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Journal of Criminal Justice

journal homepage: [www.elsevier.com/locate/jcrimjus](http://www.elsevier.com/locate/jcrimjus)

## Crime-general and crime-specific spatial patterns: A multivariate spatial analysis of four crime types at the small-area scale

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### ARTICLE INFO

#### Keywords:

Spatial pattern  
Crime-general  
Correlation  
Multivariate  
Bayesian model  
Shared component

### ABSTRACT

**Purpose:** To examine if, and how, spatial crime patterns are explained by one or more underlying crime-general patterns.

**Methods:** A set of Bayesian multivariate spatial models are applied to analyze burglary, robbery, vehicle crime, and violent crime at the small-area scale. The residual variability of each crime type is partitioned into shared and type-specific components after controlling for the effects of population density, deprivation, residential instability, and ethnic heterogeneity. Shared components account for the correlations between crime types and identify the crime-general patterns shared amongst multiple crimes.

**Results:** Two shared components are estimated to capture the crime-general pattern for all four crime types and the crime-general pattern for theft-related crimes (burglary, robbery, and vehicle crime). Robbery and violent crime exhibit the strongest positive associations with deprivation, instability, and ethnic heterogeneity. Shared components explain the largest proportions of variability for all crime types. Burglary, robbery, and vehicle crime each exhibit type-specific patterns that diverge from the crime-general patterns.

**Conclusions:** Crime-general patterns are important for understanding the spatial patterning of many crime types at the small-area scale. Multivariate spatial models provide a framework to directly quantify the correlation structures between crimes and reveal the underlying crime-general patterns shared amongst multiple crime types.

### 1. Introduction

Many crime types exhibit similar spatial patterns, are associated with the same set of risk factors, and are interpreted using the same ecological theories (Andresen, 2011; Anselin, Cohen, Cook, Gorr, & Tita, 2000; Brantingham & Brantingham, 2010; Ceccato, Haining, & Signoretta, 2002; Chamberlain & Hipp, 2015; Schmid, 1960; Schreck, McGloin, & Kirk, 2009; Wikstrom & Dolmen, 1990). For example, social disorganization theory has been widely used to explain the neighbourhood-level spatial patterning of crime and, correspondingly, structural characteristics including socioeconomic disadvantage, residential instability, and ethnic heterogeneity have been found to be associated with crime categories, such as total crime, violent crime, and property crime, as well as specific violent and non-violent crime types (Warner & Pierce, 1993; Peterson & Krivo, 1996; Hipp, 2007; Hirschfield & Bowers, 1997). Despite the theoretical and empirical similarities between the geographical distributions of many crime types at the neighbourhood or small-area scale, little research has

investigated the degree to which the spatial patterns of individual crime types are explained by one or more underlying crime-general patterns (Brantingham, 2016; Weisburd et al., 1993). Crime-general spatial patterns arise from geographically-situated processes and characteristics associated with multiple crime types and can be contrasted with crime-specific patterns, or the unique spatial patterns that arise from the processes and characteristics associated with only a single type of crime. One reason for the lack of research exploring crime-general patterns is that conventional quantitative methods analyze a single crime type (or a single dependent variable) and cannot directly model the geographical correlation structures between two or more crime types.

This paper applies a Bayesian multivariate spatial modeling approach to analyze the spatial patterns of burglary, robbery, vehicle crime, and violent crime at the small-area scale in Greater London, United Kingdom. Multivariate models provide a formal statistical framework for modeling, summarizing, and visualizing the correlation structures between multiple dependent variables (Wang & Wall, 2003).

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For crime types with similar theoretical explanations, multivariate models allow for the total area-specific risk of each crime type to be explained by multiple data-generating processes, including shared components, which capture the underlying crime-general patterns shared amongst two or more crime types, and type-specific components, which capture the divergent spatial patterns for each crime (Knorr-Held & Best, 2001; Tzala & Best, 2008). Conceptually, shared components represent geographically-varying latent processes that are simultaneously associated with two or more crime types and type-specific components represent latent processes associated with only one type.

This paper illustrates the first application of a multivariate spatial modeling approach to more than two crime types at the small-area scale. In this study, the best fitting model estimates two shared components that capture the spatial pattern shared amongst all four crimes (burglary, robbery, vehicle crime, and violent crime) and the spatial pattern shared amongst the theft-related crime types (burglary, robbery, and vehicle crime) after controlling for the effects of population density, deprivation, residential instability, and ethnic heterogeneity. The shared components are found to explain the largest proportions of residual variability for all crime types. For theoretical inference, this study highlights the importance of unobserved crime-general processes for understanding the spatial patterning of burglary, robbery, vehicle crime, and violent crime, and provides insight into where crime-general and/or crime-specific processes shape the local composition of crime. For crime prevention policy, visualizing and differentiating the shared and type-specific spatial patterns helps to understand where the risks of multiple crime types are correlated and clustered, and where interventions should target crime-general or crime-specific processes (Weisburd et al., 1993). In the following sections of this paper, the theories used to explain the spatial patterning of multiple crime types are reviewed, a set of hypotheses regarding crime-general and crime-specific spatial patterns are proposed, the Bayesian multivariate spatial modeling approach is detailed, and the crime-general and crime-specific patterns exhibited by burglary, robbery, vehicle crime, and violent crime in Greater London are visualized and discussed.

## 2. Theoretical perspectives on correlated spatial crime patterns

Little existing research has investigated how crime composition, or the mix of two or more crime types, varies within and between small-area units (Brantingham, 2016; Schreck et al., 2009). This may reflect, in part, the historical orientation of geographical analyses towards identifying determinants of specific types for law enforcement applications, rather than exploring if and how ecological crime theories are generalizable across crime types (Weisburd et al., 1993). However, the intra-urban spatial patterns of many crime types have been shown to be positively correlated at the small-area scale (Andresen & Malleson, 2011; Schmid, 1960) and many crime types have been explained using the same set of ecological theories, including social disorganization, routine activity, and crime pattern theories (Andresen, 2006; Kinney, Brantingham, Wuschke, Kirk, & Brantingham, 2008; Roncek & Maier, 1991).

Social disorganization theory hypothesizes that the high levels of crime found in some neighbourhoods result from limited informal social control (Shaw & McKay, 1942). In more disorganized communities, residents are less capable of realizing common values and mobilizing to control delinquent behaviour, leading to increased crime (Sampson & Groves, 1989). While social disorganization theory was originally proposed to explain the residential locations of young offenders, contemporary research has found that neighbourhoods with high disorganization, as operationalized by socioeconomic disadvantage, residential instability, and ethnic heterogeneity, often have high rates of total crime offenses, violent crime offenses, and property crime offenses, as well as specific offense types including robbery, burglary, and motor vehicle theft (Chamberlain & Hipp, 2015; Hipp, 2007; Morenoff,

Sampson, & Raudenbush, 2001; Peterson & Krivo, 1996; Sampson & Groves, 1989; Schreck et al., 2009; Smith, Frazee, & Davison, 2000).

Extending social disorganization theory with a focus on how cultural contexts influence crime, differential opportunity theory proposes that the strength of social ties between residents interacts with structural characteristics to influence both the frequency of crime and the composition of crime types within neighbourhoods, specifically distinguishing the processes associated with violent and non-violent crimes (Cloward & Ohlin, 1960). In socially disorganized neighbourhoods with weak social ties, conflict subcultures may lead to higher risks of violent crime as there are fewer opportunities to learn the skills required for property crime offending. In contrast, in disorganized neighbourhoods with dense ties and interconnected social networks, criminal subcultures emerge, property crime skills are more effectively transferred between residents, and higher property crime rates are anticipated. Supporting differential opportunity theory, Schreck et al. (2009) found that neighbourhoods with weaker network ties had greater ratios of violent crimes to property crimes after accounting for variables representing social disorganization.

Shifting focus from neighbourhood social or cultural processes to the locations of crime opportunities within the environment, routine activity theory hypothesizes that crime offenses result from the convergence of motivated offenders, suitable targets, and a lack of capable guardianship in space and time (Cohen & Felson, 1979). Crime pattern theory situates the tenets of the routine activity theory in the urban environment, focusing on the ways in which locations attract motivated or opportunistic offenders (Brantingham & Brantingham, 2010). Like social disorganization theory, routine activity and crime pattern theories have been applied to interpret the spatial patterns of many crime types, including aggregated crime categories (e.g., property crime, violent crime, and predatory crime) and specific crime types, such as assault, residential and street robbery, burglary, motor vehicle theft, and break and enter (Sherman, Gartin, & Buerger, 1989; Kinney et al., 2008; Roncek & Maier, 1991). While past research using routine activity and crime pattern theories has found that related crime types often exhibit similar patterns at the small-area scale (e.g., vandalism, vehicle crime, and burglary at the basomrade scale in Stockholm, Sweden (Ceccato et al., 2002), and vehicle crime, robbery, and violent crime at the census dissemination area scale in Vancouver, Canada (Andresen, 2011)), these perspectives also recognize that the spatial patterns of some crime types may be driven by the location of type-specific targets. For example, motor vehicle thefts and burglaries may be strongly correlated in many small-areas because neighbourhoods with high concentrations of residences are likely to have high concentrations of vehicles, but these crime types may have weaker correlations in areas with a high concentration of only one target type.

Routine activity and crime pattern theories both assume that criminal acts result from rational decision-making and that each crime type has a distinct set of choice-structuring properties, or opportunities, costs, and benefits (Cornish & Clarke, 1987). Crime types with similar choice-structuring properties may be substitutable and correlated both within and between small-areas, as offenders may respond to generalized, rather than crime-specific, environmental cues (Brantingham, 2016; Hakim, Spiegel, & Weinblatt, 1984). Environmental cues provide information about the behaviour that is appropriate in a given context and, as applied to rational offender decision-making, influence the attractiveness of a location for criminal behaviour (Brantingham & Brantingham, 1993; MacDonald & Gifford, 1989). For example, both burglary and vehicle theft are motivated by economic gain and, providing that the would-be offender does not specialize in one crime type, it is possible that these crime types are substitutable based on situational characteristics – such as the availability of specific target types – or environmental cues representing barriers to crime – such as the presence of a fence or a garage – or environmental cues representing the presence (or lack) of capable guardianship – such as visual indicators that a dwelling is occupied (MacDonald & Gifford, 1989). Likewise,

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