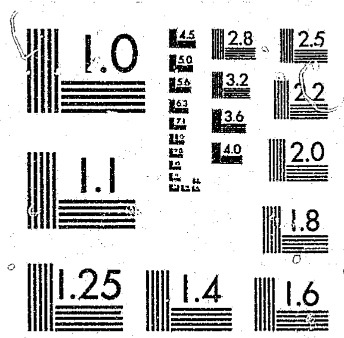

MICROCOPY RESOLUTION TEST CHART
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STREET ILLUMINATION AND CRIME: A STATISTICAL INVESTIGATION

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In 1967 the President's Crime Commission said of crime prevention activities in the U.S.: "There is probably no subject of comparable concern to which the Nation is devoting so many resources and so much effort with so little knowledge of what it is doing" [7, p. 273].

A case in point is the widespread misunderstanding concerning the effects of street lighting in crime deterrence. Popular and trade publications report the favorable results various cities have had from using new or improved street lighting to deter crimes. For example, American City reported that in five areas of New York City new lighting cut the incidence of murder, assault, and rape by 59 percent, reduced other adult crimes by 18.3 percent, and resulted in a drop of 30 percent in juvenile delinquency [5, p. 108]. The Crime Commission, however, stated that "there is no conclusive evidence that improved street lighting will have a lasting or significant impact on crime rates" [8, p. 51].

For over a year I have directed a federally sponsored study aimed at (1) impartially investigating the amount and character of crime deterrence provided by street illumination, and (2) developing methods of producing and analyzing data for subsequent studies.

Let me review one of our major activities. Although the ideal statistical approach would be to experiment with random changes in lighting, practical considerations precluded this approach and so we had to choose between

This paper will be published in the 1972 Proceedings of the American Statistical Association, Business and Economics Section. The work was supported by Grant No. NI 72-NI-99-0020 from the National Institute of Law Enforcement and Criminal Justice (LEAA/U. S. Department of Justice).

(1) making a cross-sectional analysis of the relation of crime to existing lighting conditions, or (2) evaluating the effect of scheduled lighting improvements.

The latter approach is more complex than it might appear, because uncontrollable variation in installation dates is compounded by seasonal crime rates. In addition, the isolation of long-run from transitory effects requires a rather long time period, during which the masking effect of trends may be serious. For example, in New York in 1964--after an initial 49 percent drop in serious crimes--and "after 80 percent of the city street lighting had been converted over a 4-year period at a cost of $58 million, the total felonies in the city increased by approximately 43 percent" [8, p. 51].

In view of these obstacles we decided to make a cross-sectional analysis of the relation of crime to lighting. We selected a sample of about 1,500 blocks in Kansas City, Missouri, which were stratified by composite indexes of economic status, family disintegration, racial status, and a preliminary assessment of street lighting. These indexes were derived from first-count 1970 census data, following the lines of Shevky's and Bell's social area analysis [10]. The purpose of this stratification was to get a balanced distribution of lighting conditions within each of several types of neighborhoods. With the lighting and socioeconomic data we merged the 1970 police offense records and Dun and Bradstreet's DMI commercial data. We are currently improving and expanding our data base; the analysis reported here rests on the rather severely limited initial data, and it is intended to be exploratory only.

Perhaps the most fundamental problem in organizing any study of this type is the choice of dependent variables, in this case measures of crime. Reiss and others have recommended the formulation of crime rates on the basis of exposed populations [2, 3, and 9]. Thus a rate for auto theft might be expressed in terms of the number of parked cars, and a rate for street robberies might depend on the number of pedestrians.

An alternative measure of the effect of street lighting--one which demands fewer data which we think can be interpreted more directly--may be derived by comparing the number of night offenses to the number of day offenses. We have chosen to use for this measure the ratio of night offenses to all offenses for which time of day is known, that is, the proportion of night offenses. Assuming that street lighting does not influence the incidence of daytime crime enables us to estimate the effect of lighting on night crime. To the extent that many of the factors which affect the rate of crimes during the day affect night crime proportionately, this estimate will be statistically sound.

Some of our preliminary findings are presented in the tables and figures. Table 1 indicates that only a slight decrease in the proportion of night crimes to total street crimes is associated with Mercury and Lucalux lighting types. However, Table 2 indicates that various types of street offenses, except robbery, are apparently strongly deterred by good lighting--Mercury and Lucalux. The exception of robbery may be due to sampling error or it may

be actual, perhaps a result of increased evening shopping in well-lit commercial areas, which provides a larger number of potential robbery victims. It remains to be seen whether street lighting reduces the victimization rate of street robbery at night. Tables 3 and 4 suggest that lighting inhibits most nonstreet offenses except for crimes of violence.

The analysis that led to these findings utilized a basic analytical tool called MCA, which is a dummy-variable multiple regression program [1]. Our data file contains over 5,000 cases in all, each of which lists an offense occurring at a known time of day. A dicotomous variable used to classify each offense as a night or day crime is the dependent variable. Our predictors consist of various characteristics of the neighborhood where the offense occurred. Thus, as Figure 1 shows, our model postulates that the proportion of offenses at night is an additive but possibly nonlinear function of neighborhood effects. Excluding the perverse class of street robberies, this kind of analysis yielded the estimated effects shown in Table 5. The effect of street lighting, applied to the grand mean, gives the proportions of Tables 1-4. Each line in these tables reflects an individual multiple regression analysis on a particular subsample of offenses. We chose not to use probit analysis at this stage in our work because of the rather small effects encountered.

An important aspect of our study is evaluation of the significance of the apparent lighting effect. Table 6 shows a standard ANOVA. The .5

percent critical value of the F statistic associated with the contribution of lighting is about 7.8, so the F value of 36 is highly significant. Of course with the huge residual degrees of freedom almost any effect would be significant. However, this is not the whole story. Remember that the sampling unit was the city block, not the offense. Although about 1,500 blocks were selected, only 672 had one or more offenses of the types considered here. Moreover, almost half of the offenses occurred on only 80 sample blocks. How does this statistic affect the significance of our findings?

Some insight on this question can be derived from further clarification of the assumptions in our basic model. Think of each offense as an independent Bernoulli trial resulting in night or day. Our model specifies the probability of night, varying with certain block characteristics. Assuming the validity of our model and considering the robustness of the general linear regression model, our ANOVA is probably reasonably appropriate.

Now the validity of our model can be tested in part since we have replications within blocks. Specifically, we can test the assumption that the probability that an offense occurs at night is constant among all blocks similar with respect to our predictors. Table 7 shows the ANOVA, based on 80 blocks, each with 13 or more offenses. While the block effects are significant at the .5 percent level, the relatively low F statistic suggests that with additional care and better data a quite adequate regression model can be formulated.

A more direct approach to evaluating the sampling effect on measures of significance is available. Consider the simple unadjusted effect of lighting--a contrast of the observed proportion of night offenses in poorly-lit versus well-lit areas--as at the bottom of Table 8. Each of the p's, .677 and .323, is actually a ratio estimate based on a sample of blocks; Cochran would call them estimates of proportions in cluster sampling [4]. Thus satisfactory estimates of their standard errors can easily be calculated as shown. These approximate the standard errors derived from the Bernoulli assumptions. Although these comparisons are not directly applicable to the significance of lighting in the multiple regression analysis, the work of Frankel indicates that the sample design effect is generally less for regression statistics than for differences of means [6].

One way of contrasting these two approaches is to recognize that our offense-level regression analysis is essentially equivalent to a weighted, block-level regression, with the dependent variable taken as the proportion of night offenses on each block, and with weights equal to the number of all offenses on the block. Our ANOVA is conditional on the weight variable--the number of all offenses. The ratio estimation, on the other hand, takes the sampling variation of the number of offenses into account.

In conclusion, although the variation in the number of offenses is considerable, both the ANOVA of block effects and the comparison of ratio with Bernoulli standard errors indicates that the straightforward ANOVA of the lighting effect is satisfactory despite the peculiarities of the sampling.

In general I would conclude that in analysis of this type the most appropriate solution to distortion of inference by the effects of sampling design is the development of an adequate regression model. Unless this can be accomplished there can be little satisfaction in the estimated effects of variables of interest. If an adequate model can be formulated with available data, then the sampling effects probably are negligible.

TABLE 1

Effect of Type of Lighting on the Proportion of All Street Offenses Occurring at Night

Type of Lighting	Total Number of Offenses	Proportion Occurring at Night
None	18	.80
Incandescent	1,048	.63
Mercury	37	.67
Lucalux	374	.58

TABLE 2

Effect of Quality of Lighting on the Proportion of All Street Offenses Occurring at Night

Type of Offense	Poor Lighting		Good Lighting	
	Total Number of Offenses	Proportion Occurring at Night	Total Number of Offenses	Proportion Occurring at Night
Murder, rape, and assault	210	.74	47	.62
Robbery	224	.65	80	.84
Larceny	317	.50	187	.42
Auto theft	179	.72	59	.66
Other	135	.68	34	.46

TABLE 3

Effect of Type of Lighting on the Proportion of All Nonstreet Offenses Occurring at Night

Type of Lighting	Total Number of Offenses	Proportion Occurring at Night
None	32	.51
Incandescent	1,871	.55
Mercury	93	.26
Lucalux	997	.34

TABLE 4

Effect of Quality of Lighting on the Proportion of All Nonstreet Offenses Occurring at Night

Type of Offense	Poor Lighting: Total Number of Offenses	Poor Lighting: Proportion Occurring at Night	Good Lighting: Total Number of Offenses	Good Lighting: Proportion Occurring at Night
Murder, rape, and assault	189	.67	48	.70
Robbery	142	.59	75	.42
Larceny	225	.40	576	.19
Auto theft	6	1.00	6	.49
Other	232	.66	162	.32

Model: $\hat{p} = A + B_I + C_J + \ldots$

Here I = level of first factor

B_I = effect of factor I

M_I = no. of cases with I=i

$\sum_i M_i \cdot B_i = 0$

J = level of second factor, etc.

Fig. 1. Multiple regression model.

TABLE 5

Estimated Effects of Various Factors on the Proportion of All Nighttime Offenses except Robberies

Factor	Levels (Low) 1	2	3	4	5 (High)
A, Grand Mean	...	...	.491	...	...
Degree of commercialization	-.017	.032	.022	.063	-.044
Economic status	.034	.023	.000	.040	-.106
Family disintegration	.003	-.011	.019	-.068	.007
Racial status	-.054	-.035	.047	.036	.028
Street lighting	.061	...	...	...	-.130

TABLE 6

ANOVA, Significance of Street Lighting

Source	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic
Explained by other predictors	82.071	16	5.129	17.33
Additional explained by lighting	10.736	1	10.736	36.26
Total explained by model	92.753	17	5.456	18.43
Residual	1434.184	4844	.296	...
Total	1526.937	4861	...	...

TABLE 7

ANOVA, Significance of Block Effects

Source	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic
Explained by model	70.594	17	4.153	20.16
Additional explained by block effects	32.602	62	.526	2.55
Total explained by block effects	103.196	79	1.306	6.34
Residual	449.796	2187	.206	...
Total	552.992	2226	...	...

TABLE 8

Evaluation of the Significance of the Lighting Effect through Ratio Estimation

Lighting	No. of Blocks n	No. of Offenses* ΣT_i	Sampling Fraction f	Observed Proportion $\bar{p}$	Standard Error of Ratio Estimate† $Se(\bar{p})$	Standard Error under Bernoulli Model‡ $Se'(\bar{p})$
Poor	581	3291	.095	.677	.010	.008
Good	91	1571	.514	.323	.017	.012

* Y_i = No. of night offenses (except street robbery) on block i

T_i = No. of night or day offenses (except street robbery) on block i

† $$Se(\bar{p}) = \sqrt{\frac{1-t}{nT^2} \frac{\Sigma (Y_i - pT_i)^2}{n-1}}$$

‡ $$Se'(\bar{p}) = \sqrt{\frac{\bar{p}(1-\bar{p})}{\Sigma T_i - 1}}$$

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