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Bus Stop–Environment Connection

Do Characteristics of the Built Environment Correlate with Bus Stop Crime?

Robin Liggett, Anastasia Loukaitou-Sideris, and Hiroyuki Iseki

Can we understand why some bus stops are safe and others are crime-ridden? Can we predict which features of the bus stop environment are likely to encourage or discourage crime? Can we design safer bus stops? These questions are addressed by exploring the relationship between environmental variables and bus stop crime. An earlier study used crime data, along with environmental indicators, for a sample of 60 bus stops in downtown Los Angeles. Crime rates were higher for bus stops near alleys, multifamily housing, liquor stores and check-cashing establishments, vacant buildings, and graffiti and litter. In contrast, good visibility of the bus stop from its surroundings and the existence of bus shelters contributed to lower crime rates. This earlier study was indicative but not predictive of the elements that contribute to bus stop crime. With the geographic and temporal expansion of the data (covering a larger city part over a longer time span), a series of regression models was generated that identify environmental predictors of bus stop crime. These models show that the most important predictor of crime is location. If the environment is controlled, undesirable facilities and litter result in higher crime rates, whereas visibility and many pedestrians lead to lower crime rates. The presence or absence of certain characteristics in the bus stop microenvironment can affect crime. Also, the appropriate design and layout of the physical environment can reduce opportunities for criminal actions.

Can we make bus stop environments safer for passengers by giving guidance to policy makers on the location and design of bus stops? Following the work of criminologists, environmental psychologists, and planners, it is argued that the effects of the built environment on bus stop crime can be measured and used to predict which bus stop locations tend to invite a higher proportion of criminal acts This analysis, in turn, can lead to general recommendations on land use and other built environment features that would promote safer bus stops

This analysis expands on a previous study that attempted to measure the effect of certain environmental variables on bus stop crime (*1*) The initial study used existing crime and ridership data, along with environmental and land use indicators, that were documented through extensive fieldwork for 60 intersections with bus stops in downtown Los Angeles The tentative conclusions in the first study were mostly based on *t*-tests comparing average bus stop crime rates between intersections categorized by the existence of particular environmental characteristics (e g , presence or absence of an alley) The methodological approach was limited because of the rather small sample size In this new phase of research, the study area and the time frame have been expanded With the expansion of the sample size, a series of regression models were generated that identify environmental predictors of bus stop crime Because of the spatial nature of the problem, issues of spatial autocorrelation have been explored and accounted for in building the regression models The expanded sample and scope of the research enabled some of the methodological flaws of the previous study to be corrected Given the results of this expanded study, drawing conclusions about which environmental factors create opportunities for or hinder bus stop crime can be done with more confidence

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THEORETICAL FRAMEWORK OF THE RESEARCH

Increasingly, criminologists have become aware of the importance of places of crime (2) A place is a very small area, a street corner, a bus stop, or an intersection. Researchers have noticed that crime often tends to concentrate heavily and disproportionately in a few places, or "hot spots" (*3–5*) Such observations have led to arguments for a reorientation of crime prevention efforts and a focus on the environmental context of crime instead of the socio-demographic characteristics of the offenders (*6*)

This debate underlines two distinct approaches in crime research studies (see Table 1) So-called compositional or nonecological studies stress the importance of the offenders' socio-demographic characteristics Therefore, these studies seek to identify relationships between a neighborhood's crime level and the characteristics of race and ethnicity, age and gender, poverty levels, and social mobility of inhabitants Some studies have also attempted to correlate crime with measures of family disruption (e g , percent of divorced households or female-headed families with children)

In contrast, ecological studies focus on physical attributes as covariates of crime (*7*) For such studies, it is the location and physical context of crime—not the socio-demographic characteristics of the offenders—that acquire significance Of particular interest are place characteristics (land use, built-form condition, visibility levels), as well as a site's access characteristics

Clearly, the two approaches of crime research lead to different types of crime prevention strategies Compositional studies target the potential offenders They advocate social and educational services to tackle teenage delinquency and recidivism. They argue for changes in the system of policing (e g , community policing) and reformulations of the criminal justice and penal systems to address crime

Implicit in the ecological studies is the belief that the redesign or transformation of certain place characteristics can lead to lower levels of crime These efforts are called "situational" because they link criminal activities to the specific physical attributes of hot

TABLE 1 Crime Studies

Ecological	Compositional
• Importance of physical and ecological attributes	• Importance of socio-demographic attributes (age, ethnicity, gender, class, social mobility)
• Study of the environmental context	• Study of offenders
↓	↓
Crime Prevention Strategies	
• Target environmental context ("designing out crime")	• Target potential offenders
• Situational crime prevention	• Social/educational services
• Crime Prevention Through Environmental Design (CPTED)	• Policing
	• Criminal justice

spots Ecological studies lead to crime prevention efforts that use environmental design as a tool for "designing out" crime. Environmental design is used to reduce the attributes that are believed to enhance crime and increase the "defensible space" elements that are believed to block opportunities for crime (*8, 9*). Before such design efforts and prevention policies are implemented, however, the different physical attributes that can encourage or discourage crime must be clearly understood

This study falls in the ecological category and is intended to identify and objectively measure the spatial parameters of crime The selection of the ecological approach has more to do with gained knowledge than with the belief that ecological studies are inherently better than compositional studies These two perspectives are not viewed as antithetical, because they can both contribute to the better understanding of crime and its prevention

BUS STOP CRIME IN LOS ANGELES

From previous studies, bus stop crime in Los Angeles was found to be primarily concentrated in certain hot spots (*1, 5*) These areas tend to be mostly in downtown and its outlying areas. Some hot spots are spatially clustered, while others are isolated In the previous research, the importance of the environmental setting on bus stop crime was established Bus stops in proximity, along the same bus routes, and presumably with passengers having the same socio-demographic characteristics were marked by different crime rates (*10*) Evidence was also found that certain urban form and bus stop characteristics have an effect on crime Crime rates were higher at bus stops near alleys, multifamily housing, undesirable establishments such as liquor stores and check cashing establishments, and vacant buildings, and where graffiti and litter were present. Positive environmental factors (that often translated into lower crime rates) included good visibility of the bus stop from surrounding establishments and the existence of bus shelters.

Previous studies have been indicative but not predictive of the physical elements that contribute to bus stop crime (*1, 5, 11*) The goal of this study was the ability to predict, with a significant level of certainty, the physical elements at bus stops that would affect bus stop crime Measuring the effect of each attribute was also an objective and required a significant expansion of the existing data.

The data were expanded geographically (covered a larger part of the city) and temporally (crime data for a larger time span) The expanded sample included 100 intersections with bus stops in both downtown Los Angeles and in the adjoining neighborhoods of Pico Union and Westlake. These areas were selected because of their disproportionate concentration of bus stop crime incidents in Los Angeles (*12*). The map displayed in Figure 1 shows crime and ridership levels for the selected bus stops The high-crime bus stops are concentrated along certain main streets in the downtown area, in what is considered the old historic core and along one of the major arteries through the Pico Union and Westlake areas

Crime data collected by the Los Angeles Metropolitan Transportation Authority (MTA) Transit Police of all reported crime incidents at bus stops from 1996 through 1998 were merged with bus stop crime data collected by the Los Angeles Police Department from 1994 to 1998. Because crime data were normalized by bus ridership to examine crimes per rider, data were also obtained from the MTA for average numbers of passenger boardings and alightings per bus stop. The unit of analysis for which data was collected and analyzed was the intersection where bus stops were located All bus stop crime and ridership data for bus stops in a 46-m (150 ft) radius of an intersection (about one-third of a city block) were aggregated to form a single observation in the data set This was accomplished using Environmental Systems Research Institute's ArcView to geocode data to the closest intersection

The database consisted of 2,805 bus stop crimes (crimes against people who were waiting for a bus or who had just come off a bus) recorded at the 100 study intersections Crimes were categorized into one of two types, ranging from serious crime (Type I) such as rape, robbery, and assault, to less serious crimes against people (Type II), such as pickpocket and jewelry snatching and public nuisance or public offense such as public drinking, lewd or disorderly conduct, and drug dealing About three-fourths of the crime incidents were Type II crimes (2,228), 577 incidents were Type I crimes Sixteen of the intersections in the sample had more than 50 crimes, only 4 of which were outside the downtown area

Ridership, which is measured as the average daily boardings and alightings at an intersection, ranged from a minimum of 158 riders per day to a maximum of 12,685 Eighty-three percent of the intersections had less than 5,000 riders per day, with only two intersections having more than 10,000 daily riders When crime per intersection was normalized by the number of riders about one-half of the intersections (45) had more than one crime per 100 riders. Of the top 10 intersections in total crime per 100 riders, 8 intersections were in the downtown area

ENVIRONMENTAL INVENTORY DATA

As in the earlier study, detailed primary data of environmental indicators were collected at each of the intersections added to the study [see Loukaitou-Sideris et al (*1*) for details on the data collection process] Data were collected for three groups of characteristics· (*a*) urban form characteristics around intersections, which included information on the land use and condition of the surrounding area; (*b*) bus stop characteristics, such as the existence of bus shelters, visibility, and lighting; and (*c*) street characteristics, such as street and sidewalk width, on-street parking, and traffic levels

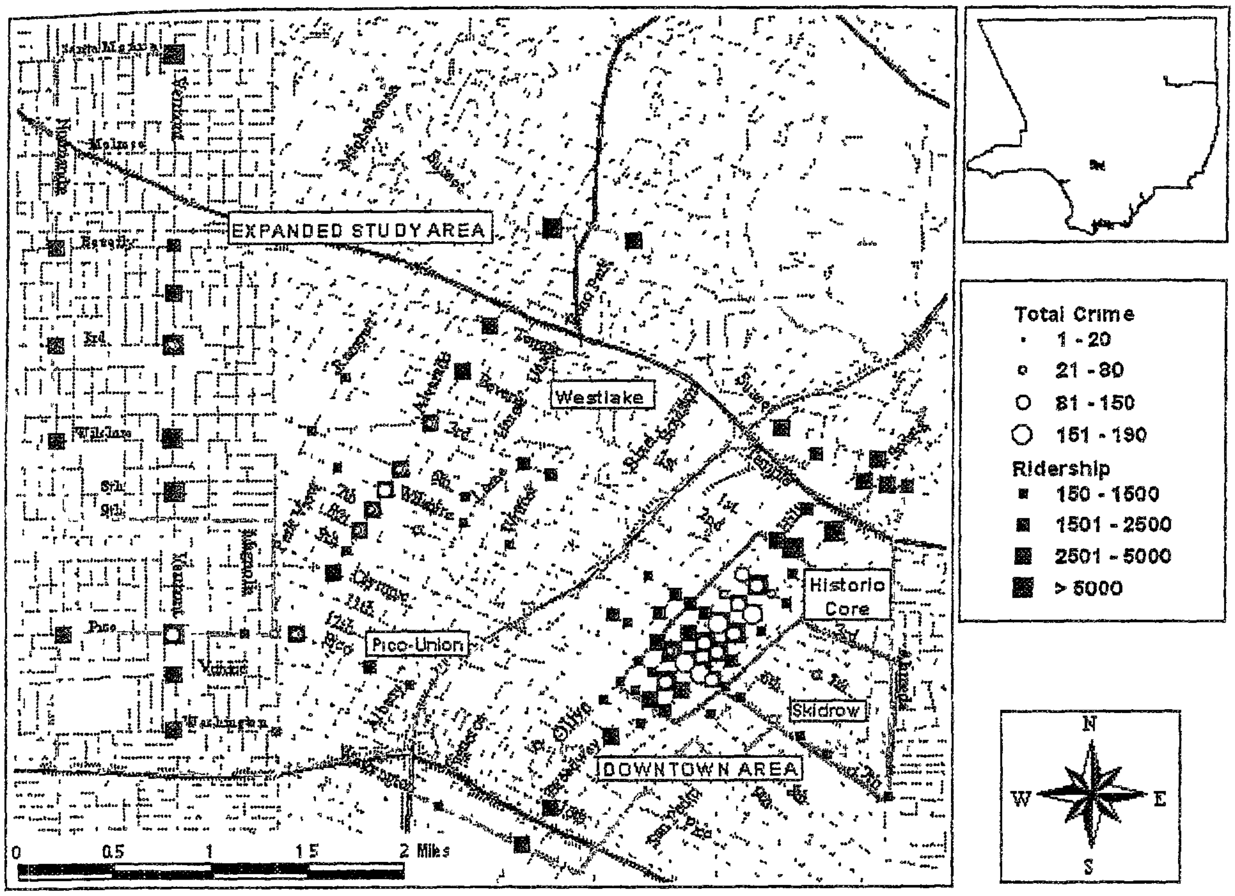

FIGURE 1 Crime and ridership in the study area

Table 2 lists environmental variables measured and associated correlations with crime counts (number of crimes) and crime rates (crimes per 100 riders) This simple correlation analysis led to a number of tentative conclusions about the relationship of certain physical attributes and bus stop crime These conclusions are summarized in Table 3

Urban Form Characteristics

Alley and Midblock Connections

Sixty-two of the 100 intersections had either an alley or midblock connection Although a moderate but significant correlation was found between the existence of an escape route such as an alley or midblock connection and crime counts, no significant correlation was found when looking at crime rates

Land Use

Land use was measured in the field by counting the number of establishments in a particular classification (e g , number of single family homes, number of surface parking lots) in the area defining the intersection In addition, as a surrogate measure for the length of street front dedicated to a particular land use at each intersection, the percentage of lots dedicated to a particular land use was calculated A 0-1 variable was used to measure the absence or presence of a particular "negative" land use (e g . liquor stores, adult movie theaters and bookstores)

Residential Single family housing was present at only four intersections, however, multifamily housing existed at 30 intersections Contrary to studies that found residential crime correlated with multifamily housing, this correlation was not found between such housing and any of the crime measures (*13–15*) This result also contradicts findings in the preliminary study that considered only bus stops in downtown Los Angeles where there was little residential housing (*1*)

Commercial Three commercial land use types were measured small or open-air establishments (concessions, kiosks), small or closed-front establishments (retail stores), and large or closed-front establishments (e g banks, department stores). Only 20 percent of the intersections had small or open-air commercial properties, while almost all intersections (86 percent) had small or closed-front commercial establishments About 80 percent of the intersections had at least one large or closed-front commercial land use A moderate correlation was found between the number of small commercial establishments (either open air or closed front) and crime counts. Small commercial establishments had a significant correlation with ridership (busy intersections tended to have small commercial establishments) A weak but significant negative correlation was found between crime counts and crime rates and the number or percentage

TABLE 2 Correlation Between Environmental Indicators and Bus Stop Crime

	Total		Type I	
	Crime Counts	Crime Rates	Crime Counts	Crime Rates
Urban Form Characteristics				
Factors Facilitating Escape				
Alley/Mid-block Connection	0 529 **	0 113	0.248 *	-0 091
Land Use				
Single-family Residential	-0 081	-0 105	0 071	0 033
Multi-family Residential	0 003	0 078	0 047	0 037
Small/Open-Air Commercial	0 462 **	0 041	0 253 *	-0 085
Small/Closed Front Commercial	0 493 **	0 008	0.363 *	-0 094
Large/Closed Front Commercial	-0 025	-0 121	-0.294 *	-0 235
Liquor Stores	0 191	0 287 **	0 163	0 123
Check Cashing Establishment	0 198 *	-0 017	0 164	-0 046
Adult Movie Theatres	-0 014	0 165	-0 075	-0 117
Adult Book Stores (only one)				
Surface Parking Lot	-0 145	0 045	-0 007	0 105
Fenced	-0 048	0.305 **	-0 136	0 085
Unfenced	-0 126	-0 206 *	0 111	0 047
With Attendant	-0 159	-0 096	-0 159	-0 096
Parking Structure	0 057	0 032	-0 053	-0 084
Condition				
Vacant Lots	-0 131	0 023	0 059	0.241
Vacant Buildings	0 130	0.356 **	-0 102	0 126
Run-down Establishments	-0 042	0.249 *	-0 157	0.247
Graffiti	0.307 **	0 036	0.202 *	-0 058
Litter	0 419 **	0.279 **	0 402 *	0 129
Bus Stop Characteristics				
Visibility	0 148	-0 308 **	0.266 *	-0 240
Standard Street Light	-0 016	0 049	0 166	0 136
Pedestrian Street light	0 293 **	0 021	0 180	-0 009
Other Lights	0 037	-0 078	-0 084	-0 087
Public Phones	0.238 *	0 034	0.362 *	0 082
Bus Shelters	-0 123	-0.250 *	0 043	-0 117
Visible Caretaker/Guard	0 239 *	-0 034	0 159	-0 080
Police Substation	0 404 **	0 189	0 059	-0 039
Pedestrian Presence (Wait Time)	0 493 **	-0 252 *	0 466 *	-0.274
Street Characteristics				
Street Vehicle Traffic	-0 070	-0.214 *	0 750	-0 026
On-street Parking	0 100	0 156	0 016	-0 051

* Correlation is significant at the 05 level
** Correlation is significant at the 01 level

of large or closed-front commercial establishments The reason for this finding may be that most of these establishments were banks and department stores, which typically have an added layer of security, with roving security guards in their immediate vicinity.

Undesirable Establishments The previous study indicated that certain establishments close to a bus stop can increase crime rates In this study, 39 intersections had at least one liquor store (five intersections had the maximum of three liquor stores) and 17 intersections had at least one check-cashing establishment A moderate positive correlation was measured between the existence of a liquor store and total crime rate This relationship did not hold, however, when looking only at Type I (serious) crime rates. Only six intersections had adult movie theaters (there was no difference

TABLE 3 Environmental Variables Related to Bus Stop Crime

Variables Associated with Higher Crime Rates	Variables Associated with Lower Crime Rates
Total Crime Rates	
• Liquor Stores and Other Undesirable Establishments • Vacant Buildings and Lots • Rundown Buildings • Level of Litter	• Large/Closed Front Commercial • Visibility • Bus Shelters • Street Traffic • Pedestrian Presence (Wait Time)
Type I Crime Rates	
• Vacant Lots • Rundown Buildings	• Large/Closed Front Commercial • Visibility • Pedestrian Presence (Wait Time)

in average crime counts or rates between intersections with and without adult movie theaters), and only one intersection had an adult bookstore Summing all types of undesirable establishments per intersection, a positive correlation was found between the existence of an undesirable establishment and crime rates ($r = 0.322$ for total crime rate).

Parking Surface parking lots were located at 76 intersections. Lots were classified as fenced and unfenced, assuming that fenced lots provided a safer environment because criminals could not escape by running through the lots Unfenced parking lots were located at 27 intersections The relationship between the number of parking lots and crime rates was the opposite of that expected Total crime per 100 riders was positively correlated with the number of fenced parking lots and negatively correlated with the number of unfenced parking lots As a result, no significant correlation was found between the total surface parking lots (fenced and unfenced) and crime rates Data were also collected on whether or not there was an attendant at a parking lot Thirty-one of the intersections had parking attendants The presence of an attendant and crime rates had no correlation, however, information was not collected on the hours an attendant was present Therefore, it was not known whether an attendant was present when a crime took place Fifteen intersections had parking structures Crime and the existence of these structures at an intersection had no relationship

Vacant Lots and Buildings Vacant lots existed at 18 intersections More than one-half of the intersections had from 1 to 20 vacant buildings A positive correlation was found between the number of vacant lots and Type I crime rates, as well as between the number of vacant buildings and total crime rates Summing the number of vacant lots and buildings per intersection, a correlation of 0 361 with the total crime rate was found

Built-Form Condition The existence of rundown establishments at an intersection and the total crime rate and Type I crime rate had a weak but significant correlation Only 13 intersections had buildings classified as rundown A significant positive correlation was found between total crime count and crime rate and the level of litter at an intersection (the level of litter was measured on a 24-point scale) Although the initial study found that crime rates were higher at intersections where graffiti were present (also measured on a 24-point scale), this relationship did not hold in the expanded data set

Bus Stop Characteristics

Visibility was important for bus stop safety All crime rates tended to be lower at intersections where bus stops were visible from establishments (there was a direct line of sight from a nearby establishment to a bus stop) No relationship was found between crime rates and the presence of streetlights at bus stops However, the fieldwork was done in the daytime and illumination levels at each intersection were unknown A positive relationship was found between the existence of public telephones at bus stops and crime counts, but not crime rates The police stated that public telephones are often used as hangouts for drug dealers Bus stops at 32 intersections had shelters Bus shelters and total crime rate had a weak but significant negative correlation No correlation was found between the existence of a visible caretaker at an establishment at an intersection and crime rates Only three intersections had police substations and these tended to have higher levels of crime However, it might be expected that station locations were selected because of crime levels and are an effect rather than a cause

A measure of pedestrian presence in the vicinity of bus stops was calculated using the average time that lapses between two consecutive buses weighted by the number of boardings (wait time) This measure is negatively correlated with all crime rates, indicating lower levels of crime where there are more "eyes on the street" (*16*)

Street Characteristics

Street or sidewalk width and crime rates had no correlation However, a negative correlation was found between the level of street traffic and total crime rate Higher levels of traffic were associated with lower crime rates The existence of on-street parking and crime had no relationship

Table 3 is a preliminary summary of environmental variables associated with bus stop crime rates Photographs in Figure 2 show environments typically associated with high- and low-crime bus stops The environmental variables were selected as potential independent variables for a multiple regression analysis

(a)

(b)

FIGURE 2 Typical high- and low-crime bus stops (*a*) high-crime bus stop, (*b*) low-crime bus stop

BUILDING A REGRESSION MODEL

A set of multiple regression models was explored to measure the effects of environmental factors on crime rates Plots of residuals from the initial regression models indicated problems of heteroskedasticity (unequal variance) This variance was corrected by a log transformation of the dependent variable The four best environmental predictors of the natural log (LN) of total crimes per 100 riders are shown in Model 1 in Table 4 These predictors include the presence of liquor stores in the near vicinity, the amount of litter at the intersection, visibility of the bus stop from adjacent establishments, and wait time (a measure of pedestrian presence). Crime rates were higher (positive regression coefficients) at intersections where litter and liquor stores existed Crime rates were lower (negative coefficients) when visibility and pedestrians were present at the bus stop The adjusted R-square for this model was weak (0 249), and coefficients for two independent variables—liquor store and wait time—were significant only at the 0.08 level.

Noting the high concentrations of crime in localized corridors in the study area, dummy variables measuring location were tested in the regression equation. Only one location variable contributed significantly to the model— location in the historic core of downtown Los Angeles The adjusted R-square for this model (shown as Model 2 in Table 4) increased to 0 389, with significant coefficients on all variables Although the magnitude and signs of the coefficients on the original four independent variables remained similar to Model 1, the standardized coefficients (beta weights) indicate that location in the historic core had the largest effect on crime rates, followed by levels of litter and pedestrian presence (wait time).

Spatial Autocorrelation

Because of the spatial clustering of the data, there was concern about the possibility of spatial autocorrelation Problems with the regression analysis because of the spatial nature of the data can lead to incorrect conclusions about the effects of the independent variables on the dependent variable For example, there is the problem of model misspecification because of possible spillover effects The number of crime incidents in one area can be expected to affect the number of crimes in neighboring areas If the model does not account for spillover effects, these effects may be incorrectly attributed to the independent variables in the analysis Also, the correlation between error terms of the regression model for spatial units that are near each other (spatial autocorrelation) violates one of the assumptions of the regression analysis. Roncek and Montgomery provide a more detailed discussion of the statistical consequences of crime in one area being affected by crime in its surroundings (*17*).

As a first step in testing for spatial autocorrelation, the Moran's I index was calculated using a program recently made available by the Crime Mapping Research Center at the National Institute of Justice (*18*). Significance tests for the Moran's I index indicated spatial autocorrelation in the dependent variable (LN of crime per 100 riders) and in the residuals of Model 1 However, the value calculated for the Moran's I index for the residuals of Model 2, which included the dummy variable for historic core, did not indicate any significant spatial autocorrelation This finding led to the belief that the spatial autocorrelation in the data set mainly resulted from the concentration of high-crime intersections in the historic core

TABLE 4 Regression Models

	MODEL 1			MODEL 2		
	b	BETA	sig.	b	BETA	sig.
Constant	-0 736		0 002	-0.853		0 000
Liquor Store (0,1)	0 449	0 163	0 080	0 452	0 164	0 051
Litter	0 111	0.377	0 000	0 096	0 324	0 000
Visibility (0,1)	-0 755	-0 280	0 003	-0 593	-0 220	0 011
Wait Time	-3 53E-05	-0 170	0 080	-5 98E-05	-0 288	0 002
Historic Core				1 269	0 398	0.000
R-square (Adjusted)	0 249			0 389		
Moran's "I" (Z-score)	4 850			1 892		
Akaike Criterion	320 013			300 252		
Schwartz Criterion	333 039			315 883		

	MODEL 3			MODEL 4		
	b	BETA	sig.	b	BETA	sig.
Constant	-0 513		0 010	-0 652		0 001
Liquor Store (0,1)	0 453	0 164	0 024	0 481	0 175	0 028
Litter	0 063	0 213	0 005	0 060	0 202	0 020
Visibility (0,1)	-0 492	-0 182	0 014	-0 662	-0 246	0 028
Wait Time	-5 27E-05	-0 254	0 001	-8 07E-05	-0 389	0 000
Historic Core	1 088	0.341	0 000			
Spatial Lag	0 654	0 261	0 000			
Crime Potential				1165 747	0 547	0 000
R-square (Adjusted)	0 471			0 460		
Moran's "I" (Z-score)	-0 091			1 560		
Akaike Criterion	286 989			287 959		
Schwartz Criterion	305 225			303 590		

NOTE. Dependent variable = LN (crime per 100 riders)

Although a simple index such as Moran's I can be used to identify whether spatial autocorrelation exists, more complex techniques are available for estimating the effects of spatial autocorrelation on a multiple regression model Two approaches were explored First, a spatial statistics package, SpaceStat, was used to control for the degree of spatial autocorrelation by including a spatially lagged dependent variable as an independent variable in the multiple variable regression model (*19*) A second approach was adapted from work by Roncek and Montgomery that included an independent variable in the multiple regression that measured crime potential (*17*) Although Roncek and Montgomery suggest this approach as a way of handling spatial autocorrelation in large samples, the approach was adapted as an alternative means of including crime spillover effects in the regression because of how the sample was structured

Including a Spatially Lagged Dependent Variable

The SpaceStat program was used to estimate a regression model that included a spatially lagged dependent variable as one of the independent variables A spatially lagged dependent variable is calculated as a weighted average of the values of the dependent variable at all other observations (i.e., intersections) In this study, the value of the lagged dependent variable for each intersection is the sum of the natural log of crime rate (dependent variable) at each other intersection weighted by the square of the inverse distance between the two intersections The resulting regression equation enabled an assessment of the significance of the other independent variables after the spatial dependence was controlled

The best regression model generated using the spatial regression package for predicting the dependent variable, LN (crime per 100 riders), is shown as Model 3 in Table 4 The beta weights indicate that the historic core dummy variable contributes the most to the prediction, followed by the spatial lag variable This finding corroborates earlier results that spatial location is the most important determinant of the crime rate at bus stops After the effect of the spatial lag variable is removed from the dependent variable, the same variables as in earlier models significantly contribute to the explanation of crime rates The signs and magnitude of the coefficients remain constant Intersections with liquor stores and litter tend to have more crime per rider, whereas visibility and pedestrian presence (wait time) have lower crime rates

Although Table 4 shows a higher R-square for the spatial lag model (Model 3), it is not appropriate to compare this R-square to one generated by ordinary least squares (OLS) Two alternative measures of fit reported by SpaceStat are directly comparable between models generated by OLS and spatial regression models—the Akaike Criterion and the Schwartz Criterion The best model is one with the lowest value for these criteria, in this case, the spatial lag model has slightly lower values than the OLS model

Crime Potential

Most of the literature addressing issues of spatial autocorrelation assumes that the observations are spatially contiguous Although observations may be points on a grid such as intersections, or zones such as city blocks or census tracts, all spatial units are assumed to be included in the analysis A main aspect captured in a regression model with a spatially lagged dependent variable is the spillover effects of crime from adjacent areas

The present data are somewhat different Because the resources were not available to collect environmental inventory data for each intersection in the area, not all intersections, and thus not all bus stop crime incidents, are included in the database Also, a random sample of intersections was unavailable. All intersections with significant levels of bus stop crime were included in the study, with a random sample of low-crime intersections to complete the 100 cases This method of sample selection has two effects on the analysis. As noted before, many of the high-crime intersections are concentrated on two streets in the historic core of downtown Los Angeles This area not only has common values for the dependent variable (crime levels), but also has similar environmental characteristics Therefore, the effects of the independent variables in the regression are overstated because of fewer independent observations If a correction is made, for example, using a spatially lagged dependent variable in the regression, spillover effects from all crimes in the adjacent areas are not actually accounted for, because these crime data are not necessarily in the database

Roncek and Montgomery introduced a crime potential variable into their regression analysis to account for spillover effects (*17*) The crime potential is based on the generalized potential model in which the crime potential at each observation (in this case, intersection) is calculated as the sum of the crime levels at every other observation divided by the distance to these observations (calculated in the same way as the lagged dependent variable in the spatial regression analysis) This crime potential variable captures possible diffusion from all locations of the study area so that misspecification of the exact range of diffusion effects is not a concern

To approximate a crime potential variable given the limitations of the data set, two additional crime variables were aggregated for each intersection: (*a*) bus crime in a radius of 153 m (500 ft) of the intersection, but excluding the 46-m (152-ft) radius that defines the dependent variable and (*b*) bus crime in a radius of 229 m (750 ft) but not within 153 m. A crime potential variable was created that weighted these two aggregates of crime based on distance from the intersection (again selecting the square of distance as the best function) and included this potential variable in the OLS regression equation Model 4 in Table 4 shows that this crime potential variable contributed significantly to the explanation of variation in the natural log of crime rates and increased the R-square to 0 460 Coefficients on the other independent variables were all significant, with slight changes in value The beta weights show that crime potential has the greatest effect, followed by wait time and visibility (eyes on the street), as in Model 3 Litter had a smaller effect than in Models 1 and 2 The historic core variable and crime potential could not be included in the regression model because of multi-colinearity problems (they have a simple correlation coefficient of 0 830) Clearly, areas with the highest crime potential are in the historic core

Although the calculation of the Moran's I index for the residuals of Models 2, 3, and 4 indicated no significant spatial autocorrelation, more confidence rests in the results of Model 3 Although the sample composition had problems, the similarity of results among the models indicates a reasonable specification for the model Clearly, an important predictor of crime is the location—physically related to factors associated with the historic core After controlling for the location, undesirable facilities and litter result in higher crime rates, whereas visibility and many pedestrians lead to lower crime rates

Using Model 3 as a starting point, specific design variables—presence of bus shelters, public telephones, and a caretaker—were tested for their effect on crime rates None of these factors added significantly to the equation, after the basic factors were controlled

Type I Crime

A similar analysis was conducted considering only Type I crime The interest was in whether different environmental factors were related to more serious crimes against persons, such as murder or rape A similar pattern was found as that for total crime—the most important environmental factors were pedestrian presence (measured as wait time) and visibility, which were both negatively correlated with crime rates, followed by the existence of litter, which was positively correlated with crime rates The existence of undesirable establishments such as liquor stores did not enter into the regression model Location in the historic core had no relationship to Type I crime, rather, the significant location dummy variables were location in the skid row area in downtown and the Westlake region of the expanded study area.

CONCLUSION: WHAT CAN BE DONE ABOUT BUS STOP CRIME?

This analysis indicates that ecological and compositional perspectives can be complementary in explaining crime incidence Most bus stop crimes tend to occur in dangerous places. Why these places have a higher crime potential than others can be partly explained by their social and compositional characteristics But within these dangerous locales that concentrate many hot spots of crime, some spaces are much more dangerous than others The design and layout of the physical environment can be conducive to crime or can reduce opportunities for criminal actions. This study found many instances of bus stops in the historic core (an area with high crime potential) that were crime ridden, whereas others in the same area and along the same bus route were mostly unscathed On the basis of the findings, it can be concluded that the presence or absence of certain environmental characteristics in the microenvironment of a bus stop can affect the incidence of crime

Transportation and municipal agencies can draw certain lessons from this study Because crime tends to be concentrated disproportionately in specific dangerous locales, intense bicycle and foot patrolling by police in these areas should reduce opportunities for crime. At the same time, an array of policy and design options—some quite simple—can complement policing Good visibility from the surrounding buildings and pedestrian presence are important variables in reducing crime. Every effort should be made to site bus stops away from desolate spaces, empty lots, and vacant buildings and in front of establishments that offer opportunities for natural surveillance The placement of bus stops near undesirable establishments (liquor stores, bars, adult bookstores and movie theaters) and near facilities that favor many cash transactions (pawnshops, check-cashing establishments) should be avoided Sometimes, this may simply mean moving a bus stop a few yards up or down a street or at the opposite corner Bus shelter design should not create an optical barrier to viewing a bus stop from surrounding establishments. Finally city agencies should strive to keep the bus stop environment free of graffiti and litter, thus sending the message that someone other than the criminal is in control of the bus stop environment.

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Contents

Foreword vii

PART 1—BUS

Bus Timetables with Even Passenger Loads as Opposed to Even Headways 3
Avishai Ceder

Trip Time Analyzers: Key to Transit Service Quality 10
Theo H. J. Muller and Peter G. Furth

Bus Stop–Environment Connection: Do Characteristics of the Built Environment Correlate with Bus Stop Crime? 20
Robin Liggett, Anastasia Loukaitou-Sideris, and Hiroyuki Iseki

Designing Synchronization into Bus Timetables 28
Avishai Ceder and Ofer Tal

Bus Rapid Transit Institutional Issues: The Route from Research to Experience 34
Mark A. Miller and Stephen M. Buckley

Bus Transit in the 21st Century: Some Perspectives and Prospects 42
Herbert S Levinson

Evaluation of Feeder Bus Systems with Probabilistic Time-Varying Demands and Nonadditive Time Costs 47
Steven I Chien, Lazar N Spasovic, Spyridon S. Elefsiniotis, and Renu S. Chhonkar