DESISTING DISTANCE DECAY: ON THE AGGREGATION OF INDIVIDUAL CRIME TRIPS*

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The distance-decay function suggests a spatial pattern of criminal activity whereby most crimes are committed nearer rather than farther from the criminals' own homes. Presumably, the farther away the target, the lower the chances of crimes. The reason usually offered for this general pattern is an individual one: The costs to the criminal in terms of time, energy, and money increases with distance. We contend that it may be misleading to draw inferences about individuals from the aggregated decay function because it conceals individual variations in ranges of operation. This argument is supported by data randomly generated by the computer that show that even when individual criminals increase their crime rate with increasing distance, a distance-decay function still emerges at the aggregate level. This is not to say that an individual-level distance-decay function does not exist, only that it must be demonstrated by data at the individual level because distance-decay effects can characterize aggregate behavior even in the absence of individual distance decay.

Since the 1960s criminologists have become increasingly interested in the spatial distribution of crimes (e.g., Brantingham and Brantingham, 1984; Evans and Herbert, 1989; Figlio et al., 1986; Georges–Abeyie and Harries, 1980; Harries, 1973; Herbert, 1982). One of the most consistent findings has been the so-called distance-decay function: Most offenders select their targets close to their own homes and the farther the distance from their homes, the fewer the crimes committed (Phillips, 1980). For instance, one-third of the robberies are committed within a mile from home, and more than 50% within a two-mile radius (Capone and Nichols, 1975, 1976).

Although the travel distance is always relatively short (White, 1932), targets that are very close to home are poor targets (Brantingham and Brantingham, 1984, 1994). Offenders rarely commit offenses on their own

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doorstep, presumably because the chances of recognition by people who know them are higher.

The distance-decay function varies somewhat with the type of crime. Armed robbers, for instance, travel farther to their targets than other types of perpetrators (Capone and Nichols, 1975, 1976; Rengert, 1989). In general, the more planning a crime entails, the farther the criminals travel (Capone and Nichols, 1975, 1976; Van Koppen and Jansen, 1997). Yet despite such variation, the distance-decay function fits all kinds of crime with very little exception (Phillips, 1980) and with much the same shape: Many crimes close to home, and the farther away, the fewer crimes committed by offenders.

The distance decay in criminal behavior is considered so robust that it is the basis of so-called Criminal Geographic Targeting, a computerized geographic profiling technique used in police investigations of complex serial crimes (LeBeau, 1987; Rossmo, 1995), and it plays an important role in offender profiling (Canter and Larkin, 1993). Usually, the distance-decay function is accepted as a fact of life without much discussion (e.g., Maltz, 1996).

The explanations of the distance-decay function fall into two categories. One traditional explanation is that it costs time, money, and energy to overcome distance (Baldwin and Bottoms, 1976; Bullock, 1955; Turner, 1969). Since most criminals commit crimes that are easy and quick to commit (Gottfredson and Hirschi, 1990), they apparently prefer to travel as little as possible. A second, but related, explanation is that offenders are more familiar with their own territories and less familiar the farther they travel (Brantingham and Brantingham, 1993). They incur risks—of losing directions, for instance—once they are in unfamiliar territory, and therefore prefer to commit their crimes nearer to home (Brantingham and Brantingham, 1984; Capone and Nichols, 1975, 1976; Rand, 1986; Rengert, 1989; Reppetto, 1974).

Both these explanations imply that the distance-decay function is the result of individual decision making by individual criminals (Brantingham and Brantingham, 1993; Canter and Larkin, 1993; Fotheringham and Pitts, 1995; Langworthy and LeBeau, 1992; Maltz et al., 1991; Richards et al., 1991a, 1991b). Brantingham and Brantingham (1984:237), for instance, explain the distance-decay function as follows:

> From a criminological perspective, if a person is searching for a target to rob and several potential targets exist, all things being equal, the closest target will be chosen. All things are never equal, but it is argued that on the whole, there is a strong spatial bias that results in more short trips than long trips within any particular category of crime.

This explanation has its intuitive appeal and fits recent criminological theories that portray criminals as actors of a shortsighted stripe in pursuit of immediate and easy gains (Gottfredson and Hirschi, 1990). We contend, however, that this particular explanation of the distance-decay function is fallacious. If individual criminals who commit a particular type of crime have a *range of operation* within which they select their targets, a distance-decay function will emerge at the aggregate level. This will also happen if targets are dispersed randomly within the range without *individual* distance decay. These individual patterns generate a distance-decay function at the aggregate level as long as individual criminals differ in their ranges of operation. Much of the research that until now has employed this aggregate function to explain individual behavior may thus be based on an artifact. To support our point, we use a randomly generated data set.

THE ECOLOGICAL FALLACY

Four decades ago Robinson (1950) demonstrated some of the problems involved in using aggregated data for drawing conclusions on individual behavior. This was later called the *ecological fallacy*. In aggregated data the objects of the statistical analysis are groups of persons, rather than individuals. Only under special circumstances, which hardly ever occur in real life, are correlations in aggregate data good predictors of correlations in individual behavior. Robinson suggested that an aggregated correlation usually is an overestimation of the individual-level correlation. The ecological fallacy has been demonstrated repeatedly and is now common knowledge for most sociologists (Gottfredson et al., 1991; Richards, 1990, 1996; Richards et al., 1991a, 1991b; Schwartz, 1994).

The distance-decay function is an aggregated function that shares properties similar to the problems presented by Robinson. It shows that the number of crimes is inversely related to the distance from the criminals' residences. This, however, does not necessarily imply that individual criminals commit more crimes closer to their home than far away. The problem lies in inferring individual behavior from aggregated patterns.

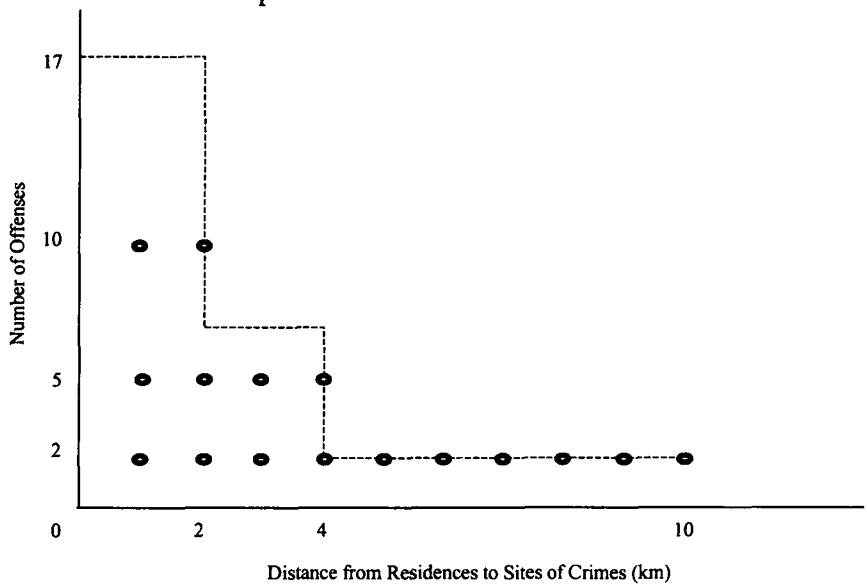
One example is the oft-cited study by Capone and Nichols (1976). In their introduction, they announce that they will treat robbery offenders "as the actors at varying geographical locations who, with a certain amount of information concerning the location of criminal opportunities in urban space, undergo a decision-making process that eventually leads to specific kinds of spatial behavioral biases" (p. 200). They offer, among others, "explanations of these biases by examining certain concepts of *individual behavior* as they relate to movement within Miami's urban system" (p. 200; emphasis added). Their analysis, however, is based on 825 robbery trips made by 825 different offenders, and yet these aggregate data are the basis for conclusions about individual behavior: "For criminal movement behavior is the product of an essentially rational spatial decision-making process that involves evaluation of an objective urban opportunity structure, the differential attractiveness of particular elements of that structure, and *the universal constraint of distance*" (p. 211; emphasis added).

The aggregated distance-decay function is an inevitable effect, as we will show, of the inclusion within the same analysis of criminals with different ranges of operation. Irrespective of differences in offense density (the range divided by the number of offenses), the relatively smaller ranges included in the data will aggregate to form a peak at the lower side of the distance scale although none of the individual offender's behavior might be characterized by distance-decay properties. The transition from individual no-decay functions to an aggregated distance-decay function is thus an aggregation fallacy. The maximum distance from home (e.g., range), given any number of offenses that are committed, can safely be assumed to vary among real-life offenders. Independent of the number of offenses committed, the distance from home of the offense committed the farthest away in a series of offenses is unlikely to be equal for all offenders.

Consider an extremely simplified situation in which three offenders commit 20 crimes each. The first offender commits his—all our hypothetical offenders are male—20 crimes within a range of two kilometers. He commits 10 crimes at a distance of one kilometer from his home and another 10 crimes 2 kilometers from home, showing no distance decay. The second offender commits 20 crimes within a range of 4 kilometers—at every kilometer from home he commits five crimes. Our third offender in this simplified example commits two crimes every kilometer within a range of 10 kilometers. A plot of the distances from home for all offenses committed by the three offenders together inevitably takes the shape of the dotted line in Figure 1. In short, despite the fact that the crimes of each individual offender are evenly distributed within his own range of operation, the aggregated function suggests distance decay. This, however, is solely caused by differences in the range of operation among offenders.

To support this point, we generated data randomly. By manipulating the data in a seemingly trivial way, we found that distance decay in aggregate geographical crime data is almost inevitable.

FIGURE 1
Simple Model With Three Offenders

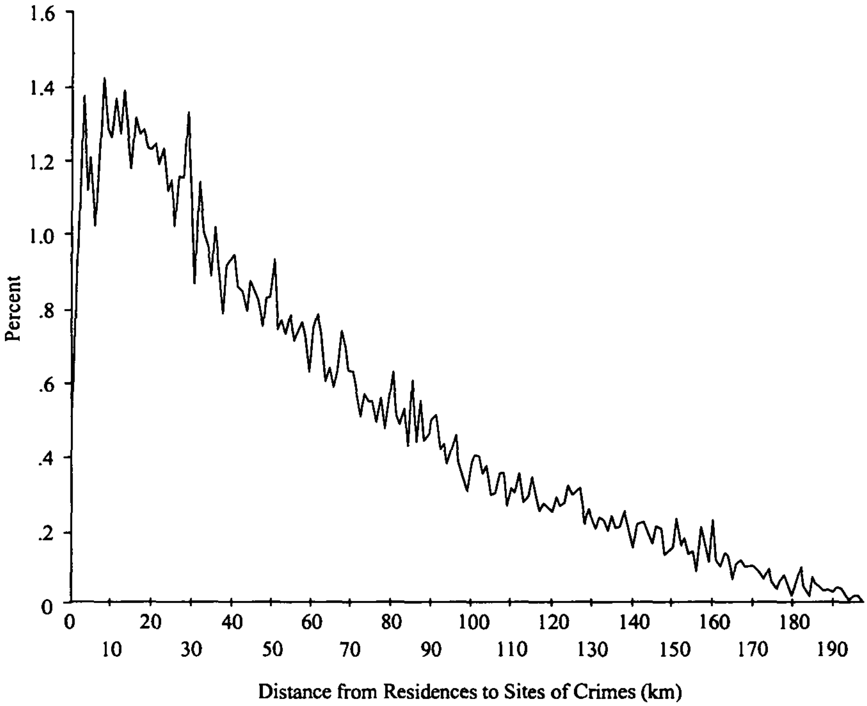


DISTANCE DECAY IN RANDOMLY GENERATED DATA

We created 1,000 hypothetical offenders who commit crimes, say robberies. We adopted the assumption that suitable targets are randomly distributed in space. The robberies were generated using three models.

In model 1 each of the hypothetical offenders was assigned an individual range of operation, which varied between 200 meters and 200 kilometers. The distribution of the ranges of the individual offenders was uniform (mean = 100.14, s.d. = 57.33, minimum = .21 km, maximum = 199.78 km). Within his assigned range each offender committed 20 offenses. The distance of each offense from the residence of the offender was found by multiplying the range with a factor. This factor in turn had a uniform random distribution over all offenders and offenses (mean = .55, s.d. = .25, minimum = .1, maximum = 1). Consequently, the 20 offenses committed by each offender have a uniform random distribution within each offender's individual range. It is important to note that none of the criminals thus shows any pattern of distance decay within his own range. Nevertheless, the aggregate curve for the 20,000 robberies committed by our robbers conforms to the well-known distance-decay function (see Figure 2).

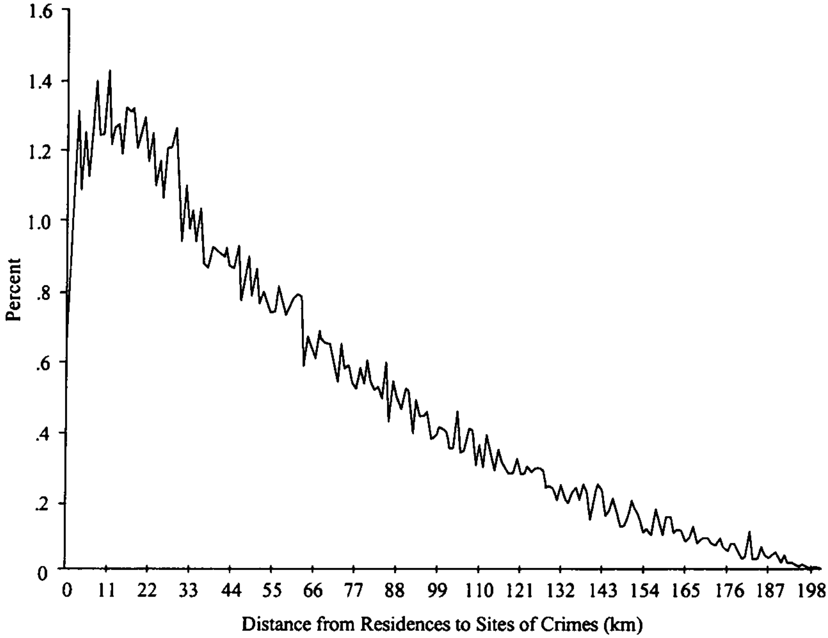
FIGURE 2
Model 1: 1000 Offenders Each Commit 20 Crimes



Model 2 was less restricted than model 1. In model 2 the number of offenses was no longer fixed. Instead, each offender was randomly assigned a number of offenses, which ranged from 1 to 100. The number of offenses again had a uniform random distribution (mean = 49.44, s.d. = 28.21). This resulted in a total of 34,018 offenses. Again at the aggregated level a distance-decay function emerged (see Figure 3). The principle can thus be generalized to a model with randomly assigned ranges and randomly assigned numbers of offenses as in model 2. If we set the maximum range for all offenders in model 2 to 200 kilometers, we find no distance decay at the aggregate level, as should indeed be expected with random data (result not shown).

The aggregate effect of the relative shorter distances is so strong that it even allowed us to formulate a third (and final) model, which produces a distance-decay curve (though it deviates slightly from the typical distance-decay curve) even though every individual was defined to exhibit a moderate distance *increase*. As in model 2 the range and the number of offenses committed by each offender were randomly assigned. In model 3, however, the distance from the offender's residence to the site of the crime

FIGURE 3
Model 2: 1000 Offenders Each Commit a Random Number of Crimes



was computed by multiplying the range with the square root of the same factor used in model 2. This gives each individual offender a slight distance increase, while in the aggregate a distance-decay function is still shown (see Figure 4).

CONCLUSIONS

We have argued that differences in the range within which criminals operate inevitably cause a pattern of distance decay at the aggregate level and that this holds even when individual criminals show a moderate increase in the number of offenses with increasing distance from home. We cannot necessarily conclude from this that there is in fact no such distance-decay effect in the activity of criminals. What we can say, however, is this: The common assumption that the distance-decay function evident in aggregated data reflects distance decay in the activities of individuals is unjustified. Rather, the distance-decay function at the aggregate level may be due to differences in the ranges of operation of different criminals. In this context, the well-known distance-decay function is indeed an artifact.

The distance-decay function may be an artifact in the analysis of individual behavior. The question remains why the distance travelled from home

FIGURE 4
Model 3: 1000 Offenders Each Commit a Random Number of Crimes With Individual Distance-Increase

to the scene of the crime varies with type of offender (Capone and Nichols, 1976; LeBeau, 1987; Rengert, 1989; Rhodes and Conly, 1981), type of crime (Capone and Nichols, 1976; Rengert, 1989) and even with variations within the same type of crime (Capone and Nichols, 1975; Van Koppen and Jansen, 1997). An explanation, put forward by Canter and Larkin, may be that there is some sort of criminal range: The range of operation of criminals differs and their range is related to type of criminal and type of offense (Canter and Larken, 1993; Capone and Nichols, 1975). Thus, range of operation, rather than the distance to the targets of crime, might be the important variable in discussing the spatial distribution of crime.

REFERENCES

Baldwin, John and A. E. Bottoms
1976 The Urban Criminal: A Study in Sheffield. London: Tavistock.

Brantingham, Patricia L. and Paul J. Brantingham
1993 Nodes, paths and edges: Considerations on the complexity of crime and the physical environment. Journal of Environmental Psychology 13:3–28.

1994 La concentration spatiale relative de la criminalité et son analyse: Vers un renouvellement de la criminologie environnementale. Criminologie 27:81–98.

Brantingham, Paul J. and Patricia L. Brantingham
1984 Patterns in Crime. New York: Macmillan.

Bullock, Henry A.
1955 Urban homicide in theory and fact. Journal of Criminal Law, Criminology, and Police Studies 45:565–575.

Canter, David and Paul Larkin
1993 The environmental range of serial rapists. Journal of Environmental Psychology 13:63–69.

Capone, Donald L. and Woodrow W. Nichols, Jr.
1975 Crime and distance: An analysis of offender behavior in space. Proceedings of the Association of American Geographers 45–49.
1976 Urban structure and criminal mobility. American Behavioral Scientist 20:199–213.

Evans, David J. and David T. Herbert (eds)
1989 The Geography of Crime. London: Routledge.

Figlio, Robert M., Simon Hakim, and George F. Rengert
1986 Metropolitan Crime Patterns. Monsey, N.Y.: Criminal Justice Press.

Fotheringham, A.S. and T.C. Pitts
1995 Directional variation in distance decay. Environment and Planning. Part A, International Journal of Urban and Regional Research 27:715–730.

Georges-Abeyie, Daniel E. and Keith D. Harries (eds.)
1980 Crime: A Spatial Perspective. New York: Columbia University Press.

Gottfredson, Denise C., Richard J. McNeil, and Gary D. Gottfredson
1991 Social area influences on delinquency: A multilevel analysis. Journal of Research in Crime and Delinquency 28:197–226.

Gottfredson, Michael R. and Travis Hirschi
1990 A General Theory of Crime. Stanford, Calif.: Stanford University Press.

Harries, Keith D.
1973 The Geography of Crime and Justice. New York: McGraw-Hill.

Herbert, David T.
1982 The Geography of Urban Crime. London: Longman.

Langworthy, Robert H. and James L. LeBeau
1992 The spatial distribution of sting targets. Journal of Criminal Justice 20:541–551.

LeBeau, James L.
1987 The journey to rape: Geographical distance and the rapist's method of approaching the victim. Journal of Police Science and Administration 15:129–136.

Maltz, Michael D.
1996 From Poisson to the problem: Applying operations research to problems of crime and justice. Journal of Quantitative Criminology 12:3–61.

Maltz, Michael D., Andrew C. Gordon, and Warren Friedman
1991 Mapping Crime in Its Community Setting: Event Geography Analysis. New York: Springer-Verlag.

Phillips, Paul D.
1980 Characteristics and typology of the journey of crime. In Daniel E. Georges-Abeyie and Keith D. Harries (eds.), Crime: A Spatial Perspective. New York: Columbia University Press.

Rand, Alicia
1986 Mobility triangles. In Robert M. Figlio, Simon Hakim, and George F. Rengert (eds.), Metropolitan Crime Patterns. Monsey, N.Y.: Criminal Justice Press.

Rengert, George F.
1989 Behavioral geography and criminal behaviour. In David J. Evans and David T. Herbert (eds.), The Geography of Crime. London: Routledge.

Reppetto, Thomas A.
1974 Residential Crime. Cambridge, Mass.: Ballinger.

Rhodes, William M. and Catherine Conly
1981 Crime and mobility: An empirical study. In Paul J. Brantingham and Patricia L. Brantingham (eds.), Environmental Criminology. Beverly Hills, Calif.: Sage.

Richards, James M.
1990 Units of analysis and the individual-differences fallacy in environmental assessment. Environment and Behavior 22:307–319.
1996 Units of analysis, measuring theory, and environmental assessment: A response and clarification. Environment and Behavior 28:220–236.

Richards, James M., Denise C. Gottfredson, and Gary D. Gottfredson
1991a Units of analysis and item statistics for environmental assessment scales. Current Psychology: Research and Reviews 9:407–413.
1991b Units of analysis and the psychometrics of environmental assessment scales. Environment and Behavior 23:423–437.

Robinson, W.S.
1950 Ecological correlations and the behavior of individuals. American Sociological Review 15:351–357.

Rossmo, D. Kim
1995 Place, space, and police investigations: Hunting serial violent criminals. In John E. Eck and David Weisburd (eds.), Crime and Place. Crime Prevention Studies, Vol. 4. Monsey, N.Y.: Criminal Justice Press.

Schwartz, Sharon
1994 The fallacy of the ecological fallacy: The potential misuse of a concept and the consequences. American Journal of Public Health 84:819–824.

Turner, Simon
1969 Delinquency and distance. In Thorsten Sellin and Marvin E. Wolfgang (eds.), Delinquency: Selected Studies. New York: Wiley.

van Koppen, Peter J. and Robert W. J. Jansen
1997 The road to the robbery: Travel patterns in commercial robberies. The British Journal of Criminology (forthcoming).

White, R. C.
1932 The relation of felonies to environmental factors in Indianapolis. Social Forces 498–509.

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