RUTGERS Center on Public Security

BRIEF

Applying Risk Terrain Modeling to Street Robberies in Newark, NJ

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Concerns about armed robbery have permeated the criminological literature over the years, partly as this behavior is so closely tied to the ebbs and flows of the drug trade and is a crime that most urban dwellers fear, threatening their property and their person and leaving traumatic impacts. As its connection to drugs attests, robbery is a crime that accompanies other crimes and permeates all parts of the urban landscape. There have been, over the years, excellent studies examining the factors effecting offenders' motivation and victims' vulnerability in robbery incidents. Where one line of studies examines the robbery risk in relation to crime attracting nature of some locales such as drug dealing or prostitution areas[i], speculation has also been directed at the crime generating nature of urban features including schools, bars and fast food outlets, and cash points[ii]. These studies have all provided important insights into the correlates of this crime but what we propose in this study is to look at robbery in the context of a combination of these factors, examining their relative risk in enhancing the probability that robbery will take place. This analysis will be done using a technique that calculates a risk terrain, combining the important layers of correlates across a continuous map surface, to produce a forecast of the likely areas that robbery will take place. So, this moves beyond simply saying that robbery will occur as a correlation of certain factors to identifying the context in which this crime is most likely to occur. We will examine the contexts of robbery using data from Newark, NJ, a city where robberies have shown the highest increase in the past year with a 12% boost from the year 2009 to 2010. Given that a clear distinction between offense subtypes is imperative since every crime is built on different situational factors, this case study selectively focuses on robberies that took place in public space (e.g. streets, sidewalks, parking lots, lots/yards, in front of commercial dwellings). We will consider the importance of different risk layers in forecasting robbery. We will combine these layers into a risk terrain model to which we will add robbery outcomes. We will then examine the predictive validity of our model and compare the increased accuracy of our approach over simple retrospective analysis of past robbery incidents.

Operationalization of the Dependent Variable

Risk terrain modeling is dependent upon the availability of valid data from reliable sources. In this case study the data on 2009 street robberies were available for the months January-August[iii].

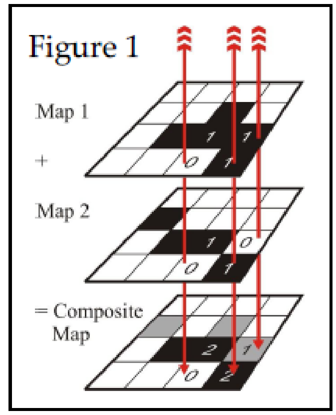
Operationalization of the Independent Variables

To begin forecasting future risk of street robberies, it was necessary to consider existing theory and literature that would help to understand this form of crime. According to the review of the empirical literature discussed above there are 7 factors that research has shown correlate with street robberies: *proximity to/high density of drug dealing areas; prostitution areas; bus stops; rail stations; bars, pubs and exotic clubs, leisure and fast-food outlets; universities; banks*. In risk terrain modeling, including all risk factors doesn't always produce better models. The model may still be meaningful and could serve operational needs, but the effectiveness of the model comes from including only the "most correlated" factors and excluding all others. This phenomenon of "less-can-be-more" in RTM has been proved empirically by Kennedy, Caplan and Piza.[iv] Accordingly, at the beginning of this case study a series of Chi-squared tests were conducted to identify the variables most significantly correlated with the outcome event.

For chi-squared tests, a blank vector grid of cells that covered the entire study area was created using the "Create Vector Grid Tool" in Hawth's Analysis Tools for ArcGIS. This assigns attributes to the vector grid cells that note whether a cell intersects with any of the features on the "risk map layers", accomplished by "selecting all cells of the vector grid that 'intersect' with point features on the street robberies map".

After running 7 chi-square analyses, only 5 of the 7 proved to be significantly correlated with street robberies ($p \leq .05$). Accordingly, in this case study, these five key factors are used: locations of retail business venues (bars, liquor stores, markets, and restaurants), locations of bus stops, locations of banks, locations of drug arrests, and location of prostitution arrests. The "drug arrest" and "prostitution arrest" independent variables include the arrests that took place in the first eight months of 2008 to predict the street robbery incidents in 2009. The locations of the other 3 independent variables were also available in address-level datasets for the year of 2008.

Operationalizing these datasets to raster map layers was done using standard tools available in ArcView's Spatial Analyst Extension. Data were first geocoded to street centerlines of Newark, NJ (obtained from Census 2000 TIGER/Line Shapefiles) to create point features representing the locations of retail business venues, bus stops, banks, drug arrests and prostitution arrests on five separate maps. The Density Tool in ArcView's Spatial Analyst Extension was then used to create a raster grid for each map and assign values to identically-sized raster cells based on the intensity, or local concentration, of points near each cell's location. This density scheme for operationalizing geocoded tabular data into raster map layers was repeated for each variable, producing maps with cell values assigned according to the immediate or nearby concentration of key variables in each respective cell. Cells within each raster map layer were then classified into four groups according to standard deviational breaks. This process was repeated for all five density map layers to produce five new raster maps of Newark with all locations designated as low to high risk for street robberies. Since the cells of different raster map layers were the same size and were classified in a consistent way, they could be summed to form a composite risk terrain, as exemplified in Figure 1 to the right.



The areas including Newark Liberty International Airport and Port Authority were excluded from the study extent as these areas do not fall within Newark Police Department jurisdiction. A risk terrain map was created using data from 2008. The predictive validity of this risk terrain was tested using counts of street robbery incidents during 2009 that were appended to the cells of the 2008 risk terrain using the Spatial Join function in ArcView. Cells of the final risk terrain map, then, had two values attributed to it: 1) risk value and 2) number of street robbery incidents during the consecutive time period. Figure 2 illustrates the risk terrain produced from the RTM approach using 2008 data, together with the street robberies in the first eight months of 2009. As shown in Figure 2, future street robbery incidents appear to be located in areas that the risk terrain map forecasted to be higher risk. Logistic regression analysis allowed us to measure the extent to which the 2008 risk terrain explained the patterns of street robbery incidents in the first eight months of 2009 (Ind. Var. = "Risk Value" [0-4]; Dep. Var. = "Presence of Any Street Robbery" [Yes or No]). As shown in Table 1, the odds ratio suggested that for every increased unit of risk, a future street robbery is almost 2.3 times more likely to occur ($p<0.001$) .

Figure 2. 2008 Risk Terrain and 2009 Street Robbery Overlay

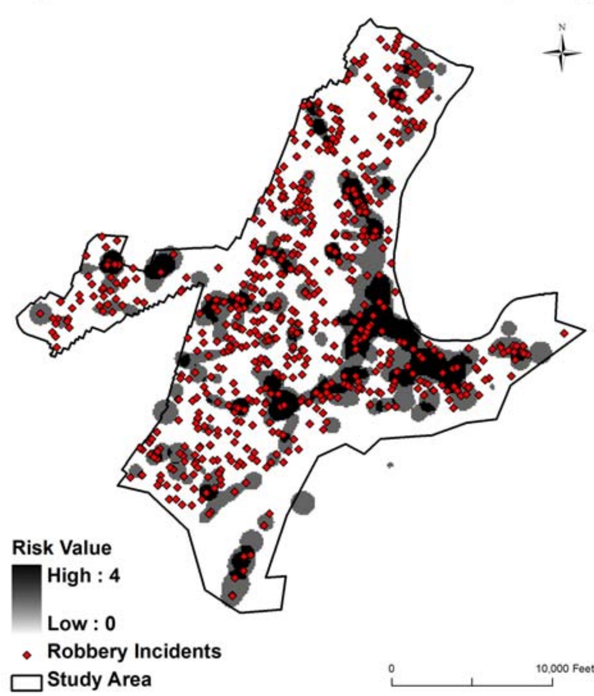


Table 1: Logistic Regressions for Risk Value on Street Robberies						
2008 Risk Terrain*						
	B	S.E.	Wald	df	Sig.	Exp(B)
Risk Value	.825	*.036*	531.881	1	.000	***2.282***
-2LL: 7864.769; **Nagelkerke R Square**: 0.04						

Although crime incidents occur at specific geographic points, most of them are recorded in reference to the addresses of certain facilities and dwellings, and in most cases we do not have the data on exact locations. So, to realistically test the efficiency of the risk terrain model with further statistical analysis, the limitations of administrative data should be taken into consideration. Accordingly, a second statistical validity analysis was conducted using ***street segments*** as units of analysis. To do that, a separate map was created by selecting the cells of the 2008 risk terrain that intersect with street segments. As shown in Figure 3, the street segments have been classified according to their risk values. While classifying risk values, the segments were classified according to the standard deviation score from the mean risk value (**minimum risk value=0, maximum risk value=4, mean=.47, sd= .82**). Figure 4, illustrates an overlay of the 2008 risk terrain with the street robberies in the first eight months of 2009 with street segments as the units of analysis. As shown in Figure 4, future street robbery incidents again appear to be located in street segments that the risk terrain map forecasted to be higher risk.

Figure 3.2008 Risk Terrain with Street Intersections

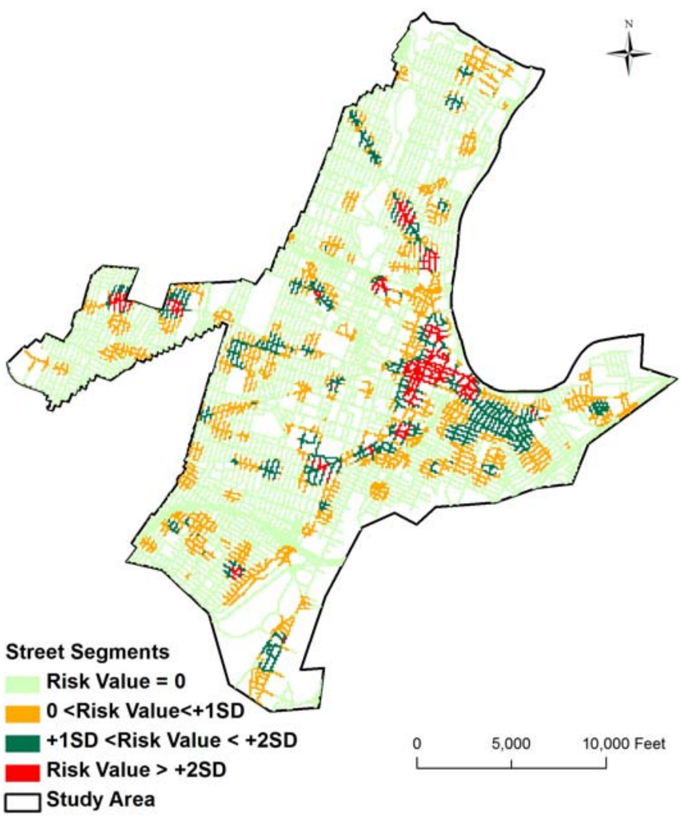
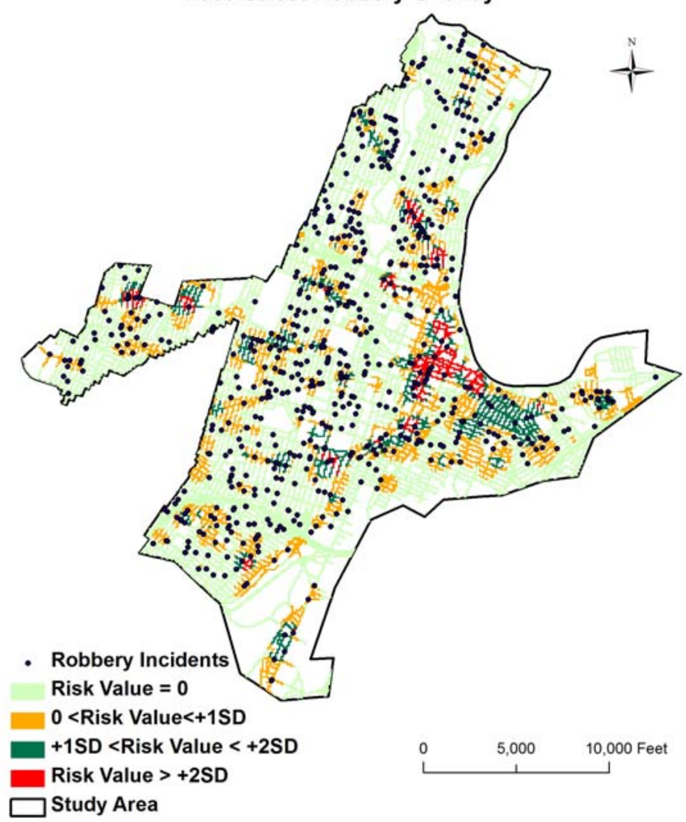


Figure 4.2008 Risk Terrain with Street Intersections and 2009 Street Robbery Overlay



Another logistic regression analysis was conducted using street segments to measure the extent to which the 2008 risk terrain explained the patterns of street robbery incidents in the first eight months of 2009 (Ind. Var. = "Risk Value" [0-4]; Dep. Var. = "Presence of Any Street Robbery" [Yes or No]). As shown in Table 2, the odds ratio suggested that for every increased unit of risk, the likelihood of a future street robbery on that street increased by 24% ($p<.001$).

Table 2: Logistic Regressions for Risk Value on Street Robberies						
2008 Risk Terrain*						
	B	S.E.	Wald	df	Sig.	Exp(B)
Risk Value	.214	*.042*	25.703	1	.000	***1.239***
-2LL: 5819.740; **Nagelkerke R Square**: 0.005						

Concluding Remarks on "Place, Space, Specific Setting, Crime and RTM"

In the past decades, studies involving crime analysis have been almost uniformly dedicated to the identification and analysis of spatial crime concentrations. Studies in general define "**PLACE"** either zero-dimensionally as a **"point in space"** such as a commercial building, a residential dwelling or uni- or bi-dimensionally as "**an area**" such as a census block, police district, or sometimes even a city. The latter component of that definition might be also differentiated as **"SPACE"** (*Block & Block, 1995, p. 146*)[v]. With the increased interest in place-based policing, place has been also defined in micro-units of addresses or clusters of addresses such as buildings or addresses; block faces, or street segments; or clusters of addresses, block faces, or street segments (*Eck & Weisburd, 1995, pp.1-33; Weisburd, et al, 2004; Weisburd, 2008*)[vi]. Regarding the backcloth of the crime incident, the specific situation—originally referred to as behavior setting—has been generally seen in a hierarchical relationship with places and space. Accordingly, the behavior setting which prepares the background of an incident is rooted in place and each place is rooted in space "a larger area governing long-run routine activity patterns of potential participants in conflict situations" (*Block & Block, 1995, p.146*)[vii]. As Bernasco and Block (2010)[viii] state, in geographic criminology "the spatial unit of analysis should match the theoretical perspectives that guide the analysis." Accordingly, rather than designing a study around "what's available" or "what is easier," researchers should aim for models which are grounded in theory and which are flexible enough to move between different levels of analysis when the analysis require to do so.

Doing a risk terrain model first identifies the pool of risk factors that's related to a specific crime incident rather than be constrained by predefined geographic boundaries set by street segments or neighborhoods. This gives researchers the tools to identify the significant risk correlates within different spatial and temporal extents. The simultaneous analysis of statistically significant risk factors enables the researcher to evaluate the aggregated—synthesized or collinear—qualities of places irrespective of all other places within a terrain (Caplan & Kennedy, 2010, p.22)[ix]. With its flexibility, the RTM approach enables the practitioners and researcher to adjust to the limitations of data and to respond to the needs of the law enforcement system, in particular. So, as demonstrated, if patrols are easier to define by street segments, RTM easily identifies where the highest risk locations are. Going beyond describing risk events or combining possible risk correlates, RTM turns into a spatial intelligence tool by equipping the researchers with skills to statistically test the significance of their models and law enforcement with skills to allocate their resources proactively with emancipation from spatial and temporal research constraints.

Endnotes

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[ii] Block, R.L. & Block, C.R. (1995). Criminal Careers of Public Places. In J.E.Eck and D.Weisburd (Eds.), *Crime and Place*. Monsey, NY: Criminal Justice Press; McCord, E.S. & Ratcliffe, J.H. (2007) A Micro-spatial analysis of the demographic and criminogenic environment of drug markets in Philadelphia, *Australian and New Zealand Journal of Criminology*. Volume 40, issue 1: 43-63; Roncek, D.W. & Maier, P.A. (1991). Bars, Blocks, and Crimes Revisited: Linking the Theory of Routine Activities to the Empiricism of Hot Spots. *Criminology* 29:725-753; Stucky, T.D. & Ottensman, J.R. 2009. Land Use and Violent Crime. *Criminology* 47:1223-64; Tilley, N., Smith, J., Finer, S., Erol, R, Charles, C. & Dobby, J. (2005). *Problem Solving Street Crime: Practical Lessons from the Street Crime Initiative*. London, United Kingdom: Home Office Research, Development and Statistics Directorate; Wright, R. & S. Decker. (1997). *Armed Robbers in Action: Stickups and Street Culture*. Boston: Northeastern University Press

[iii] We would like to specifically thank Eric Piza - GIS specialist at Newark P.D. for providing the data on risky facilities and robberies

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