RUTGERS
Center on Public Security

Crime in Context: Utilizing Risk Terrain Modeling and Conjunctive Analysis of Case Configurations to Explore the Dynamics of Criminogenic Behavior Settings | By Caplan, Kennedy, Barnum, & Piza.

Full Article:
Caplan, J. M., Kennedy, L. W., Barnum, J. D., and Piza, E. L. (2017). Crime in Context: Utilizing Risk Terrain Modeling and Conjunctive Analysis of Case Configurations to Explore the Dynamics of Criminogenic Behavior Settings. *Journal of Contemporary Criminal Justice.* DOI: 10.1177/1043986216688814.

Introduction

Risk terrain modeling (RTM) is a geospatial crime analysis tool that incorporates features of the environment, such as bars, schools, and public transportation stops, into assessments of crime vulnerability at places (Caplan, Kennedy, & Miller, 2011). The vulnerability of places to crime increases due to the collocation of criminogenic features (Kennedy, Caplan, Piza, & Buccine-Schrader, 2016). These qualities of places enable crime to emerge, concentrate, and persist (McGloin, Sullivan, & Kennedy, 2012). The objective of RTM is to create actionable spatial intelligence to aid in the allocation of resources and the implementation of tailored, risk-based interventions that address the spatial dynamics underlying crime problems (Kennedy, Caplan, & Piza, 2011).

Missing from the current RTM methodology is an easy way to explore the relative interactions of risk factors at places and their potentially varying aggravating or mitigating effects on crime. *In other words, the collocation of certain risk factors' spatial influences may result in more crimes than the collocation of a different set of risk factors' spatial influences.* Identifying these interactions and their outcomes can help to develop a sense of what to expect at different places and inform police strategies that are based on unique environmental contexts for crime.

The Study

We demonstrate how RTM outputs can be incorporated into a conjunctive analysis of case configurations (CACC) (Miethe, Hart, & Regoeczi, 2008). Whereas RTM identifies environmental risk factors for crime and places where their spatial influences collocate to increase crime vulnerability, CACC enables examination of the relative combinations of risk factors' spatial influences, their interactions at places, and their resulting effects on crime. CACC is a multivariate method for the analysis of discrete categorical data (Miethe et al., 2008) that enables comparison of distinct combinations of risk factors' spatial influences. It describes the interrelationships between risk factors' spatial influences and their varying effects on different outcomes, such as crime. Incorporating RTM outputs into a CACC provides a better understanding of the dynamics among certain risk factors and how they create unique environmental contexts that have implications for behavior. This approach is based on the concept of behavior settings created by Roger Barker (1968). Barker suggested that there was a direct relationship between human activities and their surrounding environments that can be codified through the identification of patterned behavior that is observable in specific behavior settings. He encouraged the consideration of how features of the environment combined to form social contexts in which predictable behavior outcomes would occur. RTM and CACC allow us to examine how multiple risk factors in the environment combine to create unique settings in which crime can occur (Popov & Champalov, 2012) and to make more detailed assessments of the origins of crime and strategies that can be employed to reduce it.

Methodology

This research was carried out in Glendale, Arizona, a mid-sized city located in the southwest United States. Glendale has a land area of about 56 square miles and a population of approximately 226,000 residents. We used

RTM to identify statistically significant risk factors for calendar year 2012 robbery incidents and their spatial influences which could then be incorporated into a CACC to observe how specific risk factor interactions create criminogenic behavior settings. This was completed using the Risk Terrain Modeling Diagnostics (RTMDx) Utility software (Caplan & Kennedy, 2013). In total, we examined 14 environmental features that could potentially be risk factors for robbery (see Table 1). We tested the spatial influence of all features as a function of both proximity and density (parks as proximity only) to a maximum extent of 3 blocks at half-block increments. The RTM analysis was carried out using an average block length of 472 feet and cell sizes of 236 feet.

Next, the RTM outputs were prepared for the conjunctive analysis. This involved coding the spatial influence of each risk factor, identified in the preceding RTM analysis, as a dichotomous variable representing the presence (1) or absence (0) at each micro place (i.e., 236x236 raster cell) in Glendale. The resulting standardized raster grids were spatially joined together to produce a final composite grid to which robbery counts for each cell were also joined. The conjunctive analysis was performed on this final data set (for a detailed tutorial see http://www.riskterrainmodeling.com/uploads/2/6/2/0/26205659/conjunctiveanalysistutorial_barnum2016.pdf).

Results

Risk Terrain Model

Of the 14 environmental features tested, 9 significant risk factors for robbery were identified in Glendale (see Table 1). These risk factors included apartment complexes, gas stations, convenience stores, middle schools, bus stops, liquor stores, take out restaurants, banks, and bars. The most problematic risk factor for robbery was apartment complexes; that is, being within proximity of 236 feet (i.e., half a block) of apartment complexes increased the risk of being robbed by a factor of 21.26, relative to places absent any risk factors' spatial influence. Accordingly, all places may pose a risk of robbery in Glendale, but because of the spatial influence of certain features of the landscape, some places were riskier than others.

Conjunctive Analysis

Given 9 risk factors, the total number of possible case configurations was 512 (2^9=512), of which 61 configurations were observed at least once in Glendale. We considered case configurations to be dominant if they were observed at least 10 times (Miethe et al., 2008). There were 25 dominant case configurations, which are displayed in Table 2, the CACC data matrix. Each row represents a distinct, dominant, case configuration with a unique set of attributes. These attributes reflect the presence (1) or absence (0) of risk factors' spatial influences as part of each case configuration. Collectively, the particular attributes in each row can be conceptualized as a unique behavior setting for robbery in Glendale.

Case configuration 6 was responsible for 26.90% (n=155) of robbery incidents, the largest raw share of robberies that occurred in Glendale in 2012. There were 719 observed instances (i.e., cells) of case configuration 6, which represented 2.32% of the study setting. Case configuration 6 was characterized by the presence of spatial influences of bus stops and liquor stores and the absence of the spatial influences of apartment complexes, gas stations, convenience stores, middle schools, take out restaurants, banks, and bars. Certain configurations were observed more frequently than others, and as such, were more likely to experience robbery given their larger geographic area. To control for this, the relative frequency of crime (RFC) was calculated as a proportion of robbery incidents per the number of times that behavior setting was observed. The RFC of case configuration 1 was 80, which made it the most problematic of the dominant case configurations with regard to the rate of robbery per area. It was characterized by the spatial influences of convenience stores, bus stops, and liquor stores. Table 2 also shows 8 dominant case configurations with an above average RFC. It appears that these dominant case configurations above the mean RFC were very often influenced by bus stops and liquor stores. Bus stops and liquor stores appeared to be "aggravating" risks of robbery, in that when they interacted with other features of the landscape, robbery was most likely, compared to when their spatial influences were absent.

The dominant case configurations with above average RFC can be visually represented in a map. Collectively, these 8 case configurations were observed 1,040 times, which represents about 3.35% of the entire study setting. However, these case configurations were responsible for 41.15% (n=237) of robbery incidents in 2012. When considering all dominant behavior settings (with the exception of case configuration 23, which was absent the spatial influence of any risk factors), 73.44% of crimes were captured within 18.83% of the entire study

area. Thus, a handful behavior settings represented a small portion of Glendale's overall geography, but accounted for a substantial share of robbery incident locations.

Discussion

We demonstrated how CACC could be used with RTM to explore interactions of risk factors' spatial influences at places, and their relative effects on robbery occurrence. Upon testing 14 environmental features in a risk terrain model, we identified 9 significant risk factors for robbery. Given these risk factors, there were 512 possible combinations of risk factors' spatial influences, or unique behavior settings for robbery, in Glendale, Arizona. Using CACC, we determined that 61 unique behavior settings were present throughout Glendale and we highlighted 25 dominant behavior settings. The behavior setting that accounted for the largest raw number of robbery incidents was characterized by the presence of two risk factors' spatial influences: bus stops and liquor stores (i.e., case configuration 6). The combined spatial influence of bus stops, liquor stores, and convenience stores constituted the most influential behavior setting (i.e., case configuration 1).

These behavior settings can be mapped in a GIS for analytic purposes or resource allocation. For example, by focusing resources on all dominant behavior settings, the GPD would be required to concern themselves with less than one-fifth of their entire jurisdiction to address three-fourths of their robbery incidents. Moreover, by focusing on dominant behavior settings with above average RFC, the GPD to would need to target just 3.35% of places to address over 41% of robbery incidents.

An additional benefit of the current methods is that they provide important insights about the components of criminogenic behavior settings. Specifically, RTM diagnosed environmental risk factors for robbery and CACC determined where those risk factors' spatial influences interacted to create ideal contexts for offending. In addition, the CACC enabled a better understanding of the interrelationships between risk factors and how they worked together to yield varying levels of crime. This information could help police to prioritize the risk factors, and moreover, the specific facilities within those broader groups of risk factors, that should be addressed.

We demonstrated that most crime takes place within a few dominant behavior settings that cover a small geographic area, and further, that some behavior settings were more influential on crime than others. Moreover, we identified particular environmental risk factors that aggravate the influence of other risk factors. By focusing on these micro level environmental crime contexts, police can more efficiently target their resources and implement more effective place-based interventions that fundamentally address the dynamics among environmental features that produce opportunities for crime.

Table 1. Optimal Risk Terrain Model Specifications for Calendar Year 2012 Robbery Incidents in Glendale, AZ.

Risk Factor	n	OP/SI	RRV
Apartment Complexes	231	P, 236	21.26
Gas Stations	15	P, 236	15.73
Convenience Stores	26	P, 236	15.31
Middle Schools	6	P, 1416	4.22
Bus Stops	558	P, 472	3.90
Liquor Stores	124	P, 944	3.44
Take Out Restaurants	148	P, 236	2.95
Banks	53	P, 472	2.67
Bars	74	P, 472	2.39
Restaurants (with liquor)	102	-	-
Grocery Stores	43	-	-
Colleges	5	-	-
High Schools	9	-	-
Parks	-	-	-

Note: OP=Operationalization (P=Proximity, D=Density); SI=Spatial Influence (1 Block=472 ft.); RRV=Relative Risk Value

Table 2. Conjunctive Analysis Data Matrix of Dominant Case Configurations for Calendar Year 2012 Robbery Risk Factors in Glendale, AZ

Case Configuration	Apartment Complexes	Gas Stations	Convenience Stores	Middle Schools	Bus Stops	Liquor Stores	Take Out Restaurants	Banks	Bars	Crime Count	Percent Crime	Cell Count	Percent Area	Relative Frequency of Crime
1	0	0	1	0	1	1	0	0	0	8	1.39	10	0.03	80
2	0	0	0	0	1	1	0	1	1	13	2.26	25	0.08	52
3	0	0	0	0	1	1	0	0	1	22	3.82	96	0.31	22.92
4	0	0	0	0	1	1	0	1	0	21	3.65	92	0.30	22.83
5	1	0	0	0	0	1	0	0	0	9	1.56	41	0.13	21.95
6	0	0	0	0	1	1	0	0	0	155	26.91	719	2.32	21.56
7	0	0	0	0	1	1	1	0	0	3	0.52	17	0.05	17.65
8	0	0	0	0	1	0	0	1	0	6	1.04	40	0.13	15
Mean										**237**	**41.15**	**1040**	**3.35**	
9	0	0	0	0	0	1	0	1	1	2	0.35	16	0.05	12.5
10	1	0	0	0	1	0	0	0	0	3	0.52	26	0.08	11.54
11	0	0	0	0	1	1	1	0	1	1	0.17	12	0.04	8.33
12	0	0	0	0	0	0	1	0	0	1	0.17	14	0.05	7.14
13	0	0	0	0	0	1	0	1	0	4	0.69	58	0.19	6.9
14	0	0	0	0	0	1	1	0	0	1	0.17	17	0.05	5.88
15	0	0	0	0	0	0	0	0	1	9	1.56	173	0.56	5.2
16	0	0	0	0	1	0	0	0	1	3	0.52	66	0.21	4.55
17	0	0	0	0	0	1	0	0	0	85	14.76	2007	6.47	4.24
18	0	0	0	0	1	0	0	0	0	57	9.90	1608	5.18	3.54
19	0	0	0	1	0	0	0	0	0	15	2.60	537	1.73	2.79
20	1	0	0	0	0	0	0	0	0	2	0.35	82	0.26	2.44
21	0	0	0	0	0	1	0	0	1	2	0.35	88	0.28	2.27
22	0	0	0	0	0	0	0	1	0	1	0.17	47	0.15	2.13
23	0	0	0	0	0	0	0	0	0	139	24.13	25091	80.85	0.55
24	0	0	0	1	0	1	0	0	0	0	0.00	33	0.11	0
25	1	0	0	0	1	1	0	0	0	0	0.00	20	0.06	0