


Figure 4.12. Interaction: Non-Local Betweenness (Population & Retail Employee Weighted) and Disadvantage for Violent Crime



CHAPTER 5. EDGES

Introduction

Scholars have theorized how spatial boundaries can be important for understanding the location of crime. The Brantinghams recognized the difference between physical edges and non-physical edges. For example, some edges are defined as more visually pronounced boundaries (i.e., highways, park boundaries, and rivers), whereas other edges can be relatively less visible such as city administrative boundaries. Additionally, given the definition of street segment (both sides of a street between two intersections), places where strong cognitive images are created by dissimilar land use on the two sides of a street can be seen as edges too. However, the empirical relationship between spatial boundaries (edges) and patterns of crime in place has been relatively under researched compared to other features (activity nodes and pathways).

There has been research on the proximity to highways, parks, and crime (e.g., Groff & McCord, 2012; Kimpton et al., 2016, McCutcheon et al., 2016), yet most of these studies theorized highways and parks as crime attractors, not as spatial boundaries. Moreover, fewer studies have focused on physically less visible spatial boundaries (i.e., city administrative boundaries) and how they are associated with the risk of crime in place. Only few empirical studies have examined the effects of physical and non-physical boundaries on crime (Brantingham et al., 2009, Song et al., 2013; Song et al., 2015; Kim & Hipp, 2017).

This chapter of the dissertation examines the effects of various types of boundaries by analyzing the relationship between crime in street segments and edges. Edges are operationally defined as three types of physically visible boundaries—interstate highways, rivers, and park boundaries. I measure nearness to the physical boundaries in two manners: (1) whether or not the street segment is adjacent to the feature; and (2) how far in physical distance via street network the segment is to the feature. Additionally, this chapter extends the literature by studying physically less visible boundaries – (1) city administrative boundaries. I measure nearness to the city boundaries by using the same method as the physically visible boundaries. Also, this chapter utilizes an alternative measure of physical boundaries, difference of land use on both sides of a street segment. I measure difference of land use composition at the street segment level by calculating the difference between each side of a street segment.

Physically Visible Boundaries and crime in Place

Physical boundaries are important in understanding crime in place because they can affect daily routine activities of people including potential offenders, targets, and capable guardians, and thus criminal opportunities in place. On the one hand, physical boundaries may *decrease* criminal opportunities in place. Physical boundaries can make a person undertake more effort to get to a destination crossing the physical barriers. Crossing physical boundaries like highways, rivers, or parks requires special features for connection such as bridges or tunnels. Otherwise, travelers have to circumvent them. Therefore, physical boundaries presumably increase the travel distance to get to the areas located on the other side of the boundaries. For these reasons, encountering physical boundaries forces potential offenders to detour them, which requires a longer distance to get to the areas for offending. Offenders might find targets less attractive as the distance to be covered increases. This is consistent with the well-documented literature of rational choice theories and the journey to crime literature that offenders tend to commit crime nearby one's residence based on a distance decay function.

Also, areas nearby physical boundaries may have lower risk of crime because they are less accessible and desirable for residents to live in due to the physical and social environments around them. Consequently, such areas would have fewer residential properties and inflow of population including potential offenders and targets. This is consistent with the framework of the routine activities theory (Cohen and Felson, 1979). When physical boundaries are present, the theory would expect that there would be lower probability of the convergence of potential offenders and targets at the same time and place; hence, lower risk of crime. As such, I posed the first hypothesis as follows:

> *Hypothesis 1-1: Street segments adjacent to physically visible boundaries will have lower risk of crime due to fewer criminal opportunities. Crime will increase when moving further away from the boundary with a distance decay function.*

On the other hand, areas near physical boundaries may have *higher* risk of crime due to reduced number of social ties, sense of cohesion, and informal social control among the residents on one side of the boundaries and the other. One important thing to consider when studying physical boundaries is the permeability – the level of accessibility of areas from the other side of the boundaries. Some areas near the physical boundaries are less accessible because of their physical characteristics. This may reduce the chance of social interactions among the residents living in the areas adjacent to them. For instance, rivers are particularly impermeable and crossing them requires additional cost, such as a bridge or ferry connection. So, crossing a river to get to the other side takes more time and effort; thus it impedes the chance of social interaction among residents living near the river in spite of their geographical proximity. The accessibility of highways is another example. Highways can be physical and social barriers because crossing them typically requires over- or under-passes, although they are more permeable than rivers. Indeed, Hipp, Corcoran, Wickes, & Li (2014) referred to physical boundaries as wedges and found that the presence of wedges (particularly highways) reduced the level of cohesion and informal social control for the neighborhoods adjacent to them because of lower level of accessibility ('porosity' in their term). As such, I posed the second hypothesis as follows:

> *Hypothesis 1-2: Street segments adjacent to physically visible boundaries will have higher risk of crime with a distance decay effect when moving further away. This is because of the lower permeability crossing the boundaries, thus, lower levels of social cohesion and informal social control among the residents across the boundaries.*

Physically Less Visible Boundaries (City Administrative Boundaries) and Crime in Place

The present study proposes that physically less obvious boundaries (i.e., city administrative boundaries) may also matter in understanding the patterns of crime in place. There are various reasons why city boundaries may enhance the risk of crime in place: (1) the possibility of physical land use change due to a city boundary; (2) the issue of less patrolling due to geographic distance from city police stations usually located in the city center area; and (3) the jurisdictional ambiguity and more limited communication between police agencies across city boundaries (Kim & Hipp, 2017).

Speaking of the first point, land use is one of the primary factors influencing spatial patterns of crime. Previous studies have found that land uses and regulations significantly vary across local municipalities (Gyourko, Saiz, & Summers, 2008; Quigley & Raphael, 2005). This suggests that areas adjacent to city boundaries, in some circumstances, can have very different land use types due to different land use policies across municipalities, which lead to dissimilar crime patterns in the places in spite of their geographical proximity. Therefore, a city boundary line as a type of edge is important in understanding change of land use and crime.

In terms of the second point, police agency stations typically are located in the center of the city to minimize patrolling distance in the jurisdiction. They are also in the center of sub-districts, which are not near city boundaries. One side effect of this is that areas near the city boundary will receive fewer patrols as areas nearer the police station will tend to receive more police patrols (given that such streets must be traveled through to get to outward locations in the city). Therefore, holding all else constant, there would be higher probability of crime events closer to the city boundary.

Finally, regarding the third point, areas near the city boundary can be quite ambiguous in terms of jurisdiction due to the physical invisibility of the boundary. When the boundary is less physically visible, the change of city jurisdictions is less detectable. Song et al. (2017) noted that "because of this subtlety, such edges are defined considering social and conceptual spaces. This makes this type of edge difficult to measure, particularly over large areas, because it requires social and conceptual observation" (p. 2). Such jurisdictional ambiguity across city boundaries can lead to uncertainty on which agency is responsible, and therefore result in less effective crime control in the area. This tendency may bring about higher risk of crime in places near the city boundaries along with the policing preference of officers less likely to engage in police work outside their primary boundaries (Rubinstein, 1973).

To the best of my knowledge, Kim & Hipp (2017) is the only empirical study that explicitly analyzed the relationship between crime in street segments and city administrative boundaries. They found that city boundaries showed a significant positive relationship with crime. Specifically, violent and property crimes were more prevalent in the segments on city boundaries. The findings imply that city boundaries are also important features for understanding crime in place in spite of the relative physical invisibility. In sum, I pose this hypothesis:

> *Hypothesis 2-1: Street segments adjacent to the city administrative boundaries will have higher risk of crime with a distance decay effect when moving further away.*

Land Use Difference on the Street Segment and Crime

This chapter of the dissertation suggests that land use difference on the street segment also can be operate as one type of physical boundaries. According to the Brantinghams (1993), there will be higher concentrations of crime along major sites of routine activities (nodes) and access routes (paths), and also more crime on the exterior boundaries of areas (edges) but less crime towards the interior of them. Peripheral areas of an activity space have higher risk of crime than the interiors because residents tend to not consider the area as part of their own space; thus feel less responsible for the surveillance. Although it is not easy to define where the peripheral areas exactly are, the current study utilizes a change in land use at the street segment level to identify the locations of the outer areas.

Given the definition of a street segment (both sides of a street between two intersections), a street segment itself contains elements of an edge, which makes the difference of land use between one side and the other of a street segment act as a boundary. Specifically, a street segment can be seen as an edge because both sides of a segment can be divided into two geographically distinct areas based on the center line of the street. Thus, measuring the share of each land use type on each side of the street segment allows us to capture the composition of land use classification difference at the street segment level. Moreover, the land use difference at the street segment level may be a cognitive barrier that can be recognized as a spatial boundary. As abovementioned, permeability of boundaries is important given that less permeable boundaries require additional cost and effort to cross to get to the other side. Such characteristics may impede social interactions and formation of informal social control among residents living on one and the other side of a street segment. Specifically, residents living on one side of a street segment might feel that the other side is not part of their own space if the qualities of land uses between two sides are too dissimilar. Then, social ties, cohesion, and the level of informal social control among the residents across the street may be weakened, which may lead to increase in the risk of crime.

Indeed, in an empirical study of the Municipality of Burnaby in British Columbia, Canada, Song et al. (2013) defined edges as boundaries of each Residential – Single Family zone and a buffer area with a width of 0 to 100 meters from the outer boundary of the Residential – Single Family zones. Then, they extended the definition of edges by considering adjacent land use type (Commercial, Residential Multiple Family, Institutional, Natural, and Industrial areas). They found that crime is 64 percent higher in these edges than in the interior of the neighborhoods. In a similar study, Song et al. (2015) also observed that criminal victimization rates were 2–3 times higher on the edges compared to elsewhere. These studies defined edges as where single family zoning changes to other types of land uses (Song et al., 2013; 2015). Yet, changes from non-residential land use (i.e., retail) to another type (residential, office, industrial land use etc.) should be considered too. Although relatively infrequent, there are predominant retail, office, industrial, or other land use areas in a city. At the border of two or more areas with different land use characteristics, people may have cognitive distinctions between them. Therefore, simply ignoring the changes from non-residential land use to another might lead to less comprehensive results. In sum, I pose this hypothesis:

> *Hypothesis 2-2: Street segments with greater difference of land use between the two sides will have higher risk of crime.*

Data and Methods

I measured physically visible boundaries and city boundaries in two manners: (1) a dichotomous variable representing whether a street segment is on the boundary of interest (highways, rivers, park boundaries, and city administrative boundaries), and (2) a measure of the street network distance from the centroid of a segment to the boundary of interest. The issue of permeability in studying physical boundaries and crime suggests the importance of capturing real-life geography via the street network system. Previous studies used straight-line distances to measure proximity to physical boundaries. However, this may introduce a potential bias because it does not incorporate how permeable the features are based on the actual configuration of the street network.

Although previous studies utilized Euclidean distance measures to explore how crime concentrates along edges, it is more appropriate to use distance based on the street network rather than Euclidean distance (straight-line distance) when calculating nearness of a street segment to boundaries. Researchers frequently use Euclidean distance because it is less computationally demanding. Arguably, street-network distances are more relevant to the real-life environment because they account for the street geography and certain physical barriers; consequently they are more predictive of physical activity than Euclidean distance. Also, street segments that are quite close to boundaries, but are not geographically accessible to the boundary, are likely to be differently impacted by boundaries than segments that are directly accessible via the street network.

To calculate street network distance from the centroid of a segment to the boundaries of interest, I utilize the Origin-Destination (OD) cost matrix analysis function in network analysis toolbox in ArcGIS 10.3. Because the OD cost matrix analysis only considers point origins and destinations in the calculation of the shortest distances via the street network, I convert the features of highways, rivers, park boundaries, and city boundaries to multiple points along the boundaries of the features with a 100-foot-interval using the Create Points along Lines toolbox in ArcGIS 10.3. That is, the line features of physical boundaries will be transformed as multi-points at 100 feet intervals along line features. These converted points of the boundaries will be the destinations in OD cost matrix analysis while centroids of street segments will be the origins when calculating street network distance from segments to the boundaries.

I define a street segment as being on the boundary of interest if the distance via the street network from the segment centroid to the boundaries is less or equal to 40 meters (about 131 feet). The distance of 40 meters is based on the finding of Song et al. (2015) that criminal victimization rates were 2–3 times higher on an edge compared to elsewhere, yet this effect decreased very quickly further than 40 meters from the edge. The highways, rivers, and parks boundary data come from 2010 Environmental Systems Research Institute (ESRI) street map data. The highway data include highways and interstates. Rivers are defined by named rivers and streams. Parks are national, state, and local parks. I used the Census 2010 place boundary shapefile for the city administrative boundaries. I calculate the street network distances considering a restriction of freeway line barriers in the street network. In other words, freeways are not included as part of the street network while calculating street network distances from street segment to the boundaries, but considered as line barriers that prohibit travel anywhere they intersect the network. This is because it is less plausible to include freeways in the network in calculation of the distances while having freeway lines as physical boundaries. The street network distance measures were calculated in kilometers (One mile is about 1.6 kilometers).

To measure the difference in land use at the street segment level, I utilize land use datasets from the Southern California Association of Governments (SCAG). I identify which land parcels belong to which sides of a street segment based on their spatial locations. For example, in Figure 5.1, a land parcel, *p1* has the block identification of block *A* because it has its centroid within block *A*, whereas parcel *p13* has block identification of block *B* for the same reason. All parcels are associated with the contiguous street segment and the blocks they are located within. Then, they are aggregated to the street segment and block level. I ended up with segment/block combinations that refer to each side of the street.

The entire process identifies the parcels' association with a side of the street segment. Using this information, I will measure the difference of land use in a street segment based on proportions of five land types (i.e., residential, retail, office, industrial, and other land use) on both sides of a street segment, which takes following form:

$$LUdiff_a = \sqrt{\sum_{k=1}^{K} (LUa_{ki} - LUa_{kj})^2} \tag{5-1}$$

where, $LUdiff_a$ represents the land use difference measure of a segment a, LUa_{ik} refers to proportion of a particular land use type *k* on *i* side of a given street segment *a*, and LUa_{jk} is the proportion on the *j* side of segment a.

I included a set of variables that account for the effects of social environment (structural characteristics) of the street segments. As mentioned earlier, I imputed 2010 Census block data to adjacent street segments to have Census measures at the street segment level. Specifically, I constructed a *concentrated disadvantage index,* which is a factor score computed after a factor analysis of four measures: (1) percent at or below 125% of the poverty level; (2) percent single-parent households; (3) average household income; and (4) percent with at least a bachelor's degree. The last two measures had reversed loadings in the factor score. To measure *residential stability*, this study utilizes the percent home owners. The present study controls for the presence of racial/ethnic minorities in street segments as the percent African-American and the percent Latino/Hispanic. To capture the level of *racial/ethnic heterogeneity*, a Herfindahl index based on five racial/ethnic groups (white, African-American, Latino, Asian, and other races) was computed. Besides the variables included above, this study also accounted for the percent *occupied units* is used to measure vacancies. The dependent variables of this chapter are the number of violent and property crime incidents. The crime data come from the Southern California Crime Study (SCCS) as described in Chapter 3. I used the average of violent and property crime incident data in 2010, 2011, and 2012 at the street segment level.

Analytic strategy

This chapter of the dissertation estimates a series of models in which measures of the spatial boundaries discussed above are included while controlling for the effects of structural characteristic measures included in the previous chapter. The general form of these models are

$$E(y) = exp(\alpha + \beta_2 x + \beta_3 z + \beta_4 wz + \beta_5 j) \qquad (5\text{-}2)$$

where y is the dependent variable to be explained (the number of crime events), α is an intercept, x represents a matrix of various measures of three physically visible boundaries and two physically less visible boundaries in the models, z is a matrix of the structural characteristic variables, wz is a matrix of the spatially lagged structural characteristic measures, and j is a matrix of the dummy variables for cities. I included block population as the exposure variable, effectively making the outcomes interpretable as rates. Models 1-5 include the measures of physically visible boundaries (highways, rivers, and park boundaries) and those of physically less obvious boundaries (city administrative boundaries and land use difference in street segment), respectively. Then, Model 6 is a full model that includes all measures of in Models 1-5, simultaneously. Finally, in order to see if there exist interaction effects between the measures of spatial boundaries and socioeconomic status of street segments, I estimate a set of models including the measures in Models 1-5 with the interaction terms with the concentrated disadvantage index, respectively. To capture possible non-linear relationships, squared and cubic terms are included for the primary measures included in each model. The summary statistics are presented in Table 5.1.

Figure 5.2 is a map of Los Angeles City with street segments colored according to the level of local land use difference at the street segment level. Red streets are the areas with higher level of land use difference, while the blue streets indicate the areas with lower level of land use difference. As shown, there is some variation in terms of land use difference between the two sides of street segments. Also, I observe that red streets generally represent the outer boundaries of space in the city of Los Angeles in terms of land use changes, whereas blue and green streets are located in more interior areas. Thus, the land use difference between the two sides of a street segment can be a plausible alternative to properly measure peripheral areas of activity space based on land use changes.

<<< Table 5.1 about here >>>

<<< Figure 5.2 about here >>>

Results

I begin with the coefficients for the variables capturing the effects of physically visible boundaries (highways, rivers, and park boundaries) in Tables 5.2 and 5.3. First, there are strong positive effects for the variables capturing segments that are adjacent to highways (the dichotomous measures); such areas have higher risk of violent and property crime. For example, a street segment that is adjacent to highways has 61 percent more violent crime than a segment that is not adjacent to highways (exp (0.4797) – 1 = 0.61). Likewise, a segment adjacent to highways also has 43 percent higher risk of property crime. I displayed the combined effects of the distance measures and the indicator variables capturing adjacency to highways by plotting the predicted crime rates for these segments ranging from 1st to 95th percentile of the distribution (0 to 5.5 Km) in Figures 5.2 and 5.3.

<<< Tables 5.2 and 3 about here >>>

As shown, the distance decay effect is plotted as the parametric form, whereas the indicator variable for a segment adjacent to a boundary is added to the predicted value for the shortest distance (0-.5 Km), which explains the apparent spike in the plot. By including this boundary effect, I more accurately display the spatial pattern estimated in the model. For example, Figures 5.2 and 5.3 show that segments adjacent to highways have higher levels of violent and property crime, with a consistent distance decay effect in which there are lower levels of crime moving further away from highways. This supports hypothesis 1-2 that street segments adjacent to the physically visible boundaries will have higher risk of crime with a distance decay effect.

<<< Figures 5.3 and 4 about here >>>

There are similar findings for segments that are adjacent to parks on violent and property crimes as seen in Figures 5.2 and 5.3. A segment adjacent to a park has 7 percent more violent crime and 10 percent more property crime. Figures 5.2 and 5.3 also demonstrate that there is a distance decay effect in which there are lower violent and property crime rates further away from parks. The last physically visible boundaries I studied were rivers. Rivers also exhibit a similar pattern compared to the other two physical boundaries studied here. I find that segments adjacent to rivers have 21 percent more violent crime and 12 percent more property crime than other segments. For rivers, there is a distance decay effect for property crime but not for violent crime.

Property crime is less prevalent in segments that are further away from rivers, although the effect is relatively smaller compared to the other two physical boundaries. In contrast, I find no evidence of a distance decay effect of rivers for violent crime.

<<< Figures 5.5 and 6 about here >>>

Next, I turn to the findings of physically less visible boundaries – City boundaries (Figures 5.4 and 5). Although city boundaries are less physically obvious —and sometimes may even be difficult to observe—I find that they nonetheless are associated with elevated rates of violent and property crime. A street segment that is on a city border has about 10 percent more violent crime and about 7 percent more property crime than other street segments. In looking at distance from city boundaries, crimes are more prevalent on a segment on city boundaries and they exhibit distance decay effects moving farther from city boundaries. The results are consistent with the hypothesis 2-1 that street segments adjacent to the city administrative boundaries would have higher risk of crime with a distance decay effect when moving further away.

Finally, turning to the findings of another measure of physically less visible boundaries (land use difference at the street segment level), I see that there are crime enhancing effects for violent and property crime (Figures 5.6 and 5.7). For instance, each 0.1 increase in land use difference results in about 3 and 2 percent increase in the risk of violent and property crime. This means that street segments with higher level of land use difference between the two sides have higher risk of violent and property crime, which supports the Hypothesis 2-2.

<<< Figures 5.7 and 5.8 about here >>>

Moderating Effects: Spatial Boundaries, Socioeconomic Status, and Crime in Place

In this section, I discuss the effects of various measures of spatial boundaries on the risk of crime in street segments, moderated by the socioeconomic status of the place measured by the concentrated disadvantage index. For each form of moderation, there is a model using violent crime as the outcome, and a model using property crime as the outcome. Tables 5.3 and 4 show the interaction terms consisting of various boundary measures and socioeconomic status. I have plotted the predicted values of crime in Figures 5.8-17 according to the coefficient results of the interaction term and the main effects at varying levels of the concentrated disadvantage index (Low = -1 SD, Med = mean, and High = +1 SD).

<<< Tables 5.3 and 5.4 about here >>>

<<< Figures 5.9 and 5.10 about here >>>

In the models looking at distance to highways, high disadvantaged street segments are at higher risk of violent and property crime, in general. The distance decay effects are more pronounced in low disadvantaged segments (better-off areas) when moving further away from the highway; the patterns for violent and property crime are plotted in Figures 5.8 and 9. In viewing the physical boundaries of parks, I find that high disadvantaged areas generally have higher risk of crime, regardless of the distance from the park boundaries; and the distance decay effects moving away from the boundaries are more apparent in the better-off street segments. This pattern is plotted in Figures 5.10 and 5.11. For rivers, likewise, street segments adjacent to rivers have higher risk of violent crime notwithstanding the level of disadvantage. The distance decay pattern is more obvious in better-off street segments for violent crime, while there is little evidence that closeness to rivers matters for violent crime in high disadvantaged areas. For property crime, I observe the distance decay effect regardless of the level of disadvantage, yet better-off areas tend to have higher risk of property crime than the others (Figures 5.12 and 13).

<<< Figures 5.11-14 about here >>>

Now, I turn to the findings of physically less visible boundaries: How the effects of city boundaries and land use difference at the street segment level are moderated by the socioeconomic status (Figures 5.14 and 15). First, I find that the effect of being on the city boundary is moderated by the level of concentrated disadvantage. Again, there is evidence that segments on a city boundary will have even higher violent and property crime rates. I also find that the distance decay pattern for violent crime is moderated by the level of disadvantage. For example, I observe that violent crime decreases as the distance from city boundaries increases, and this crime-reducing pattern is more pronounced in better-off street segments. For property crime, I find a similar pattern but the effect size is relatively smaller than the findings for violent crime. Finally, Figure 5.16 and 17 reveal the association between the land use difference at the street segment level and crime. As shown, the relationship varies across different levels of socioeconomic status of the street segments. As the level of land use difference between the sides of a street segment increases, violent and property crime also increases; and this pattern is more apparent in better-off areas. This means that the crime-enhancing effect of the land use difference at the street segment level matters more in better-off areas than in worse-off areas.

<<< Figures 5.15-18 about here >>>

Discussion

Although previous studies have theorized the importance of spatial boundaries (edges) in understanding crime in place, the relationship between edges and the level of crime has been empirically less studied. The current study examines edges in urban settings and the spatial patterns for crime at the street segment level using data from 130 cities across the Southern

California region. Therefore, one strong point of the project is having a substantial amount of statistical and explanatory power along with data from the large study area. I typified edges by physical visibility: (1) highways, parks, and rivers as physically visible boundaries, and (2) city boundaries and the land use difference at the street segment level as relatively less visible boundaries.

As a natural extension of Kim & Hipp (2017), this chapter of the dissertation introduces theoretically and methodologically more refined measurements of edges by using distance based on the street network rather than straight-line distance. Also, the current study employed the difference of land use between one side and the other of a street segment as a novel measure of edges as it may act as a spatial boundary given the definition of a street segment. The results suggest that spatial boundaries are important to consider in understanding the spatial patterns of crime. Therefore, one primary contribution of the present study is empirically testing the importance of various types of spatial boundaries for crime in place.

First, the results showed that segments near highways have more crime, in general, and there is a distance decay effect in which crime decreases moving further away from highways. These findings are consistent with previous studies that crime decreases moving away from spatial boundaries (Kim & Hipp, 2017; McCutcheon et al., 2016; Brantingham et al., 2009; Rengert, Chakravorty, & Henderson, 2000). One possible explanation for the results is that streets near highways are relatively more accessible by vehicle for non-local residents from outside compared to areas near other types of edges (i.e., rivers) because highways are built for the purpose of vehicle traffic access. Moreover, areas near highways may have lower levels of natural surveillance and informal social control because they are relatively less desirable for residents to live due to the physical and social environment. As mentioned earlier, Hipp et al.

(2014) found that highways can reduce the level of cohesion and informal social control for the neighborhoods in which they occurred. Therefore, potential offenders may perceive more criminal opportunities in the areas near highways because such areas are easier to access from outside along with fewer capable guardians.

Second, the results showed that areas near parks have higher risk of violent and property crime, and there is also a distance decay effect as crime decreases moving further away. Street segments near parks may have more inflow of people due to the purpose of parks, which may lead to an increase in criminal opportunities and crime events. Also, previous studies found that parks can act as crime attractors because parks are large public areas with less informal social control and natural surveillance (Groff & McCord, 2012; Kimpton et al., 2016). Another possible explanation is that areas adjacent to parks may have fewer regular residents to serve as eyes on the street or capable guardians watching and keeping the neighborhood safe. Moreover, due to hours of operation, there would be fewer capable guardians in parks (or areas near parks) after sunset as it gets dark. Indeed, Kimpton et al. (2016) observed more violent crime, thefts, public nuisance, and property damages after the sunset from evening to night time periods (4 p.m. to midnight). Third, rivers operated somewhat differently and the effects were less apparent compared to highways and parks. For instance, street segments near rivers had modestly more violent and property crime, which may be due to relative rarity of rivers in the study area. I found less evidence of a distance decay effect for violent crime, while property crime is slightly less prevalent in segments that are further away from rivers. This suggests that physically visible boundaries with different characteristics may have different impacts on crime (Kim & Hipp, 2017).

The current study suggests that physically less visible boundaries such as city administrative boundaries can operate as edges, and found a significant positive relationship with crime with a distance decay effect when moving further away from city boundaries. I observed that violent and property crimes were more prevalent if a segment was on a city border as theorized and hypothesized above. The result suggests that in spite of invisibility, city boundaries may also act as important boundaries in understanding crime in place. Yet, the theorization of the current study for city boundaries is still speculative. I hope future research study the patterns of offender behaviors and policing strategies across city boundaries with more than one agency.

Another measure of physically less visible boundaries is the land use difference at the street segment level. Consistent with previous studies and Hypothesis 2-2, I observed that higher level of land use difference between the two sides results in higher risk of violent and property crime. As theorized, the results imply that the land use difference can be a cognitive edge which may affect the level of informal social control, although it is relatively less visible. Potential offenders might find more criminal opportunities in the peripheral areas because such areas are less likely to be considered as core parts of someone's activity space. Consequently, there will be less territoriality and people may feel less responsible for the surveillance; and thus lower level of guardianship in place. Future research might extend this pattern further by empirically examining the resident's cognitive perception of edges by the land use difference between two sides of the street and the level of informal social control. For example, it is still unclear how people actually distinguish the peripheral or central areas of the activity space and how the level of informal social control is related to the exterior or interior locations of the space.

The findings of moderating effects suggest that the spatial patterns of crime driven by various types of edges can vary by the level of socioeconomic status of the place. For example, I found that high disadvantaged areas are generally at higher risk of crime and the distance decay patterns of highways, parks, rivers, and city boundaries are more apparent in low disadvantaged street segments. Thus, there appears to be a cumulative advantage effect—the crime-reducing effect of distance moving away from the boundaries helps better-off street segments more so than the disadvantaged. In contrast, for the distance decay effect for rivers, better-off areas tend to have higher risk of property crime. These findings make sense given that there may be more potential targets for property crime in better-off areas closer to rivers because some better-off residents tend to live by waters due to desire for a better view.

Finally, I found that the crime-enhancing pattern of the land use difference on two sides of a street for violent and property crime is stronger in better-off streets. Therefore, better-off streets with higher level of land use difference are at higher risk of crime. One possible explanation for this finding is that a crime prevention mechanism based on informal social control among residents in better-off areas may be more vulnerable as the street segments are located in more peripheral areas. Also, residents in better-off street segments may be more sensitive to change of land use boundaries so that they see the other side of the street as less part of their own area, which may lead to decreases in social ties, cohesion, and the level of informal social control among the residents across the street. Yet, this explanation is still speculative. Therefore future research studying land use difference across two sides of a street, informal social control among residents, and crime is necessary.

This study has some limitations. First, although I suggested possible explanations for the patterns observed, specifically testing how the presence of these boundaries enhances or reduces the risk of crime in street segments is beyond the scope of the present study. Future research should delve into the mechanisms of edge effects on crime. Second, methodologically, there may be other possibilities for slicing up boundary features into intervals to convert boundary lines to points to calculate the street network distance. For example, other intervals should be assessed and compared to the results of the current study to see if the findings still remain. Finally, the current study can be improved by appropriately testing how changes in the location of edges over time can affect spatio-temporal patterns of crime. Although some features may remain stable over time (i.e., rivers), other boundaries can be significantly changed in terms of the locations and characteristics. For instance, highways can be newly constructed or connected to other highways or ramps. Parks and land use difference at the street segment can be changed by land use planning policy. City jurisdiction boundaries are also subject to change because of urban planning, political, or administrative reasons. Therefore, a study looking at how the changes in edges over time can impact changes in crime is needed.

In conclusion, the present study examined the relationships between various types of spatial boundaries and crime in street segments. I empirically tested two types of boundaries: physically visible boundaries (i.e., highways, parks, and rivers) as well as less visible boundaries (city administrative boundaries and land use difference at the street segment level). I found that street segments adjacent to the spatial boundaries generally have higher risk of crime. I also observed that there are distance decay effects of the boundaries for violent and property crime. Although much empirical research focuses solely on physical boundaries, this study examined the effects of spatial boundaries and crime, while accounting for the effects of structural characteristics. Moreover, the current study confirmed that the effects of various boundaries can be moderated by the socioeconomic status of place. Therefore, a primary contribution of the current study is to expand understanding of boundaries and crime by taking into consideration of both physical environment in terms of edges and social environment pertaining to structural characteristics of place.

Chapter 5 Tables

Table 5.1. Summary Statistics

	N	Mean	S. D.	Min	Max
Outcomes					
3 year average violent crime	326452	0.13	0.52	0	44.33
3 year average property crime	326452	0.59	2.27	0	315
Edge measures					
Distance from highways (Km)	326336	2.05	1.76	0	22.50
Distance from rivers (Km)	326336	6.41	4.81	0	62.70
Distance from parks (Km)	326337	1.10	1.25	0	26.75
Distance from city borders (Km)	326452	1.91	2.06	0	13.31
Land use difference at street segment	326452	0.23	0.31	0	1.84
Structural Characteristics					
Concentrated disadvantage	326452	-1.77	8.78	-15	15
Racial/ethnic heterogeneity	326452	0.44	0.17	0	0.79
% Home owners	326452	68.74	26.55	0	100
% Black	326452	5.56	11.39	0	100
% Latino	326452	34.86	28.04	0	100
% Occupied units	326452	94.03	8.39	0.39	100
% Age 15-29	326452	19.97	8.20	0	100
Land use 2008					
% Industrial land use	326412	0.02	0.09	0	1
% Office land use	326412	0.02	0.09	0	1
% Residential land use	326412	0.73	0.28	0	1
% Retail land use	326412	0.04	0.12	0	1
Spatial lags (.25 mile)					
Concentrated disadvantage	326452	-1.25	8.03	-15	15
Racial/ethnic heterogeneity	326452	0.47	0.16	0	0.77
% Home owners	326452	65.32	24.76	0	100
% Black	326452	5.53	10.21	0	100
% Latino	326452	36.18	27.15	0	100
% Occupied units	326452	93.94	7.19	1.42	100
% Age 15-29	326452	20.63	7.01	0	100

Table 5.2. Estimated Models (Violent Crime)

Violent Crime	Highway	River	Park	City	LU diff.	Full
Boundaries						
Distance from highways	-0.1128 **					-0.1254 **
	-6.8647					-7.3608
Distance from highways (sq)	0.0105 *					0.0206 **
	2.5366					4.5538
Distance from highways (cu)	-0.0006 *					-0.0016 **
	-2.1883					-5.1055
Highway (1/0)	0.4913 **					0.4797 **
	15.4114					15.1397
Distance from rivers		0.0037				0.0354 **
		0.3451				3.2865
Distance from rivers (sq)		-0.0005				-0.0048 **
		-0.4040				-3.5550
Distance from rivers (cu)		0.0000				0.0001 **
		0.2325				3.0705
River (1/0)		-0.1814 *				0.1912 *
		-2.1747				2.3005
Distance from parks			-0.1674 **			-0.1036 **
			-7.3329			-4.2957
Distance from parks (sq)			-0.0197 *			-0.0395 **
			-2.5183			-4.5598
Distance from parks (cu)			0.0012 **			0.0017 **
			2.6888			3.5185
Park (1/0)			0.0621 *			0.0695 *
			2.2685			2.5360
Distance from city borders				-0.1172 **		-0.1157 **
				-6.5726		-6.5113
Distance from city borders (sq)				0.0187 **		0.0178 **
				4.1522		4.0111

Distance from city borders (cu)				-0.0011 **		-0.0010 **
				-3.7913		-3.2400
City border (1/0)				0.0625 *		0.0939 **
				2.2811		2.7007
Land use difference					1.1164 **	1.0786 **
					11.8691	11.4744
Land use difference (sq)					-1.2633 **	-1.2462 **
					-6.3199	-6.2421
Land use difference (cu)					0.4909 **	0.4817 **
					4.5787	4.4987
Structural Characteristics						
Concentrated disadvantage	0.0049 **	0.0050 **	0.0046 **	0.0055 **	0.0054 **	0.0050 **
	3.2013	3.2817	3.0275	3.5640	3.5212	3.2300
Racial/ethnic heterogeneity	-1.8222 **	-1.8298 **	-1.7965 **	-1.8171 **	-1.7651 **	-1.7087 **
	-30.2273	-30.2622	-29.6899	-30.0802	-29.0847	-28.2021
% Home owners	-0.0028 **	-0.0030 **	-0.0030 **	-0.0031 **	-0.0030 **	-0.0029 **
	-7.0779	-7.5666	-7.5084	-7.7159	-7.6022	-7.3683
% Black	0.0085 **	0.0087 **	0.0079 **	0.0083 **	0.0081 **	0.0073 **
	8.9515	9.0665	8.2957	8.7045	8.4881	7.6634
% Latino	0.0025 **	0.0025 **	0.0023 **	0.0025 **	0.0026 **	0.0024 **
	3.7456	3.7391	3.4520	3.7843	3.8791	3.6394
% Occupied units	-0.0153 **	-0.0156 **	-0.0155 **	-0.0153 **	-0.0154 **	-0.0151 **
	-15.5473	-15.7499	-15.7230	-15.5579	-15.6029	-15.3346
% Age 15-29	0.0006	0.0008	0.0009	0.0009	0.0011	0.0006
	0.6444	0.8315	0.9078	0.9323	1.0951	0.5811
Land use						
% Industrial land use	0.4381 **	0.4166 **	0.4816 **	0.4164 **	0.3328 **	0.4205 **
	7.2454	6.8690	7.9248	6.8870	5.3478	6.7475
% Office land use	-0.0641	-0.0348	-0.0700	-0.0214	-0.1032	-0.1724 *
	-0.8858	-0.4801	-0.9641	-0.2969	-1.3925	-2.3143
% Residential land use	-0.3737 **	-0.3816 **	-0.3912 **	-0.3841 **	-0.2558 **	-0.2678 **

	-13.9584	-14.2565	-14.4014	-14.3425	-9.2280	-9.4789
% Retail land use	2.9606 **	3.0835 **	3.0800 **	3.0815 **	3.0076 **	2.8826 **
	73.7674	77.4135	76.6921	77.4889	73.2520	69.0720
Spatial lags (.25 mile)						
Concentrated disadvantage	0.0239 **	0.0233 **	0.0236 **	0.0252 **	0.0235 **	0.0240 **
	10.2977	10.0024	10.1475	10.8752	10.0970	10.2088
Racial/ethnic heterogeneity	1.1955 **	1.2038 **	1.2191 **	1.2599 **	1.1525 **	1.2157 **
	17.2519	17.3485	17.5458	18.1503	16.5789	17.4328
% Home owners	-0.0088 **	-0.0093 **	-0.0087 **	-0.0097 **	-0.0087 **	-0.0082 **
	-17.8349	-18.8725	-17.7124	-19.6540	-17.5134	-16.3527
% Black	0.0217 **	0.0218 **	0.0220 **	0.0201 **	0.0224 **	0.0219 **
	19.8515	19.5575	20.0719	18.1376	20.3751	19.4743
% Latino	0.0100 **	0.0109 **	0.0108 **	0.0103 **	0.0105 **	0.0092 **
	12.2482	13.3160	13.2485	12.5779	12.8796	11.1686
% Occupied units	-0.0216 **	-0.0221 **	-0.0224 **	-0.0211 **	-0.0224 **	-0.0211 **
	-14.3340	-14.6222	-14.7401	-13.9467	-14.9146	-13.8978
% Age 15-29	0.0081 **	0.0080 **	0.0073 **	0.0066 **	0.0082 **	0.0069 **
	6.1487	6.0257	5.4758	4.9833	6.1935	5.1509
Intercept	-3.3132 **	-3.3892 **	-2.4346 **	-3.3001 **	-3.6653 **	-2.4358 **
	-11.4449	-11.6355	-8.2206	-11.3893	-12.6698	-8.1650
N	326296	326296	326297	326412	326412	326296
Pseudo R-sq	0.2486	0.2467	0.2485	0.2473	0.2485	0.2526

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects are included but not reported in the tables

Table 5.3. Estimated Models (Property Crime)

Property Crime	**Highway**	**River**	**Park**	**City**	**LU diff.**	**Full**
Boundaries						
Distance from highways	-0.2380 **					-0.2384 **
	-22.8080					-22.5470
Distance from highways (sq)	0.0231 **					0.0269 **
	8.8020					9.9434
Distance from highways (cu)	-0.0010 **					-0.0014 **
	-5.7227					-7.6433
Highway (1/0)	0.3670 **					0.3599 **
	15.1415					14.9243
Distance from rivers		-0.0778 **				-0.0485 **
		-12.9363				-8.0666
Distance from rivers (sq)		0.0067 **				0.0038 **
		9.0910				5.1692
Distance from rivers (cu)		-0.0002 **				-0.0001 **
		-6.3768				-3.3502
River (1/0)		-0.1432 **				0.1205 **
		-3.3259				2.8089
Distance from parks			-0.0470 **			-0.0443 **
			-3.8060			-3.5391
Distance from parks (sq)			-0.0255 **			-0.0219 **
			-7.1360			-5.9073
Distance from parks (cu)			0.0010 **			0.0009 **
			5.6816			4.7906
Park (1/0)			0.0963 **			0.1018 **
			5.6644			6.0062
Distance from city borders				-0.1950 **		-0.1972 **
				-18.4788		-18.7149
Distance from city borders (sq)				0.0365 **		0.0376 **
				13.7441		14.2068
Distance from city borders (cu)				-0.0019 **		-0.0020 **

							-11.0626				-11.2682	
City border (1/0)							0.0688	**			0.0666	**
							3.9654				3.8371	
Land use difference									-0.1304	*	-0.0643	
									-2.0901		-1.0374	
Land use difference (sq)									0.7996	**	0.6392	**
									5.8042		4.6771	
Land use difference (cu)									-0.4165	**	-0.3442	**
									-5.4949		-4.5819	
Structural Characteristics												
Concentrated disadvantage	-0.0009		-0.0003		-0.0003		-0.0001		-0.0002		-0.0007	
	-0.9529		-0.2795		-0.2983		-0.1560		-0.2596		-0.7382	
Racial/ethnic heterogeneity	-2.1177	**	-2.1358	**	-2.1312	**	-2.1249	**	-2.1270	**	-2.0875	**
	-56.7986		-57.0071		-56.8905		-56.7794		-56.7487		-56.0208	
% Home owners	-0.0019	**	-0.0022	**	-0.0021	**	-0.0022	**	-0.0023	**	-0.0019	**
	-7.4781		-8.6063		-8.3302		-8.9229		-9.1149		-7.4785	
% Black	0.0049	**	0.0051	**	0.0047	**	0.0049	**	0.0048	**	0.0044	**
	6.6896		6.9378		6.4075		6.5908		6.5135		5.9580	
% Latino	-0.0028	**	-0.0024	**	-0.0025	**	-0.0024	**	-0.0025	**	-0.0029	**
	-6.9529		-6.0282		-6.2962		-6.1038		-6.2156		-7.3566	
% Occupied units	-0.0071	**	-0.0071	**	-0.0071	**	-0.0069	**	-0.0069	**	-0.0072	**
	-10.6850		-10.7478		-10.6360		-10.3805		-10.4763		-10.9546	
% Age 15-29	0.0053	**	0.0050	**	0.0051	**	0.0052	**	0.0050	**	0.0050	**
	8.4998		8.0987		8.1621		8.3369		8.1279		8.1076	
Land use												
% Industrial land use	1.6576	**	1.6486	**	1.6659	**	1.6495	**	1.5920	**	1.5612	**
	39.8262		39.2608		39.6085		39.3820		37.5131		36.9997	
% Office land use	0.4134	**	0.5138	**	0.4866	**	0.5041	**	0.4431	**	0.3017	**
	9.0426		11.2134		10.5959		11.0034		9.5184		6.5028	
% Residential land use	-0.1092	**	-0.1148	**	-0.1526	**	-0.1145	**	-0.0273		-0.0668	**
	-6.4657		-6.7766		-8.8598		-6.7640		-1.5188		-3.6775	
% Retail land use	3.1369	**	3.3098	**	3.2783	**	3.3134	**	3.2255	**	3.0135	**

	102.1942		107.8707		106.0299		107.9934		103.5673		96.1504	
Spatial lags (.25 mile)												
Concentrated disadvantage	0.0098	**	0.0110	**	0.0109	**	0.0122	**	0.0115	**	0.0095	**
	7.1833		8.0428		7.9908		8.9844		8.4971		6.9634	
Racial/ethnic heterogeneity	1.3487	**	1.3927	**	1.3781	**	1.4180	**	1.3835	**	1.3311	**
	31.9437		32.8800		32.5328		33.4348		32.6854		31.3916	
% Home owners	-0.0076	**	-0.0090	**	-0.0088	**	-0.0093	**	-0.0090	**	-0.0075	**
	-24.5507		-28.7741		-28.3581		-29.8489		-28.8121		-23.9967	
% Black	0.0048	**	0.0046	**	0.0039	**	0.0028	**	0.0040	**	0.0053	**
	5.6462		5.3448		4.5913		3.3116		4.6842		6.1761	
% Latino	-0.0018	**	-0.0007		-0.0011	*	-0.0009	†	-0.0011	*	-0.0014	**
	-3.7113		-1.4791		-2.2654		-1.9523		-2.3299		-2.8919	
% Occupied units	-0.0163	**	-0.0164	**	-0.0167	**	-0.0151	**	-0.0159	**	-0.0167	**
	-17.5465		-17.7150		-17.9926		-16.3702		-17.1762		-18.0257	
% Age 15-29	0.0123	**	0.0107	**	0.0096	**	0.0091	**	0.0103	**	0.0105	**
	14.5021		12.6080		11.4102		10.7639		12.2360		12.4347	
Intercept	-3.3104	**	-3.3254	**	-2.8494	**	-3.4249	**	-3.6715	**	-2.2785	**
	-19.2944		-19.2527		-16.2291		-19.9528		-21.3771		-12.8999	
N	326296		326296		326297		326412		326412		326296	
Pseudo R-sq	0.1170		0.1138		0.1142		0.1141		0.1139		0.1189	

*** $p < .01$(two-tail test), * $p < .05$ (two-tail test), † $p < .05$ (one-tail test)*

T-values below coefficient estimates.

City fixed effects are included but not reported in the tables

Table 5.4. Interaction Models (Violent Crime)

Violent Crime	Highway		River		Park		City		LU diff.	
Boundaries	-0.1955	**	-0.0226	†	-0.2507	**	-0.1889	**	0.9143	**
	-8.6031		-1.9348		-9.7411		-9.2801		8.2363	
Boundaries (sq)	0.0277	**	0.0014		-0.0024		0.0378	**	-0.5456	*
	4.3748		1.0056		-0.2814		7.3356		-2.3169	
Boundaries (cu)	-0.0017	**	0.0000		0.0006		-0.0023	**	0.1278	
	-3.5702		-0.7928		1.1623		-6.5850		1.0195	
Boundaries (1/0)	0.5585	**	-0.2228	*	-0.0132		0.0405			
	14.4921		-2.4801		-0.4382		1.3639			
*Concentrated disadvantage	0.0093	**	0.0013		0.0137	**	0.0132	**	0.0301	**
	4.3315		1.1045		4.9579		6.5149		2.6748	
*Concentrated disadvantage (sq)	-0.0009		0.0003	*	-0.0014		-0.0034	**	-0.1147	**
	-1.5757		2.2589		-1.4033		-6.4780		-4.8529	
*Concentrated disadvantage (cu)	0.0001		0.0000	**	0.0000		0.0002	**	0.0577	**
	1.4945		-3.9539		0.6723		5.2334		4.6115	
Boundaries (1/0) interaction	-0.0128	**	-0.0036		0.0158	**	-0.0073	*		
	-3.3957		-0.3093		5.1066		-2.3048			
Concentrated disadvantage	-0.0065	**	-0.0009	**	-0.0069	**	-0.0014		0.0105	**
	2.7695		2.8421		3.0785		0.6293		6.0644	
Intercept	-3.1921	**	-3.3135	**	-2.3336	**	-3.2814	**	-3.7255	**
	-11.0137		-11.3496		-7.8534		-11.3229		-12.8659	
N	326296		326296		326297		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Table 5.5. Interaction Models (Property Crime)

Property Crime	Highway		River		Park		City		LU diff.	
Boundaries	-0.2590	**	-0.0966	**	-0.0596	**	-0.1933	**	-0.1432	*
	-23.0593		-15.2742		-4.8597		-18.3285		-2.2816	
Boundaries (sq)	0.0301	**	0.0098	**	-0.0145	**	0.0360	**	0.8273	**
	10.1902		12.1067		-4.0087		13.5900		5.9375	
Boundaries (cu)	-0.0013	**	-0.0003	**	0.0006	**	-0.0019	**	-0.4213	**
	-6.5205		-9.5429		3.3608		-10.9931		-5.4739	
Boundaries (1/0)	0.3554	**	-0.1698	**	-0.0975	**	0.0706	**		
	14.2782		-3.9604		-5.6698		4.0678			
*Concentrated disadvantage	0.0057	**	-0.0011		0.0098	**	0.0064	**	0.0143	*
	4.8235		-1.5868		6.9784		5.3645		2.0760	
*Concentrated disadvantage (sq)	0.0002		0.0004	**	0.0007		-0.0021	**	-0.0321	*
	0.5430		4.9899		1.5356		-6.7482		-2.1066	
*Concentrated disadvantage (cu)	0.0000		0.0000	**	-0.0001	**	0.0001	**	0.0122	
	-1.0448		-6.2225		-2.9509		6.3365		1.4600	
Boundaries (1/0) interaction	0.0054	*	-0.0107	†	0.0090	**	-0.0040	*		
	2.0487		-1.8723		4.8490		-2.0335			
Concentrated disadvantage	-0.0114	**	-0.0048	**	-0.0109	**	-0.0019		-0.0000	
	8.2315		2.8495		8.4059		1.4062		0.0016	
Intercept	-3.2174	**	-3.3403	**	-2.8668	**	-3.4113	**	-3.6748	**
	-18.7439		-19.3074		-16.2591		-19.8689		-21.3902	
N	326296		326296		326297		326412		326412	

*** p < .01(two-tail test), * p < .05 (two-tail test), † p < .05 (one-tail test)*

T-values below coefficient estimates.

City fixed effects and other controls are included but not reported in the tables

Chapter 5 Figures

Figure 5.1. Associations between street segment, residential parcels, and blocks

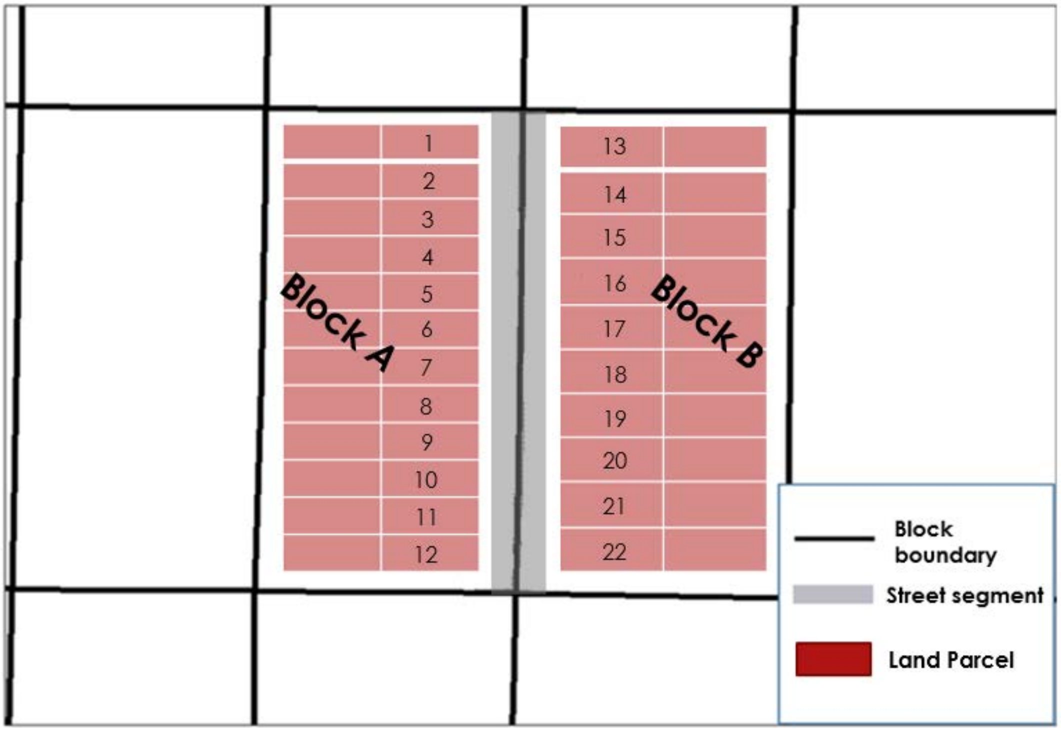


Figure 5.2. Land use difference at the street segment level in Los Angeles

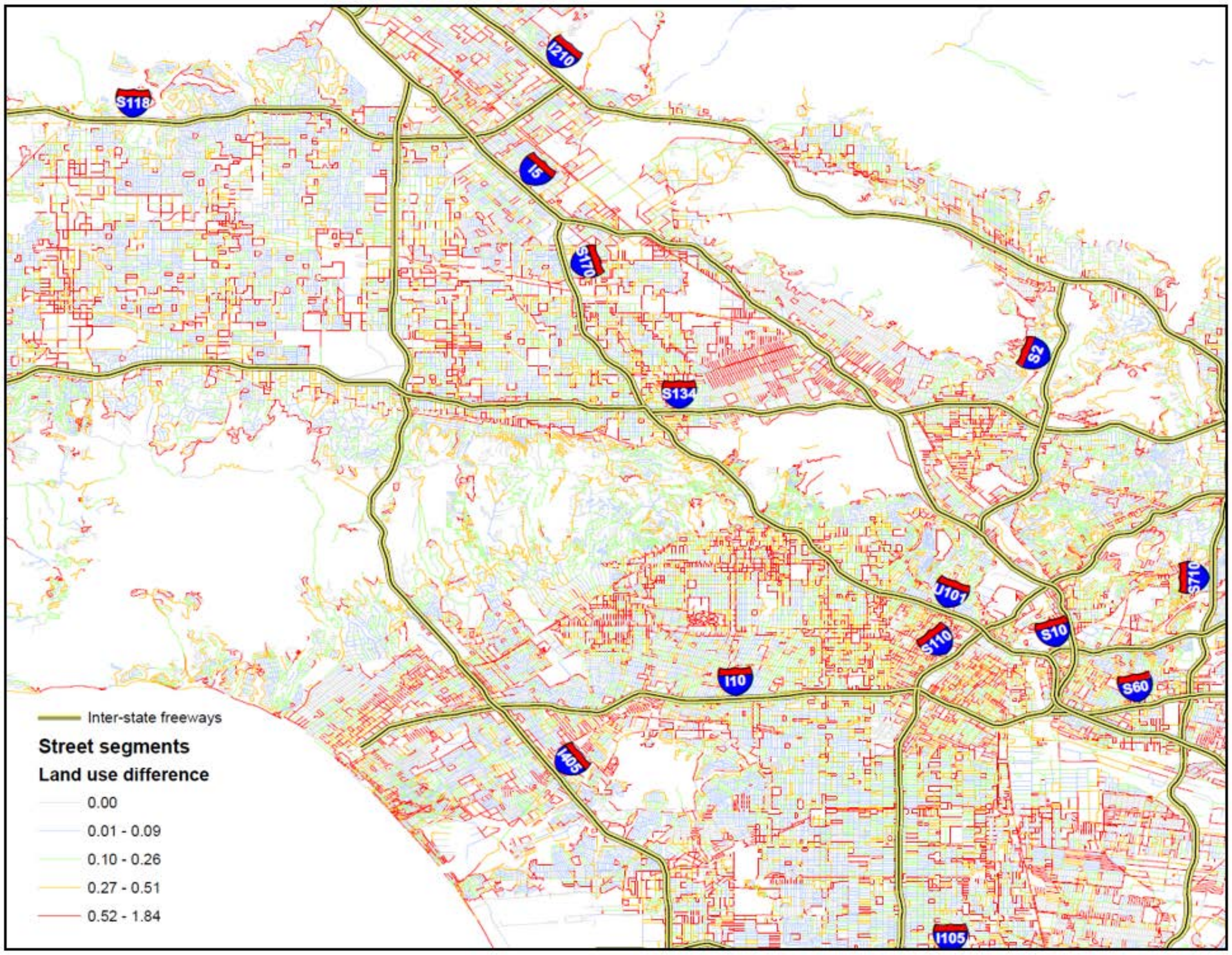


Figure 5.3. Physically Visible Boundaries and Violent Crime in Street Segment

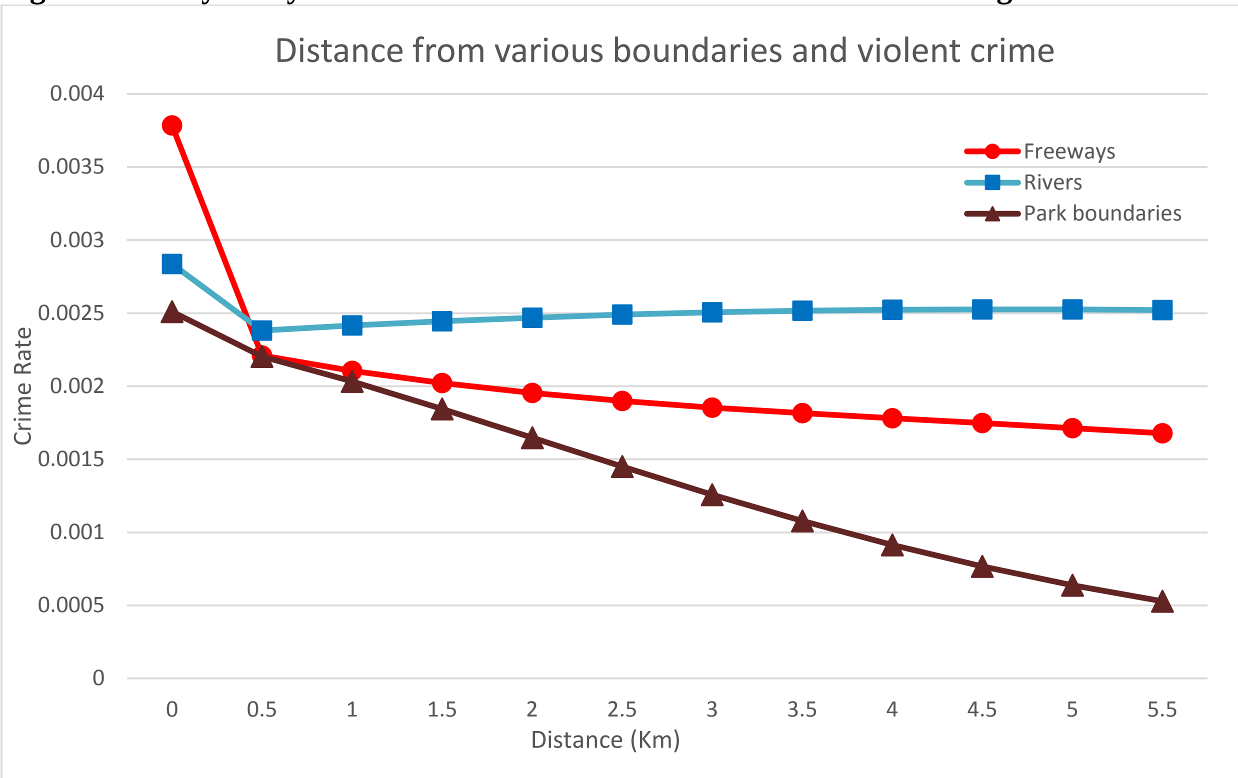


Figure 5.4. Physically Visible Boundaries and Property Crime in Street Segment

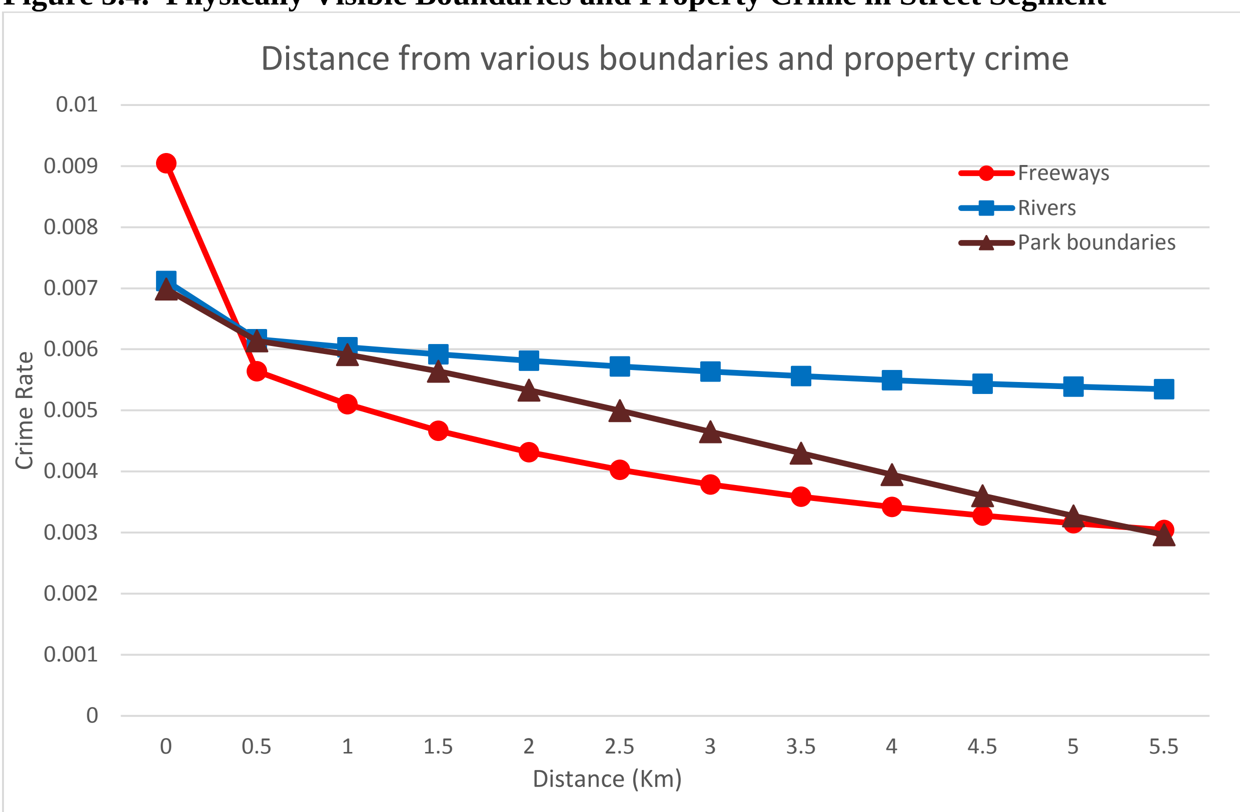


Figure 5.5. City Boundaries and Violent Crime in Street Segment

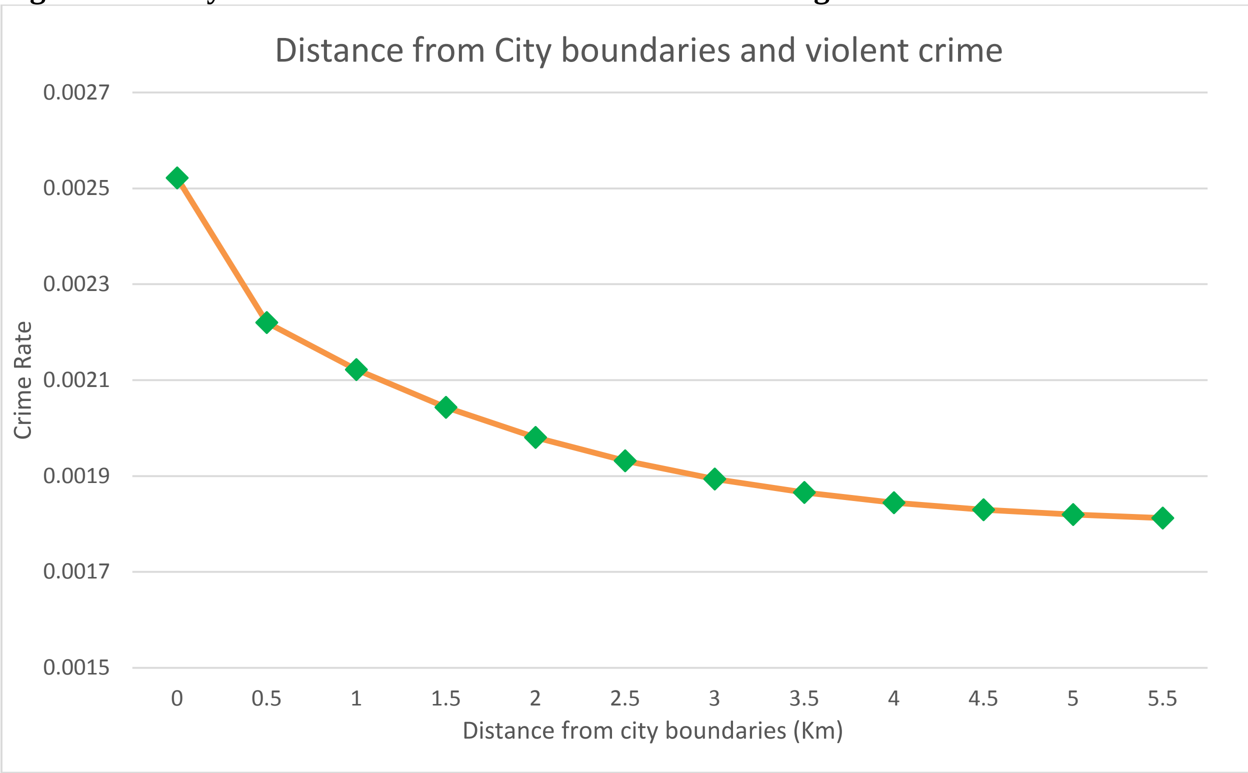


Figure 5.6. City Boundaries and Property Crime in Street Segment

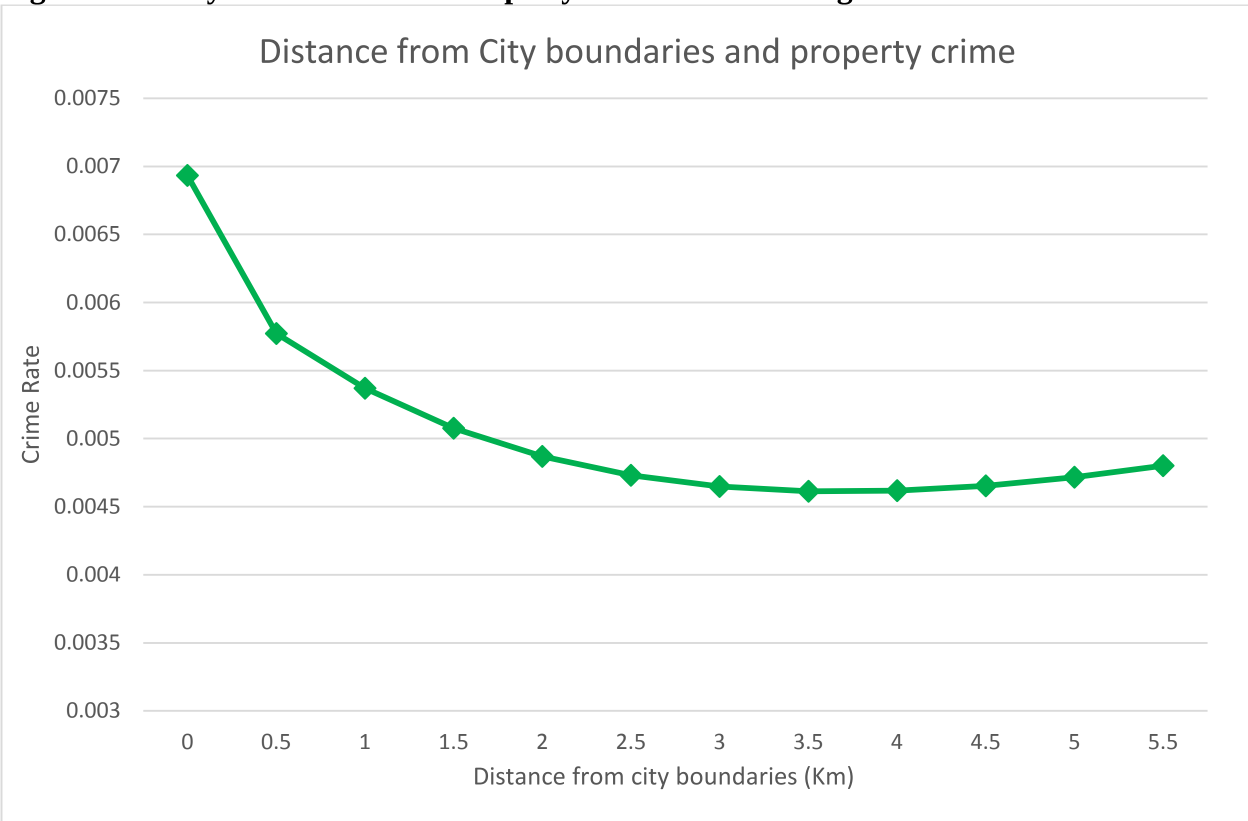


Figure 5.7. Land use difference and Violent Crime in Street Segment

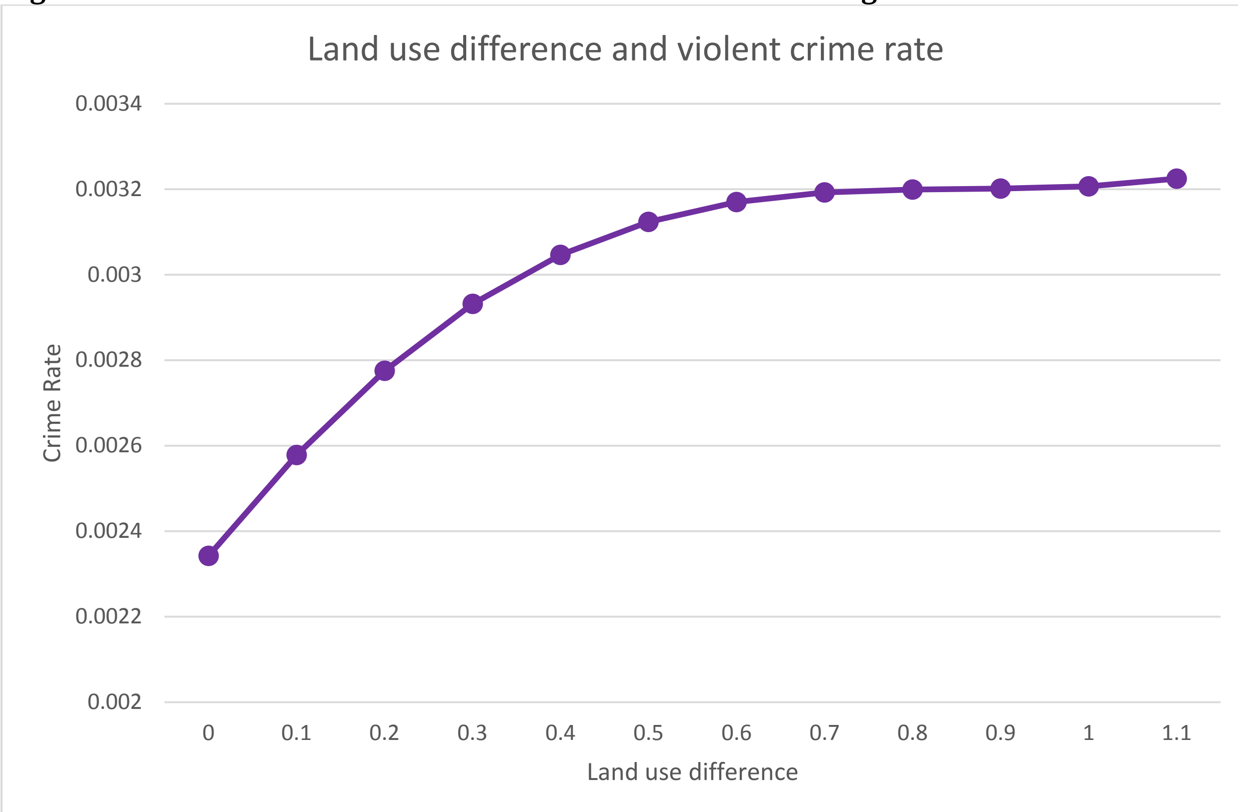


Figure 5.8. Land use difference and Property Crime in Street Segment

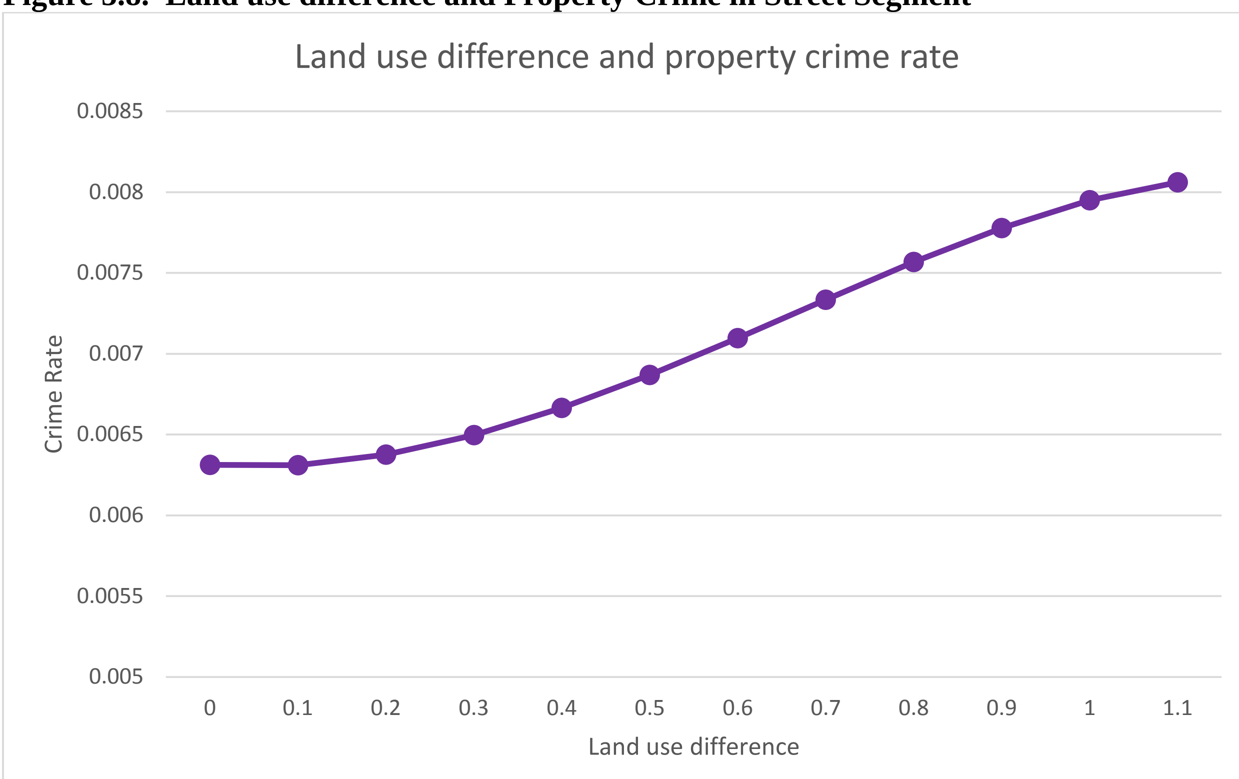


Figure 5.9. Interaction: Highways and Disadvantage (Violent Crime)

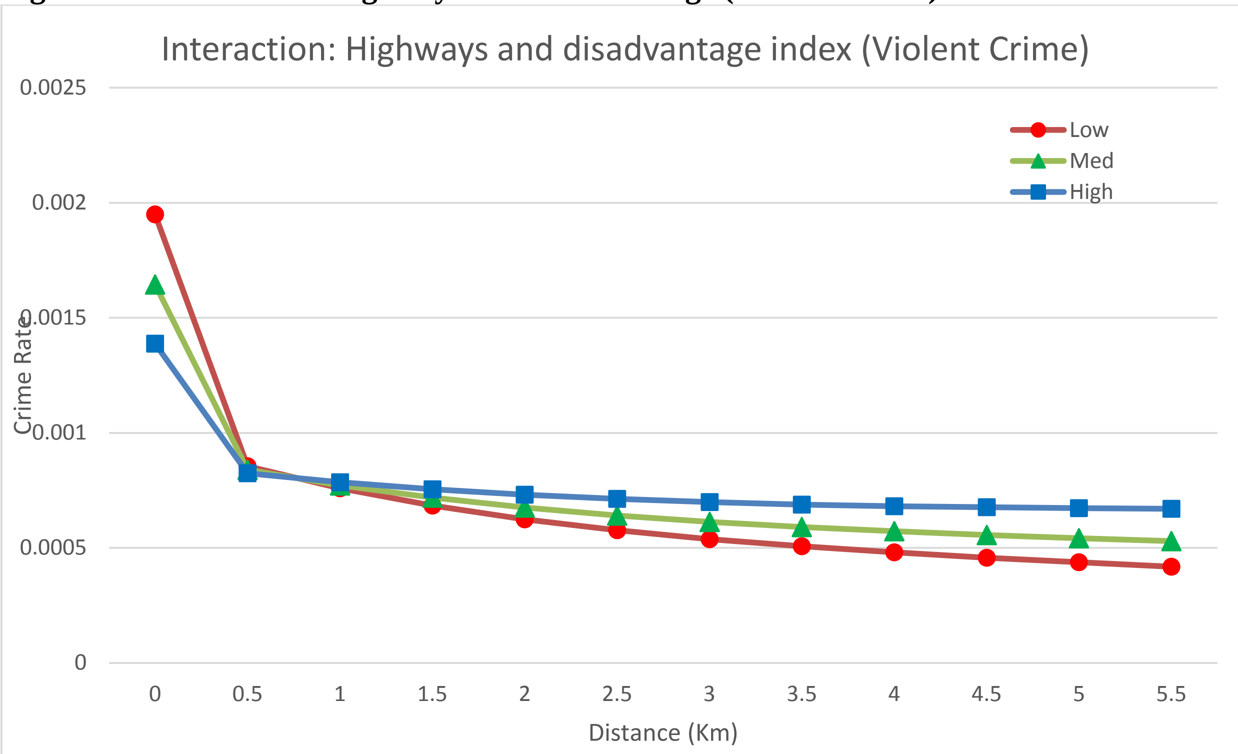


Figure 5.10. Interaction: Highways and Disadvantage (Property Crime)

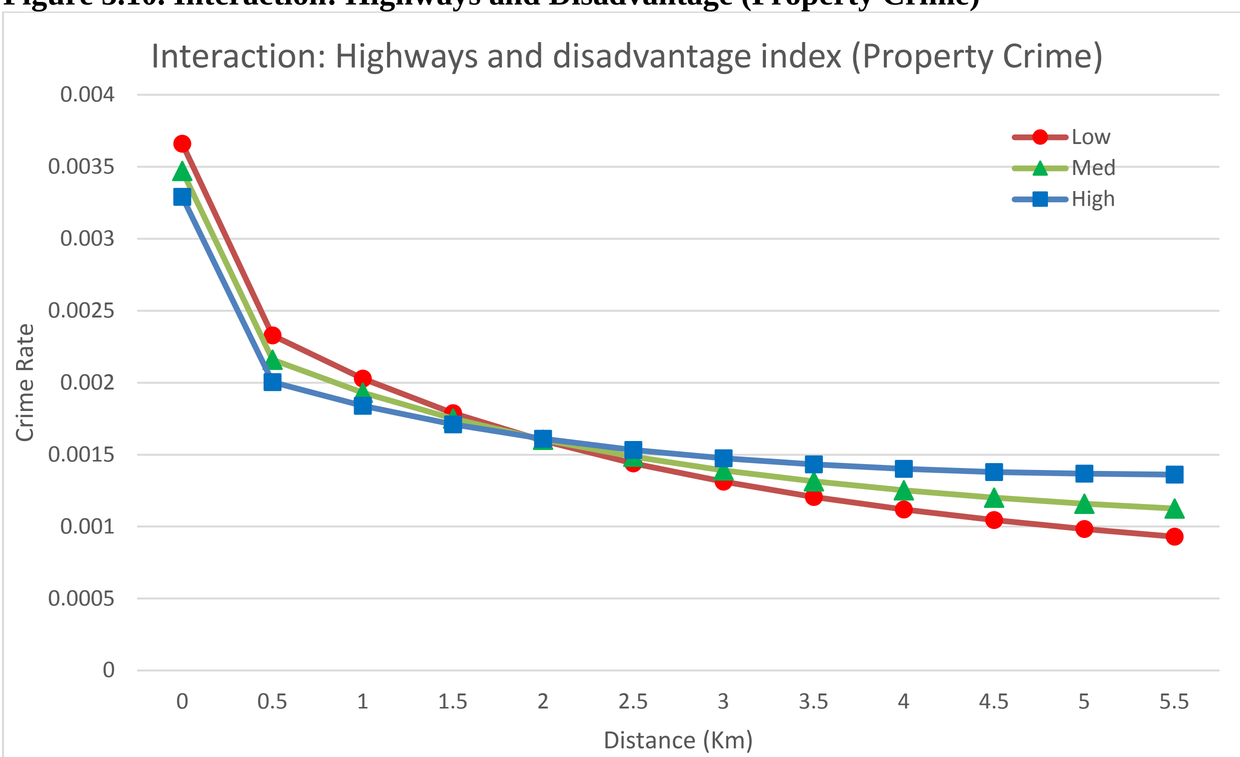


Figure 5.11. Interaction: Park Boundaries and Disadvantage (Violent Crime)

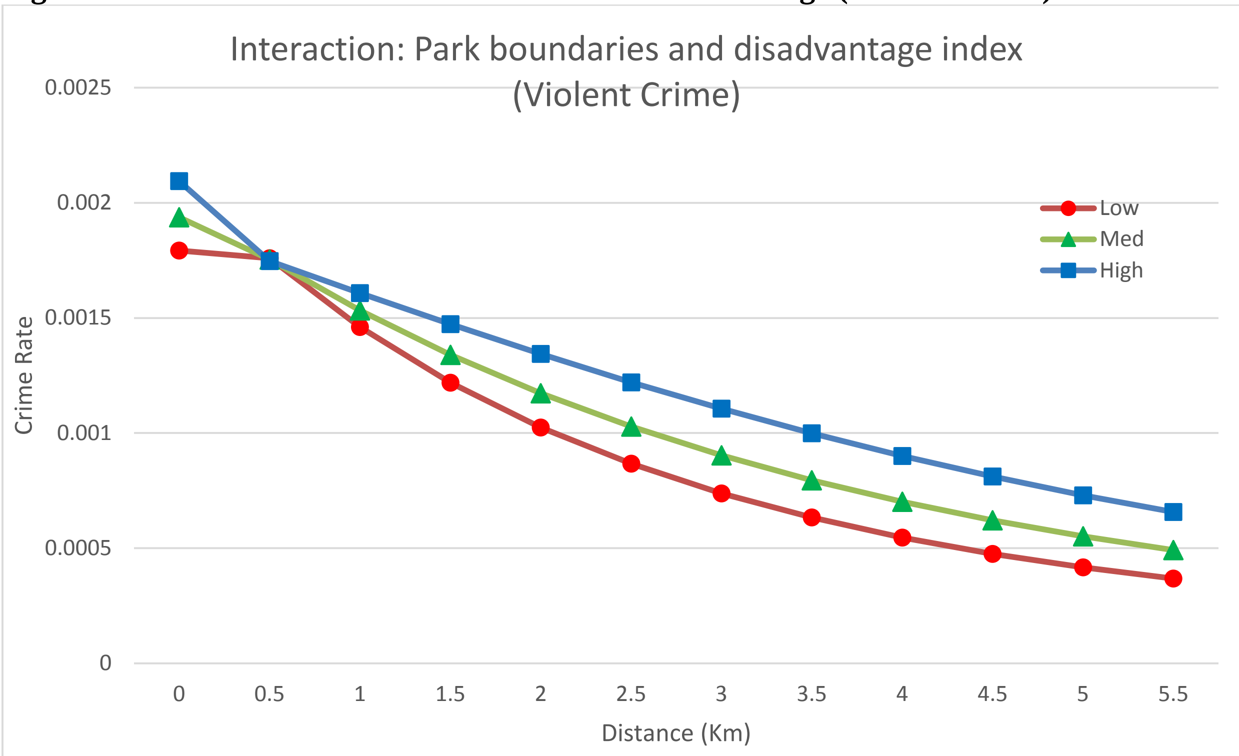


Figure 5.12. Interaction: Park Boundaries and Disadvantage (Property Crime)

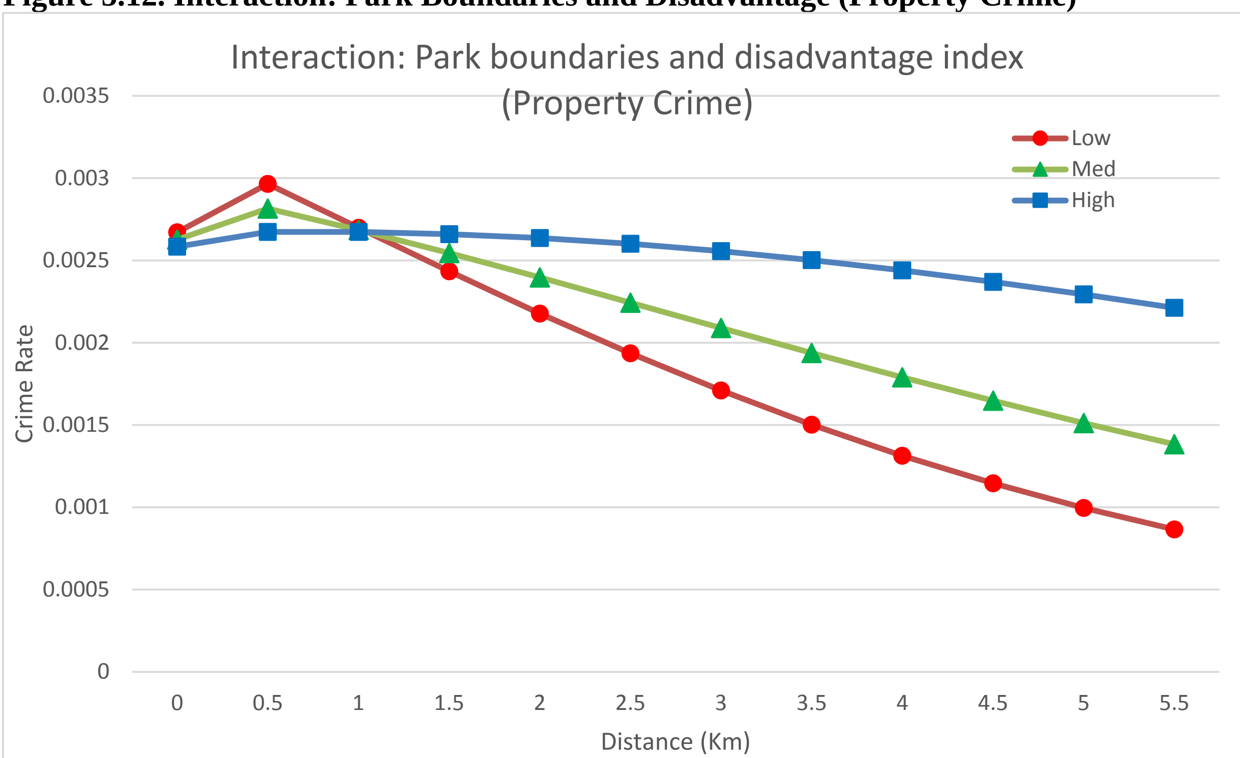


Figure 5.13. Interaction: Rivers and Disadvantage (Violent Crime)

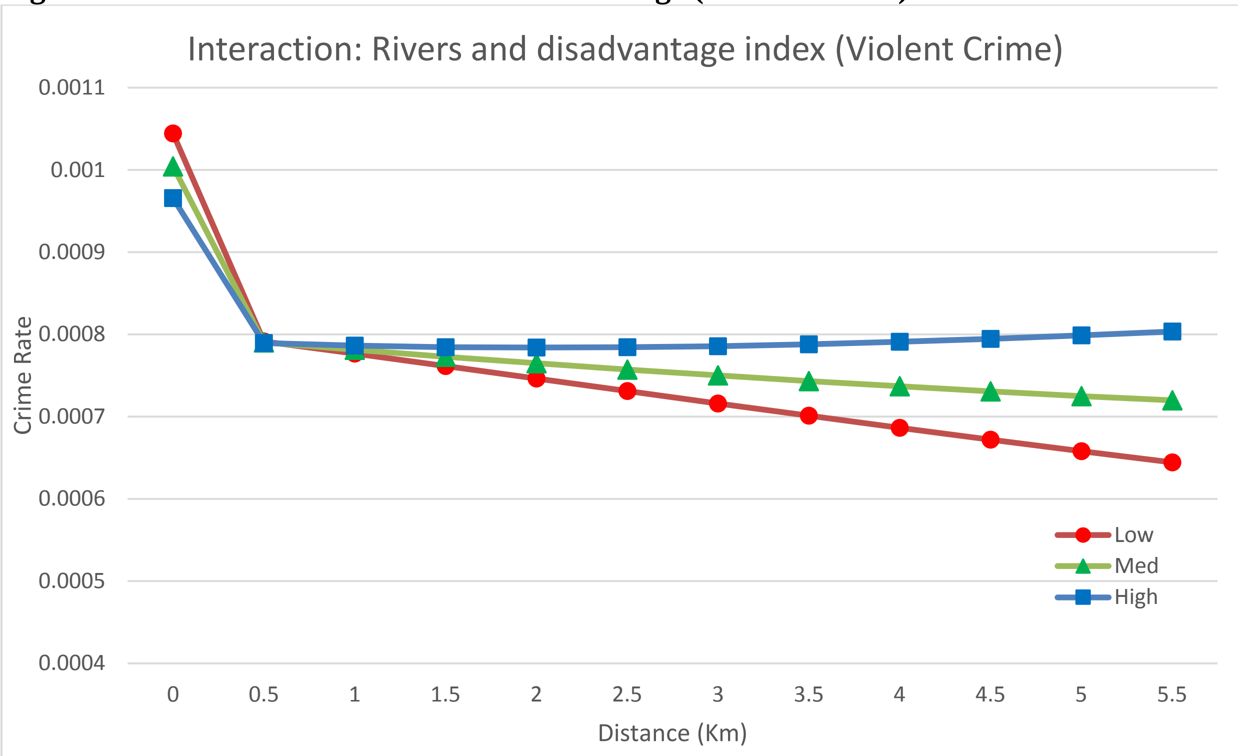


Figure 5.14. Interaction: Rivers and Disadvantage (Property Crime)

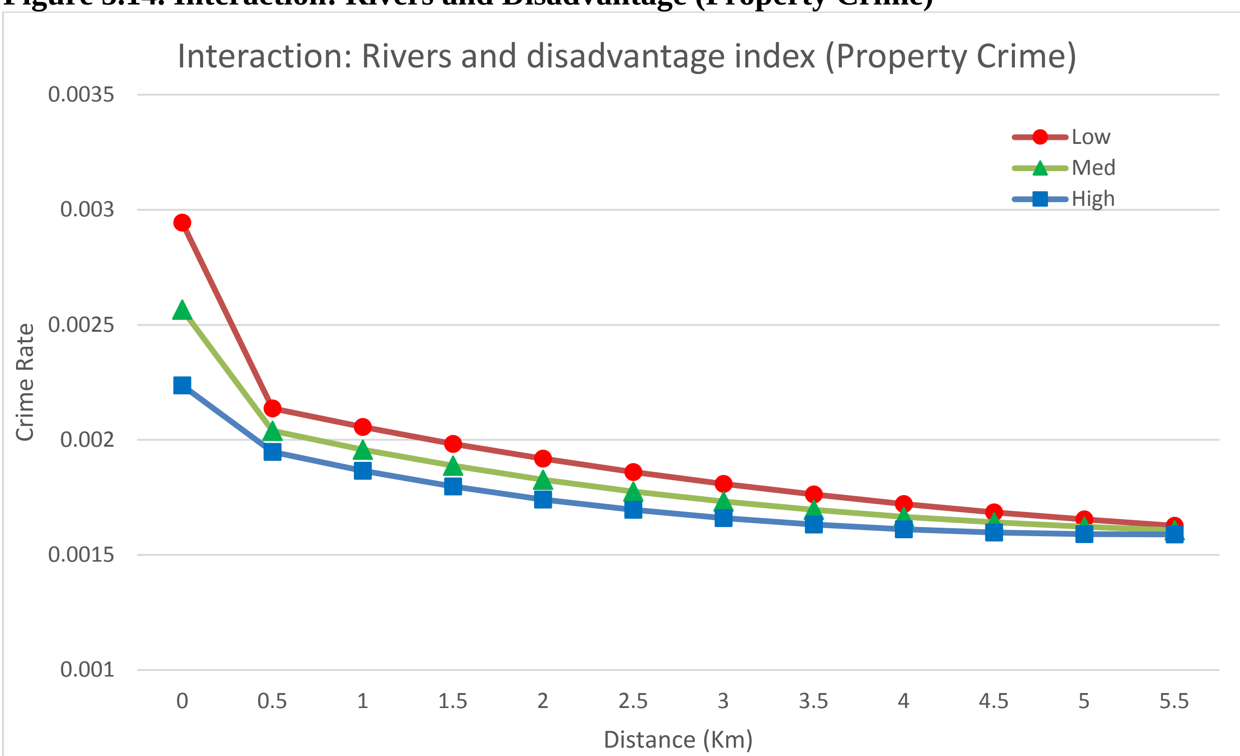


Figure 5.15. Interaction: City Boundaries and Disadvantage (Violent Crime)

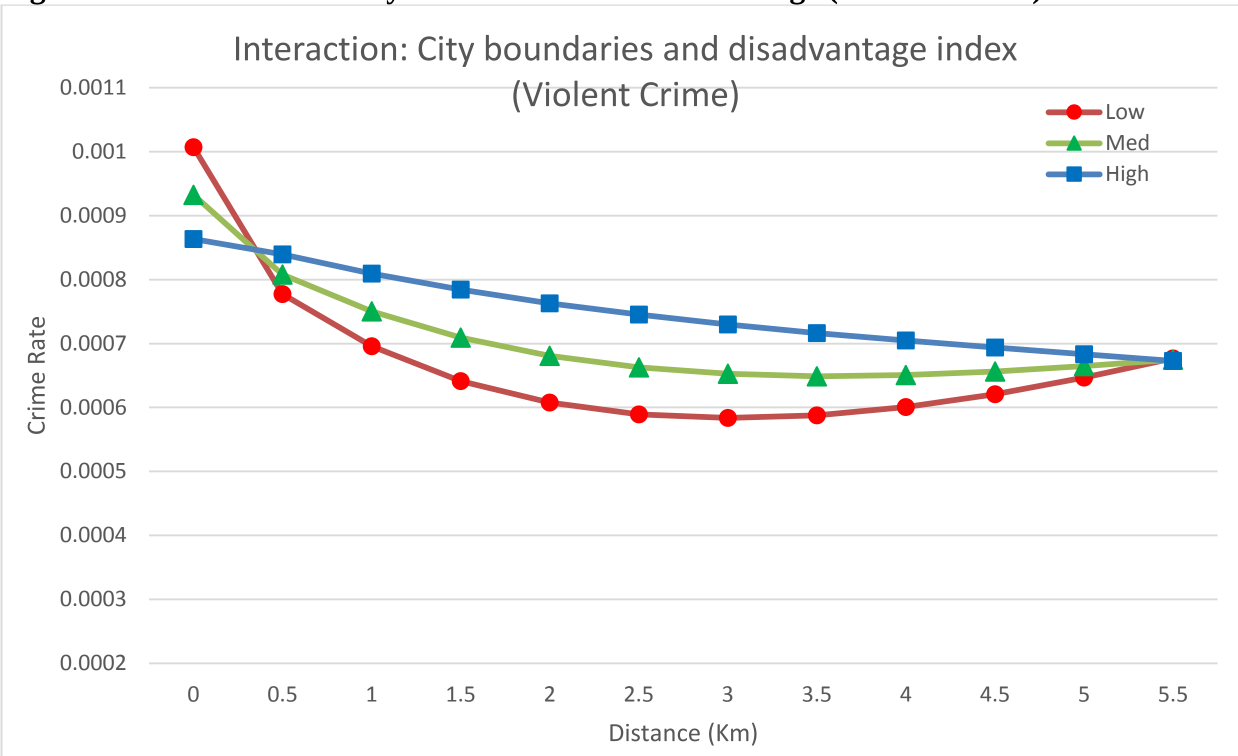


Figure 5.16. Interaction: City Boundaries and Disadvantage (Property Crime)

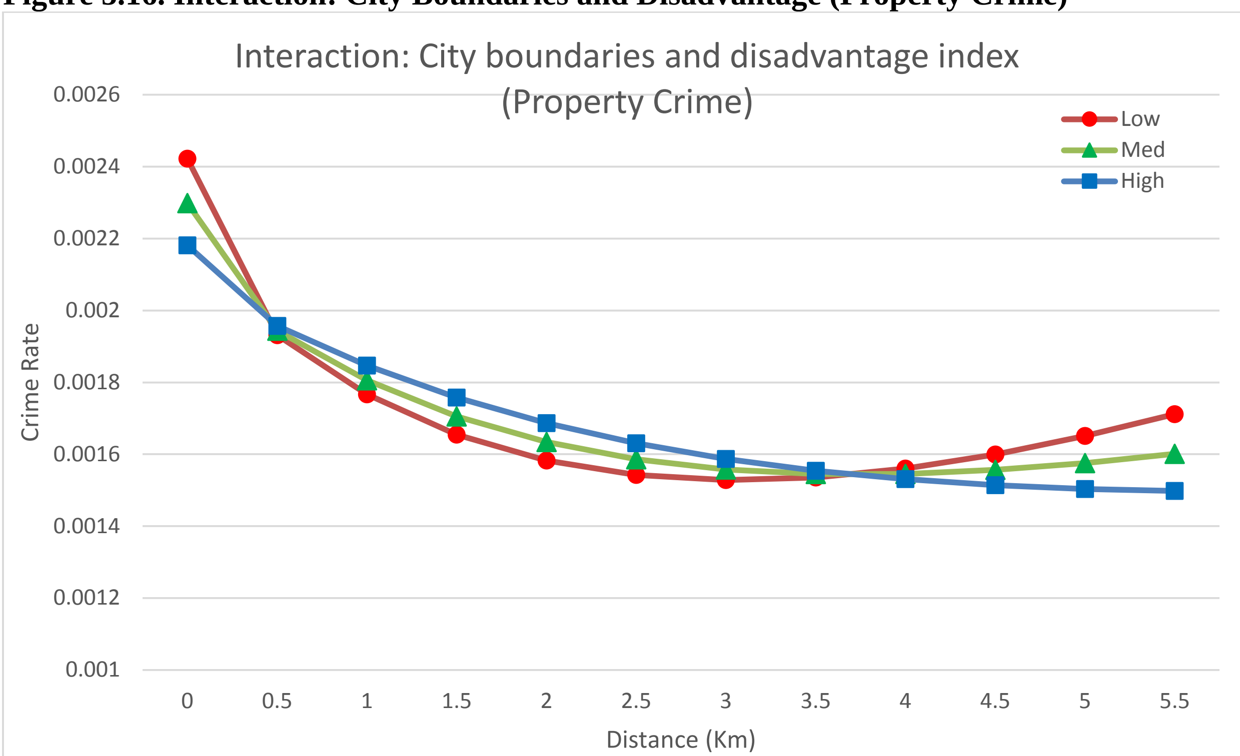


Figure 5.17. Interaction: Land Use Difference and Disadvantage (Violent Crime)

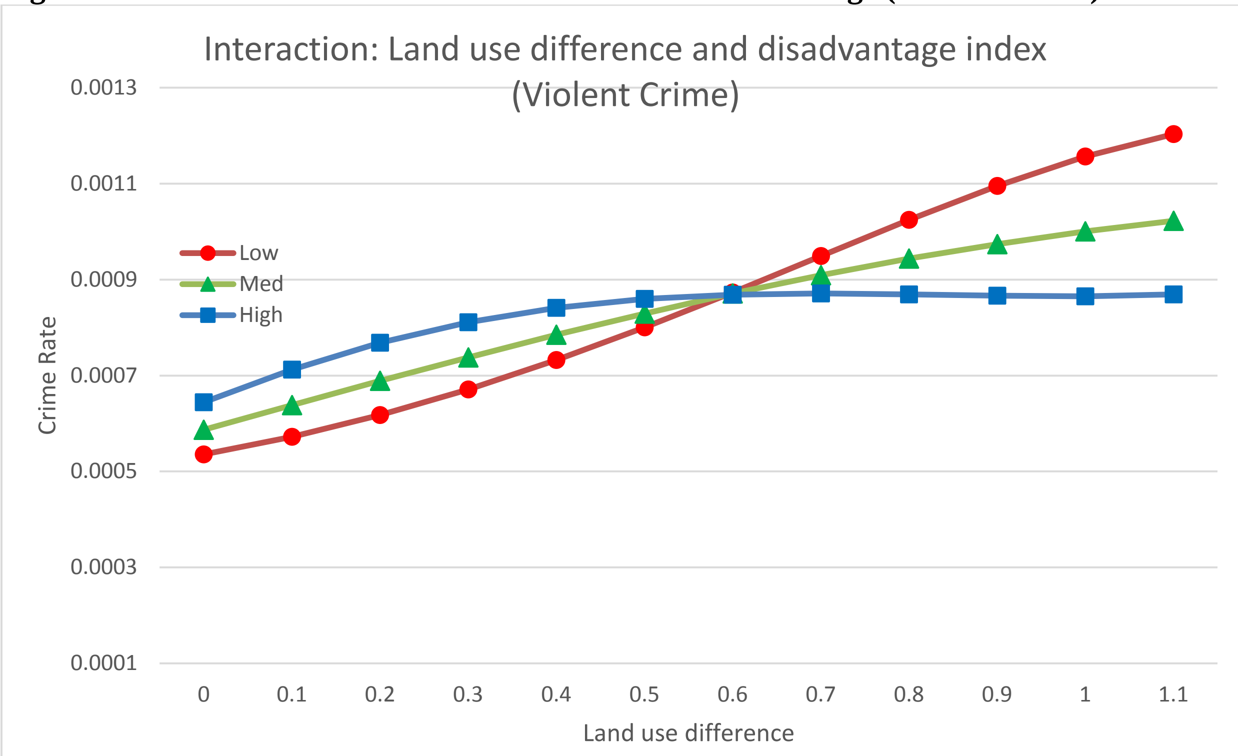
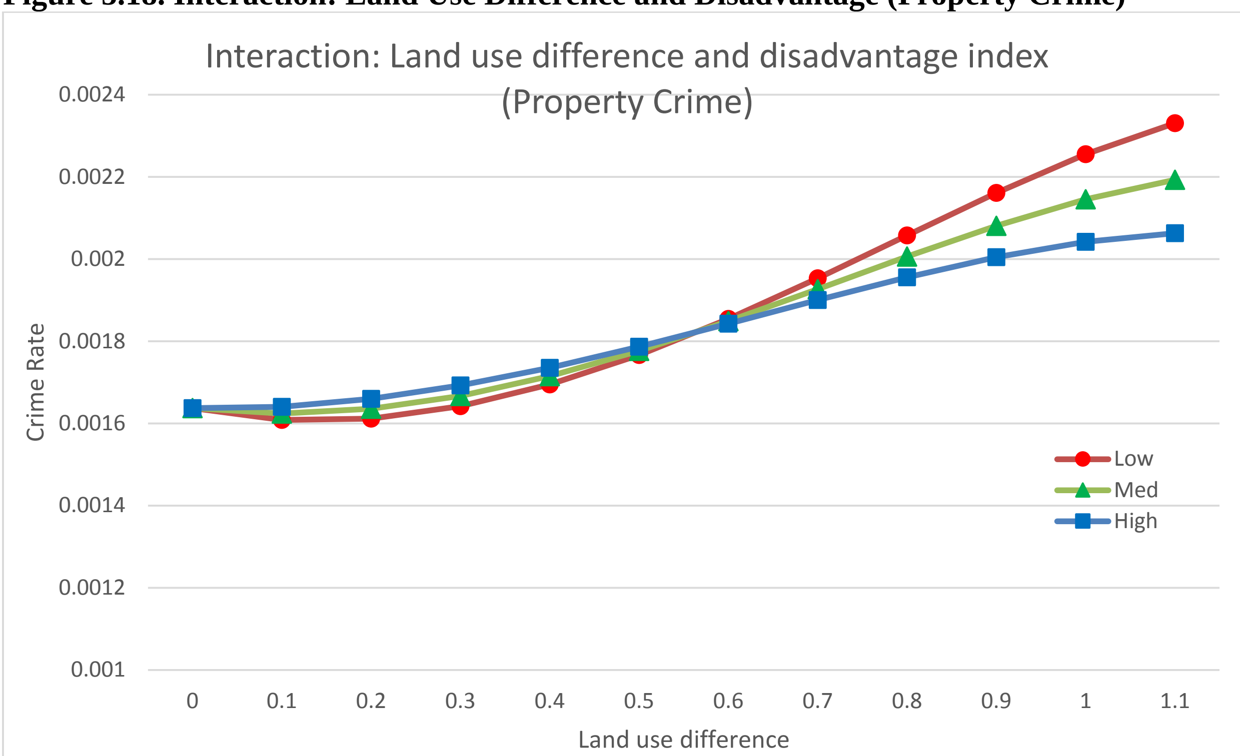


Figure 5.18. Interaction: Land Use Difference and Disadvantage (Property Crime)



CHAPTER 6. DISSERTATION CONCLUSION

A primary aspect of this dissertation centers on the tendency of crime to spatially concentrate within the study area. Scholars have long paid attention to how the level of crime varies across cities or broader areas, and this tendency of crime concentration is repeatedly observed at various geographic levels from census tracts down to street segments. Scholars have observed that the pattern of crime concentration is quit consistent in different regions and over time. A body of studies has recognized the importance of certain aspects of areas that might have direct relevance in explaining why some areas have more crime than others. These aspects include the physical and social environment of the area. Studies examined how social structural characteristics and criminal opportunities provided by physical environments impacted crime in place.

This dissertation flows naturally out of the larger research agenda on how physical and social environments in urban settings dictate the activity patterns of persons; and thus influence spatial crime patterns. Although existing studies successfully theorized and revealed the effects of the physical environment on crime, less attention has been paid to distinguishing the specific characteristics of the physical environment that may be most important for understanding the location of crime. Drawing on the literature on crime pattern theory and the geometry of crime, in this dissertation, I specifically focused on the question of what characteristics of physical environments determine why some areas seem to have more crime, while accounting for the effects of social structural characteristics of place. Thus, the dissertation draws a comprehensive picture of spatial patterns of crime by considering the effects of physical environments and structural characteristics on crime patterns in street segments informed by routine activities theory, crime pattern theory, environmental criminology, and social disorganization theory.

Drawing from a variety of literatures, the first analytic chapter focused on one notion of physical environments – activity nodes. The results suggest that various characteristics of activity nodes where people develop their routine activities need to be considered in understanding spatial patterns of crime. While most prior work focuses on simple land use patterns, the dissertation suggests that other characteristics such as various business types, number of employees, local ownership status, and age of business have consequences for crime patterns in the area. These business characteristics are important because they can largely determine routine activities of people including potential offenders, targets, and guardians, and thus criminal opportunities in place. The dissertation studied the spatial patterns of crime at the street segment level by incorporating more detailed characteristics of businesses in place. In doing so, the dissertation revealed that not only the types of businesses but also other characteristics are important for understanding the association between businesses and crime in place, while accounting for the effect of social environment in street segments.

The second analytic chapter reveals that the physical configurations of street network also particularly strong determinants of spatial crime patterns. As shown and discussed, street segments with more potential passers-by along the street network have higher risk of crime in general but the pattern turns to be crime-reducing after certain threshold. This is consistent with Jane Jacobs' proposition that eyes on the street may function as natural surveillance as it reaches *sufficiently enough number*. Otherwise, passers-by initially increase criminal opportunities in place as there would be more inflow of people coming in-and-out, which increase the probability of the convergence of potential offenders and targets at the same time and place. Street network configurations are important because the type and number of people visiting a given area are largely contingent on the physical configurations of pathways along which they move in a city.

Although previous research utilized and applied the theoretical and methodological concepts of centrality to study spatial patterns of crime, the dissertation refined these measures by incorporating residential and non-residential business characteristics in where people are from and where they go when they travel within a given area. This is an important improvement because travel patterns and physical pathways that potential offenders and targets might take can be largely affected by the characteristics of the origins and destinations of their travels. Therefore, by taking into account the characteristics of where people are from and go via the street network, the dissertation attempted to more accurately capture the potential amount of people passing by a given street segment based on physical configuration of the street network, and how it affects the level of crime in place. Moreover, unlike previous studies, the current project takes into consideration the social structural characteristics of street segment, and empirically tests how the effect of passers-by can vary at different levels of the socioeconomic status of place.

Finally, the last analytic chapter of the dissertation looked at the relationship between spatial boundaries in urban setting and the risk of crime in street segments. Areas near the boundaries were shown to be at higher risk of violent and property crime with a distance decay pattern as they move further away from the boundaries. In addition, one unique measurement included in the dissertation was the land use difference between the two sides of a street segment. I employed this measure because land use difference can be a cognitive barrier that people perceive it as a spatial boundary. As presented, street segments with higher land use difference would have higher risk of violent and property crime.

The findings of the dissertation suggest that arguably the spatial characteristics of physical environments represent the potential for processes of crime in place as much as social demographic data (e.g., Census data). This suggests that physical environments are as equally important as social structural characteristics for understanding the patterns of crime in place. Additionally, the dissertation reveals that social environment may moderate the effects of activity nodes, pathways, and edges on crime. Therefore, the findings imply a need for studies to move beyond a dichotomy of dividing the structural characteristics or criminal opportunities from physical environment, but more explicitly incorporate both types of environments together when studying spatial patterns of crime.

A next step in research of physical and social environments, and crime in place is, to more explicitly theorize distinction between different regional contexts. The study area of the dissertation was the Sothern California region. However, I have little specific theoretical guidance in this area because the criminological theories employed are not city or region specific. It is not clear the findings are generalizable to other study area contexts or whether some cities might be different in the spatial patterns of crime pertaining to the physical and social environments. There might be different spatial patterns of crime by cities, the states, and the regions in which the physical and social environments are embedded in.

One limitation of the dissertation is that it is designed as cross-sectional. A challenge with studying the relationships between structural characteristics and crime is the possibility of endogeneity. In other words, it is likely that the structural characteristics and physical environment of the present can be affected by spatial crime pattern of the past. Indeed, Hipp (2010) found that neighborhoods with more crime are likely to experience changing structural characteristics (i.e., increasing levels of residential instability, concentrated disadvantage, a diminishing retail environment, and more African Americans) ten years later. If this reciprocal relationship is true, an implication is that a cross-sectional design may actually find how crime affects physical and social environments rather than the reverse.

Another study limitation is that there is no empirical evidence that physical and social environmental factors employed in the dissertation have a high correspondence with potential offender's movement or behavior patterns or capable guardian's willingness to act prevent crime. That is, it is still unclear through what mechanism the physical and social environments impact individual's routine activity patterns, offender's perception of criminal opportunities, and the level of informal social control in street segments. This direction for future research has the potential to determine whether activity nodes, pathways, edges, and structural characteristics are more valid measures. In doing so, it might elaborate on the distinctions between perceptual and behavioral proxies.

Another limitation regards the measurement of social environment employed in the dissertation. One challenge of constructing the data of structural characteristics is that Census data are not available at geographic units smaller than Census block. To address this, I employed an imputation method to apportion the Census block level data to adjacent street segments developed by Kim (2016). Although Kim (2016) demonstrated the effectiveness of this imputation method, and I suspect that more sophisticated imputation techniques may not make a substantial difference, it would be ideal to actually have segment-level social environment data.

Finally, the dissertation used aggregated types of crime measures (e.g., violent and property crime). Yet, it is possible that the effects of social and physical environments might be stronger (or weaker) depending on the type of individual offense. For instance, there is a variety of spatial and temporal contexts for an occurrence of robbery. Also, the routine activities associated with robbery are different from those for other types of violent crime. Likewise, routine activity patterns for criminal opportunities for larceny and motor vehicle thefts are expected to be quite distinct (Felson & Boba 2010). However, the dissertation and most criminological research essentially treats all of these crimes as being equivalent by including them all in one violent or property crime variable. Although I have no specific motivation for distinguishing violent and property crime types into more specific offense categories in this dissertation, it seems plausible to employ more precise measures distinguishing specific Part I crime offense types (e.g., homicide, robbery, aggravated assault, burglary, larceny, and motor vehicle theft), which may unpack further the relationship between physical and social environments, and the risk of crime in place.

The findings of the dissertation have implications for public policy as law enforcement should consider hotspot policing (Braga, 2005; Braga, Kennedy, Waring, & Piehl, 2001; Sherman & Weisburd, 1995; Weisburd & Green, 1995). The dissertation is generally about identifying where the so-called crime hotspots are in the Southern California region and what social and physical characteristics of place may bring about the tendency of crime concentration in those street segments. Since the measures of the physical and social environment are shown to affect crime, it is reasonable to expect that crime will cluster at certain street segments as well as the surrounding areas. Therefore, law enforcement may want to consider increasing the number of patrol officers and the level of surveillance specifically targeting these places in order to reduce crime.

In closing, the dissertation suggests that along with social structural characteristics, physical environment conceptualized as activity nodes, pathways, and edges is fundamental to studying spatial crime patterns. The risk of crime in place is not equally situated in space but different by physical and social environments of the area. The findings of the dissertation might be useful in predictive hotspot policing. All in all, the dissertation suggests that physical and social attributes of place are essential to understanding spatial patterns of crime.

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APPENDIX

Table A3.1. Categories of 10 Consumer Facing Businesses

Code	Description	Name in Data	10 groups
1	Movie Theaters	movietheaters	Amenity
	Recreational Facilities and Instruction	recreational	Amenity
2	Beer, Wine, and Liquor Stores	alcohol	Drink
	Drinking Places (Alcoholic Beverages)	drinking	Drink
3	Deposit-taking Institutions	deptakinst	Finance
	Personal Financial	personalfinance	Finance
4	Healthcare Provider Offices	hlthprovoffice	Health
	Hospitals	hospital	Health
	Medical Laboratories	medlabs	Health
5	Religious Organizations	religious	Orgs
	Social Service Organizations	socialservorgs	Orgs
6	Full-Service Restaurants	fullrestaurant	Restaurant
	Limited-Service Food and Beverage	limtrestaurant	Restaurant
7	Apparel Retailing	appretail	Retail
	General Merchandise Retailing	genmerchretail	Retail
	Home Products Retailing	homeprodretail	Retail
	Personal Products Retailing	personprodretail	Retail
	Specialty Retailing	specialretail	Retail
8	Elementary and Secondary Schools	elemsecschool	School
	Other Learning	otherlearning	School
9	Auto Services	autoserv	Service
	Child Care Services	childcare	Service
	Gas Stations	gasstation	Service
	Laundry	laundry	Service
	Hair Care Services	haircare	Service
	Other Personal Services	otherpersonalser	Service
	Repair Services	repairserv	Service
10	Convenience Stores	convstore	Store
	Drug Stores	drugstore	Store
	Groceries	groceries	Store
	Specialty Food	specialfood	Store

Cluster Name: **Amenity**
Cluster Code: **1**

Number of Industries	5

NAICS	NAICS Name	Description
611620	Sports and Recreation Instruction	This industry comprises establishments, such as camps and schools, primarily engaged in offering instruction in athletic activities to groups of individuals. Overnight and day sports instruction camps are included in this industry. Camps, sports instruction; Professional sports instructors (i.e., not participating in sporting events); Cheerleading instruction; Riding instruction academies or schools; Gymnastics instruction; Sports (e.g., baseball, basketball, football, golf) instruction; Martial arts instruction, camps or schools; Swimming instruction
713910	Golf Courses and Country Clubs	This industry comprises (1) establishments primarily engaged in operating golf courses (except miniature) and (2) establishments primarily engaged in operating golf courses, along with dining facilities and other recreational facilities that are known as country clubs. These establishments often provide food and beverage services, equipment rental services, and golf instruction services.
713940	Fitness and Recreational Sports Centers	This industry comprises establishments primarily engaged in operating fitness and recreational sports facilities featuring exercise and other active physical fitness conditioning or recreational sports activities, such as swimming, skating, or racquet sports.
713950	Bowling Centers	This industry comprises establishments engaged in operating bowling centers. These establishments often provide food and beverage services.
512131	Motion Picture Theaters (except Drive-Ins)	This U.S. industry comprises establishments primarily engaged in operating motion picture theaters (except drive-ins) and/or exhibiting motion pictures or videos at film festivals, and so forth.

Cluster Name: **Drink**
Cluster Code: **2**

Number of Industries	2	
NAICS	**NAICS Name**	**Description**
722410	Drinking Places (Alcoholic Beverages)	This industry comprises establishments known as bars, taverns, nightclubs, or drinking places primarily engaged in preparing and serving alcoholic beverages for immediate consumption. These establishments may also provide limited food services.
445310	Beer, Wine, and Liquor Stores	This industry comprises establishments primarily engaged in retailing packaged alcoholic beverages, such as ale, beer, wine, and liquor.

Cluster Name: **Finance**
Cluster Code: **3**

Number of Industries 4

NAICS	NAICS Name	Description
522110	Commercial Banking	This industry comprises establishments primarily engaged in accepting demand and other deposits and making commercial, industrial, and consumer loans. Commercial banks and branches of foreign banks are included in this industry.
522130	Credit Unions	This industry comprises establishments primarily engaged in accepting members' share deposits in cooperatives that are organized to offer consumer loans to their members.
524210	Insurance Agencies and Brokerages	This industry comprises establishments primarily engaged in acting as agents (i.e., brokers) in selling annuities and insurance policies.
541213	Tax Preparation Services	This U.S. industry comprises establishments (except offices of CPAs) engaged in providing tax return preparation services without also providing accounting, bookkeeping, billing, or payroll processing services. Basic knowledge of tax law and filing requirements is required.

Cluster Name: Health
Cluster Code: 4

Number of Industries 23

NAICS	NAICS Name	Description
621111	Offices of Physicians (except Mental Health Specialists)	This U.S. industry comprises establishments of health practitioners having the degree of M.D. (Doctor of Medicine) or D.O. (Doctor of Osteopathy) primarily engaged in the independent practice of general or specialized medicine (except psychiatry or psychoanalysis) or surgery. These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621112	Offices of Physicians, Mental Health Specialists	This U.S. industry comprises establishments of health practitioners having the degree of M.D. (Doctor of Medicine) or D.O. (Doctor of Osteopathy) primarily engaged in the independent practice of psychiatry or psychoanalysis. These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621210	Offices of Dentists	This industry comprises establishments of health practitioners having the degree of D.M.D. (Doctor of Dental Medicine), D.D.S. (Doctor of Dental Surgery), or D.D.Sc. (Doctor of Dental Science) primarily engaged in the independent practice of general or specialized dentistry or dental surgery. These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers. They can provide either comprehensive preventive, cosmetic, or emergency care, or specialize in a single field of dentistry.
621310	Offices of Chiropractors	This industry comprises establishments of health practitioners having the degree of D.C. (Doctor of Chiropractic) primarily engaged in the independent practice of chiropractic. These practitioners provide diagnostic and therapeutic treatment of neuromusculoskeletal and related disorders through the manipulation and adjustment of the spinal column and extremities, and operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621320	Offices of Optometrists	This industry comprises establishments of health practitioners having the degree of O.D. (Doctor of Optometry) primarily engaged in the independent practice of optometry. These practitioners examine, diagnose, treat, and manage diseases and disorders of the visual system, the eye and associated structures as well as diagnose related systemic conditions. Offices of optometrists prescribe and/or provide eyeglasses, contact lenses, low vision aids, and vision therapy. They operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers, and may also provide the same services as opticians, such as selling and fitting prescription eyeglasses and contact lenses.
621330	Offices of Mental Health Practitioners (except Physicians)	This industry comprises establishments of independent mental health practitioners (except physicians) primarily engaged in (1) the diagnosis and treatment of mental, emotional, and behavioral disorders and/or (2) the diagnosis and treatment of individual or group social dysfunction brought about by such causes as mental illness, alcohol and substance abuse, physical and emotional trauma, or stress. These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621340	Offices of Physical, Occupational and Speech Therapists, and Audiologists	This industry comprises establishments of independent health practitioners primarily engaged in one of the following: (1) providing physical therapy services to patients who have impairments, functional limitations, disabilities, or changes in physical functions and health status resulting from injury, disease or other causes, or who require prevention, wellness or fitness services; (2) planning and administering educational, recreational, and social activities designed to help patients or individuals with disabilities, regain physical or mental functioning or to adapt to their disabilities; and (3) diagnosing and treating speech, language, or hearing problems. These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621391	Offices of Podiatrists	This U.S. industry comprises establishments of health practitioners having the degree of D.P.M. (Doctor of Podiatric Medicine) primarily engaged in the independent practice of podiatry. These practitioners diagnose and treat diseases and deformities of the foot and operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621399	Offices of All Other Miscellaneous Health Practitioners	This U.S. industry comprises establishments of independent health practitioners (except physicians; dentists; chiropractors; optometrists; mental health specialists; physical, occupational, and speech therapists; audiologists; and podiatrists). These practitioners operate private or group practices in their own offices (e.g., centers, clinics) or in the facilities of others, such as hospitals or HMO medical centers.
621410	Family Planning Centers	This industry comprises establishments with medical staff primarily engaged in providing a range of family planning services on an outpatient basis, such as contraceptive services, genetic and prenatal counseling, voluntary sterilization, and therapeutic and medically induced termination of pregnancy. Birth control clinics; Fertility clinics; Childbirth preparation classes; Pregnancy counseling centers

NAICS	NAICS Name	Description
621420	Outpatient Mental Health and Substance Abuse Centers	This industry comprises establishments with medical staff primarily engaged in providing outpatient services related to the diagnosis and treatment of mental health disorders and alcohol and other substance abuse. These establishments generally treat patients who do not require inpatient treatment. They may provide a counseling staff and information regarding a wide range of mental health and substance abuse issues and/or refer patients to more extensive treatment programs, if necessary.
621491	HMO Medical Centers	This U.S. industry comprises establishments with physicians and other medical staff primarily engaged in providing a range of outpatient medical services to the health maintenance organization (HMO) subscribers with a focus generally on primary health care. These establishments are owned by the HMO. Included in this industry are HMO establishments that both provide health care services and underwrite health and medical insurance policies.
621492	Kidney Dialysis Centers	This U.S. industry comprises establishments with medical staff primarily engaged in providing outpatient kidney or renal dialysis services.
621493	Freestanding Ambulatory Surgical and Emergency Centers	This U.S. industry comprises establishments with physicians and other medical staff primarily engaged in (1) providing surgical services (e.g., orthoscopic and cataract surgery) on an outpatient basis or (2) providing emergency care services (e.g., setting broken bones, treating lacerations, or tending to patients suffering injuries as a result of accidents, trauma, or medical conditions necessitating immediate medical care) on an outpatient basis. Outpatient surgical establishments have specialized facilities, such as operating and recovery rooms, and specialized equipment, such as anesthetic or X-ray equipment.
621498	All Other Outpatient Care Centers	This U.S. industry comprises establishments with medical staff primarily engaged in providing general or specialized outpatient care (except family planning centers, outpatient mental health and substance abuse centers, HMO medical centers, kidney dialysis centers, and freestanding ambulatory surgical and emergency centers). Centers or clinics of health practitioners with different degrees from more than one industry practicing within the same establishment (i.e., Doctor of Medicine and Doctor of Dental Medicine) are included in this industry.
621991	Blood and Organ Banks	This U.S. industry comprises establishments primarily engaged in collecting, storing, and distributing blood and blood products and storing and distributing body organs.
621999	All Other Miscellaneous Ambulatory Health Care Services	This U.S. industry comprises establishments primarily engaged in providing ambulatory health care services (except offices of physicians, dentists, and other health practitioners; outpatient care centers; medical and diagnostic laboratories; home health care providers; ambulances; and blood and organ banks).
622110	General Medical and Surgical Hospitals	This industry comprises establishments known and licensed as general medical and surgical hospitals primarily engaged in providing diagnostic and medical treatment (both surgical and nonsurgical) to inpatients with any of a wide variety of medical conditions. These establishments maintain inpatient beds and provide patients with food services that meet their nutritional requirements. These hospitals have an organized staff of physicians and other medical staff to provide patient care services. These establishments usually provide other services, such as outpatient services, anatomical pathology services, diagnostic X-ray services, clinical laboratory services, operating room services for a variety of procedures, and
622210	Psychiatric and Substance Abuse Hospitals	This industry comprises establishments known and licensed as psychiatric and substance abuse hospitals primarily engaged in providing diagnostic, medical treatment, and monitoring services for inpatients who suffer from mental illness or substance abuse disorders. The treatment often requires an extended stay in the hospital. These establishments maintain inpatient beds and provide patients with food services that meet their nutritional requirements. They have an organized staff of physicians and other medical staff to provide patient care services. Psychiatric, psychological, and social work services are available at the facility. These hospitals usually provide other services, such as outpatient services, clinical laboratory services, diagnostic X-ray services, and electroencephalograph services.
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	This industry consists of establishments known and licensed as specialty hospitals primarily engaged in providing diagnostic and medical treatment to inpatients with a specific type of disease or medical condition (except psychiatric or substance abuse). Hospitals providing long-term care for the chronically ill and hospitals providing rehabilitation, restorative, and adjustive services to physically challenged or disabled people are included in this industry. These establishments maintain inpatient beds and provide patients with food services that meet their nutritional requirements. They have an organized staff of physicians and other medical staff to provide patient care services. These hospitals may provide other services, such as outpatient services, diagnostic X-ray services, clinical laboratory services, operating room services, physical therapy services, educational and vocational services, and psychological and social work services.
339116	Dental Laboratories	This U.S. industry comprises establishments primarily engaged in manufacturing dentures, crowns, bridges, and orthodontic appliances customized for individual application.
621511	Medical Laboratories	This U.S. industry comprises establishments known as medical laboratories primarily engaged in providing analytic or diagnostic services, including body fluid analysis, generally to the medical profession or to the patient on referral from a health practitioner. Blood analysis laboratories; Medical pathology laboratories; Medical bacteriological laboratories; Medical testing laboratories; Medical forensic laboratories

NAICS Name	NAICS	
621512	Diagnostic Imaging Centers	This U.S. industry comprises establishments known as diagnostic imaging centers primarily engaged Tomography (CT-scan) centers; Medical radiological laboratories; Dental or medical X-ray laboratories; Ultrasound imaging centers; Magnetic resonance imaging (MRI) centers

Cluster Name: **Organizations**
Cluster Code: **5**

Number of Industries 15

NAICS	NAICS Name	Description
624110	Child and Youth Services	This industry comprises establishments primarily engaged in providing nonresidential social assistance services for children and youth. These establishments provide for the welfare of children in such areas as adoption and foster care, drug prevention, life skills training, and positive social development. Adoption agencies; Youth centers (except recreational only); Child guidance organizations; Youth self-help organizations; Foster care placement services
624120	Services for the Elderly and Persons with Disabilities	This industry comprises establishments primarily engaged in providing nonresidential social assistance services to improve the quality of life for the elderly, persons diagnosed with intellectual and developmental disabilities, or persons with disabilities. These establishments provide for the welfare of these individuals in such areas as day care, nonmedical home care or homemaker services, social activities, group support, and companionship.
624190	Other Individual and Family Services	This industry comprises establishments primarily engaged in providing nonresidential individual and family social assistance services (except those specifically directed toward children, the elderly, persons diagnosed with intellectual and developmental disabilities, or persons with disabilities). Community action services agencies; Marriage counseling services (except by offices of mental health practitioners); Crisis intervention centers; Multipurpose social services centers; Family social services agencies; Self-help organizations (except for disabled persons, the elderly, persons diagnosed with intellectual and developmental disabilities); Family welfare services; Suicide crisis centers; Hotline centers; Telephone counseling services
624210	Community Food Services	This industry comprises establishments primarily engaged in the collection, preparation, and delivery of food for the needy. Establishments in this industry may also distribute clothing and blankets to the poor. These establishments may prepare and deliver meals to persons who by reason of age, disability, or illness are unable to prepare meals for themselves; collect and distribute salvageable or donated food; or prepare and provide meals at fixed or mobile locations. Food banks, meal delivery programs, and soup kitchens are included in this industry.
624221	Temporary Shelters	This U.S. industry comprises establishments primarily engaged in providing (1) short term emergency shelter for victims of domestic violence, sexual assault, or child abuse and/or (2) temporary residential shelter for homeless individuals or families, runaway youth, and patients and families caught in medical crises. These establishments may operate their own shelters or may subsidize housing using existing homes, apartments, hotels, or motels.
624229	Other Community Housing Services	This U.S. industry comprises establishments primarily engaged in providing one or more of the following community housing services: (1) Transitional housing to low-income individuals and families; (2) volunteer construction or repair of low-cost housing, in partnership with the homeowner who may assist in the construction or repair work; and (3) the repair of homes for elderly or disabled homeowners. These establishments may subsidize housing using existing homes, apartments, hotels, or motels or may require a low-cost mortgage or sweat equity. These establishments may also provide low-income families with furniture and household supplies.

624230	Emergency and Other Relief Services	This industry comprises establishments primarily engaged in providing food, shelter, clothing, medical relief, resettlement, and counseling to victims of domestic or international disasters or conflicts (e.g., wars).
813212	Voluntary Health Organizations	This U.S. industry comprises establishments primarily engaged in raising funds for health related research, such as disease (e.g., heart, cancer, diabetes) prevention, health education, and patient services. Disease awareness fundraising organizations; Health research fundraising organizations; Disease research (e.g., heart, cancer) fundraising organizations; Voluntary health organizations
813219	Other Grantmaking and Giving Services	This U.S. industry comprises establishments (except voluntary health organizations) primarily engaged in raising funds for a wide range of social welfare activities, such as educational, scientific, cultural, and health. Community chests; United fund councils; Federated charities; United funds for colleges
813311	Human Rights Organizations	This U.S. industry comprises establishments primarily engaged in promoting causes associated with human rights either for a broad or specific constituency. Establishments in this industry address issues, such as protecting and promoting the broad constitutional rights and civil liberties of individuals and those suffering from neglect, abuse, or exploitation; promoting the interests of specific groups, such as children, women, senior citizens, or persons with disabilities; improving relations between racial, ethnic, and cultural groups; and promoting voter education and registration. These organizations may solicit contributions and offer memberships to support these causes. Civil liberties organizations; Senior citizens' advocacy organizations; Human rights advocacy organizations; Veterans' rights organizations
813312	Environment, Conservation and Wildlife Organizations	This U.S. industry comprises establishments primarily engaged in promoting the preservation and protection of the environment and wildlife. Establishments in this industry address issues, such as clean air and water; global warming; conserving and developing natural resources, including land, plant, water, and energy resources; and protecting and preserving wildlife and endangered species. These organizations may solicit contributions and offer memberships to support these causes. Animal rights organizations; Natural resource preservation organizations; Conservation advocacy organizations; Wildlife preservation organizations; Humane societies
813319	Other Social Advocacy Organizations	This U.S. industry comprises establishments primarily engaged in social advocacy (except human rights and environmental protection, conservation, and wildlife preservation). Establishments in this industry address issues, such as peace and international understanding; community action (excluding civic organizations); or advancing social causes, such as firearms safety, drunk driving prevention, or drug abuse awareness. These organizations may solicit contributions and offer memberships to support these causes. Community action advocacy organizations; Substance abuse prevention advocacy organizations; Firearms advocacy organizations; Taxpayers' advocacy organizations; Peace advocacy organizations
813410	Civic and Social Organizations	This industry comprises establishments primarily engaged in promoting the civic and social interests of their members. Establishments in this industry may operate bars and restaurants for their members. Alumni associations; Granges; Automobile clubs (except travel); Parent-teacher associations; Booster clubs; Scouting organizations; Ethnic associations; Social clubs; Fraternal lodges; Veterans' membership organizations

813990	Other Similar Organizations (except Business, Professional, Labor, and Political Organizations)	This industry comprises establishments (except religious organizations, social advocacy organizations, civic and social organizations, business associations, professional organizations, labor unions, and political organizations) primarily engaged in promoting the interests of their members. Athletic associations, regulatory or administrative; Property owners' associations; Condominium and homeowners' associations; Tenant associations (except advocacy); Cooperative owners' associations
813110	Religious Organizations	This industry comprises (1) establishments primarily engaged in operating religious organizations, such as churches, religious temples, and monasteries, and/or (2) establishments primarily engaged in administering an organized religion or promoting religious activities. Churches; Shrines, religious; Monasteries (except schools); Synagogues; Mosques, religious; Temples, religious

Cluster Name: **Restaurants**
Cluster Code: **6**

Number of Industries 4

NAICS	NAICS Name	Description
722511	Full-Service Restaurants	This U.S. industry comprises establishments primarily engaged in providing food services to patrons who order and are served while seated (i.e., waiter/waitress service) and pay after eating. These establishments may provide this type of food service to patrons in combination with selling alcoholic beverages, providing carryout services, or presenting live nontheatrical entertainment.
722514	Cafeterias, Grill Buffets, and Buffets	This U.S. industry comprises establishments, known as cafeterias, grill buffets, or buffets, primarily engaged in preparing and serving meals for immediate consumption using cafeteria-style or buffet serving equipment, such as steam tables, refrigerated areas, display grills, and self-service nonalcoholic beverage dispensing equipment. Patrons select from food and drink items on display in a continuous cafeteria line or from buffet stations.
722515	Snack and Nonalcoholic Beverage Bars	This U.S. industry comprises establishments primarily engaged in (1) preparing and/or serving a specialty snack, such as ice cream, frozen yogurt, cookies, or popcorn or (2) serving nonalcoholic beverages, such as coffee, juices, or sodas for consumption on or near the premises. These establishments may carry and sell a combination of snack, nonalcoholic beverage, and other related products (e.g., coffee beans, mugs, coffee makers) but generally promote and sell a unique snack or nonalcoholic beverage. Carryout service doughnut shops with on-premises baking; Carryout service bagel shops with on-premises baking; Carryout service pretzel shops with on-premises baking;Carryout service cookie shops with on-premises baking; Coffee shops, on-premises brewing; Ice cream parlors
722513	Limited-Service Restaurants	This U.S. industry comprises establishments primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where patrons generally order or select items and pay before eating. Food and drink may be consumed on premises, taken out, or delivered to the customer's location. Some establishments in this industry may provide these food services in combination with selling alcoholic beverages. Delicatessen restaurants; Pizza delivery shops; Family restaurants, limited-service; Takeout eating places; Fast-food restaurants; Takeout sandwich shops; Limited-service pizza parlors

Cluster Name: Retail
Cluster Code: 7

Number of Industries 42

NAICS	NAICS Description	Description
448110	Men's Clothing Stores	This industry comprises establishments primarily engaged in retailing a general line of new men's and boys' clothing. These establishments may provide basic alterations, such as hemming, taking in or letting out seams, or lengthening or shortening sleeves.
448120	Women's Clothing Stores	This industry comprises establishments primarily engaged in retailing a general line of new women's, misses' and juniors' clothing, including maternity wear. These establishments may provide basic alterations, such as hemming, taking in or letting out seams, or lengthening or shortening sleeves.
448130	Children's and Infants' Clothing Stores	This industry comprises establishments primarily engaged in retailing a general line of new children's and infants' clothing. These establishments may provide basic alterations, such as hemming, taking in or letting out seams, or lengthening or shortening sleeves.
448140	Family Clothing Stores	This industry comprises establishments primarily engaged in retailing a general line of new clothing for men, women, and children, without specializing in sales for an individual gender or age group. These establishments may provide basic alterations, such as hemming, taking in or letting out seams, or lengthening or shortening sleeves.
448150	Clothing Accessories Stores	This industry comprises establishments primarily engaged in retailing single or combination lines of new clothing accessories, such as hats and caps, costume jewelry, gloves, handbags, ties, wigs, toupees, and belts; Costume jewelry stores, Wig and hairpiece stores, Neckwear stores
448190	Other Clothing Stores	This industry comprises establishments primarily engaged in retailing specialized lines of new clothing (except general lines of men's, women's, children's, infants', and family clothing). These establishments may provide basic alterations, such as hemming, taking in or letting out seams, or lengthening or shortening sleeves. Bridal gown (except custom) shops; Leather coat stores; Costume shops; Lingerie stores; Fur apparel stores; Swimwear stores; Hosiery stores;Uniform (except athletic) stores
448210	Shoe Stores	This industry comprises establishments primarily engaged in retailing all types of new footwear (except hosiery and specialty sports footwear, such as golf shoes, bowling shoes, and spiked shoes). Establishments primarily engaged in retailing new tennis shoes or sneakers are included in this industry.
452111	Department Stores (except Discount Department Stores)	This U.S. industry comprises establishments known as department stores that have separate departments for various merchandise lines, such as apparel, jewelry, home furnishings, and linens, each with separate cash registers and sales associates. Department stores in this industry generally do not have central customer checkout and cash register facilities.
452112	Discount Department Stores	This U.S. industry comprises establishments known as department stores that have central customer checkout areas, generally in the front of the store, and that may have additional cash registers located in one or more individual departments. Department stores in this industry sell a wide range of general merchandise (except fresh, perishable foods).
452910	Warehouse Clubs and Supercenters	This industry comprises establishments known as warehouse clubs, superstores or supercenters primarily engaged in retailing a general line of groceries in combination with general lines of new merchandise, such as apparel, furniture, and appliances.
452990	All Other General Merchandise Stores	This industry comprises establishments primarily engaged in retailing new goods in general merchandise stores (except department stores, discount department stores, warehouse clubs, superstores, and supercenters). These establishments retail a general line of new merchandise, such as apparel, automotive parts, dry goods, hardware, groceries, housewares or home furnishings, and other lines in limited amounts, with none of the lines predominating. Dollar stores; General stores; General merchandise catalog showrooms (except catalog mail-order); General merchandise trading posts; Home and auto supply stores; Variety stores
453310	Used Merchandise Stores	This industry comprises establishments primarily engaged in retailing used merchandise, antiques, and secondhand goods (except motor vehicles, such as automobiles, RVs, motorcycles, and boats; motor vehicle parts; tires; and mobile homes). Antique shops; Used household-type appliance stores; Used book stores; Used merchandise thrift shops; Used clothing stores; Used sporting goods stores

NAICS	NAICS Description	Description
453210	Office Supplies and Stationery Stores	This industry comprises establishments primarily engaged in one or more of the following: (1) retailing new stationery, school supplies, and office supplies; (2) retailing a combination of new office equipment, furniture, and supplies; and (3) retailing new office equipment, furniture, and supplies in combination with selling new computers.
443141	Household Appliance Stores	This U.S. industry comprises establishments known as appliance stores primarily engaged in retailing an array of new household appliances, such as refrigerators, dishwashers, ovens, irons, coffeemakers, hair dryers, electric razors, room air-conditioners, microwave ovens, sewing machines, and vacuum cleaners, or retailing new appliances in combination with appliance repair services.
442110	Furniture Stores	This industry comprises establishments primarily engaged in retailing new furniture, such as household furniture (e.g., baby furniture, box springs, and mattresses) and outdoor furniture; office furniture (except those sold in combination with office supplies and equipment); and/or furniture sold in combination with major appliances, home electronics, home furnishings, or floor coverings.
442210	Floor Covering Stores	This industry comprises establishments primarily engaged in retailing new floor coverings, such as rugs and carpets, vinyl floor coverings, and floor tile (except ceramic or wood only); or retailing new floor coverings in combination with installation and repair services.
442291	Window Treatment Stores	This U.S. industry comprises establishments primarily engaged in retailing new window treatments, such as curtains, drapes, blinds, and shades.
442299	All Other Home Furnishings Stores	This U.S. industry comprises establishments primarily engaged in retailing new home furnishings (except floor coverings, furniture, and window treatments). Bath shops; Kitchenware stores; Chinaware stores; Linen stores; Electric lamp shops; Picture frame stores; Glassware stores; Wood-burning stove stores; Houseware stores
444210	Outdoor Power Equipment Stores	This industry comprises establishments primarily engaged in retailing new outdoor power equipment or retailing new outdoor power equipment in combination with activities, such as repair services and selling replacement parts.
444220	Nursery, Garden Center, and Farm Supply Stores	This industry comprises establishments primarily engaged in retailing nursery and garden products, such as trees, shrubs, plants, seeds, bulbs, and sod, that are predominantly grown elsewhere. These establishments may sell a limited amount of a product they grow themselves. Also included in this industry are establishments primarily engaged in retailing farm supplies, such as animal (non-pet) feed.
444130	Hardware Stores	This industry comprises establishments known as hardware stores primarily engaged in retailing a general line of new hardware items, such as tools and builders' hardware.
444110	Home Centers	This industry comprises establishments known as home centers primarily engaged in retailing a general line of new home repair and improvement materials and supplies, such as lumber, plumbing goods, electrical goods, tools, housewares, hardware, and lawn and garden supplies, with no one merchandise line predominating. The merchandise lines are normally arranged in separate departments.
444120	Paint and Wallpaper Stores	This industry comprises establishments known as paint and wallpaper stores primarily engaged in retailing paint, wallpaper, and related supplies.
444190	Other Building Material Dealers	This industry comprises establishments (except those known as home centers, paint and wallpaper stores, and hardware stores) primarily engaged in retailing specialized lines of new building materials, such as lumber, fencing, glass, doors, plumbing fixtures and supplies, electrical supplies, prefabricated buildings and kits, and kitchen and bath cabinets and countertops to be installed.
453991	Tobacco Stores	This U.S. industry comprises establishments primarily engaged in retailing cigarettes, cigars, tobacco, pipes, and other smokers' supplies. Cigar stores; Smokers' supply stores; Cigarette stands (i.e., permanent); Tobacco stores
446120	Cosmetics, Beauty Supplies, and Perfume Stores	This industry comprises establishments known as cosmetic or perfume stores or beauty supply shops primarily engaged in retailing cosmetics, perfumes, toiletries, and personal grooming products.
446199	All Other Health and Personal Care Stores	This U.S. industry comprises establishments primarily engaged in retailing specialized lines of health and personal care merchandise (except drugs, medicines, optical goods, cosmetics, beauty supplies, perfume, and food supplement products). Convalescent supply stores; Prosthetic stores; Hearing aid stores; Sick room supply stores
453910	Pet and Pet Supplies Stores	This industry comprises establishments primarily engaged in retailing pets, pet foods, and pet supplies.

NAICS	NAICS Description	Description
453998	All Other Miscellaneous Store Retailers (except Tobacco Stores)	This U.S. industry comprises establishments primarily engaged in retailing specialized lines of merchandise (except motor vehicle and parts dealers; furniture and home furnishings stores; electronics and appliance stores; building material and garden equipment and supplies dealers; food and beverage stores; health and personal care stores; gasoline stations; clothing and clothing accessories stores; sporting goods, hobby, book and music stores; general merchandise stores; florists; office supplies, stationery and gift stores; used merchandise stores; pet and pet supplies stores; art dealers; manufactured home (i.e., mobile home) dealers; and tobacco stores). This industry also includes establishments primarily engaged in retailing a general line of new and used merchandise on an auction basis (except electronic auctions). Art supply stores; General merchandise auction houses; Candle shops; Home security equipment stores; Cemetery memorial (e.g., headstones, markers, vaults) dealers; Hot tub stores; Collectors' items (e.g., autograph, coin, card, stamp) shops; Swimming pool supply stores; Fireworks shops (permanent location); Trophy (e.g., awards and plaques) shops; Flower shops, artificial or dried
451211	Book Stores	This U.S. industry comprises establishments primarily engaged in retailing new books.
451212	News Dealers and Newsstands	This U.S. industry comprises establishments primarily engaged in retailing current newspapers, magazines, and other periodicals.
443142	Electronics Stores	This U.S. industry comprises: (1) establishments known as consumer electronics stores primarily engaged in retailing a general line of new consumer-type electronic products such as televisions, computers, and cameras; (2) establishments specializing in retailing a single line of consumer-type electronic products; (3) establishments primarily engaged in retailing these new electronic products in combination with repair and support services; (4) establishments primarily engaged in retailing new prepackaged computer software; and/or (5) establishments primarily engaged in retailing prerecorded audio and video media, such as CDs, DVDs, and tapes.
451140	Musical Instrument and Supplies Stores	This industry comprises establishments primarily engaged in retailing new musical instruments, sheet music, and related supplies; or retailing these new products in combination with musical instrument repair, rental, or music instruction.
451110	Sporting Goods Stores	This industry comprises establishments primarily engaged in retailing new sporting goods, such as bicycles and bicycle parts; camping equipment; exercise and fitness equipment; athletic uniforms; specialty sports footwear; and sporting goods, equipment, and accessories.
451120	Hobby, Toy, and Game Stores	This industry comprises establishments primarily engaged in retailing new toys, games, and hobby and craft supplies (except needlecraft).
532230	Video Tape and Disc Rental	This industry comprises establishments primarily engaged in renting prerecorded video tapes and discs for home electronic equipment.
446130	Optical Goods Stores	This industry comprises establishments primarily engaged in one or more of the following: (1) retailing and fitting prescription eyeglasses and contact lenses; (2) retailing prescription eyeglasses in combination with the grinding of lenses to order on the premises; and (3) selling nonprescription eyeglasses.
453220	Gift, Novelty, and Souvenir Stores	This industry comprises establishments primarily engaged in retailing new gifts, novelty merchandise, souvenirs, greeting cards, seasonal and holiday decorations, and curios.
453110	Florists	This industry comprises establishments known as florists primarily engaged in retailing cut flowers, floral arrangements, and potted plants purchased from others. These establishments usually prepare the arrangements they sell.
448310	Jewelry Stores	This industry comprises establishments primarily engaged in retailing one or more of the following items: (1) new jewelry (except costume jewelry); (2) new sterling and plated silverware; and (3) new watches and clocks. Also included are establishments retailing these new products in combination with lapidary work and/or repair services.
448320	Luggage and Leather Goods Stores	This industry comprises establishments known as luggage and leather goods stores primarily engaged in retailing new luggage, briefcases, and trunks, or retailing these new products in combination with a general line of leather items (except leather apparel), such as belts, gloves, and handbags.
451130	Sewing, Needlework, and Piece Goods Stores	This industry comprises establishments primarily engaged in retailing new sewing supplies, fabrics, patterns, yarns, and other needlework accessories or retailing these products in combination with selling new sewing machines.

Cluster Name: **School**
Cluster Code: **8**

Number of Industries 5

NAICS	NAICS Name	Description
611519	Other Technical and Trade Schools	This U.S. industry comprises establishments primarily engaged in offering job or career vocational or technical courses (except cosmetology and barber training, aviation and flight training, and apprenticeship training). The curriculums offered by these schools are highly structured and specialized and lead to job-specific certification. Bartending schools; Modeling schools; Broadcasting schools; Real estate schools; Computer repair training; Truck driving schools; Graphic arts schools
624310	Vocational Rehabilitation Services	This industry comprises (1) establishments primarily engaged in providing vocational rehabilitation or habilitation services, such as job counseling, job training, and work experience, to unemployed and underemployed persons, persons with disabilities, and persons who have a job market disadvantage because of lack of education, job skill, or experience and (2) establishments primarily engaged in providing training and employment to persons with disabilities. Vocational rehabilitation job training facilities (except schools) and sheltered workshops (i.e., work experience centers) are included in this industry.
611610	Fine Arts Schools	This industry comprises establishments primarily engaged in offering instruction in the arts, including dance, art, drama, and music. Art (except commercial and graphic) instruction; Music instruction (e.g., piano, guitar); Dance instruction; Music schools (except academic); Dance studios; Performing arts schools (except academic); Drama schools (except academic); Photography schools (except commercial photography); Fine arts schools (except academic)
611692	Automobile Driving Schools	This U.S. industry comprises establishments primarily engaged in offering automobile driving instruction.
611110	Elementary and Secondary Schools	This industry comprises establishments primarily engaged in furnishing academic courses and associated course work that comprise a basic preparatory education. A basic preparatory education ordinarily constitutes kindergarten through 12th grade. This industry includes school boards and school districts. Elementary schools; Parochial schools, elementary or secondary; High schools; Primary schools; Kindergartens; Schools for the physically disabled, elementary or secondary; Military academies, elementary or secondary

Cluster Name: **Service**
Cluster Code: **9**

Number of Industries 42

NAICS	NAICS Name	Description
532111	Passenger Car Rental	This U.S. industry comprises establishments primarily engaged in renting passenger cars without drivers, generally for short periods of time.
441310	Automotive Parts and Accessories Stores	This industry comprises one or more of the following: (1) establishments known as automotive supply stores primarily engaged in retailing new, used, and/or rebuilt automotive parts and accessories; (2) automotive supply stores that are primarily engaged in both retailing automotive parts and accessories and repairing automobiles; and (3) establishments primarily engaged in retailing and installing automotive accessories.
441320	Tire Dealers	This industry comprises establishments primarily engaged in retailing new and/or used tires and tubes or retailing new tires in combination with automotive repair services.
811111	General Automotive Repair	This U.S. industry comprises establishments primarily engaged in providing (1) a wide range of mechanical and electrical repair and maintenance services for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers or (2) engine repair and replacement. Automobile repair garages (except gasoline service stations); General automotive repair shops; Automotive engine repair and replacement shops.
811112	Automotive Exhaust System Repair	This U.S. industry comprises establishments primarily engaged in replacing or repairing exhaust systems of automotive vehicles, such as passenger cars, trucks, and vans. Automotive exhaust system replacement and repair shops; Automotive muffler replacement and repair shops
811113	Automotive Transmission Repair	This U.S. industry comprises establishments primarily engaged in replacing or repairing transmissions of automotive vehicles, such as passenger cars, trucks, and vans.
811118	Other Automotive Mechanical and Electrical Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in providing specialized mechanical or electrical repair and maintenance services (except engine repair and replacement, exhaust systems repair, and transmission repair) for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers. Automotive brake repair shops; Automotive radiator repair shops; Automotive electrical repair shops; Automotive tune-up shops
811121	Automotive Body, Paint, and Interior Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing or customizing automotive vehicles, such as passenger cars, trucks, and vans, and all trailer bodies and interiors; and/or painting automotive vehicles and trailer bodies. Automotive body shops; Automotive upholstery shops; Automotive paint shops
811122	Automotive Glass Replacement Shops	This U.S. industry comprises establishments primarily engaged in replacing, repairing, and/or tinting automotive vehicle, such as passenger car, truck, and van, glass.
488410	Motor Vehicle Towing	This industry comprises establishments primarily engaged in towing light or heavy motor vehicles, both local and long distance. These establishments may provide incidental services, such as storage and emergency road repair services.
811191	Automotive Oil Change and Lubrication Shops	This U.S. industry comprises establishments primarily engaged in changing motor oil and lubricating the chassis of automotive vehicles, such as passenger cars, trucks, and vans.
811192	Car Washes	This U.S. industry comprises establishments primarily engaged in cleaning, washing, and/or waxing automotive vehicles, such as passenger cars, trucks, and vans, and trailers. Automotive detail shops; Mobile car and truck washes; Car washes
811198	All Other Automotive Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in providing automotive repair and maintenance services (except mechanical and electrical repair and maintenance; body, paint, interior, and glass repair; motor oil change and lubrication; and car washing) for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers. Automotive air-conditioning repair shops; Automotive tire repair (except retreading) shops; Automotive rustproofing and undercoating shops
624410	Child Day Care Services	This industry comprises establishments primarily engaged in providing day care of infants or children. These establishments generally care for preschool children, but may care for older children when they are not in school and may also offer pre-kindergarten educational programs.
447110	Gasoline Stations with Convenience Stores	This industry comprises establishments engaged in retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline) in combination with convenience store or food mart items. These establishments can either be in a convenience store (i.e., food mart) setting or a gasoline station setting. These establishments may also provide automotive repair services.

NAICS	NAICS Name	Description
447190	Other Gasoline Stations	This industry comprises establishments known as gasoline stations (except those with convenience stores) primarily engaged in one of the following: (1) retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline, alternative fuels) or (2) retailing these fuels in combination with activities, such as providing repair services; selling automotive oils, replacement parts, and accessories; and/or providing food services.
812320	Drycleaning and Laundry Services (except Coin-Operated)	This industry comprises establishments primarily engaged in one or more of the following: (1) providing drycleaning services (except coin-operated); (2) providing laundering services (except linen and uniform supply or coin-operated); (3) providing dropoff and pickup sites for laundries and/or drycleaners; and (4) providing specialty cleaning services for specific types of garments and other textile items (except carpets and upholstery), such as fur, leather, or suede garments; wedding gowns; hats; draperies; and pillows. These establishments may provide all, a combination of, or none of the cleaning services on the premises.
812310	Coin-Operated Laundries and Drycleaners	This industry comprises establishments primarily engaged in (1) operating facilities with coin-operated or similar self-service laundry and drycleaning equipment for customer use on the premises and/or (2) supplying and servicing coin-operated or similar self-service laundry and drycleaning equipment for customer use in places of business operated by others, such as apartments and dormitories.
611511	Cosmetology and Barber Schools	This U.S. industry comprises establishments primarily engaged in offering training in barbering, hair styling, or the cosmetic arts, such as makeup or skin care. These schools provide job-specific certification.
812111	Barber Shops	This U.S. industry comprises establishments known as barber shops or men's hair stylist shops primarily engaged in cutting, trimming, and styling men's and boys' hair; and/or shaving and trimming men's beards.
812112	Beauty Salons	This U.S. industry comprises establishments (except those known as barber shops or men's hair stylist shops) primarily engaged in one or more of the following: (1) cutting, trimming, shampooing, coloring, waving, or styling hair; (2) providing facials; and (3) applying makeup (except permanent makeup). Beauty parlors or shops; Facial salons or shops; Combined beauty and barber shops; Hairdressing salons or shops; Cosmetology salons or shops; Unisex or women's hair stylist shops
812113	Nail Salons	This U.S. industry comprises establishments primarily engaged in providing nail care services, such as manicures, pedicures, and nail extensions.
532220	Formal Wear and Costume Rental	This industry comprises establishments primarily engaged in renting clothing, such as formal wear, costumes (e.g., theatrical), or other clothing (except laundered uniforms and work apparel).
532299	All Other Consumer Goods Rental	This U.S. industry comprises establishments primarily engaged in renting consumer goods and products (except consumer electronics and appliances; formal wear and costumes; prerecorded video tapes and discs for home electronic equipment; home health furniture and equipment; and recreational goods). Included in this industry are furniture rental centers and party rental supply centers.
541940	Veterinary Services	This industry comprises establishments of licensed veterinary practitioners primarily engaged in the practice of veterinary medicine, dentistry, or surgery for animals; and establishments primarily engaged in providing testing services for licensed veterinary practitioners. Animal hospitals; Veterinary clinics; Veterinarians' offices; Veterinary testing laboratories
812191	Diet and Weight Reducing Centers	This U.S. industry comprises establishments primarily engaged in providing nonmedical services to assist clients in attaining or maintaining a desired weight. The sale of weight reduction products, such as food supplements, may be an integral component of the program. These services typically include individual or group counseling, menu and exercise planning, and weight and body measurement monitoring.
812199	Other Personal Care Services	This U.S. industry comprises establishments primarily engaged in providing personal care services (except hair, nail, facial, nonpermanent makeup, or nonmedical diet and weight reducing services). Depilatory or electrolysis (i.e., hair removal) salons; Saunas; Ear piercing services; Steam or turkish baths; Hair replacement (except by offices of physicians) or weaving services; Tanning salons; Massage parlors; Tattoo parlors; Permanent makeup salons
812910	Pet Care (except Veterinary) Services	This industry comprises establishments primarily engaged in providing pet care services (except veterinary), such as boarding, grooming, sitting, and training pets.
812990	All Other Personal Services	This industry comprises establishments primarily engaged in providing personal services (except personal care services, death care services, drycleaning and laundry services, pet care services, photofinishing services, or parking space and/or valet parking services). Bail bonding or bondsperson services; Shoeshine services; Coin-operated personal services machine (e.g., blood pressure, locker, photographic, scale, shoeshine); concession operators; Social escort services; Consumer buying services; Wedding planning services; Dating services

NAICS	NAICS Name	Description
541921	Photography Studios, Portrait	This U.S. industry comprises establishments known as portrait studios primarily engaged in providing still, video, or digital portrait photography services. Home photography services; School photography services; Passport photography services; Videotaping services for special events (e.g., weddings)
812921	Photofinishing Laboratories (except One-Hour)	This U.S. industry comprises establishments (except those known as "one-hour" photofinishing labs) primarily engaged in developing film and/or making photographic slides, prints, and enlargements.
812922	One-Hour Photofinishing	This U.S. industry comprises establishments known as "one-hour" photofinishing labs primarily engaged in developing film and/or making photographic slides, prints, and enlargements on a short turnaround or while-you-wait basis.
561622	Locksmiths	This U.S. industry comprises establishments primarily engaged in (1) selling mechanical or electronic locking devices, safes, and security vaults, along with installation, repair, rebuilding, or adjusting services or (2) installing, repairing, rebuilding, and adjusting mechanical or electronic locking devices, safes, and security vaults.
811212	Computer and Office Machine Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing and maintaining computers and office machines without retailing new computers and office machines, such as photocopying machines; computer terminals, storage devices, and printers; and CD-ROM drives.
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	This industry comprises establishments primarily engaged in the repair and maintenance of commercial and industrial machinery and equipment. Establishments in this industry either sharpen/install commercial and industrial machinery blades and saws or provide welding (e.g., automotive, general) repair services; or repair agricultural and other heavy and industrial machinery and equipment (e.g., forklifts and other materials handling equipment, machine tools, commercial refrigeration equipment, construction equipment, and mining machinery).
811411	Home and Garden Equipment Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing and servicing home and garden equipment without retailing new home and garden equipment, such as lawnmowers, handheld power tools, edgers, snow- and leaf-blowers, and trimmers.
811412	Appliance Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing and servicing household appliances without retailing new appliances, such as refrigerators, stoves, washing machines, clothes dryers, and room air-conditioners.
811211	Consumer Electronics Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing and maintaining consumer electronics, such as televisions, stereos, speakers, video recorders, CD players, radios, and cameras, without retailing new consumer electronics.
811213	Communication Equipment Repair and Maintenance	This U.S. industry comprises establishments primarily engaged in repairing and maintaining communications equipment without retailing new communication equipment, such as telephones, fax machines, communications transmission equipment, and two-way radios.
811420	Reupholstery and Furniture Repair	This industry comprises establishments primarily engaged in one or more of the following: (1) reupholstering furniture; (2) refinishing furniture; (3) repairing furniture; and (4) repairing and restoring furniture.
811430	Footwear and Leather Goods Repair	This industry comprises establishments primarily engaged in repairing footwear and/or repairing other leather or leather-like goods without retailing new footwear and leather or leather-like goods, such as handbags and briefcases.
811490	Other Personal and Household Goods Repair and Maintenance	This industry comprises establishments primarily engaged in repairing and servicing personal or household-type goods without retailing new personal or household-type goods (except home and garden equipment, appliances, furniture, and footwear and leather goods). Establishments in this industry repair items, such as garments; watches; jewelry; musical instruments; bicycles and motorcycles; and motorboats, canoes, sailboats, and other recreational boats.

Cluster Name: **Store**

Cluster Code:

		Number of Industries 11
NAICS	**NAICS Name**	**Description**
445120	Convenience Stores	This industry comprises establishments known as convenience stores or food marts (except those with fuel pumps) primarily engaged in retailing a limited line of goods that generally includes milk, bread, soda, and snacks.
446110	Pharmacies and Drug Stores	This industry comprises establishments known as pharmacies and drug stores engaged in retailing prescription or nonprescription drugs and medicines.
445110	Supermarkets and Other Grocery (except Convenience) Stores	This industry comprises establishments generally known as supermarkets and grocery stores primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry. Included in this industry are delicatessen-type establishments primarily engaged in retailing a general line of food.
311811	Retail Bakeries	This U.S. industry comprises establishments primarily engaged in retailing bread and other bakery products not for immediate consumption made on the premises from flour, not from prepared dough.
445210	Meat Markets	This industry comprises establishments primarily engaged in retailing fresh, frozen, or cured meats and poultry. Delicatessen-type establishments primarily engaged in retailing fresh meat are included in this industry. Baked ham stores; Meat markets; Butcher shops; Poultry dealers; Frozen meat shops
445220	Fish and Seafood Markets	This industry comprises establishments primarily engaged in retailing fresh, frozen, or cured fish and seafood products.
445230	Fruit and Vegetable Markets	This industry comprises establishments primarily engaged in retailing fresh fruits and vegetables.
445291	Baked Goods Stores	This U.S. industry comprises establishments primarily engaged in retailing baked goods not for immediate consumption and not made on the premises.
445292	Confectionery and Nut Stores	This U.S. industry comprises establishments primarily engaged in retailing candy and other confections, nuts, and popcorn not for immediate consumption and not made on the premises.
445299	All Other Specialty Food Stores	This U.S. industry comprises establishments primarily engaged in retailing miscellaneous specialty foods (except meat, fish, seafood, fruit and vegetables, confections, nuts, popcorn, and baked goods) not for immediate consumption and not made on the premises. Coffee and tea (i.e., packaged) stores; Soft drink (i.e., bottled) stores; Dairy product stores; Spice stores; Gourmet food stores; Water (i.e., bottled) stores
446191	Food (Health) Supplement Stores	This U.S. industry comprises establishments primarily engaged in retailing food supplement products, such as vitamins, nutrition supplements, and body enhancing supplements.

Figure A3.1. Number of Drink Business and Violent Crime

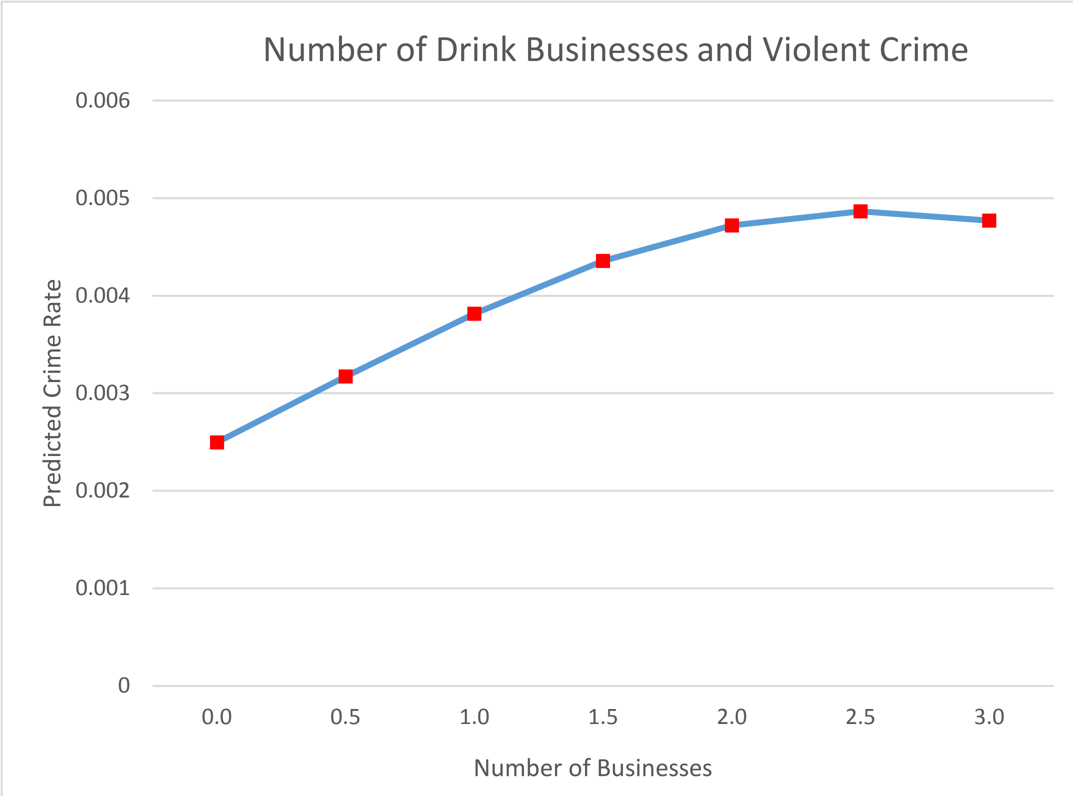

Figure A3.2. Number of Retail Business and Violent Crime

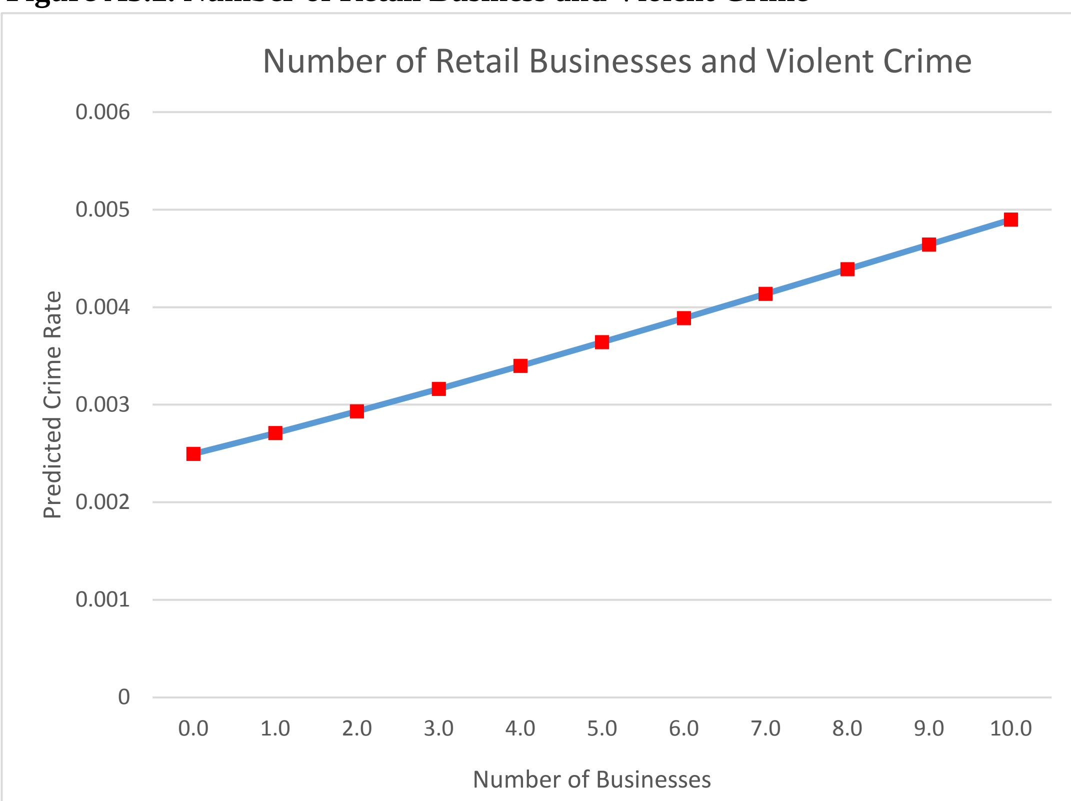

Figure A3.3. Number of School Business and Violent Crime

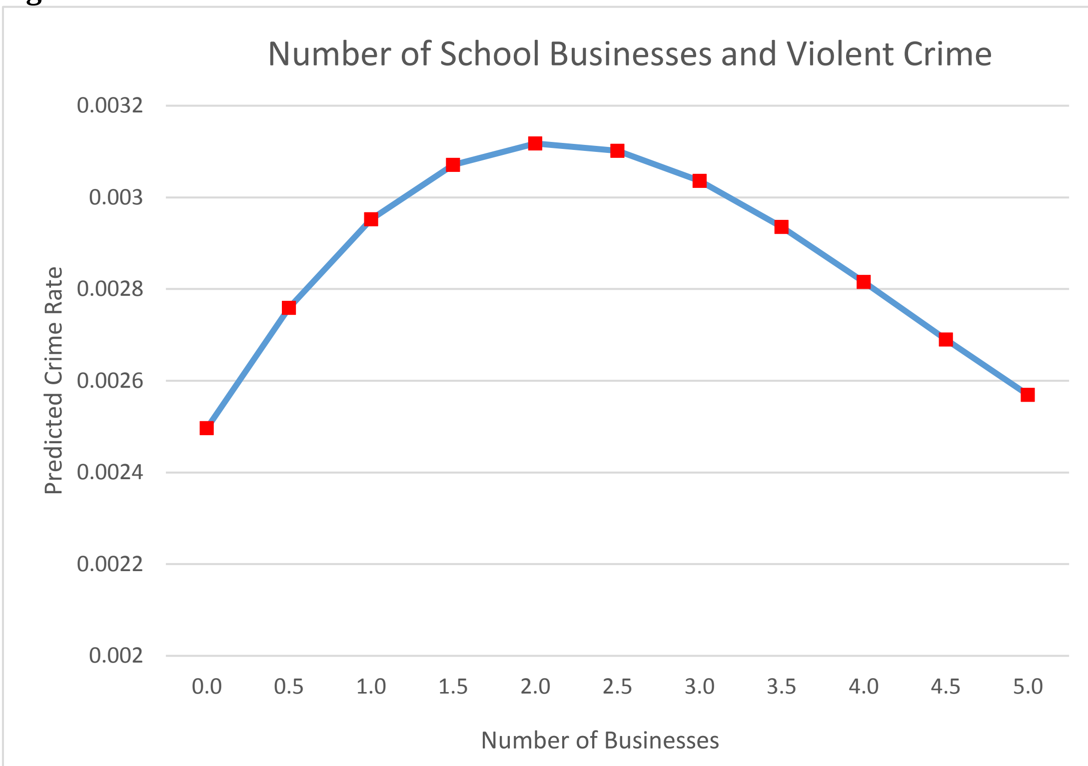

Figure A3.4. Number of Service Business and Violent Crime

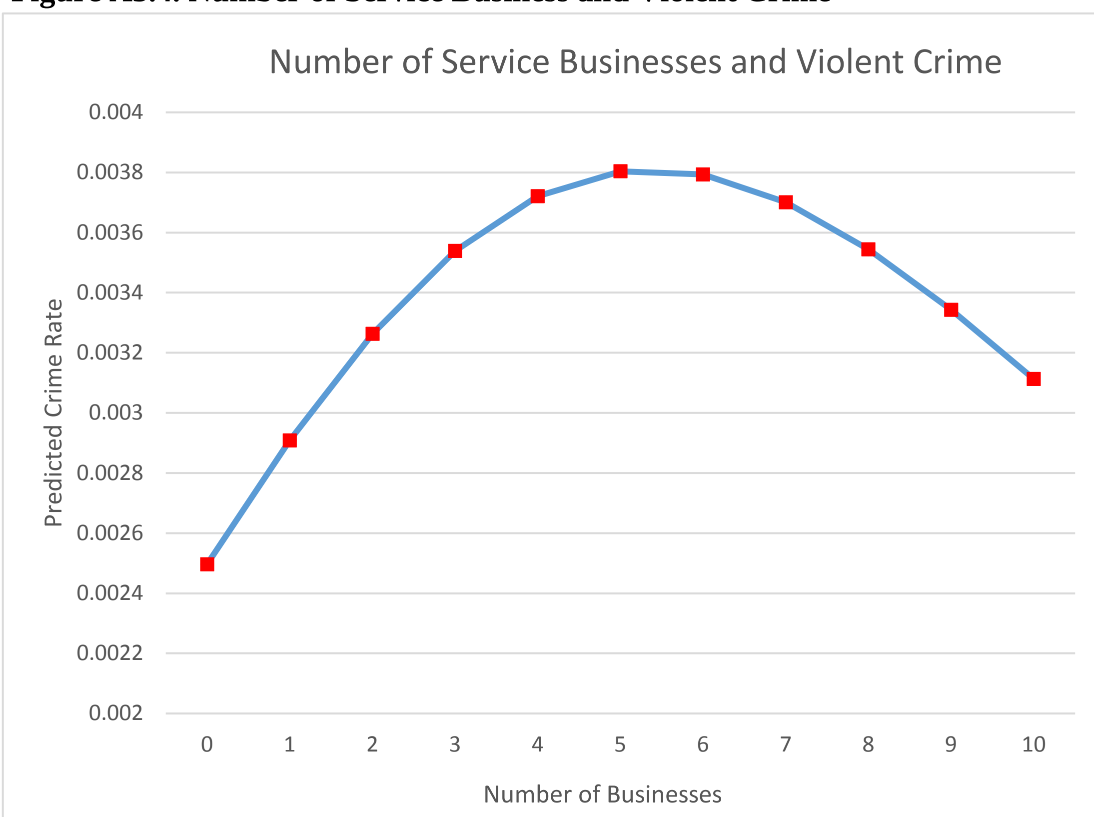

Figure A3.5. Number of Finance Business and Violent Crime

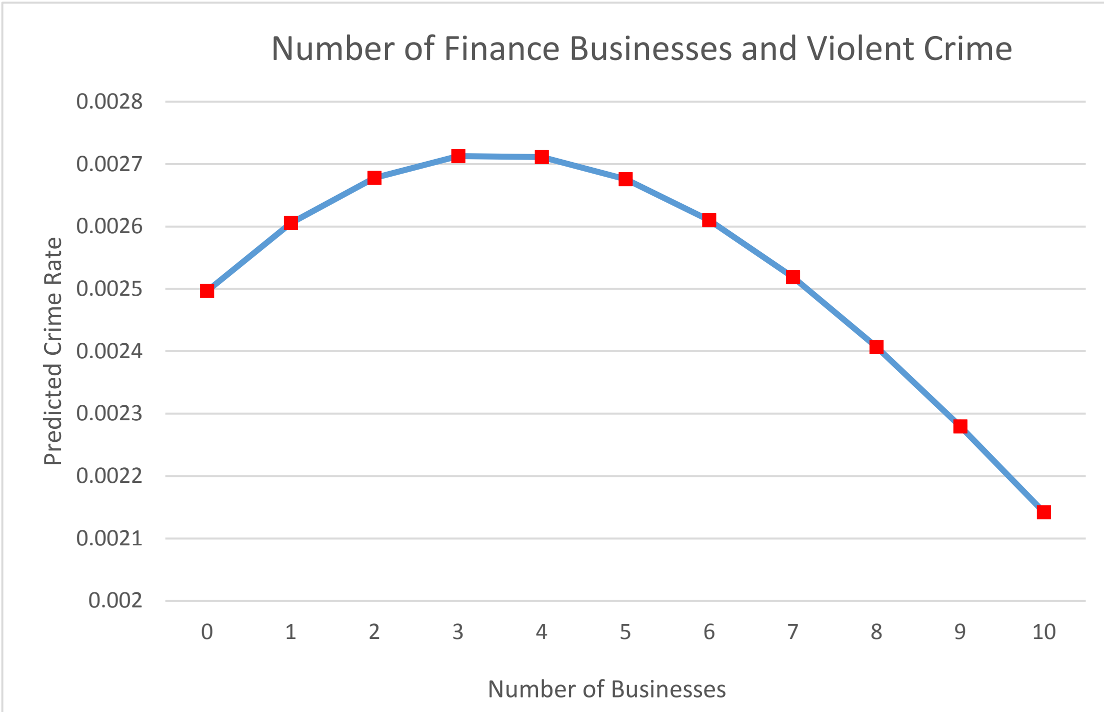

Figure A3.6. Number of Restaurants and Violent Crime

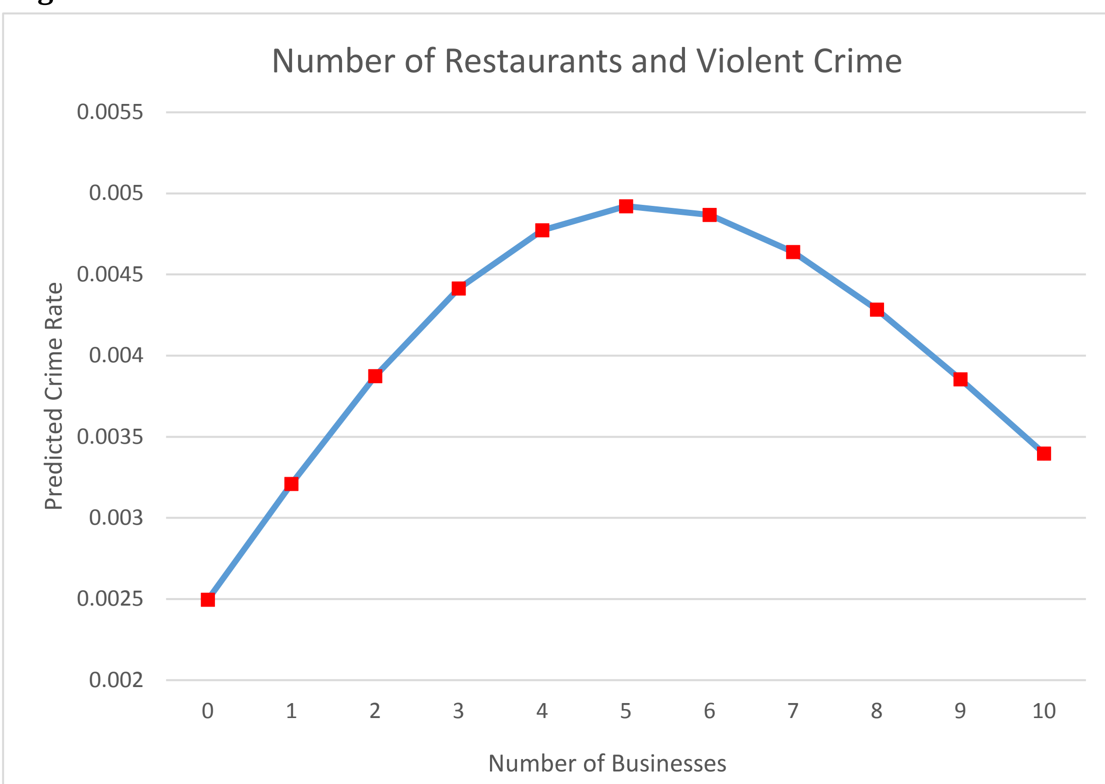

Figure A3.7. Number of Health Businesses and Violent Crime

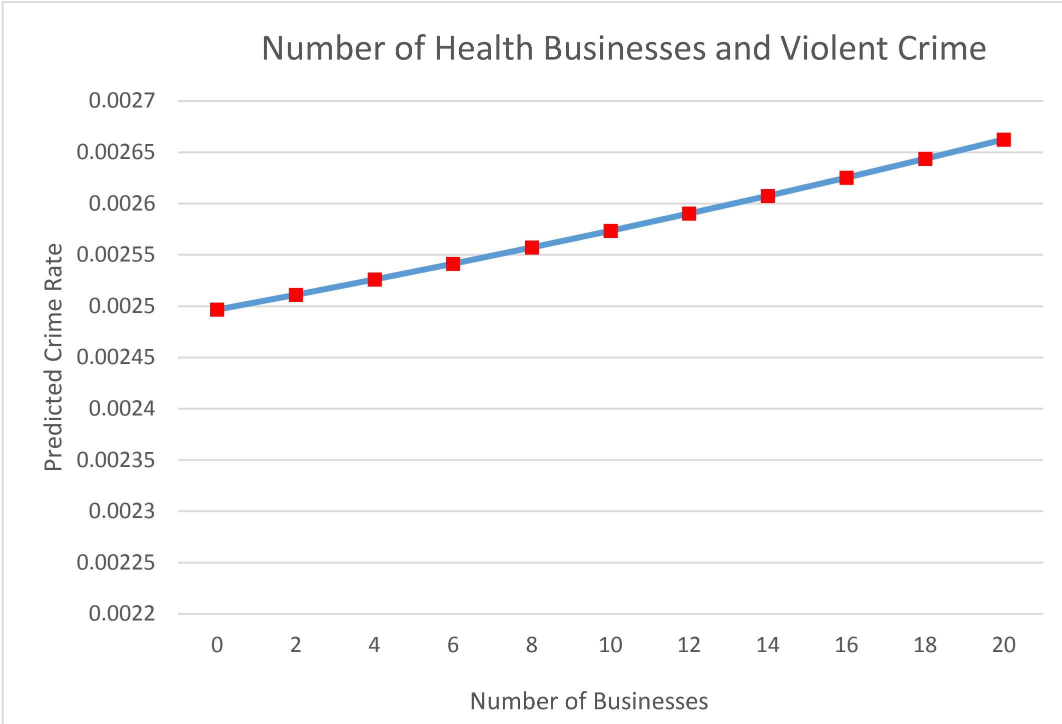

Figure A3.8. Number of Amenities and Violent Crime

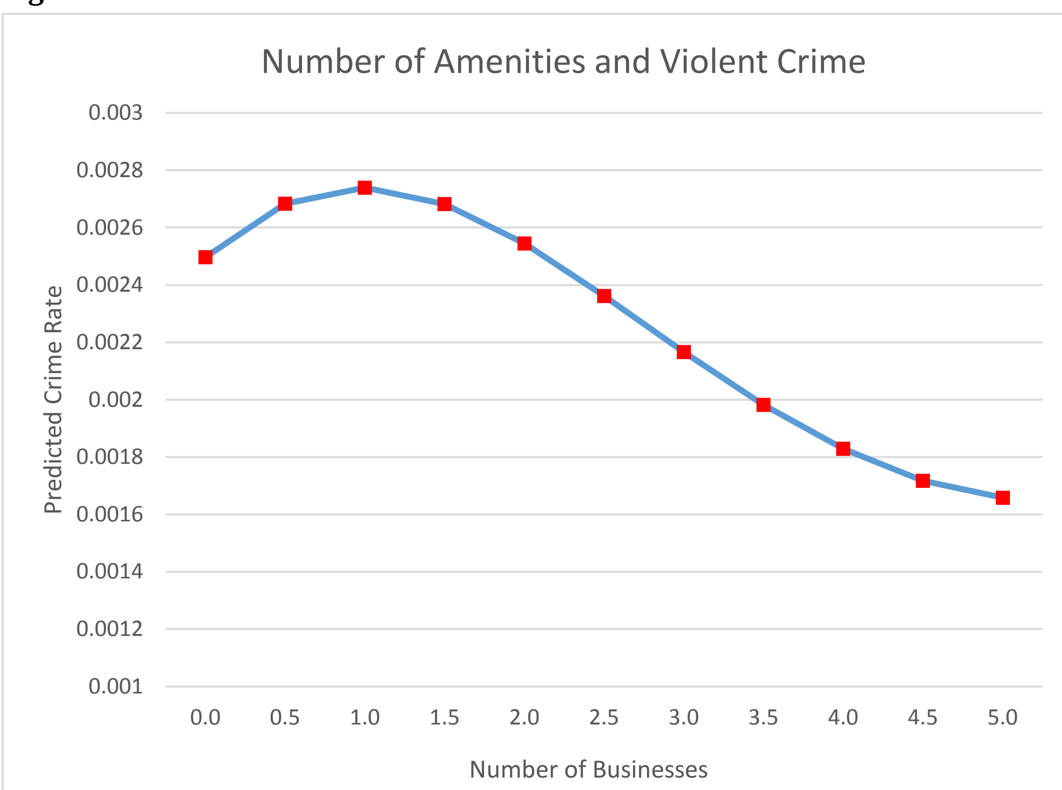

Figure A3.9. Number of Organizations and Violent Crime

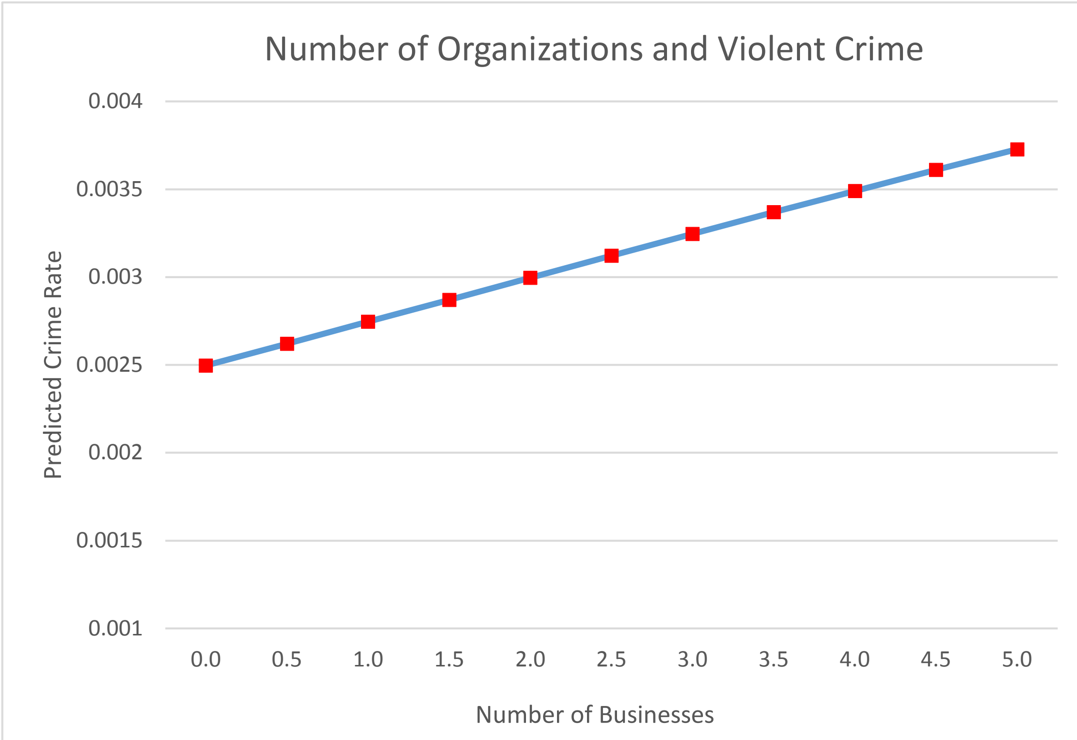

Figure A3.10. Number of Stores and Violent Crime

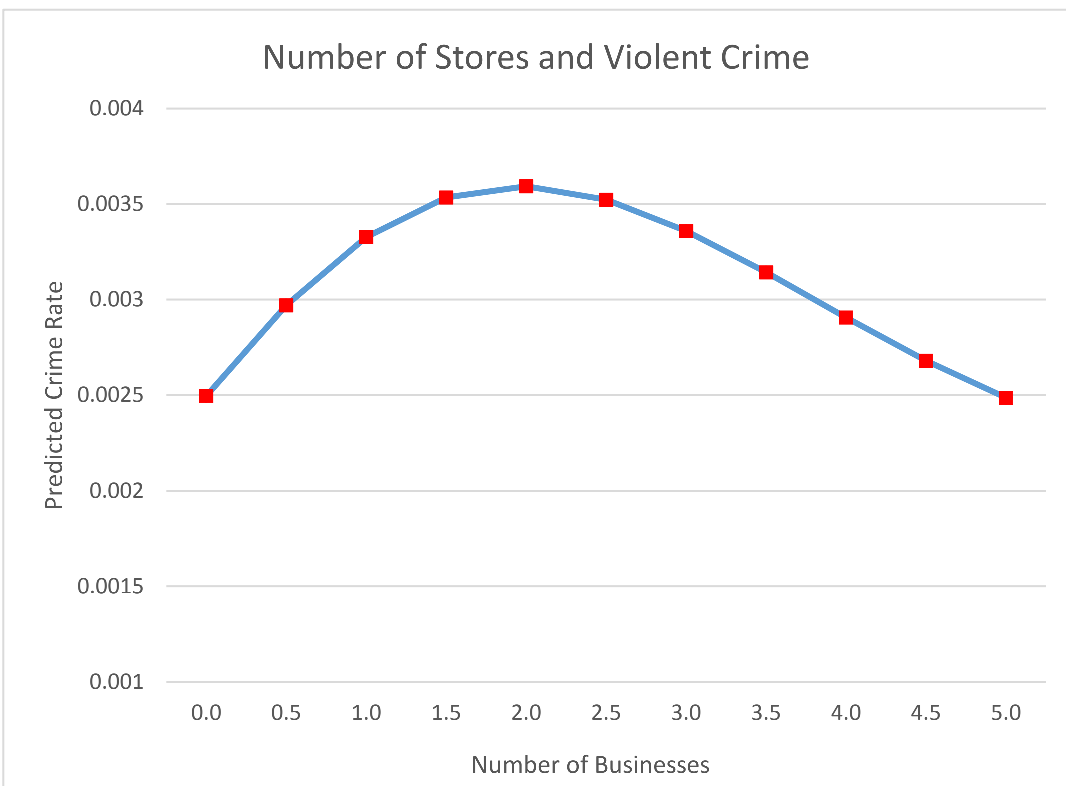

Figure A3.11. Number of Employees of Drink Business and Violent Crime

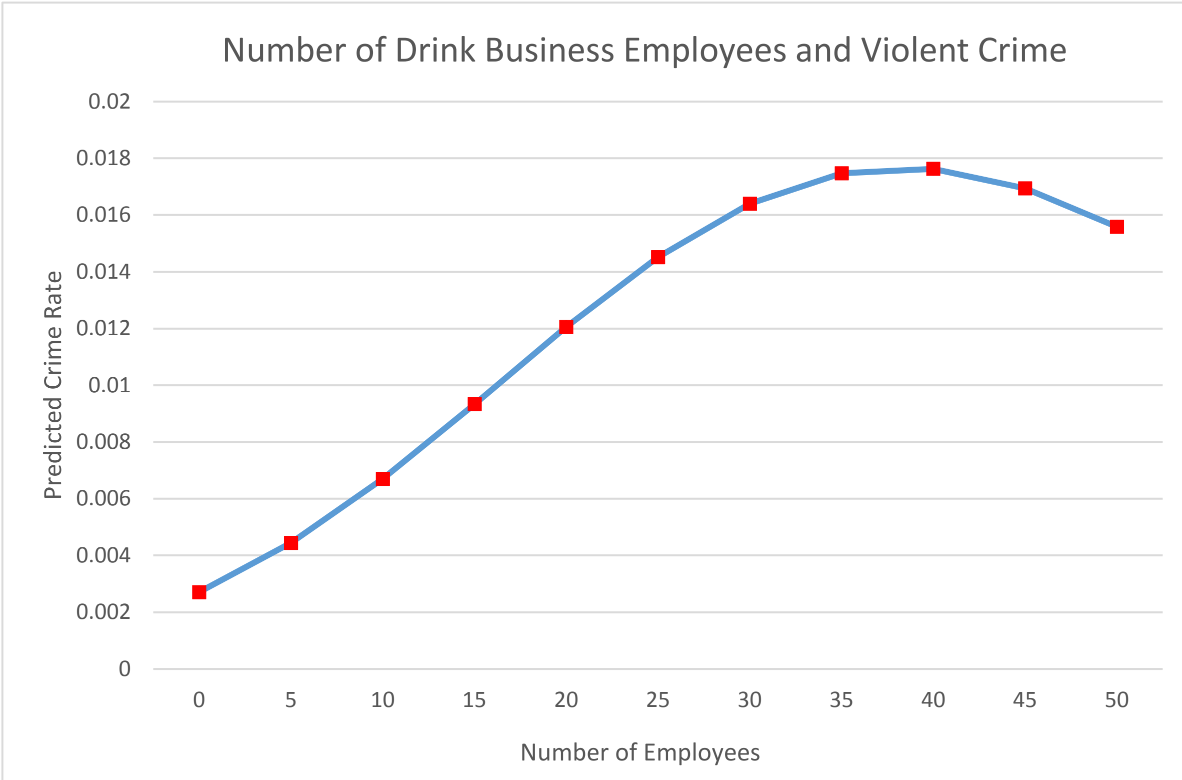

Figure A3.12. Number of Employees of Retail Business and Violent Crime

Figure A3.13. Number of Employees of School Business and Violent Crime

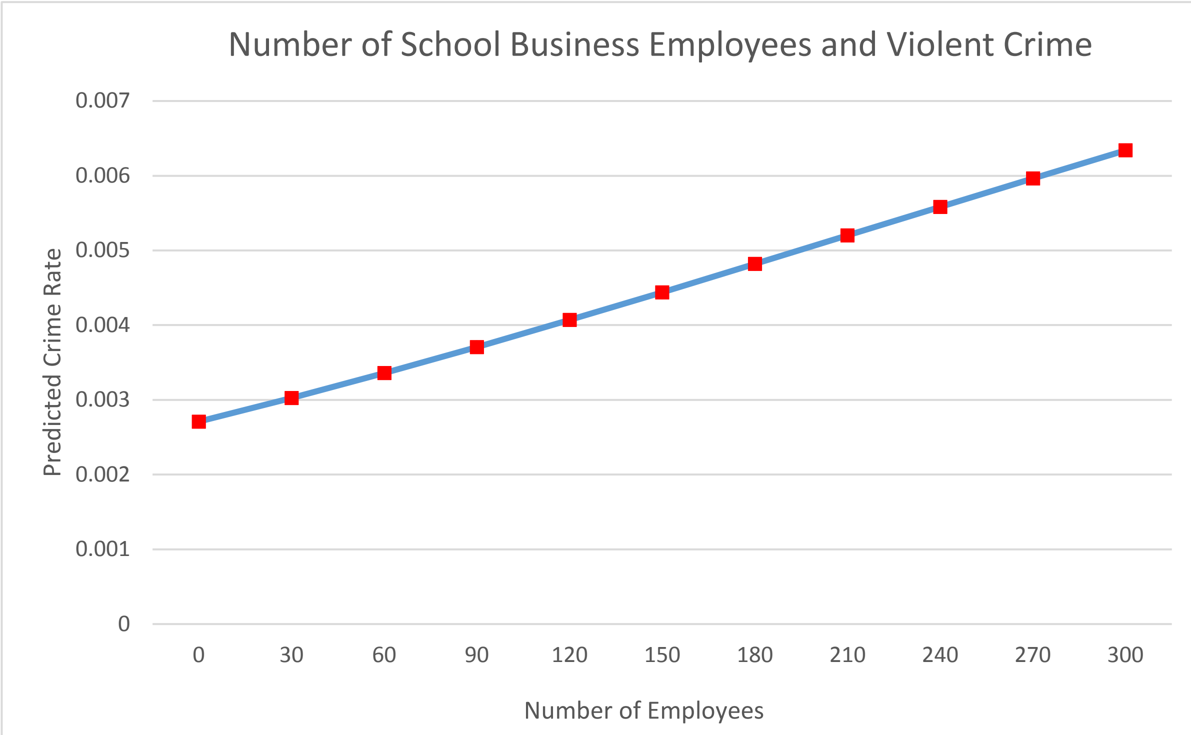

Figure A3.14. Number of Employees of Service Business and Violent Crime

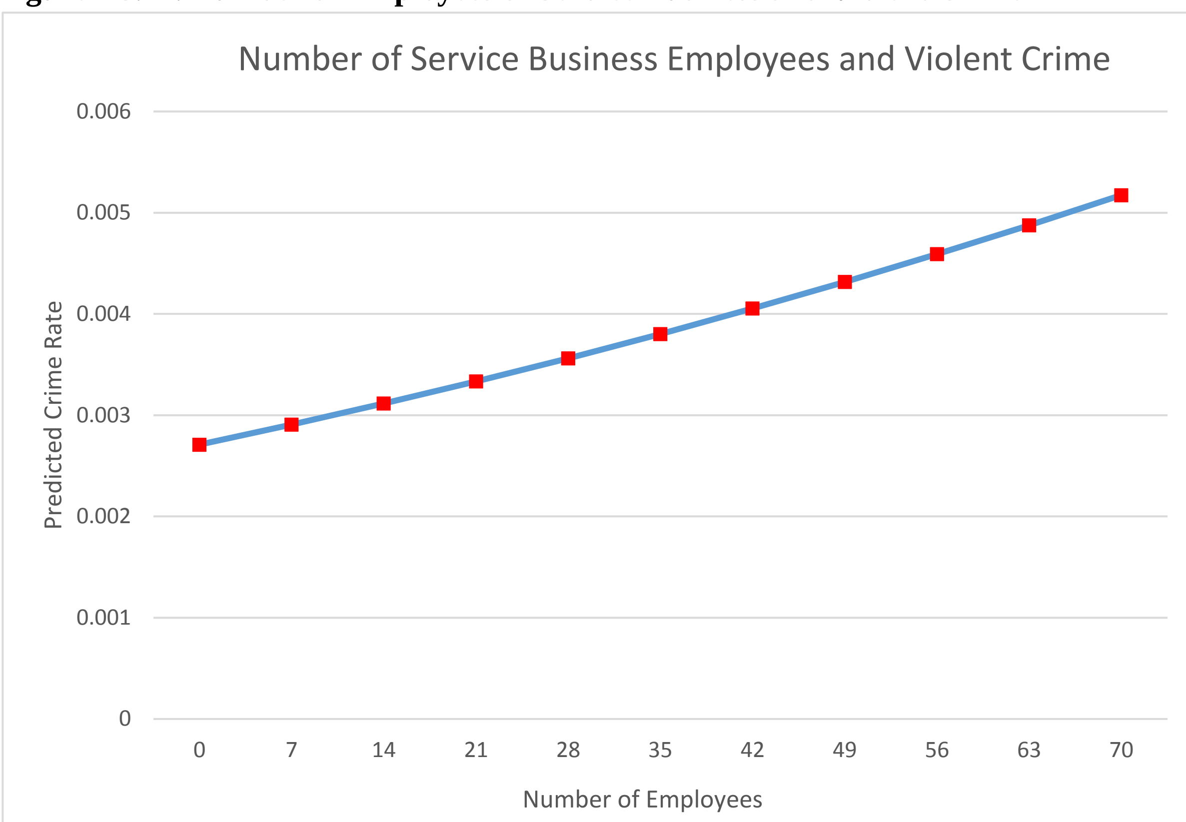

Figure A3.15. Number of Employees of Finance Business and Violent Crime

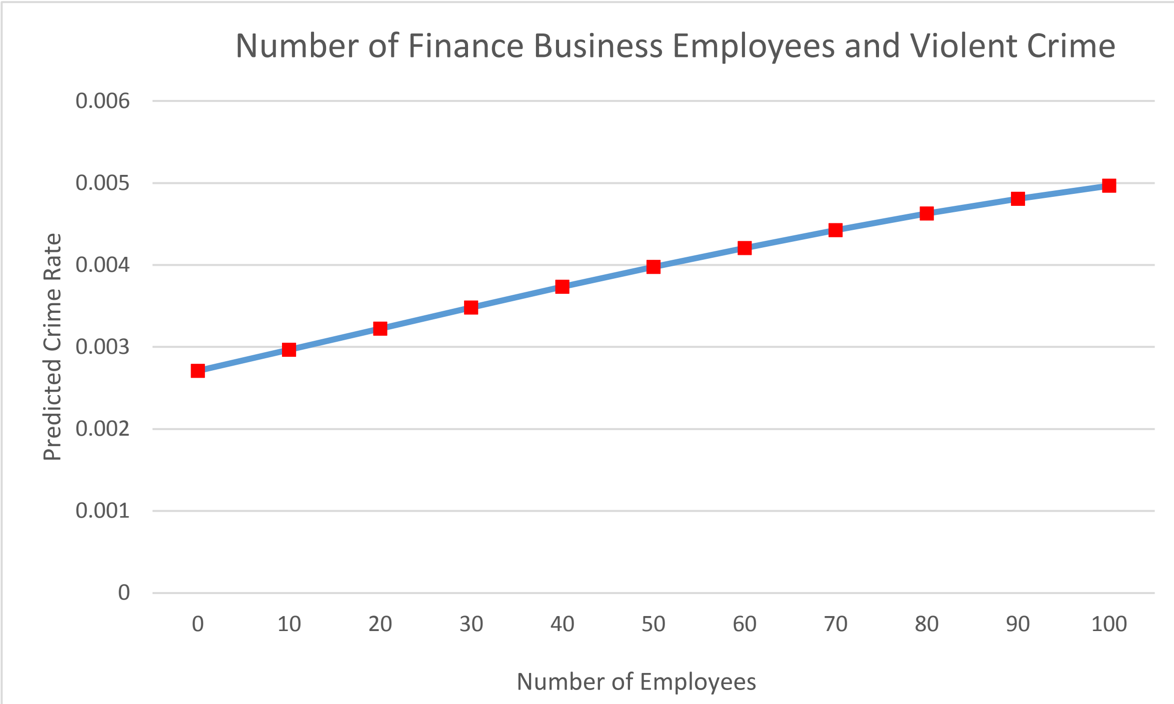

Figure A3.16. Number of Employees of Restaurants and Violent Crime

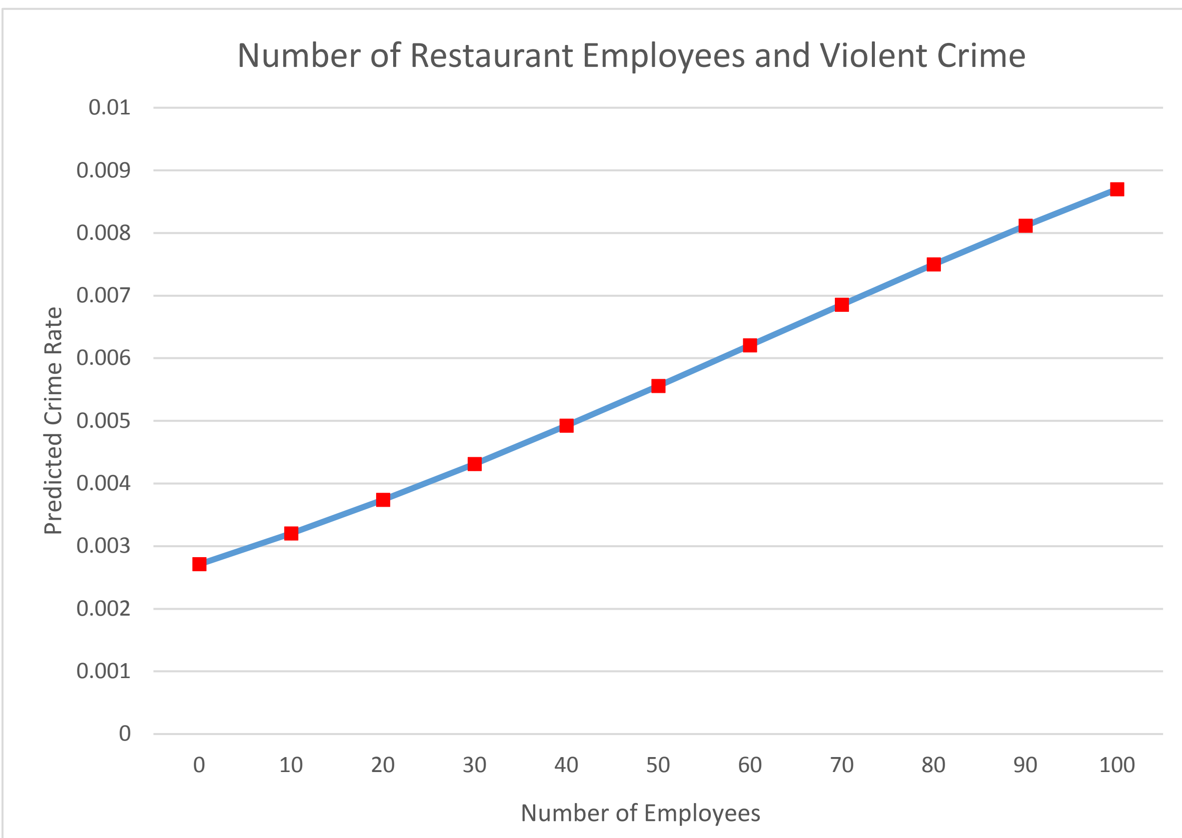

Figure A3.17. Number of Employees of Health Businesses and Violent Crime

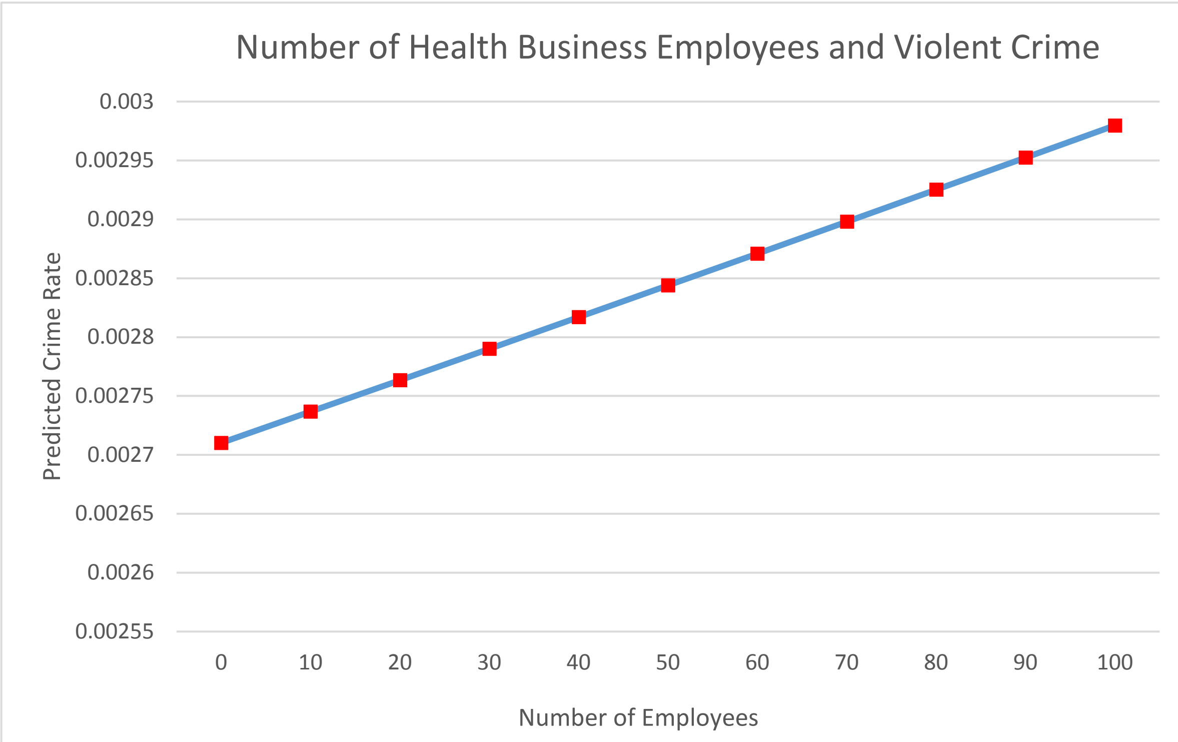

Figure A3.18. Number of Employees of Amenities and Violent Crime

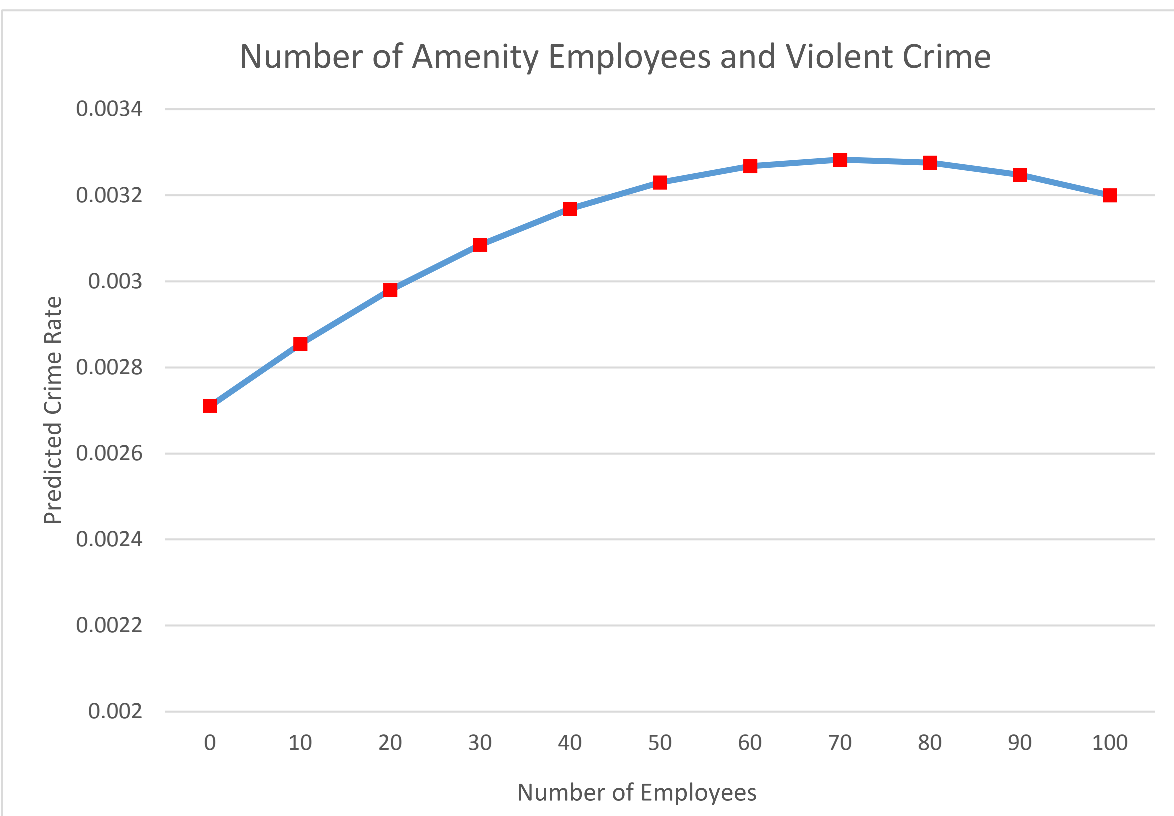

Figure A3.19. Number of Employees of Organizations and Violent Crime

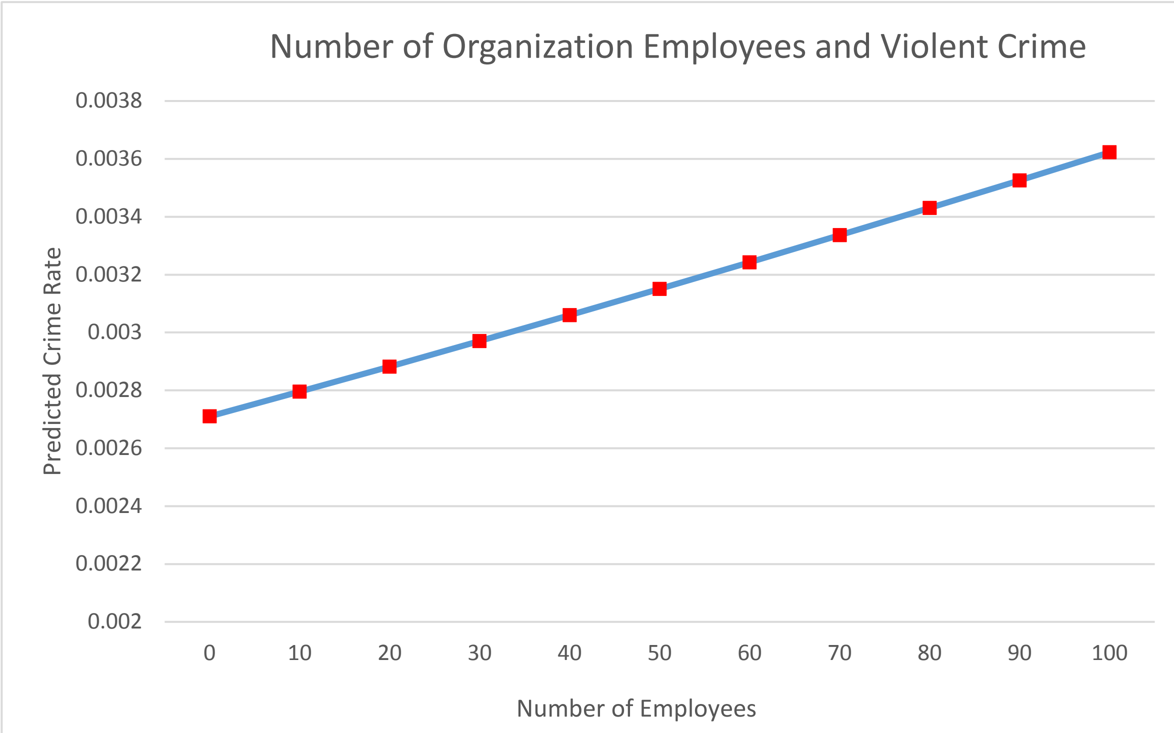

Figure A3.20. Number of Employees of Stores and Violent Crime

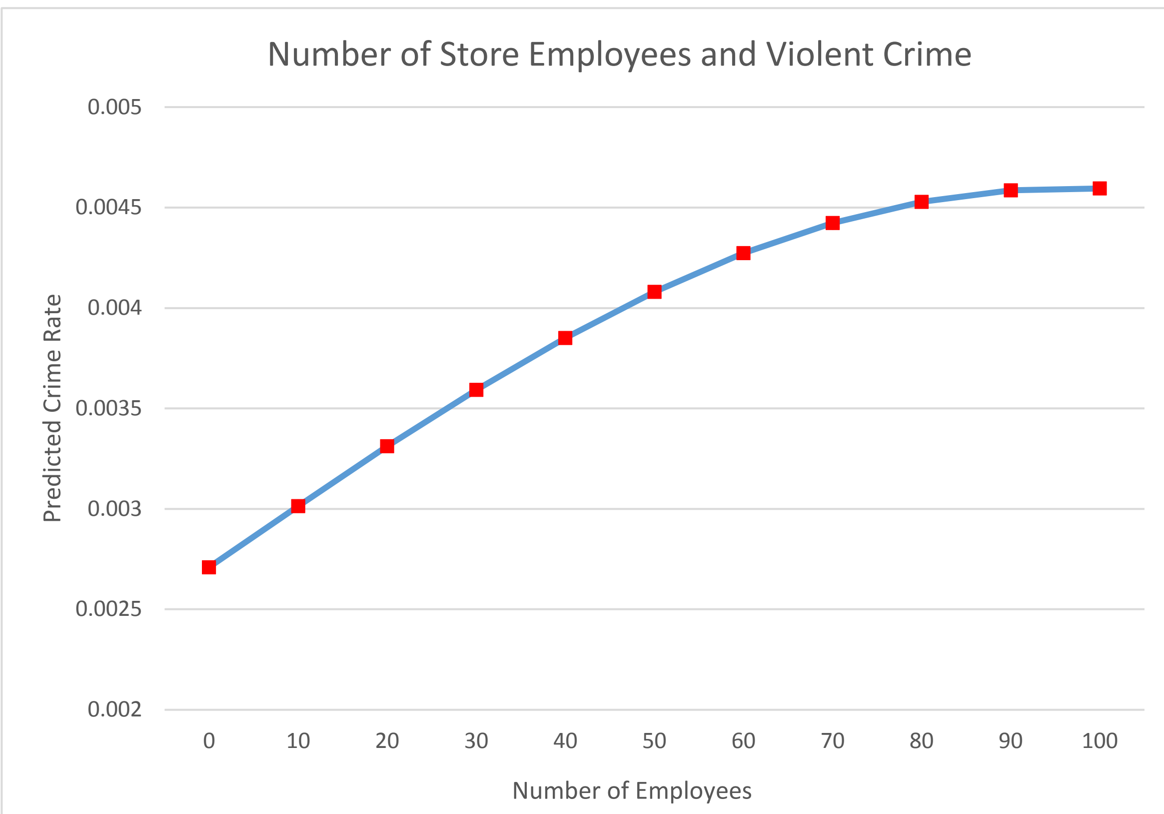

Figure A3.21. Number of Local Drink Business and Violent Crime

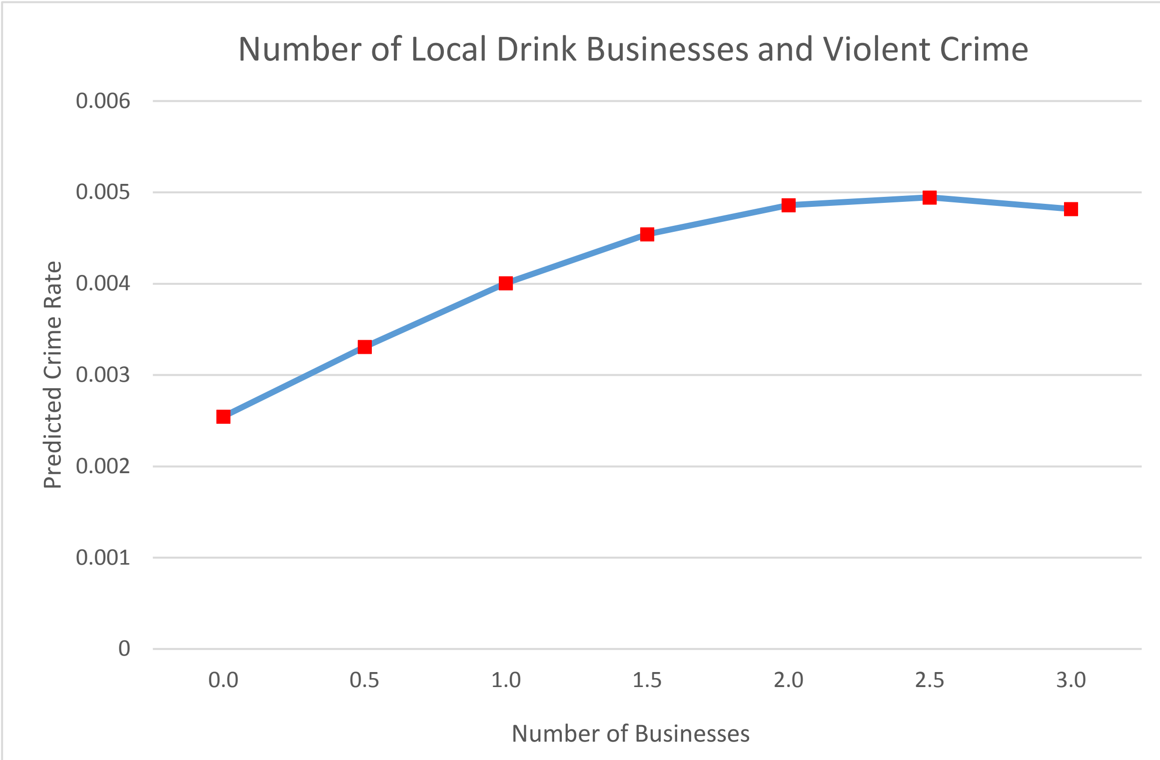

Figure A3.22. Number of Local Retail Business and Violent Crime

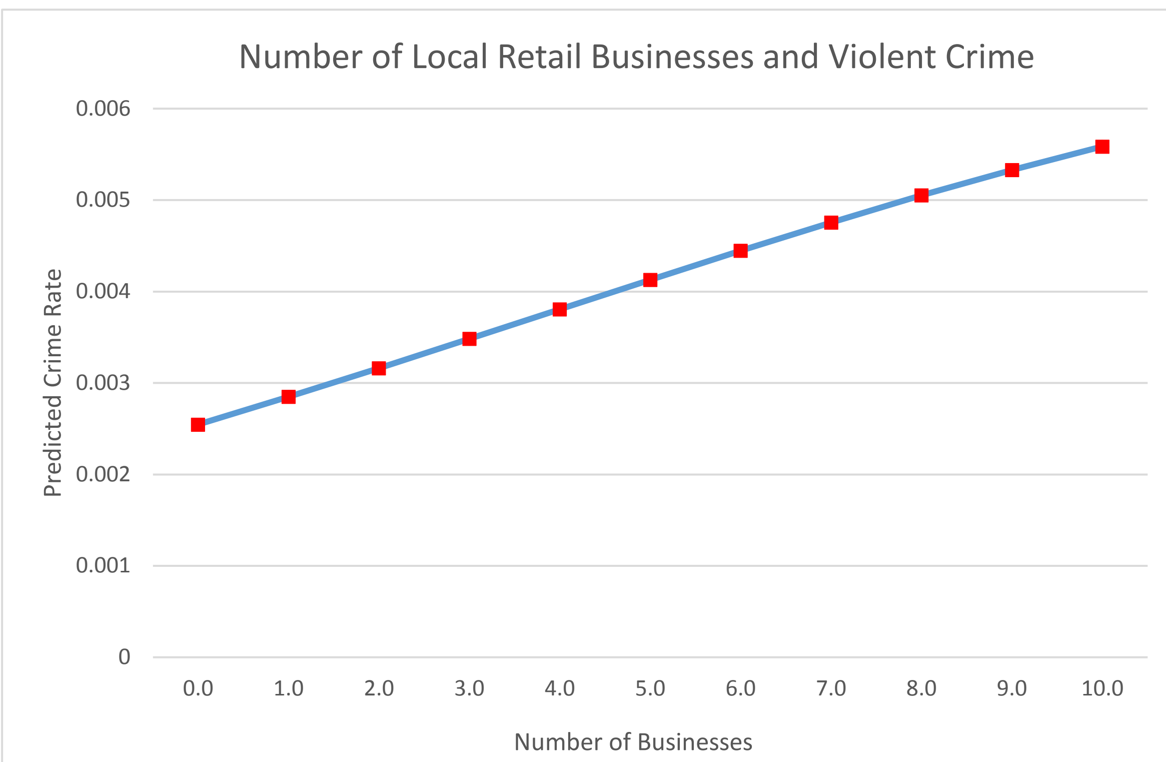

Figure A3.23. Number of Local School Business and Violent Crime

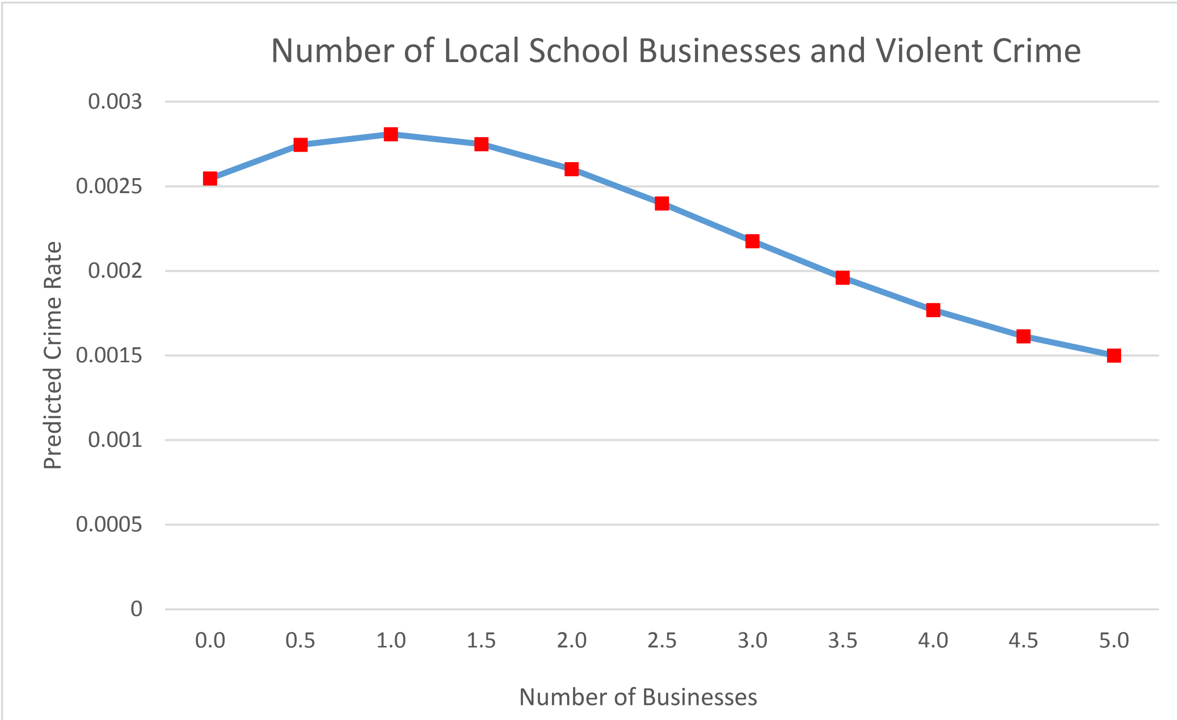

Figure A3.24. Number of Local Service Business and Violent Crime

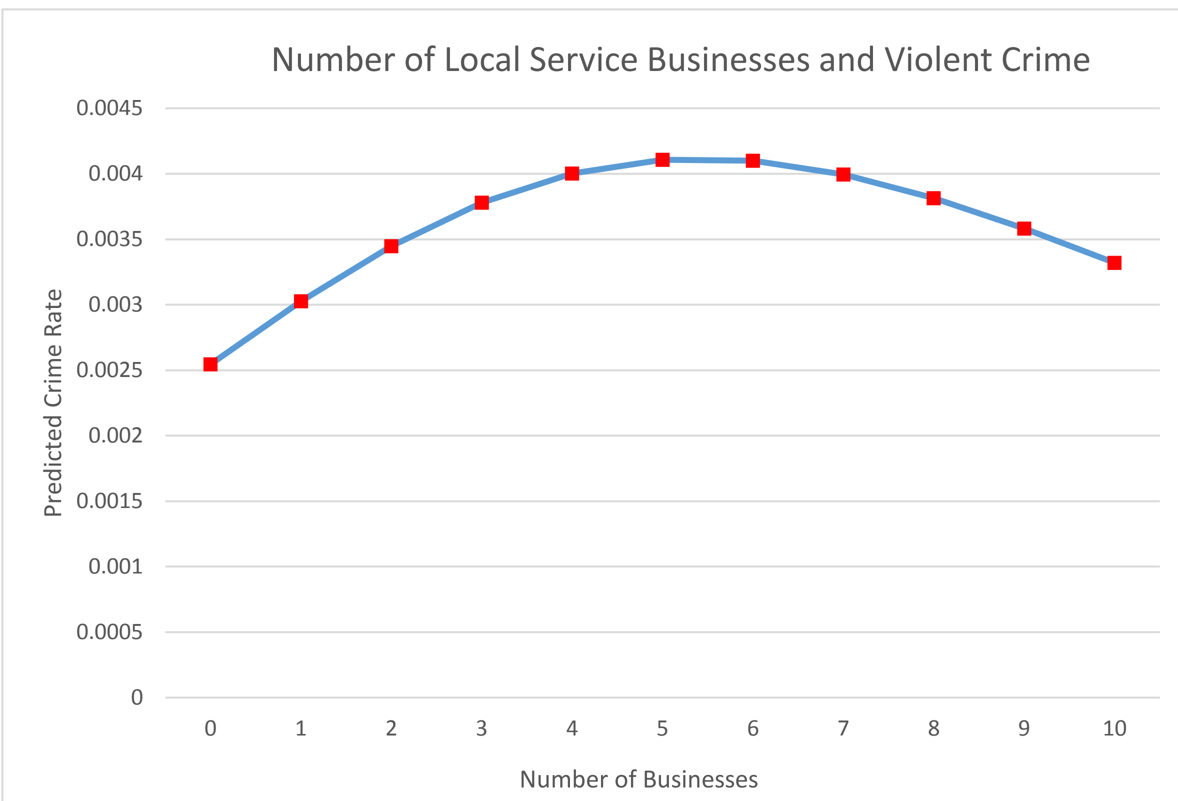

Figure A3.25. Number of Local Finance Business and Violent Crime

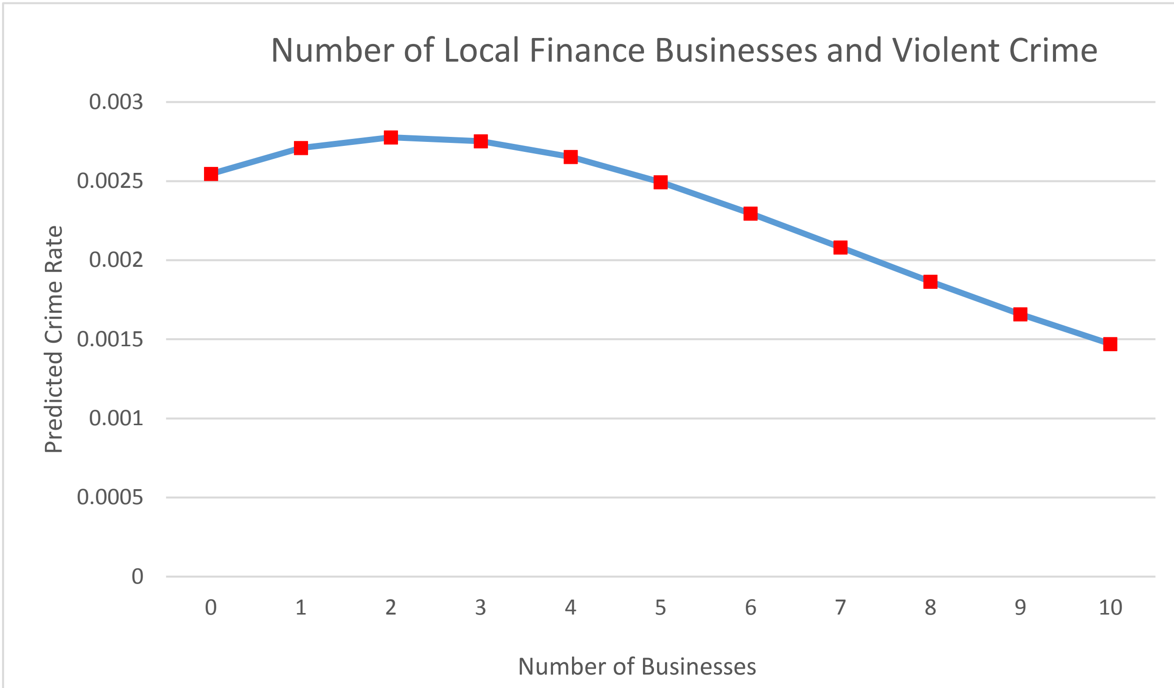

Figure A3.26. Number of Local Restaurants and Violent Crime

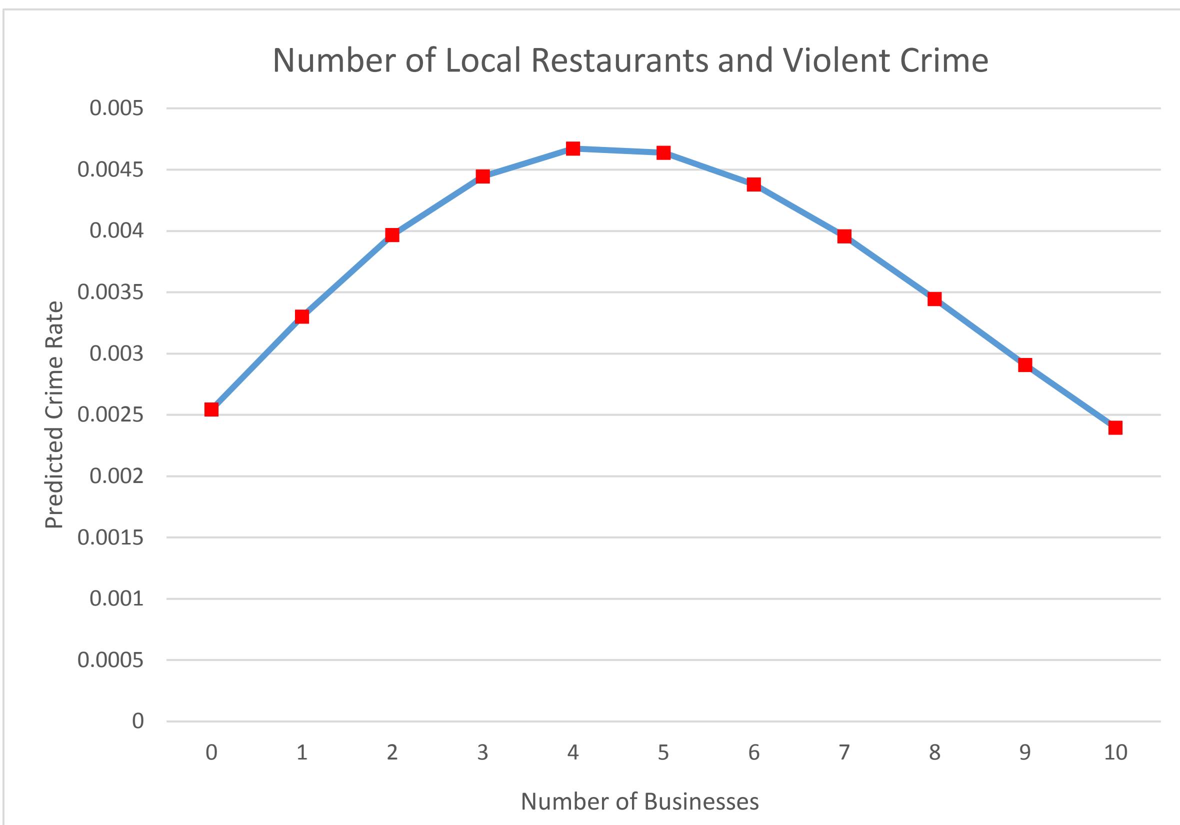

Figure A3.27. Number of Local Health Businesses and Violent Crime

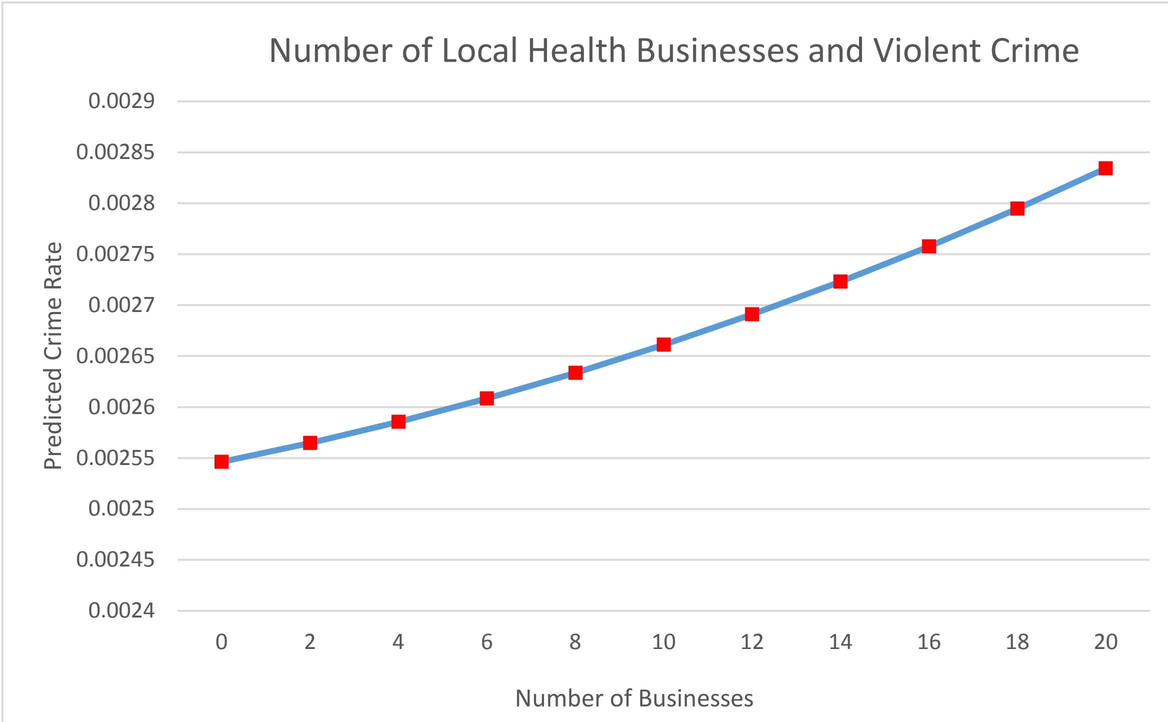

Figure A3.28. Number of Local Amenities and Violent Crime

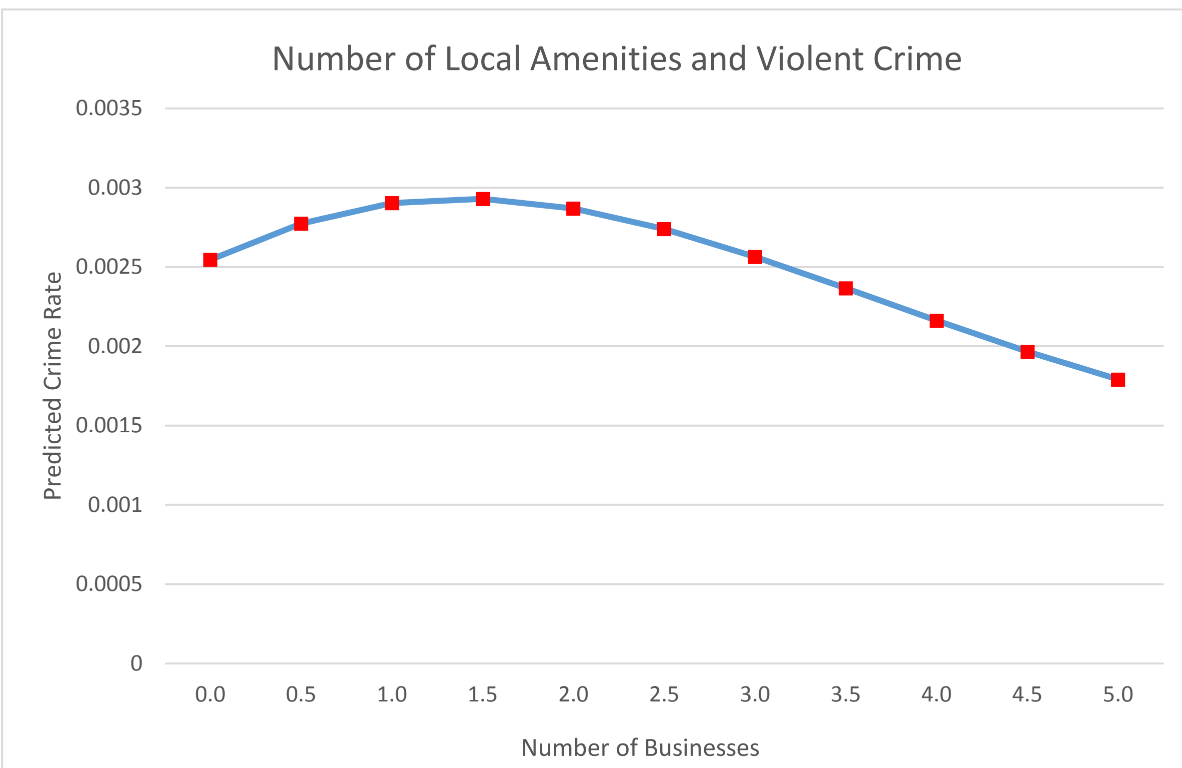

Figure A3.29. Number of Local Organizations and Violent Crime

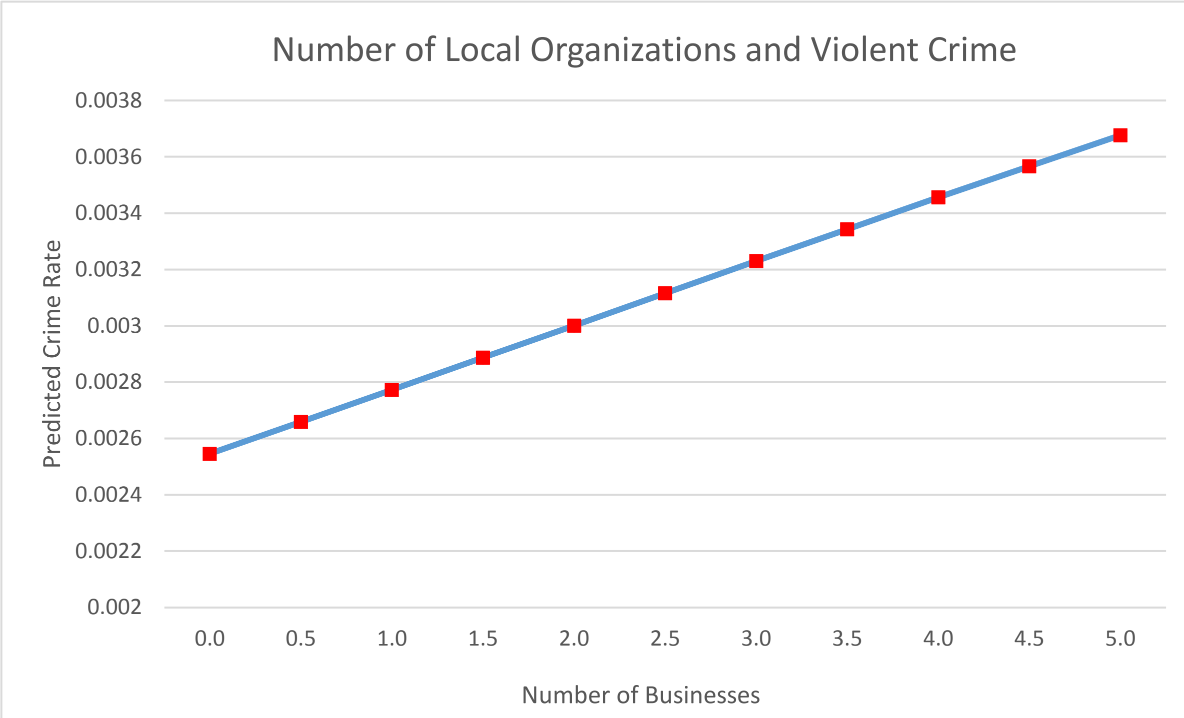

Figure A3.30. Number of Local Stores and Violent Crime

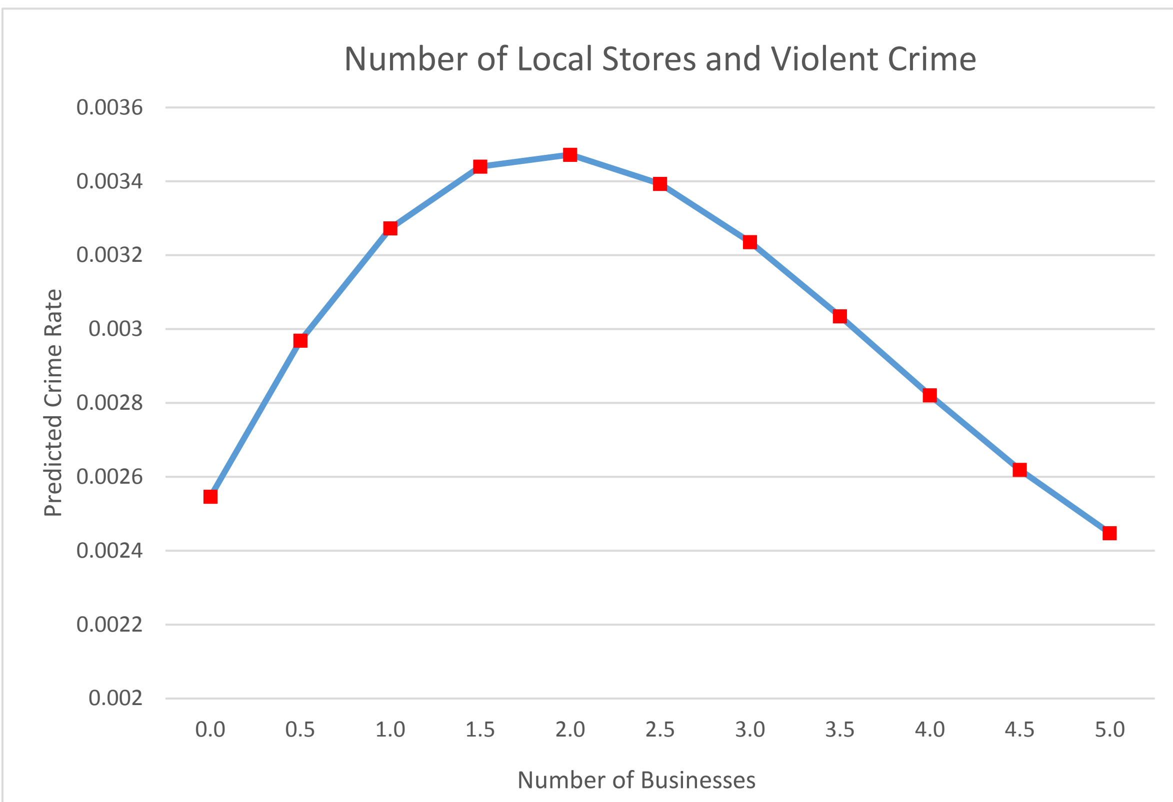

Figure A3.31. Age of Drink Business and Violent Crime

Figure A3.32. Age of Retail Business and Violent Crime

Figure A3.33. Age of School Business and Violent Crime

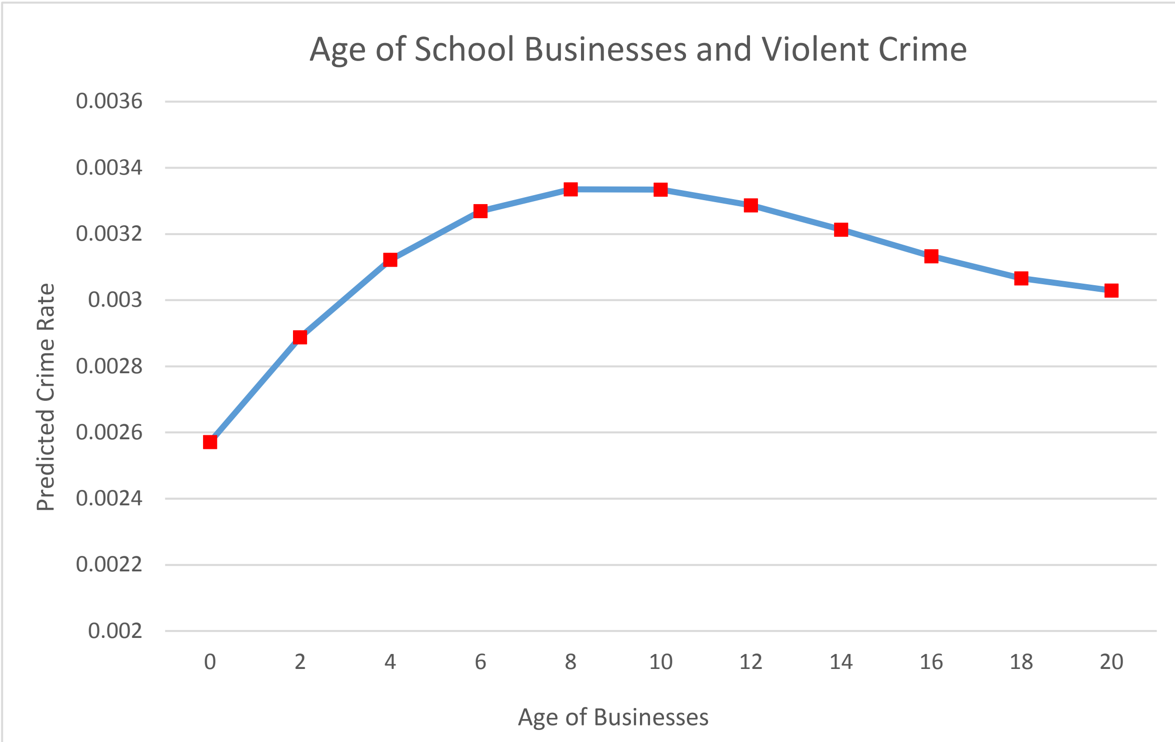

Figure A3.34. Age of Service Business and Violent Crime

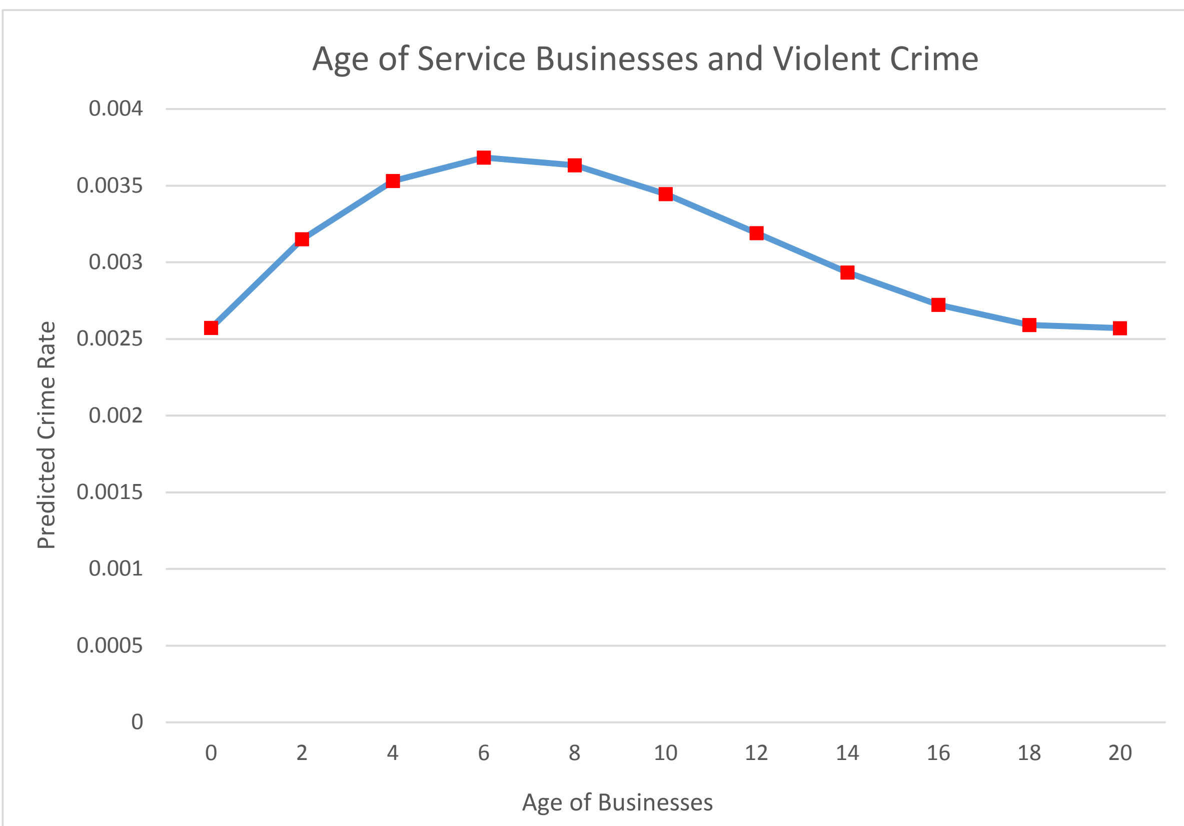

Figure A3.35. Age of Finance Business and Violent Crime

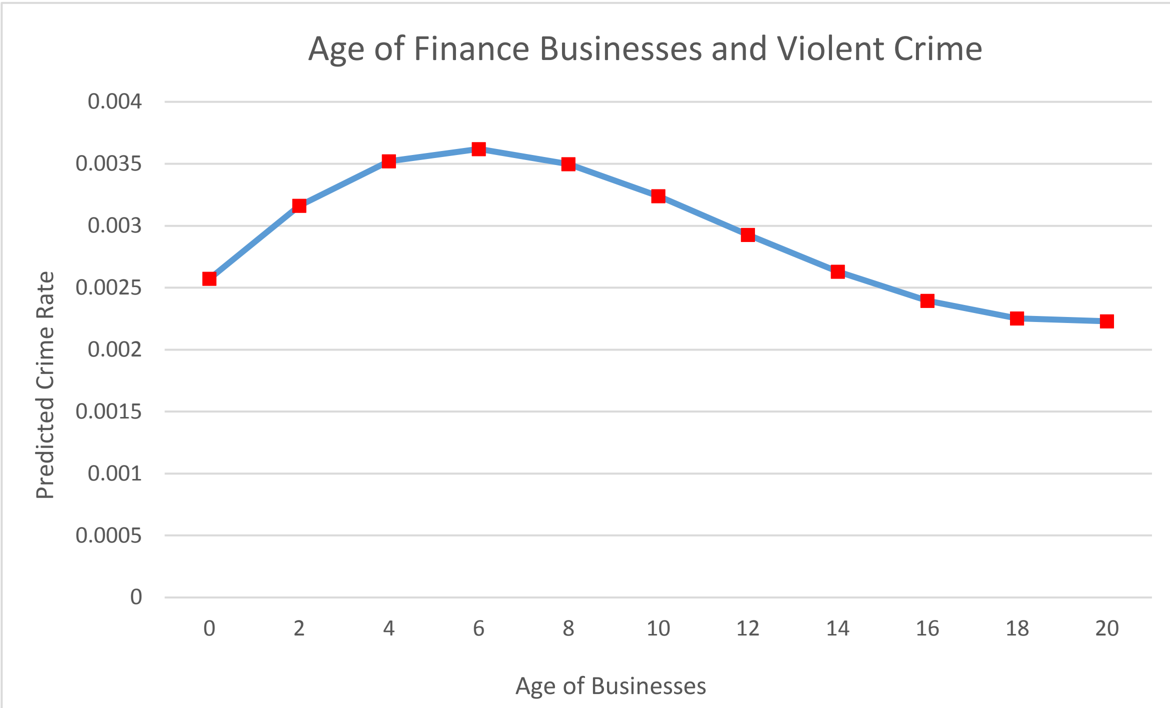

Figure A3.36. Age of Restaurants and Violent Crime

Figure A3.37. Age of Health Businesses and Violent Crime

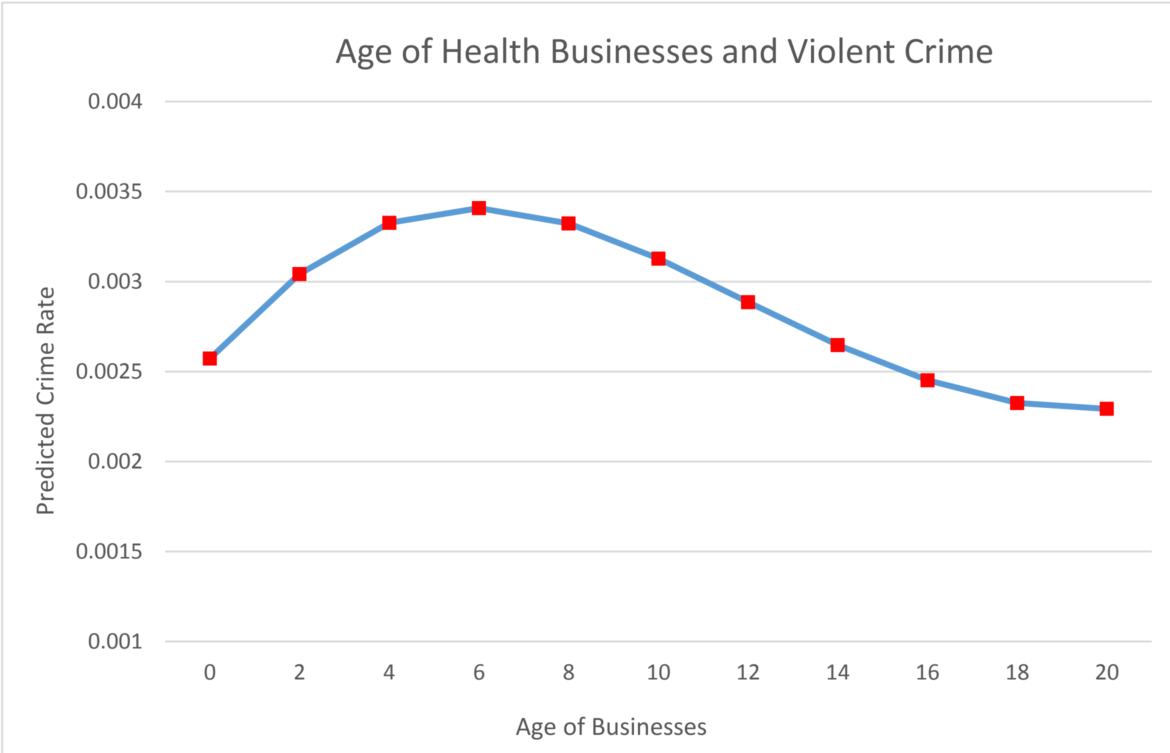

Figure A3.38. Age of Amenities and Violent Crime

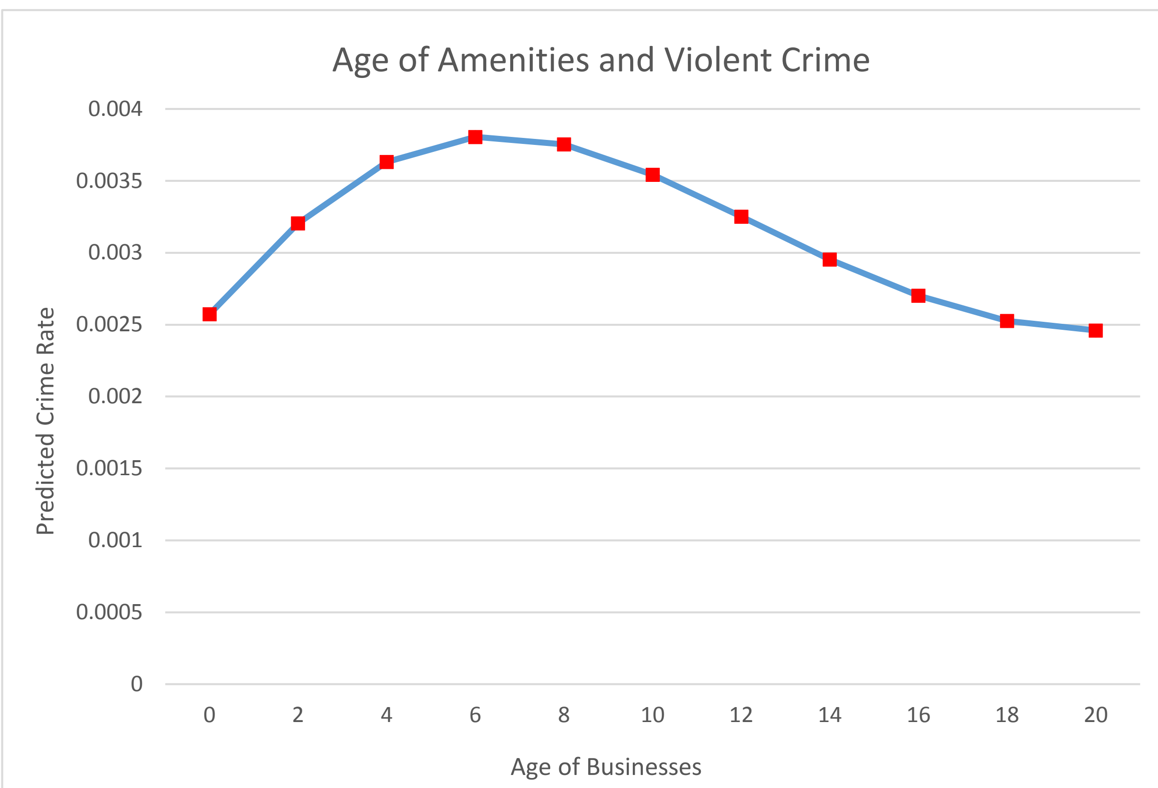

Figure A3.39. Age of Organizations and Violent Crime

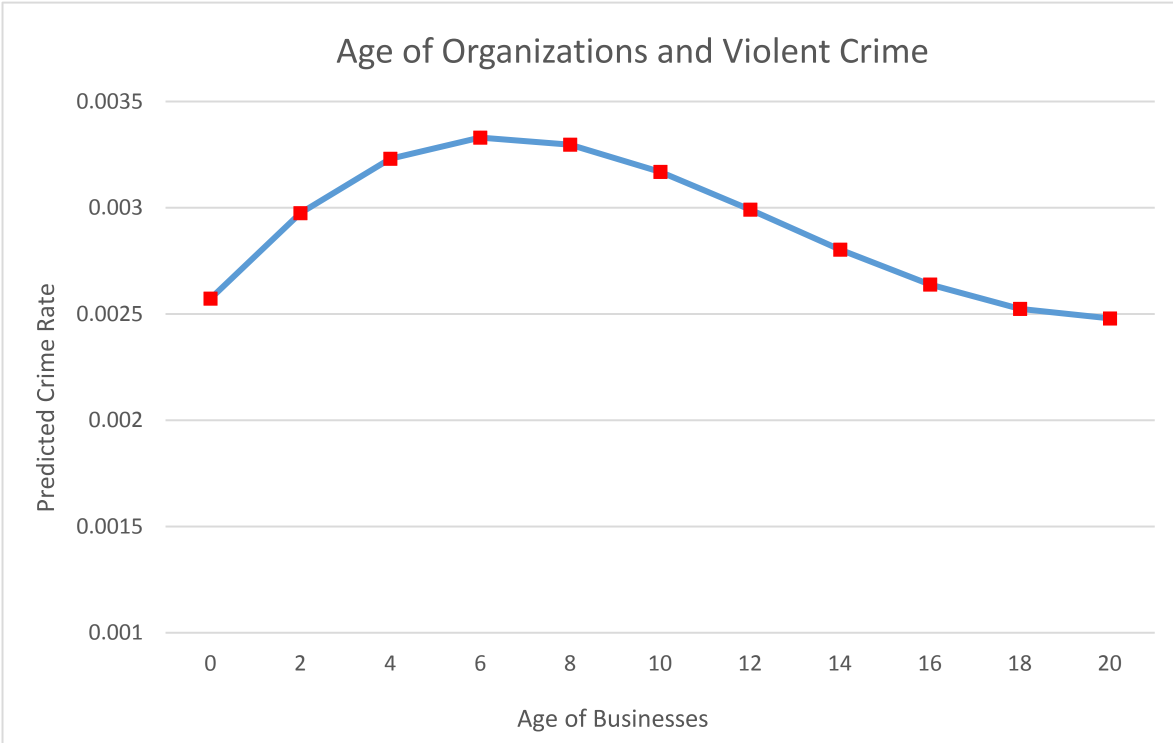

Figure A3.40. Age of Stores and Violent Crime

Figure A3.41. Number of Drink Business and Property Crime

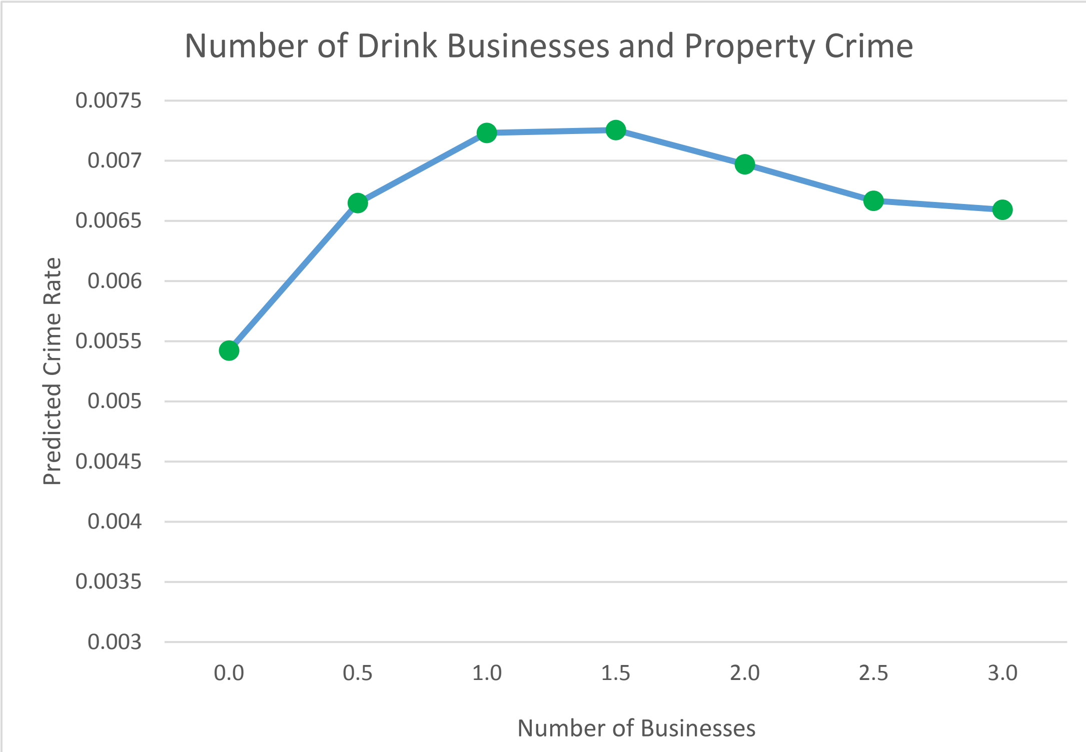

Figure A3.42. Number of Retail Business and Property Crime

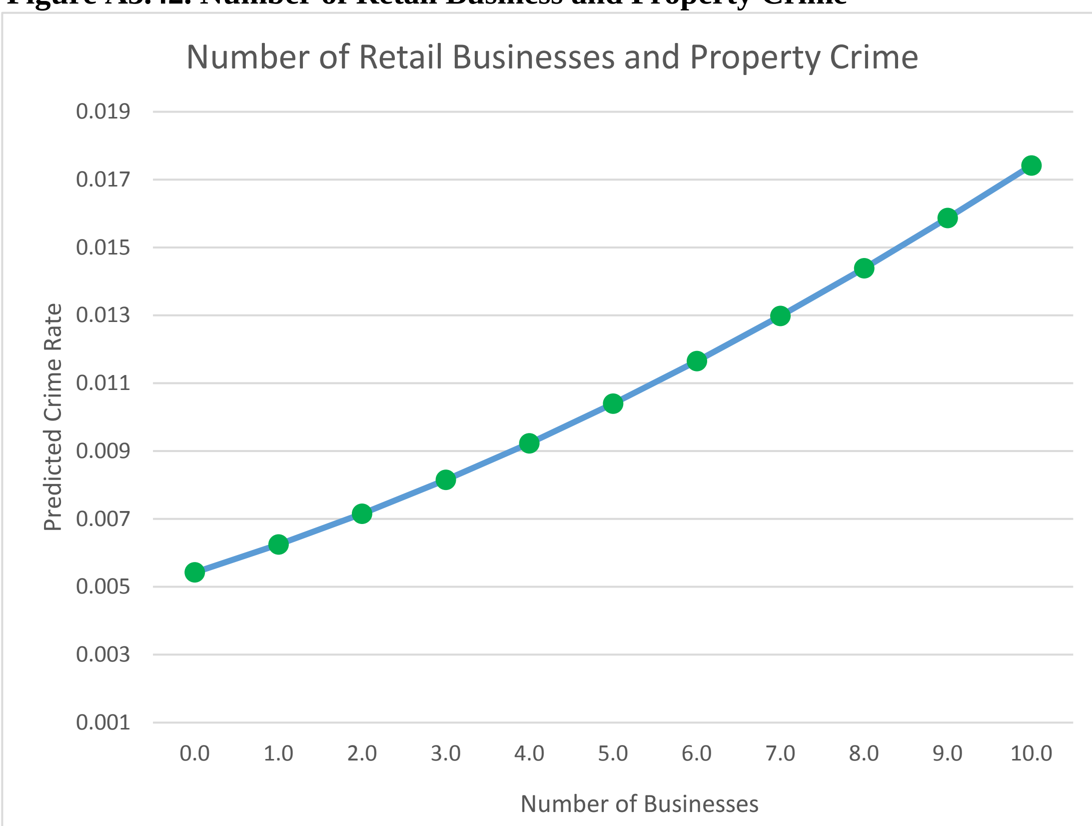

Figure A3.43. Number of School Business and Property Crime

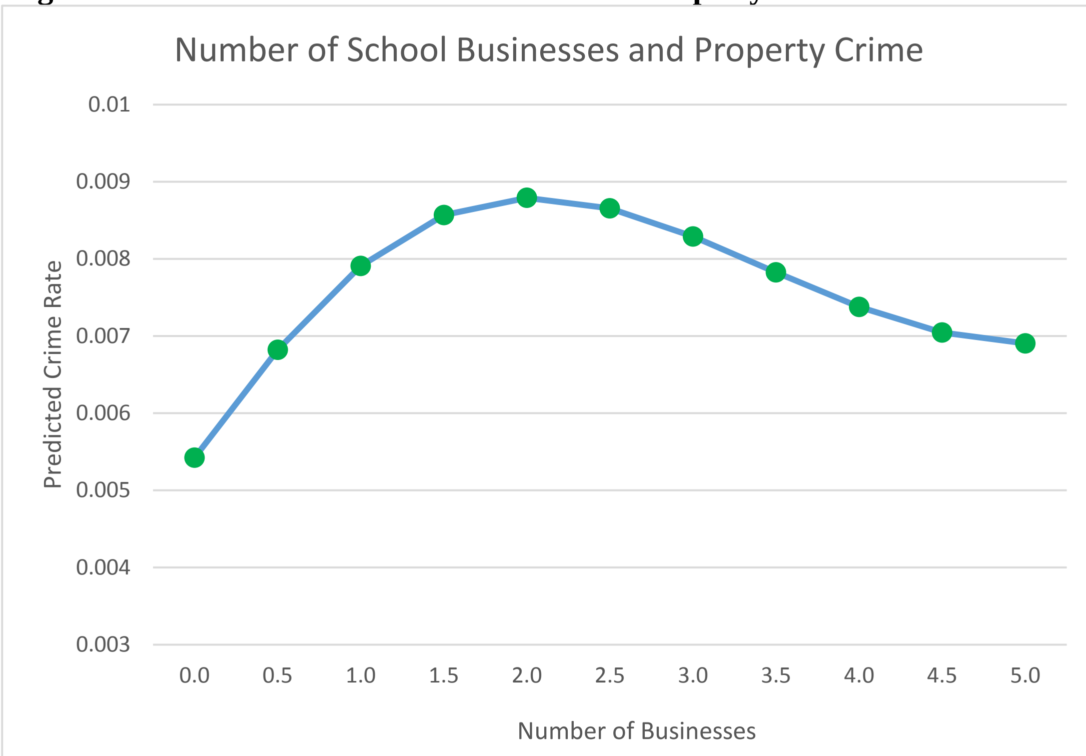

Figure A3.44. Number of Service Business and Property Crime

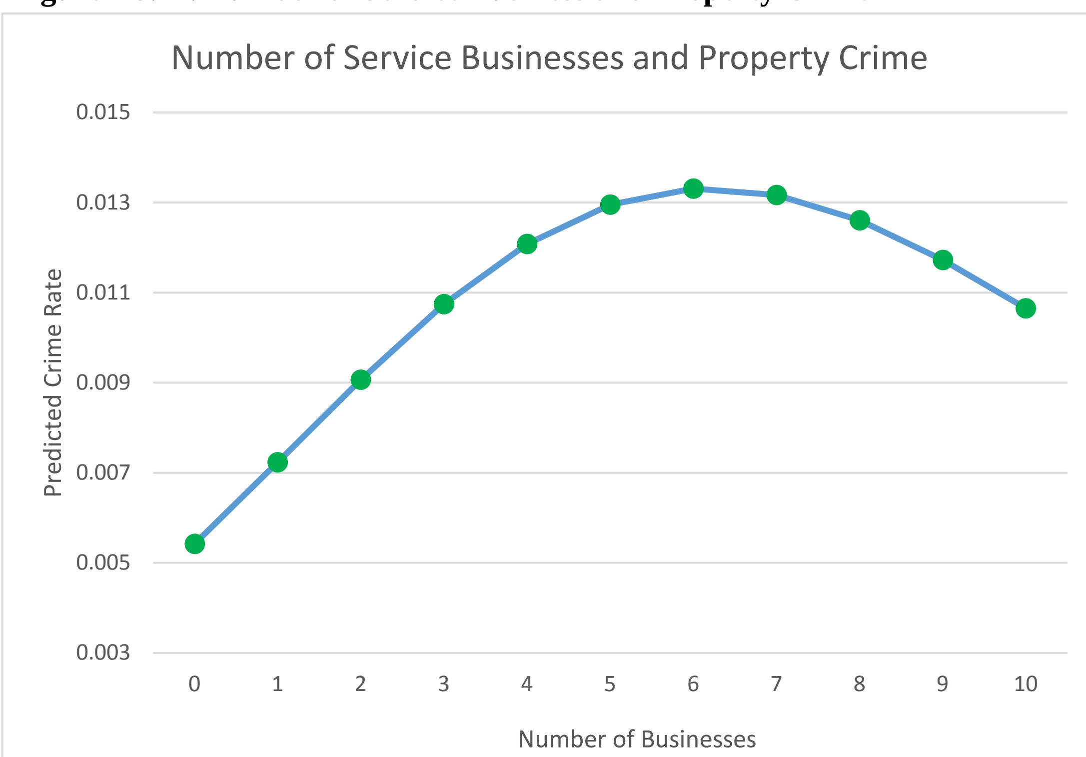

Figure A3.45. Number of Finance Business and Property Crime

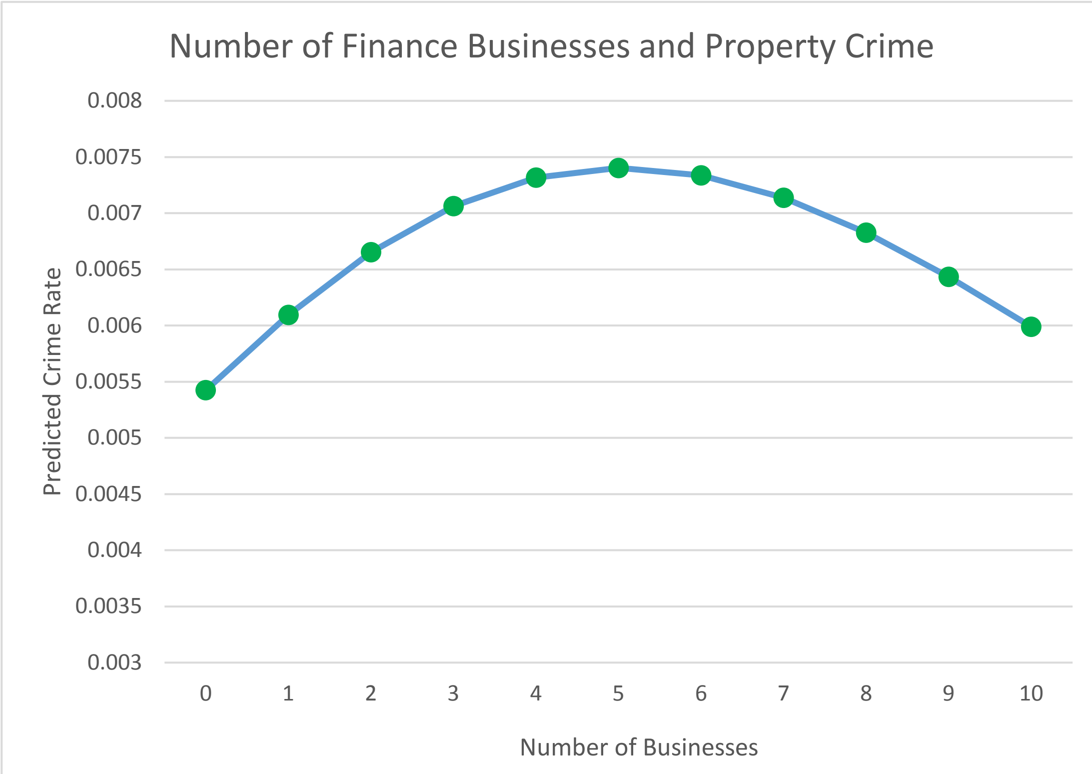

Figure A3.46. Number of Restaurants and Property Crime

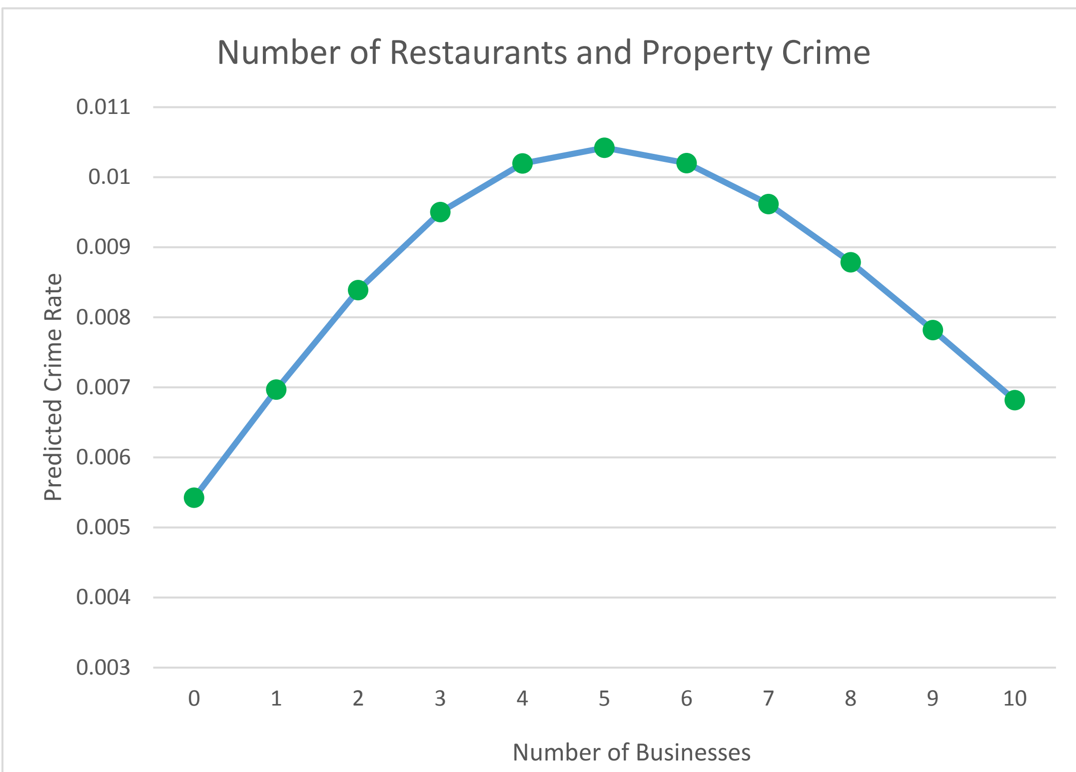

Figure A3.47. Number of Health Businesses and Property Crime

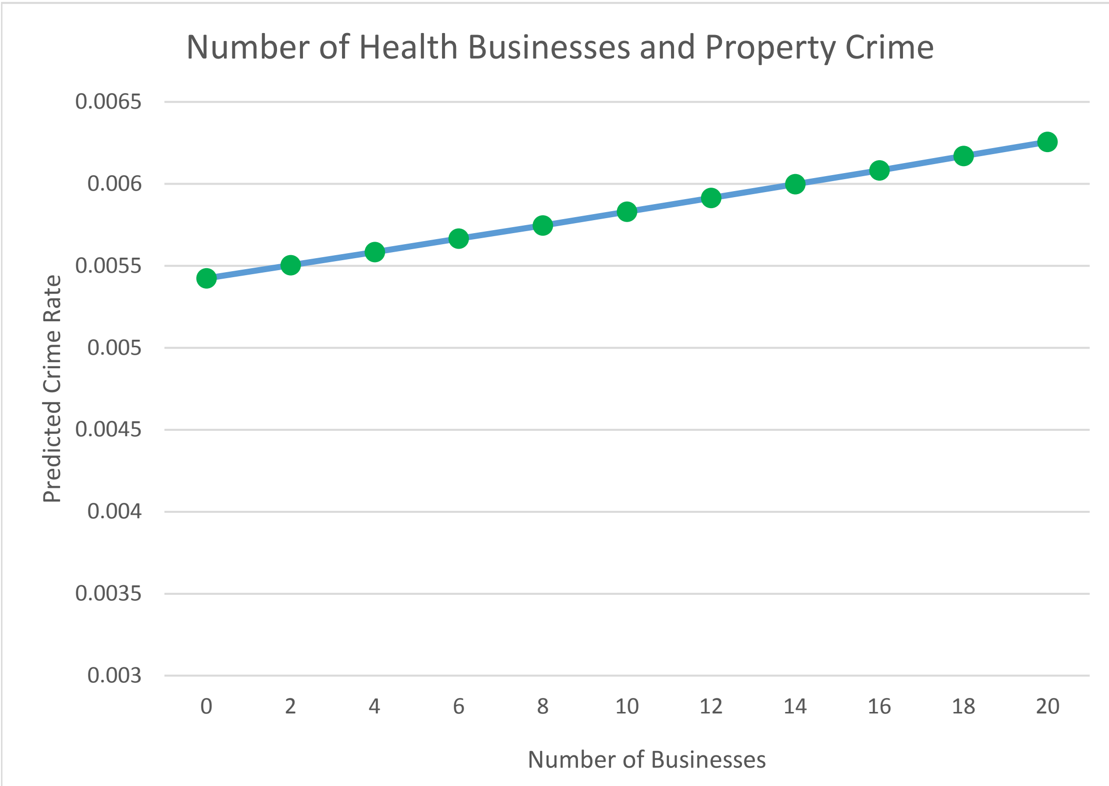

Figure A3.48. Number of Amenities and Property Crime

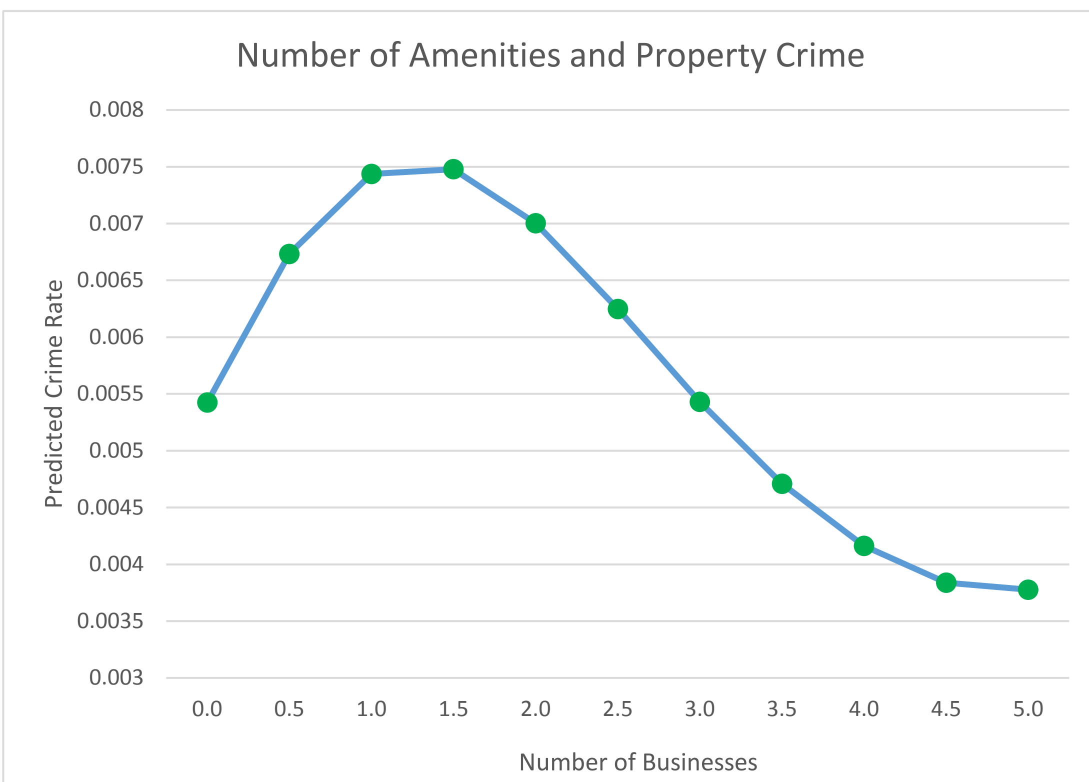

Figure A3.49. Number of Organizations and Property Crime

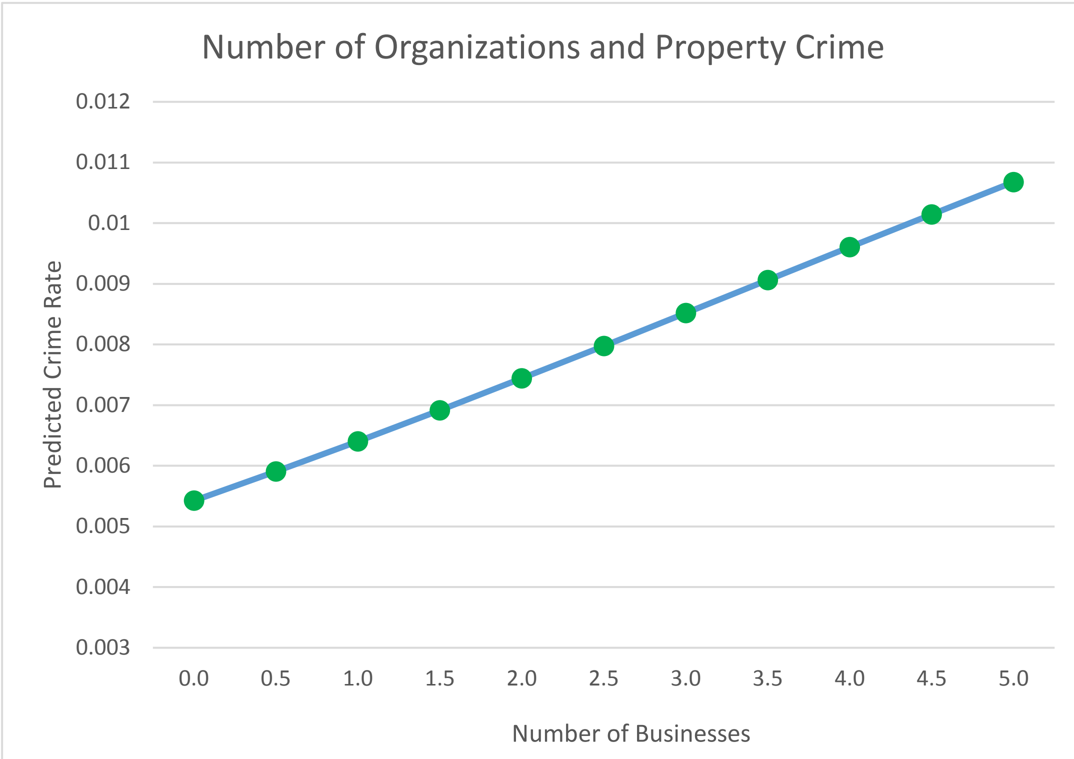

Figure A3.50. Number of Stores and Property Crime

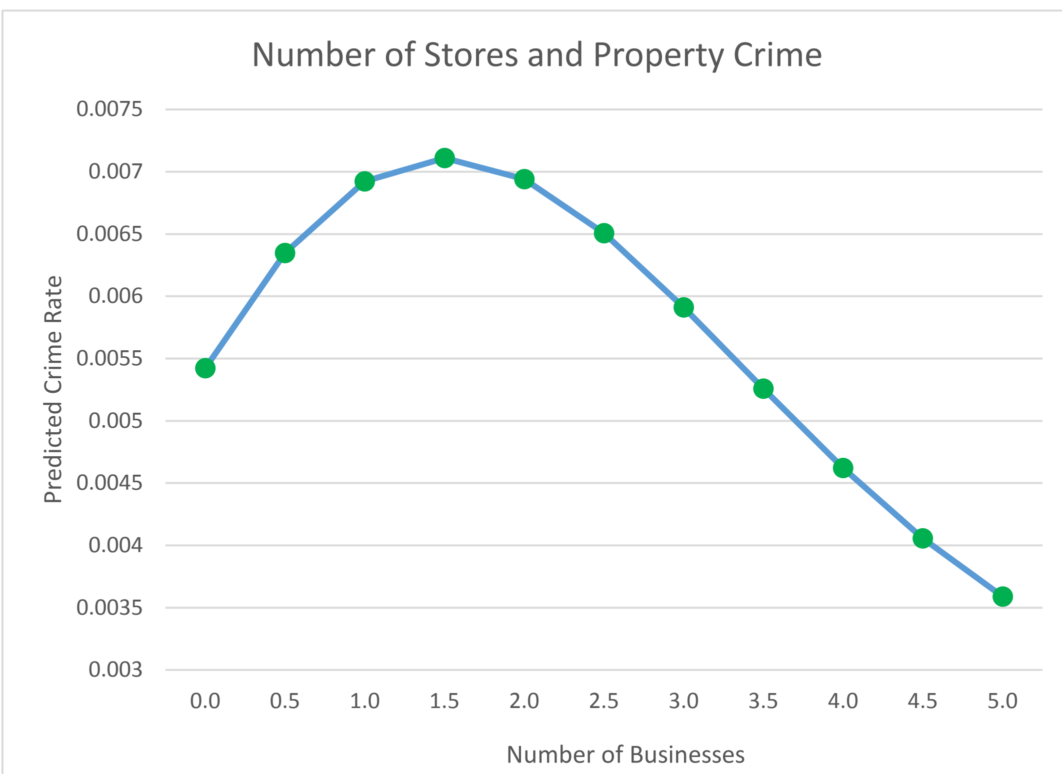

Figure A3.51. Number of Employees of Drink Business and Property Crime

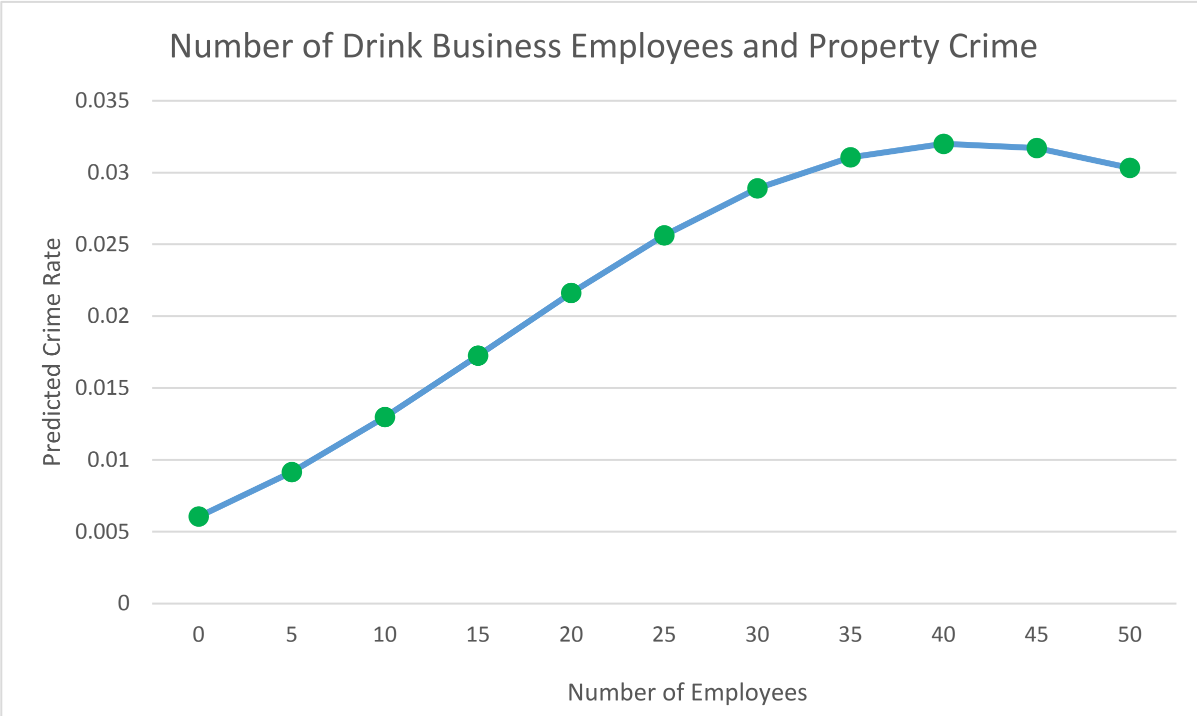

Figure A3.52. Number of Employees of Retail Business and Property Crime

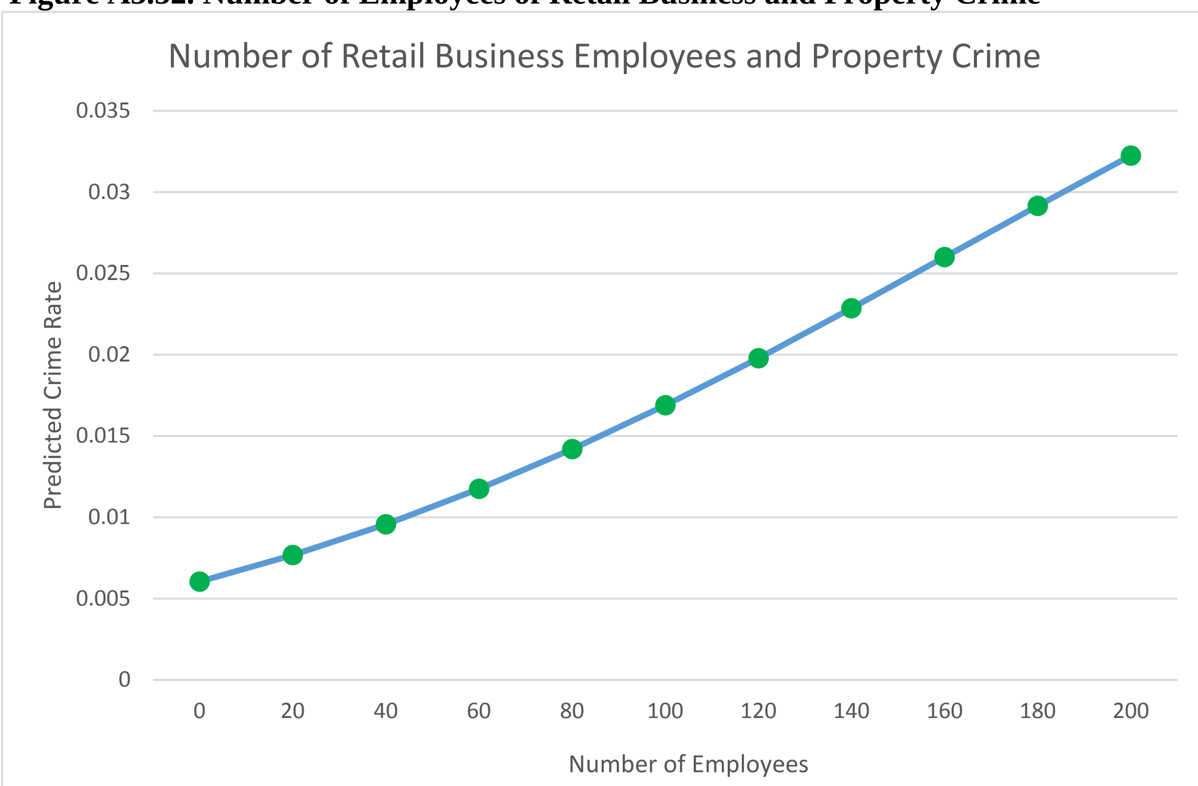

Figure A3.53. Number of Employees of School Business and Property Crime

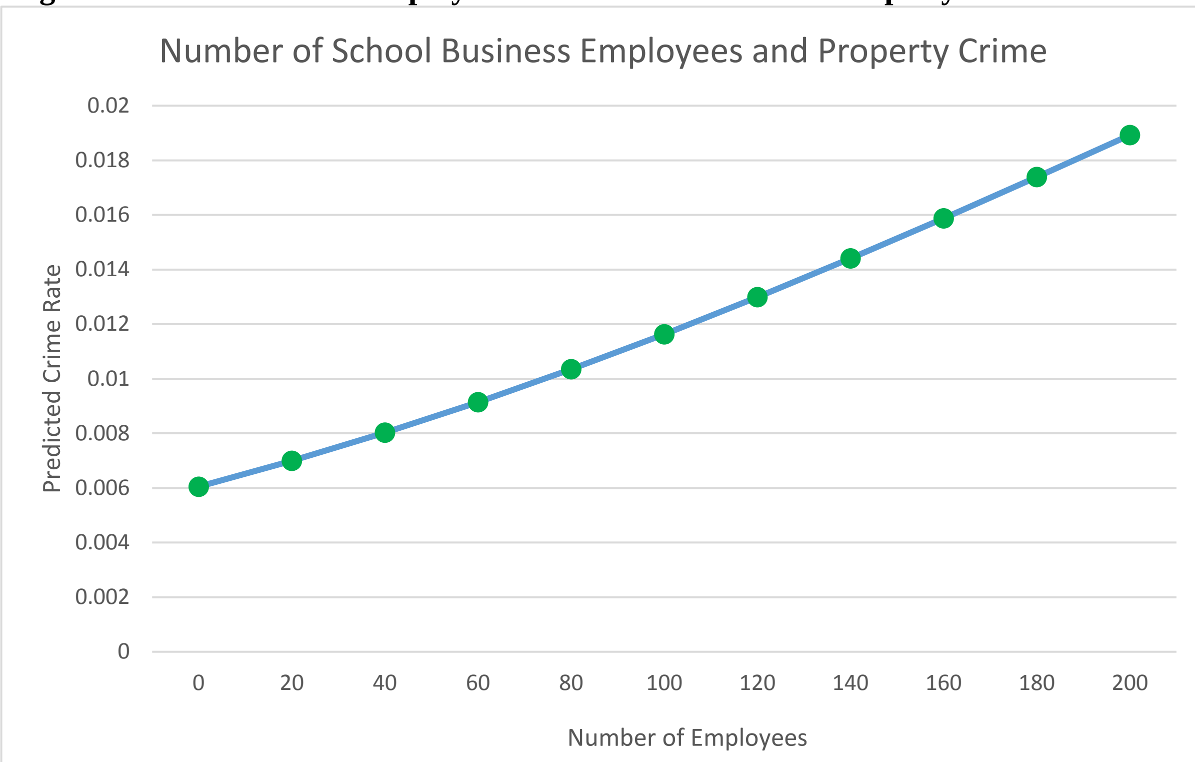

Figure A3.54. Number of Employees of Service Business and Property Crime

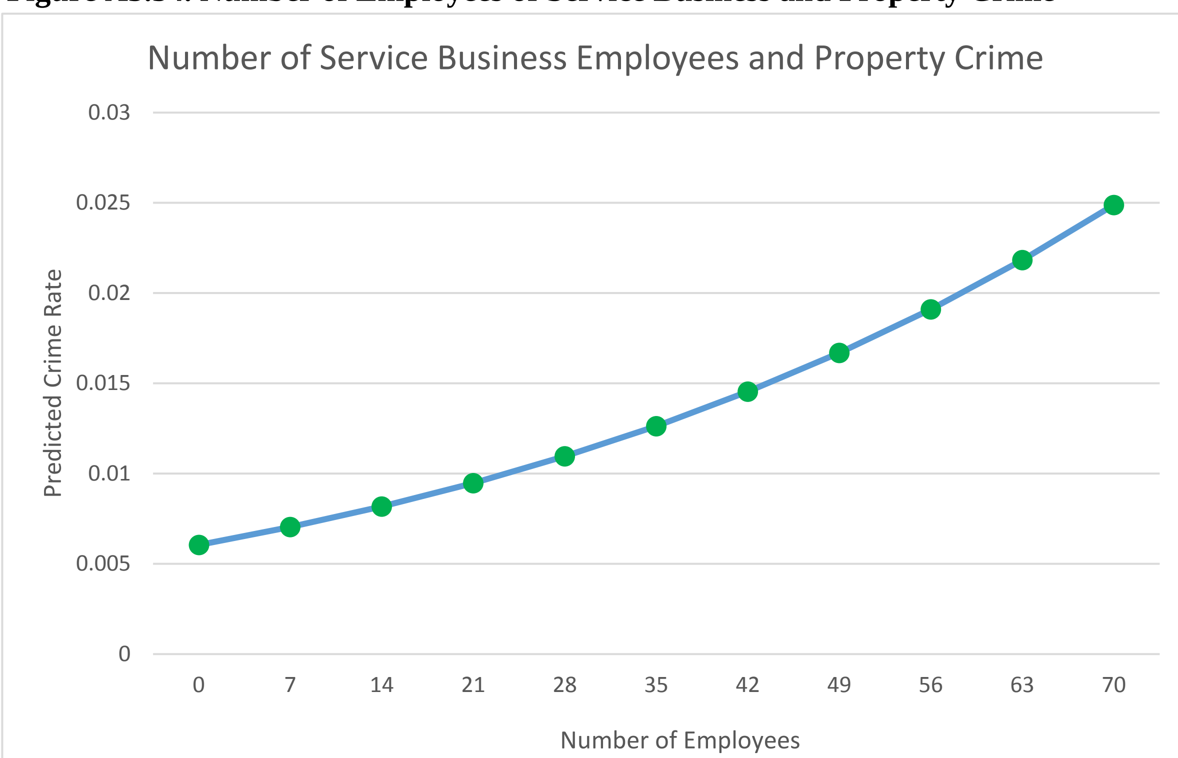

Figure A3.55. Number of Employees of Finance Business and Property Crime

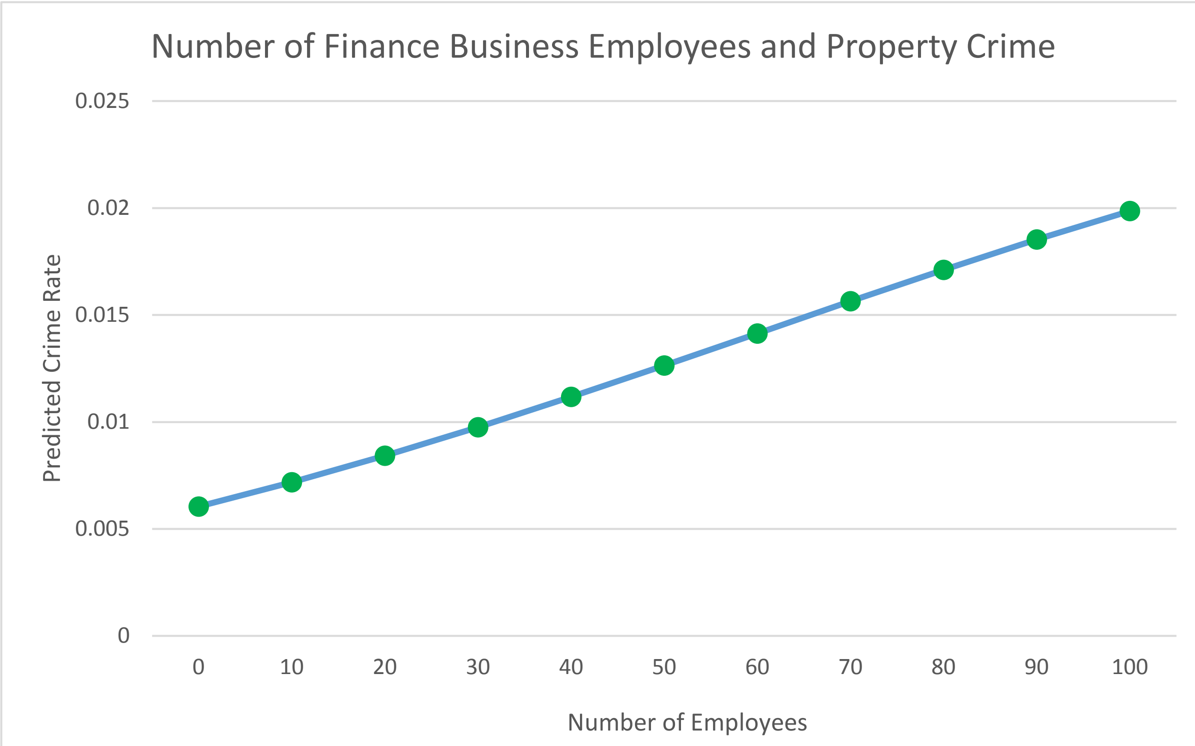

Figure A3.56. Number of Employees of Restaurants and Property Crime

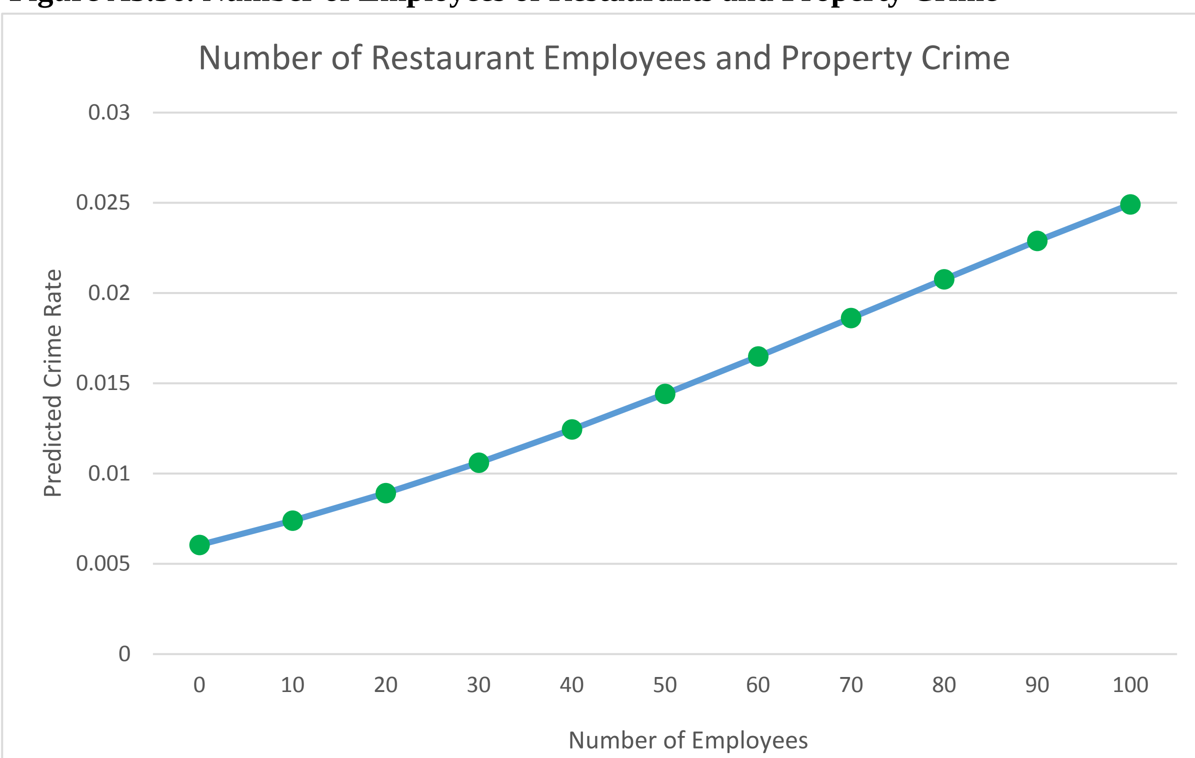

Figure A3.57. Number of Employees of Health Businesses and Property Crime

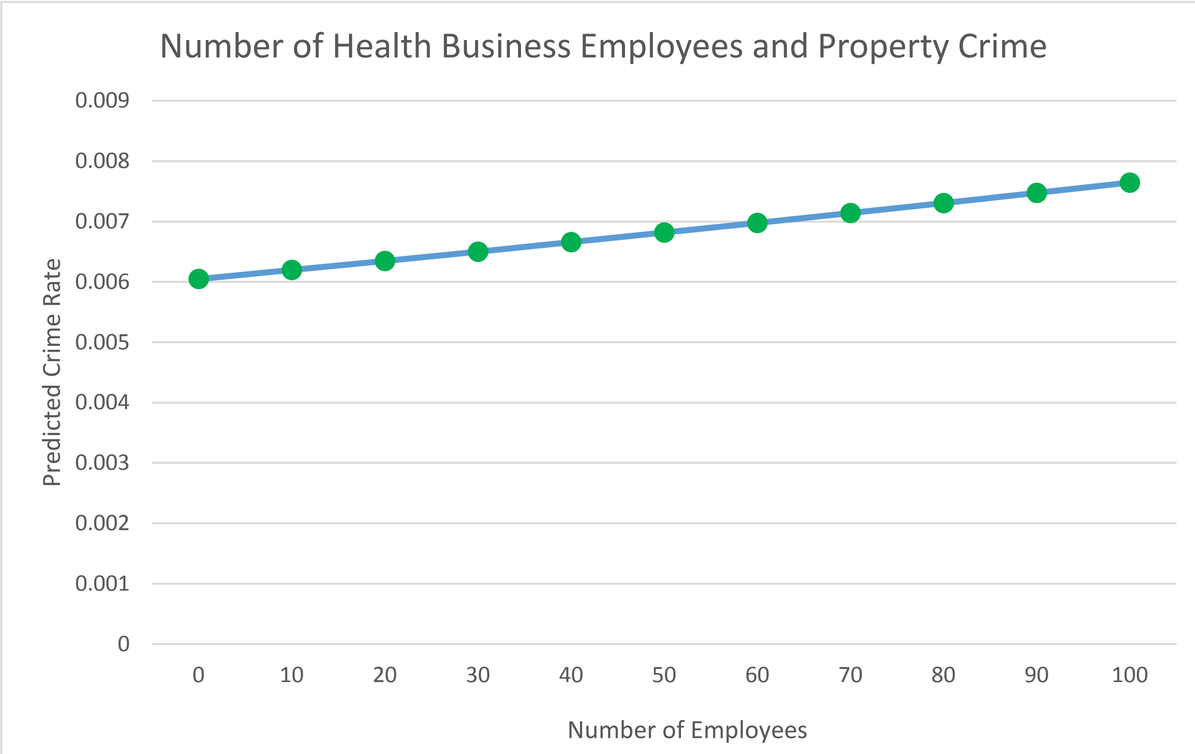

Figure A3.58. Number of Employees of Amenities and Property Crime

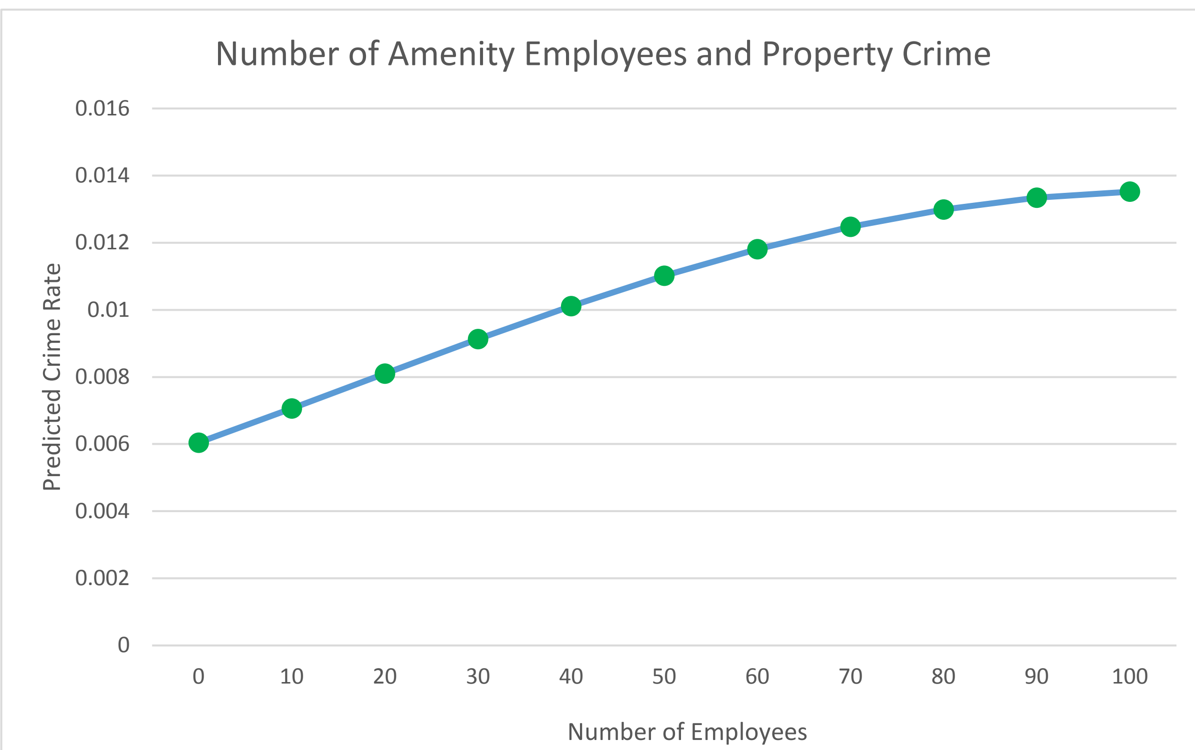

Figure A3.59. Number of Employees of Organizations and Property Crime

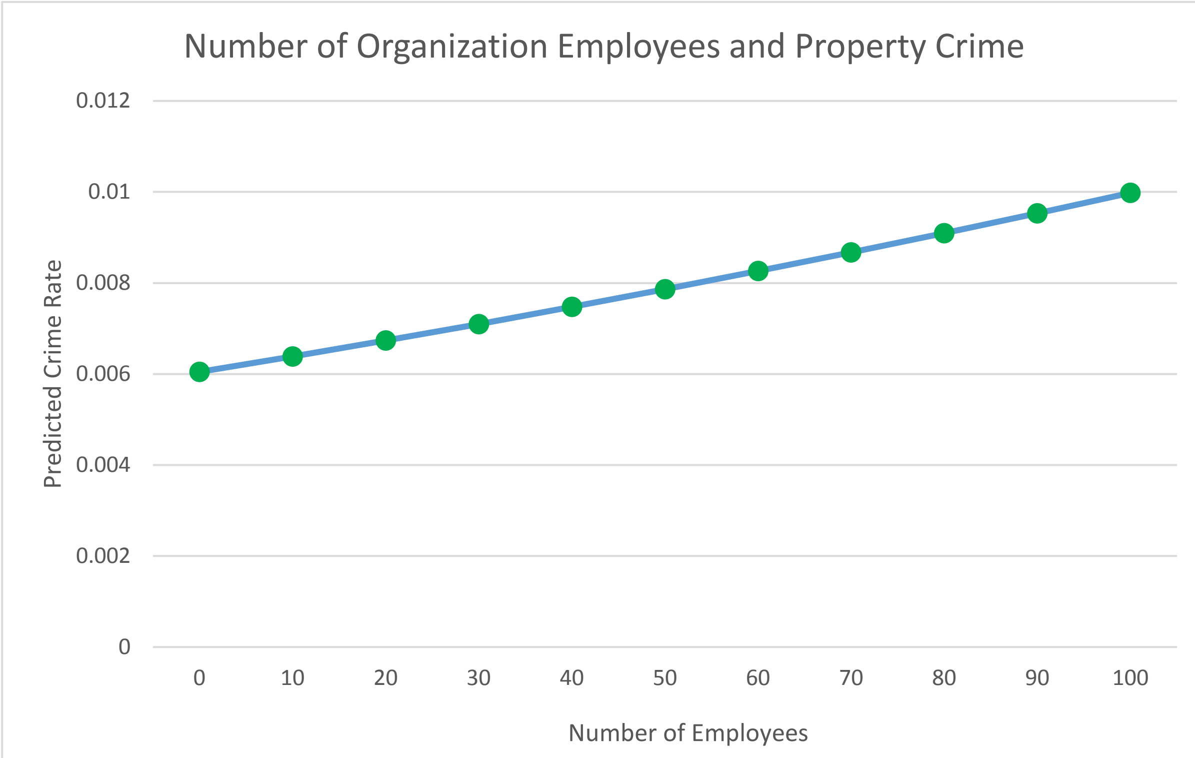

Figure A3.60. Number of Employees of Stores and Property Crime

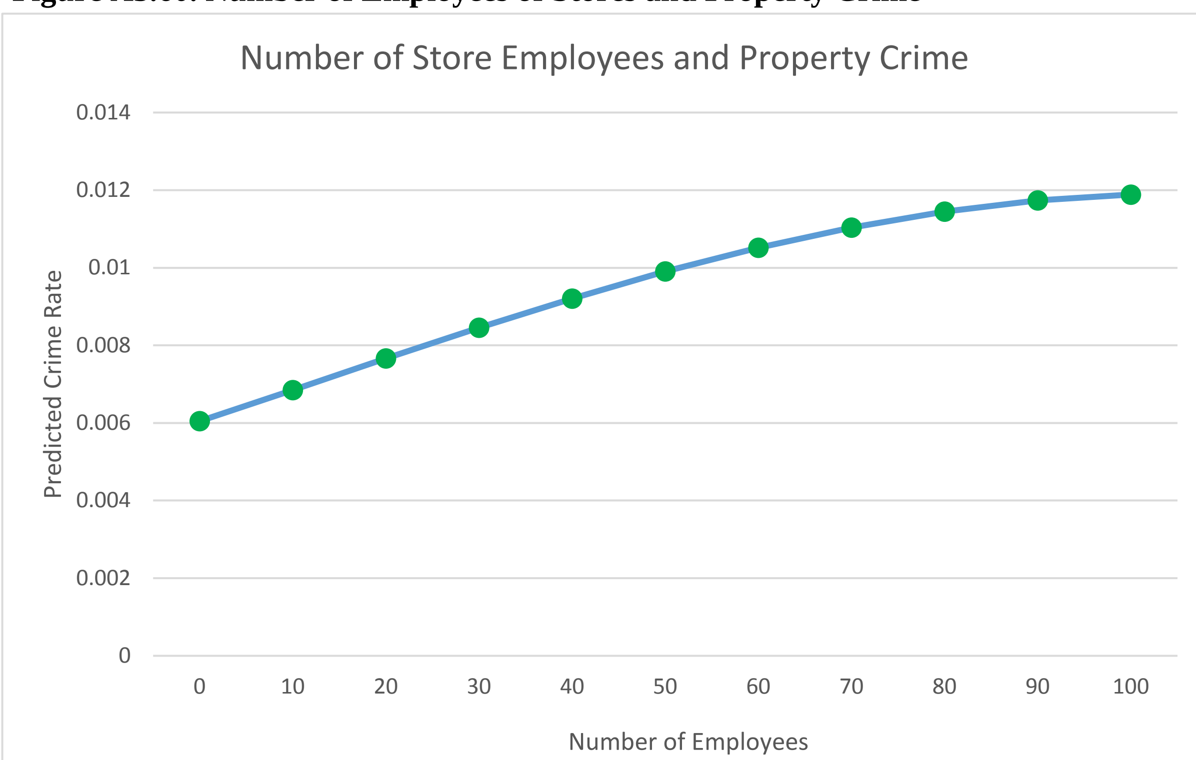

Figure A3.61. Number of Local Drink Business and Property Crime

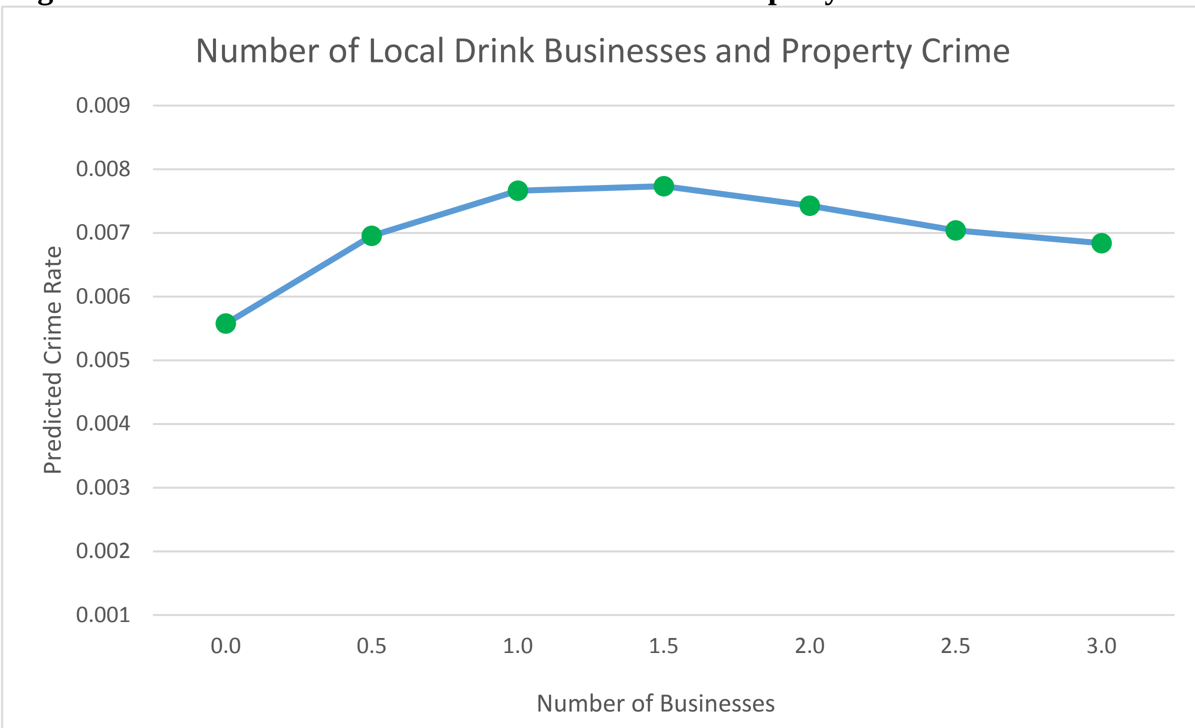

Figure A3.62. Number of Local Retail Business and Property Crime

Figure A3.63. Number of Local School Business and Property Crime

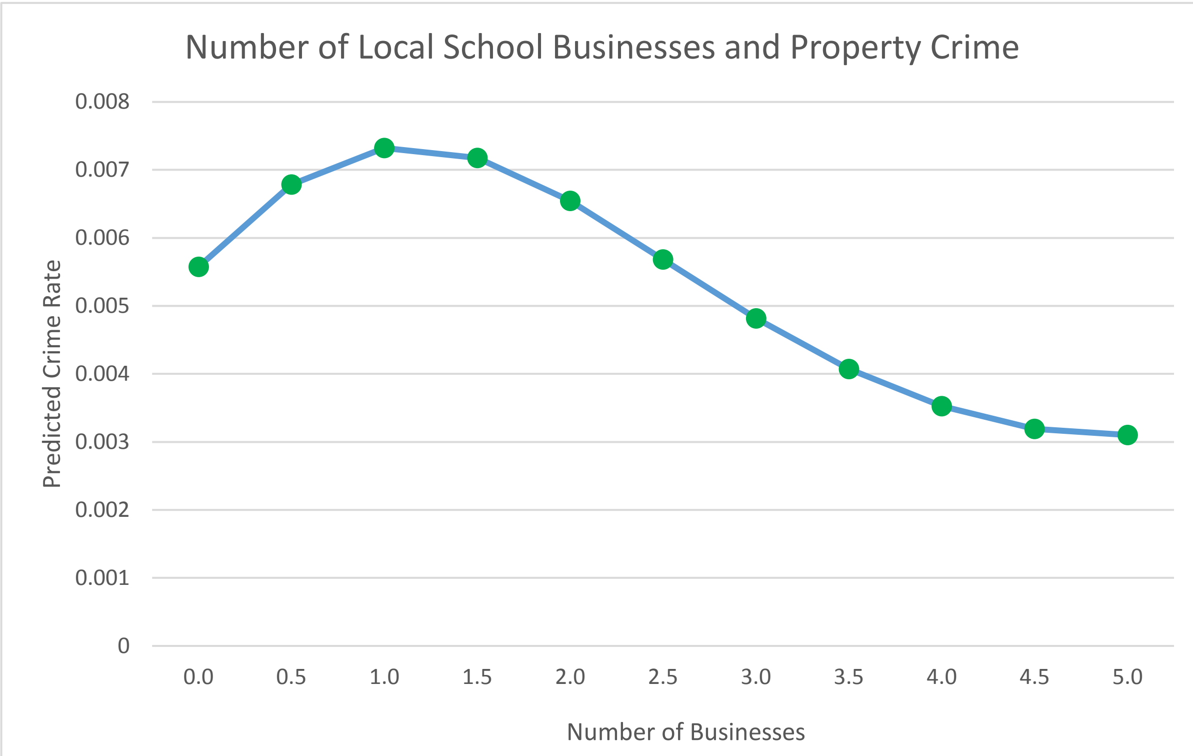

Figure A3.64. Number of Local Service Business and Property Crime

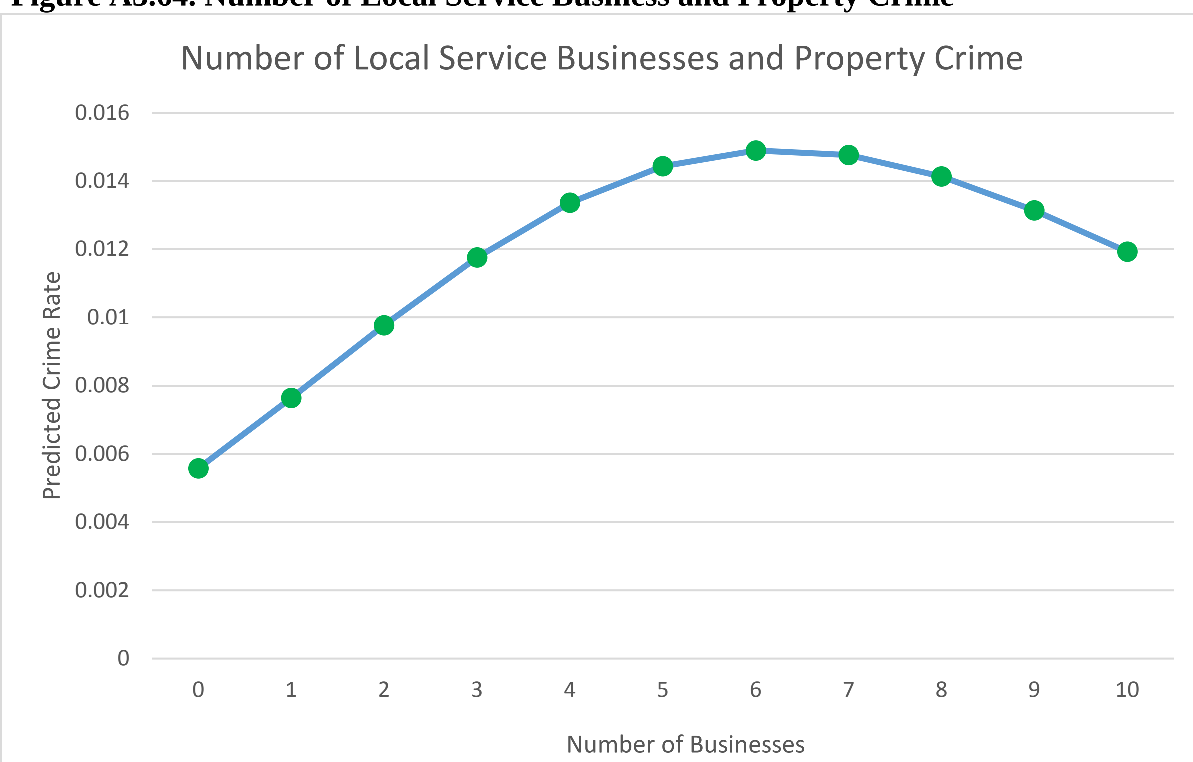

Figure A3.65. Number of Local Finance Business and Property Crime

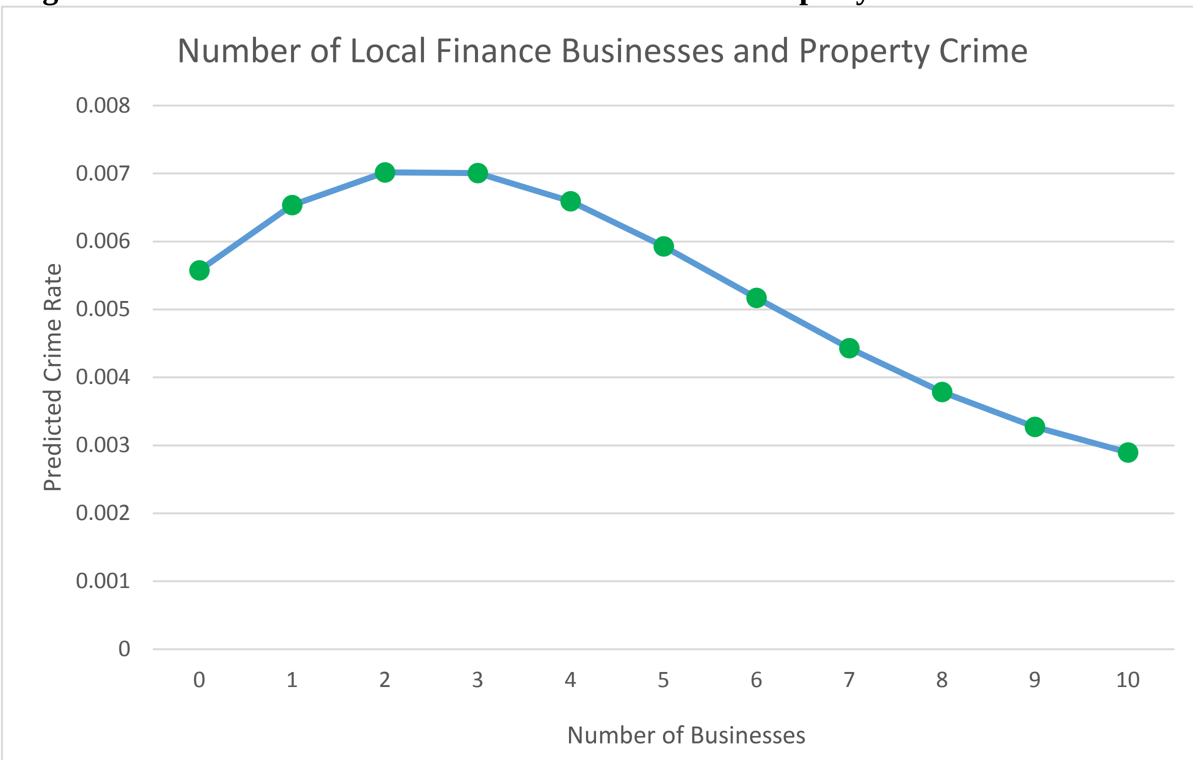

Figure A3.66. Number of Local Restaurants and Property Crime

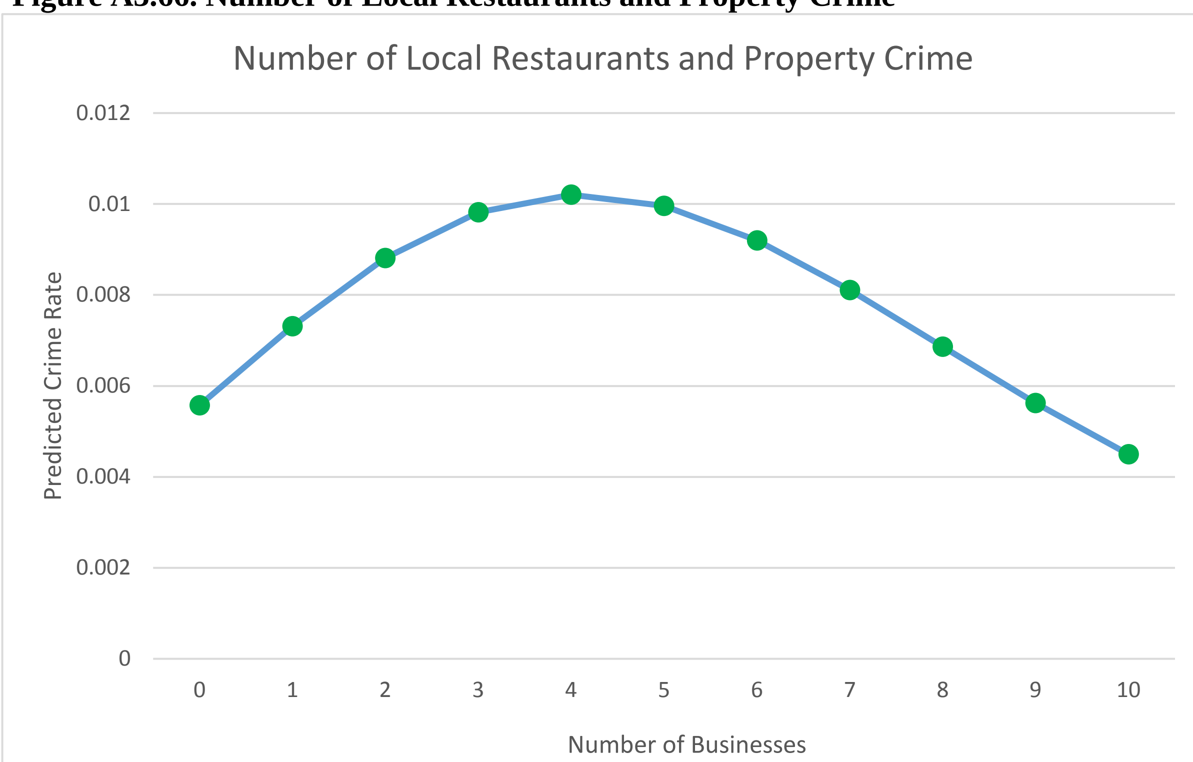

Figure A3.67. Number of Local Health Businesses and Property Crime

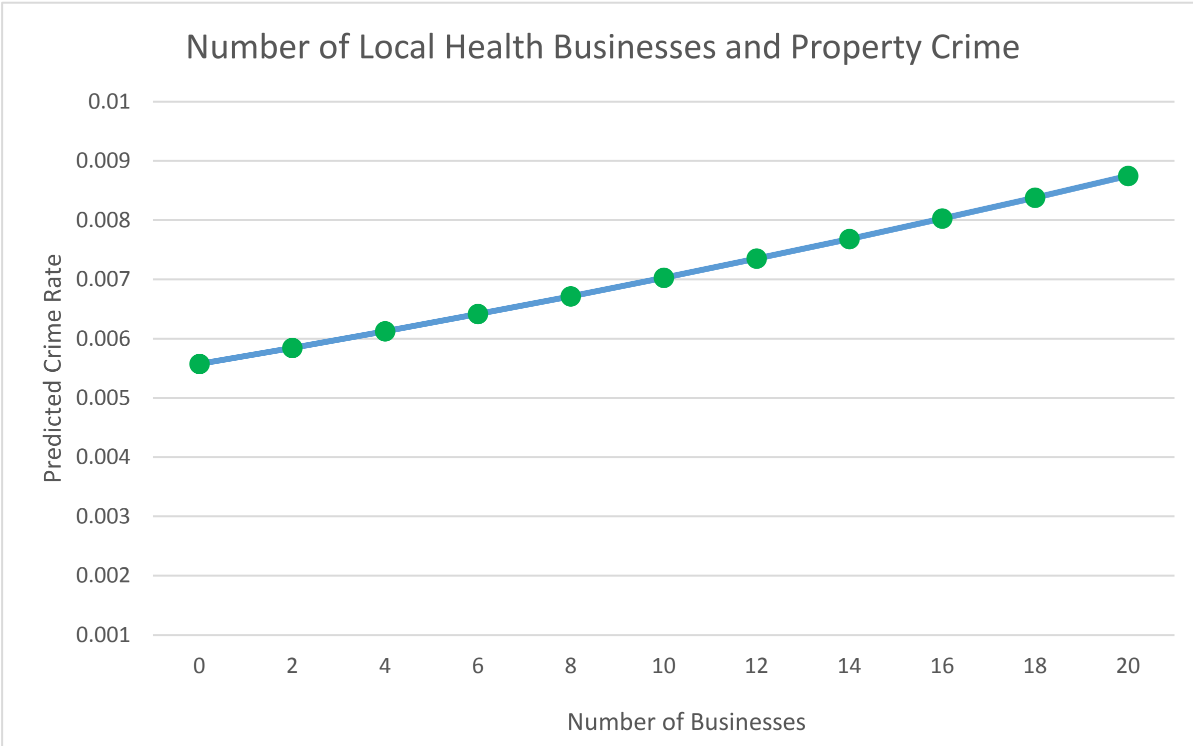

Figure A3.68. Number of Local Amenities and Property Crime

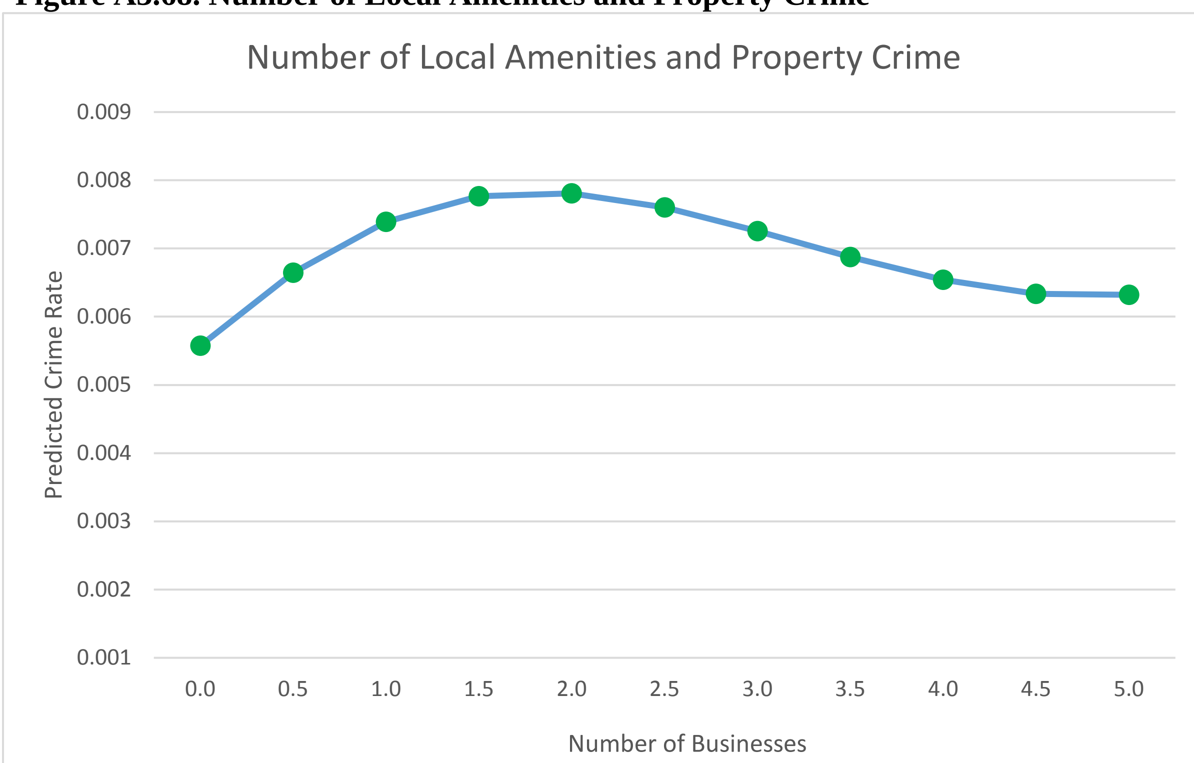

Figure A3.69. Number of Local Organizations and Property Crime

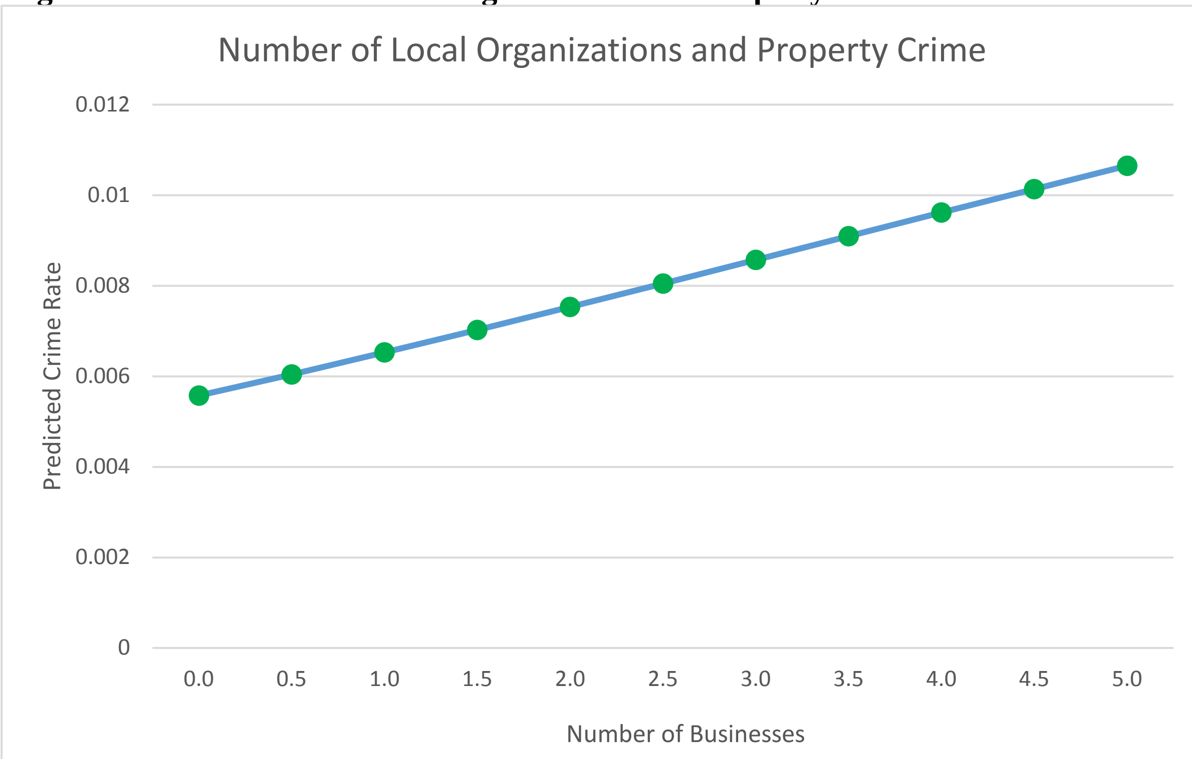

Figure A3.70. Number of Local Stores and Property Crime

Figure A3.71. Age of Drink Business and Property Crime

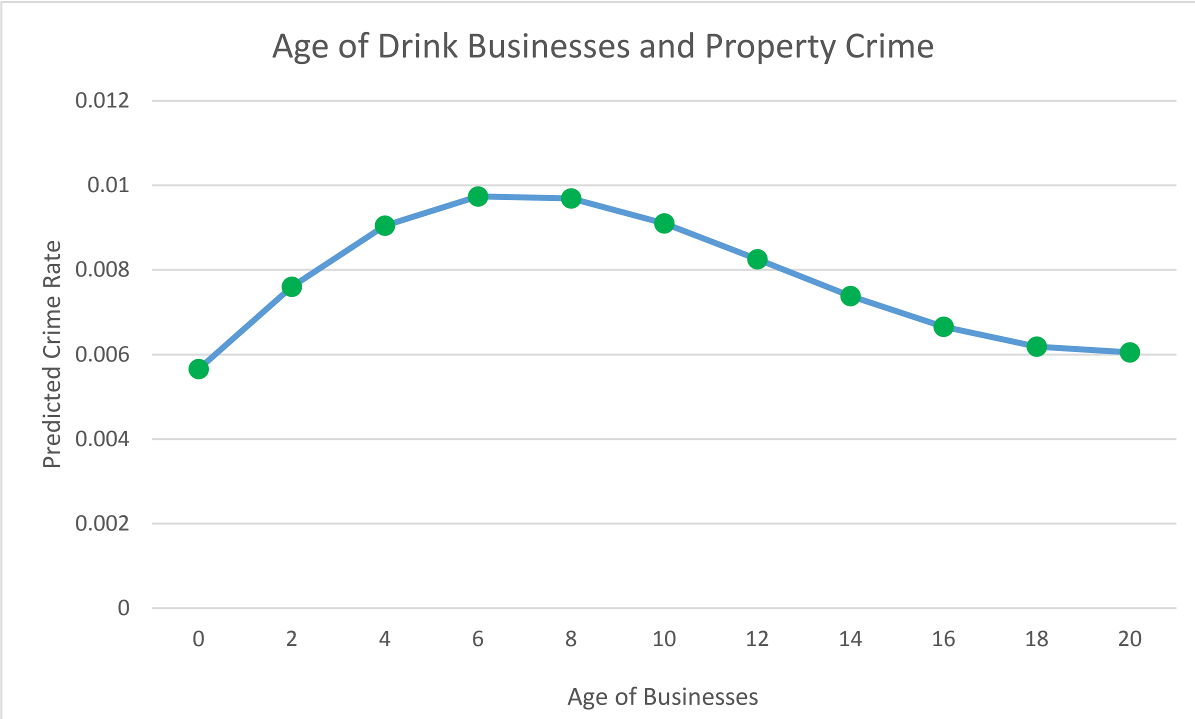

Figure A3.72. Age of Retail Business and Property Crime

Figure A3.73. Age of School Business and Property Crime

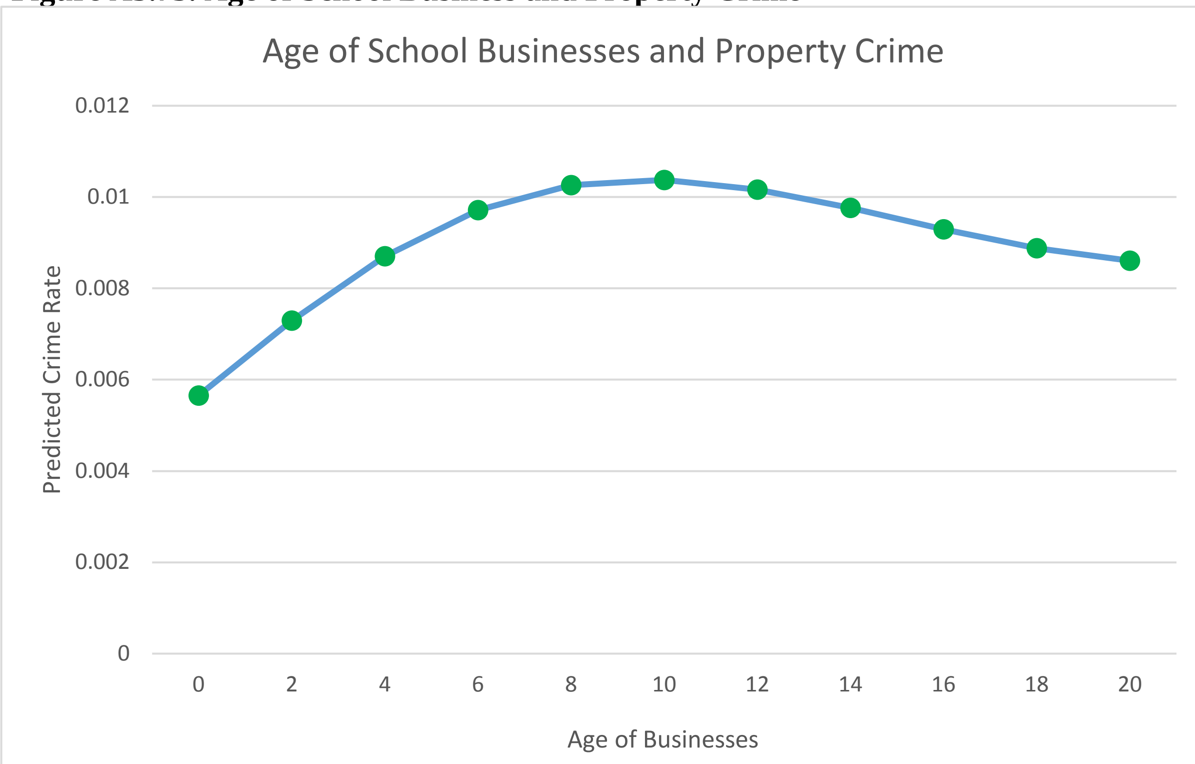

Figure A3.74. Age of Service Business and Property Crime

Figure A3.75. Age of Finance Business and Property Crime

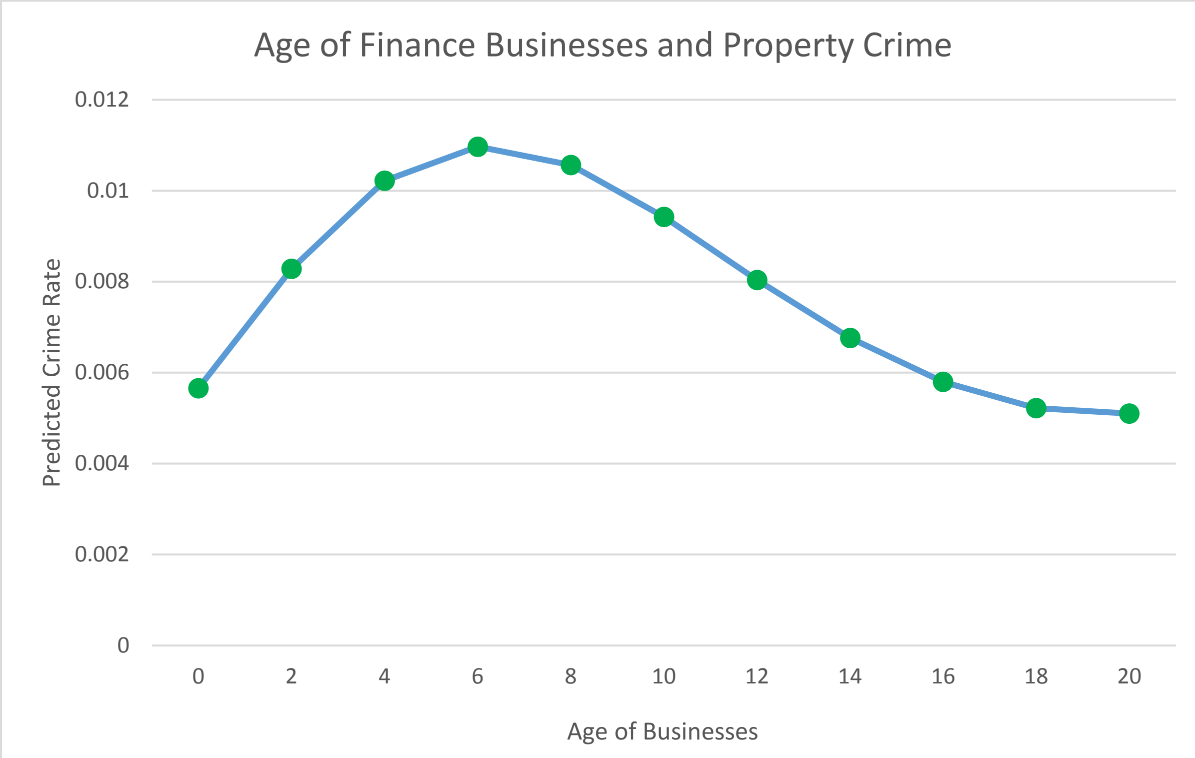

Figure A3.76. Age of Restaurants and Property Crime

Figure A3.77. Age of Health Businesses and Property Crime

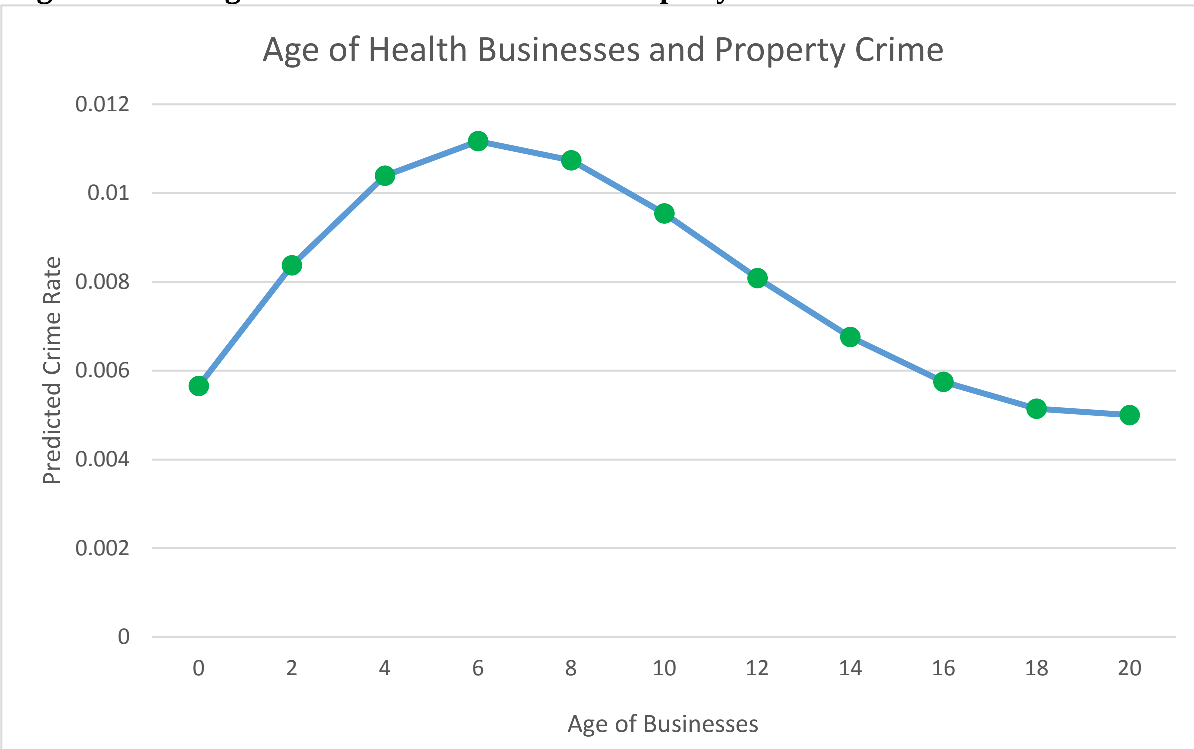

Figure A3.78. Age of Amenities and Property Crime

Figure A3.79. Age of Organizations and Property Crime

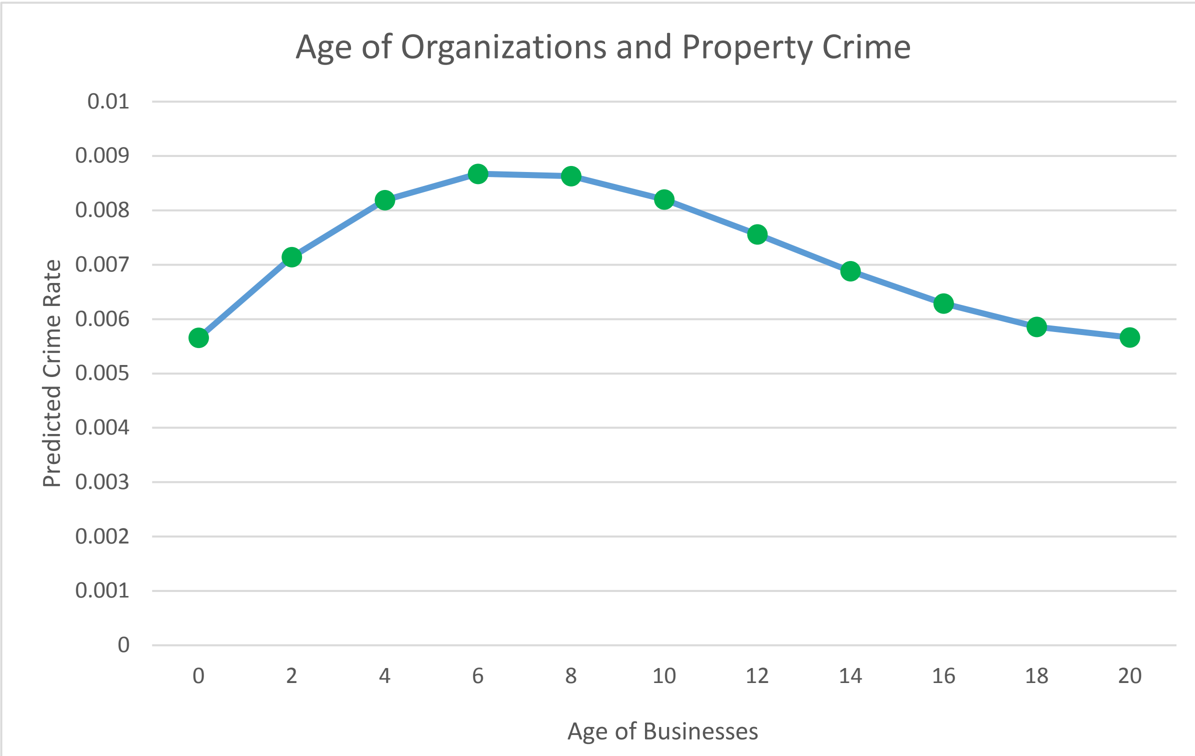

Figure A3.80. Age of Stores and Property Crime

Figure A3.81. Interaction: Number of Drink Business and Disadvantage

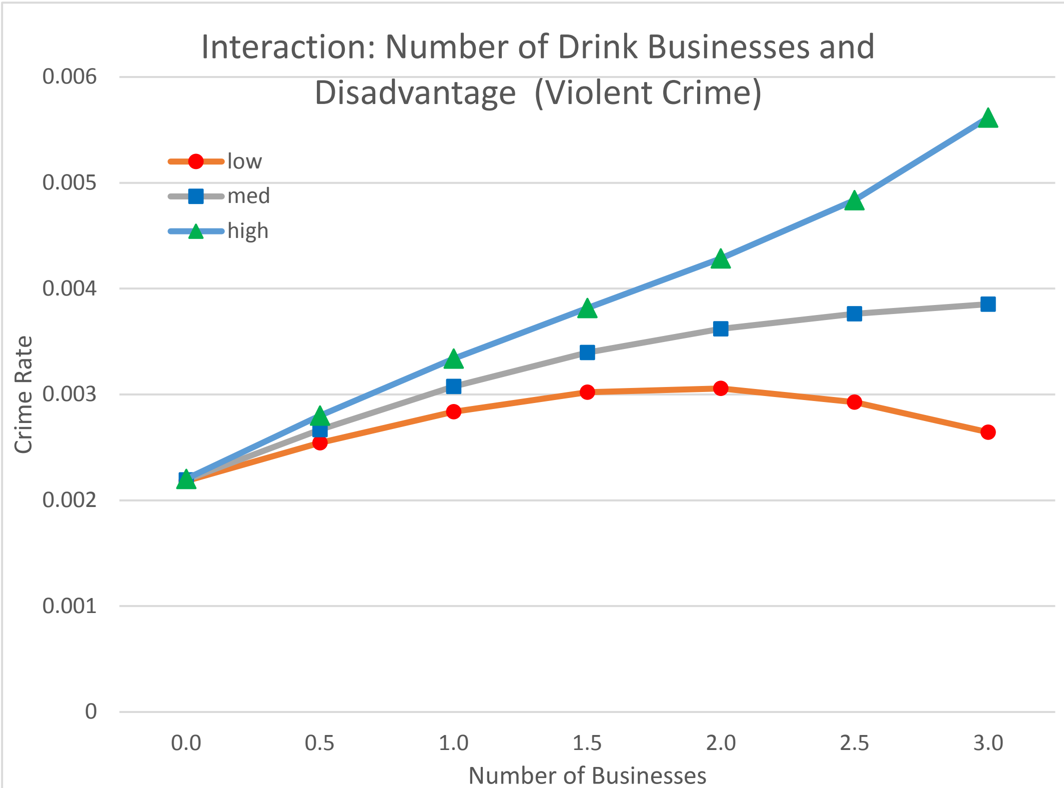

Figure A3.82. Interaction: Number of Retail Business and Disadvantage

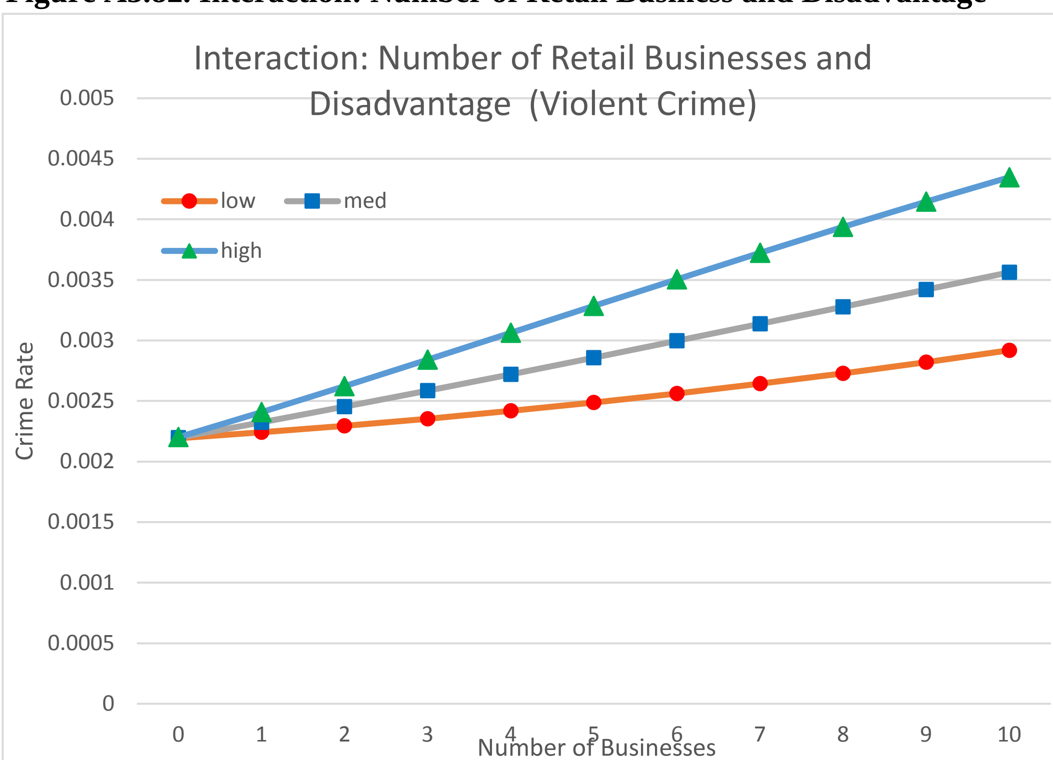

Figure A3.83. Interaction: Number of School Business and Disadvantage

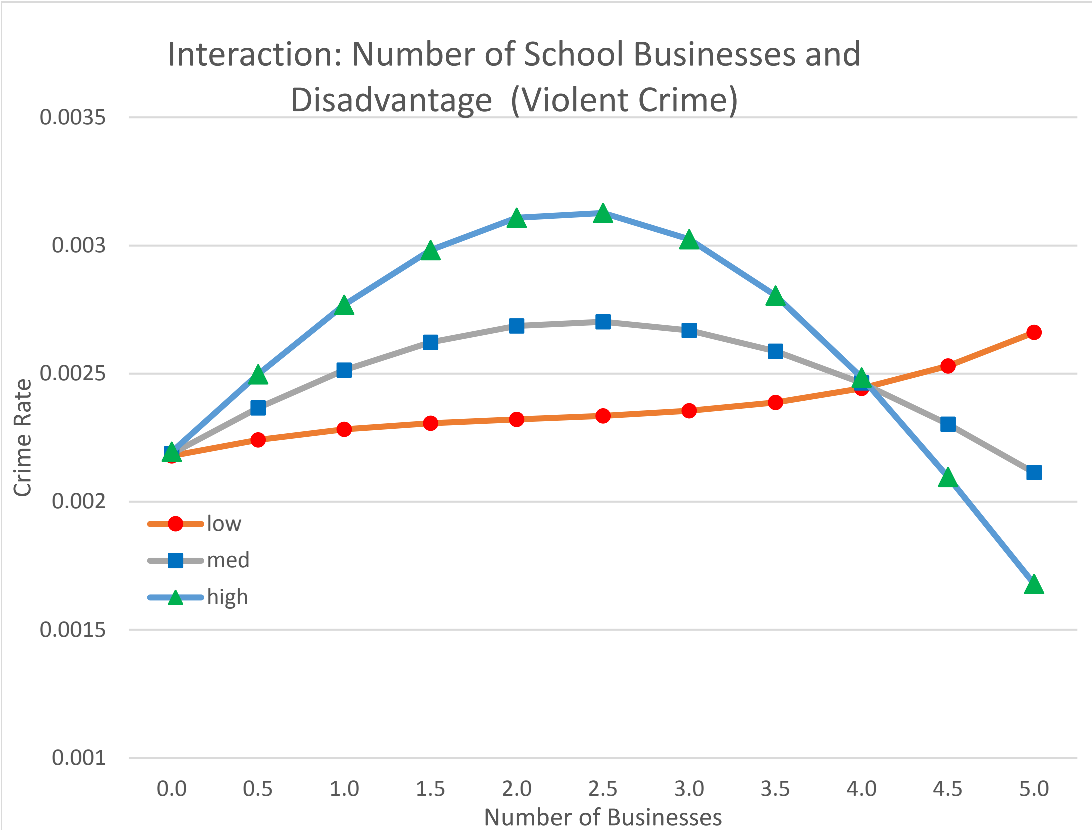

Figure A3.84. Interaction: Number of Service Business and Disadvantage

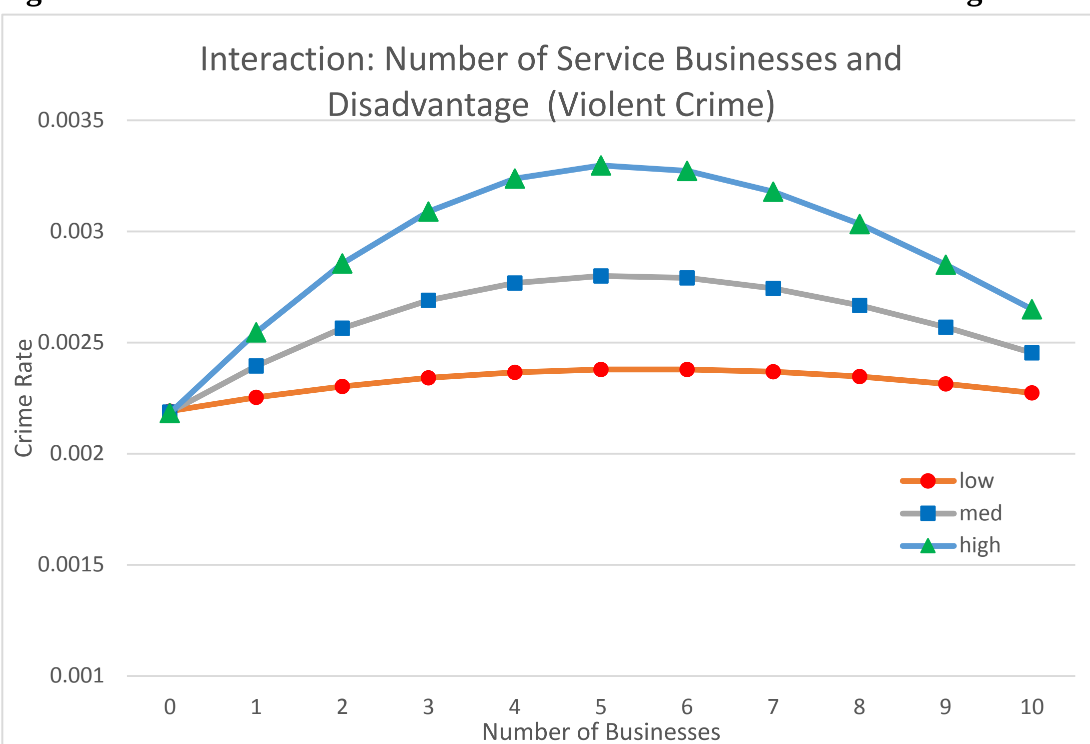

Figure A3.85. Interaction: Number of Finance Business and Disadvantage

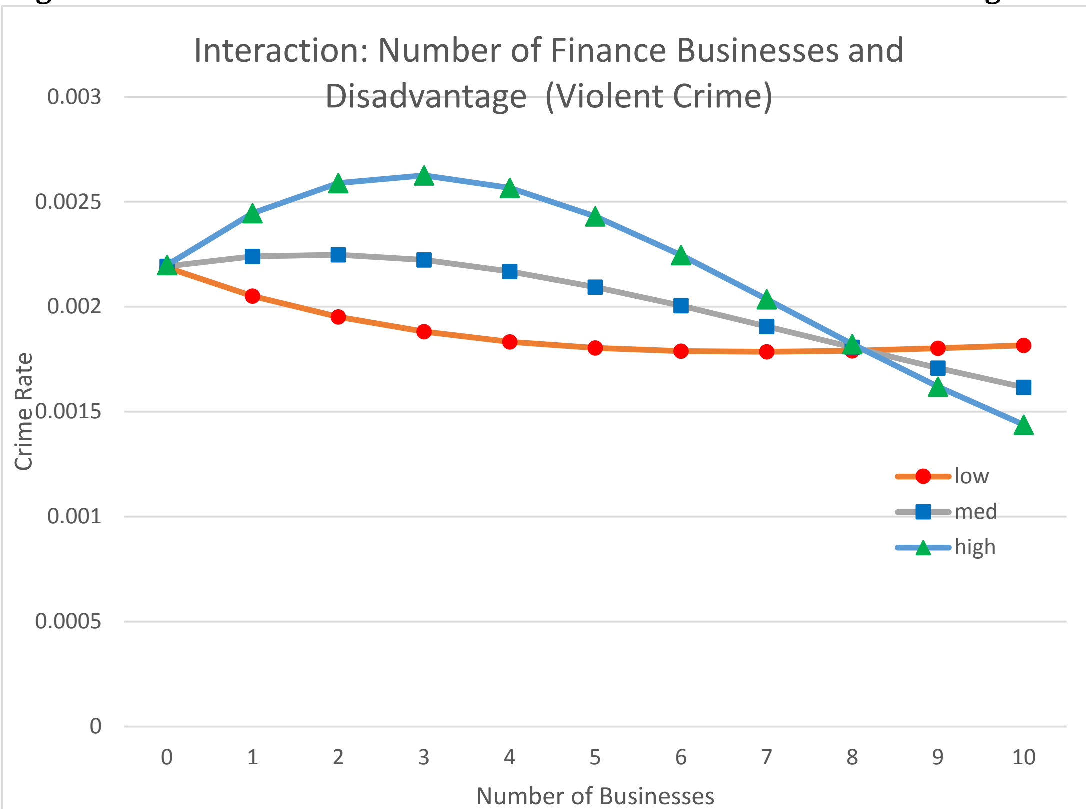

Figure A3.86. Interaction: Number of Restaurants and Disadvantage

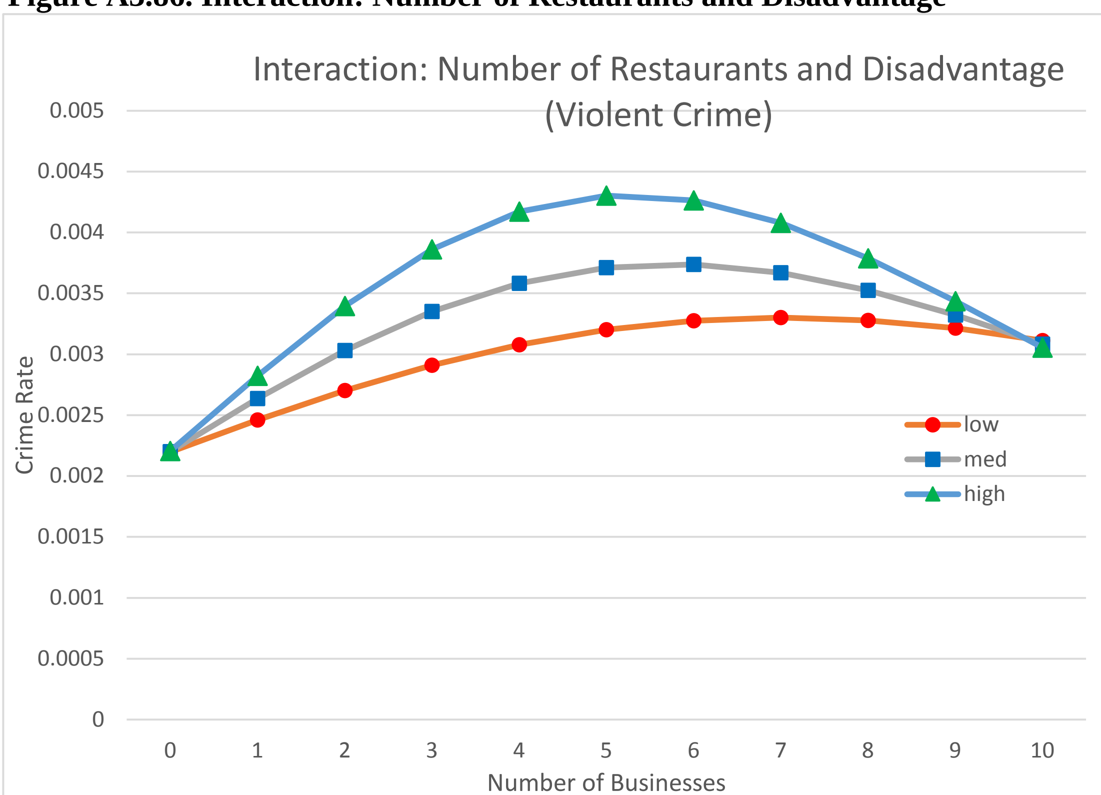

Figure A3.87. Interaction: Number of Health Businesses and Disadvantage

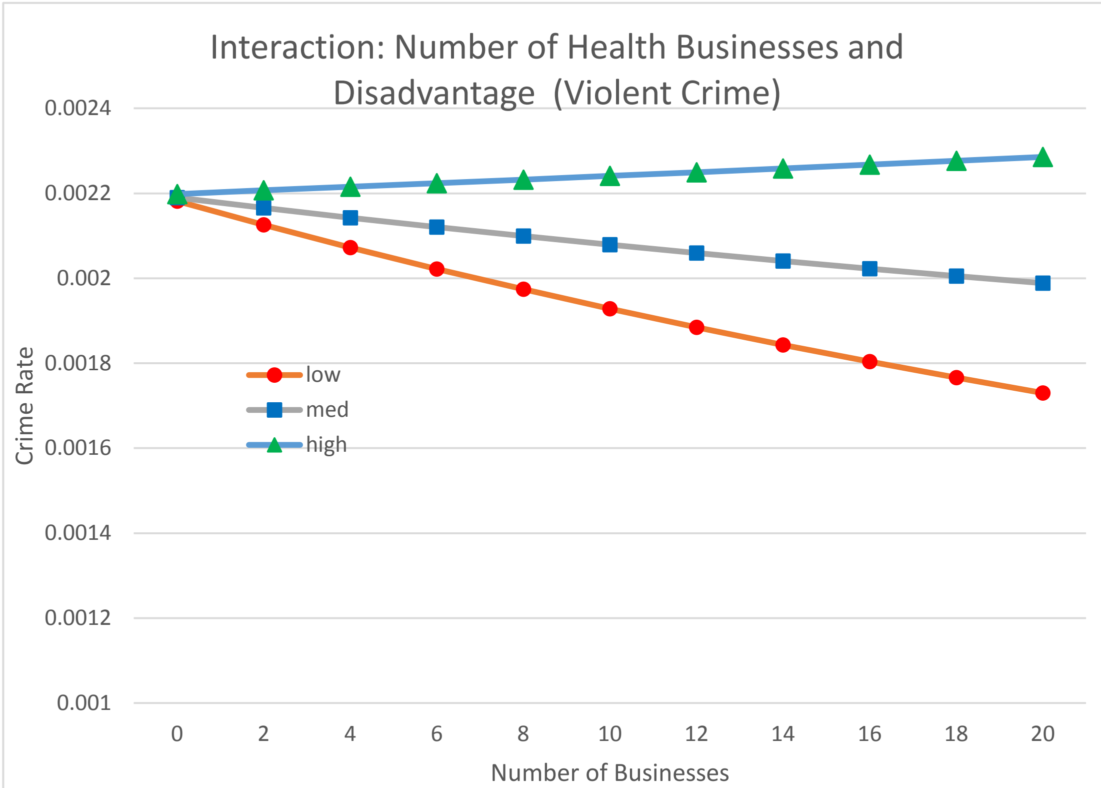

Figure A3.88. Interaction: Number of Amenities and Disadvantage

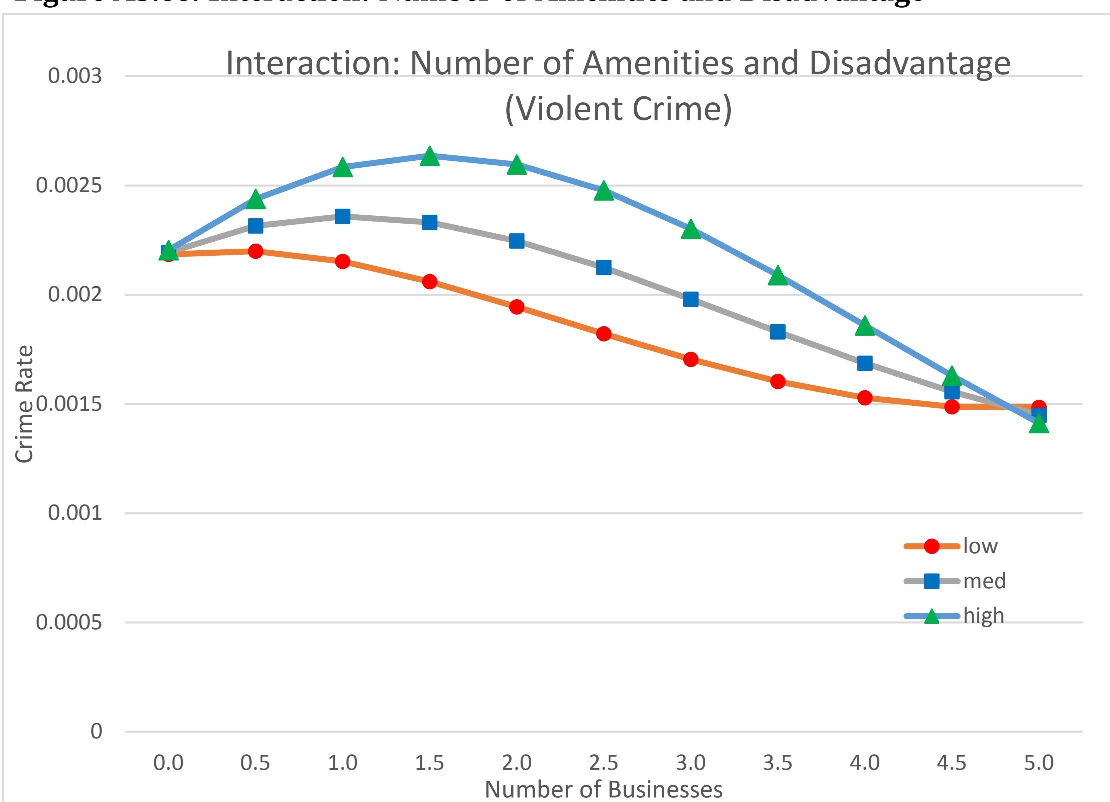

Figure A3.89. Interaction: Number of Organizations and Disadvantage

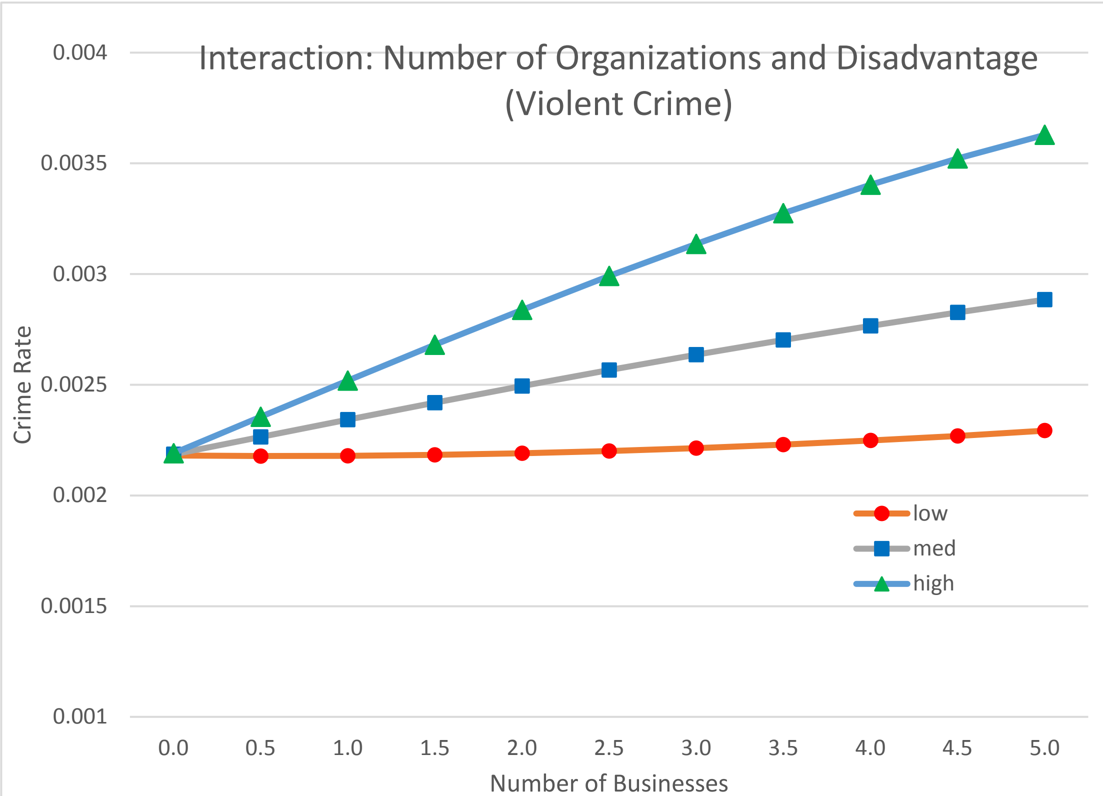

Figure A3.90. Interaction: Number of Stores and Disadvantage

Figure A3.91. Interaction: Number of Employees of Drink Business and Disadvantage

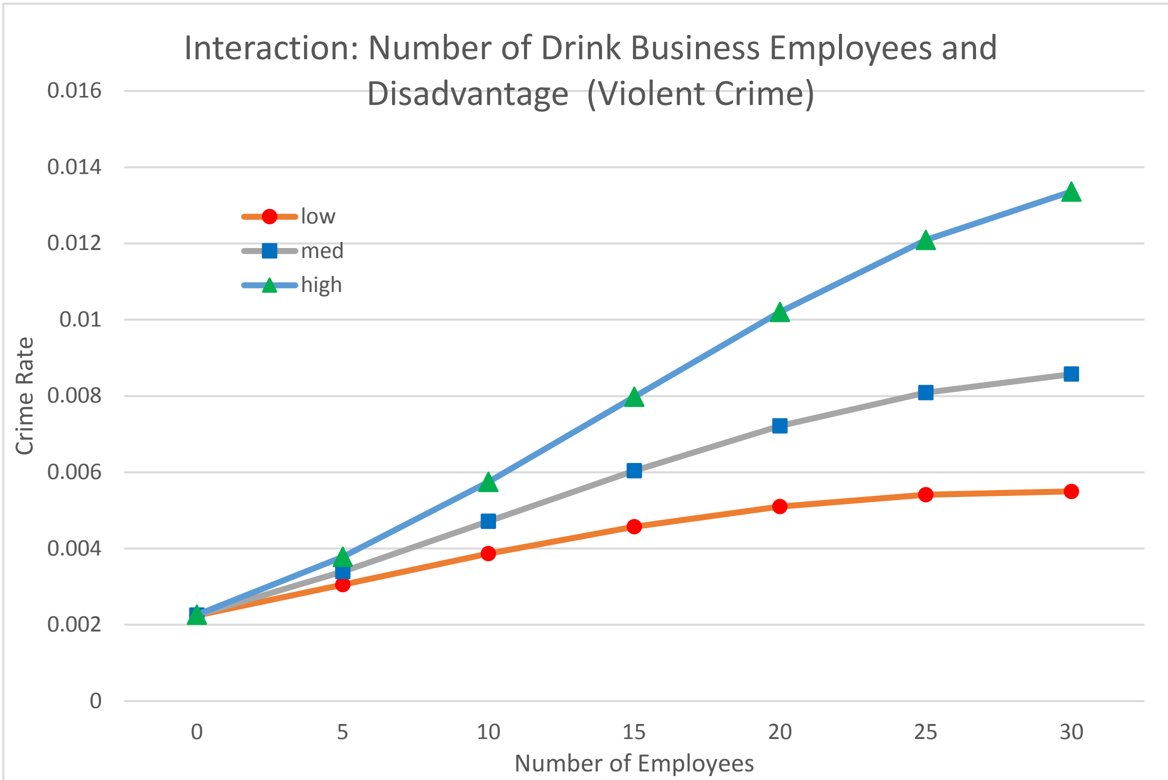

Figure A3.92. Interaction: Number of Employees of Retail Business and Disadvantage

Figure A3.93. Interaction: Number of Employees of School Business and Disadvantage

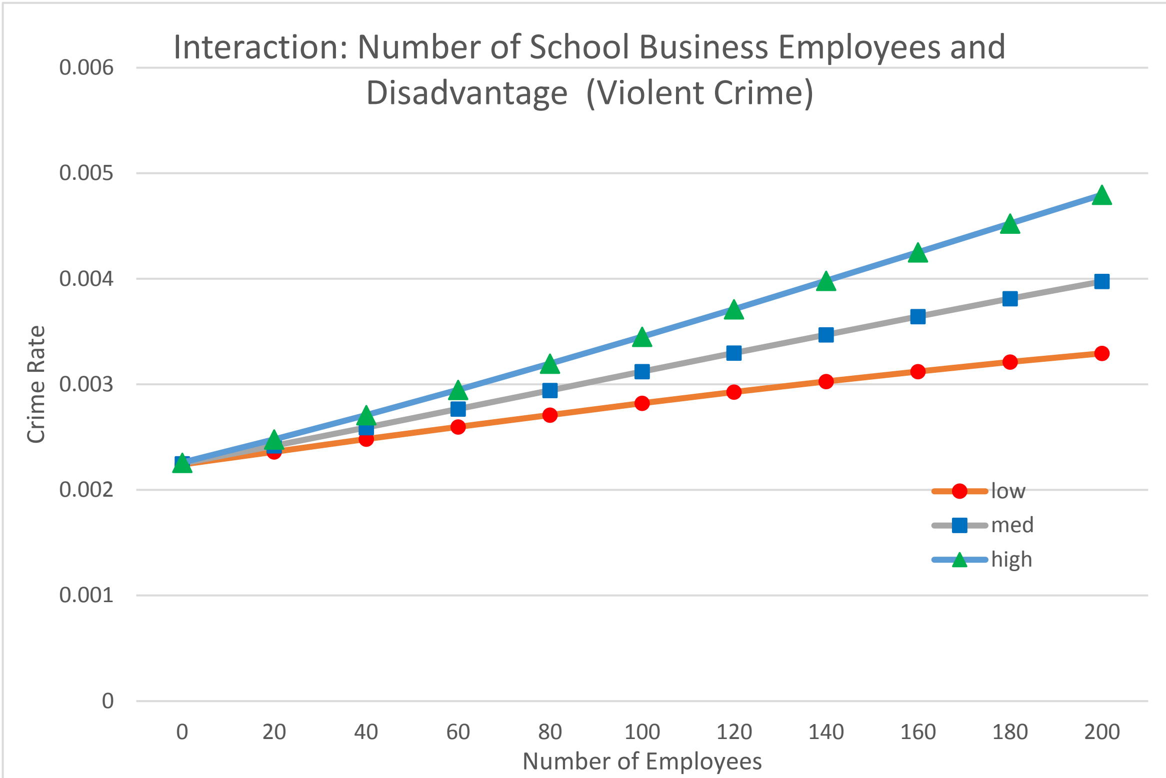

Figure A3.94. Interaction: Number of Employees of Service Business and Disadvantage

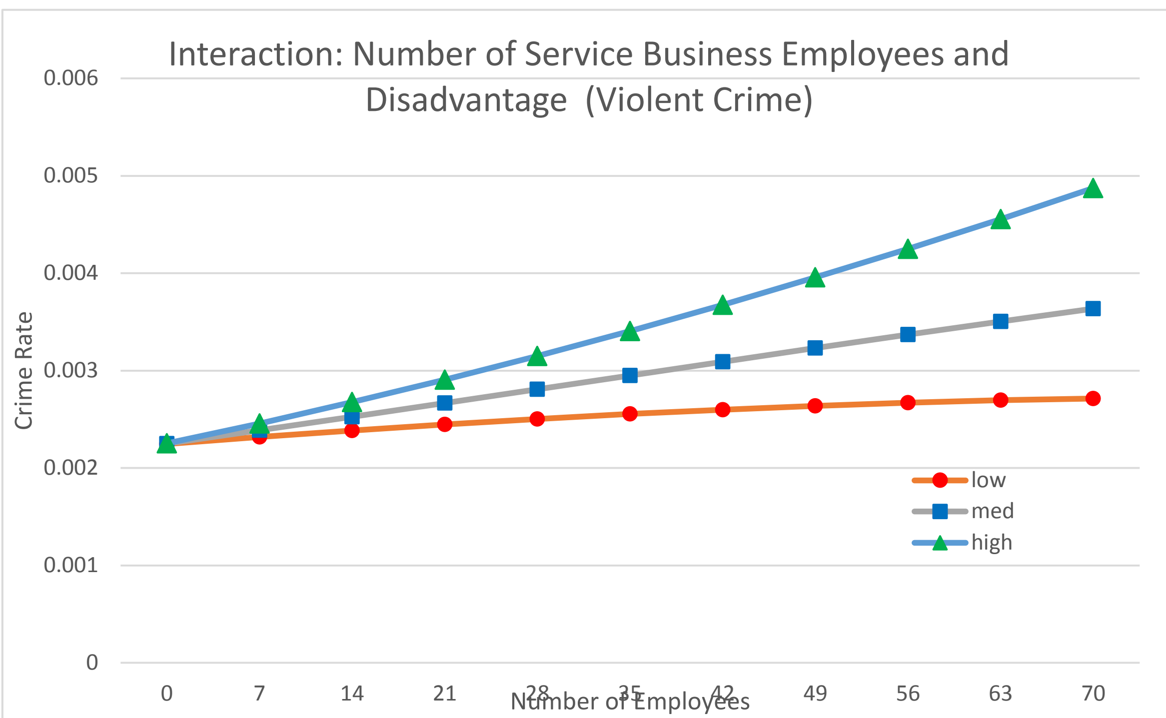

Figure A3.95. Interaction: Number of Employees of Finance Business and Disadvantage

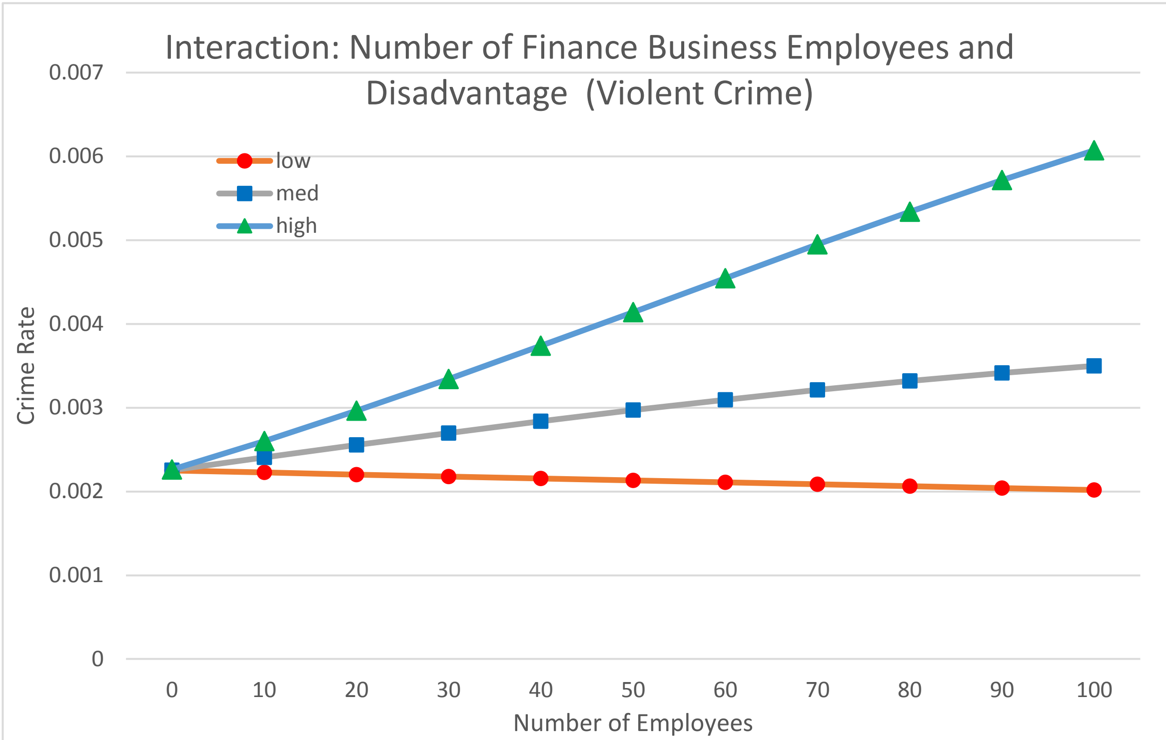

Figure A3.96. Interaction: Number of Employees of Restaurants and Disadvantage

Figure A3.97. Interaction: Number of Employees of Health Businesses and Disadvantage

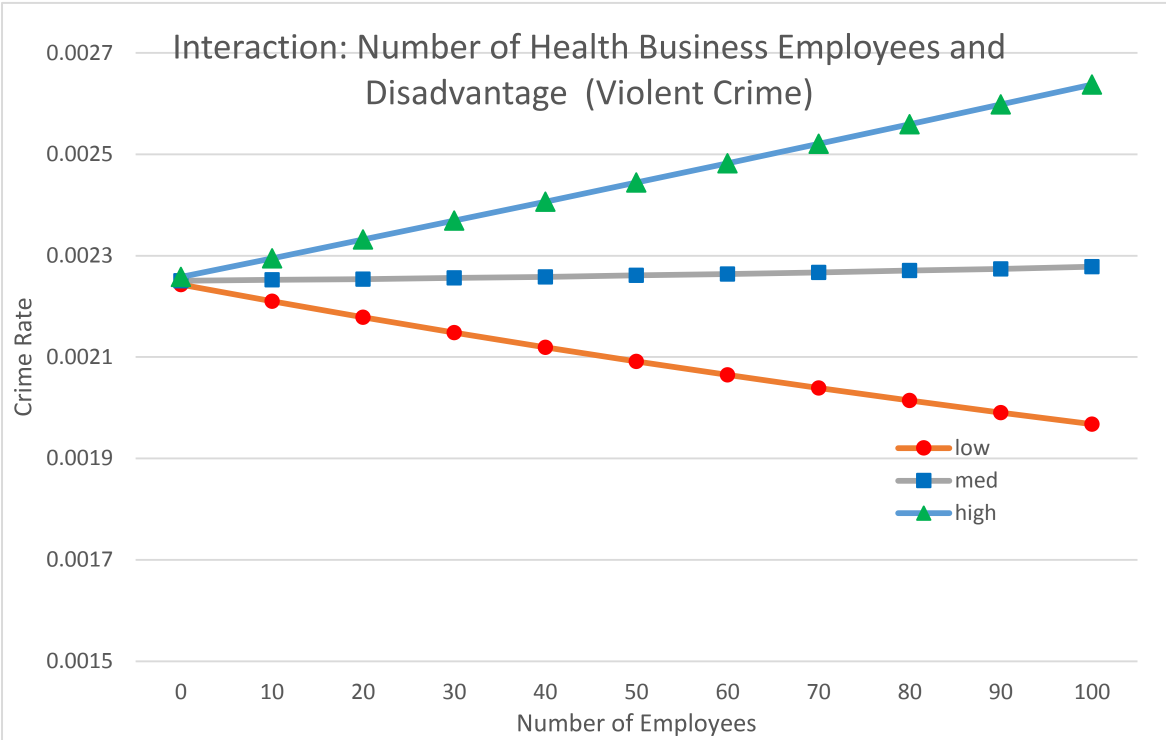

Figure A3.99. Interaction: Number of Employees of Amenities and Disadvantage

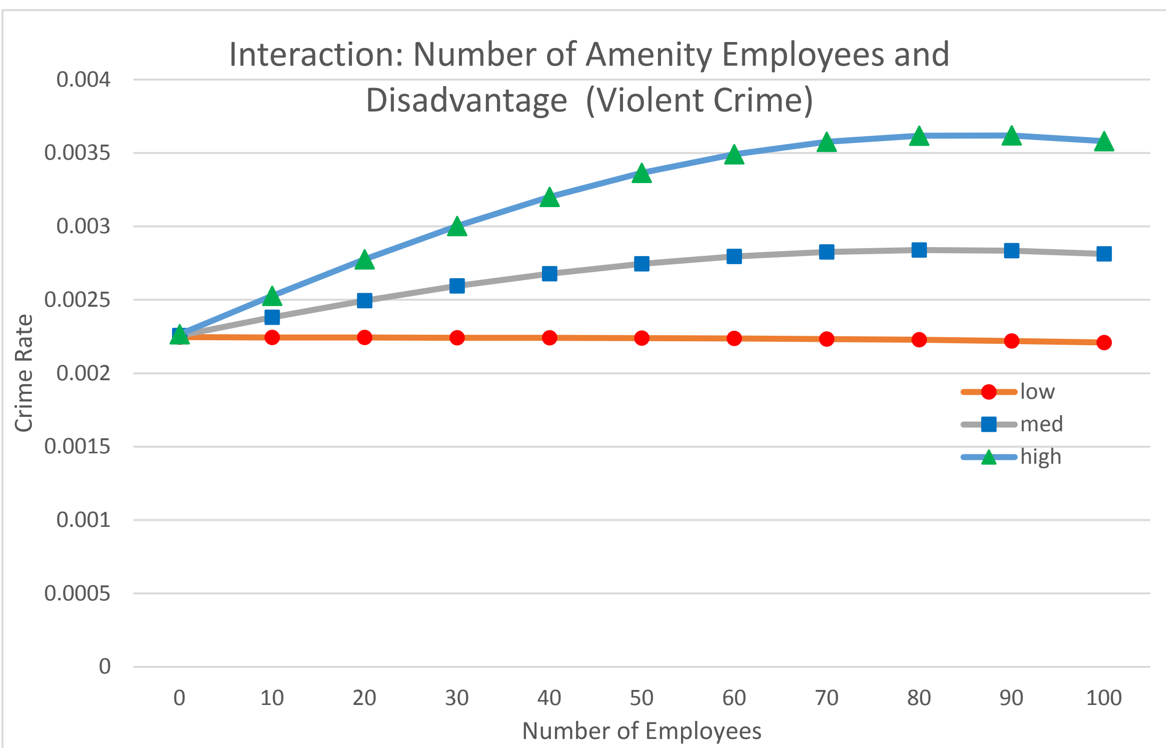

Figure A3.99. Interaction: Number of Employees of Organizations and Disadvantage

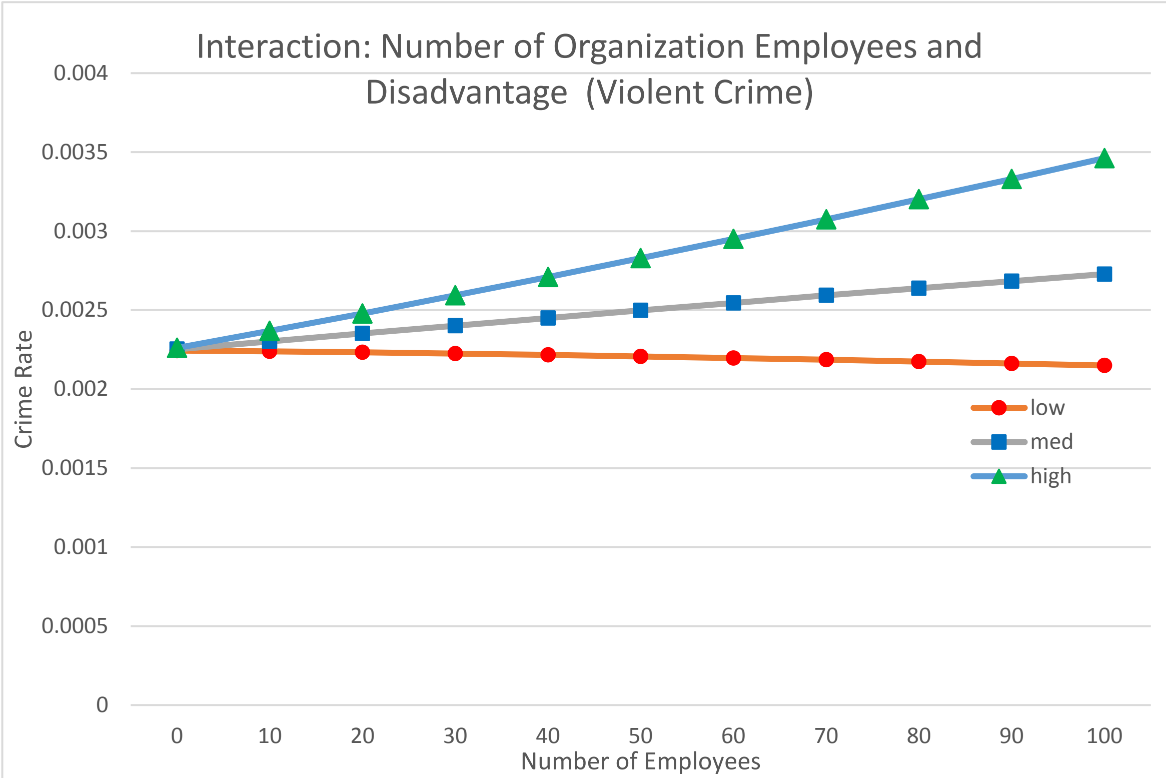

Figure A3.100. Interaction: Number of Employees of Stores and Disadvantage

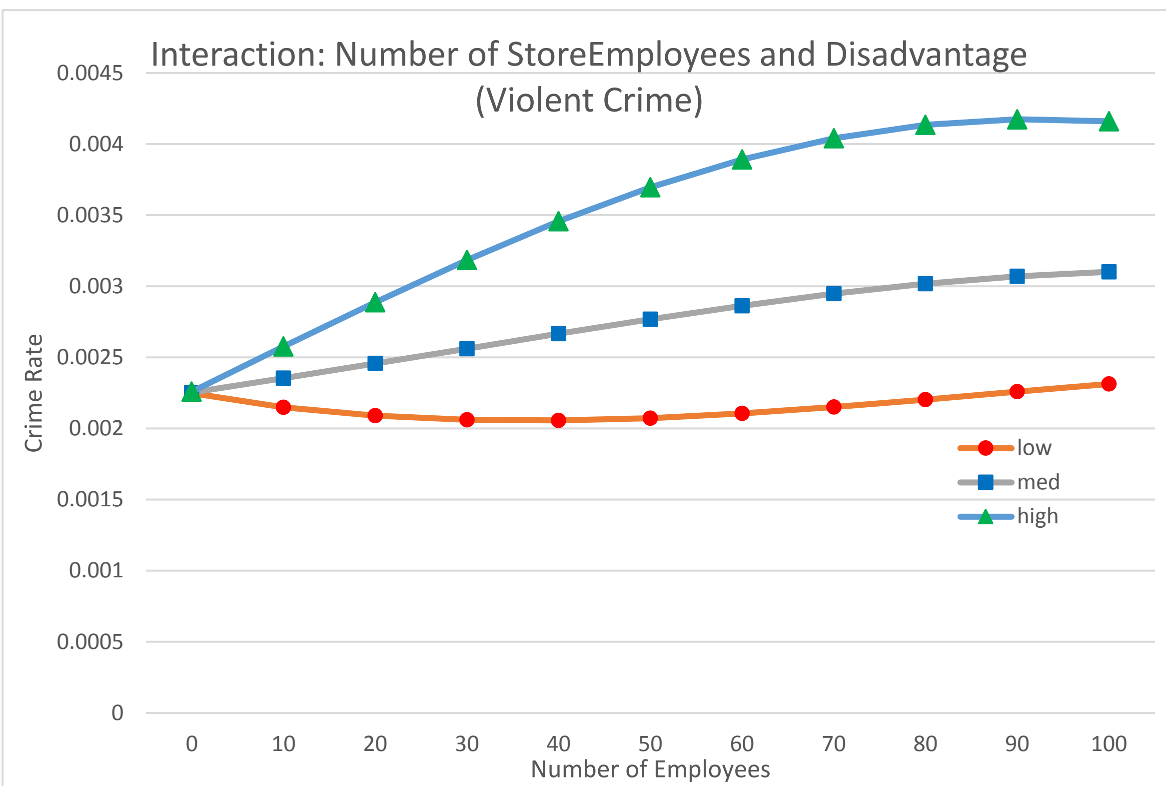

Figure A3.101. Interaction: Number of Local Drink Business and Disadvantage

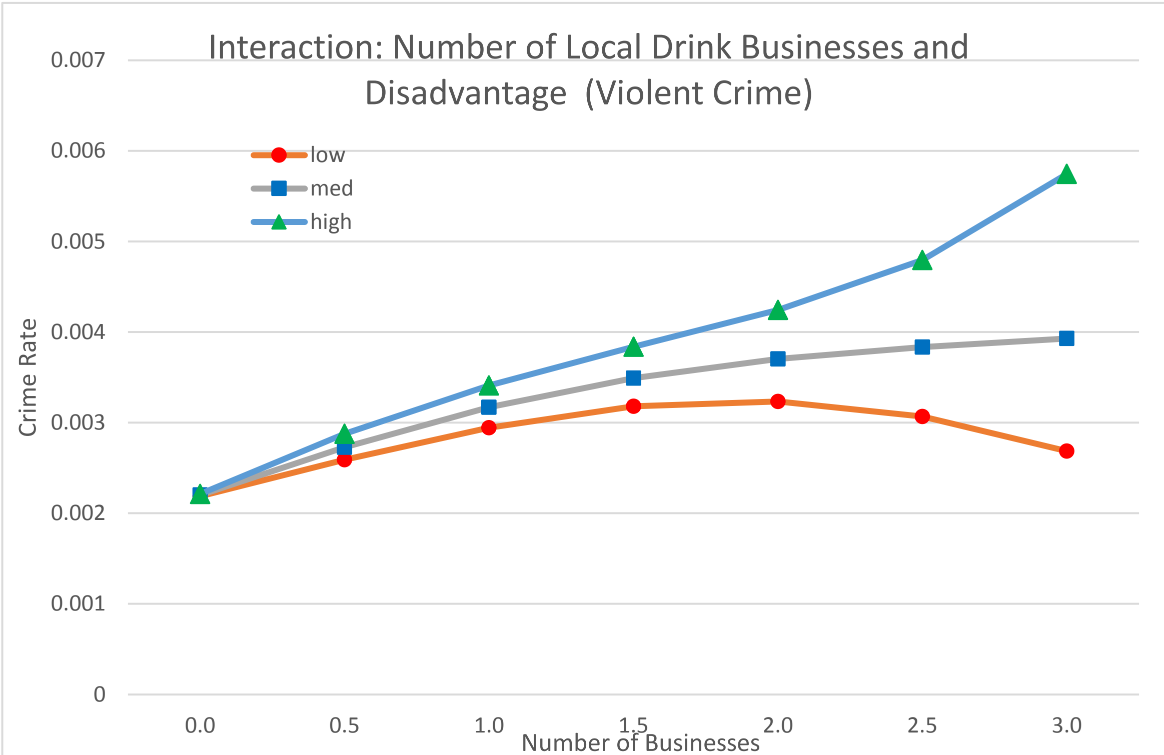

Figure A3.102. Interaction: Number of Local Retail Business and Disadvantage

Figure A3.103. Interaction: Number of Local School Business and Disadvantage

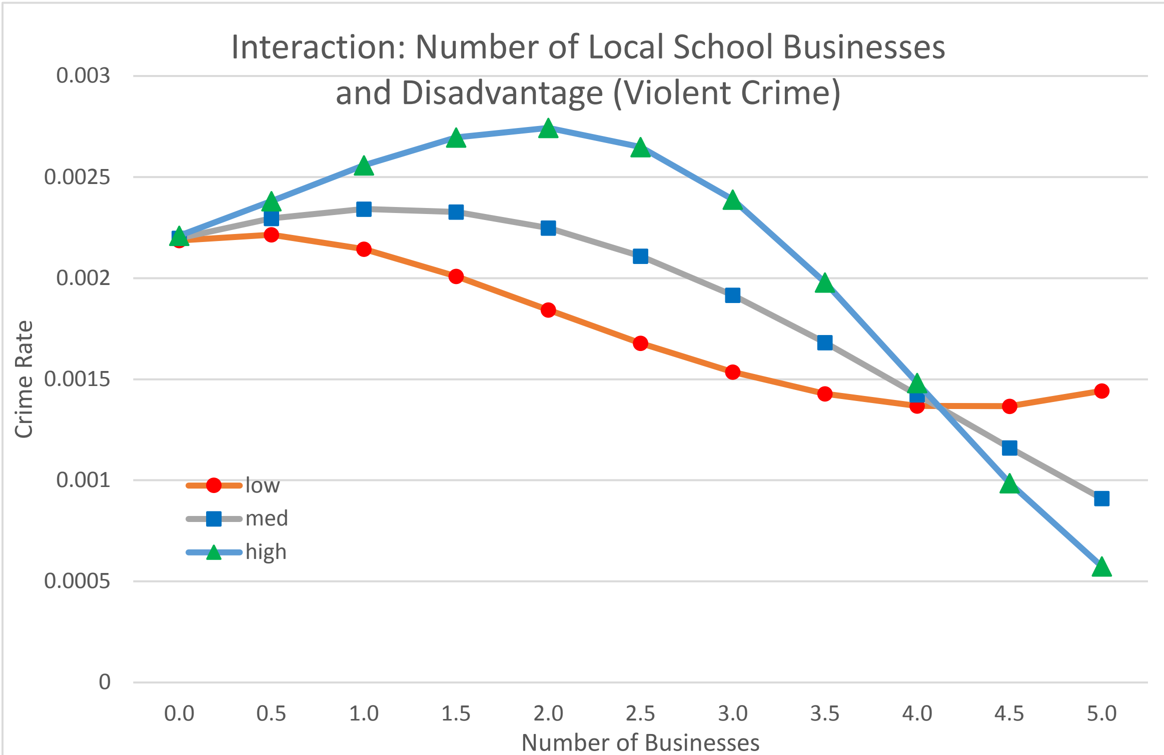

Figure A3.104. Interaction: Number of Local Service Business and Disadvantage

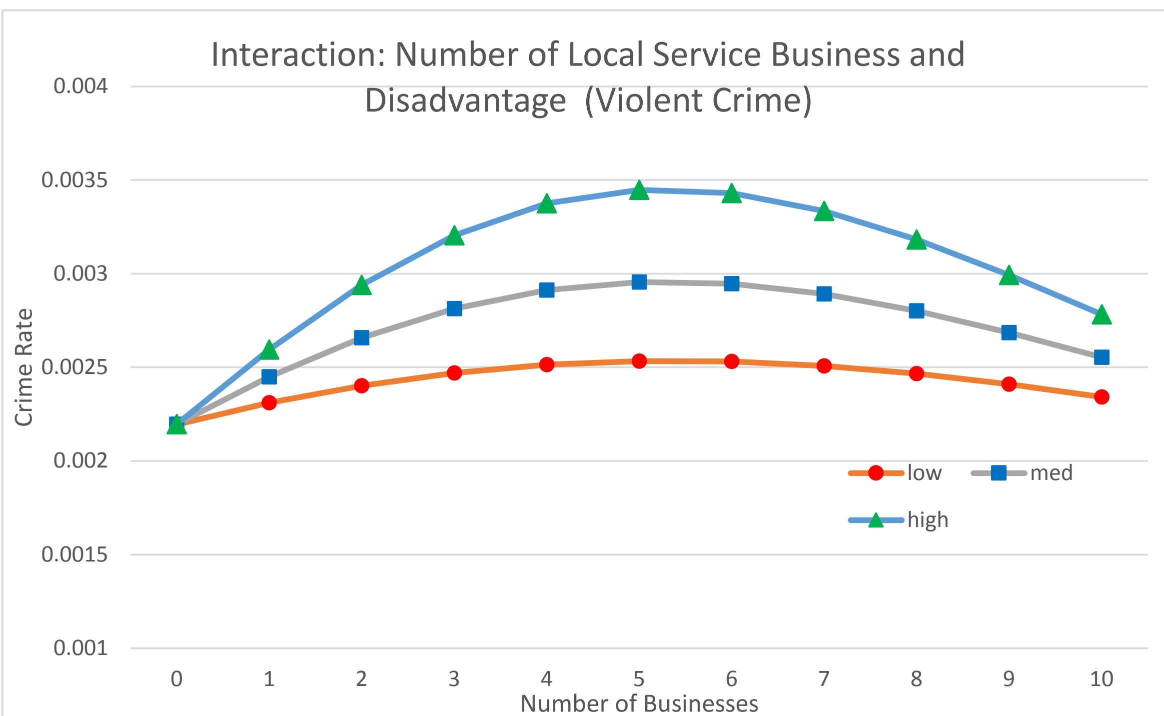

Figure A3.105. Interaction: Number of Local Finance Business and Disadvantage

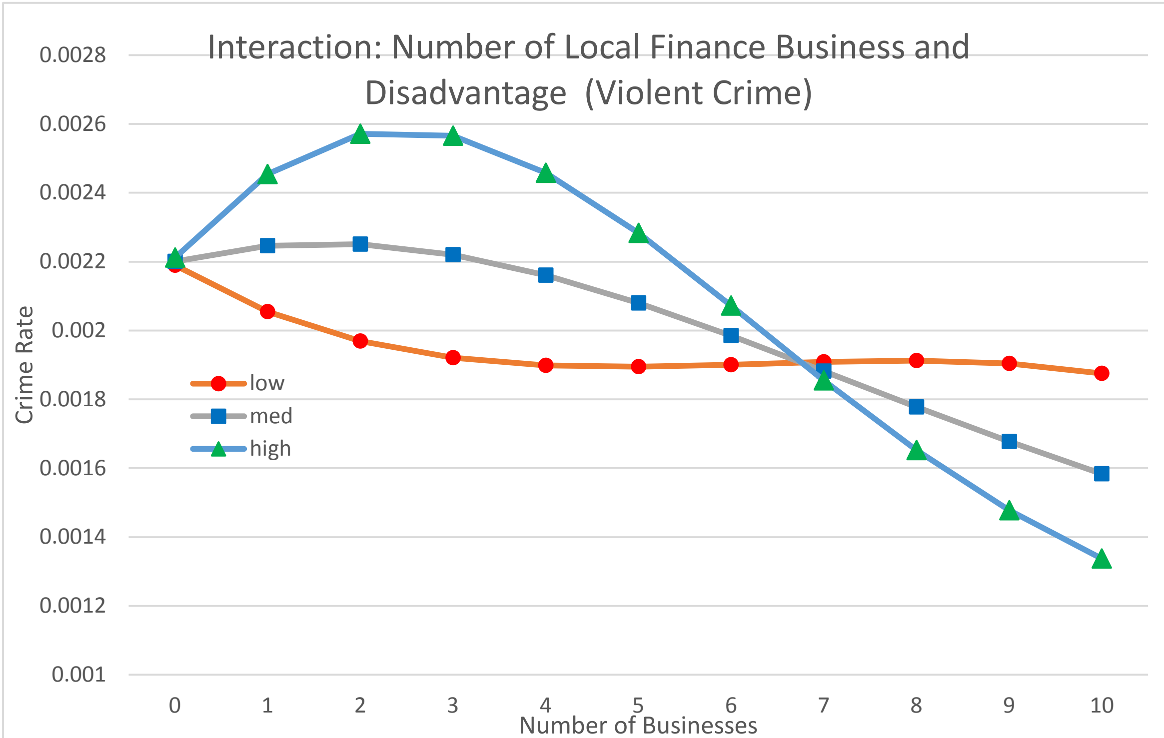

Figure A3.106. Interaction: Number of Local Restaurants and Disadvantage

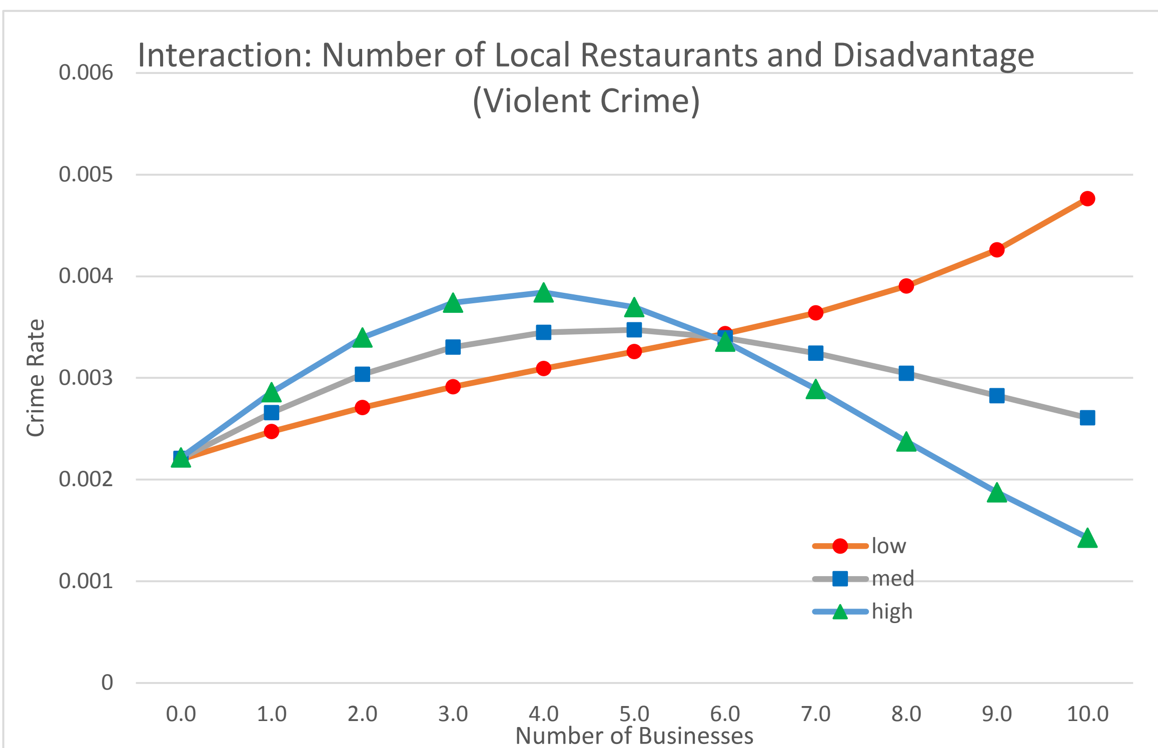

Figure A3.107. Interaction: Number of Local Health Businesses and Disadvantage

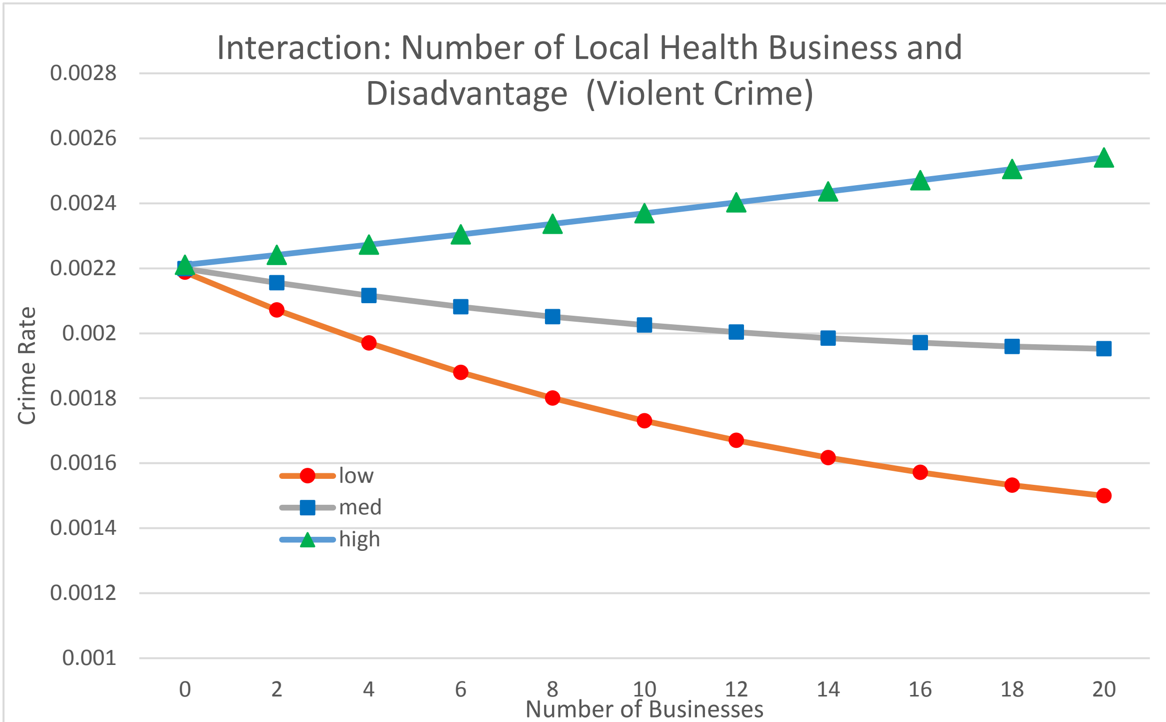

Figure A3.108. Interaction: Number of Local Amenities and Disadvantage

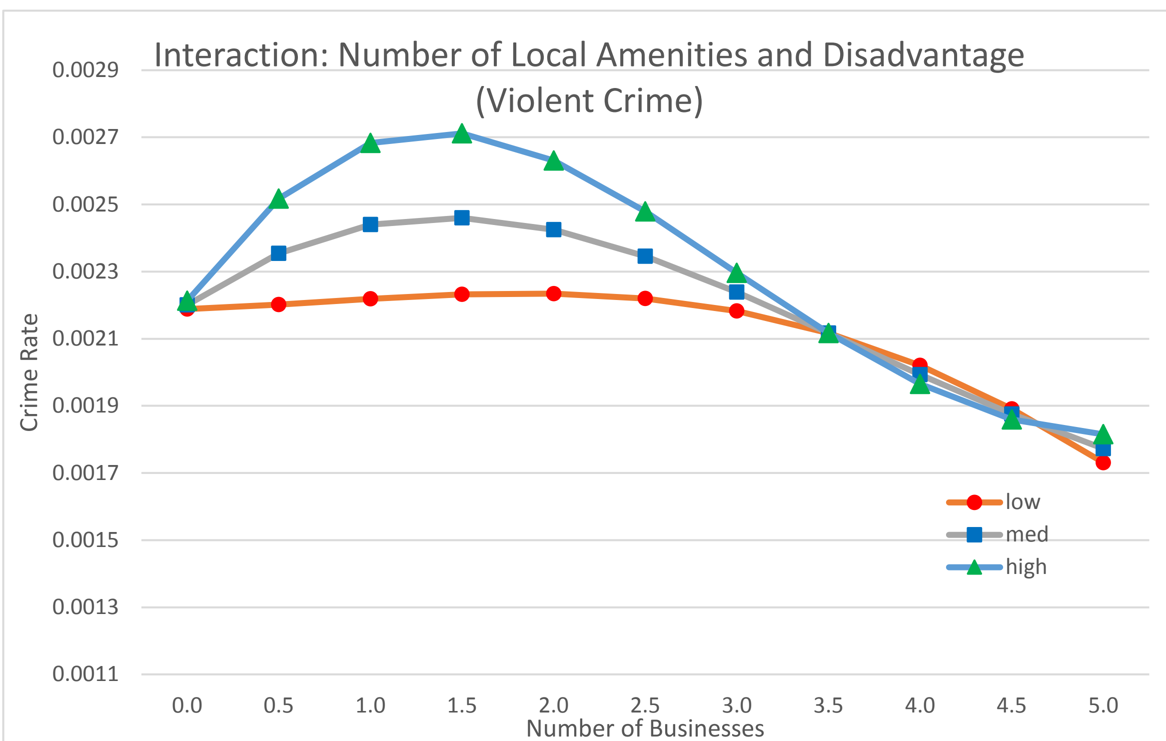

Figure A3.109. Interaction: Number of Local Organizations and Disadvantage

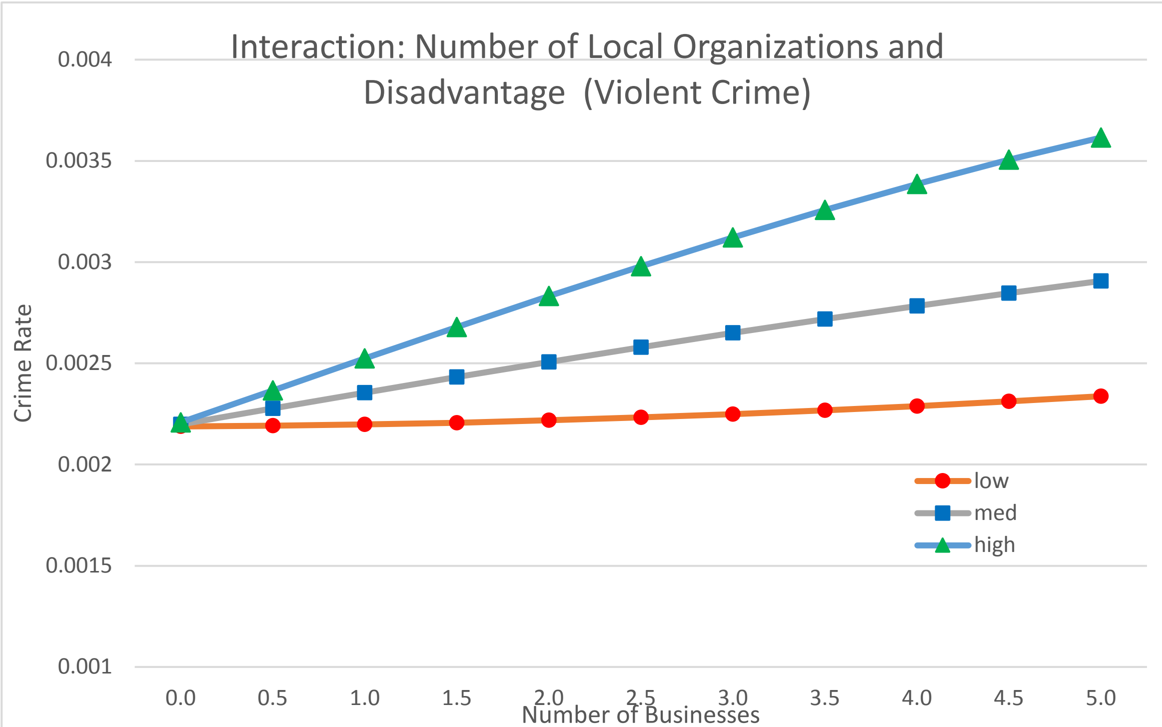

Figure A3.110. Interaction: Number of Local Stores and Disadvantage

Figure A3.111. Interaction: Age of Drink Business and Disadvantage

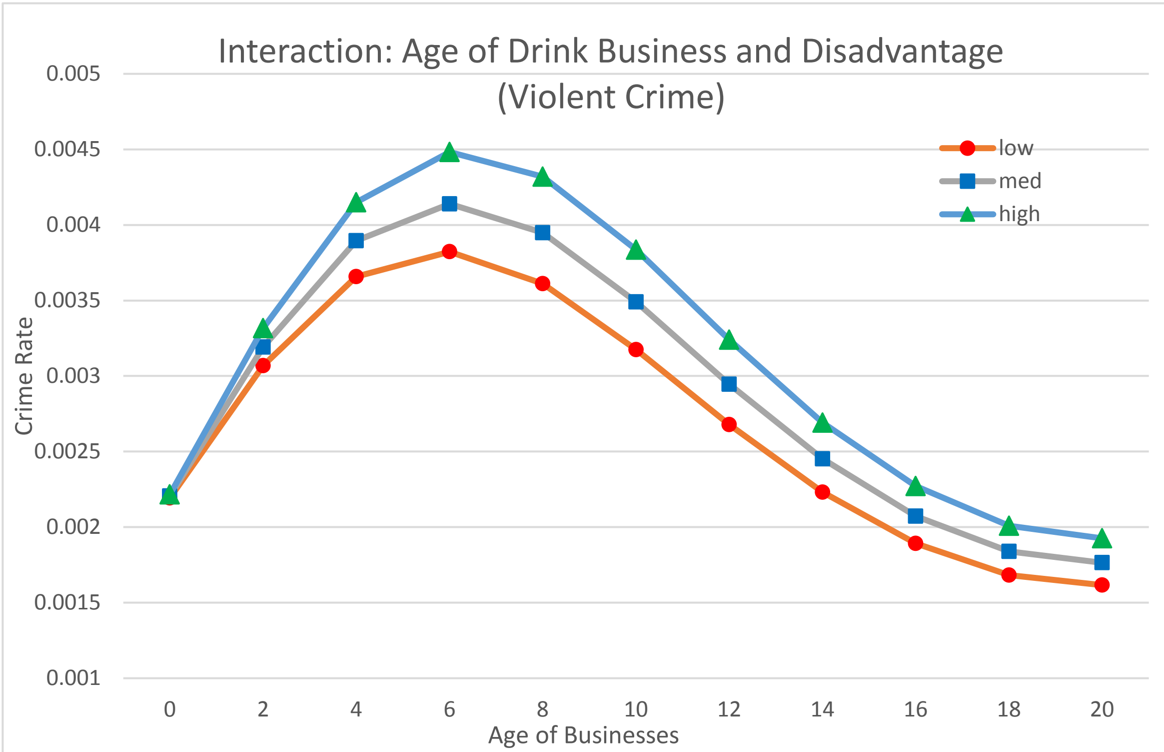

Figure A3.112. Interaction: Age of Retail Business and Disadvantage

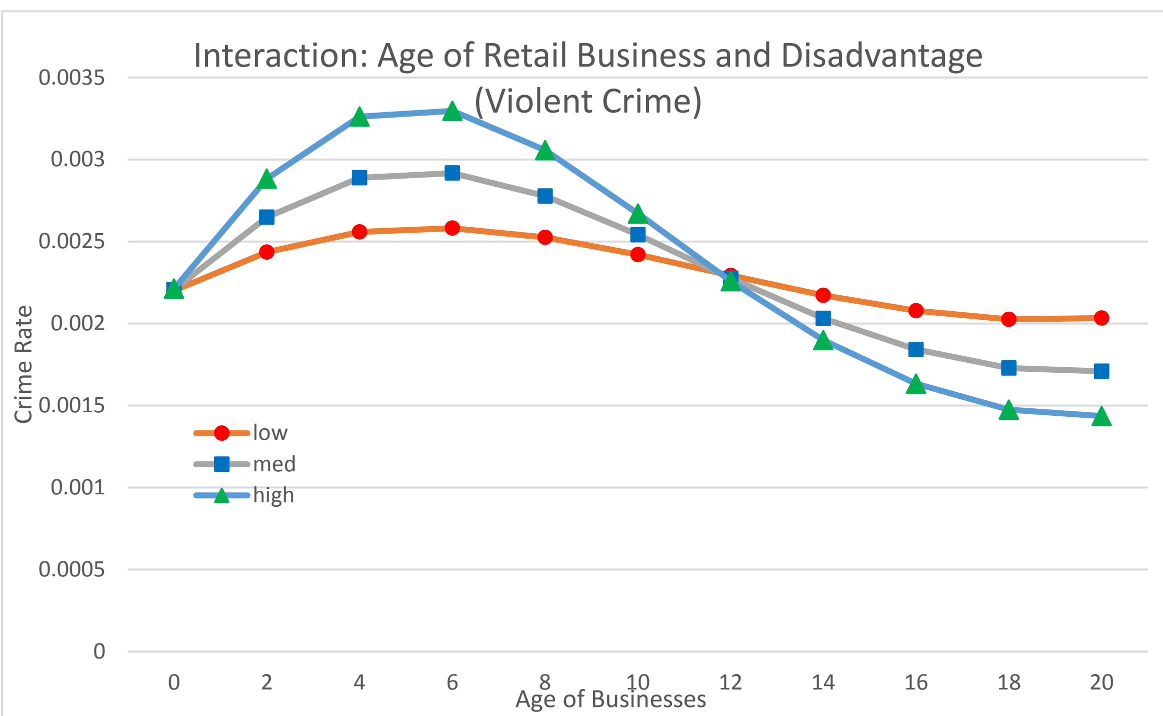

Figure A3.113. Interaction: Age of School Business and Disadvantage

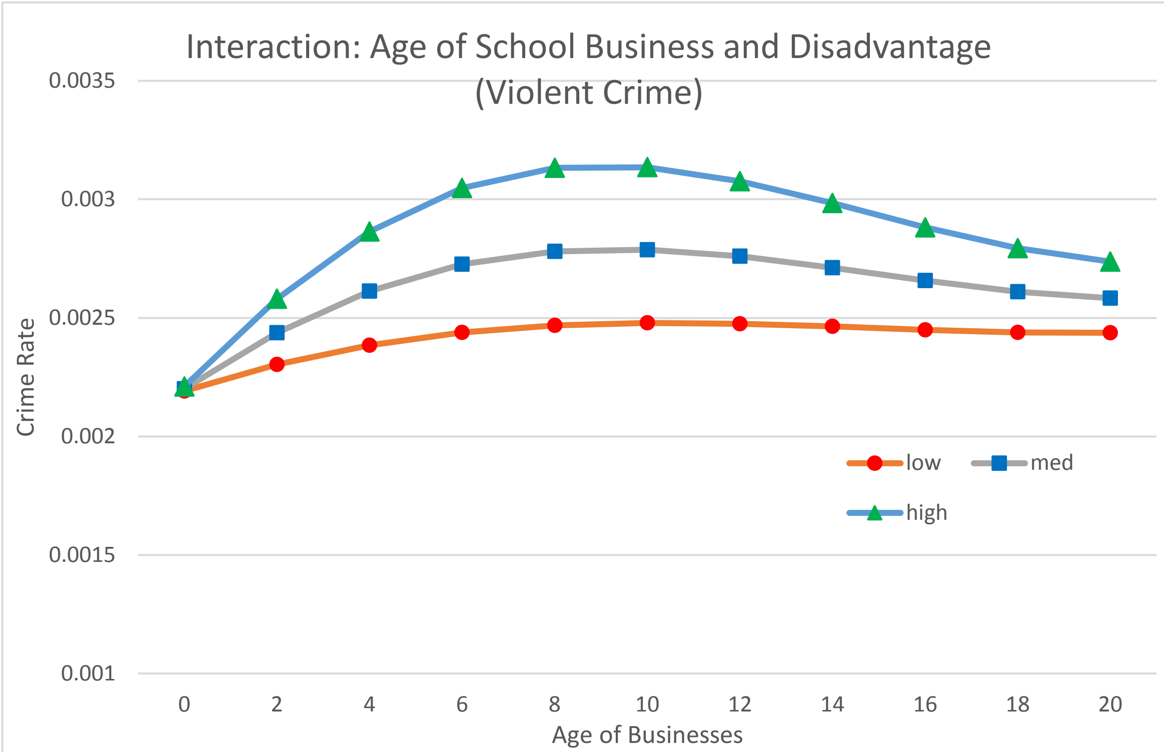

Figure A3.114. Interaction: Age of Service Business and Disadvantage

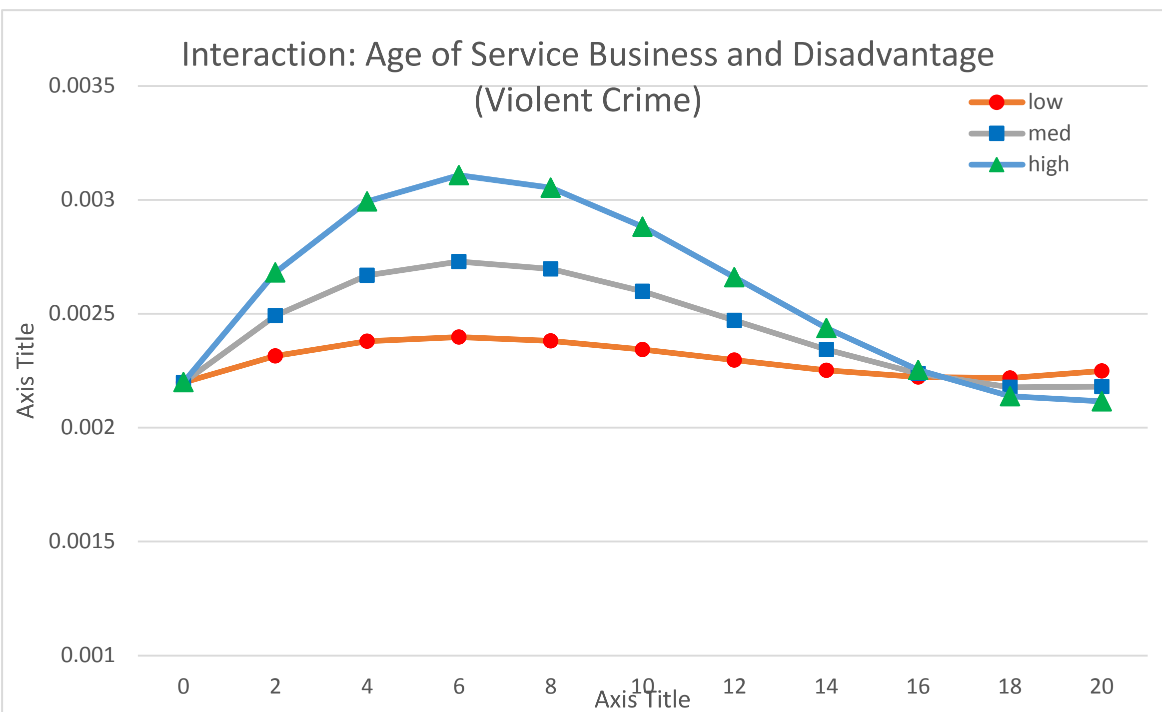

Figure A3.115. Interaction: Age of Finance Business and Disadvantage

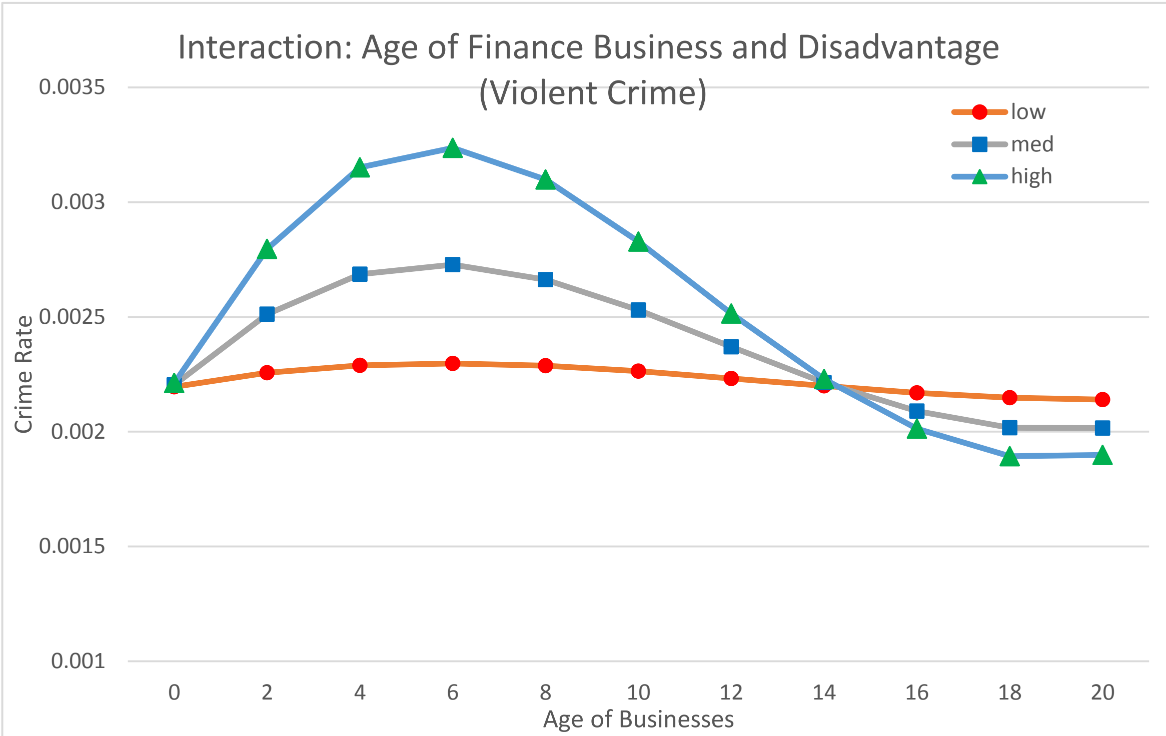

Figure A3.116. Interaction: Age of Restaurants and Disadvantage

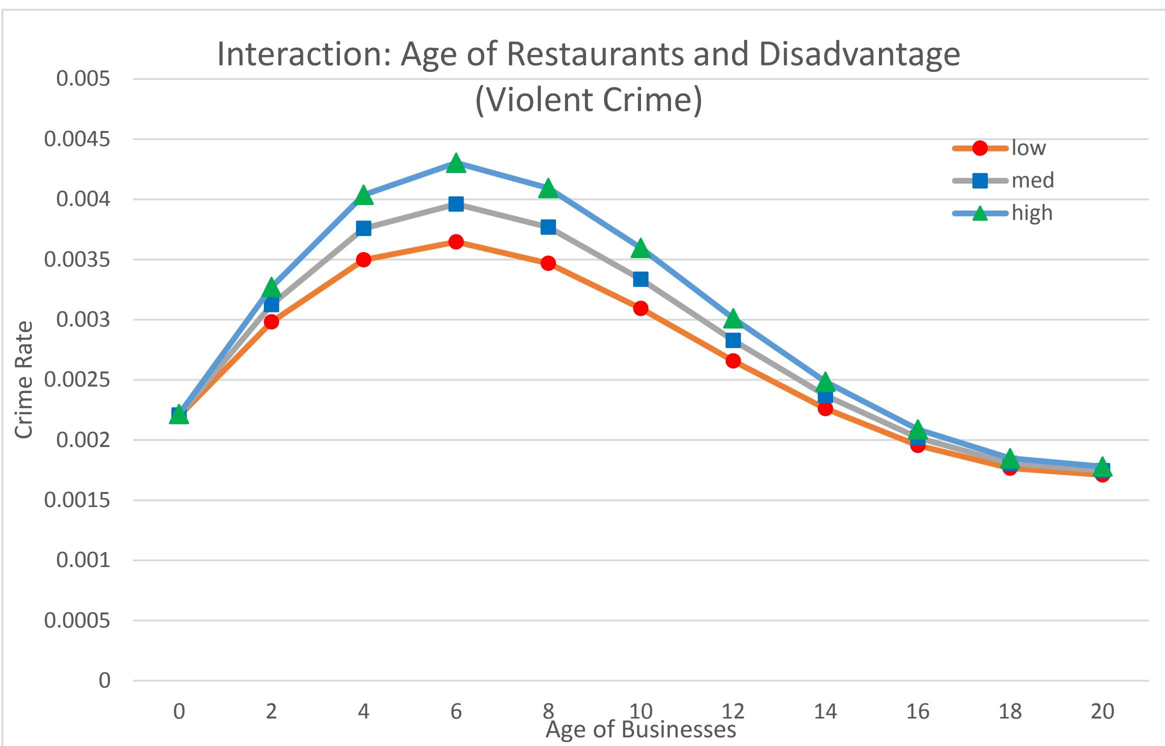

Figure A3.117. Interaction: Age of Health Businesses and Disadvantage

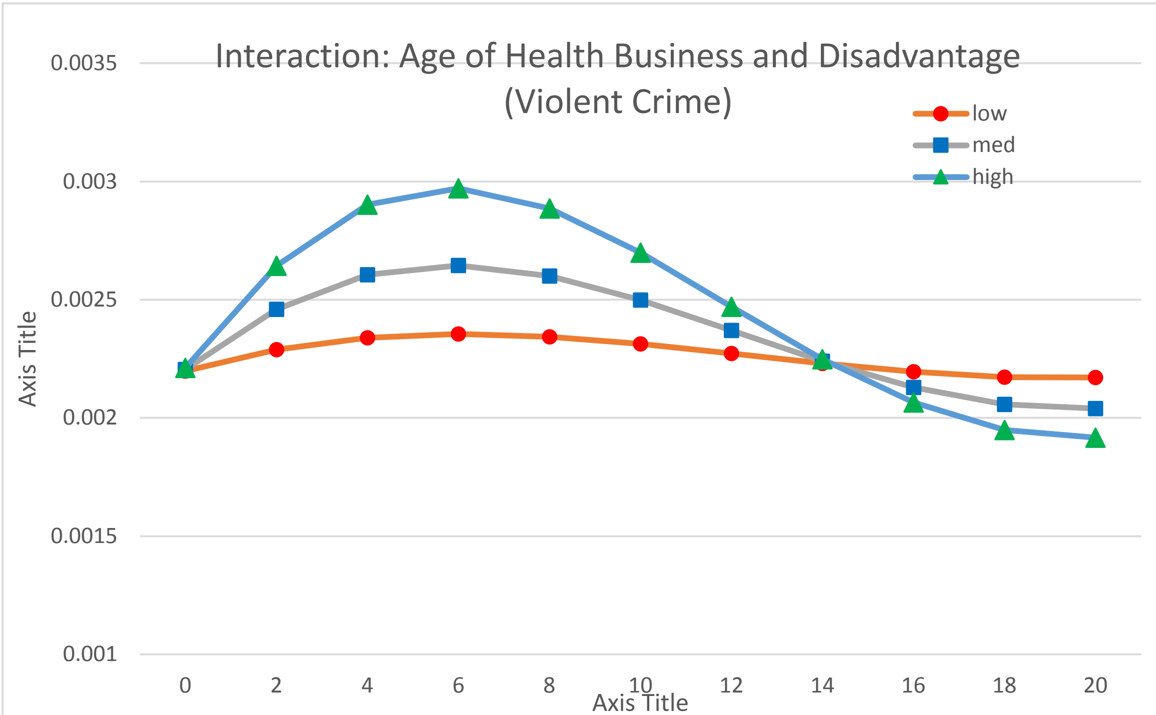

Figure A3.118. Interaction: Age of Amenities and Disadvantage

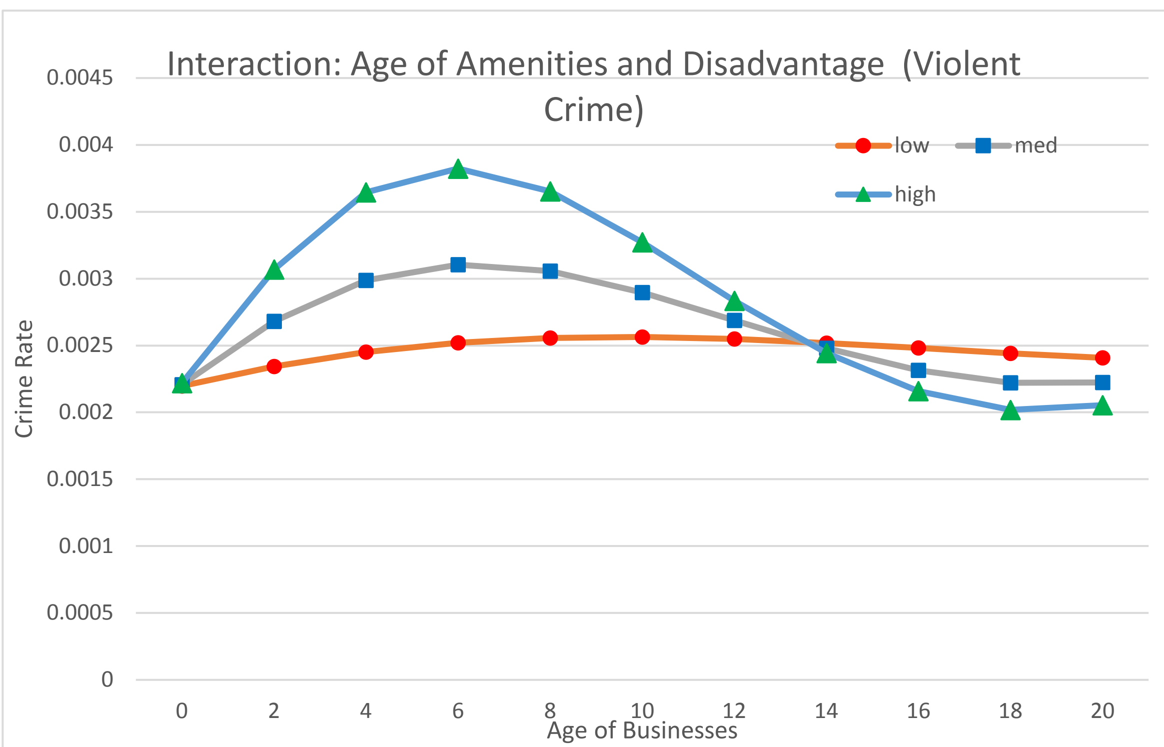

Figure A3.119. Interaction: Age of Organizations and Disadvantage

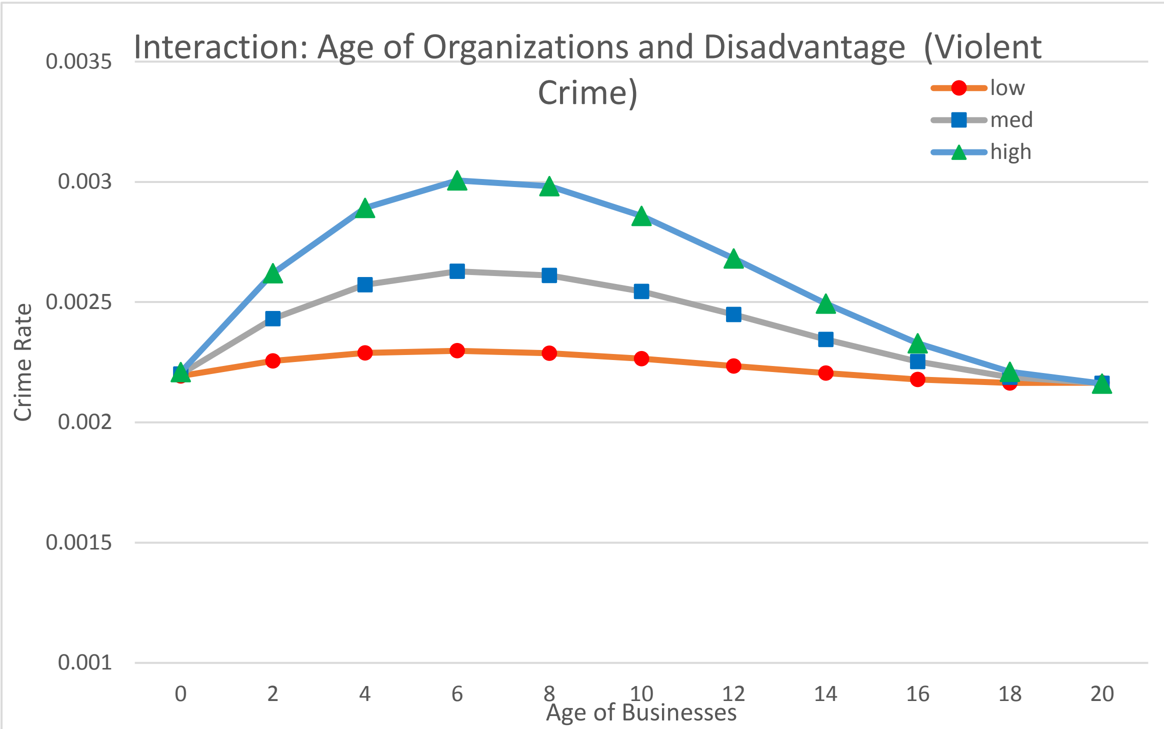

Figure A3.120. Interaction: Age of Stores and Disadvantage

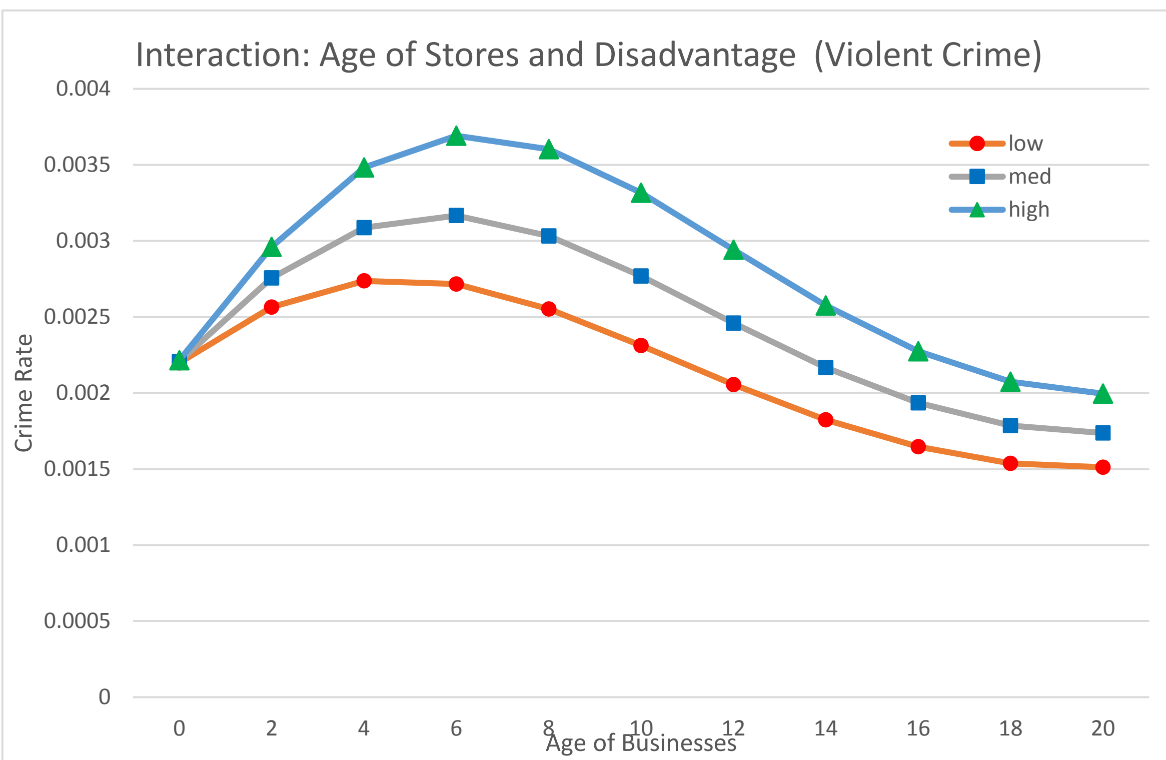

Figure A3.121. Interaction: Number of Drink Business and Disadvantage

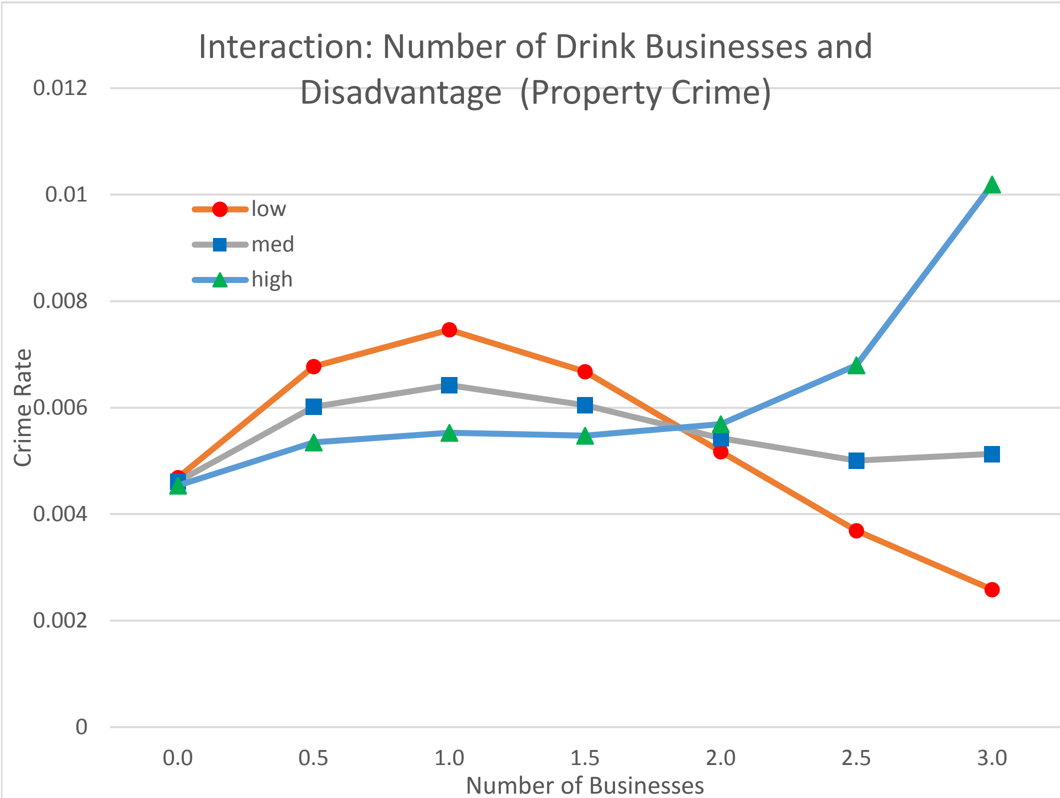

Figure A3.122. Interaction: Number of Retail Business and Disadvantage

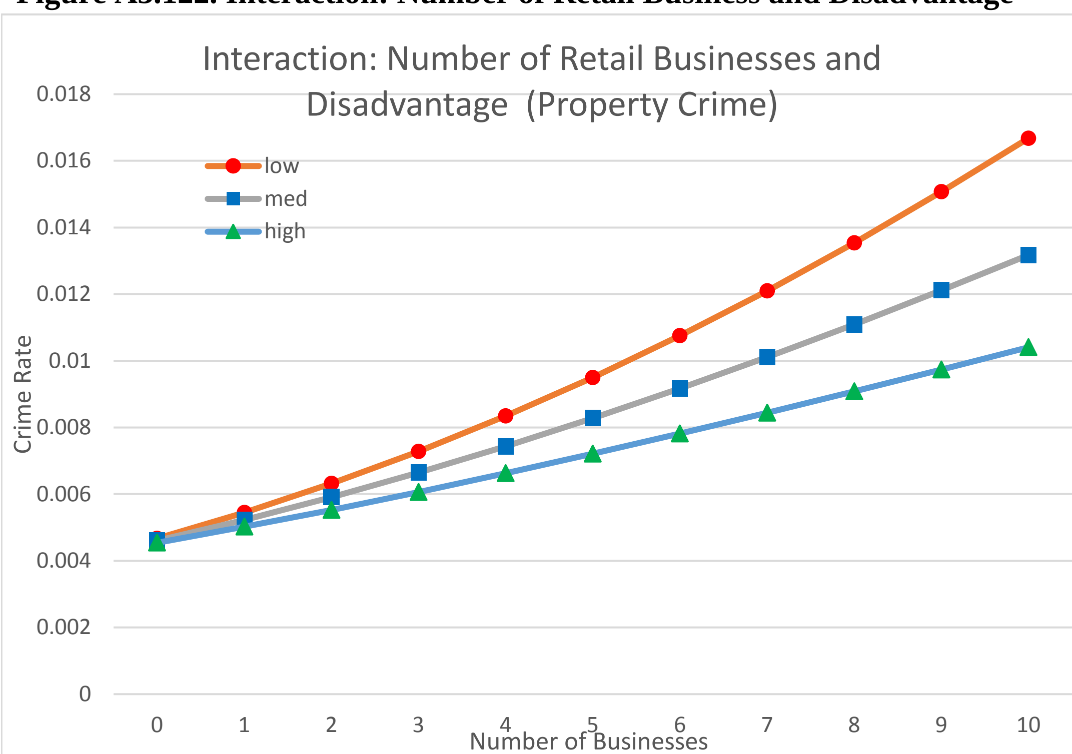

Figure A3.123. Interaction: Number of School Business and Disadvantage

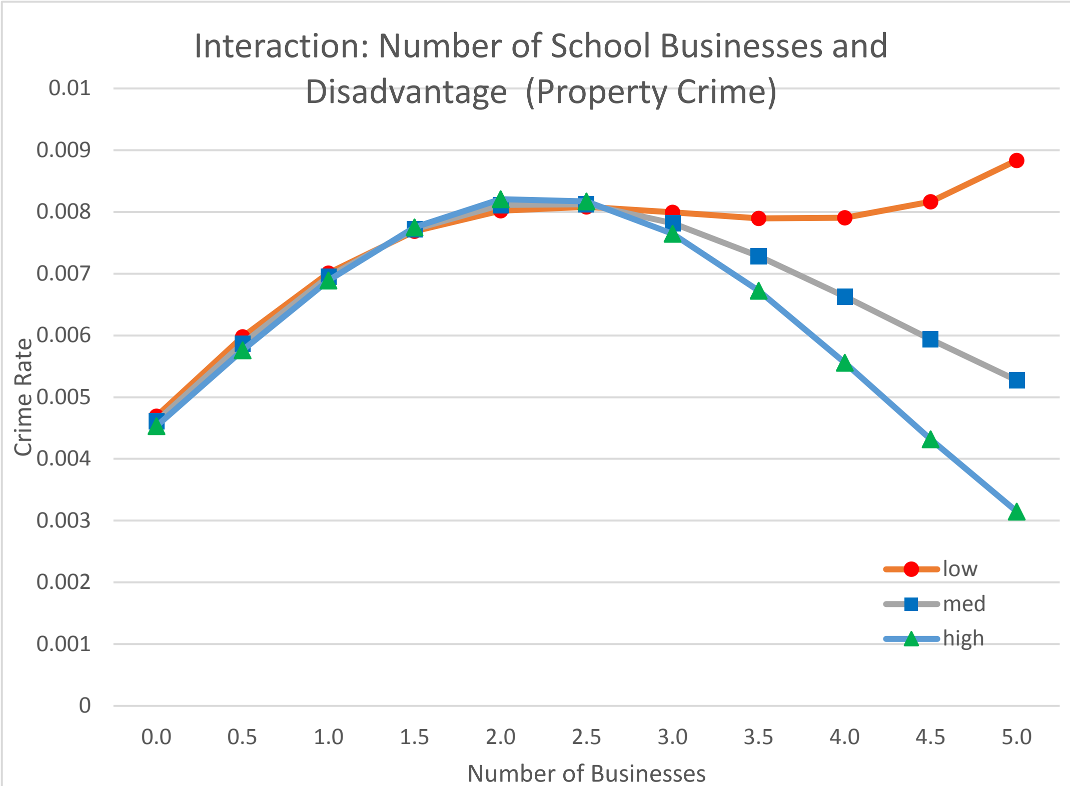

Figure A3.124. Interaction: Number of Service Business and Disadvantage

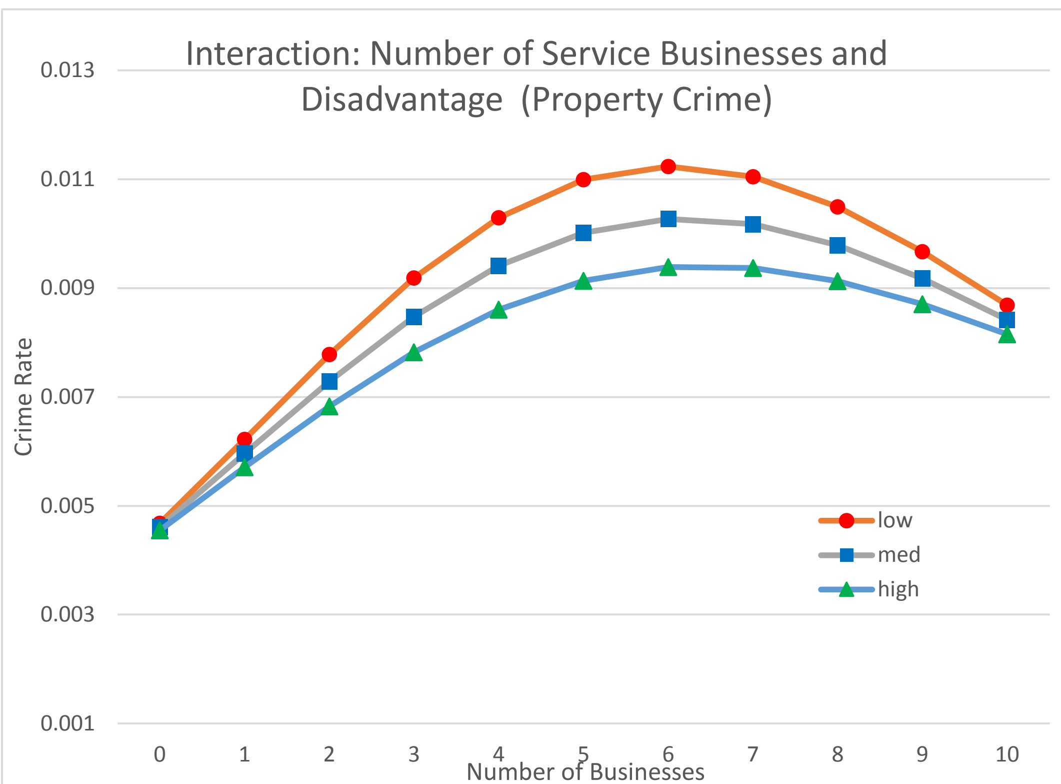

Figure A3.125. Interaction: Number of Finance Business and Disadvantage

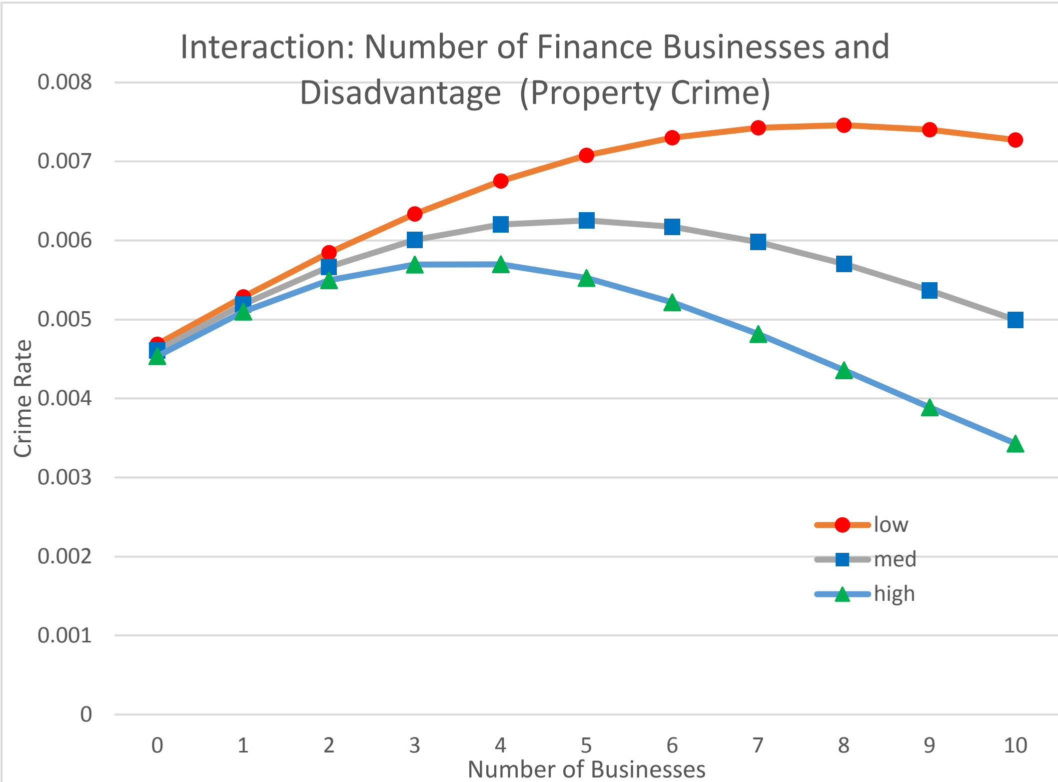

Figure A3.126. Interaction: Number of Restaurants and Disadvantage

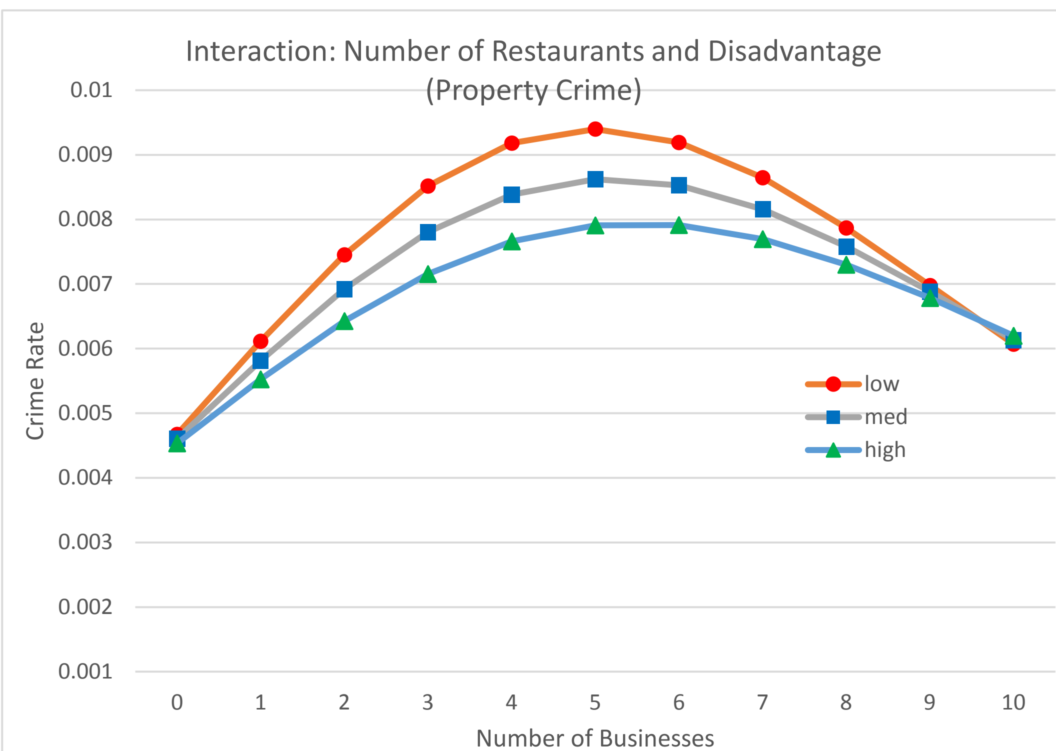

Figure A3.127. Interaction: Number of Health Businesses and Disadvantage

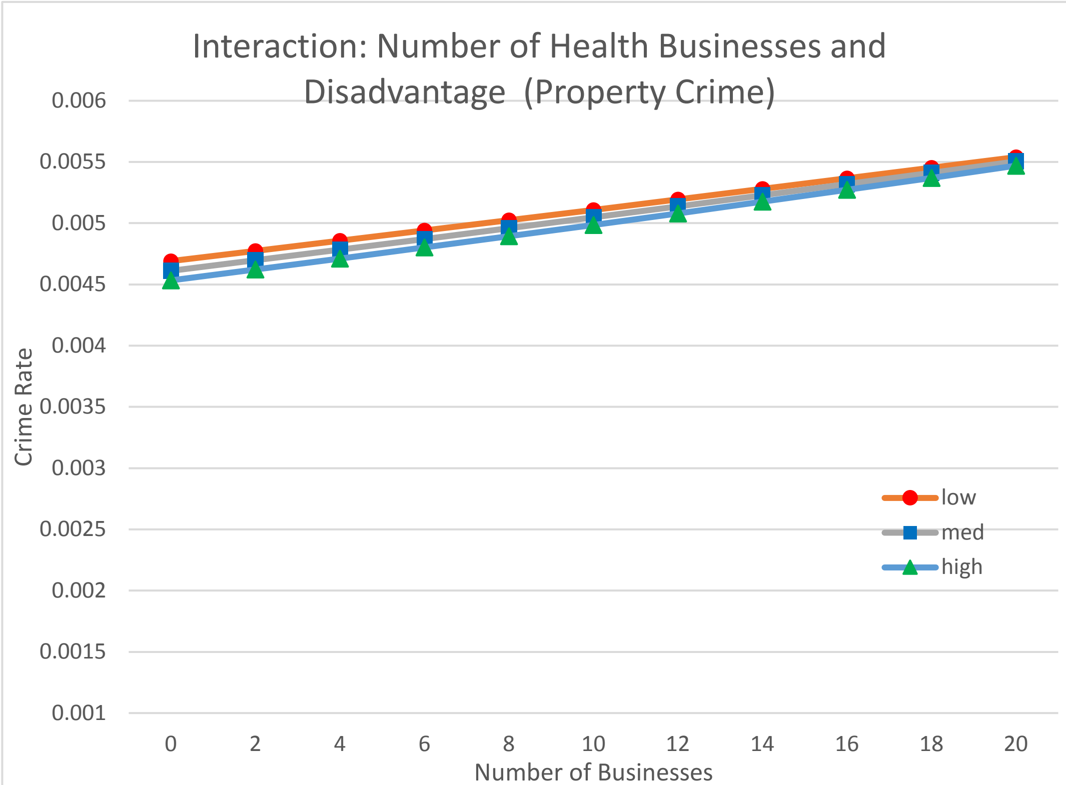

Figure A3.128. Interaction: Number of Amenities and Disadvantage

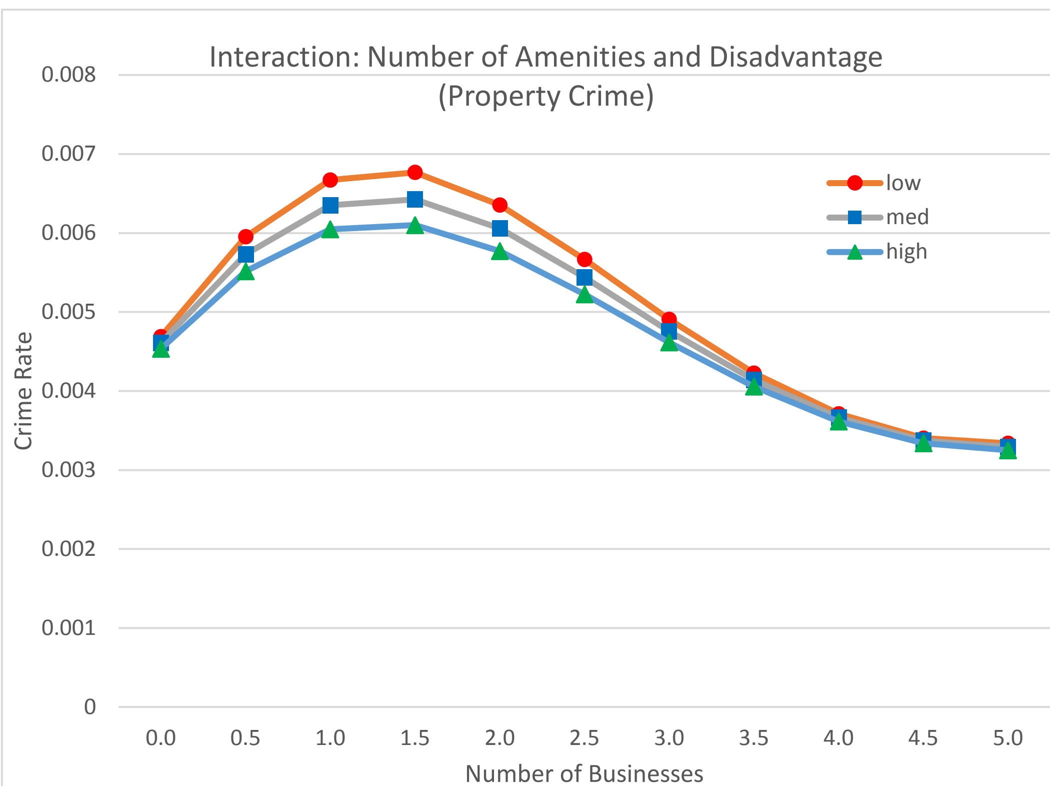

Figure A3.129. Interaction: Number of Organizations and Disadvantage

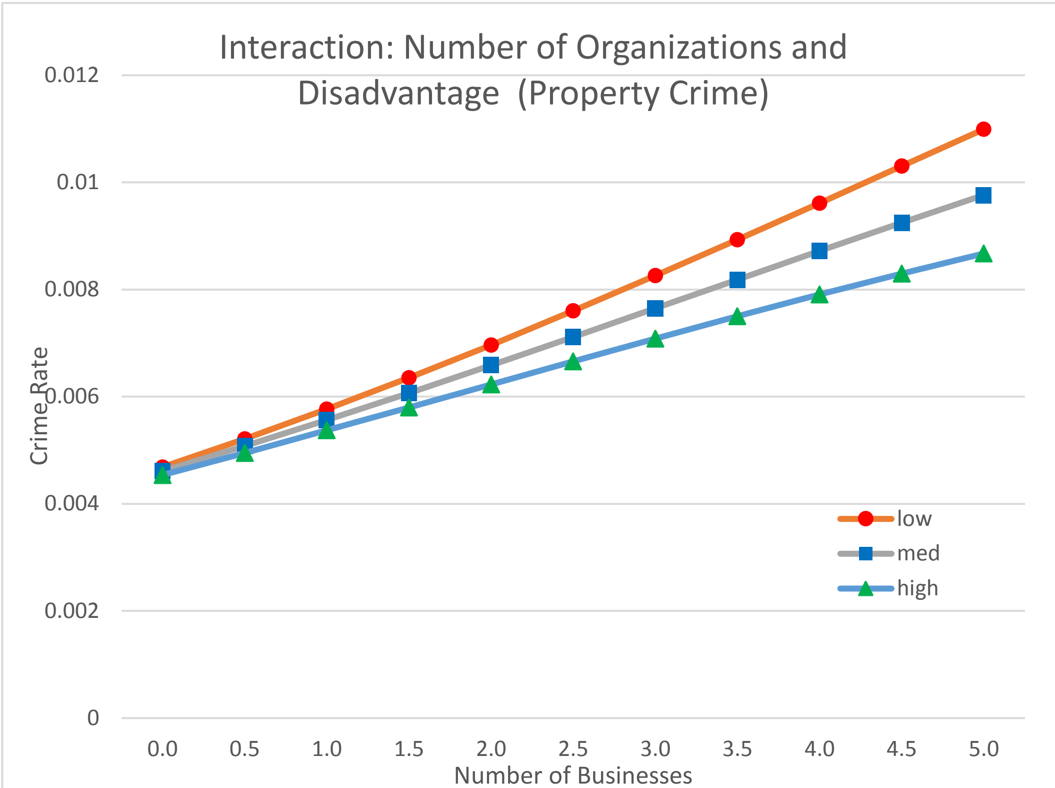

Figure A3.130. Interaction: Number of Stores and Disadvantage

Figure A3.131. Interaction: Number of Employees of Drink Business and Disadvantage

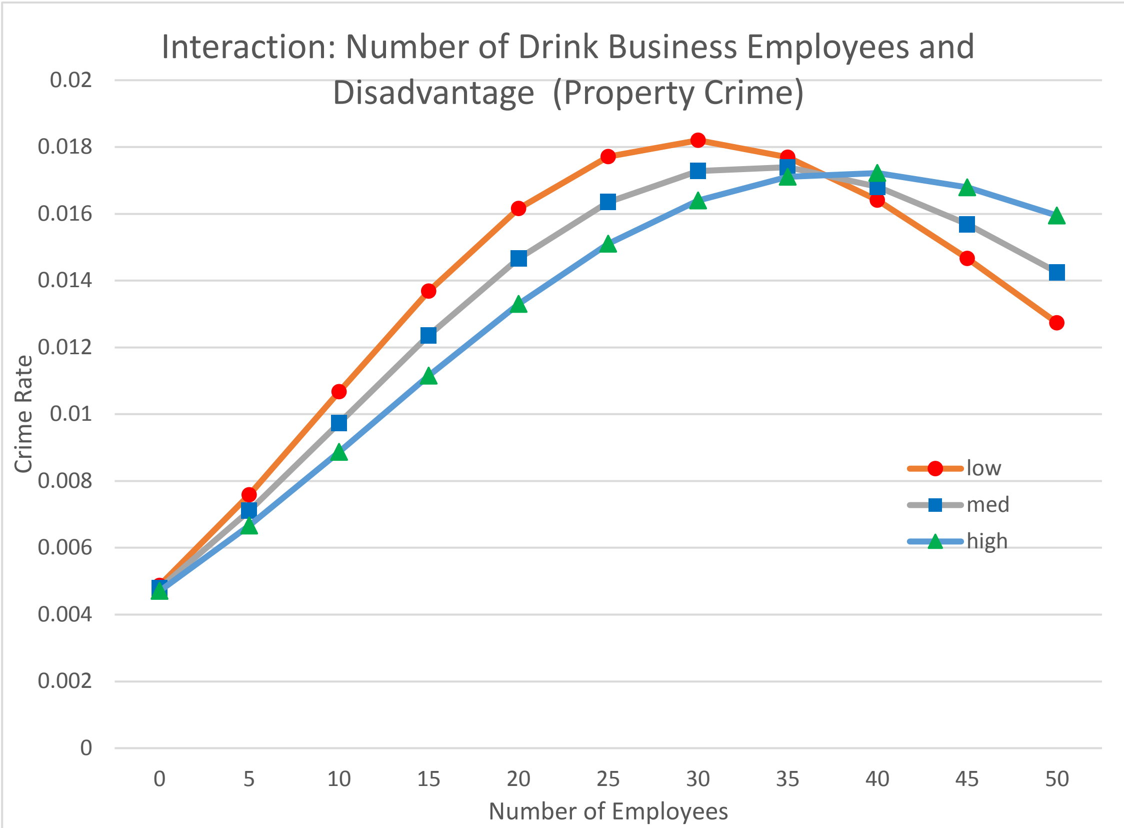

Figure A3.132. Interaction: Number of Employees of Retail Business and Disadvantage

Figure A3.133. Interaction: Number of Employees of School Business and Disadvantage

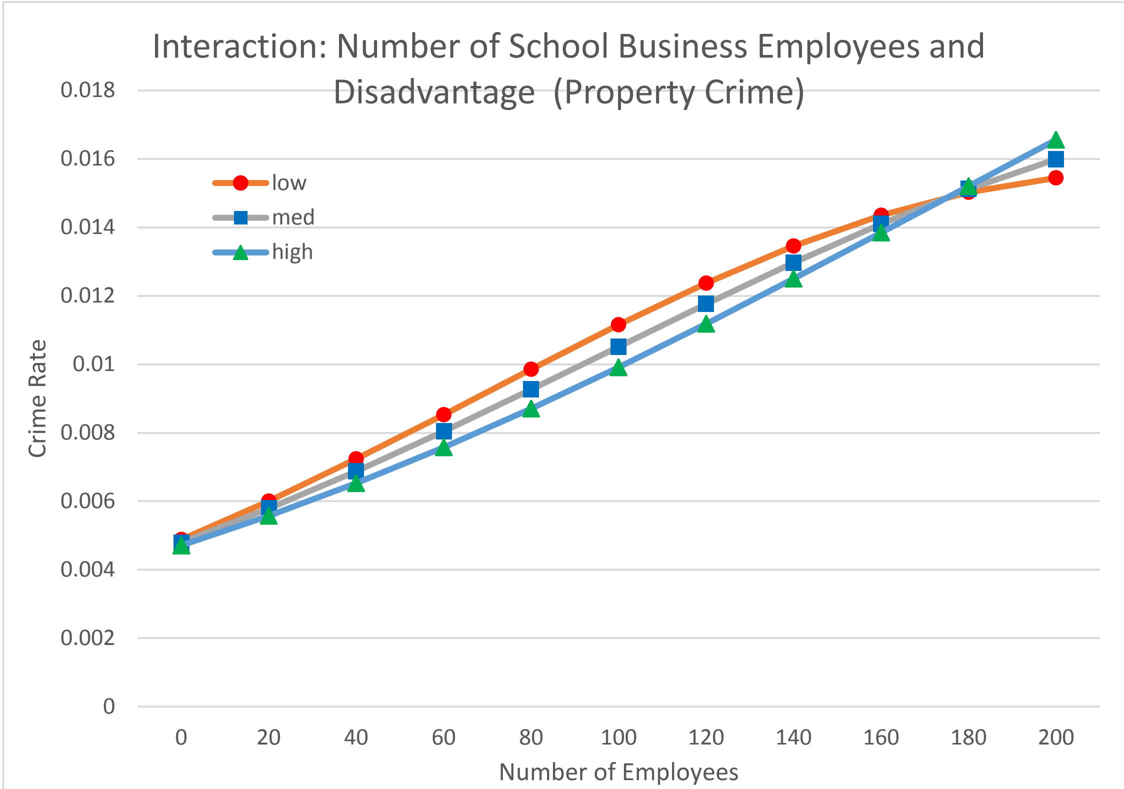

Figure A3.134. Interaction: Number of Employees of Service Business and Disadvantage

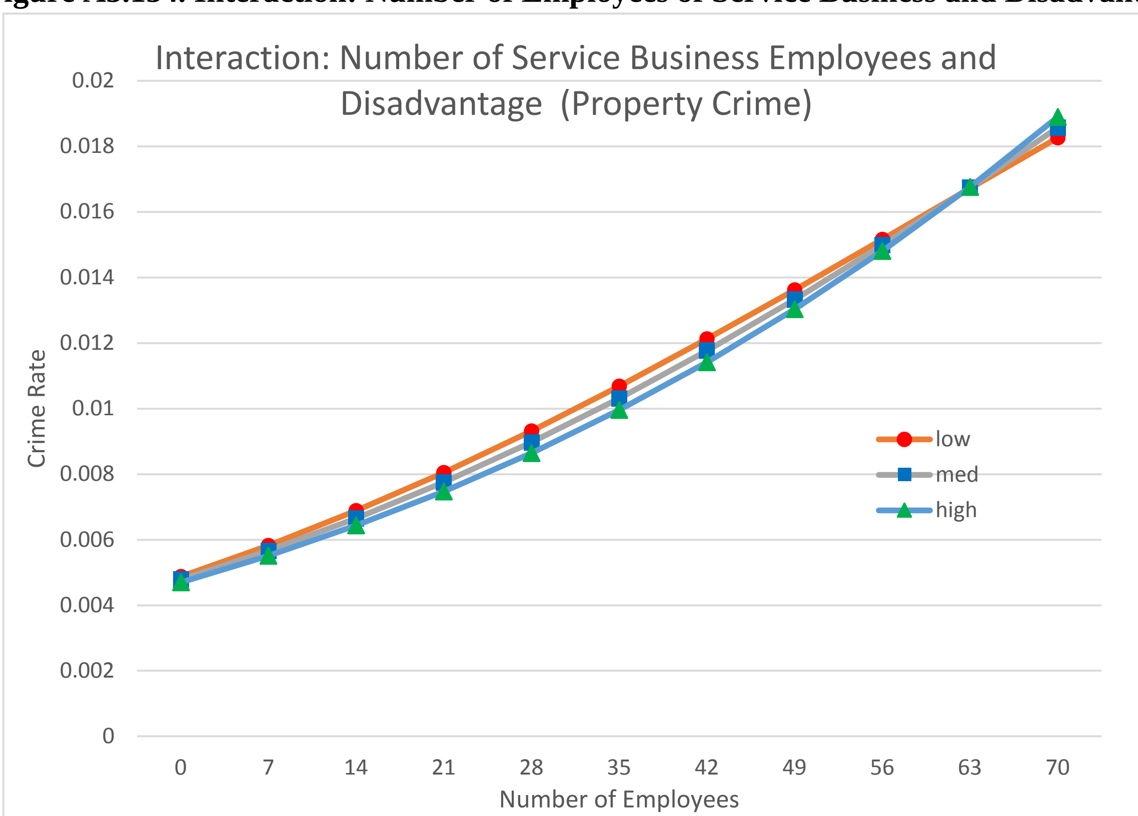

Figure A3.135. Interaction: Number of Employees of Finance Business and Disadvantage

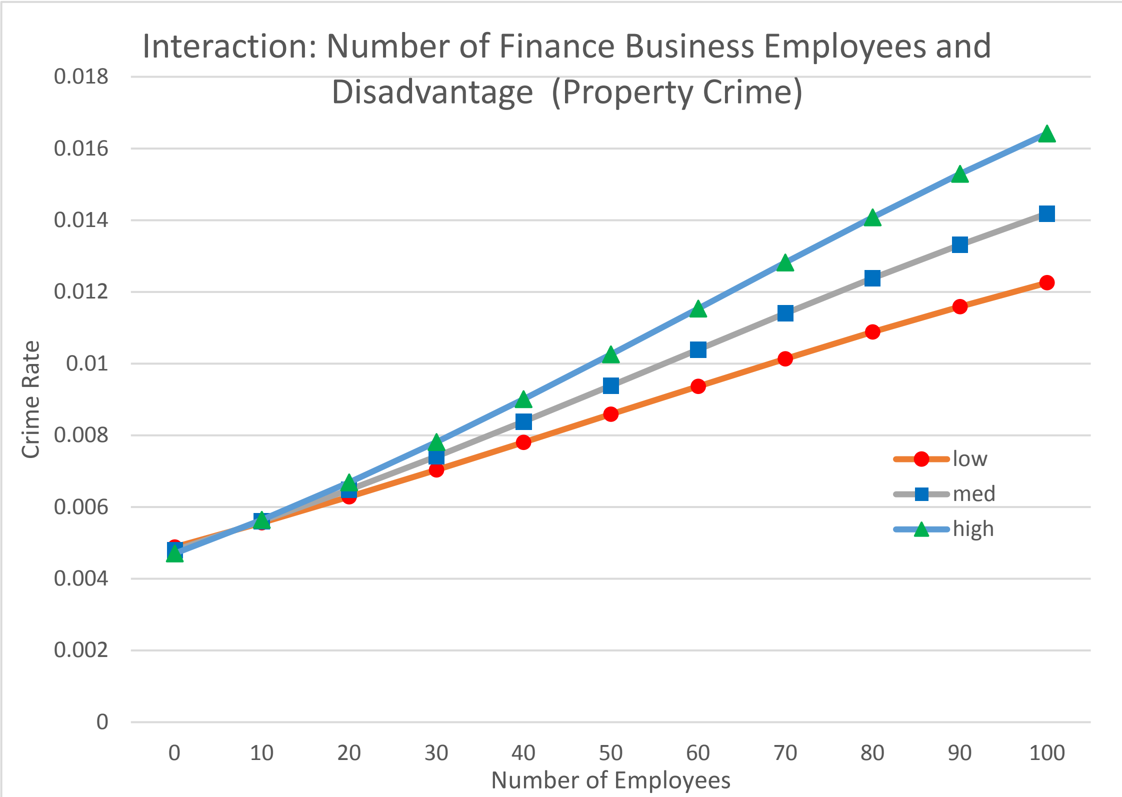

Figure A3.136. Interaction: Number of Employees of Restaurants and Disadvantage

Figure A3.137. Interaction: Number of Employees of Health Businesses and Disadvantage

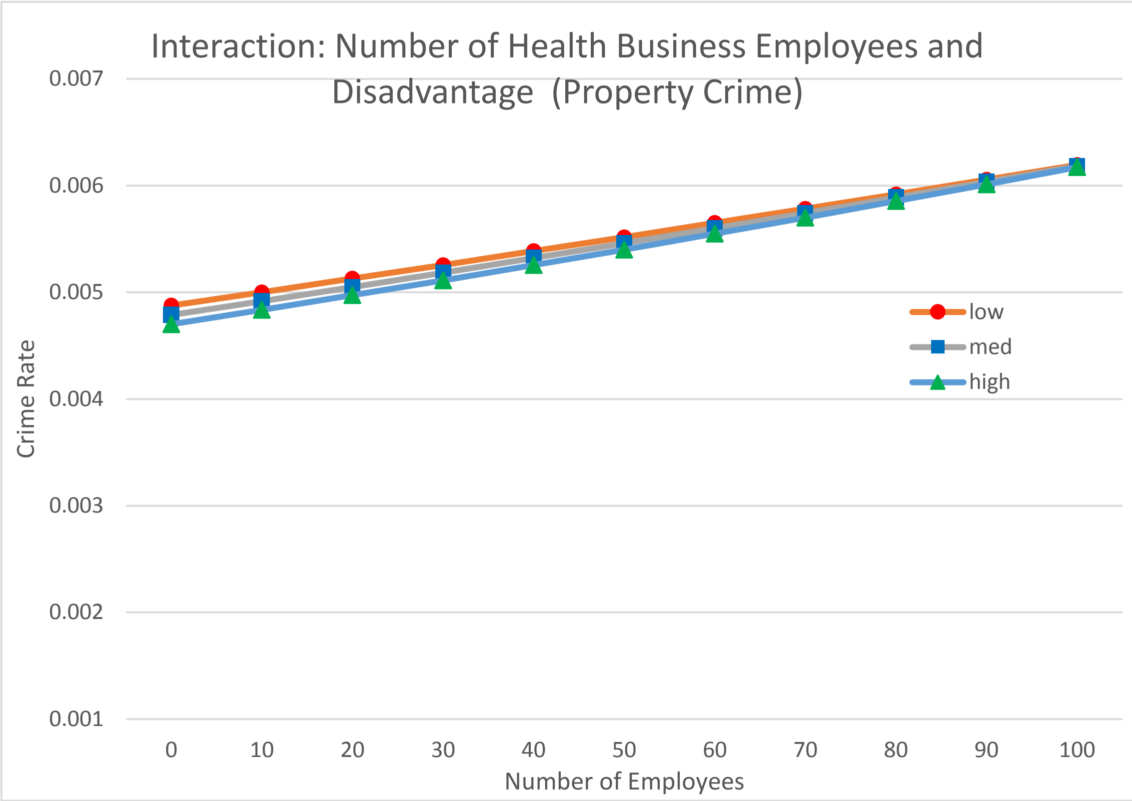

Figure A3.138. Interaction: Number of Employees of Amenities and Disadvantage

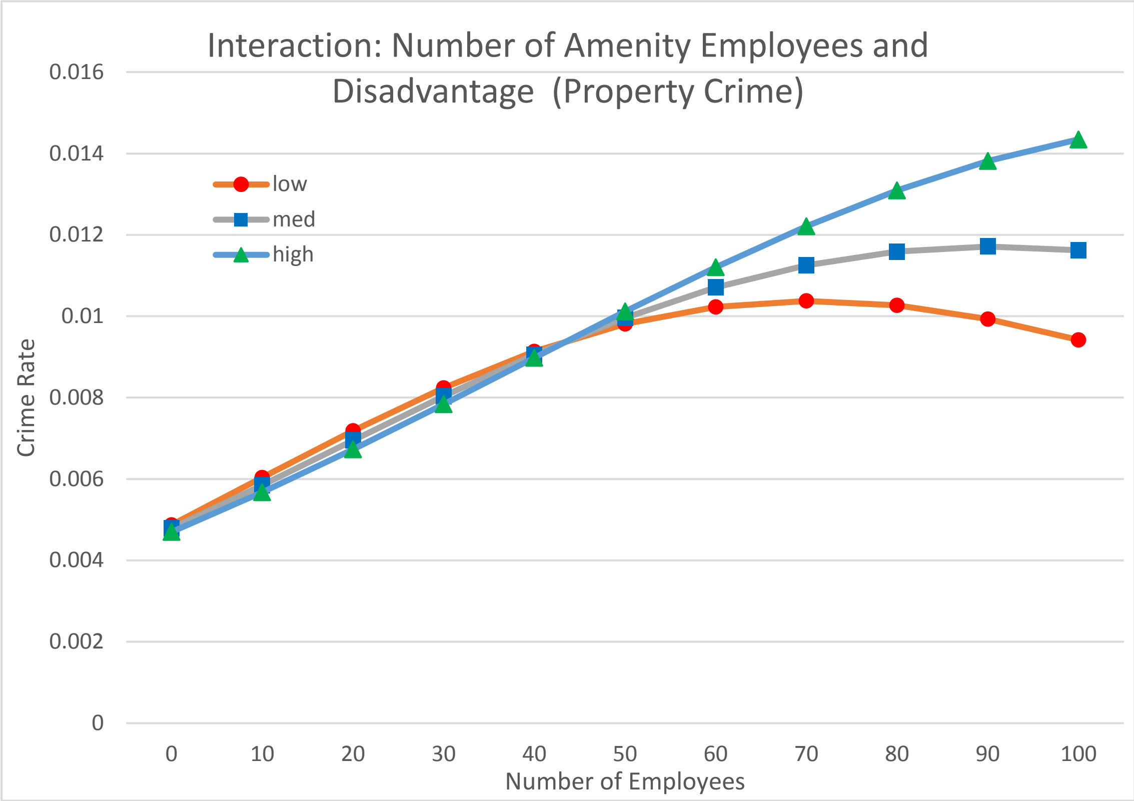

Figure A3.139. Interaction: Number of Employees of Organizations and Disadvantage

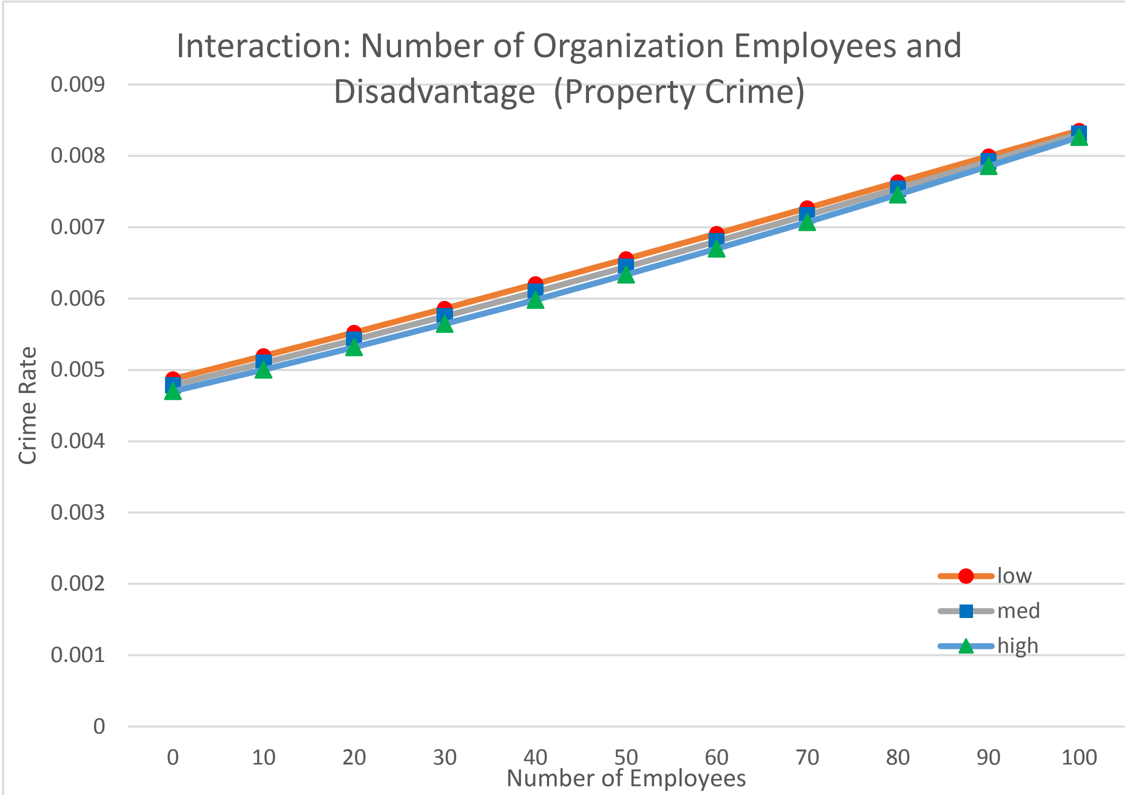

Figure A3.140. Interaction: Number of Employees of Stores and Disadvantage

Figure A3.141. Interaction: Number of Local Drink Business and Disadvantage

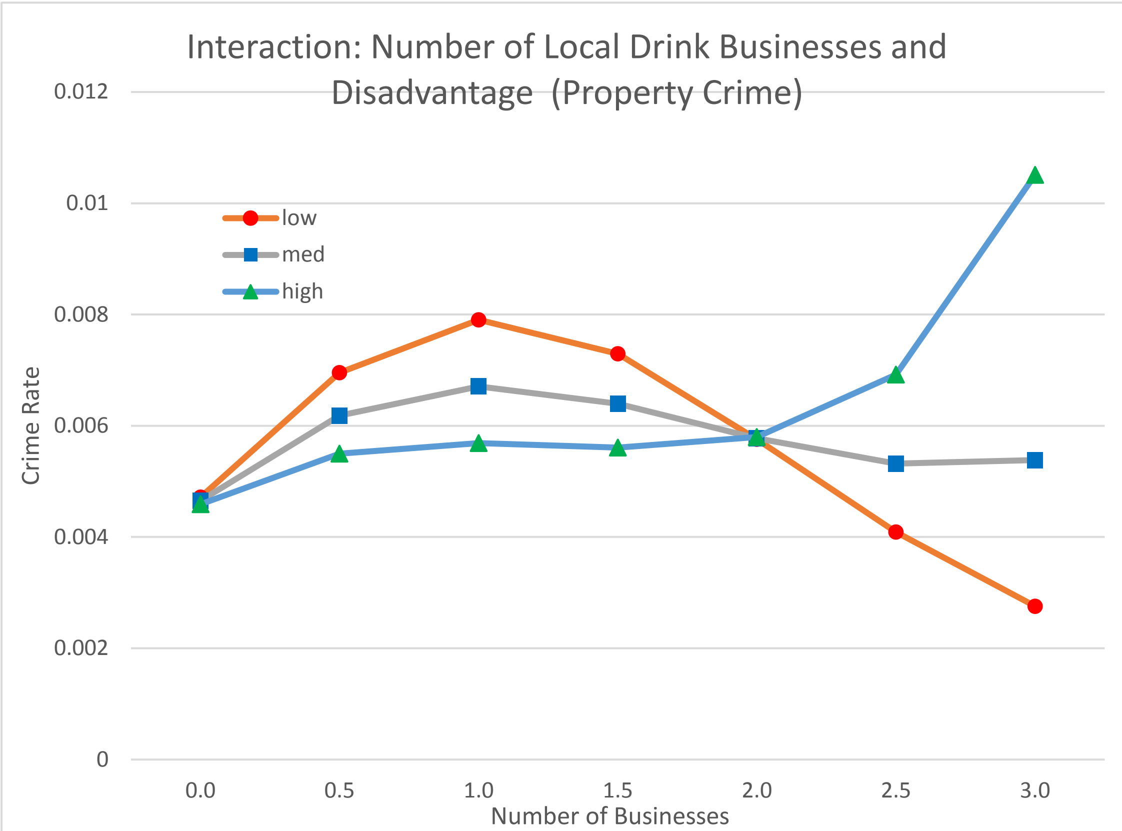

Figure A3.142. Interaction: Number of Local Retail Business and Disadvantage

Figure A3.143. Interaction: Number of Local School Business and Disadvantage

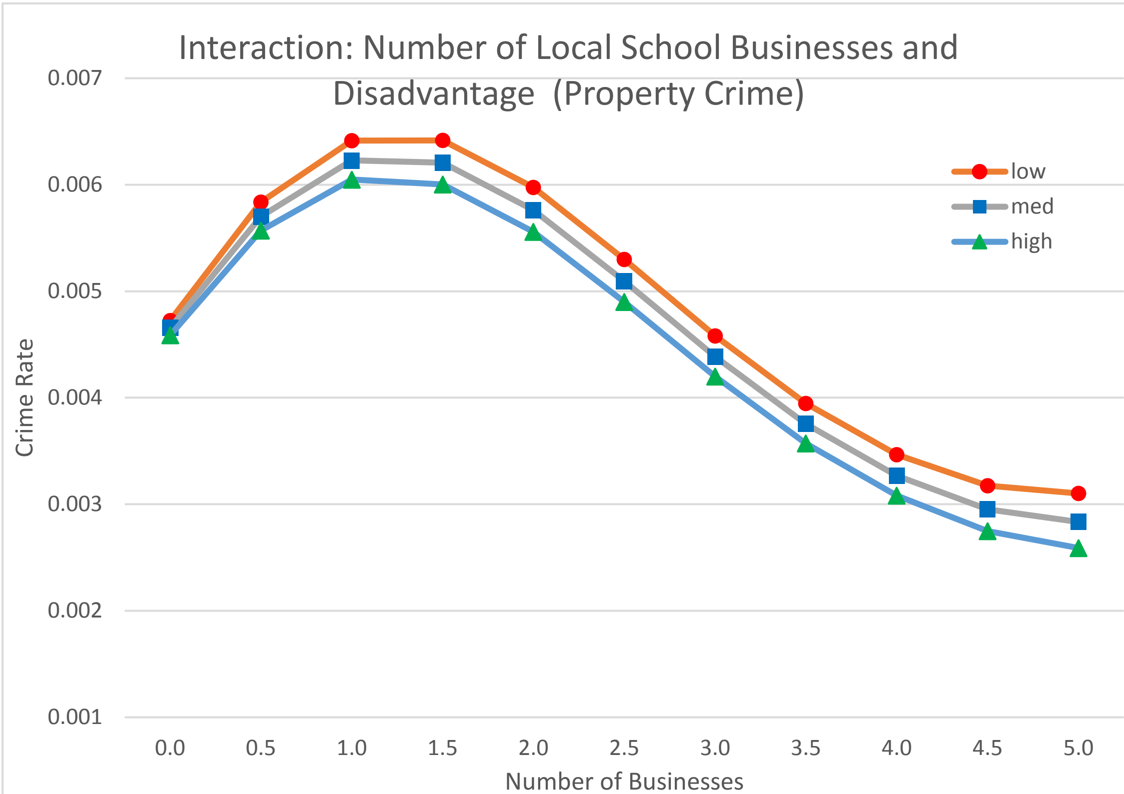

Figure A3.144. Interaction: Number of Local Service Business and Disadvantage

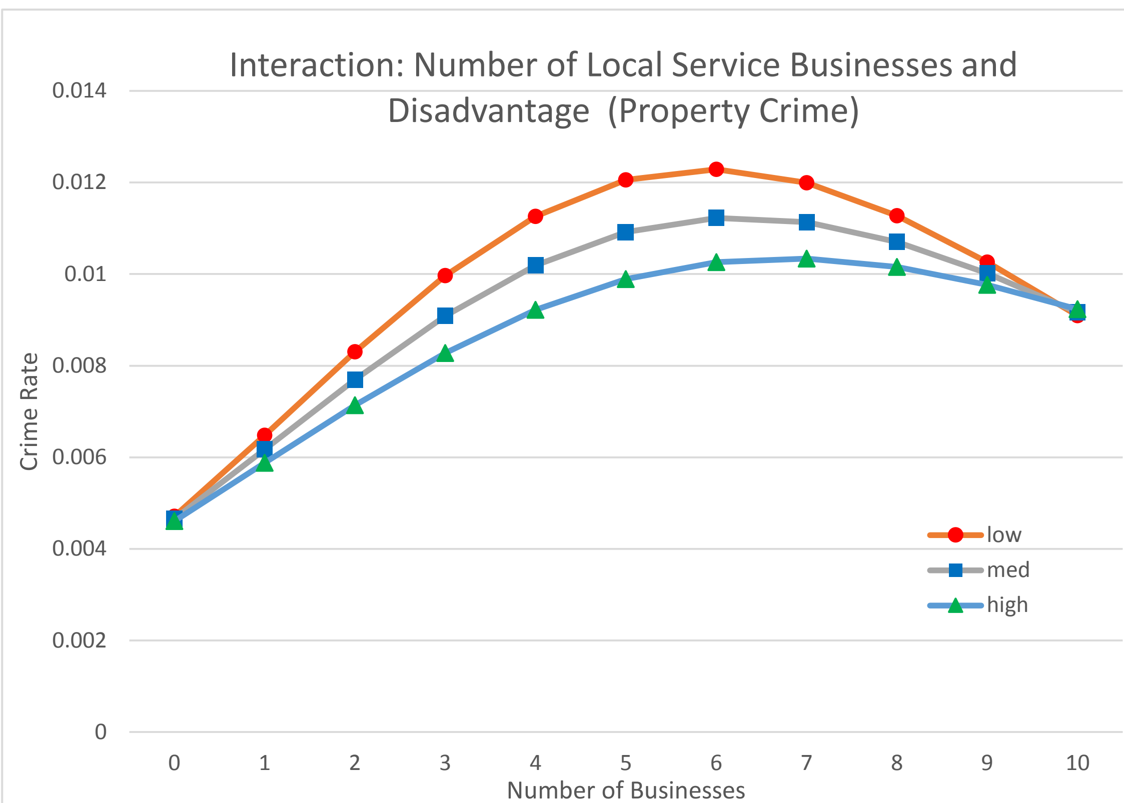

Figure A3.145. Interaction: Number of Local Finance Business and Disadvantage

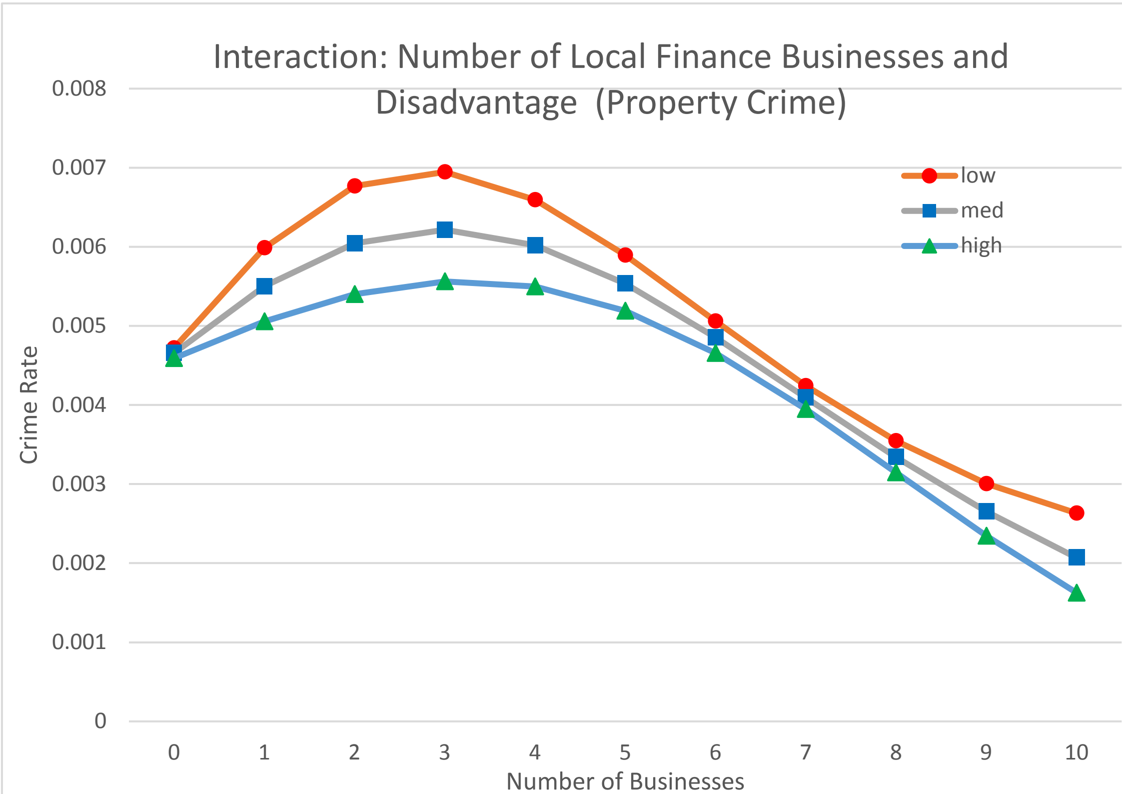

Figure A3.146. Interaction: Number of Local Restaurants and Disadvantage

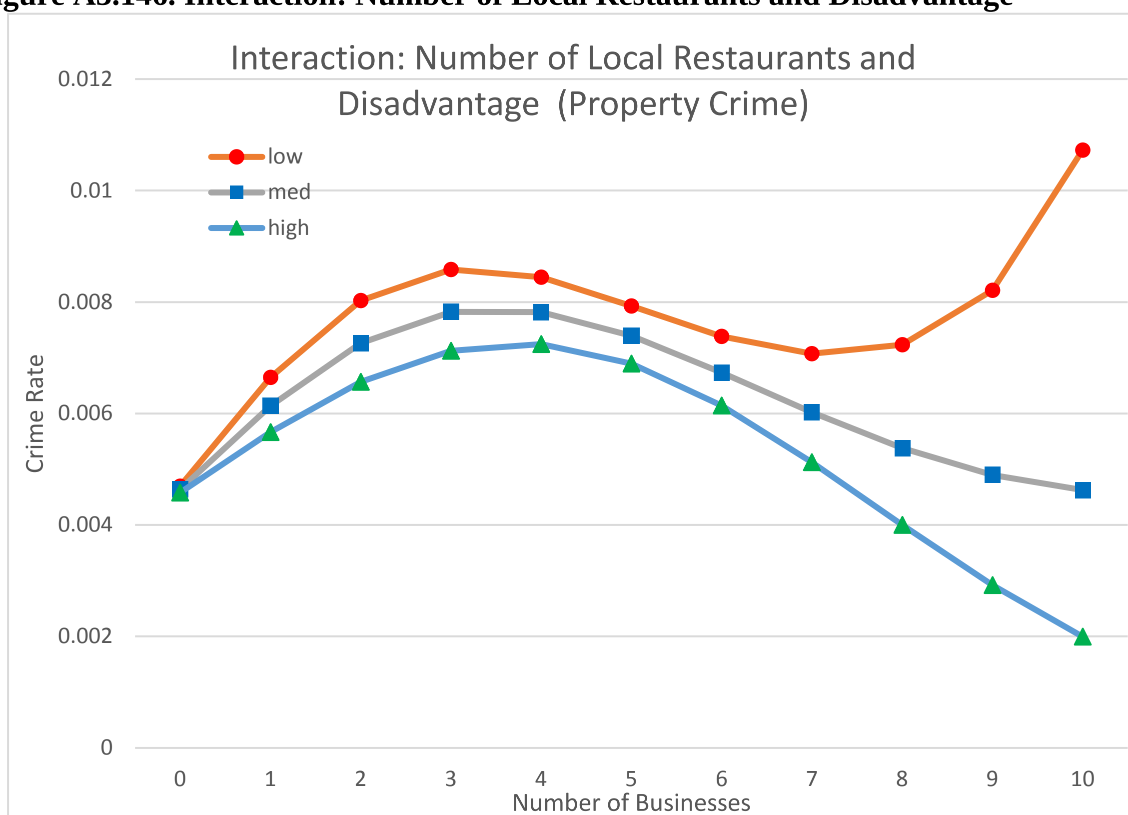

Figure A3.147. Interaction: Number of Local Health Businesses and Disadvantage

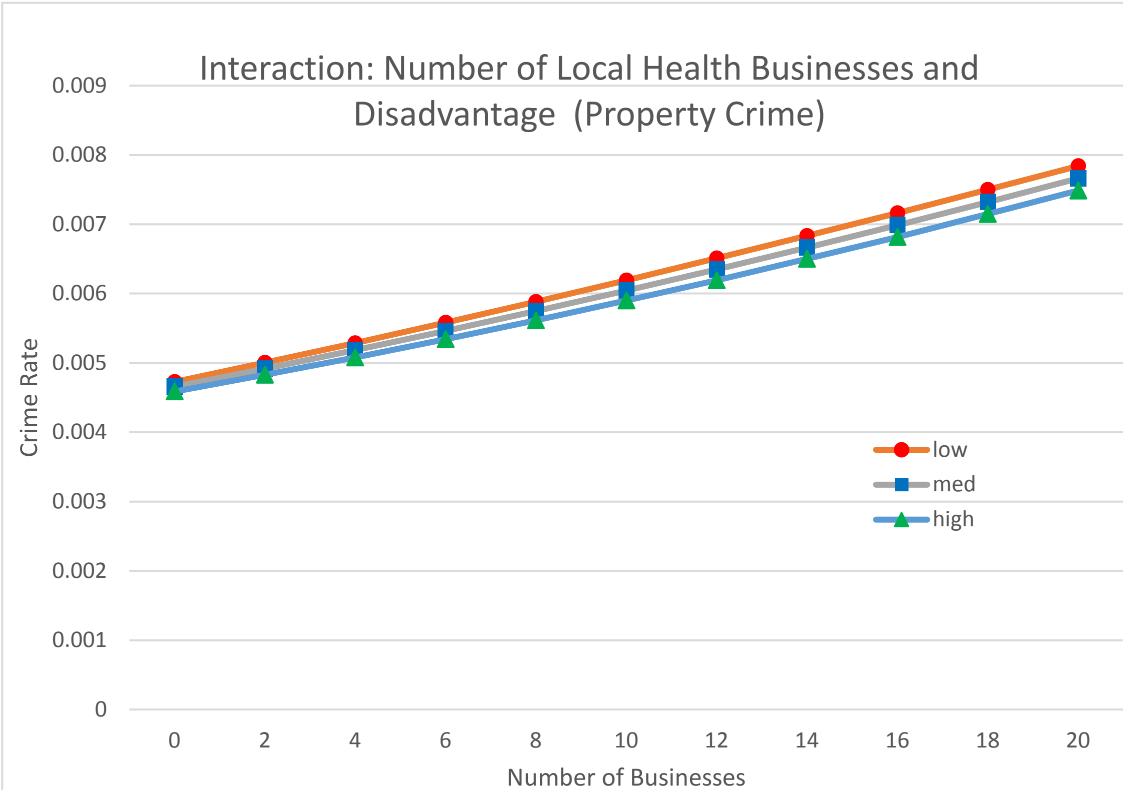

Figure A3.148. Interaction: Number of Local Amenities and Disadvantage

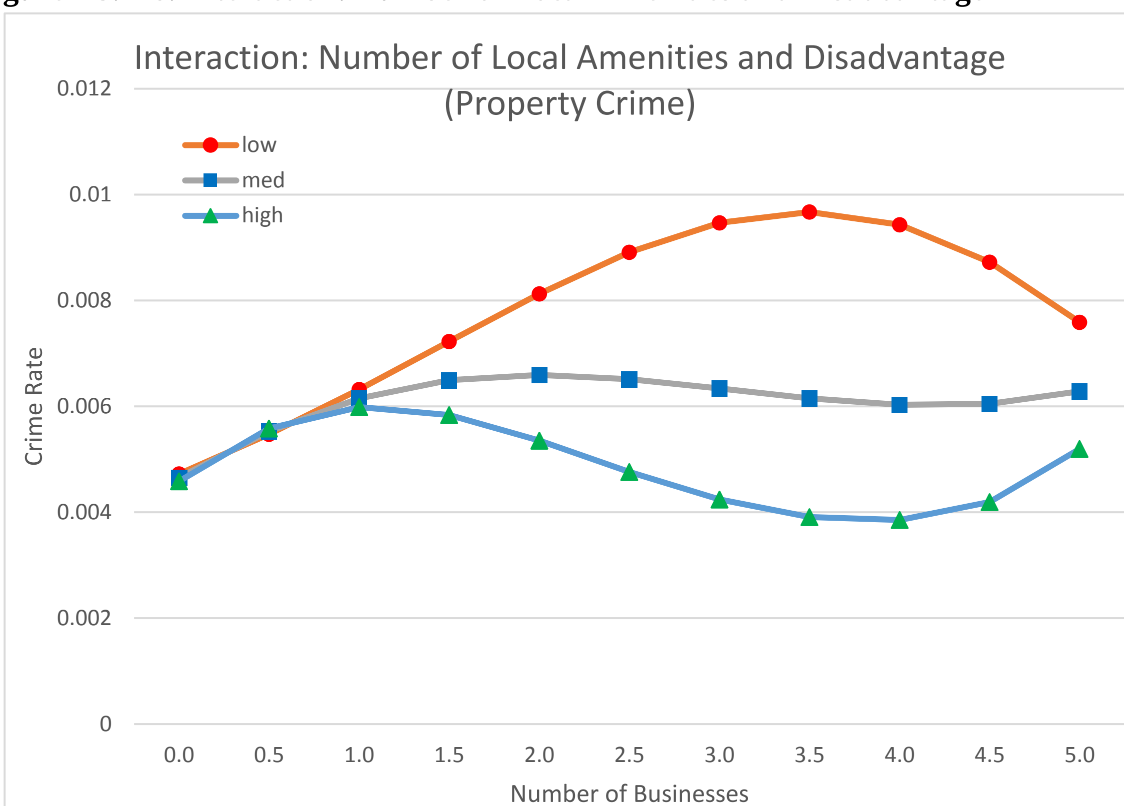

Figure A3.149. Interaction: Number of Local Organizations and Disadvantage

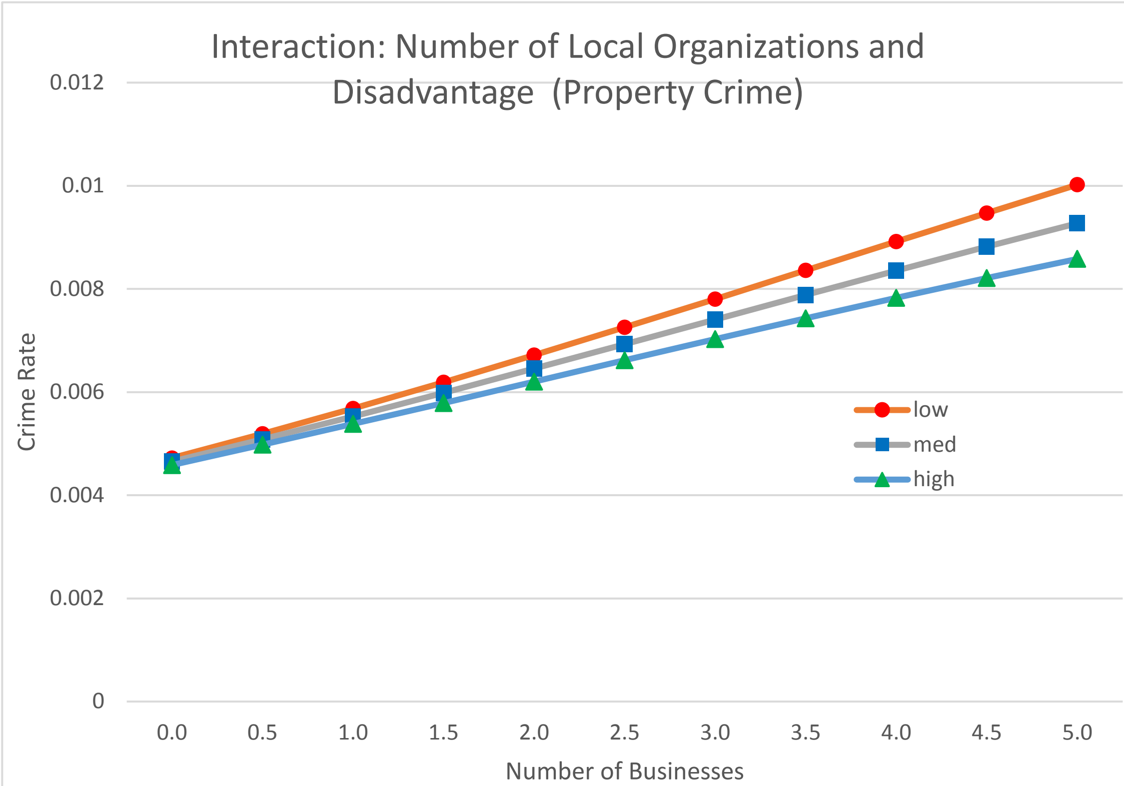

Figure A3.150. Interaction: Number of Local Stores and Disadvantage

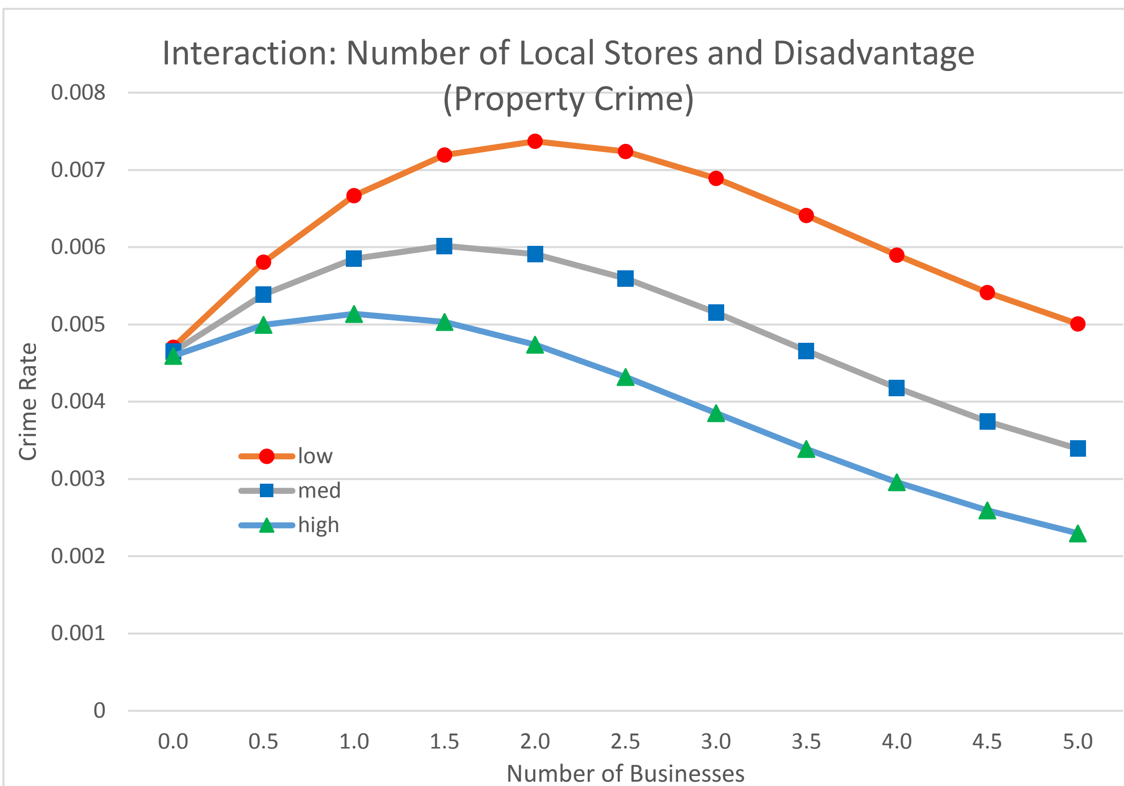

Figure A3.151. Interaction: Age of Drink Business and Disadvantage

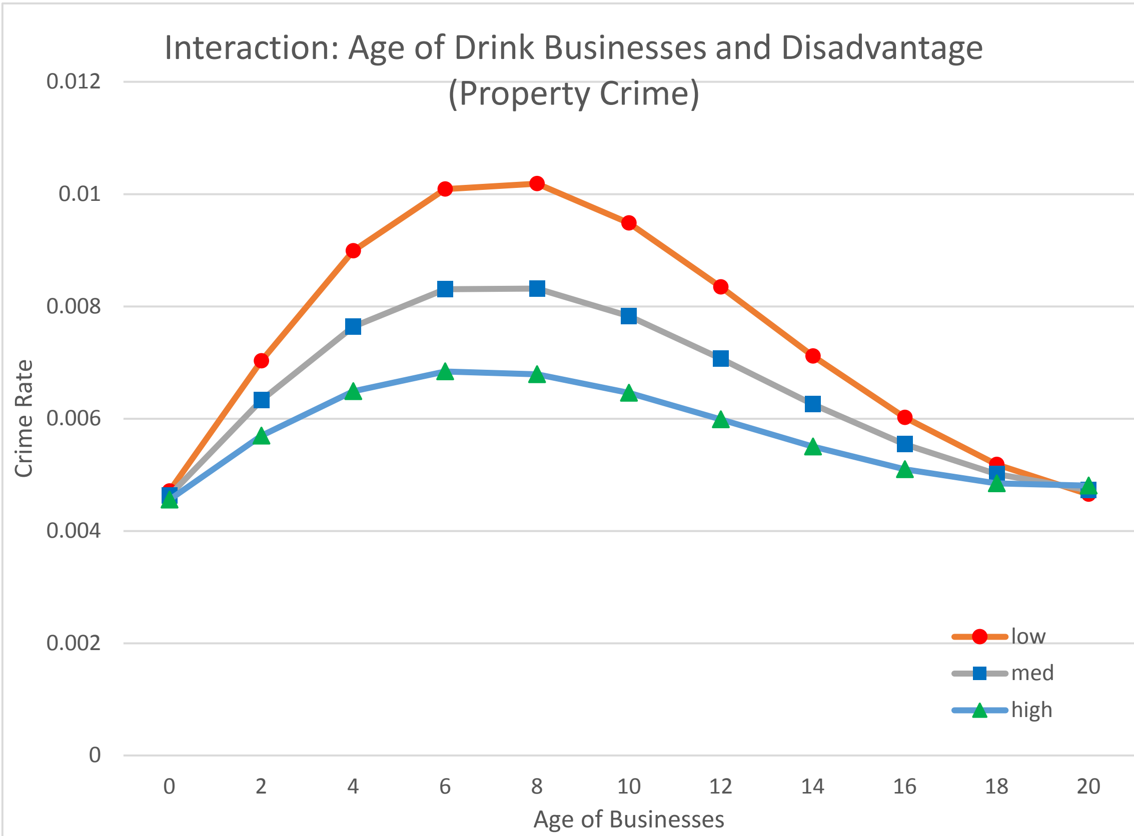

Figure A3.152. Interaction: Age of Retail Business and Disadvantage

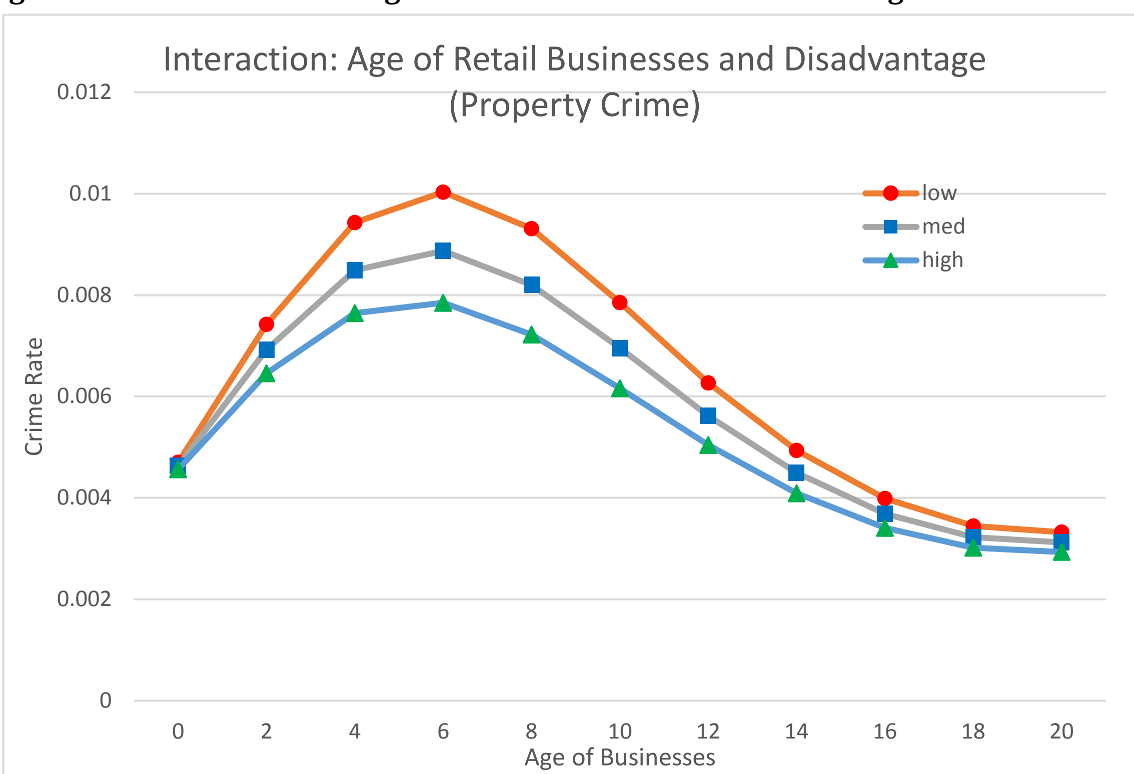

Figure A3.153. Interaction: Age of School Business and Disadvantage

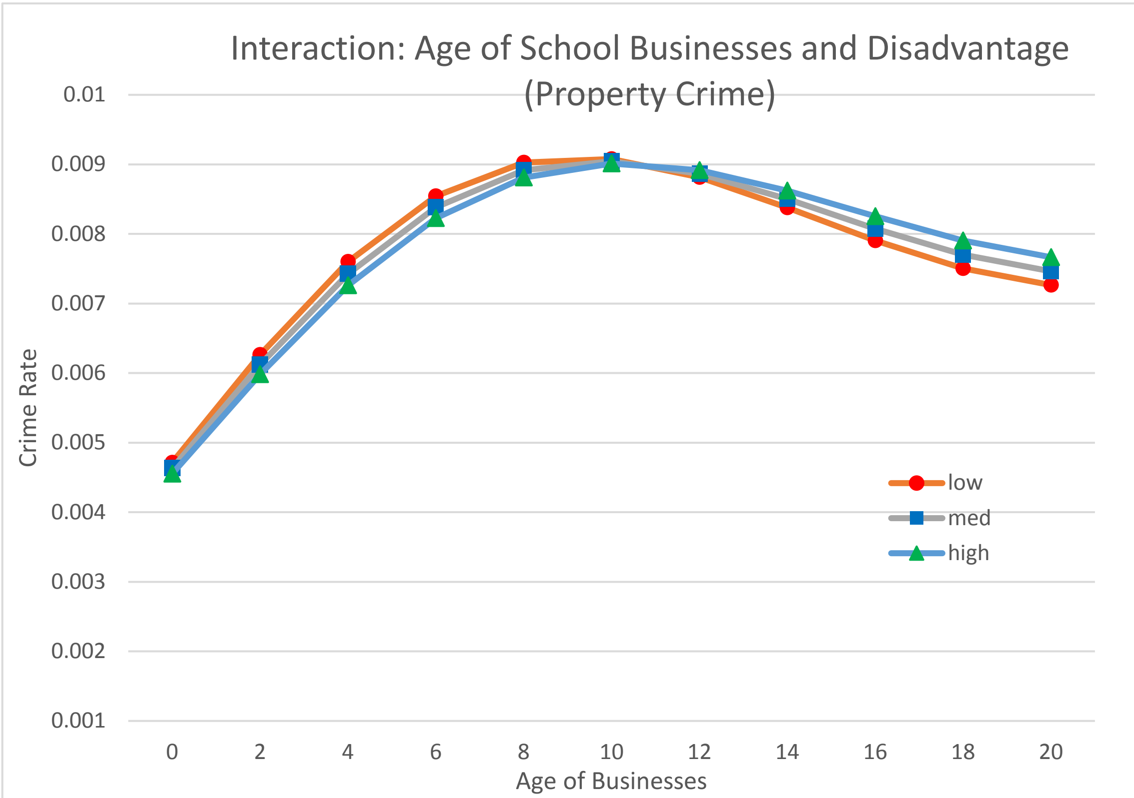

Figure A3.154. Interaction: Age of Service Business and Disadvantage

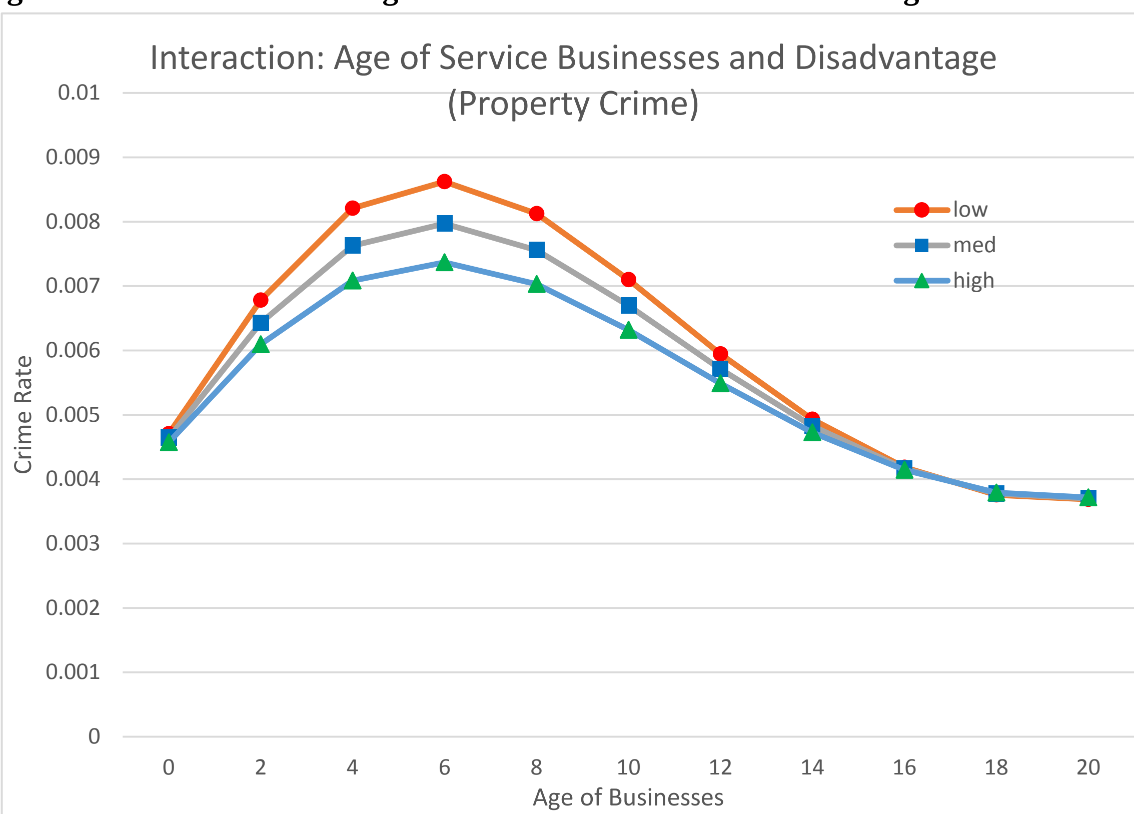

Figure A3.155. Interaction: Age of Finance Business and Disadvantage

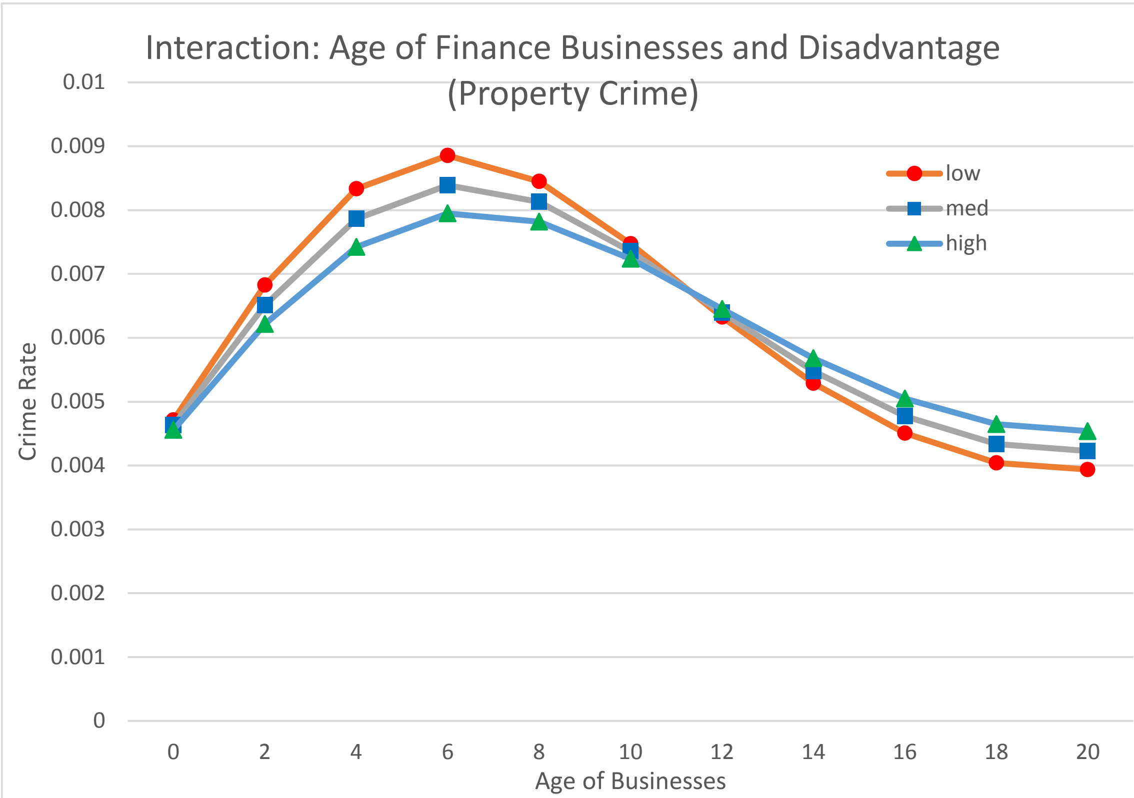

Figure A3.156. Interaction: Age of Restaurants and Disadvantage

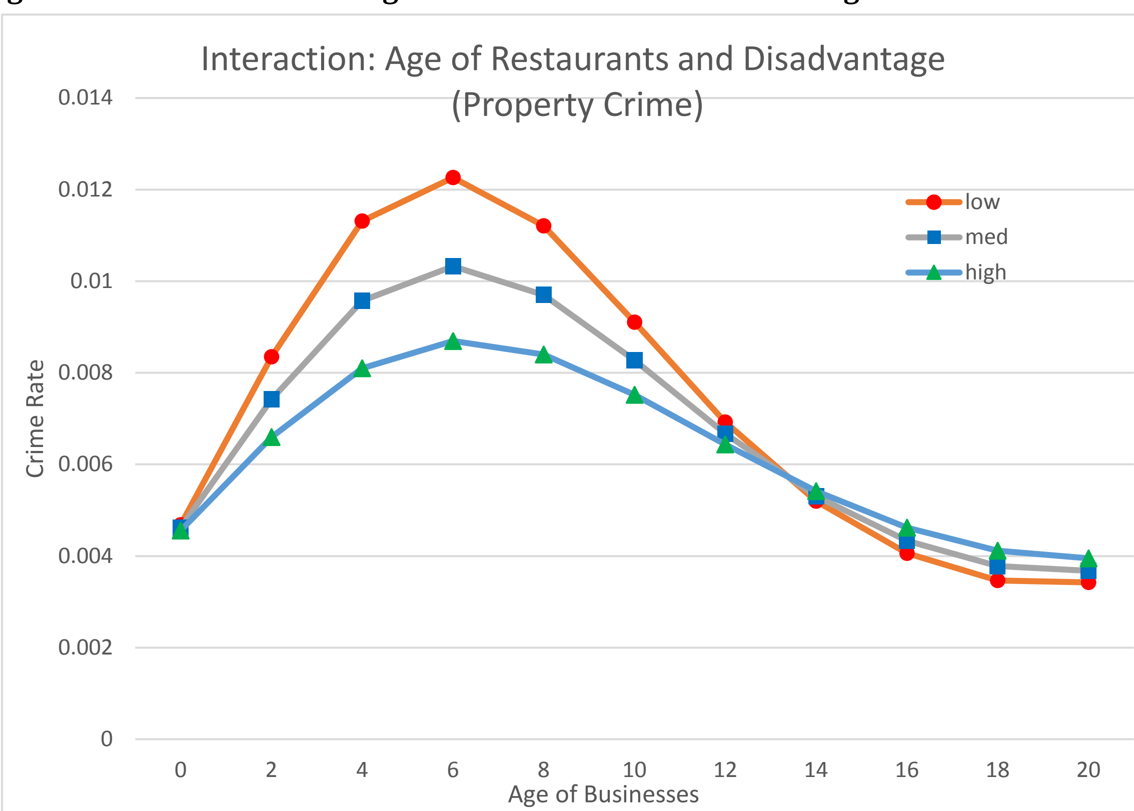

Figure A3.157. Interaction: Age of Health Businesses and Disadvantage

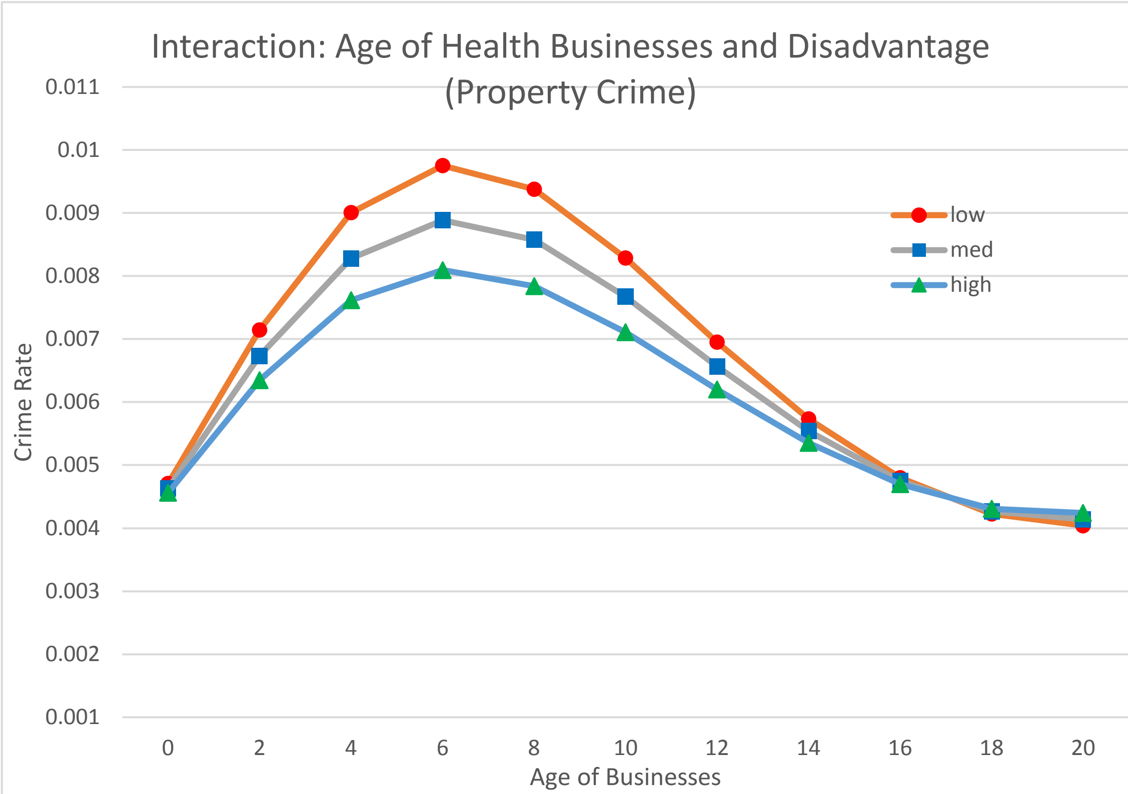

Figure A3.158. Interaction: Age of Amenities and Disadvantage

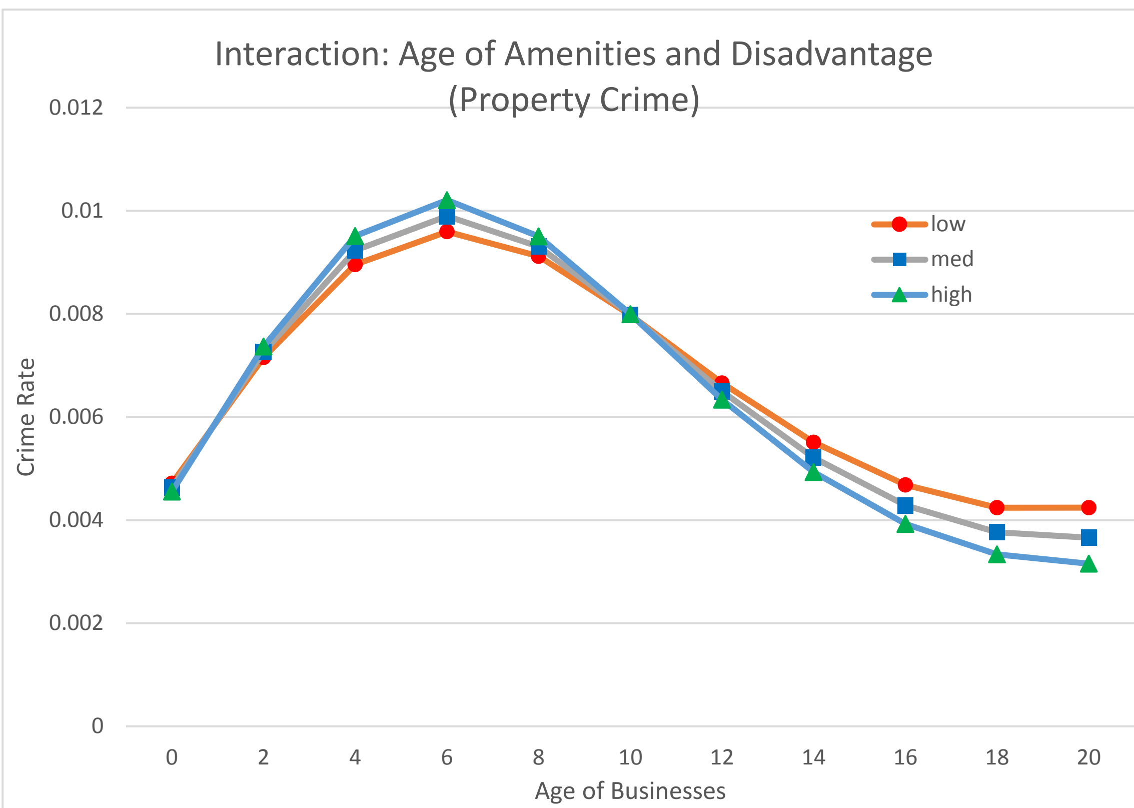

Figure A3.159. Interaction: Age of Organizations and Disadvantage

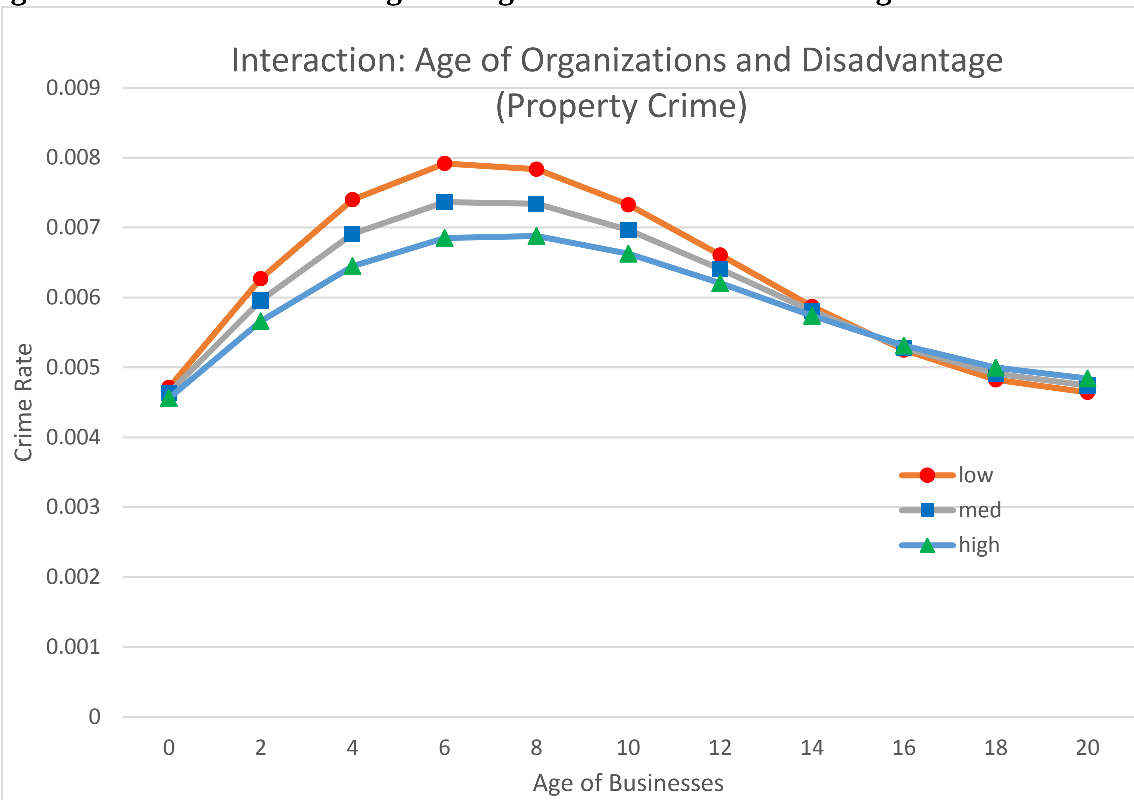

Figure A3.160. Interaction: Age of Stores and Disadvantage

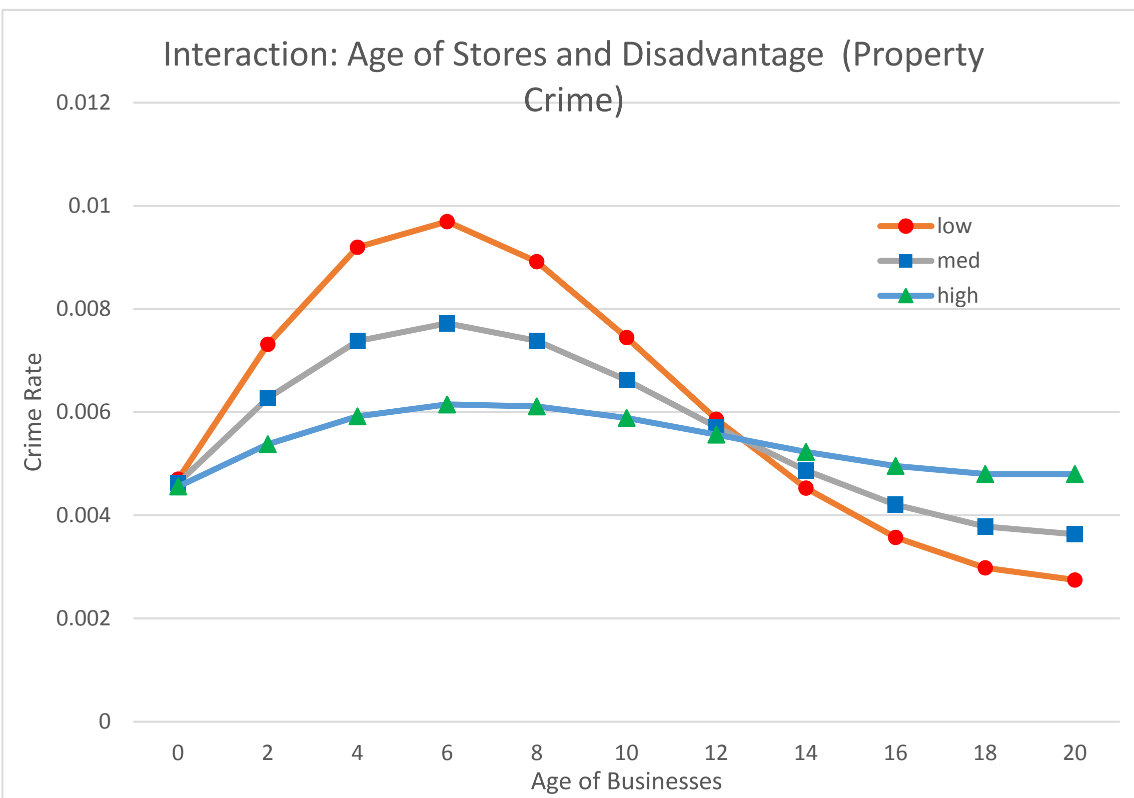

Figure A4.1. Local Reach and Violent Crime

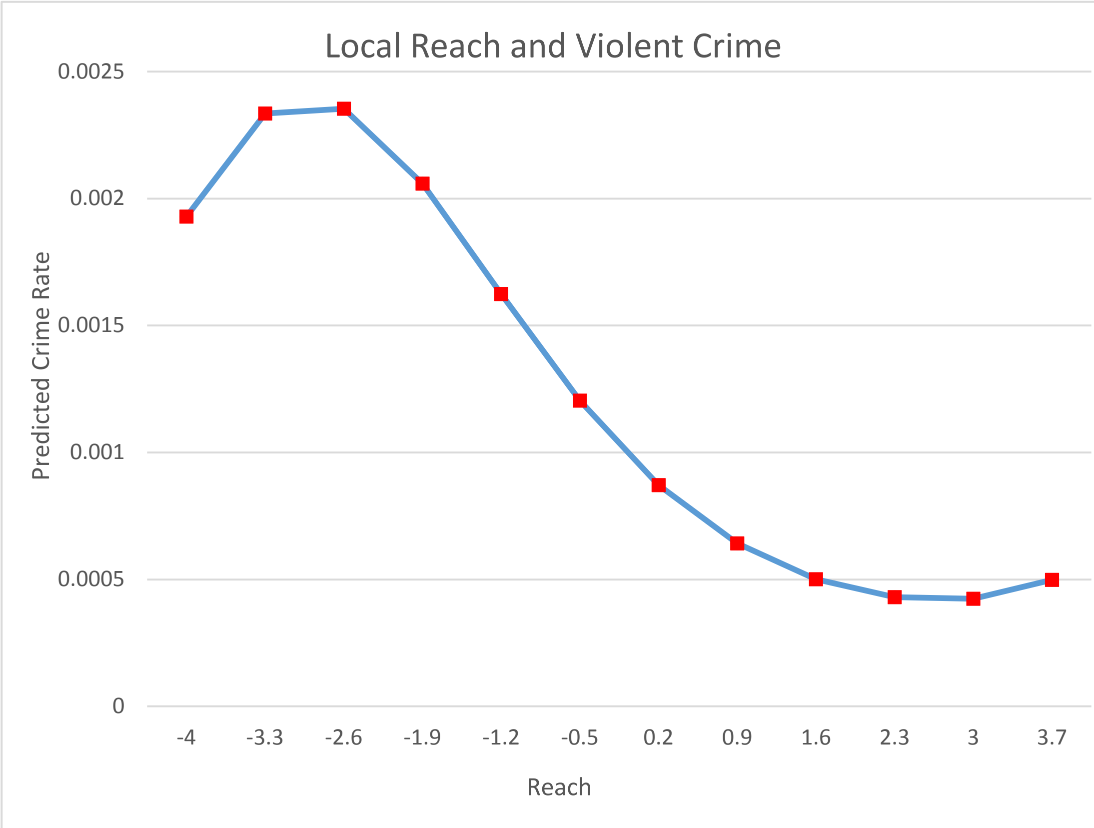

Figure A4.2. Local Betweenness and Violent Crime

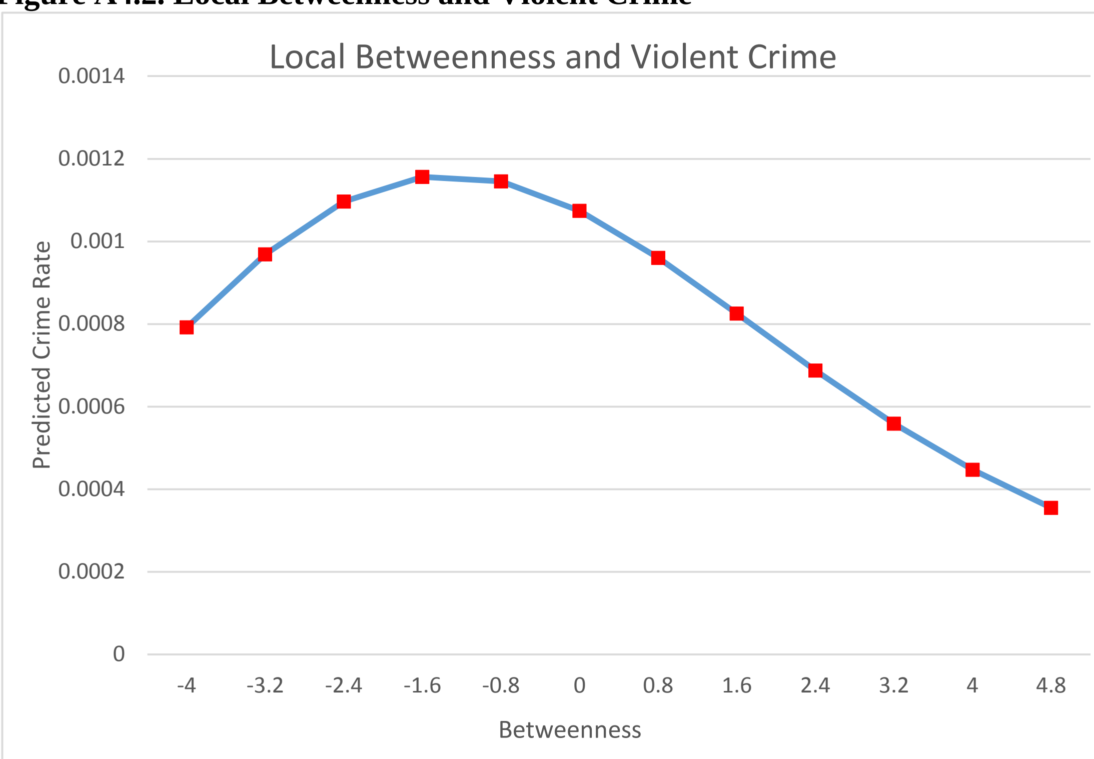

Figure A4.3. Local Betweenness (population weighted) and Violent Crime

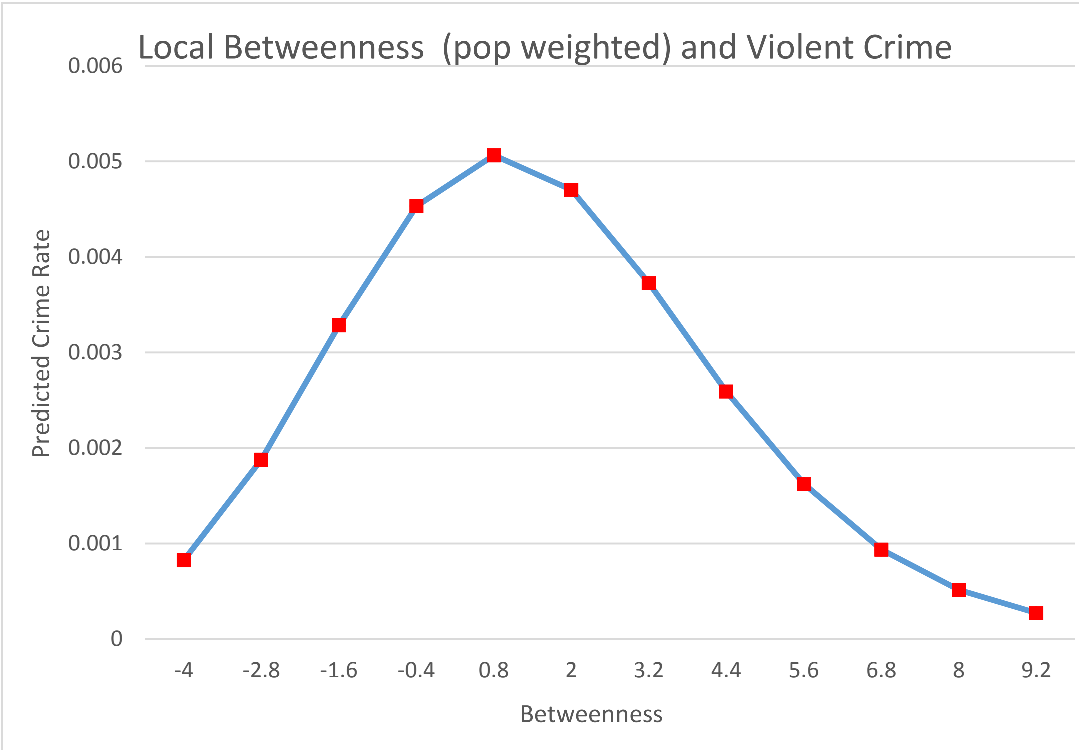

Figure A4.4. Local Betweenness (population-drink emp weighted) and Violent Crime

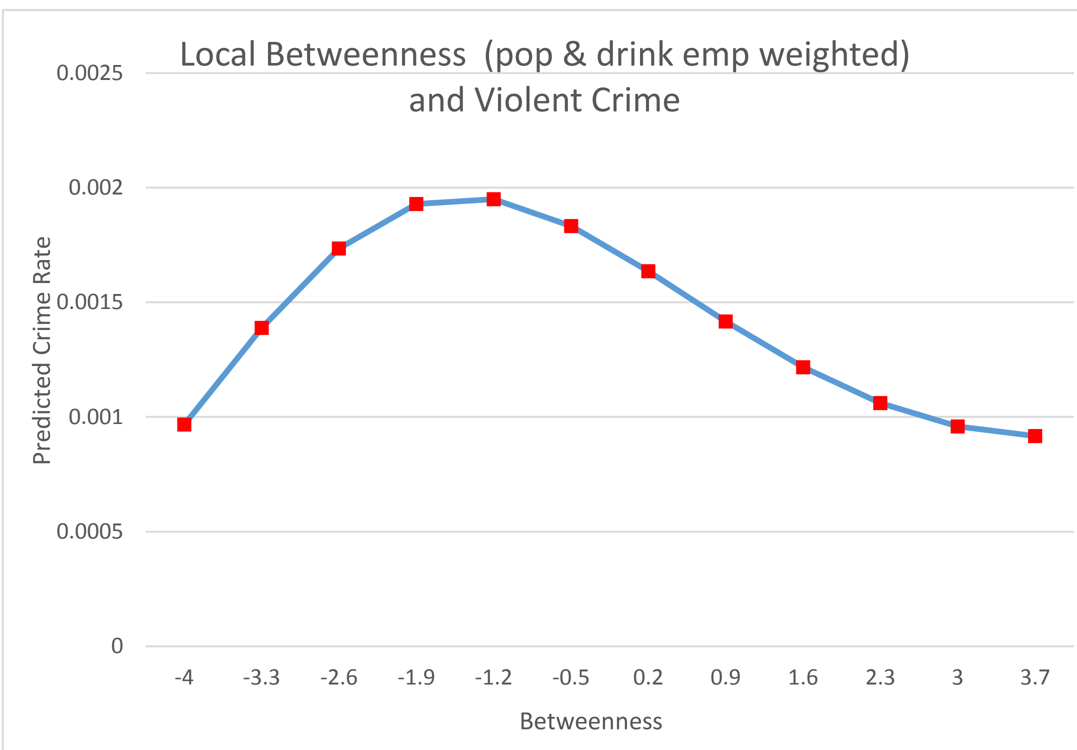

Figure A4.5. Local Betweenness (population-retail emp weighted) and Violent Crime

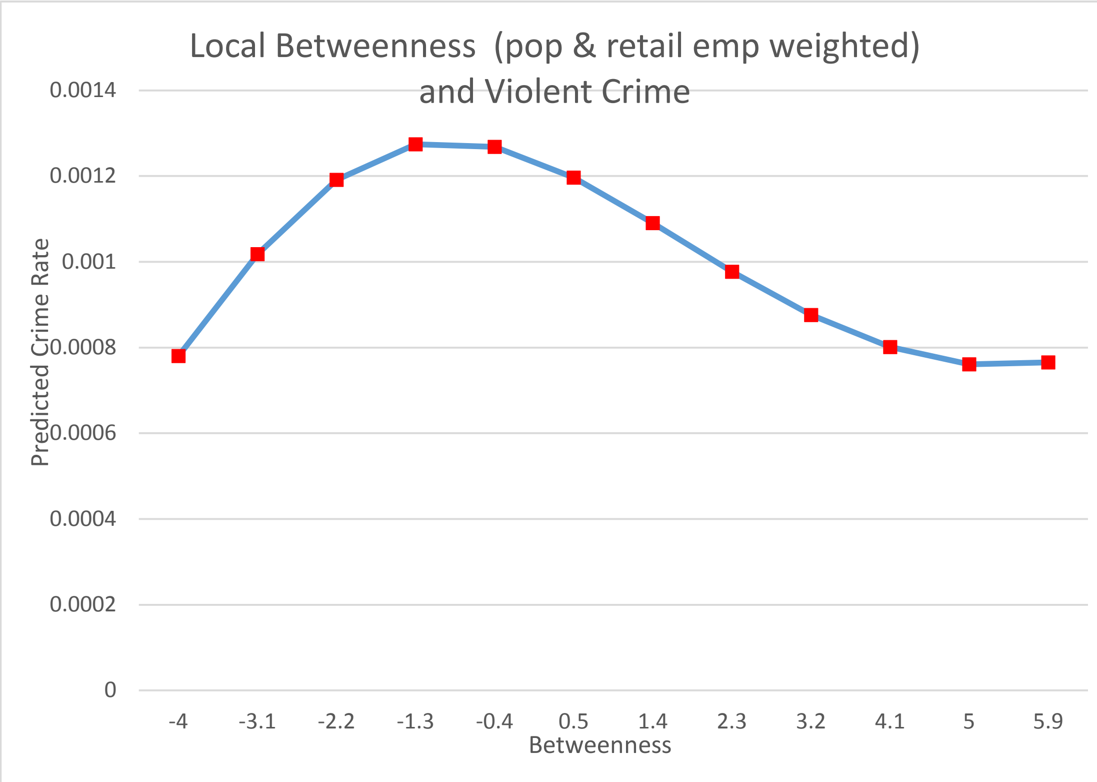

Figure A4.6. Local Betweenness (population-school emp weighted) and Violent Crime

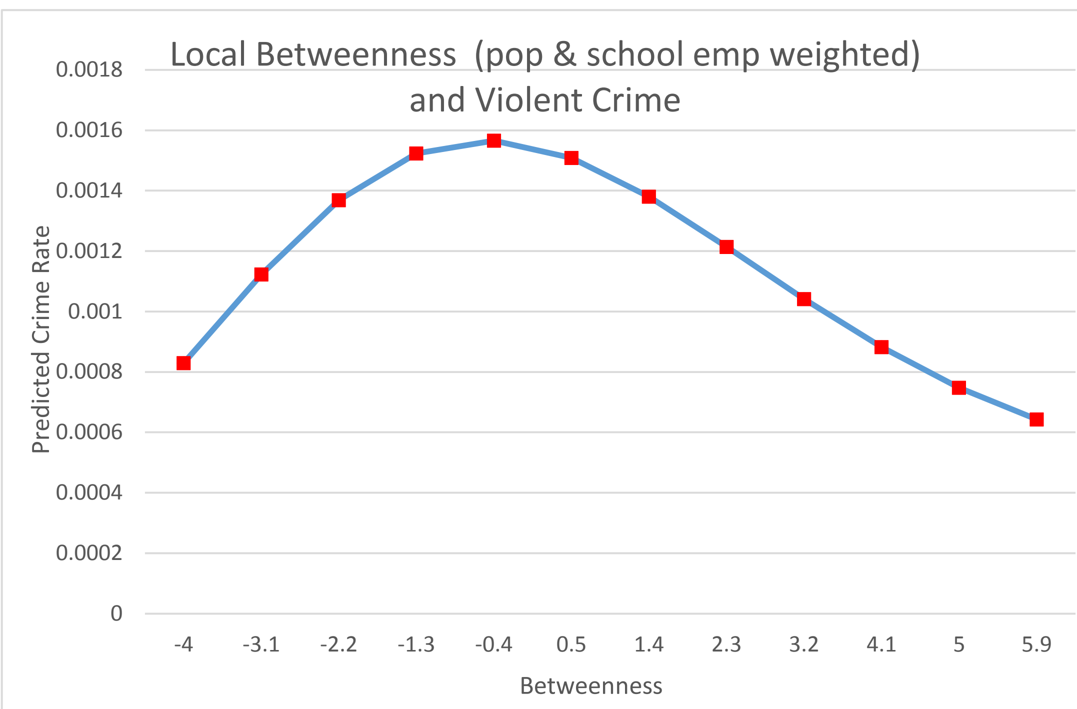

Figure A4.7. Local Betweenness (population-service emp weighted) and Violent Crime

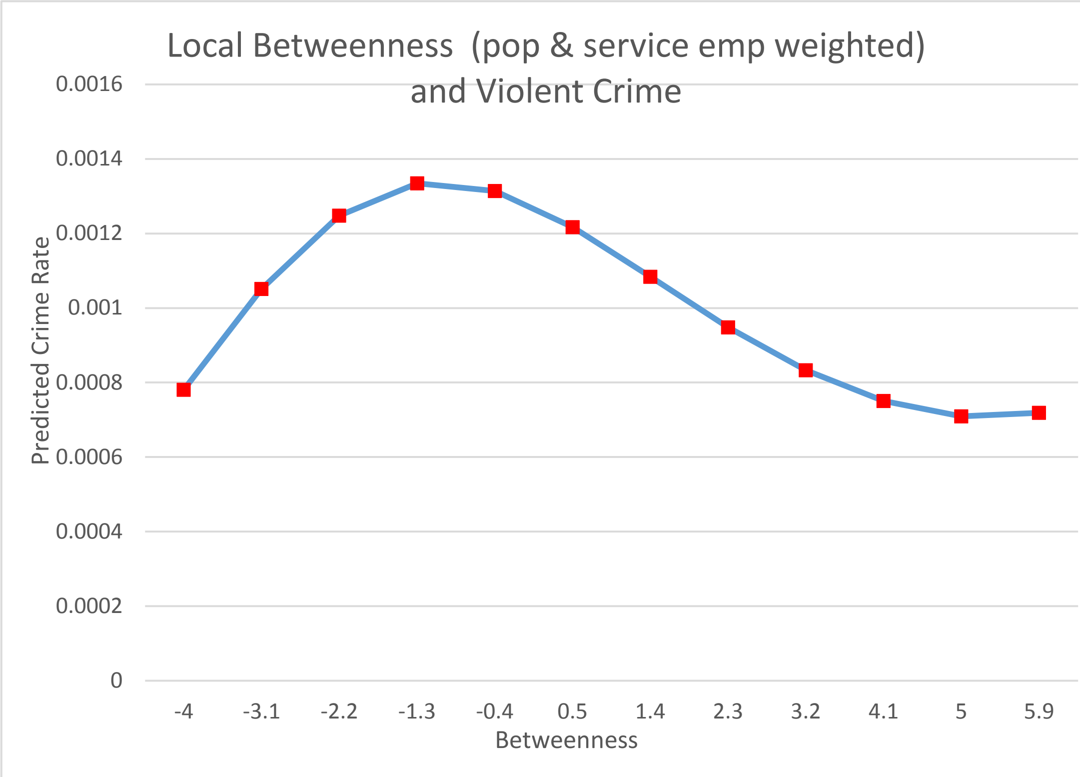

Figure A4.8. Local Betweenness (population-finance emp weighted) and Violent Crime

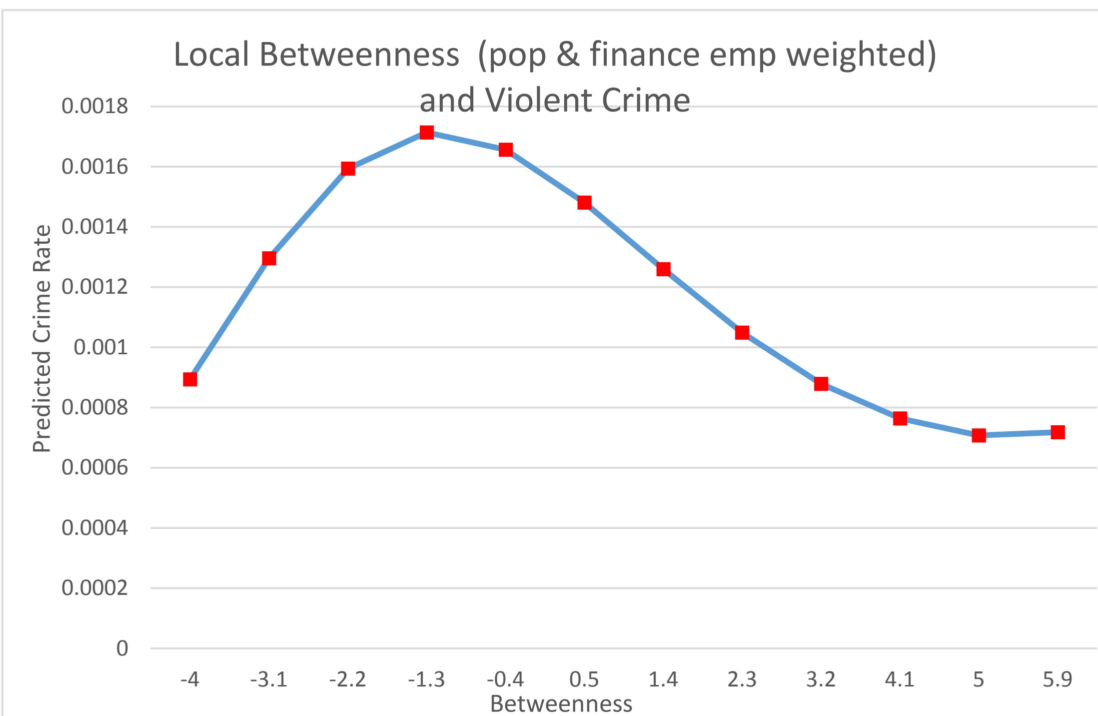

Figure A4.9. Local Betweenness (population-restaurant emp weighted) and Violent Crime

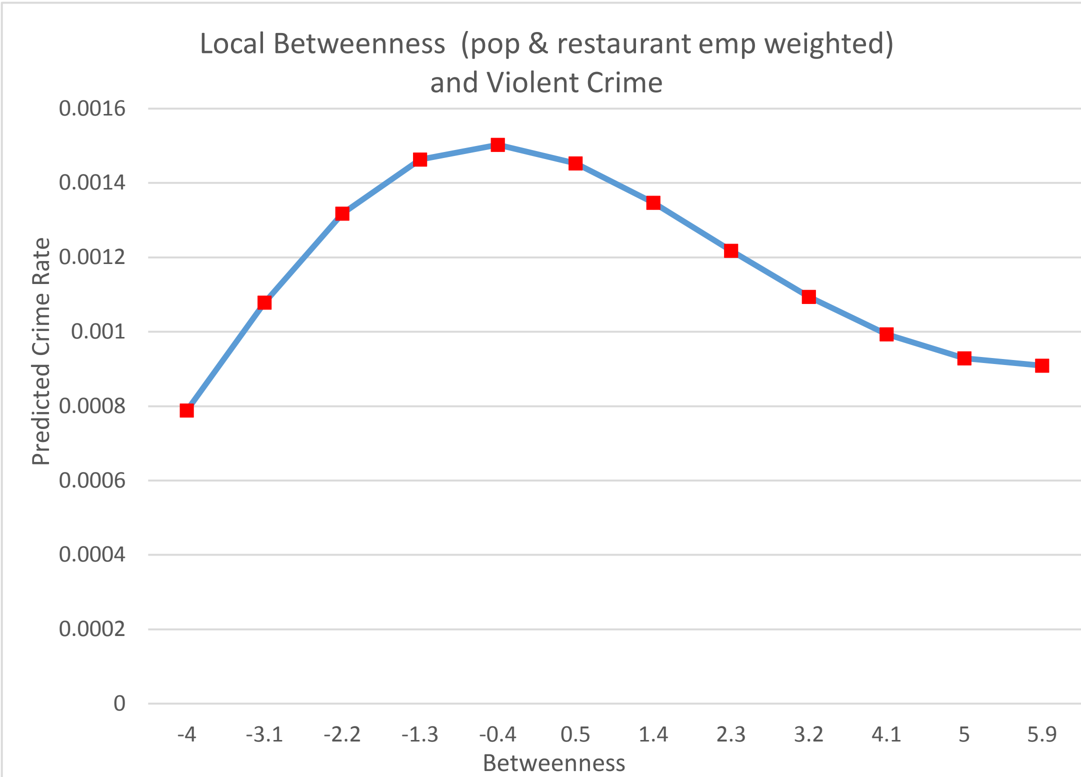

Figure A4.10. Local Betweenness (population-health emp weighted) and Violent Crime

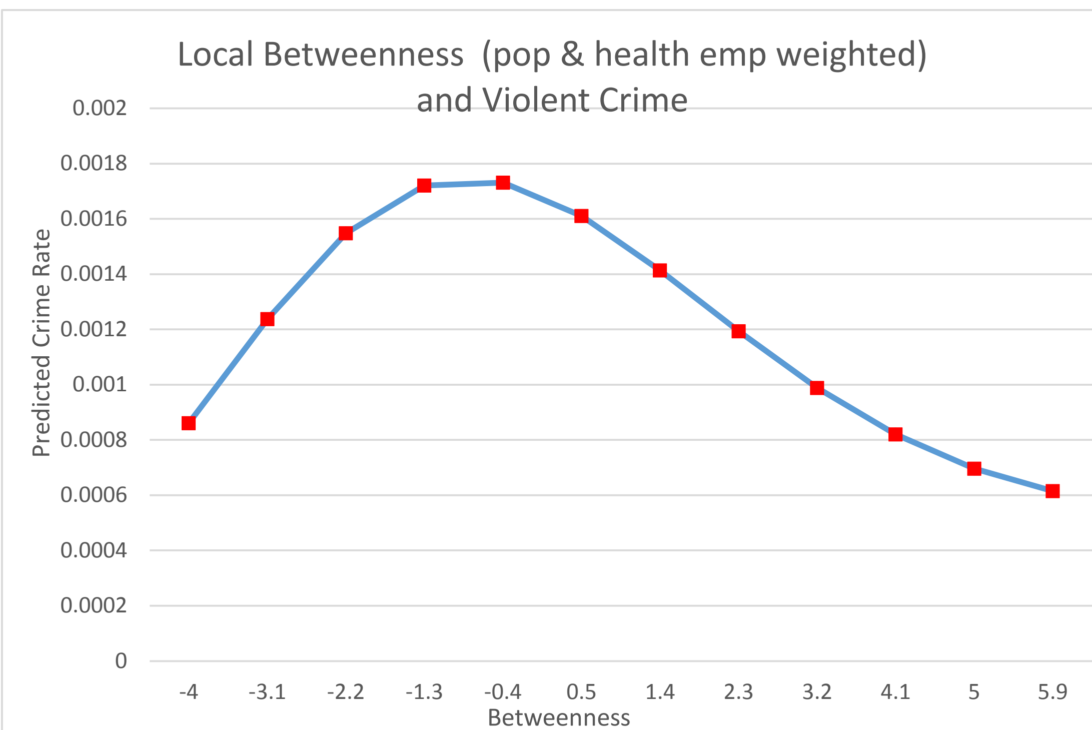

Figure A4.11. Local Betweenness (population-amenity emp weighted) and Violent Crime

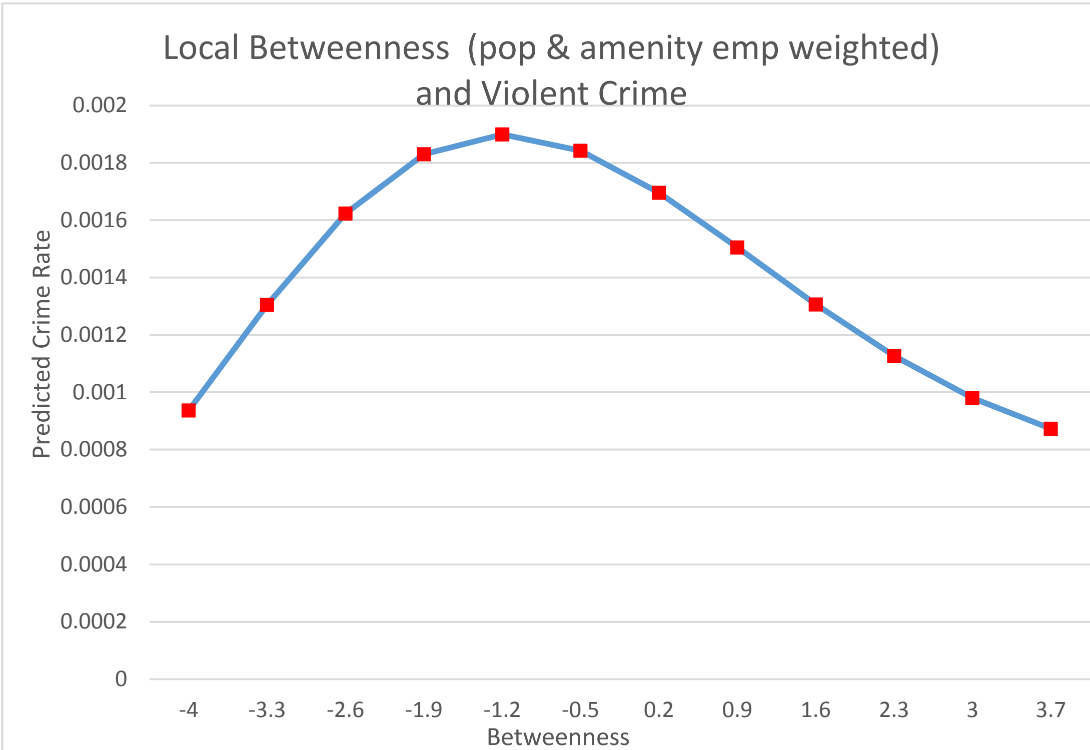

Figure A4.12. Local Betweenness (population-organization emp weighted) and Violent Crime

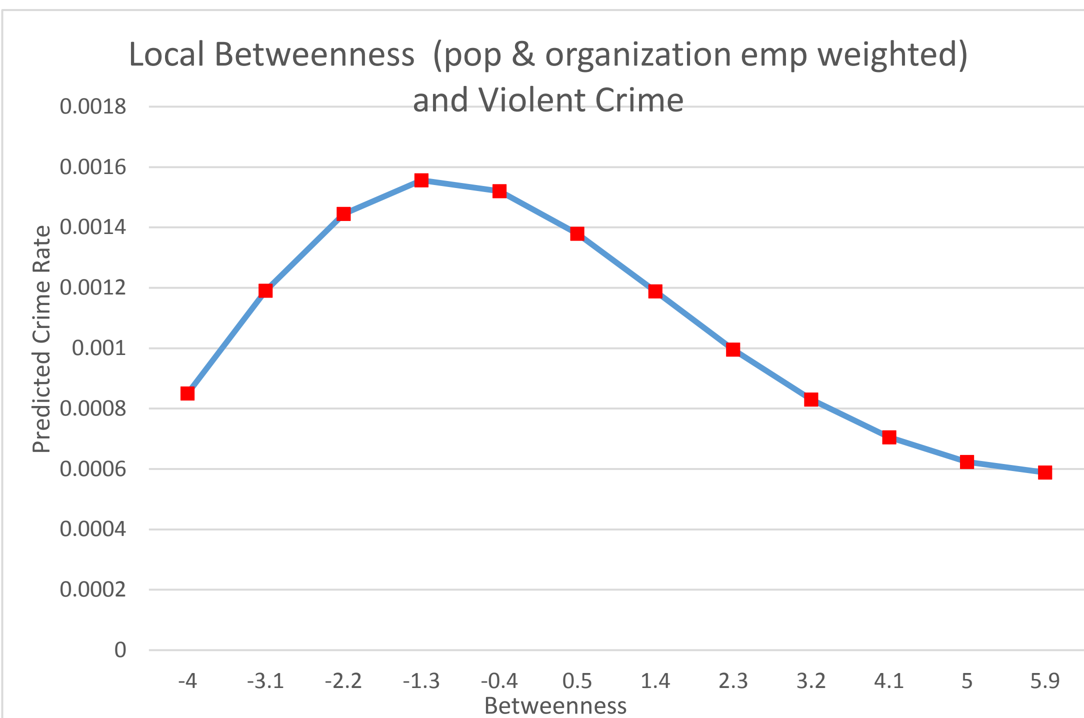

Figure A4.13. Local Betweenness (population-store emp weighted) and Violent Crime

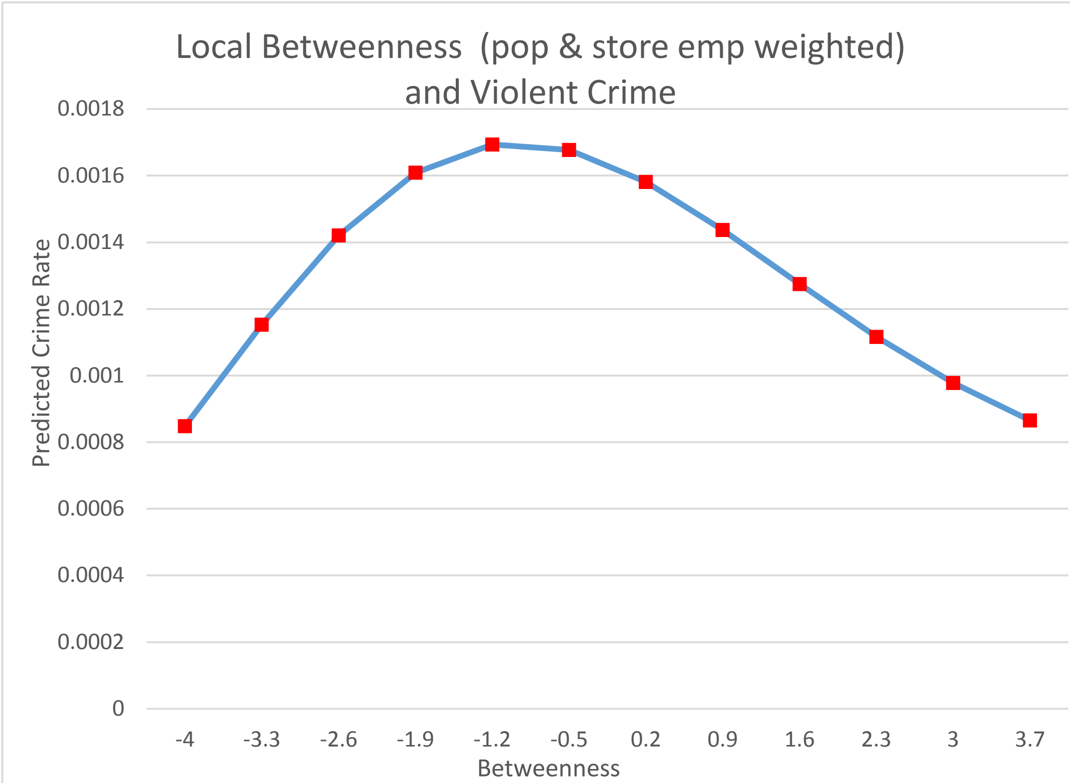

Figure A4.14. Local Reach and Property Crime

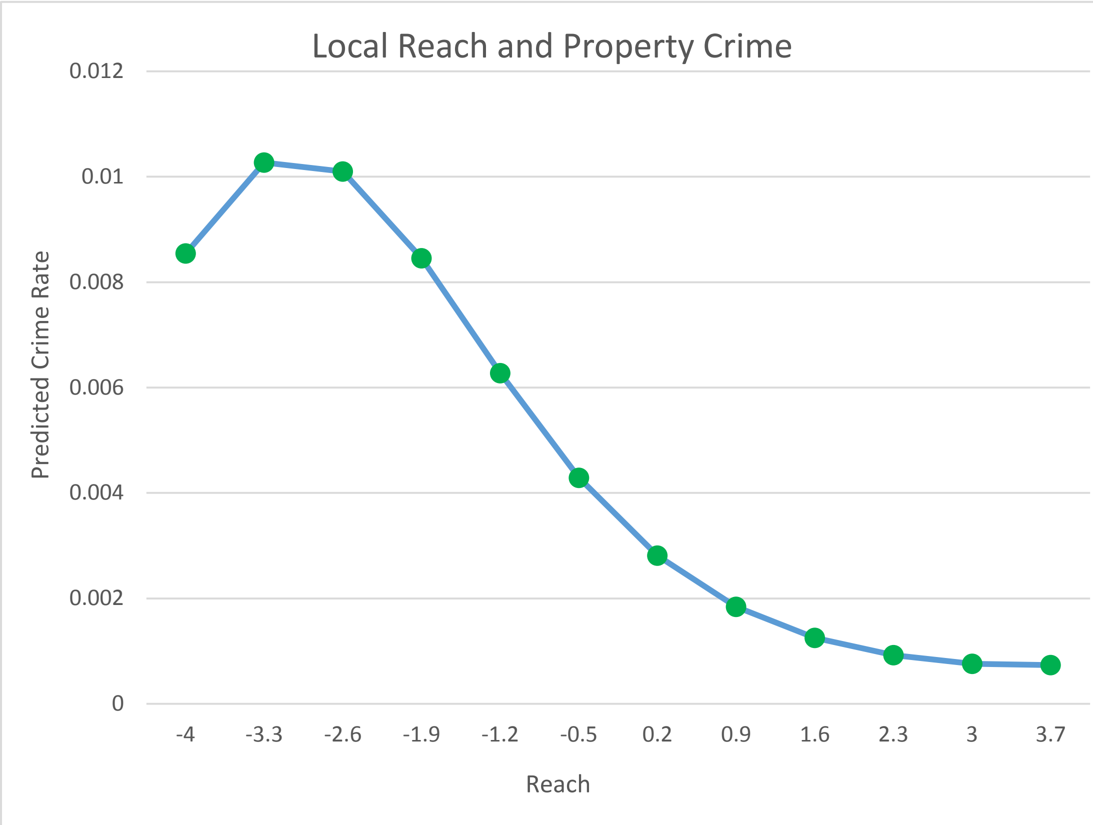

Figure A4.15. Local Betweenness and Property Crime

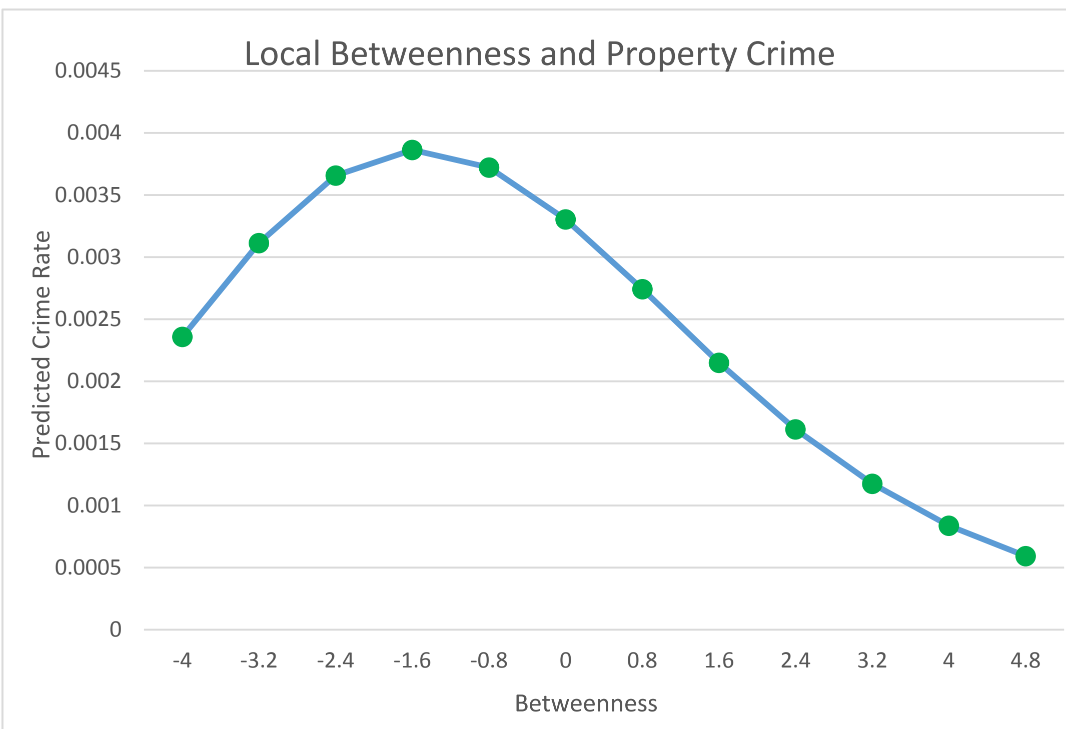

Figure A4.16. Local Betweenness (population weighted) and Property Crime

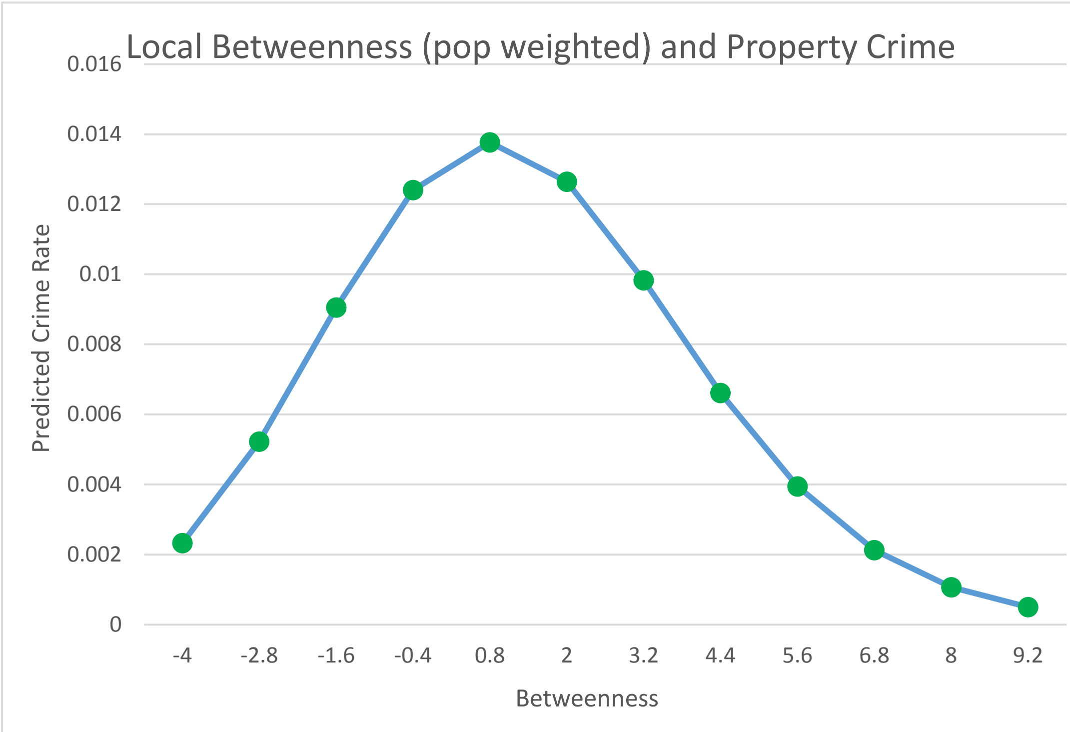

Figure A4.17. Local Betweenness (population-drink emp weighted) and Property Crime

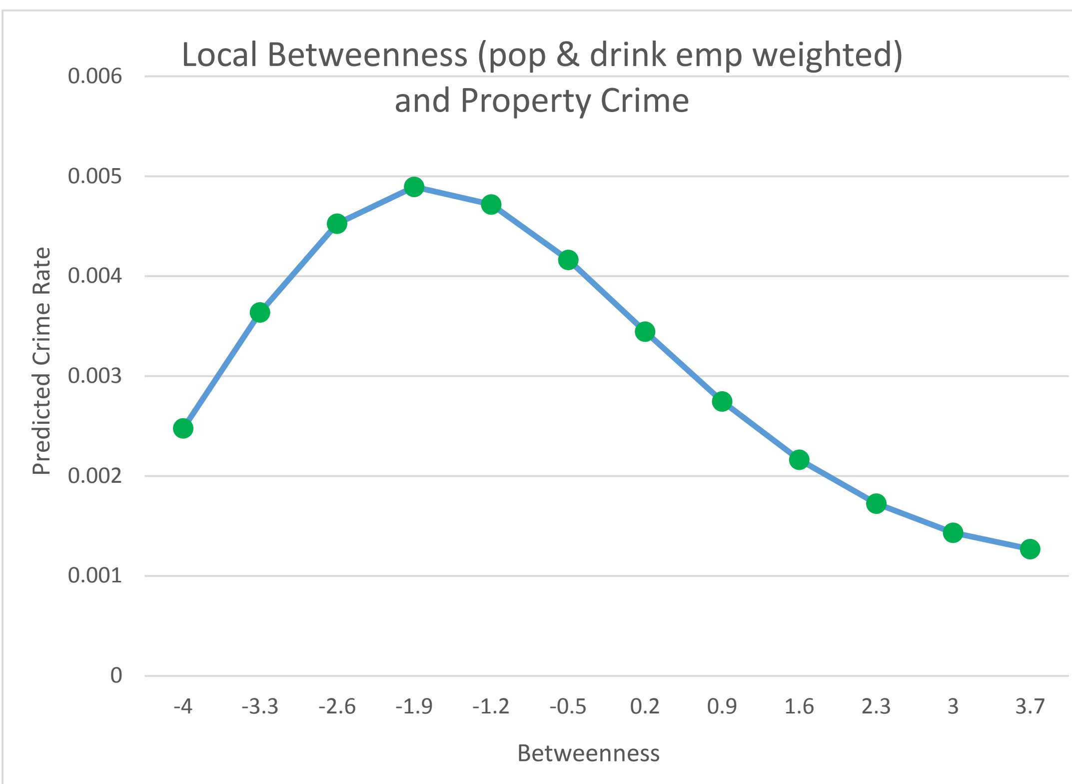

Figure A4.18. Local Betweenness (population-retail emp weighted) and Property Crime

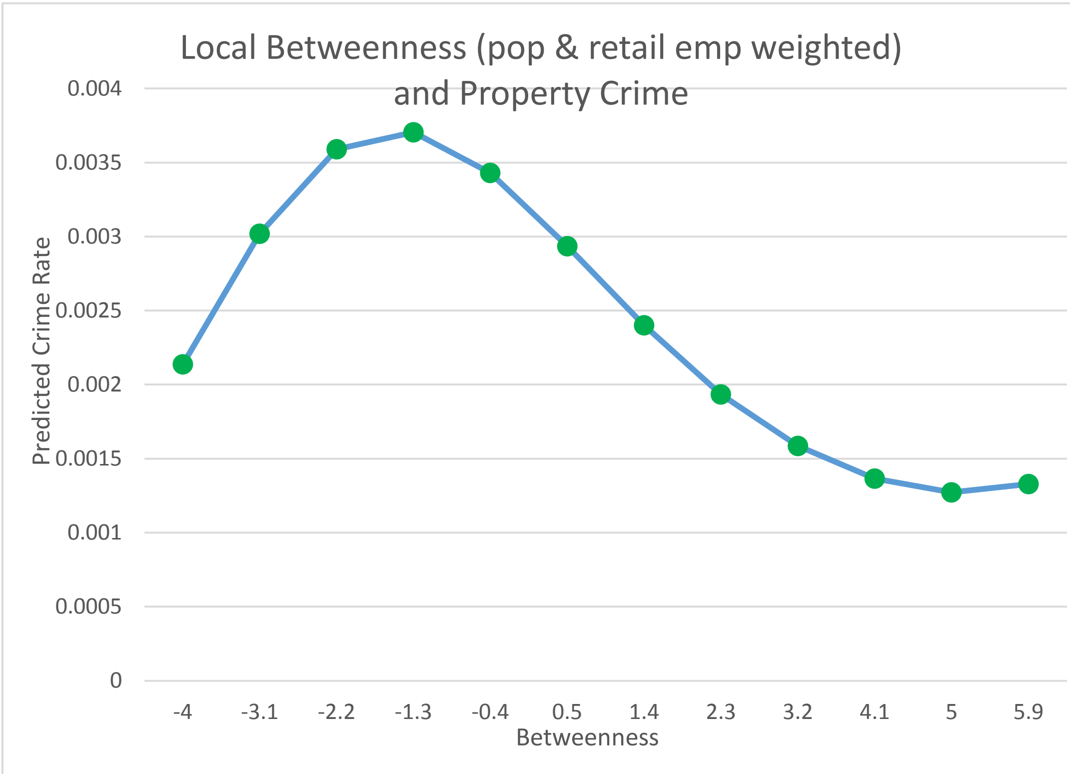

Figure A4.19. Local Betweenness (population-school emp weighted) and Property Crime

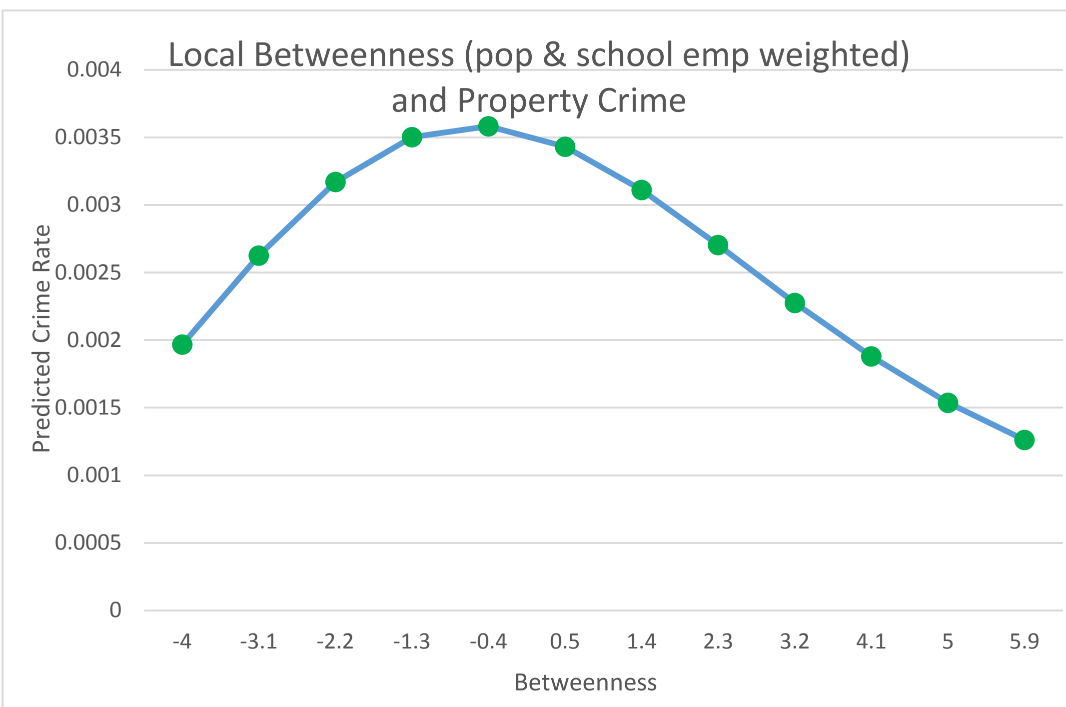

Figure A4.20. Local Betweenness (population-service emp weighted) and Property Crime

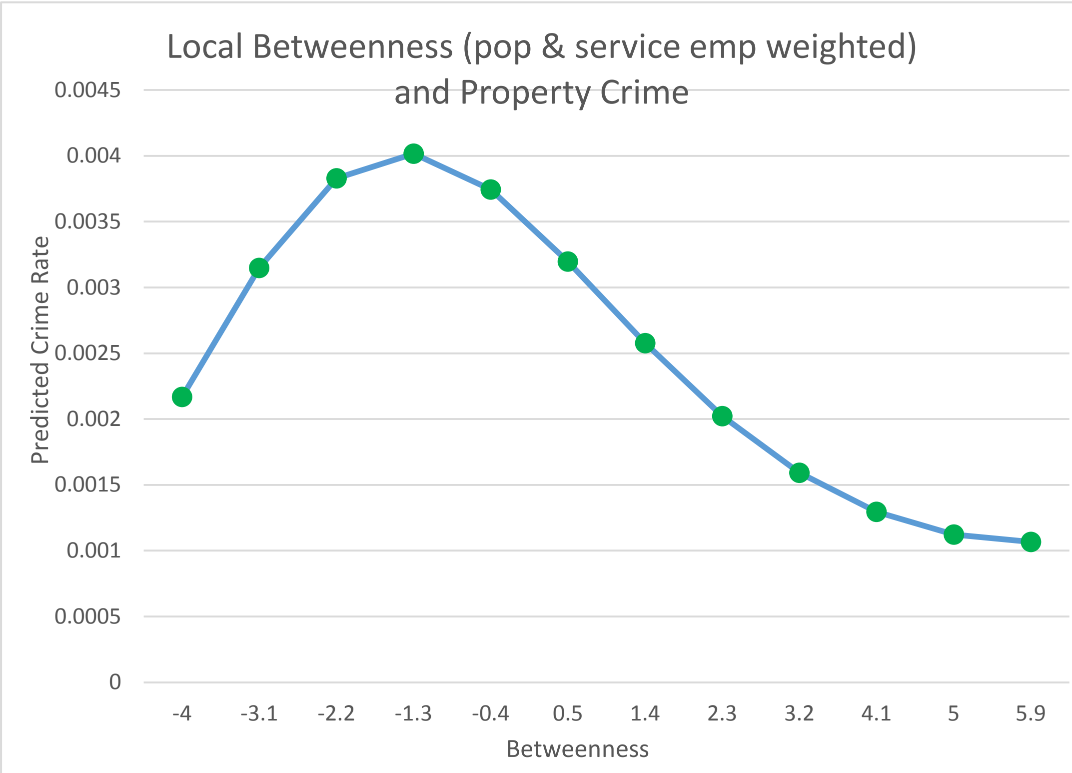

Figure A4.21. Local Betweenness (population-finance emp weighted) and Property Crime

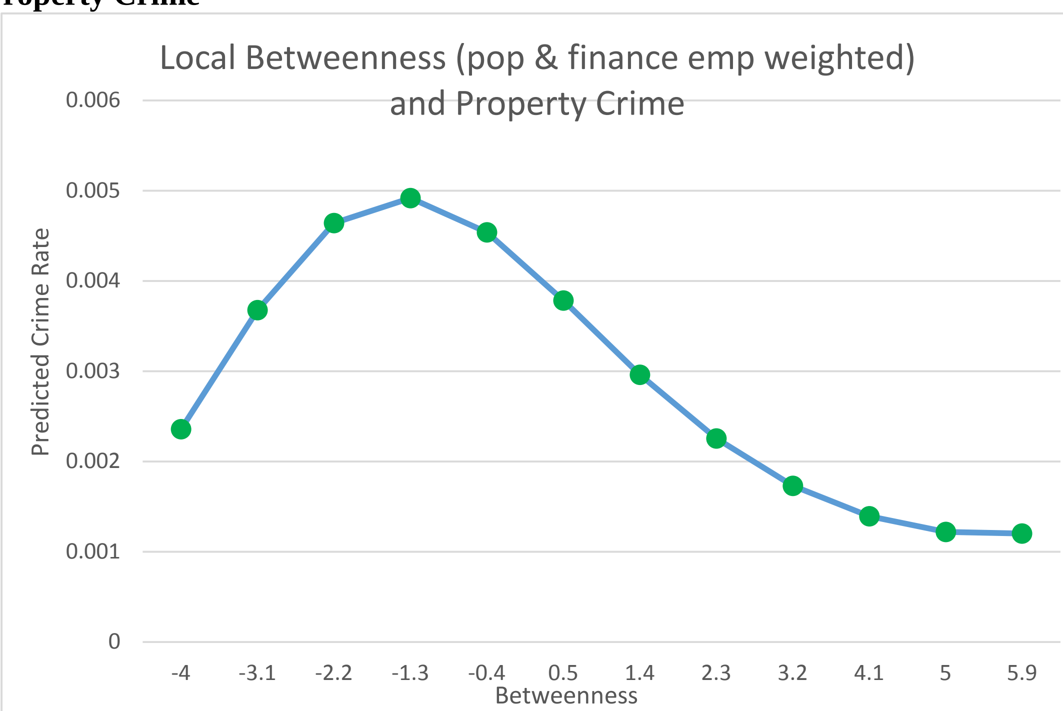

Figure A4.22. Local Betweenness (population-restaurant emp weighted) and Property Crime

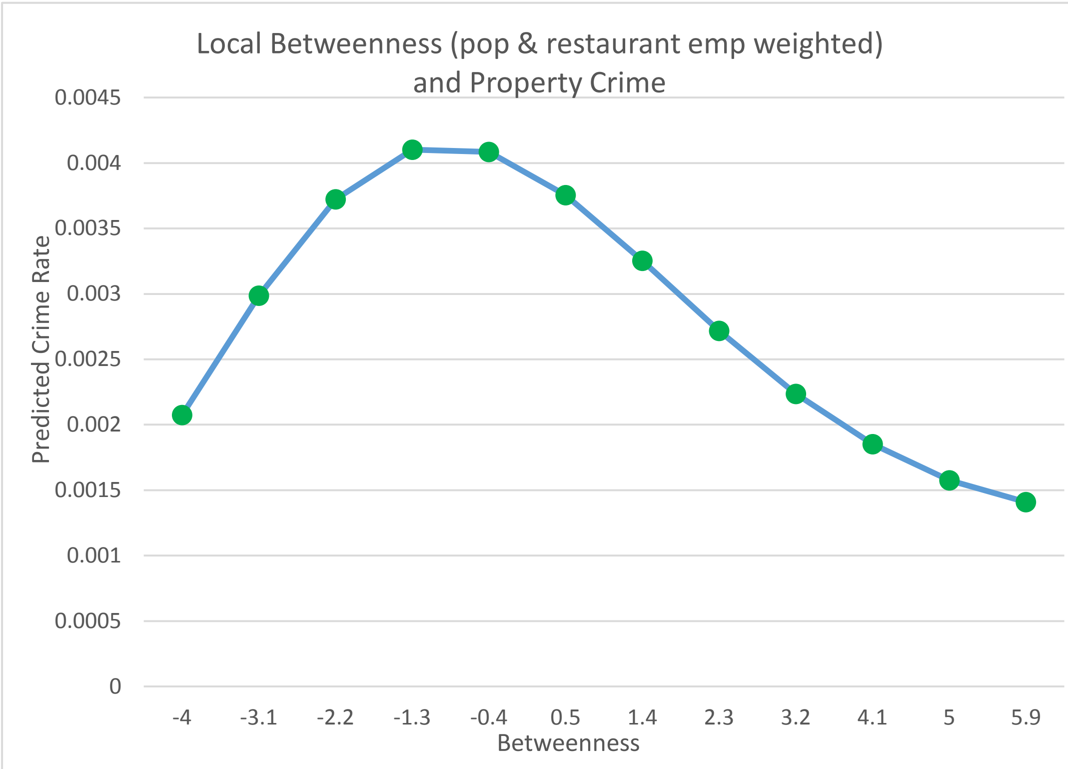

Figure A4.23. Local Betweenness (population-health emp weighted) and Property Crime

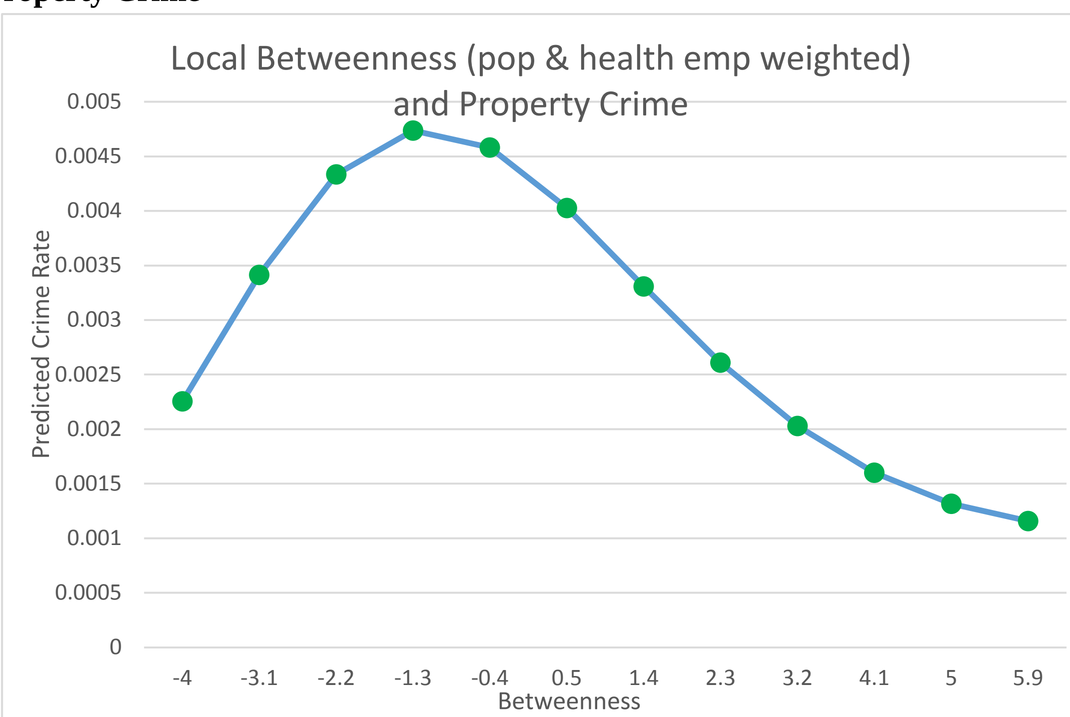

Figure A4.24. Local Betweenness (population-amenity emp weighted) and Property Crime

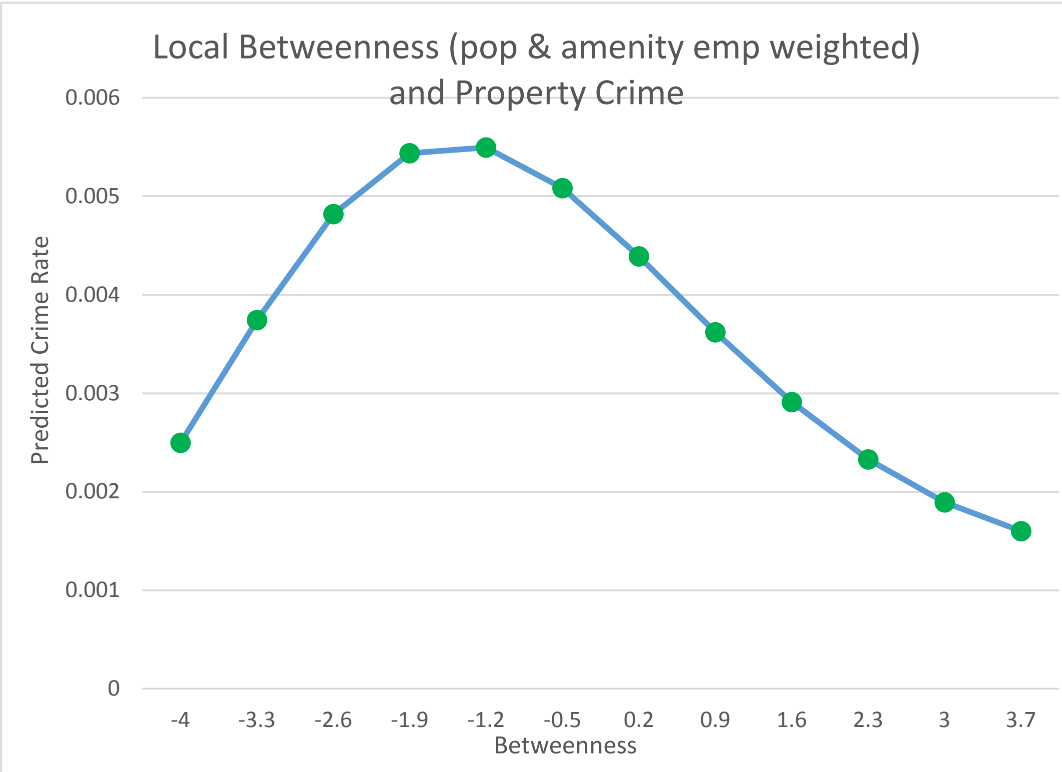

Figure A4.25. Local Betweenness (population-organization emp weighted) and Property Crime

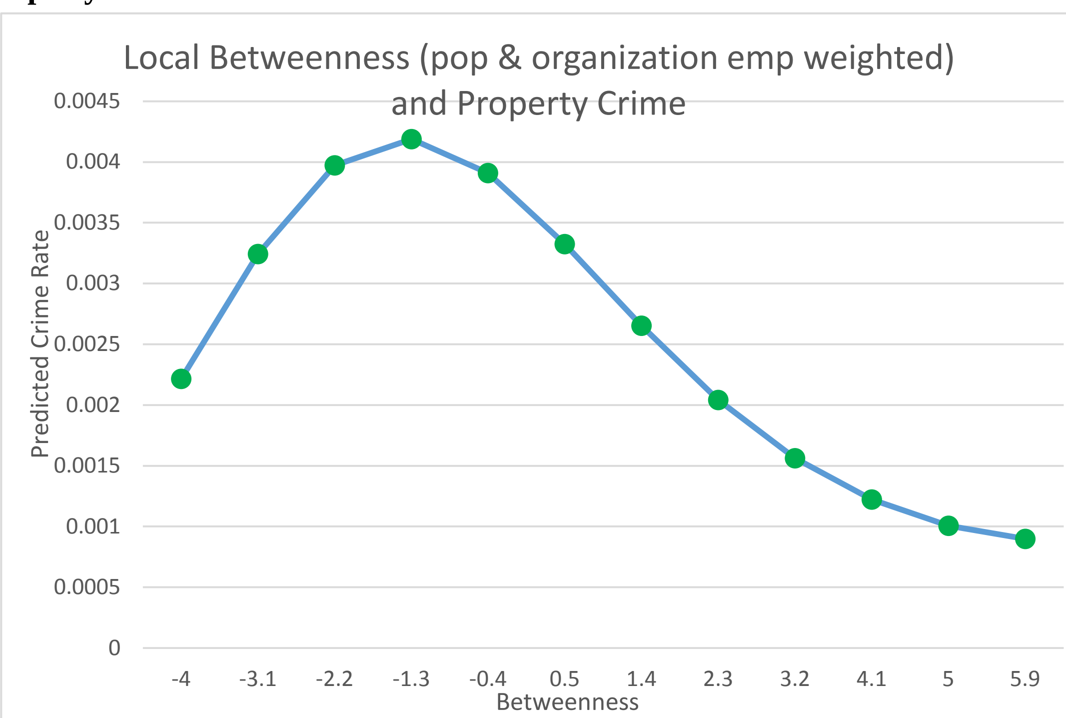

Figure A4.26. Local Betweenness (population-store emp weighted) and Property Crime

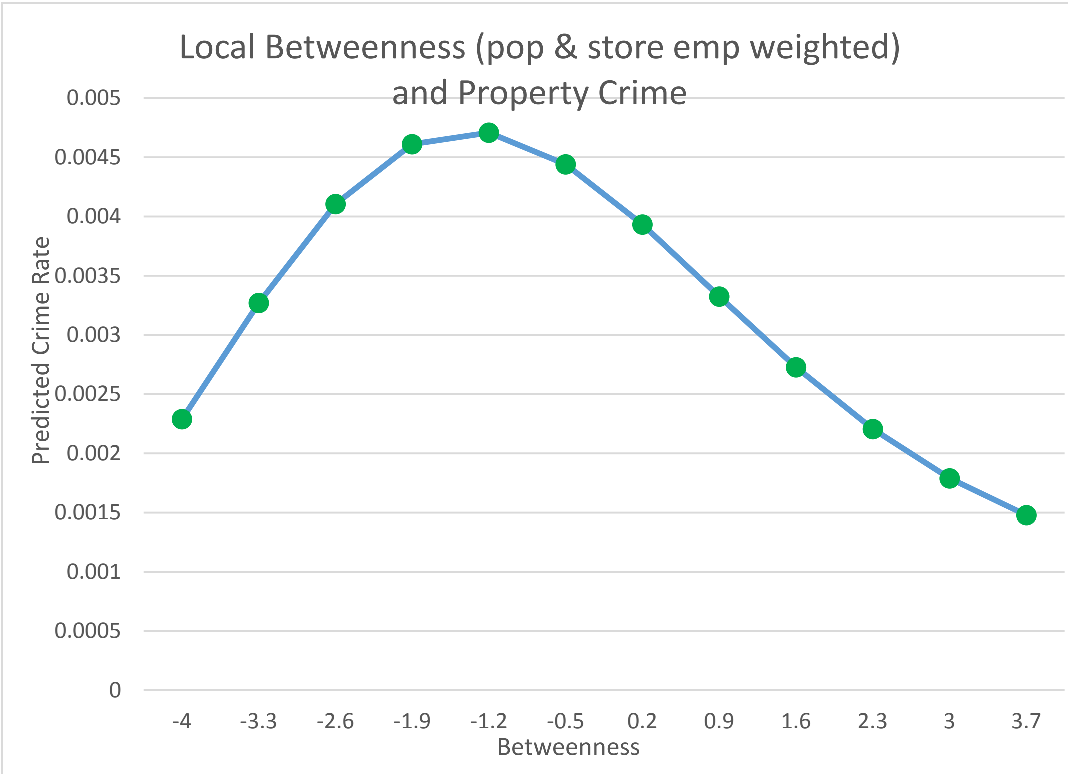

Figure A4.27. Non-Local Reach and Violent Crime

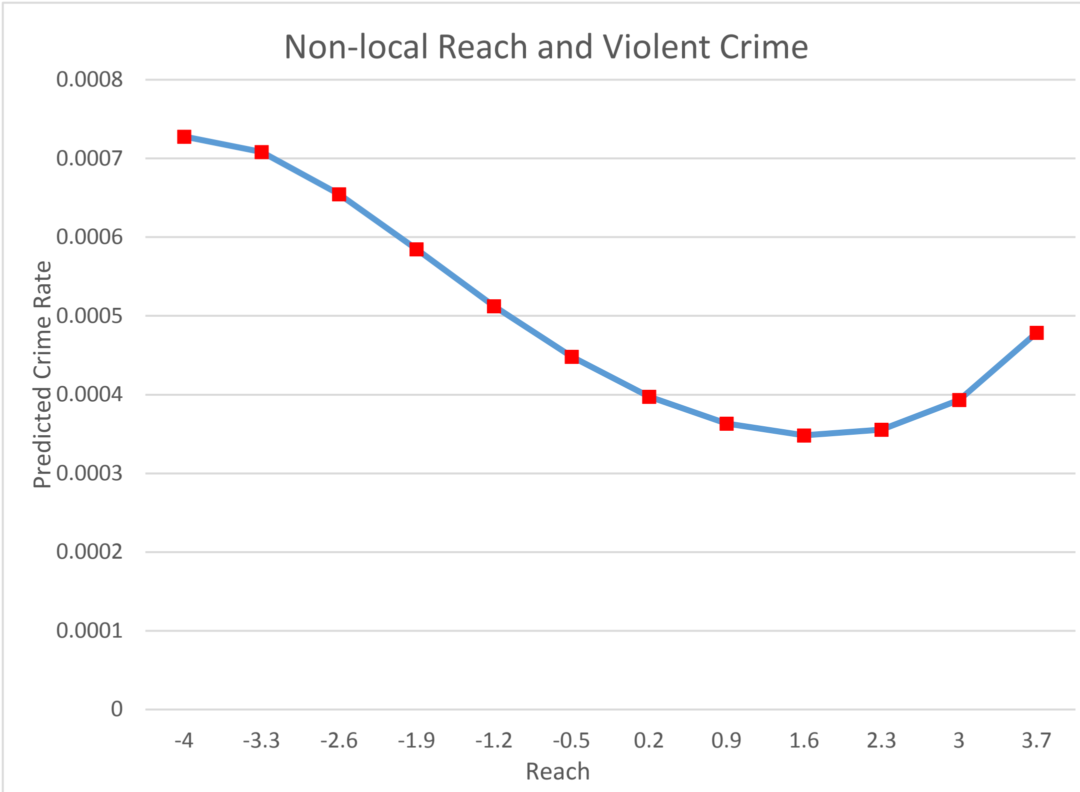

Figure A4.28. Non-Local Betweenness and Violent Crime

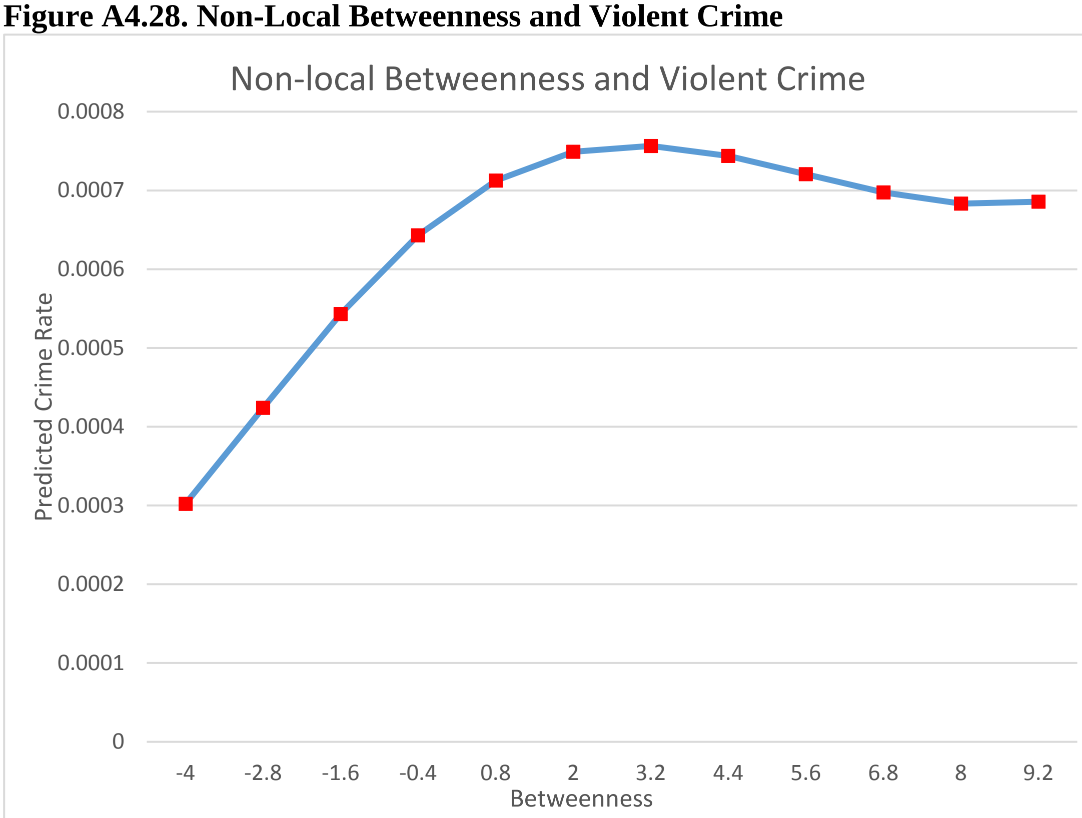

Figure A4.29. Non-Local Betweenness (population weighted) and Violent Crime

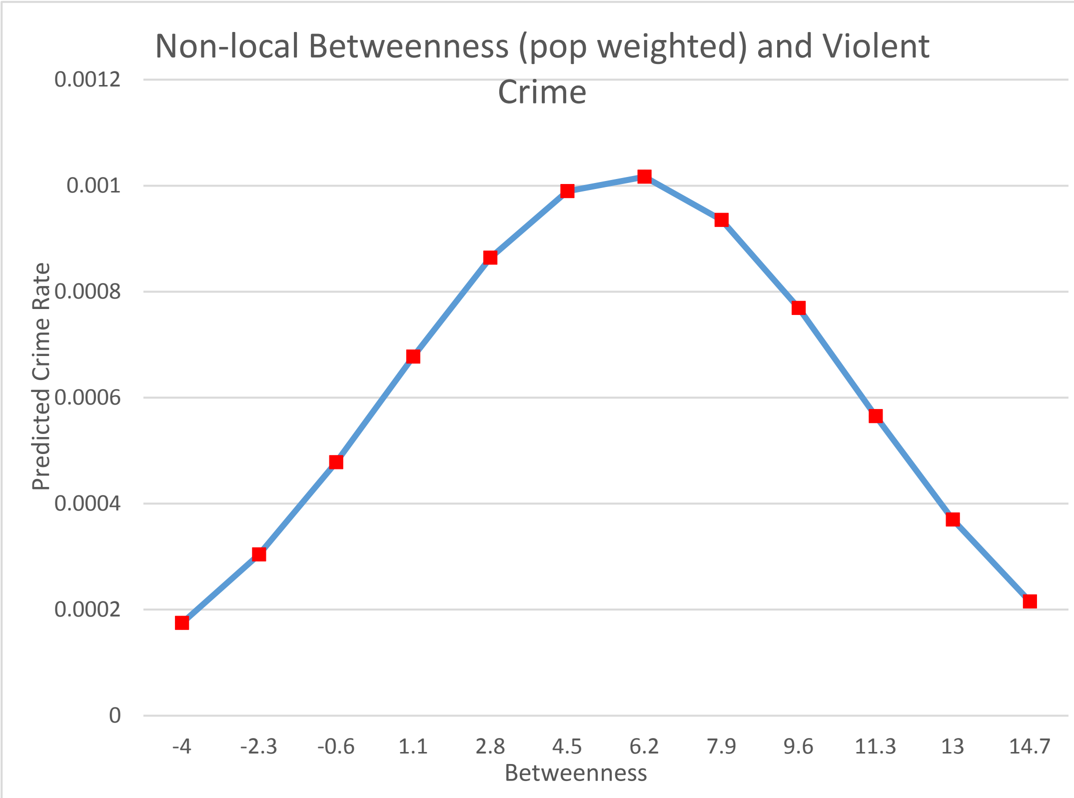

Figure A4.30. Non-Local Betweenness (population-drink emp weighted) and Violent Crime

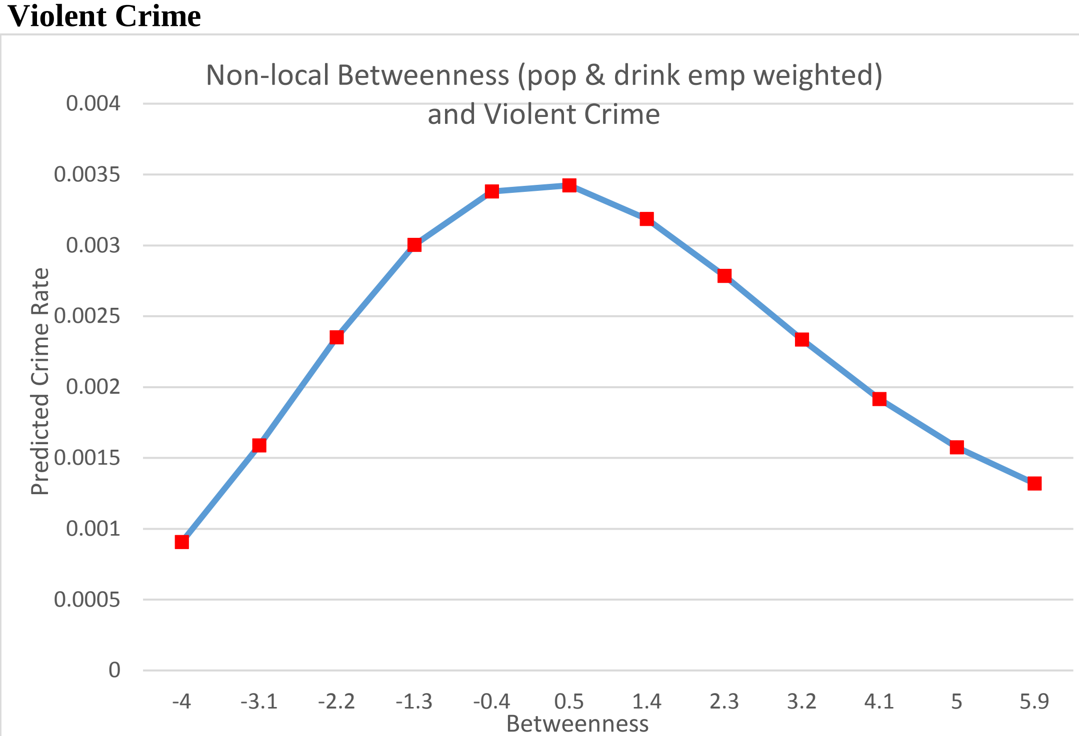

Figure A4.31. Non-Local Betweenness (population-retail emp weighted) and Violent Crime

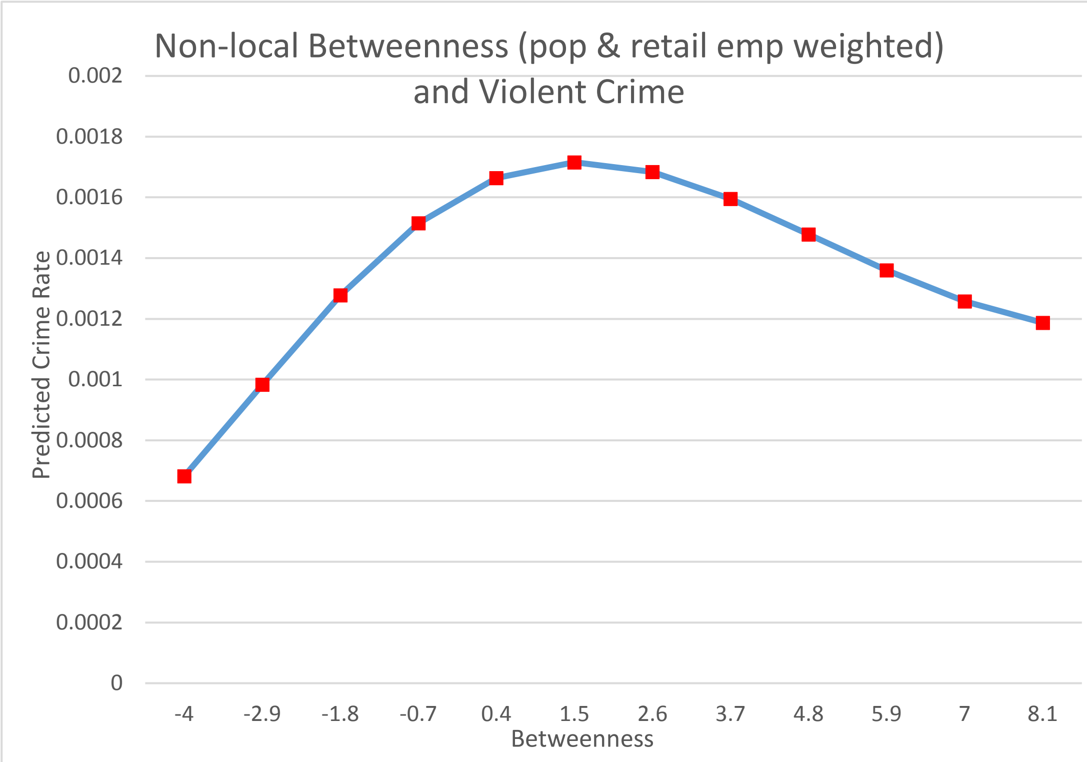

Figure A4.32. Non-Local Betweenness (population-school emp weighted) and Violent Crime

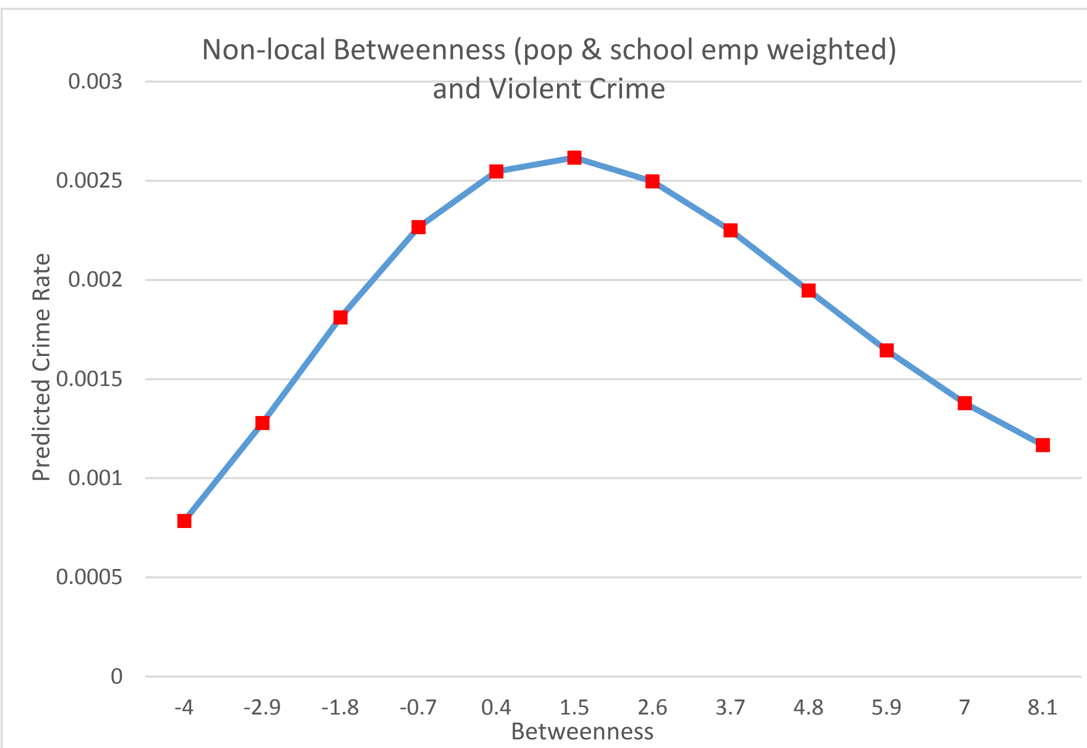

Figure A4.33. Non-Local Betweenness (population-service emp weighted) and Violent Crime

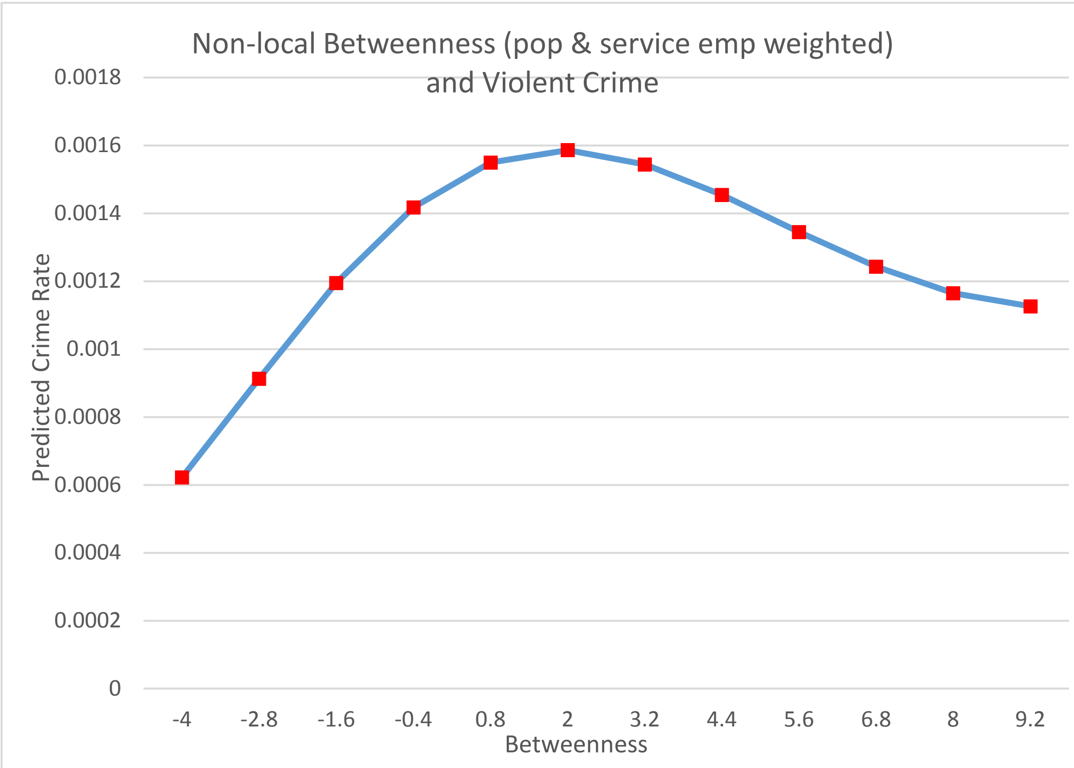

Figure A4.34. Non-Local Betweenness (population-finance emp weighted) and Violent Crime

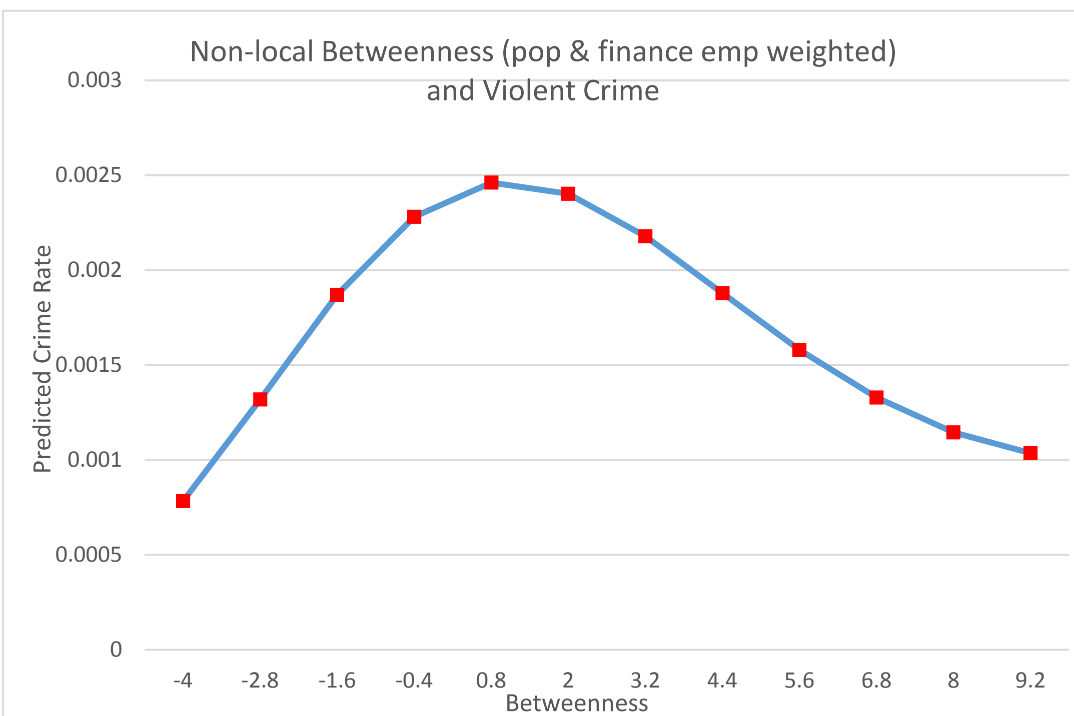

Figure A4.35. Non-Local Betweenness (population-restaurant emp weighted) and Violent Crime

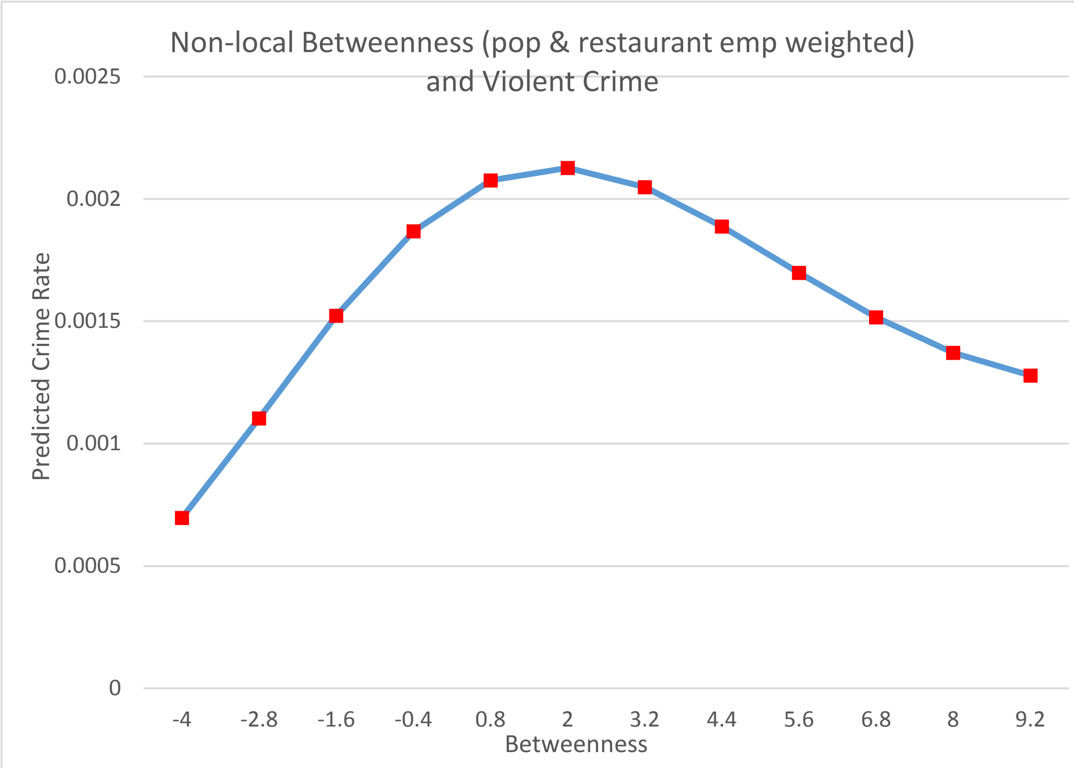

Figure A4.36. Non-Local Betweenness (population-health emp weighted) and Violent Crime

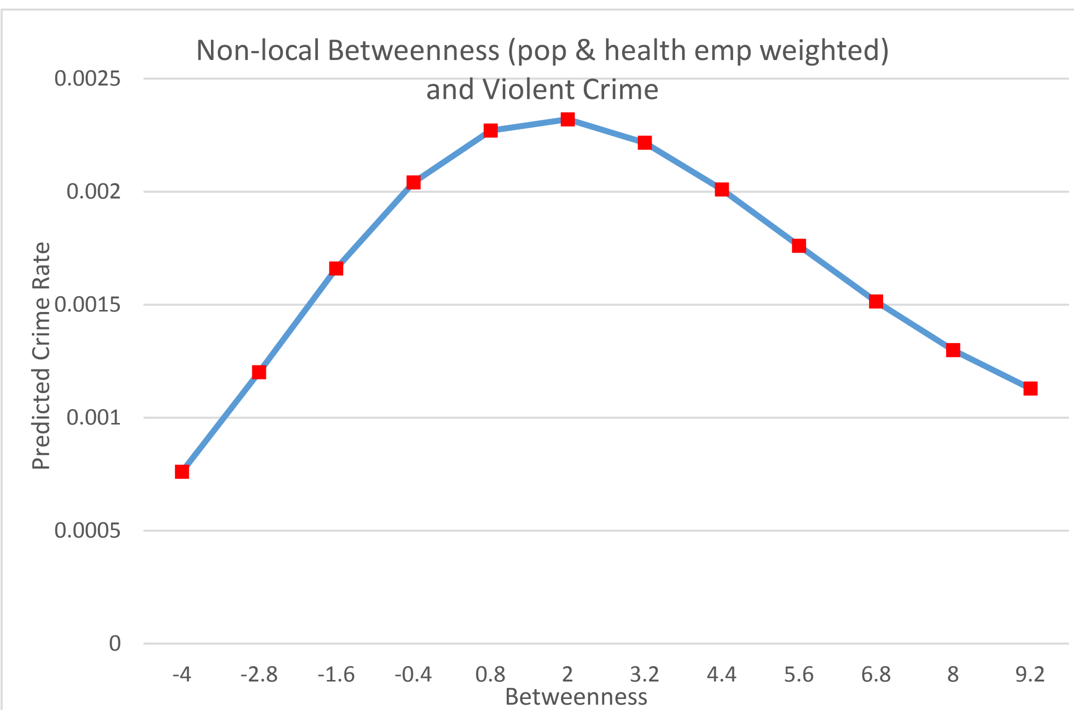

Figure A4.37. Non-Local Betweenness (population-amenity emp weighted) and Violent Crime

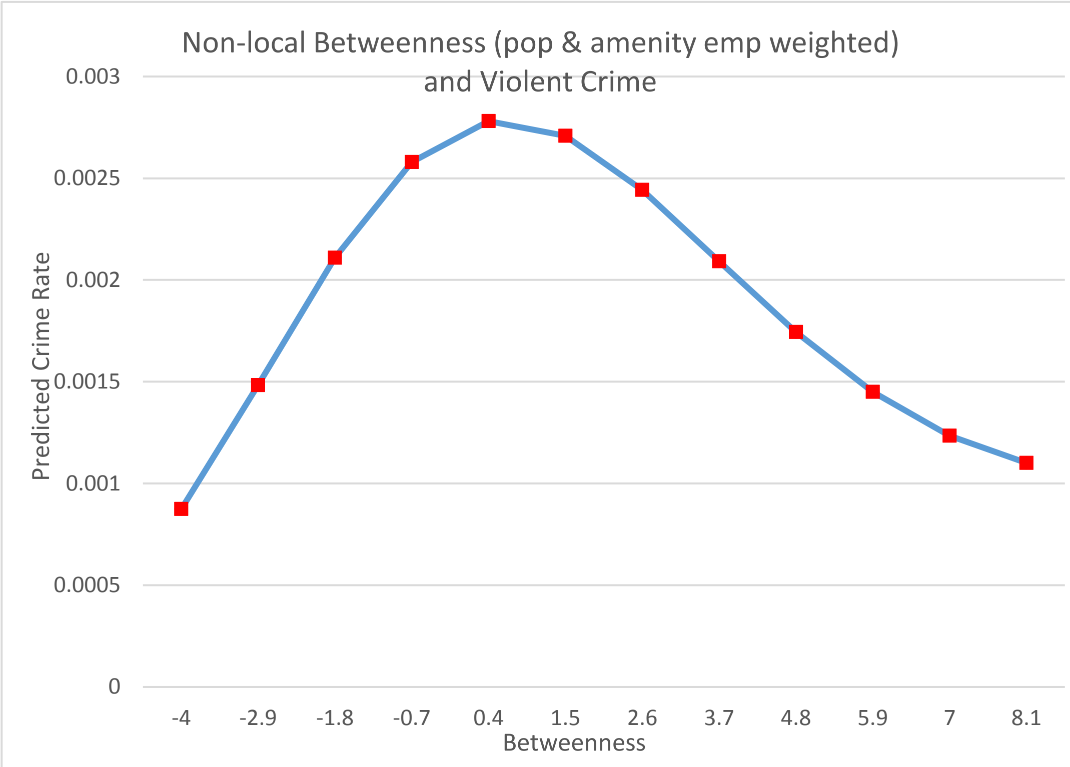

Figure A4.38. Non-Local Betweenness (population-organization emp weighted) and Violent Crime

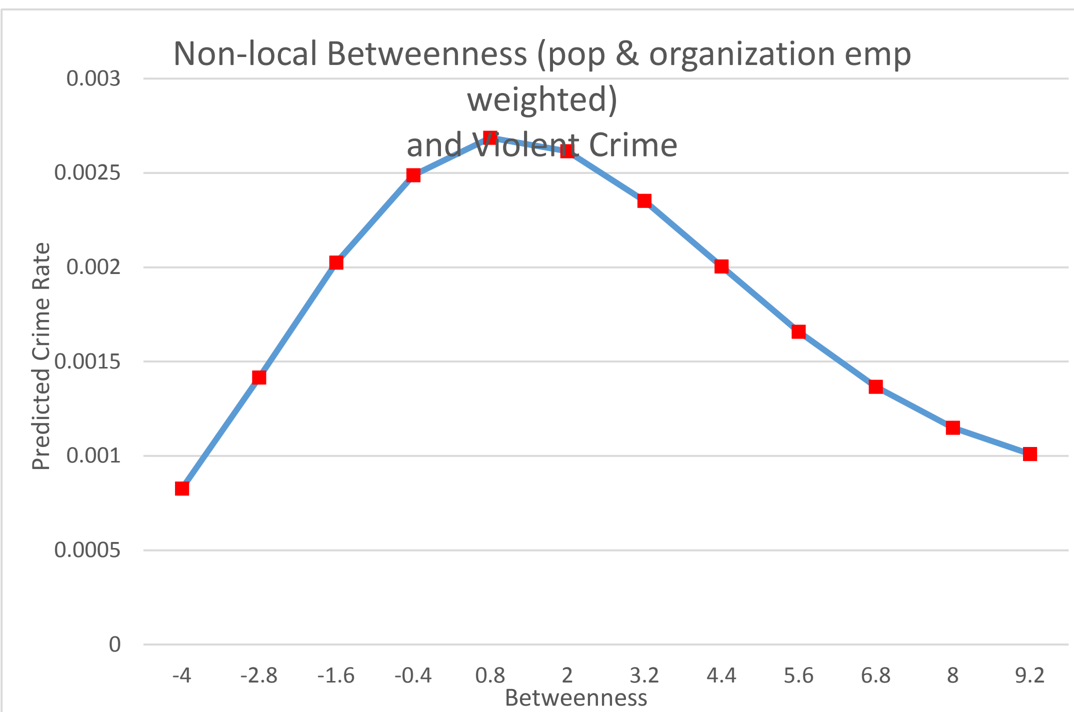

Figure A4.39. Non-Local Betweenness (population-store emp weighted) and Violent Crime

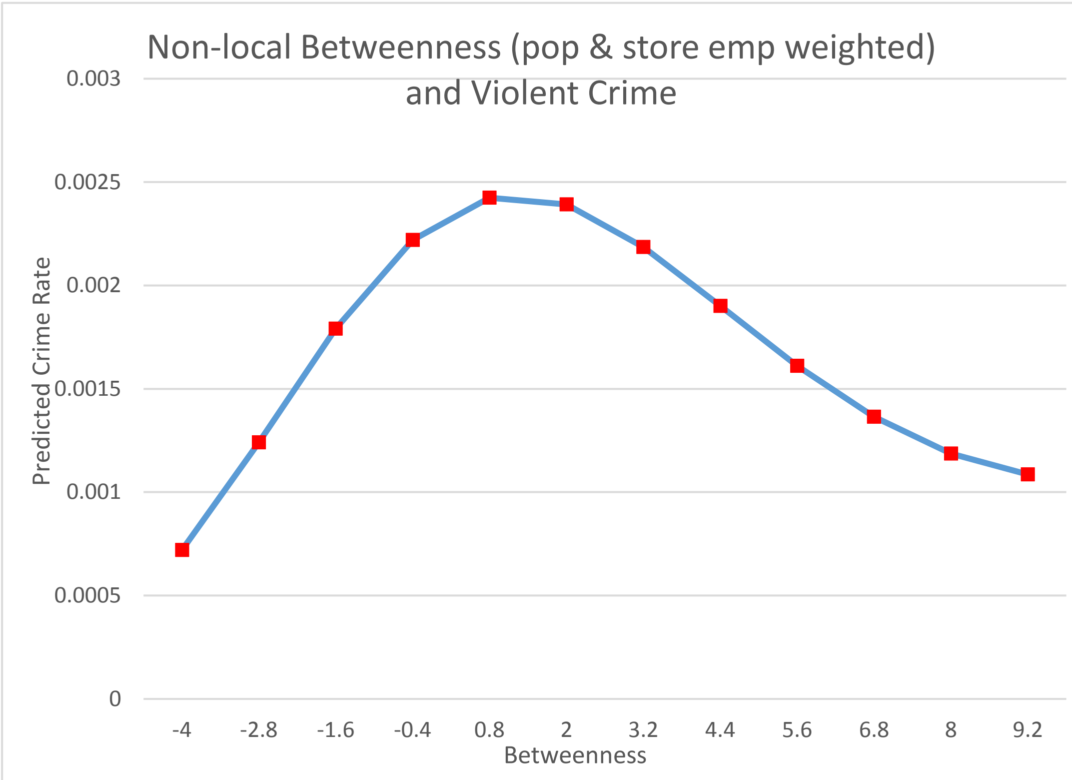

Figure A4.40. Non-Local Reach and Property Crime

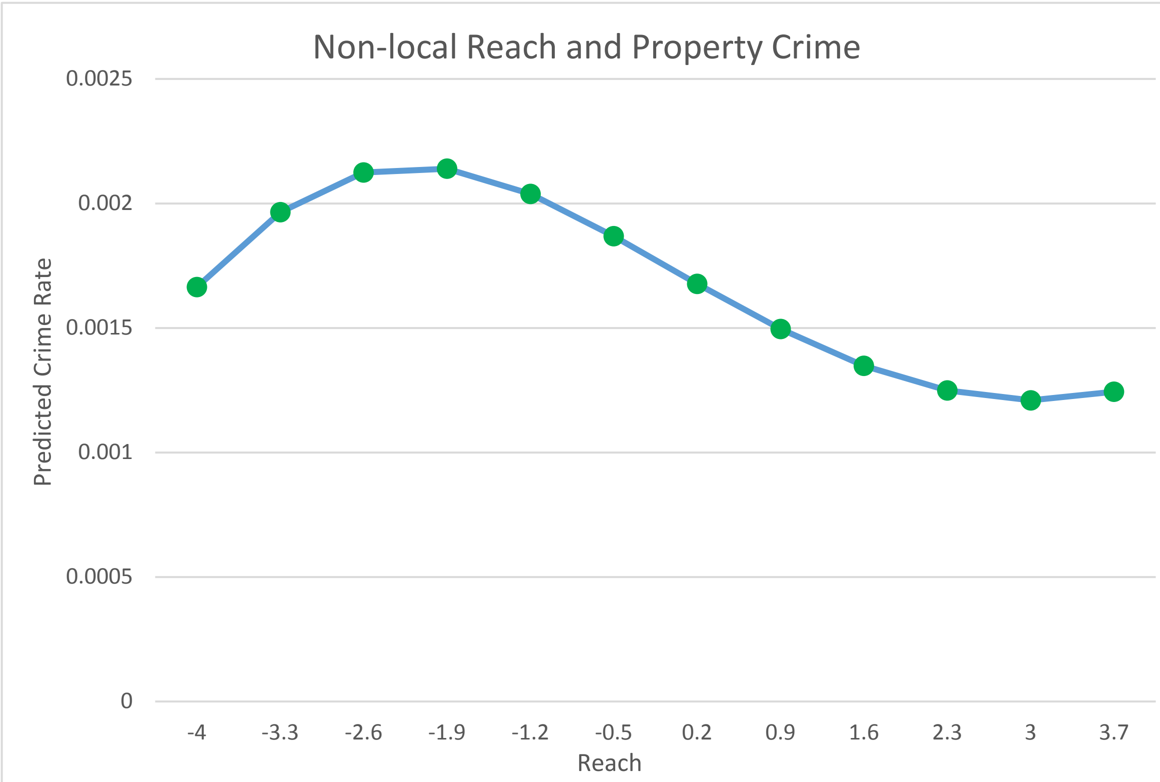

Figure A4.41. Non-Local Betweenness and Property Crime

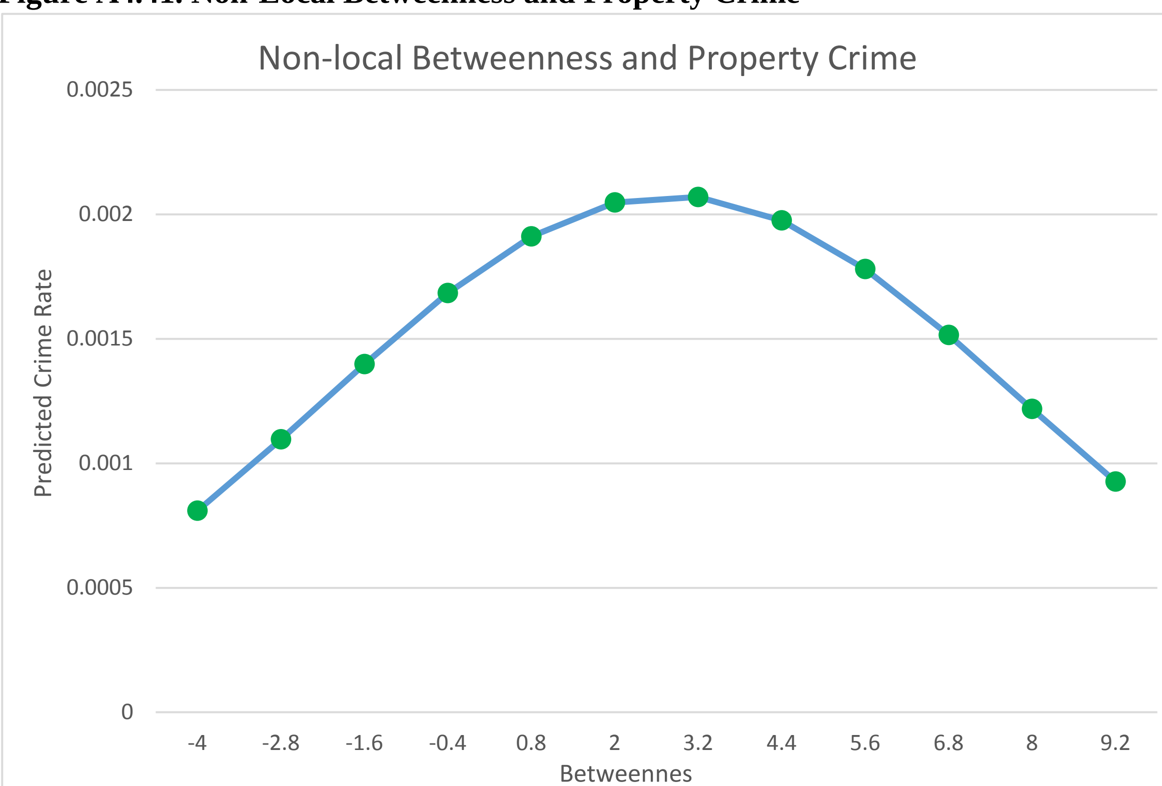

Figure A4.42. Non-Local Betweenness (population weighted) and Property Crime

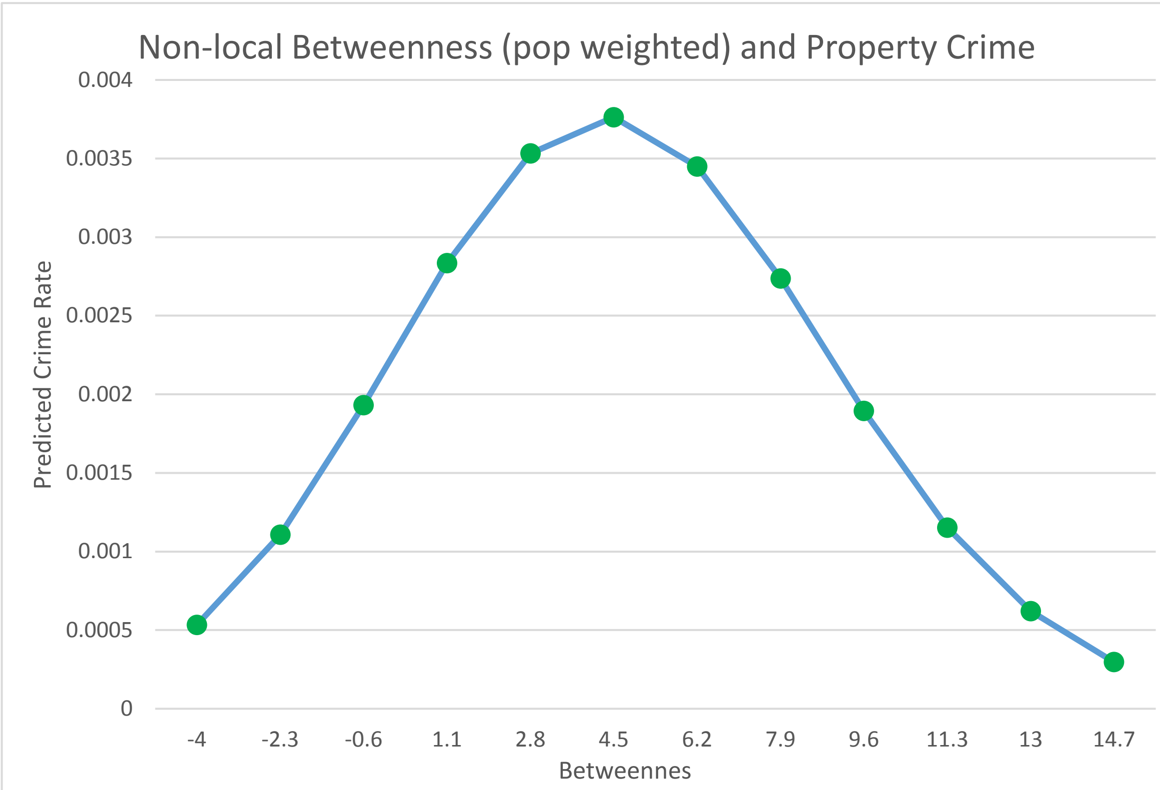

Figure A4.43. Non-Local Betweenness (population-drink emp weighted) and Property Crime

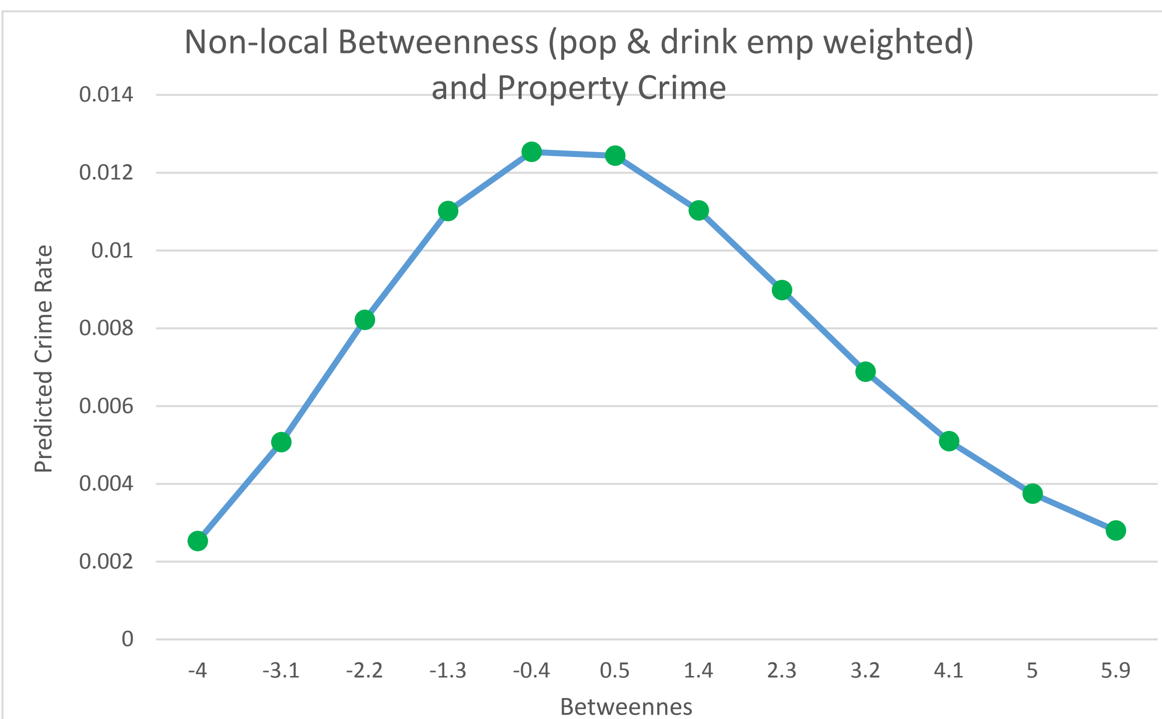

Figure A4.44. Non-Local Betweenness (population-retail emp weighted) and Property Crime

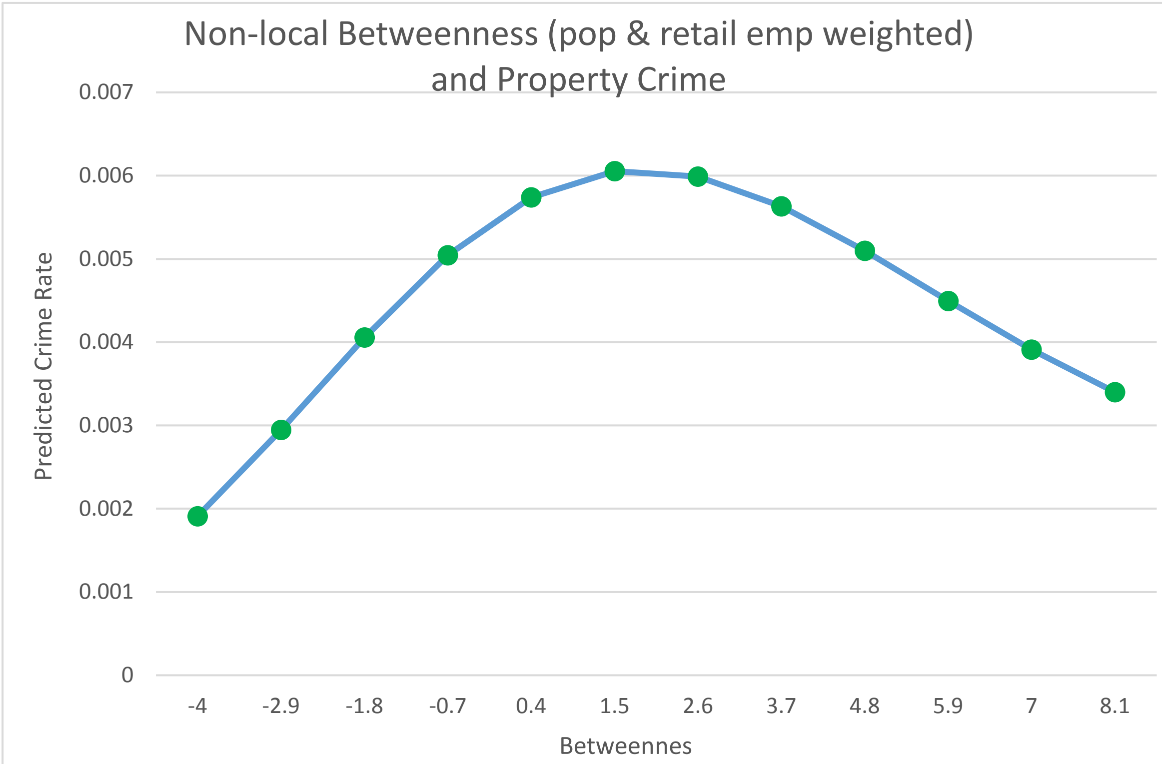

Figure A4.45. Non-Local Betweenness (population-school emp weighted) and Property Crime

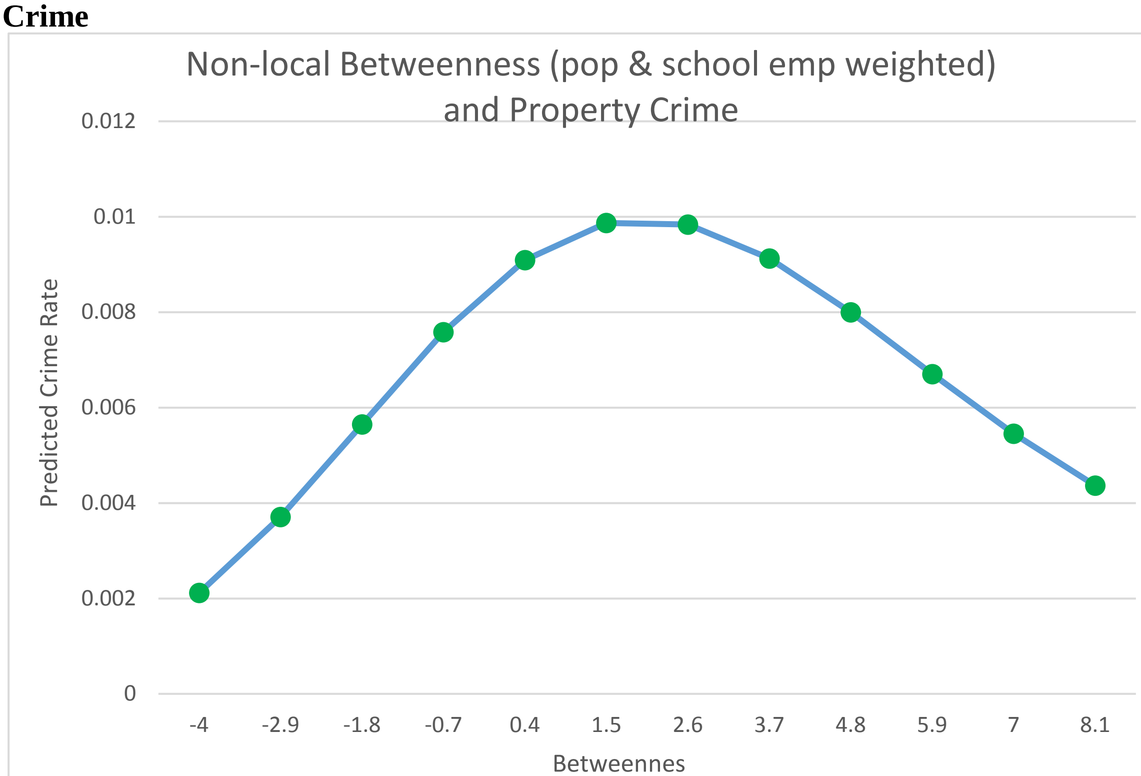

Figure A4.46. Non-Local Betweenness (population-service emp weighted) and Property Crime

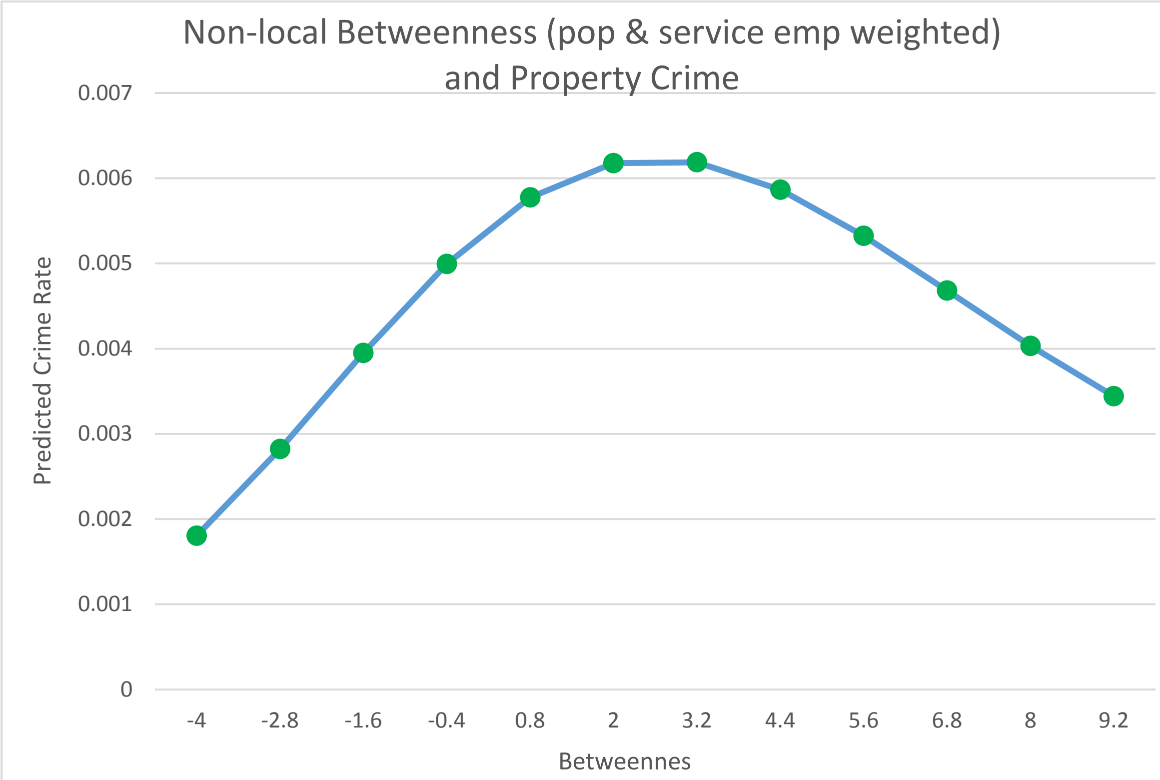

Figure A4.47. Non-Local Betweenness (population-finance emp weighted) and Property Crime

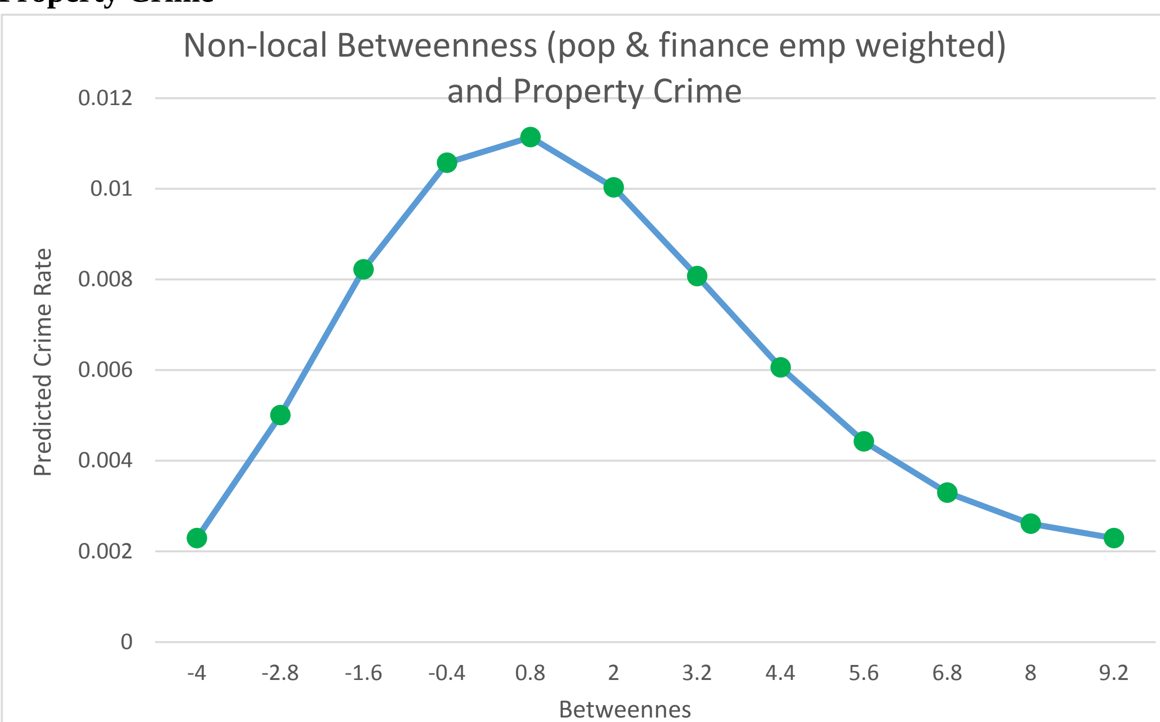

Figure A4.48. Non-Local Betweenness (population-restaurant emp weighted) and Property Crime

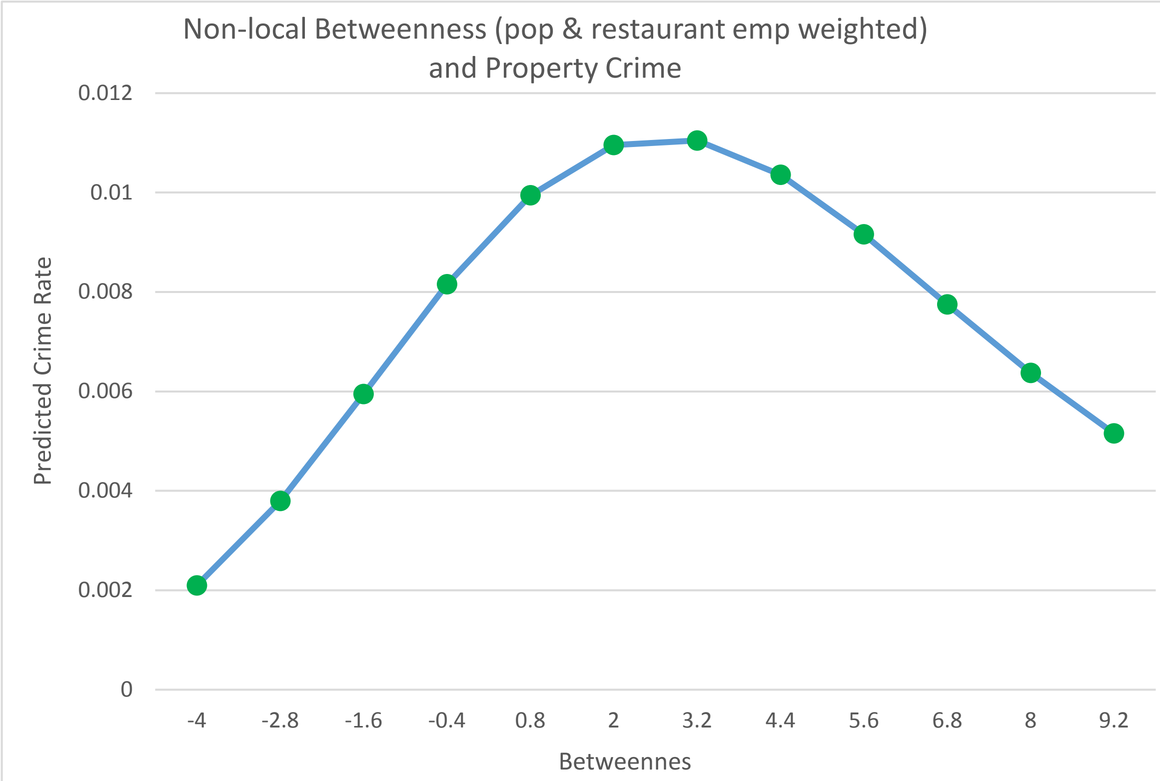

Figure A4.39. Non-Local Betweenness (population-health emp weighted) and Property Crime

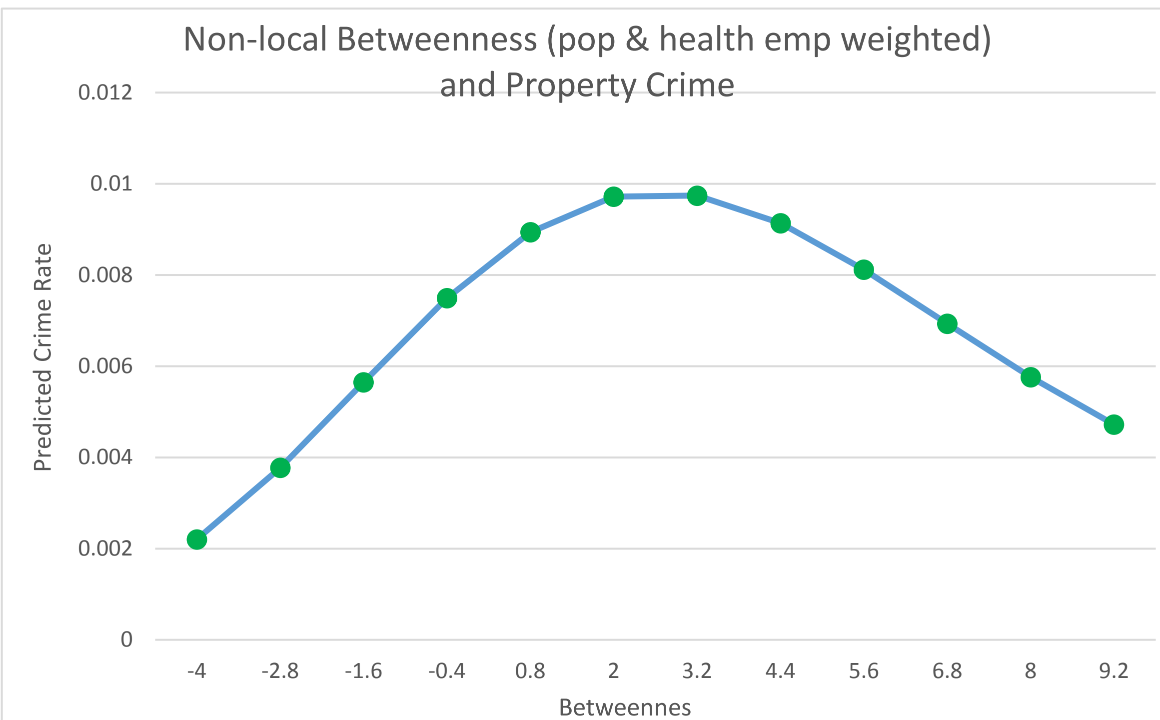

Figure A4.50. Non-Local Betweenness (population-amenity emp weighted) and Property Crime

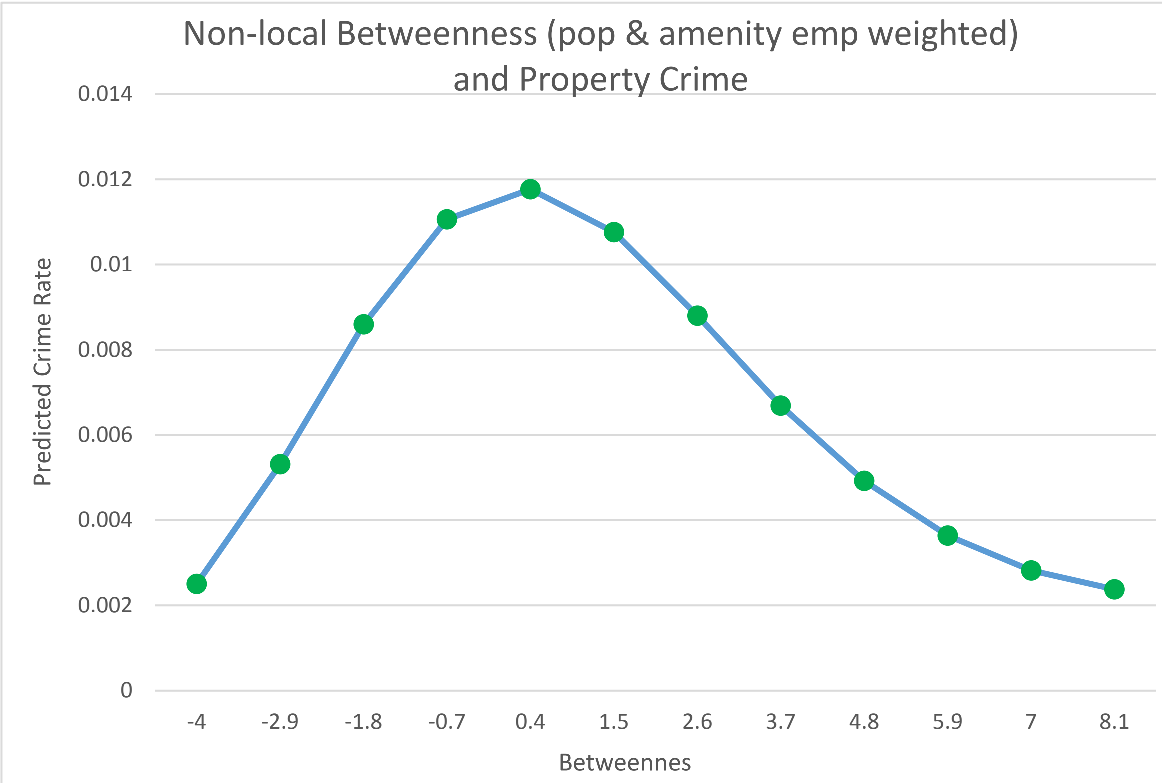

Figure A4.51. Non-Local Betweenness (population-org emp weighted) and Property Crime

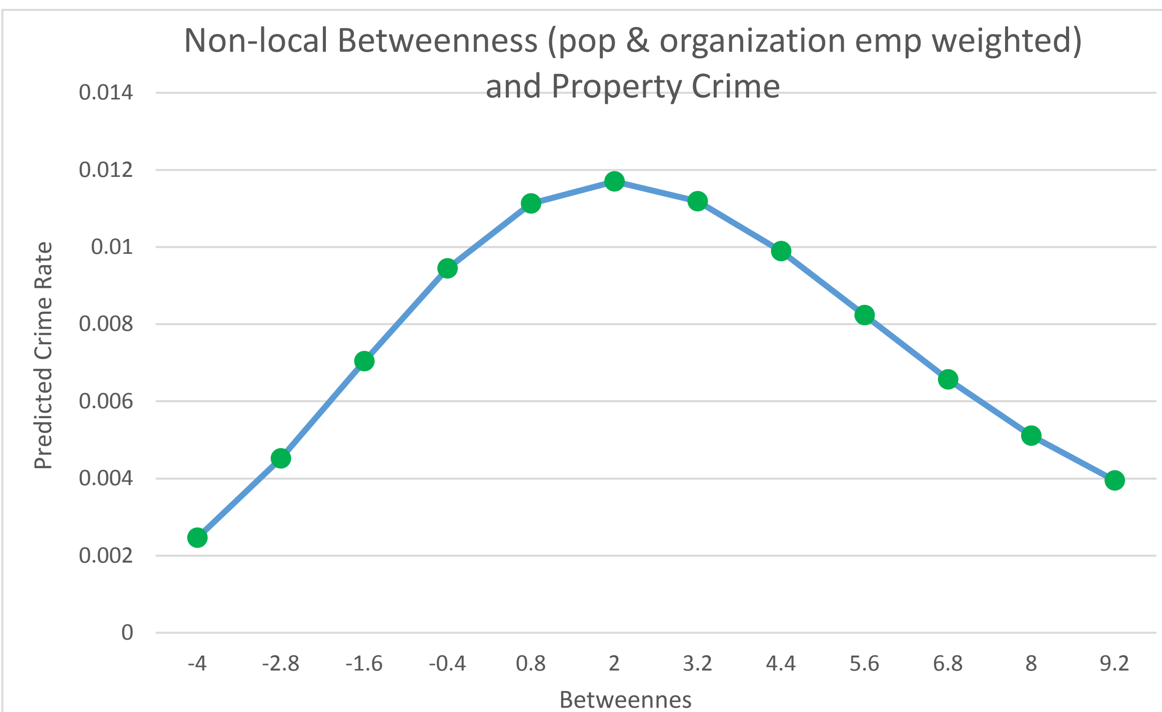

Figure A4.52. Non-Local Betweenness (population-store emp weighted) and Property Crime

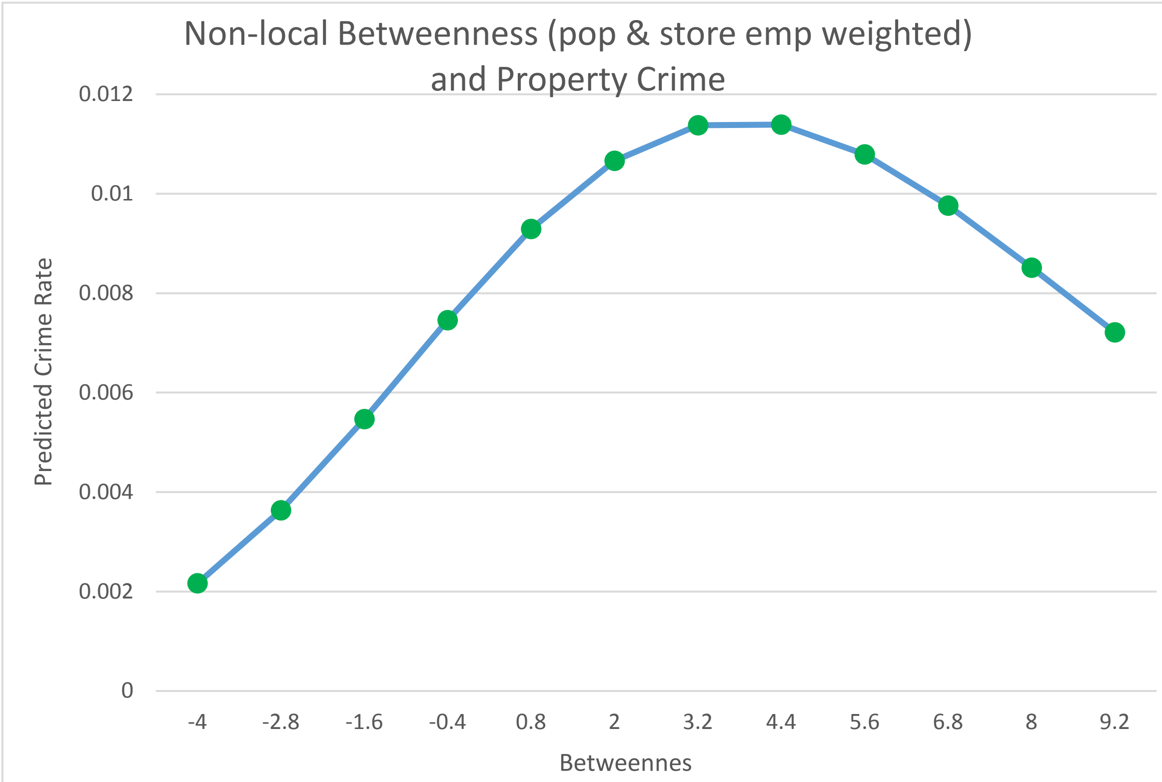

Figure A4.53. Local Reach and Disadvantage (Violent)

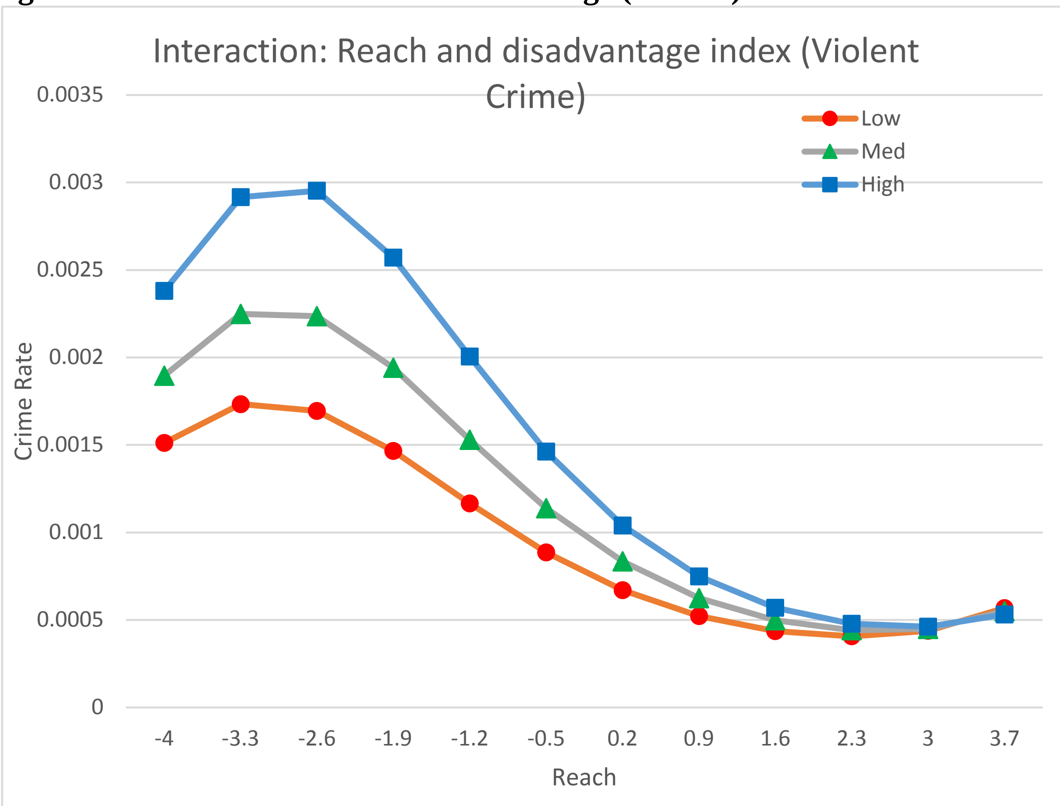

Figure A4.54. Local Betweenness and Disadvantage (Violent)

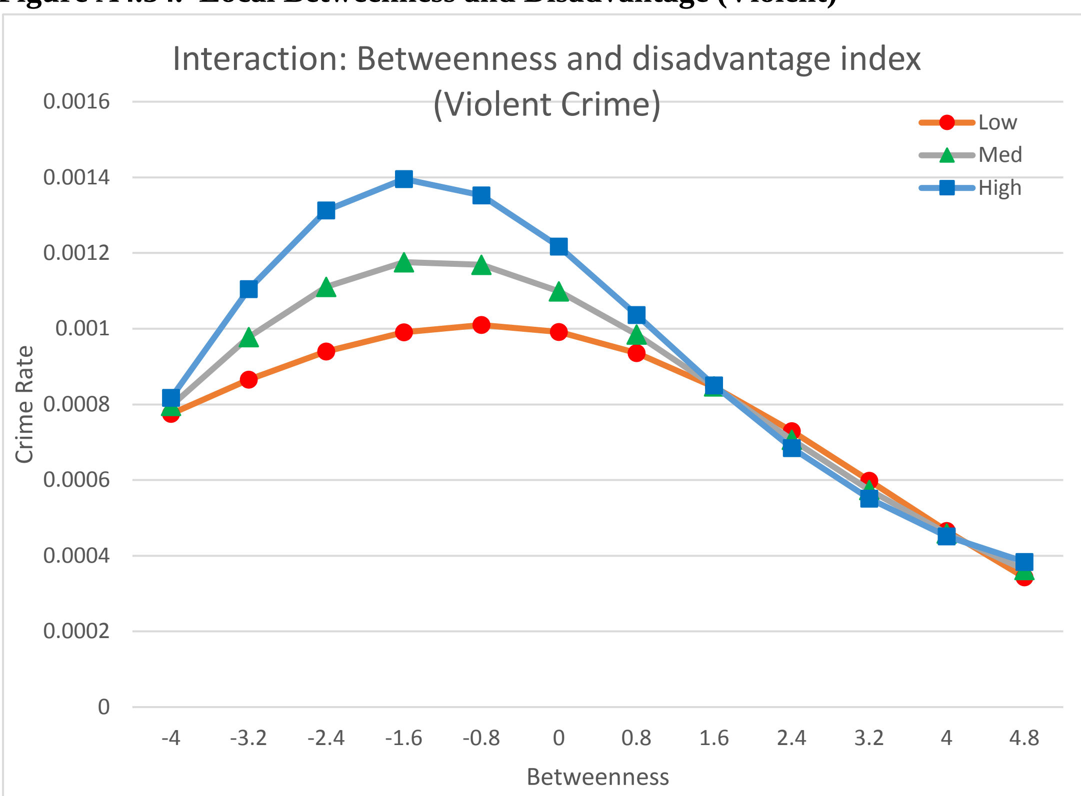

Figure A4.55. Local Betweenness (pop wgt) and Disadvantage (Violent)

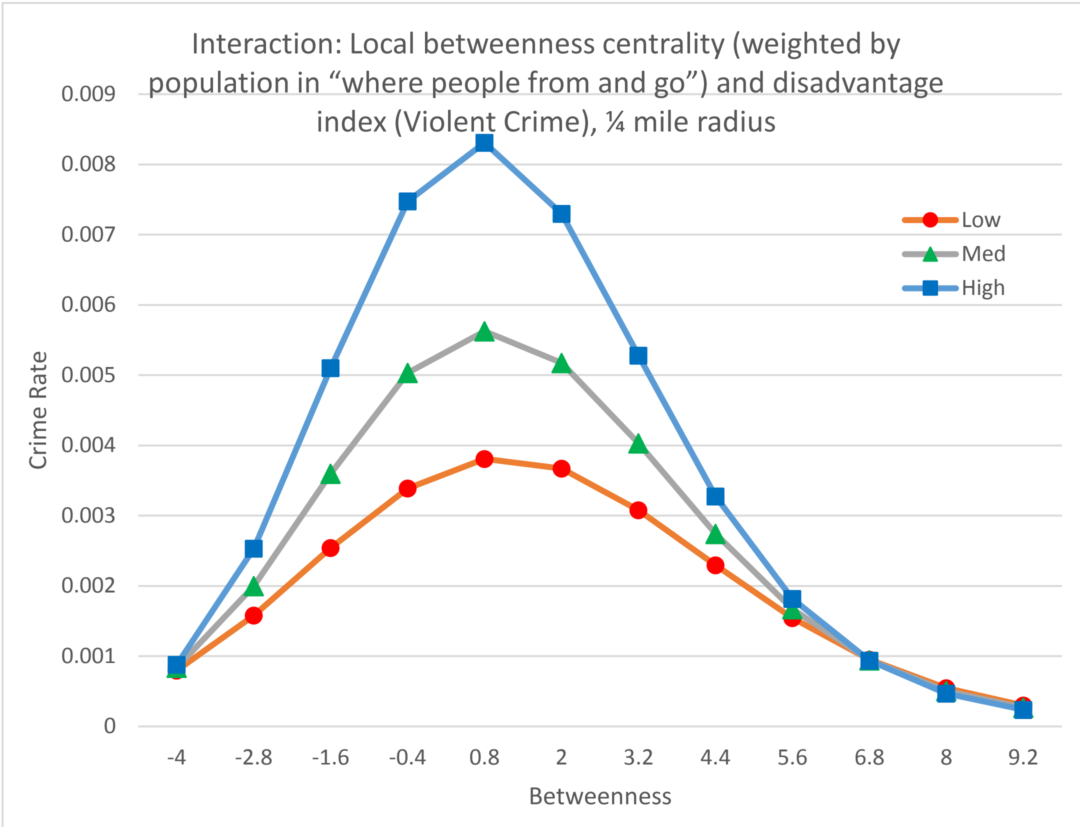

Figure A4.56. Local Betweenness (pop-drink emp wgt) and Disadvantage (Violent)

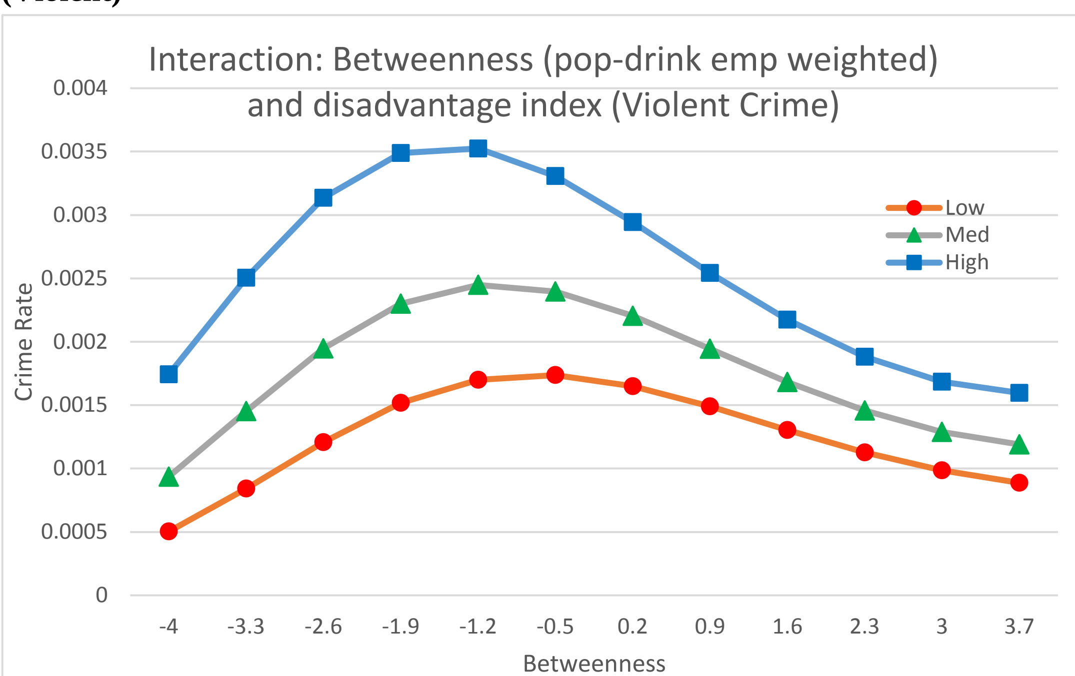

Figure A4.57. Local Betweenness (pop-retail emp wgt) and Disadvantage (Violent)

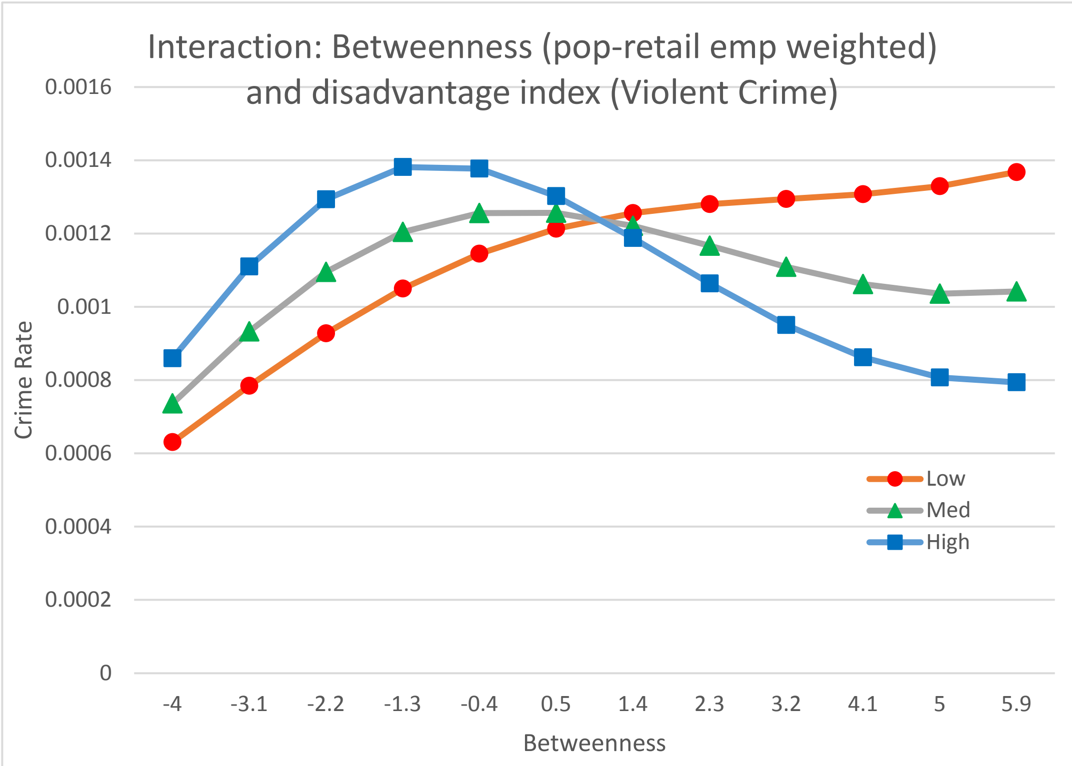

Figure A4.58. Local Betweenness (pop-school emp wgt) and Disadvantage (Violent)

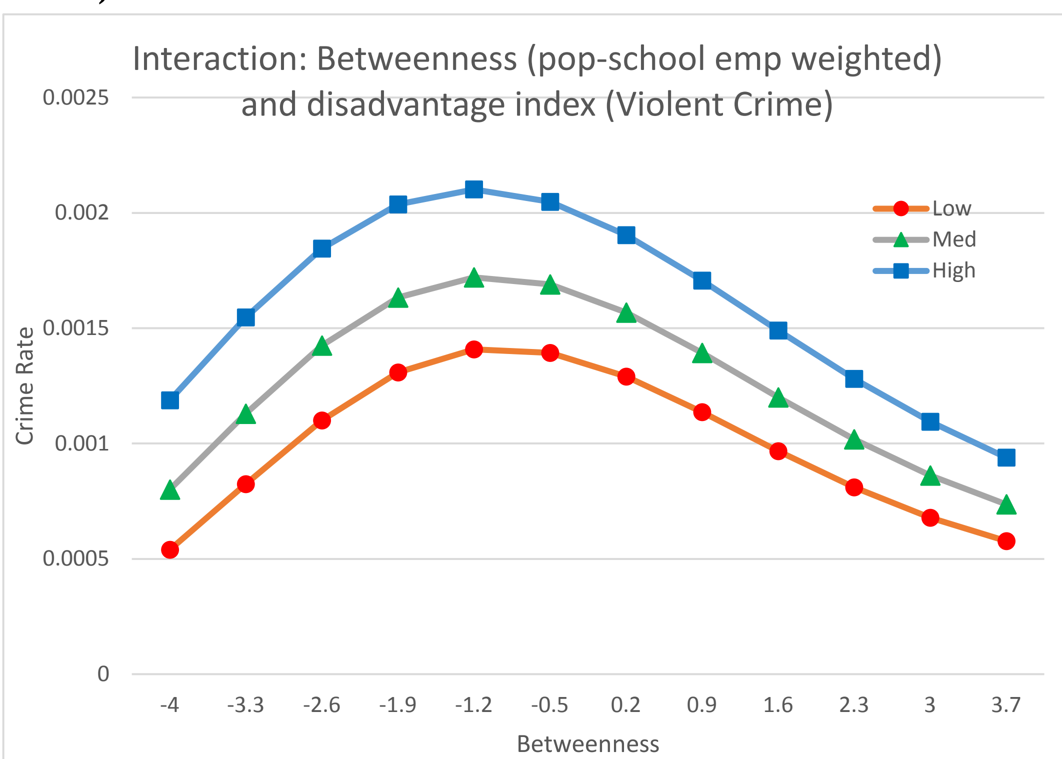

Figure A4.59. Local Betweenness (pop-service emp wgt) and Disadvantage (Violent)

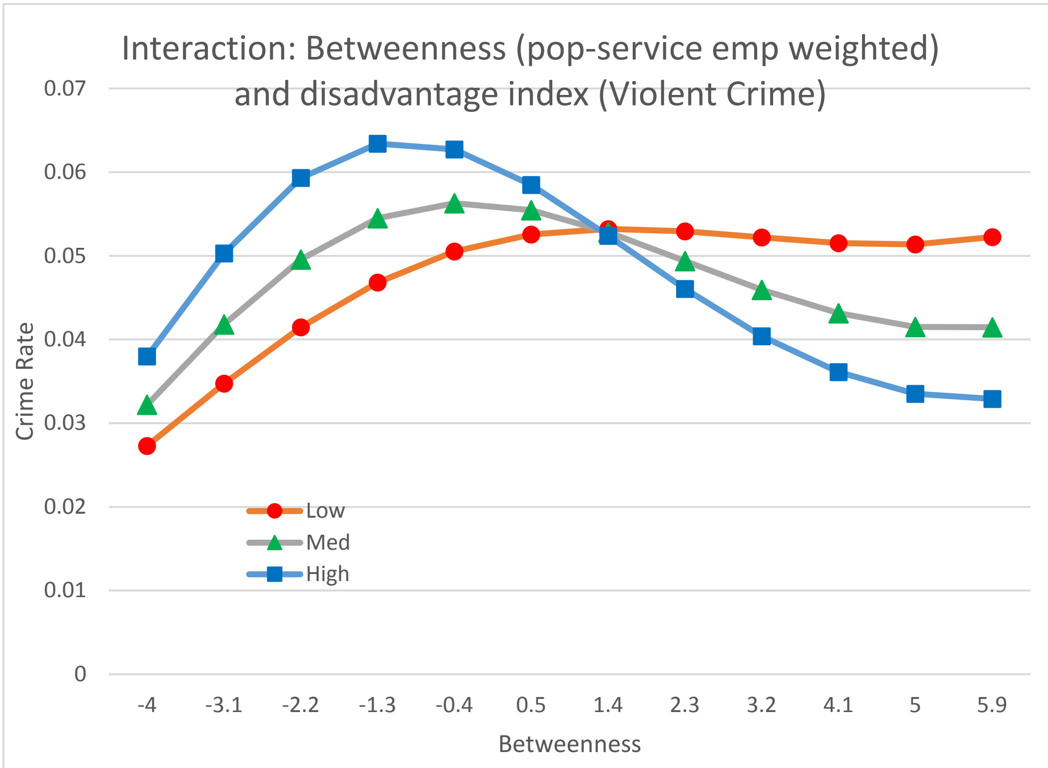

Figure A4.60. Local Betweenness (pop-finance emp wgt) and Disadvantage (Violent)

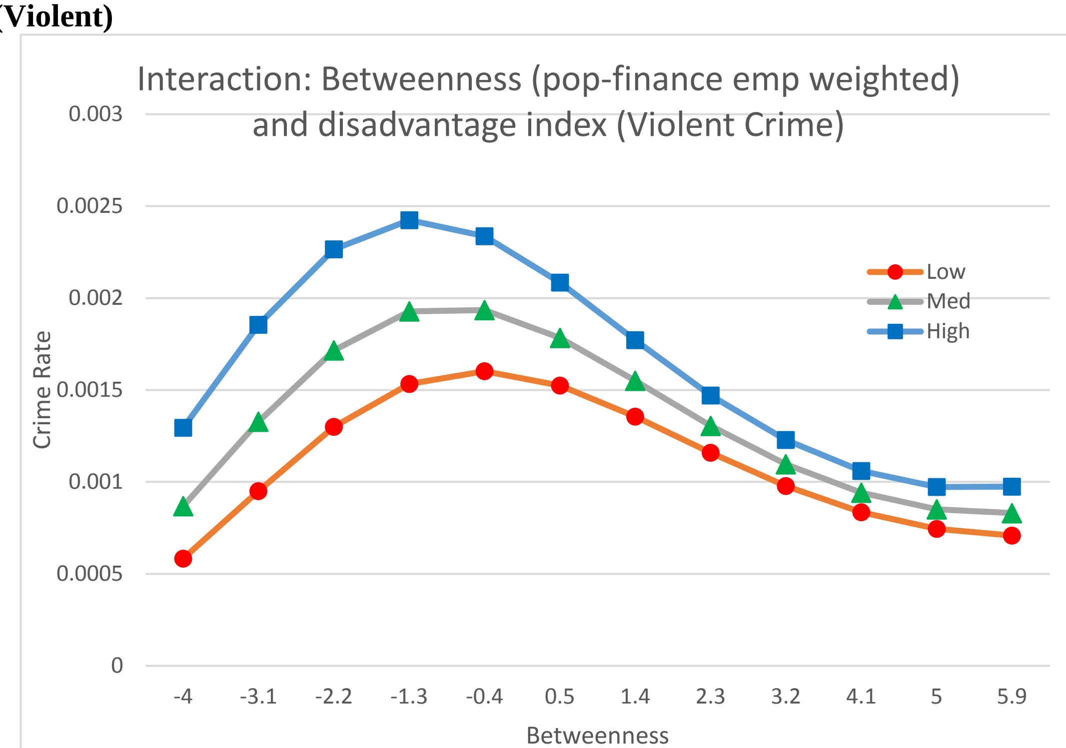

Figure A4.61. Local Betweenness (pop-restaurant emp wgt) and Disadvantage (Violent)

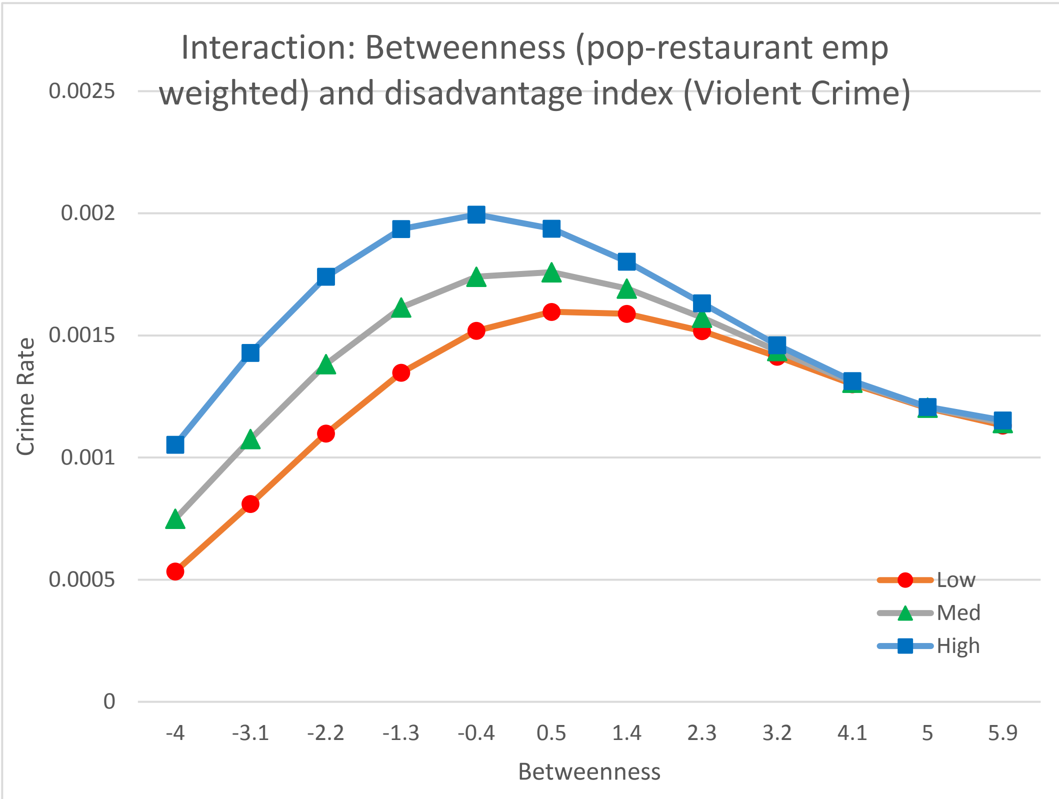

Figure A4.62. Local Betweenness (pop-health emp wgt) and Disadvantage (Violent)

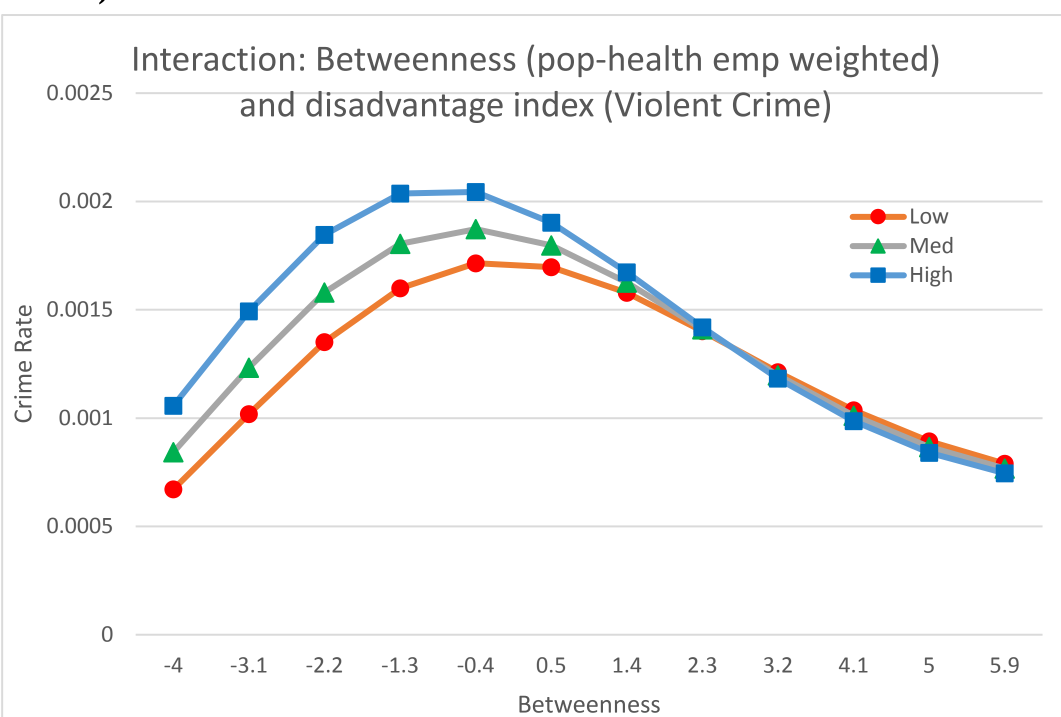

Figure A4.63. Local Betweenness (pop-amenity emp wgt) and Disadvantage (Violent)

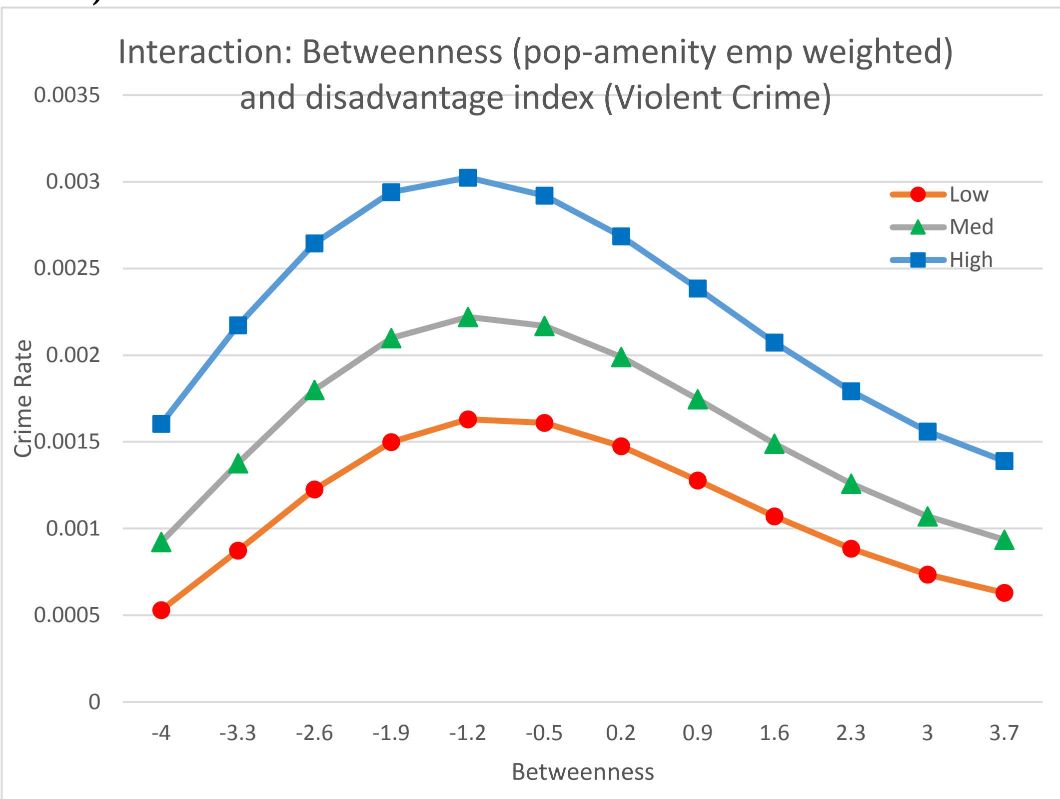

Figure A4.64. Local Betweenness (pop-org emp wgt) and Disadvantage (Violent)

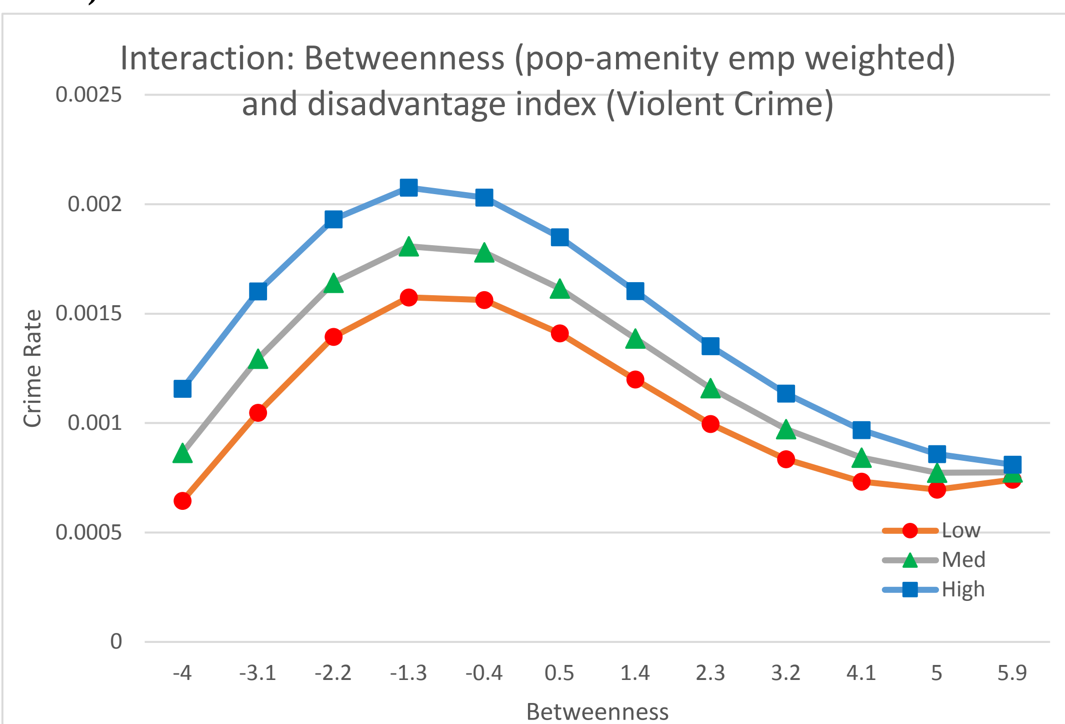

Figure A4.65. Local Betweenness (pop-store emp wgt) and Disadvantage (Violent)

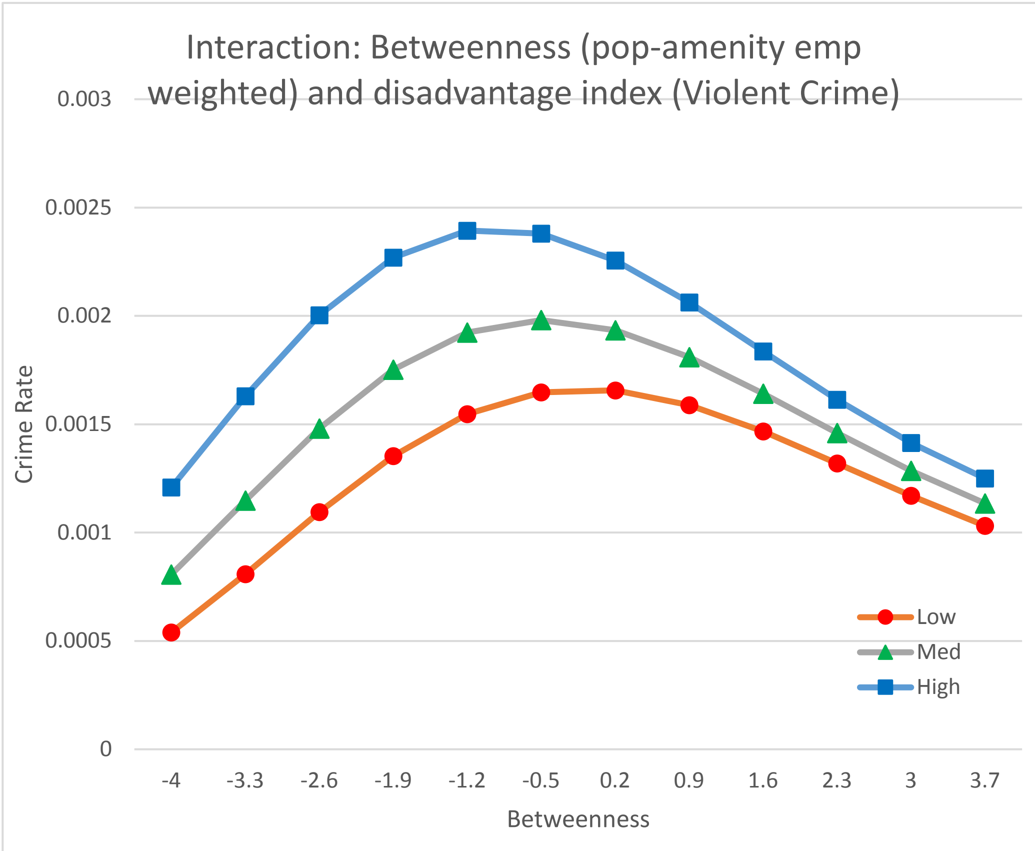

Figure A4.66. Local Reach and Disadvantage (Property)

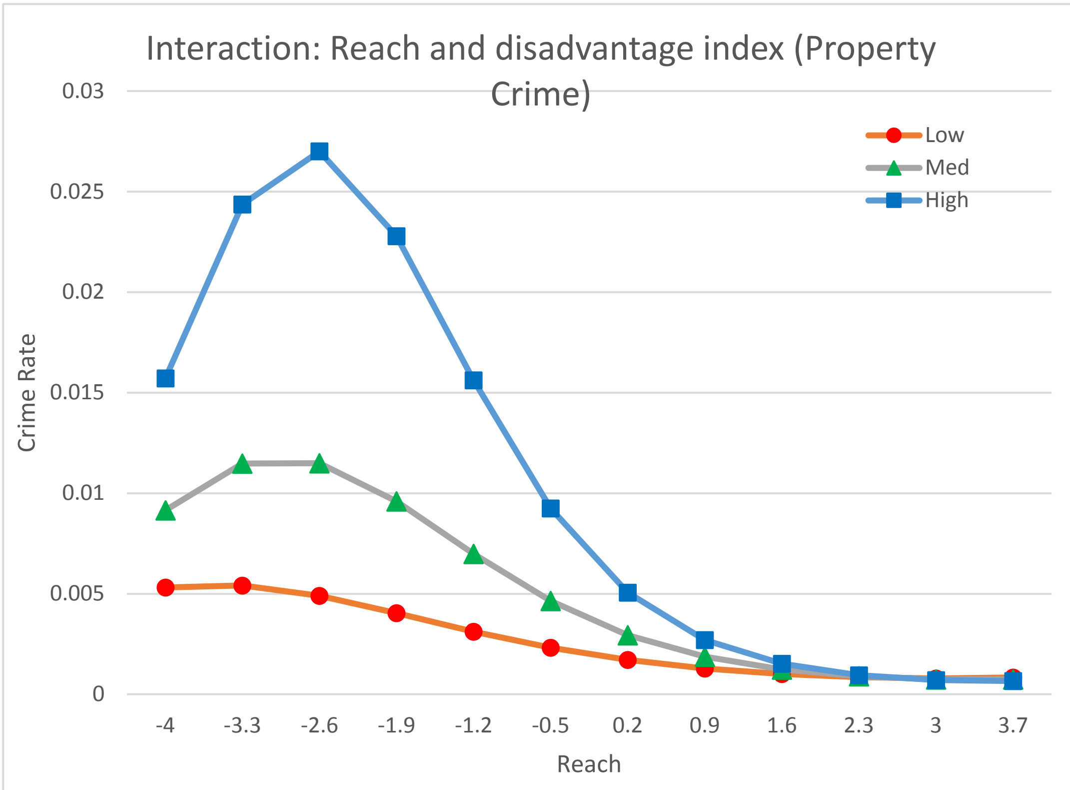

Figure A4.67. Local Betweenness and Disadvantage (Property)

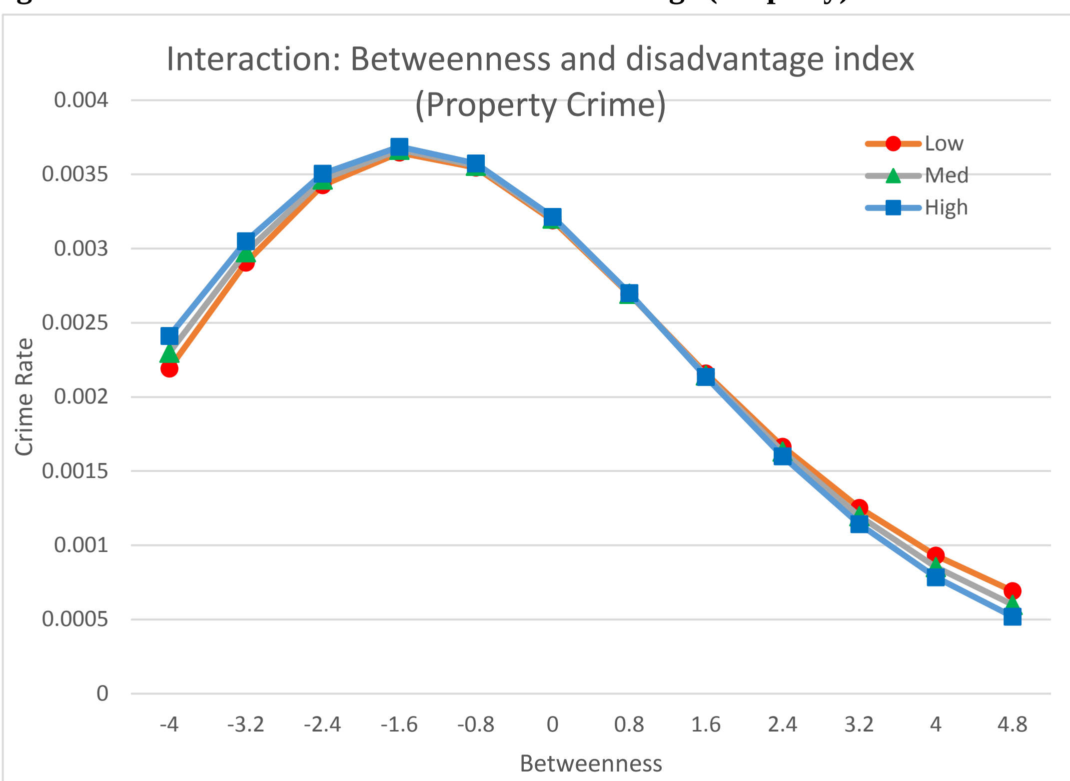

Figure A4.68. Local Betweenness (pop wgt) and Disadvantage (Property)

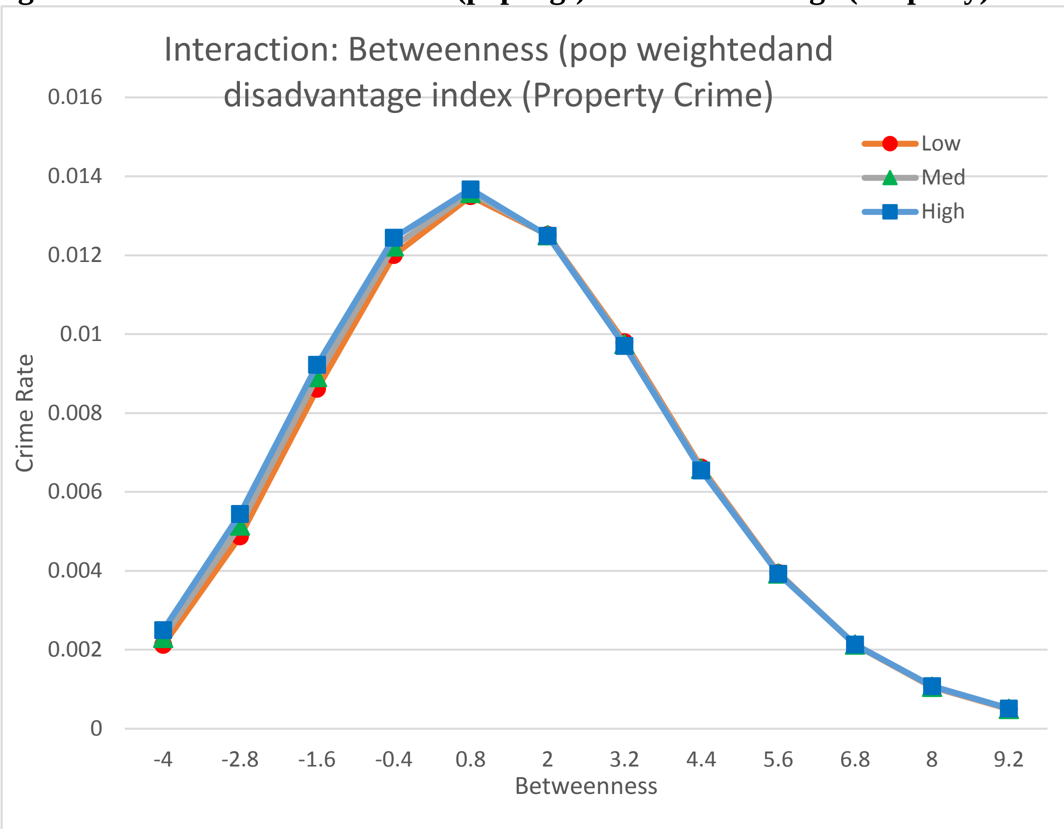

Figure A4.69. Local Betweenness (pop-drink emp wgt) and Disadvantage (Property)

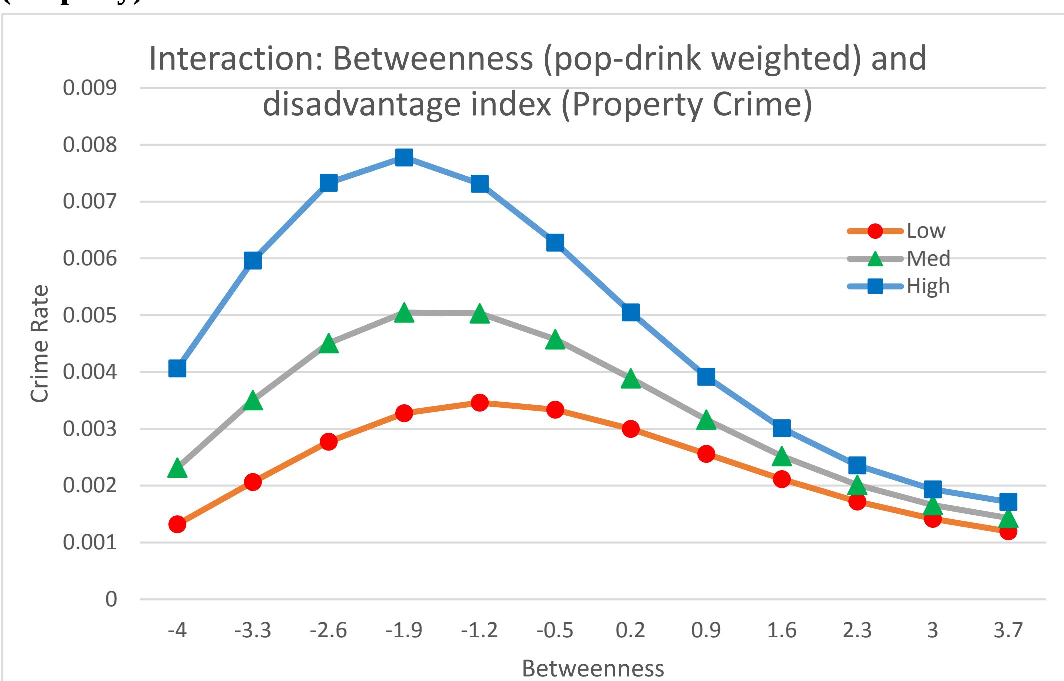

Figure A4.70. Local Betweenness (pop-retail emp wgt) and Disadvantage (Property)

Figure A4.71. Local Betweenness (pop-school emp wgt) and Disadvantage (Property)

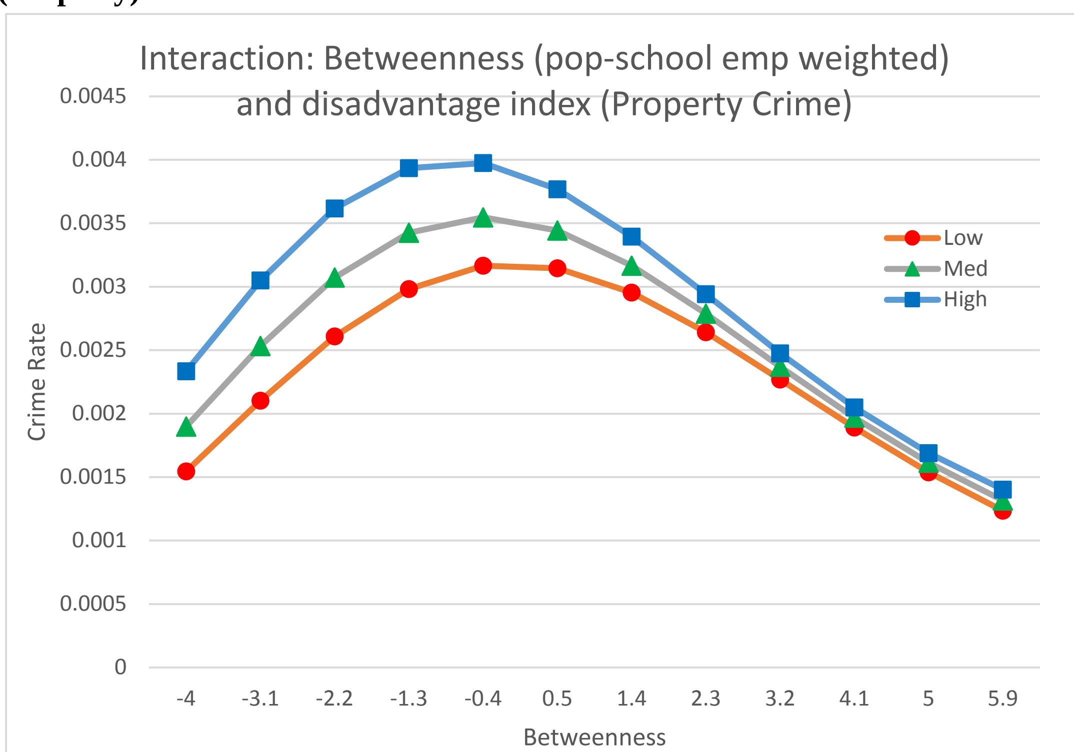

Figure A4.72. Local Betweenness (pop-service emp wgt) and Disadvantage (Property)

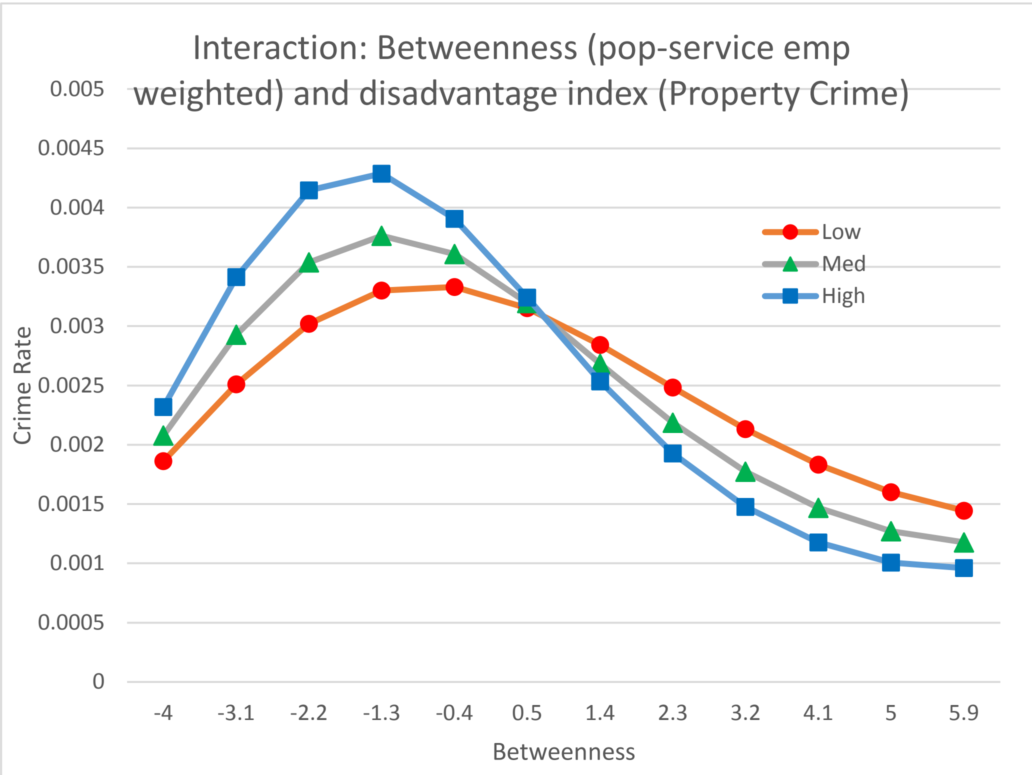

Figure A4.73. Local Betweenness (pop-finance emp wgt) and Disadvantage (Property)

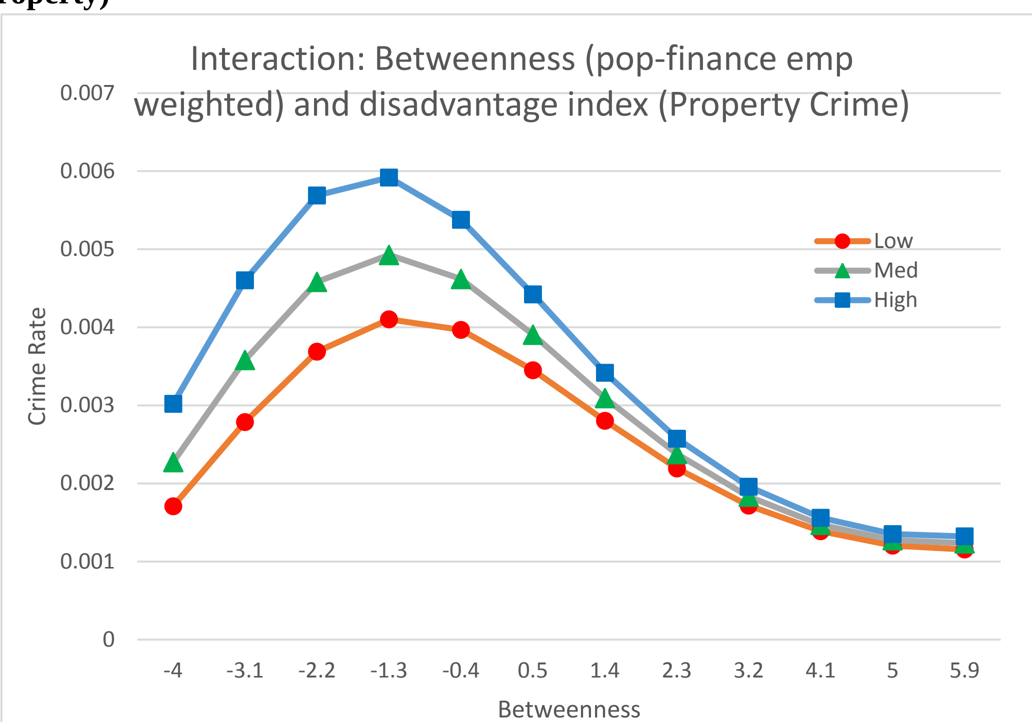

Figure A4.74. Local Betweenness (pop-restaurant emp wgt) and Disadvantage (Property)

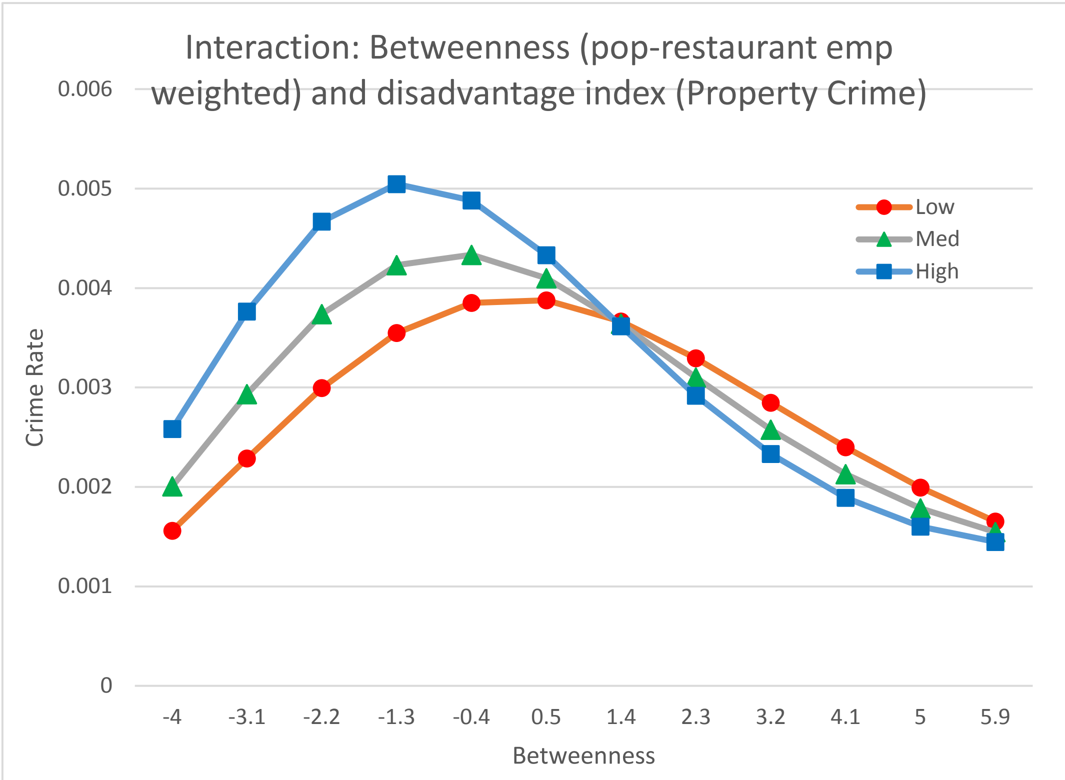

Figure A4.75. Local Betweenness (pop-health emp wgt) and Disadvantage (Property)

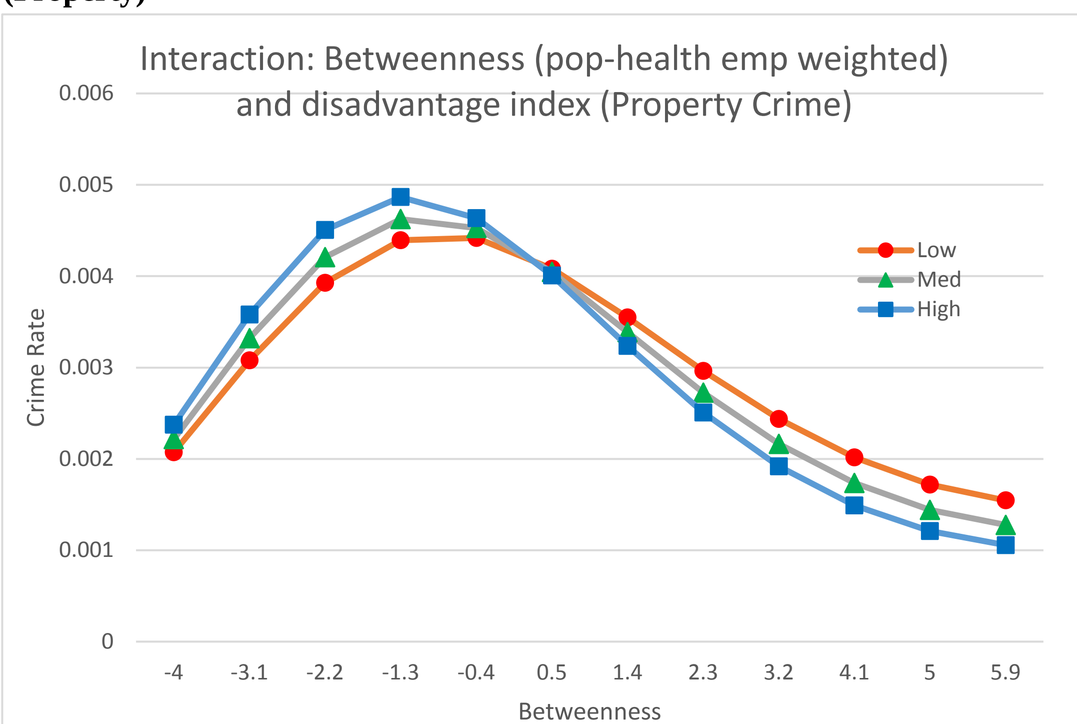

Figure A4.76. Local Betweenness (pop-amenity emp wgt) and Disadvantage (Property)

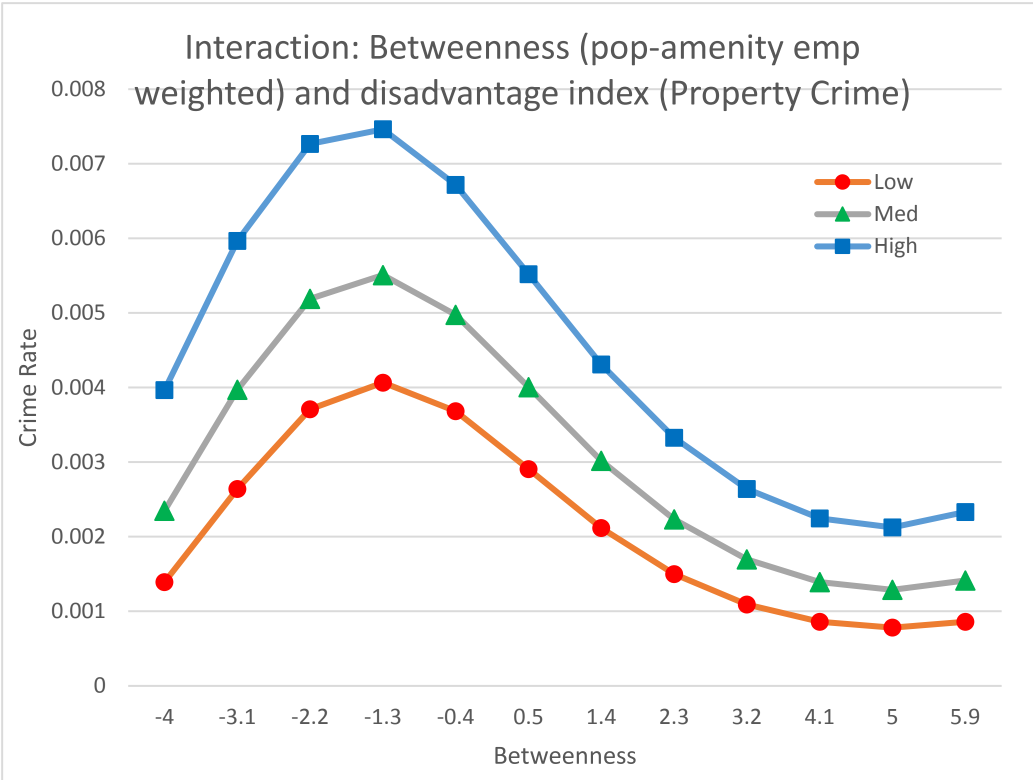

Figure A4.77. Local Betweenness (pop-org emp wgt) and Disadvantage (Property)

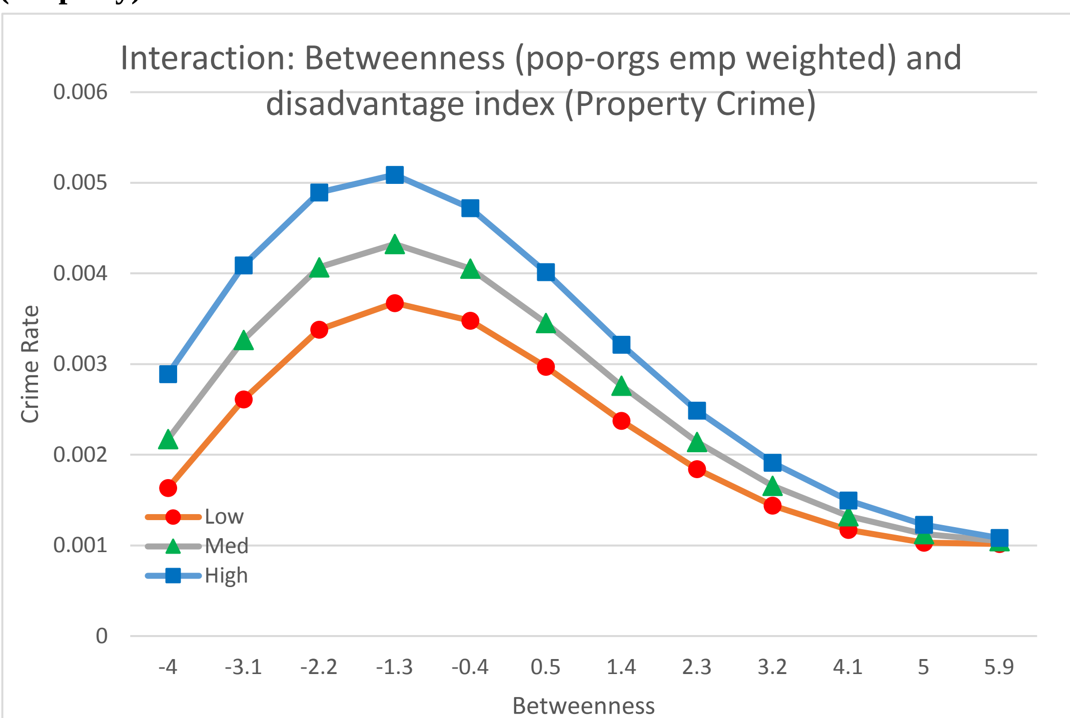

Figure A4.78. Local Betweenness (pop-store emp wgt) and Disadvantage (Property)

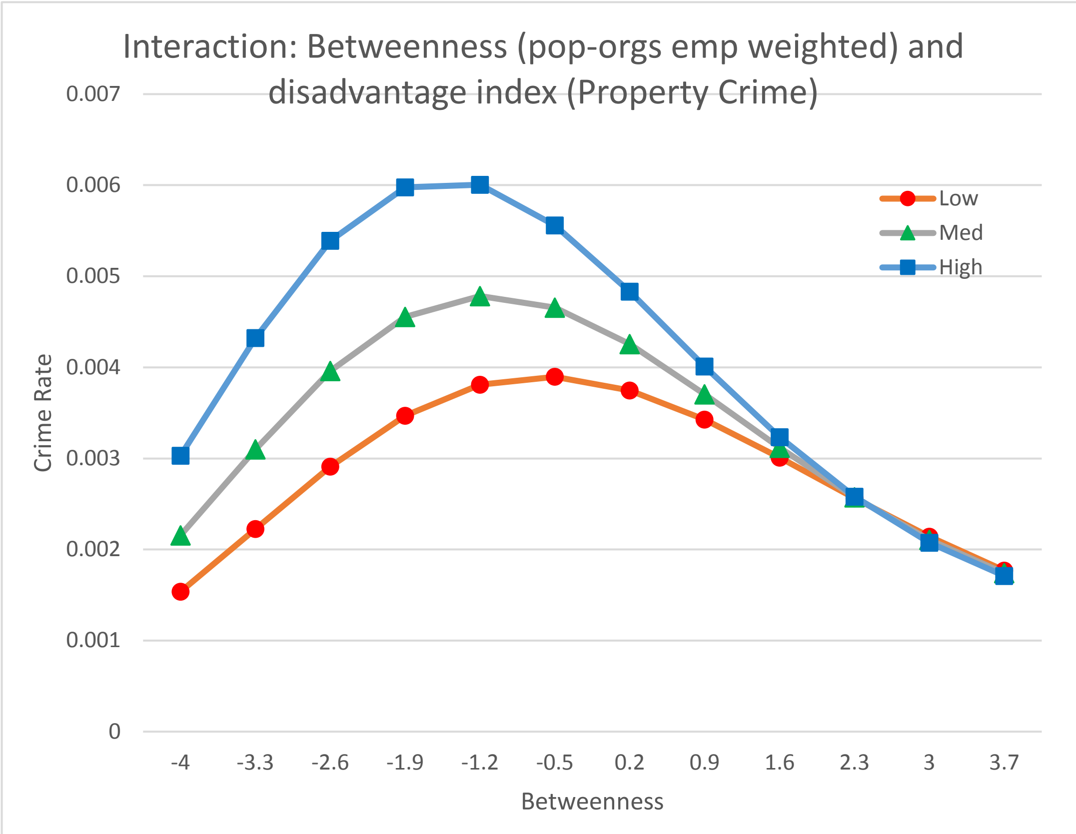

Figure A4.79. Non-Local Reach and Disadvantage (Violent)

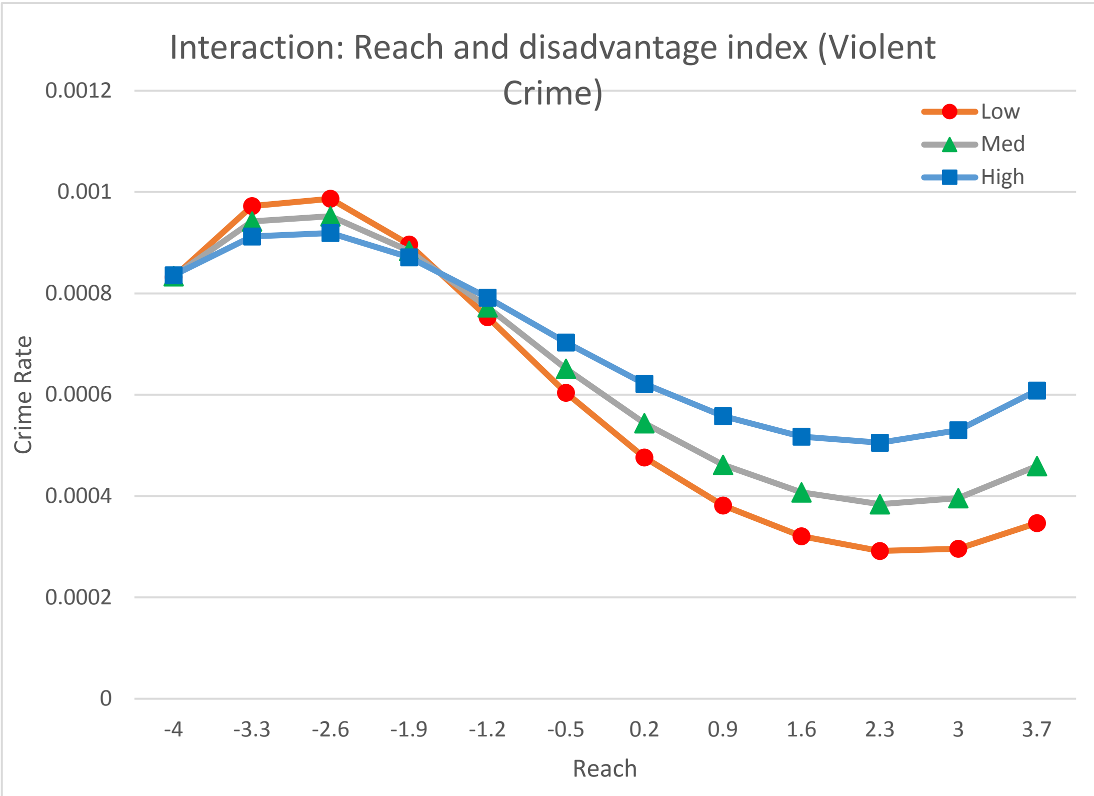

Figure A4.80. Non-Local Betweenness and Disadvantage (Violent)

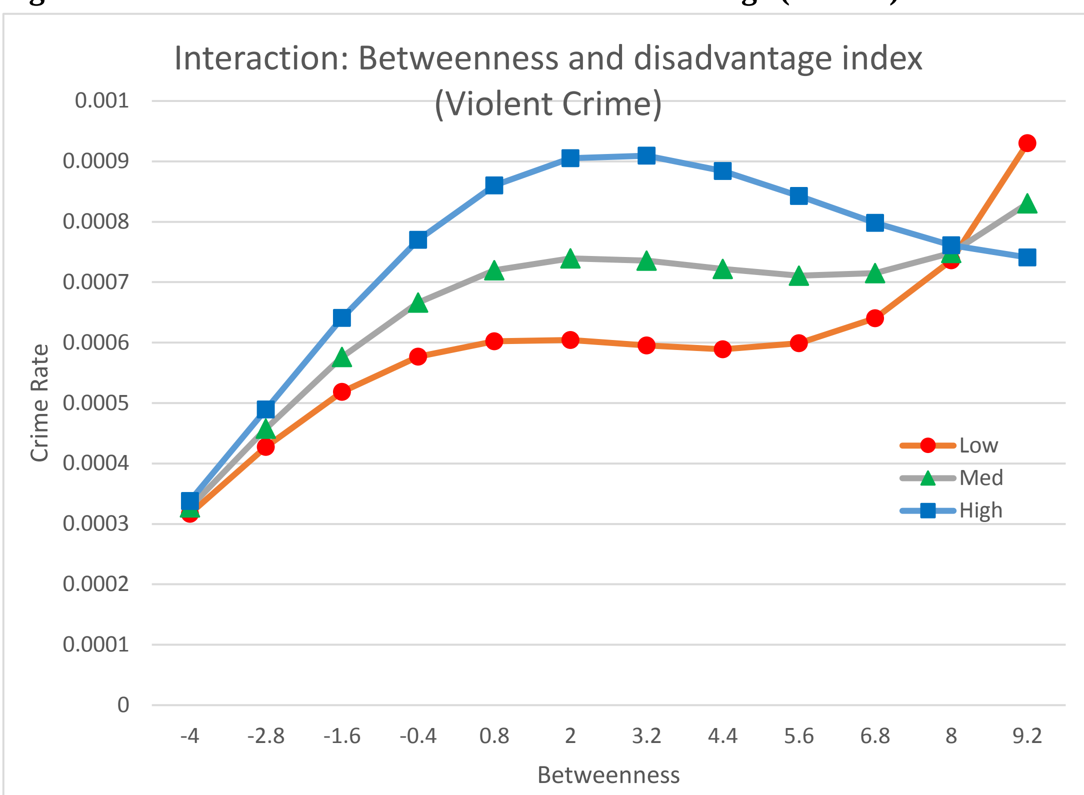

Figure A4.81. Non-Local Betweenness (pop wgt) and Disadvantage (Violent)

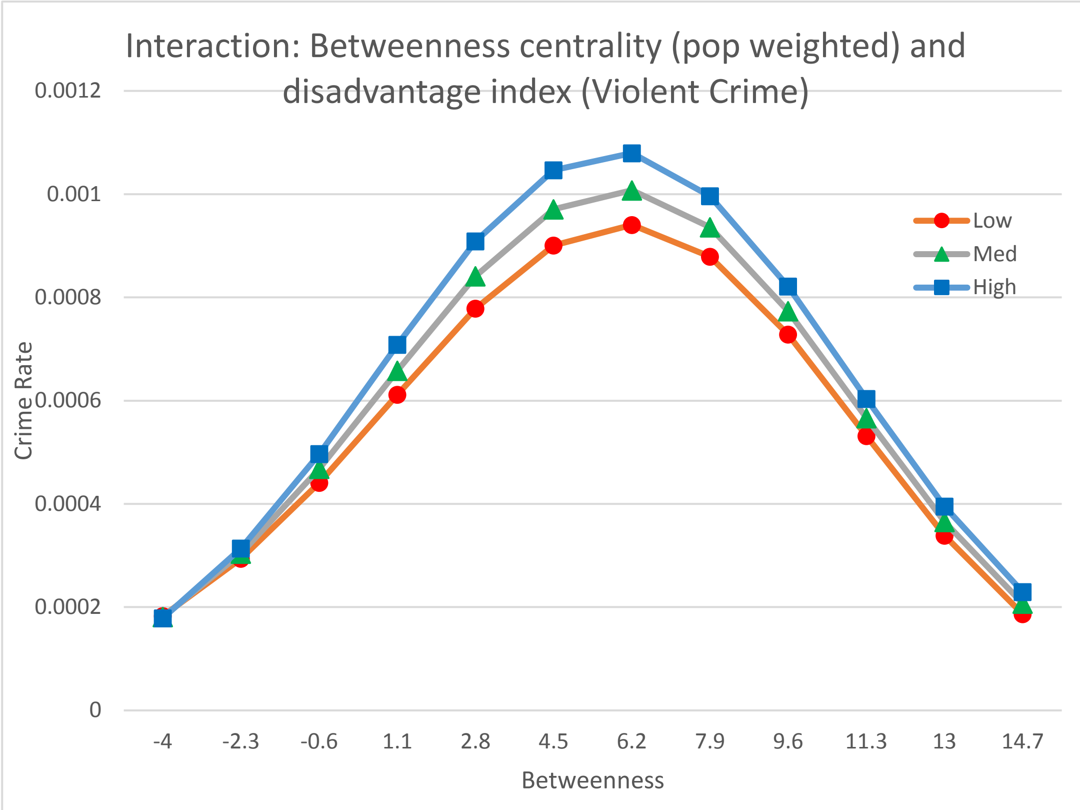

Figure A4.82. Non-Local Betweenness (pop-drink emp wgt) and Disadvantage (Violent)

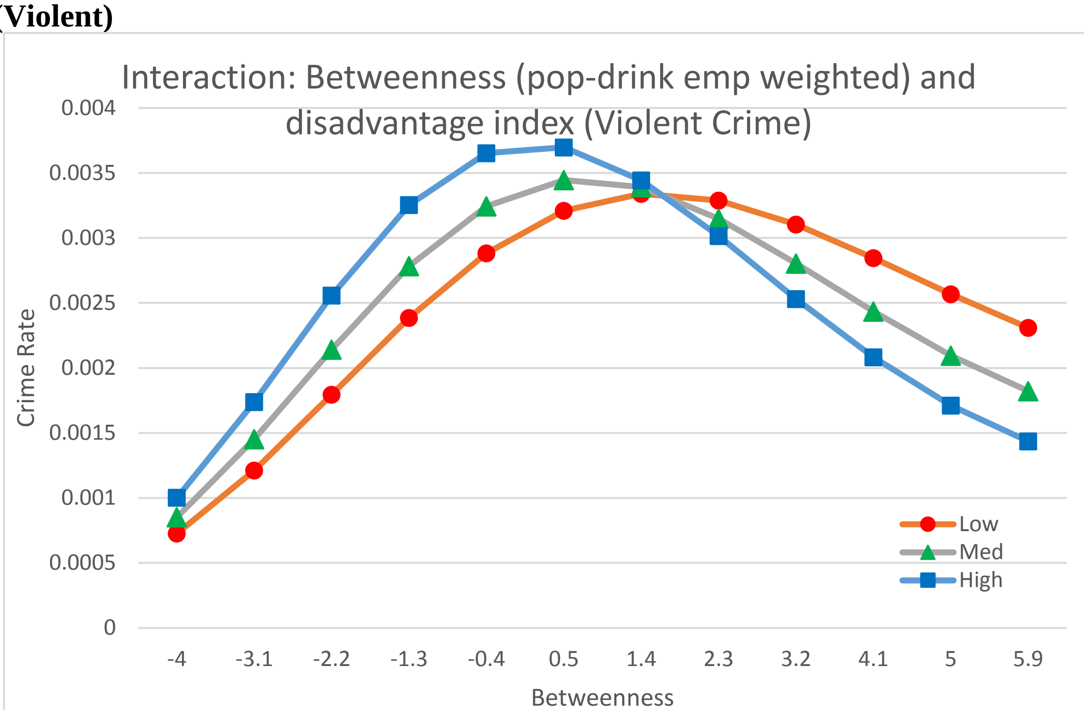

Figure A4.83. Non-Local Betweenness (pop-retail emp wgt) and Disadvantage (Violent)

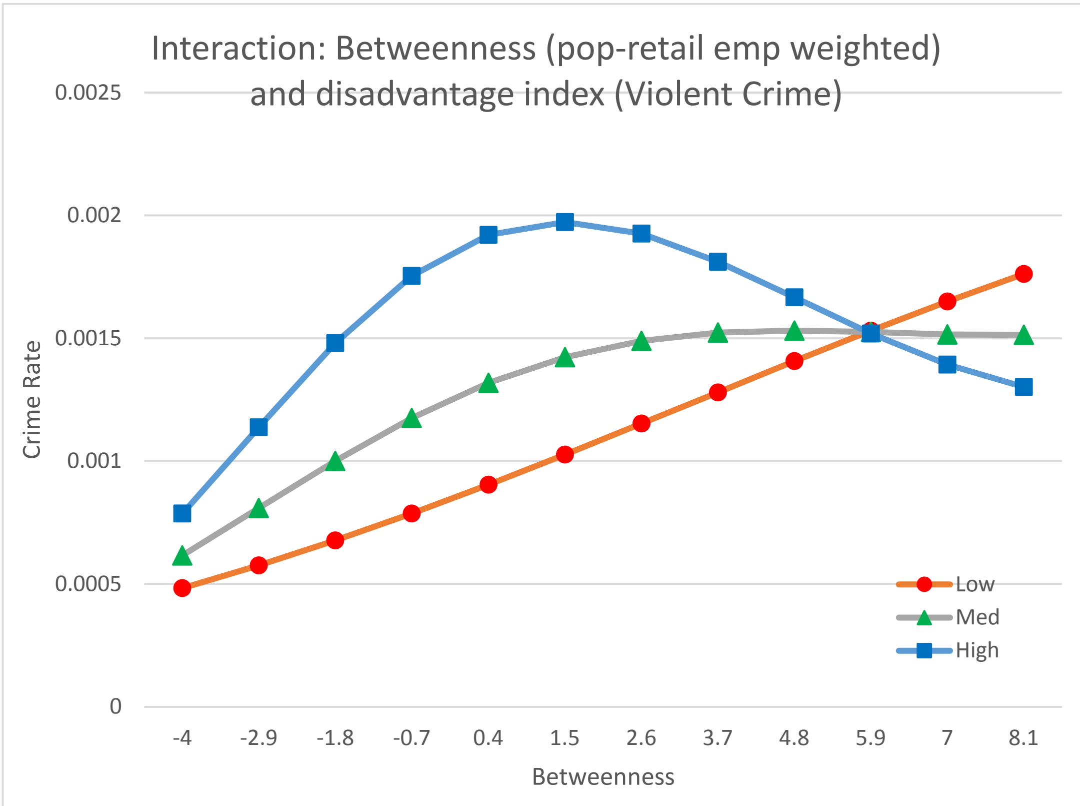

Figure A4.84. Non-Local Betweenness (pop-school emp wgt) and Disadvantage (Violent)

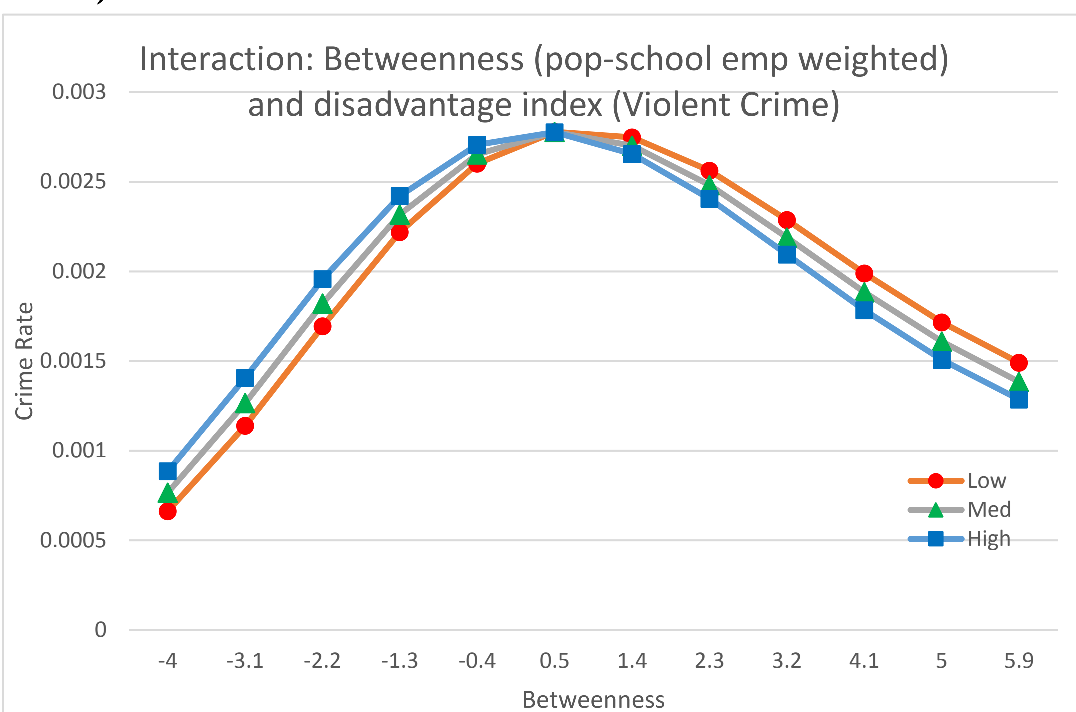

Figure A4.85. Non-Local Betweenness (pop-service emp wgt) and Disadvantage (Violent)

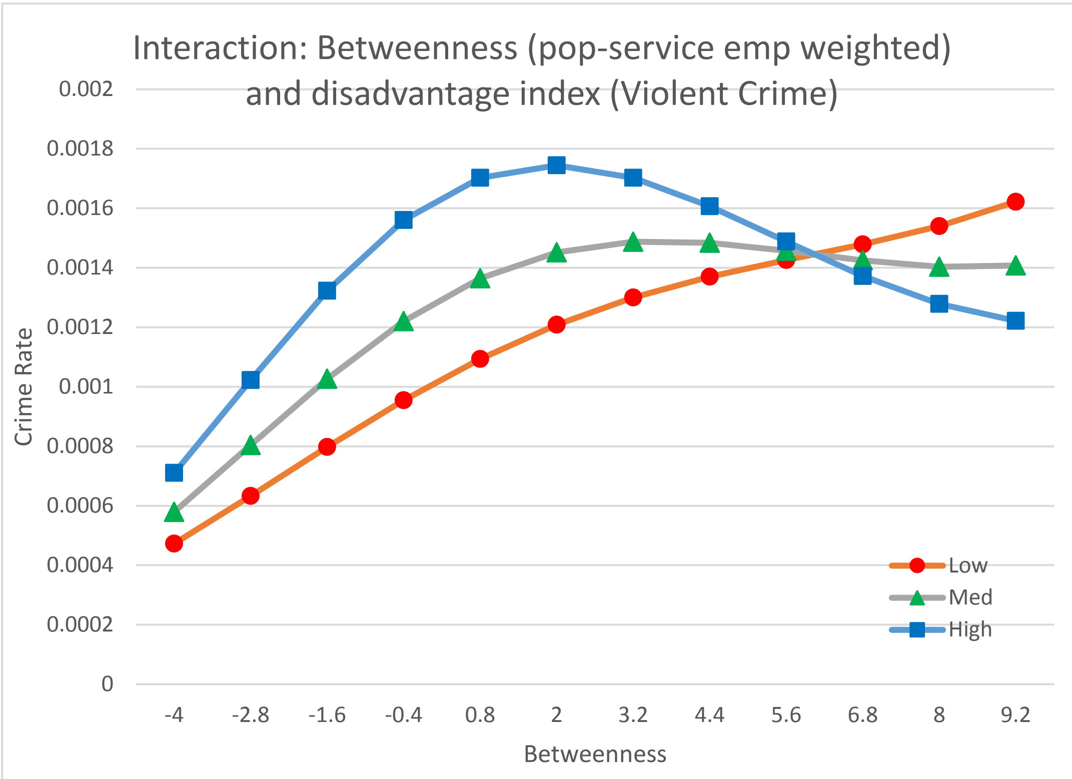

Figure A4.86. Non-Local Betweenness (pop-finance emp wgt) and Disadvantage (Violent)

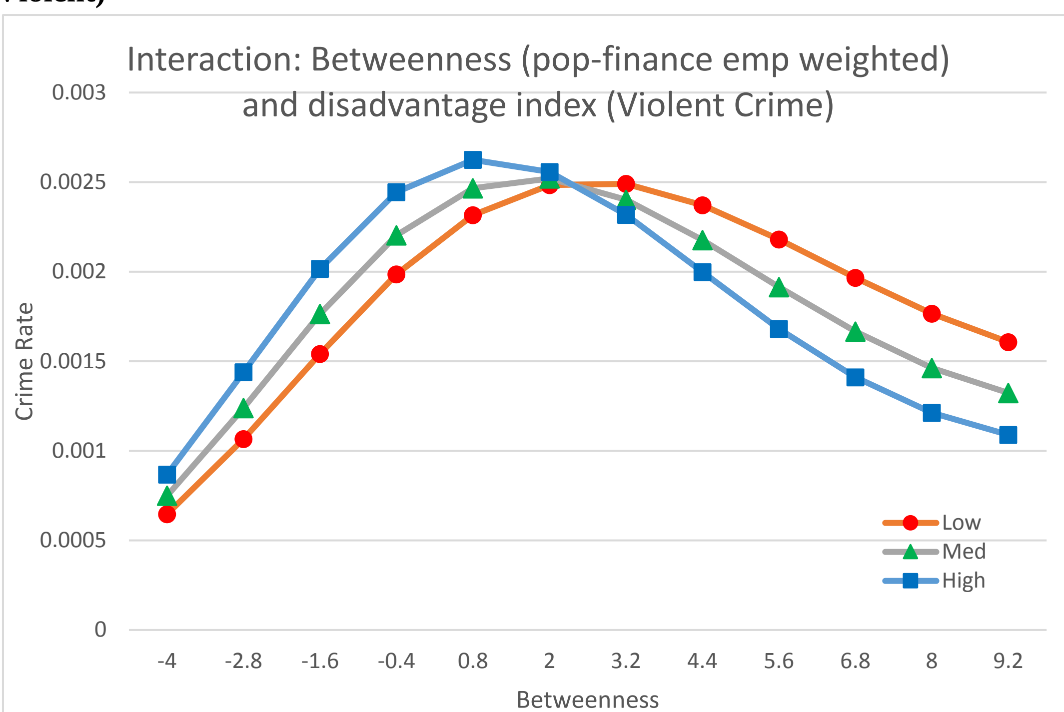

Figure A4.87. Non-Local Betweenness (pop-restaurant emp wgt) and Disadvantage (Violent)

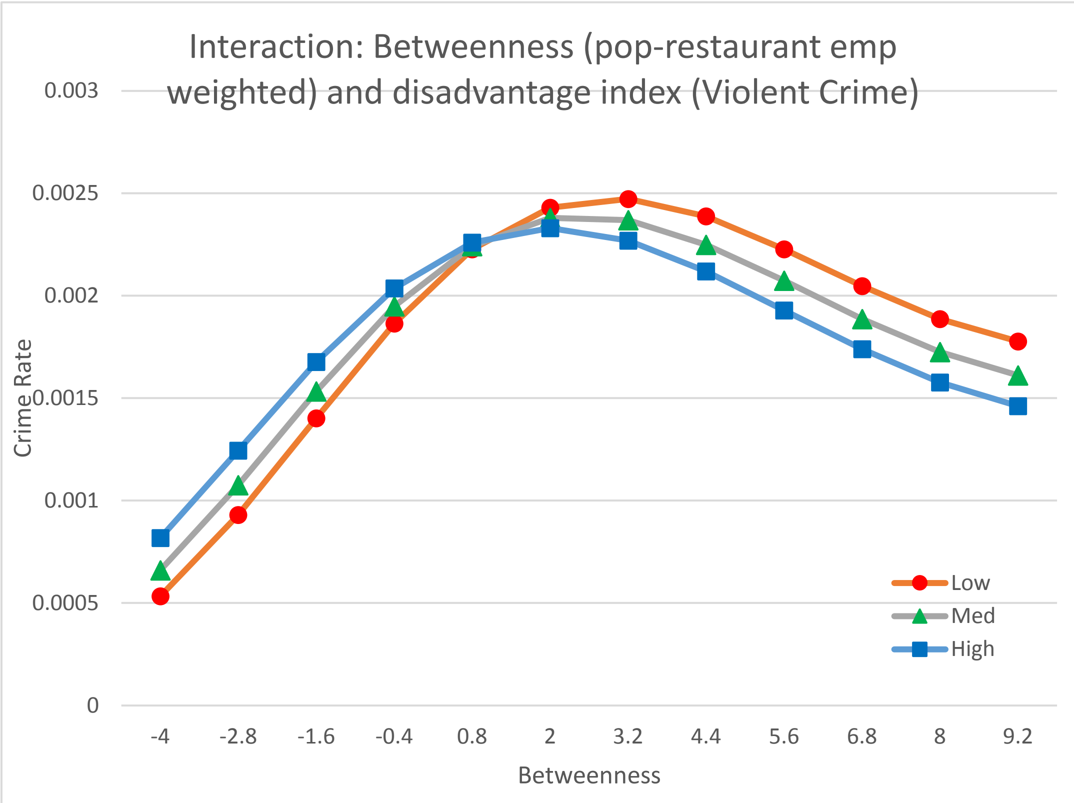

Figure A4.88. Non-Local Betweenness (pop-health emp wgt) and Disadvantage (Violent)

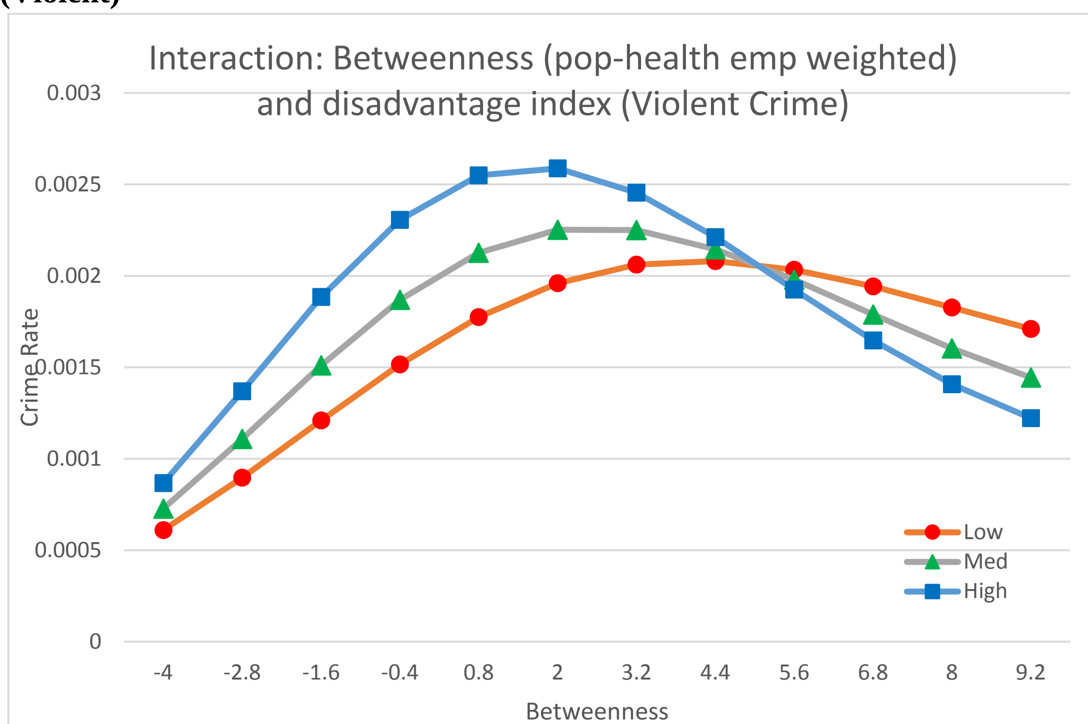

Figure A4.89. Non-Local Betweenness (pop-amenity emp wgt) and Disadvantage (Violent)

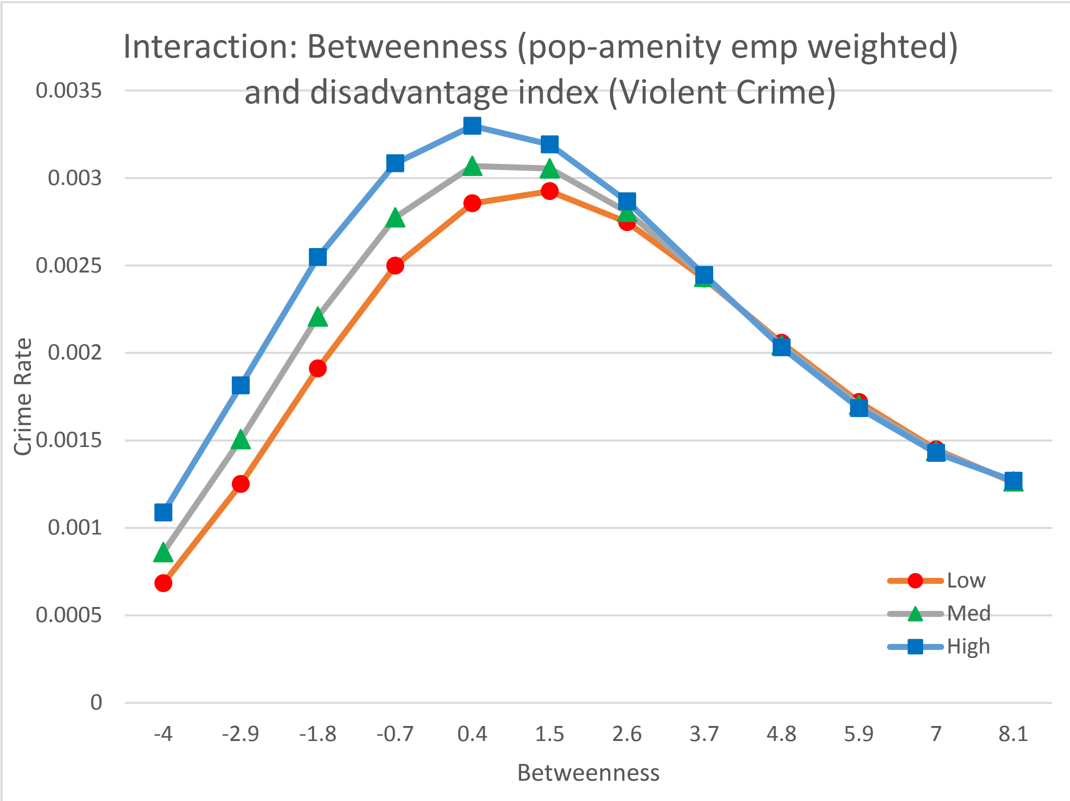

Figure A4.90. Non-Local Betweenness (pop-org emp wgt) and Disadvantage (Violent)

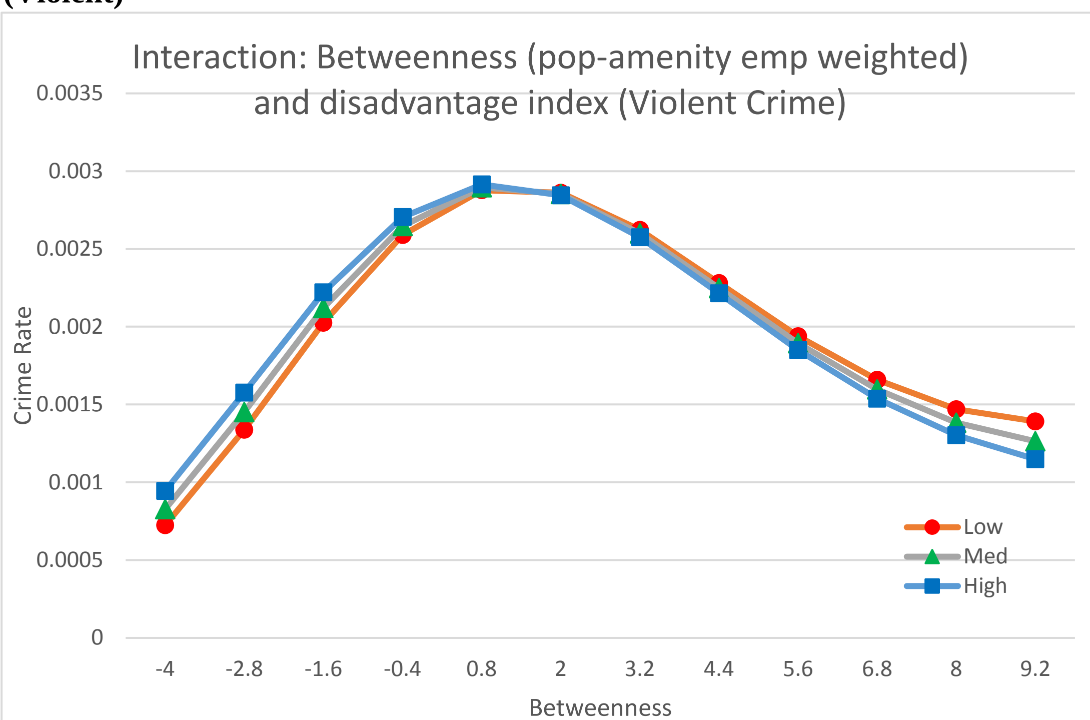

Figure A4.91. Non-Local Betweenness (pop-store emp wgt) and Disadvantage (Violent)

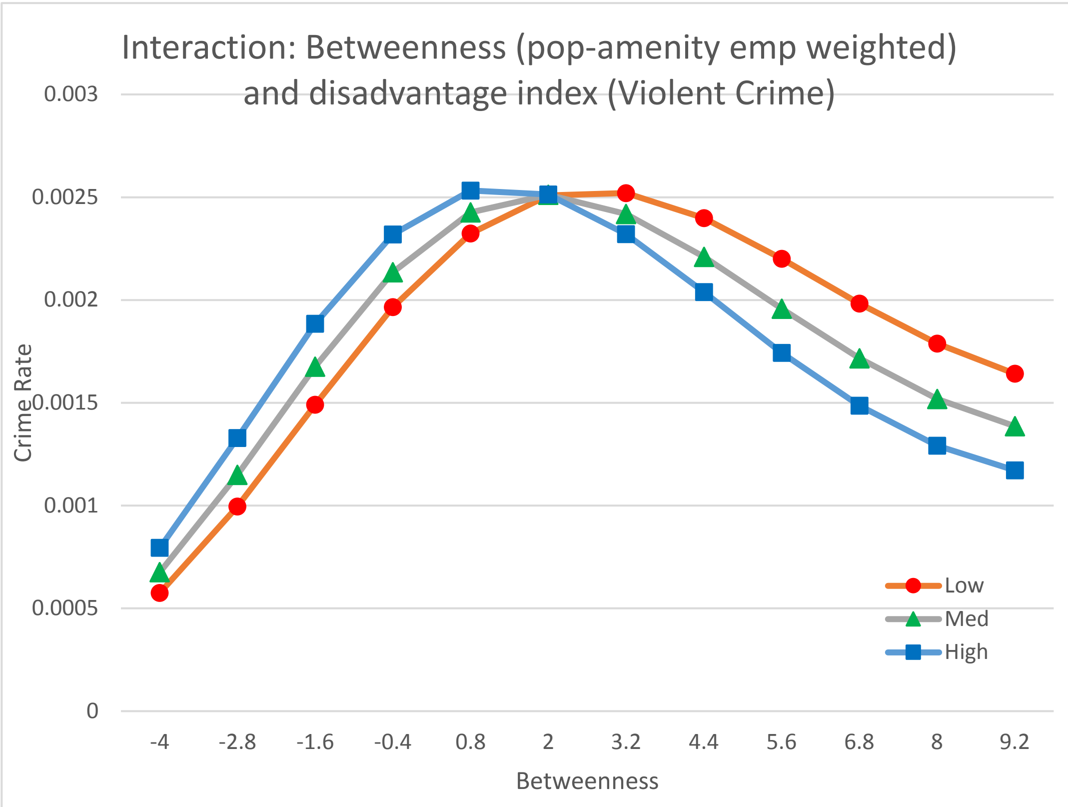

Figure A4.92. Non-Local Reach and Disadvantage (Property)

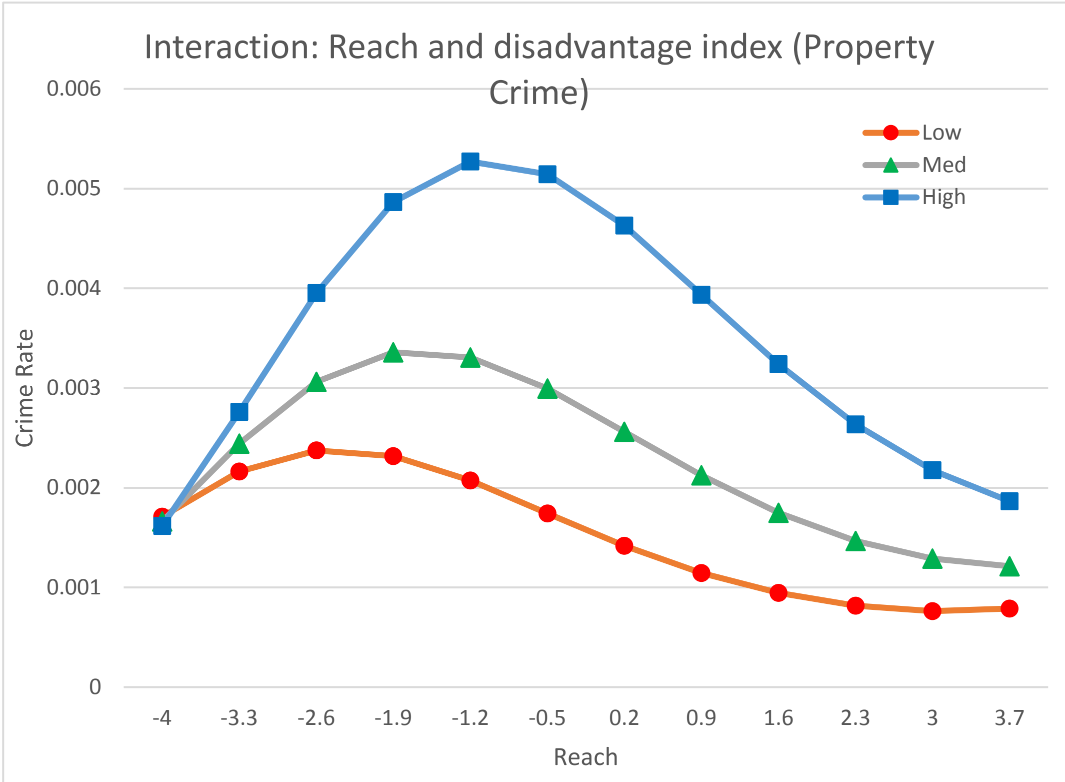

Figure A4.93. Non-Local Betweenness and Disadvantage (Property)

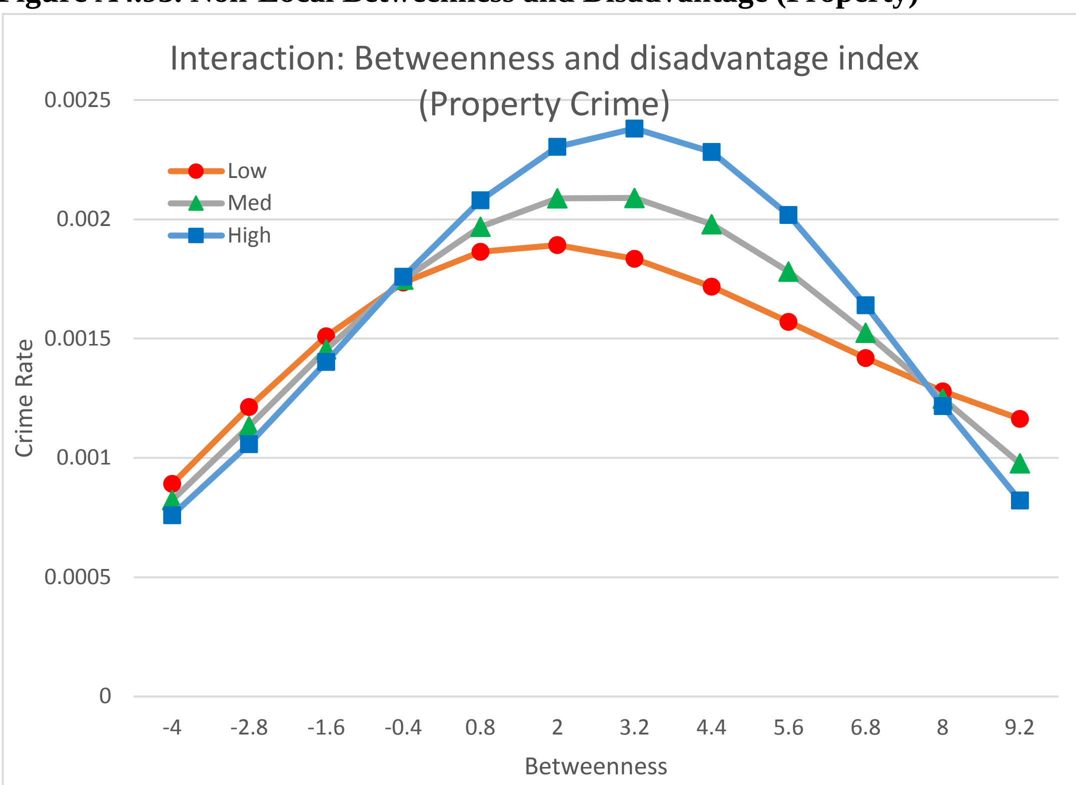

Figure A4.94. Non-Local Betweenness (pop wgt) and Disadvantage (Property)

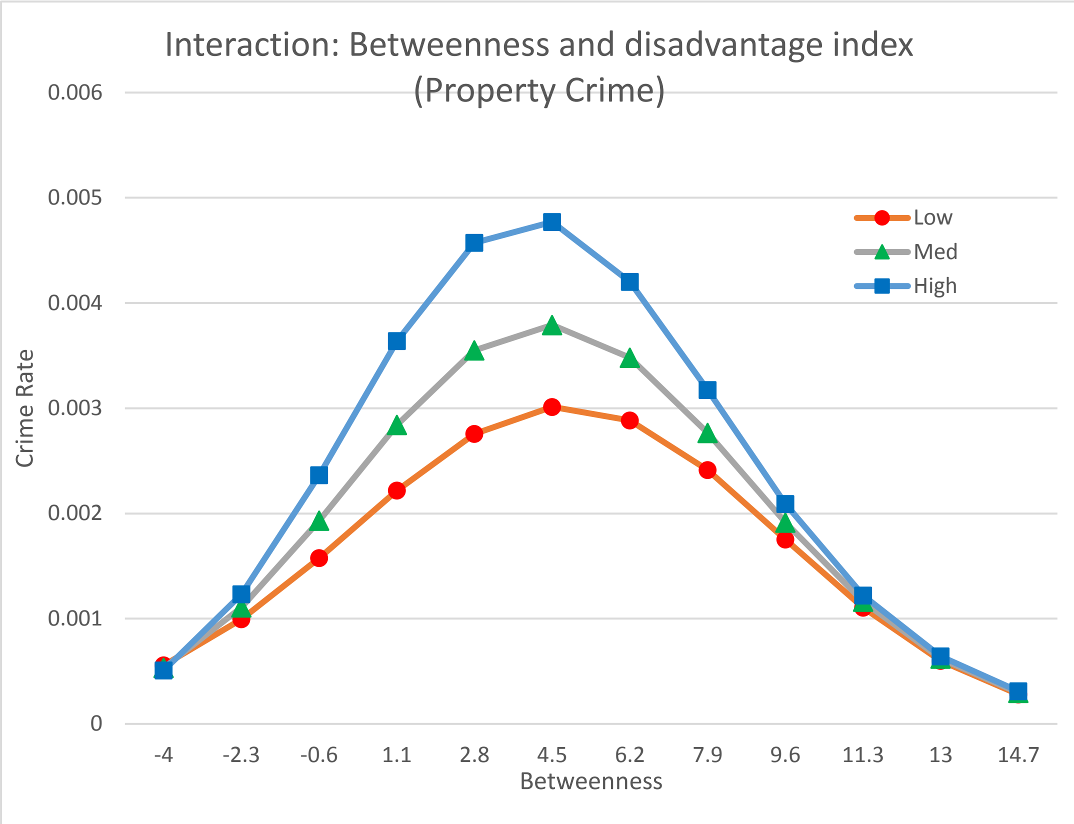

Figure A4.95. Non-Local Betweenness (pop-drink emp wgt) and Disadvantage (Property)

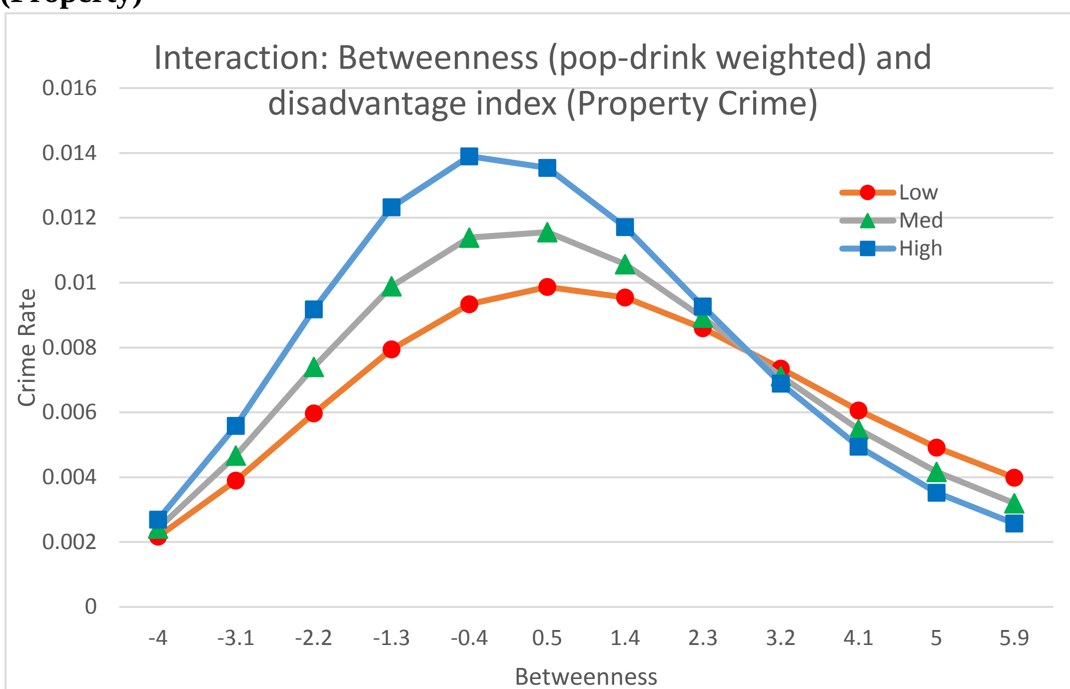

Figure A4.96. Non-Local Betweenness (pop-retail emp wgt) and Disadvantage (Property)

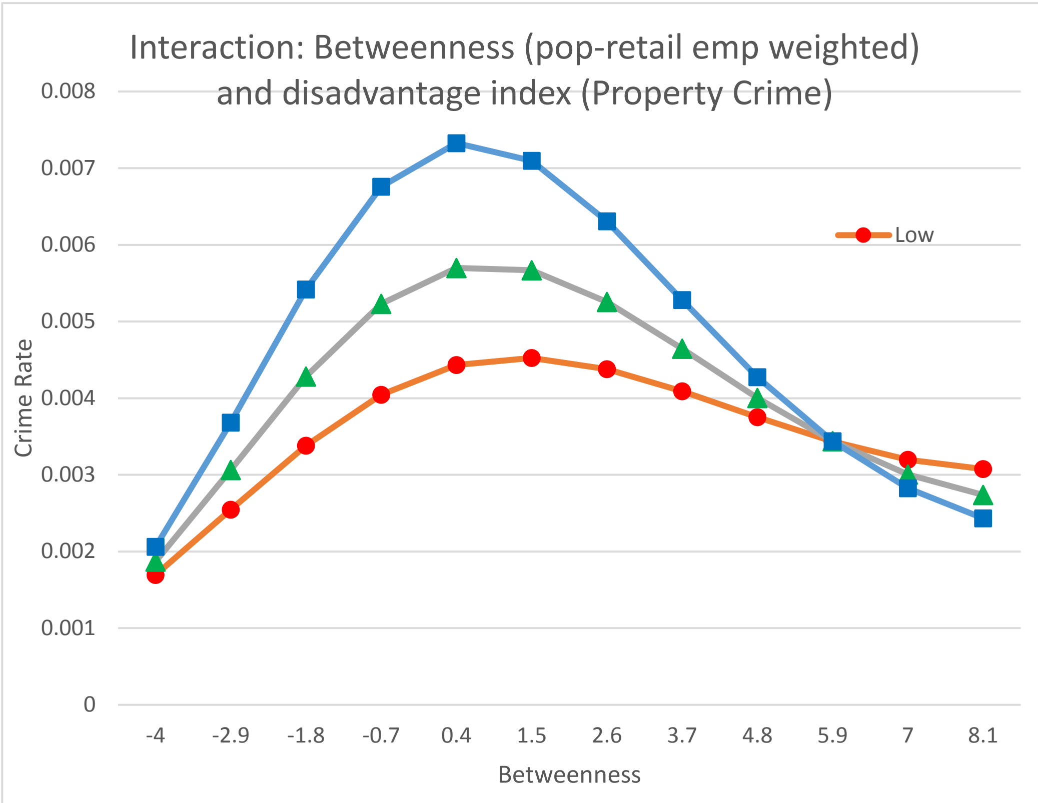

Figure A4.97. Non-Local Betweenness (pop-school emp wgt) and Disadvantage (Property)

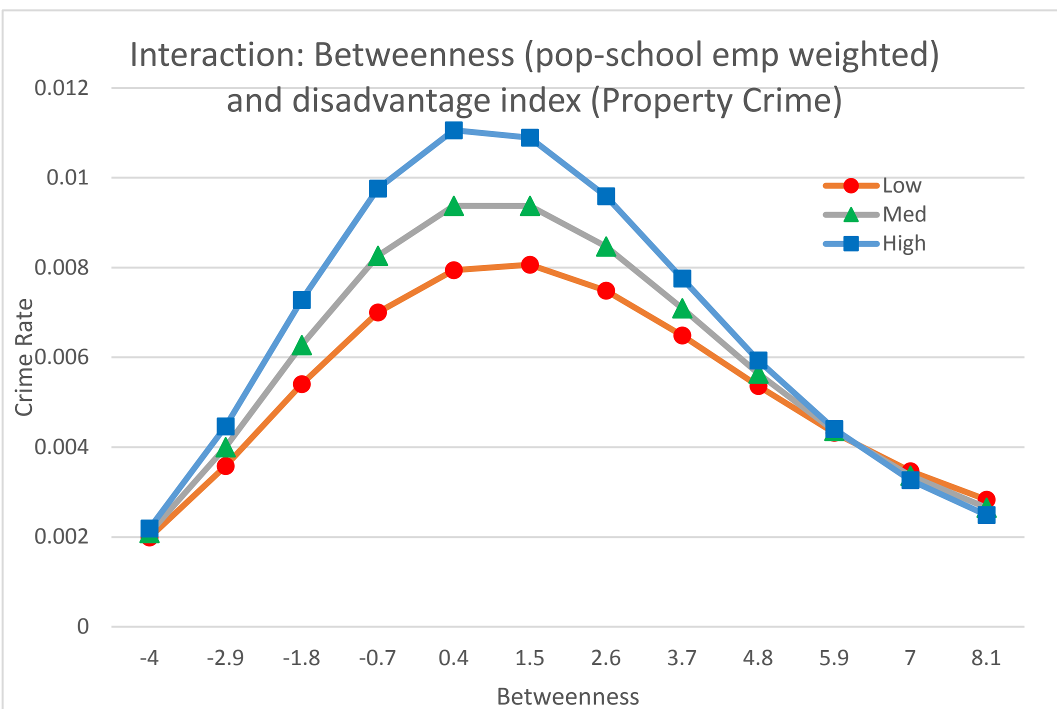

Figure A4.98. Non-Local Betweenness (pop-service emp wgt) and Disadvantage (Property)

Figure A4.99. Non-Local Betweenness (pop-finance emp wgt) and Disadvantage (Property)

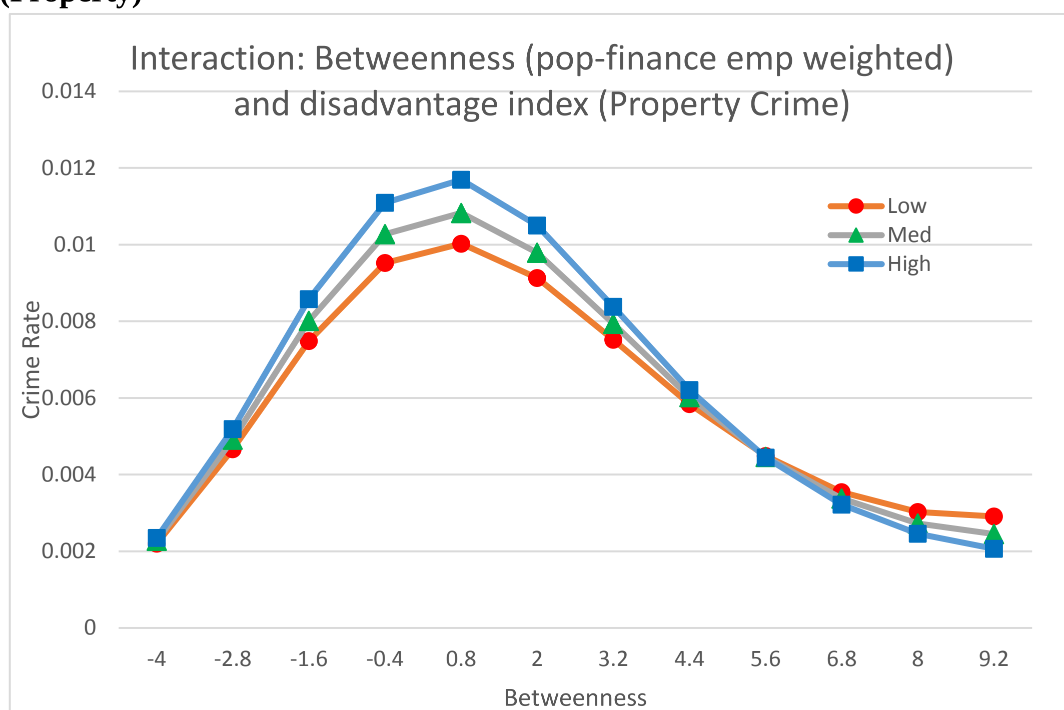

Figure A4.100. Non-Local Betweenness (pop-restaurant emp wgt) and Disadvantage (Property)

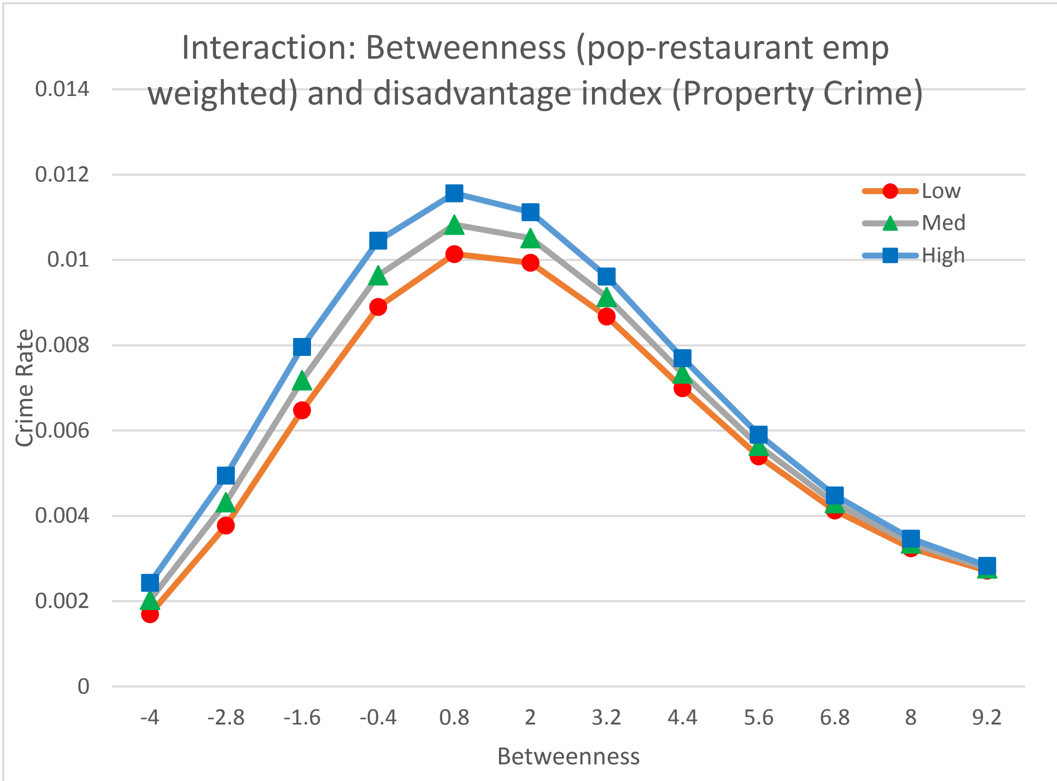

Figure A4.101. Non-Local Betweenness (pop-health emp wgt) and Disadvantage (Property)

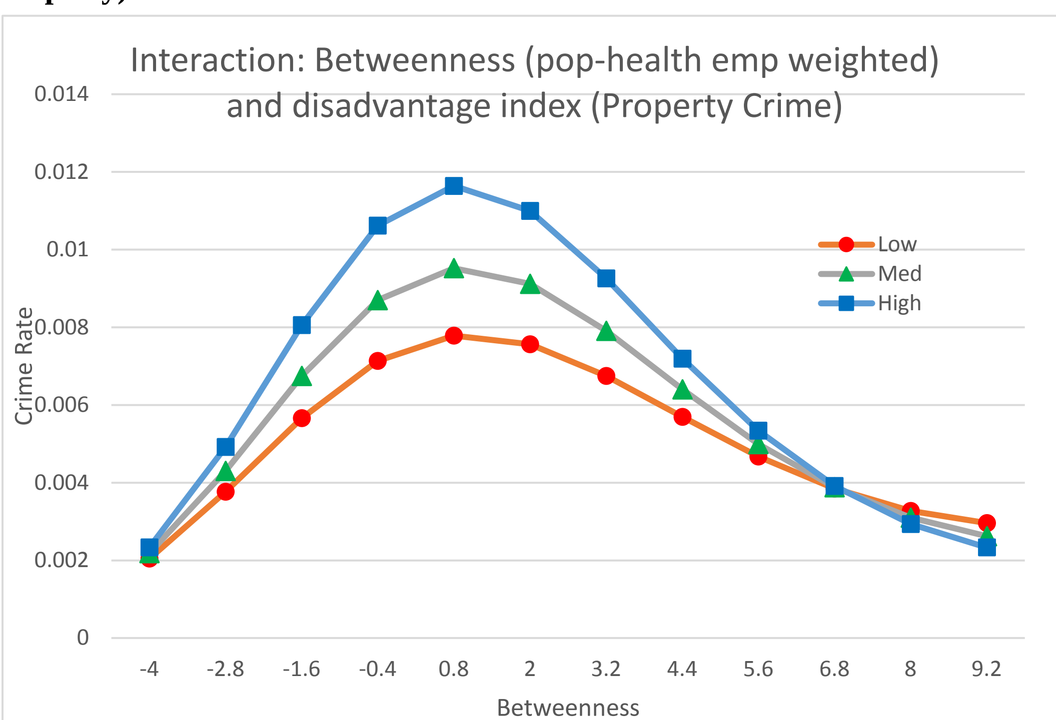

Figure A4.102. Non-Local Betweenness (pop-amenity emp wgt) and Disadvantage (Property)

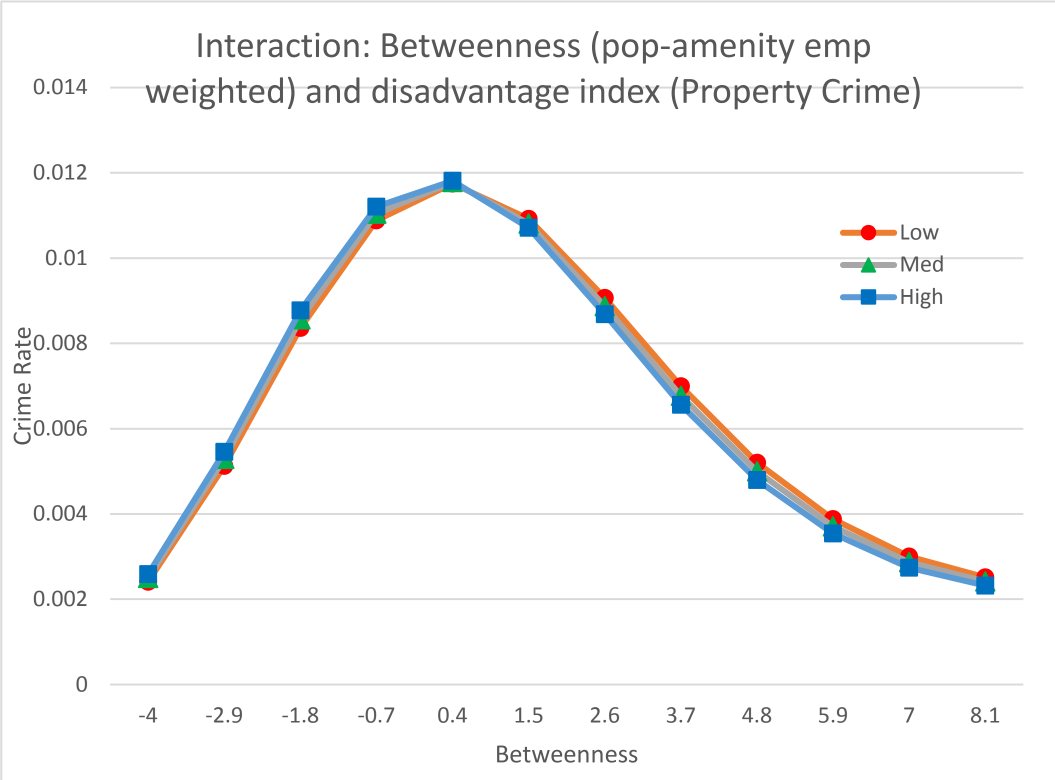

Figure A4.103. Non-Local Betweenness (pop-org emp wgt) and Disadvantage (Property)

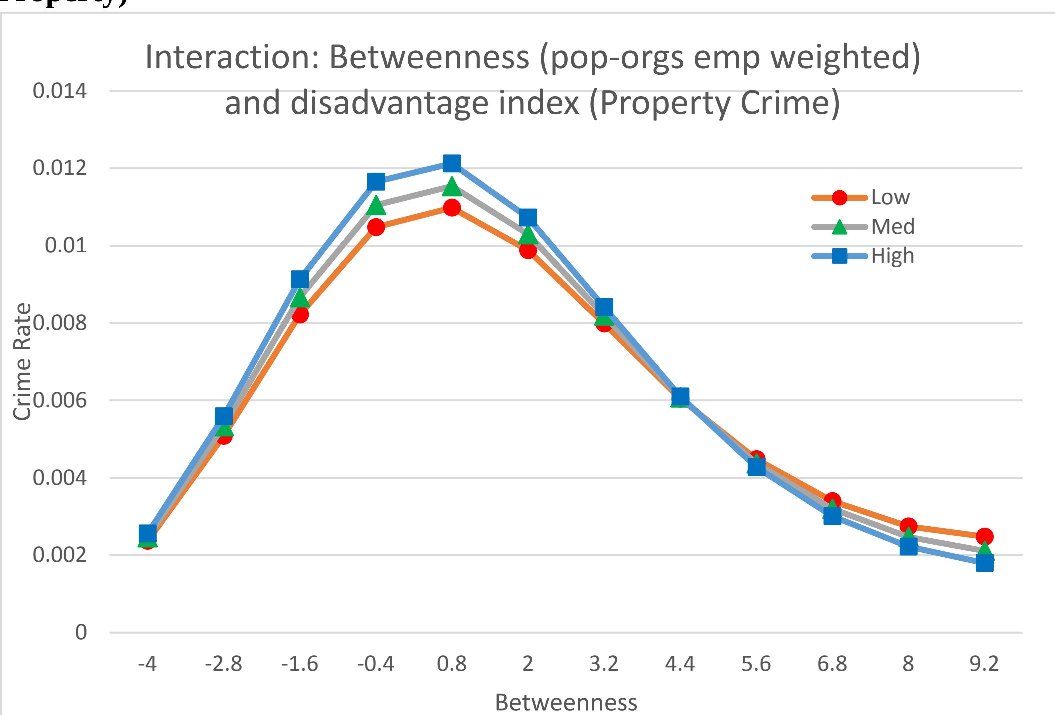

Figure A4.104. Non-Local Betweenness (pop-store emp wgt) and Disadvantage (Property)