Regression Analysis of the Effect of Punishment Regimes on Crime Rates in 1960

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ABSTRACT

Background: The effectiveness of punishment regimes on crime rates in the 1960s are of interest to society because of its policy implications.

Methods: We analyzed aggregate data from 1960 on 47 US states from the Uniform Crime Report of the FBI and other US government sources to assess the effectiveness of punishment regimes on crime rates. We used linear regression to estimate the effect of the probability of imprisonment (Prob) and the average time served by offenders in state prisons before their first release (Time).

Results: Among the 47 states evaluated, Prob and Time are negatively associated with crime rate. We adjusted for percentage of males aged 14–24 in the state population, mean years of schooling of the population aged 25 years or over, per capita expenditure on police protection in 1960, unemployment rate ratio of urban males aged 35-39 and urban males aged 14-24, income inequality, and an indicator variable for a southern state (all $P < 0.005$). After adjusting for these factors, crime rate decreases by 2% for each 1,000 month increase in Time ($P = 0.997$) when all other covariates are constant and crime rate decreases by 6% for each 1% increase in Prob ($P = 0.005$) when all other covariates are constant.

Conclusions: The negative associations between punishment regimes and crime rate suggest they were effective deterrents of crime in 1960. Due to the statistical significance of probability of imprisonment on crime rate, this may be the area of focus to decrease crime rates in the United States.

STATISTICAL ANALYSIS

The outcome variable of interest was crime rate measured as the number of offenses per 100,000 population in 1960 (Crime). The main predictors of interest were the average time in months served by offenders in state prisons before their first release (Time) and the probability of imprisonment measured as the ratio of number of commitments to number of offenses (Prob) since Time and Prob measure punishment regimes. Therefore, the base linear regression model includes Time and Prob as predictor variables. The distributions of all variables were assessed using histograms. Crime was log-transformed because Crime is a rate variable whose distribution may be approximated by a Poisson distribution and the residuals of Crime are skew. Means and standard deviations (SD) were calculated for continuous variables, and frequencies and percentages were calculated for categorical variables as shown in Table 1. Pearson correlation coefficients were calculated for all pairs of covariates to identify multicollinearity. Of the aggregated data from 1960 on 47 states of the United States, all of the available data were evaluated and formed the data set for this report. The crime rate reported measures for the number of offenses per 100,000 population. Based on the pairwise correlations, there was potentially problematic collinearity between per capita expenditure on police protection in 1960

(Po1) and per capita expenditure on police protection in 1959 (Po2); the unemployment rate of urban males aged 35-39 (U2) and the unemployment rate of urban males aged 14-24 (U1); and wealth measured as the median value of transferable assets or family income (Wealth) and income inequality measured as the percentage of families earning below half the median income (Ineq). To account for the potential multicollinearity, we averaged Po1 and Po2 to create a new variable that measures the average per capita expenditure on police protection between 1959 and 1960 (Po_avg); created a new variable (Ur) that measures the ratio of the unemployment rate of urban males aged 35-39 (U2) and the unemployment rate of urban males aged 14-24 (U1); and considered excluding either Wealth or Ineq from the final model.

Univariate linear regression analyses were performed for all predictor variables against Crime and log-transformed Crime as shown in Table 2. Linearity of the each univariate model was assessed using Loess curves in R. Additional predictors were identified by a stepwise model selection procedure in SAS using the Schwarz Bayesian Criteria (SBC) with a stay/entry level of 0.15 based on the F-statistic. Effect modification by the indicator variable for a southern state (So) and confounding by the percentage of nonwhites in the population (NW) was assessed using the final multivariate linear model. Outliers were identified using studentized residuals. Influential points and high leverage points were assessed using Cook's distance and hat values, respectively. Statistical analyses were performed using SAS (version 9.4, Cary, NC) and R (version 3.4.1).

RESULTS

Univariate Analyses

Based on the assessment of linearity using Loess curves, we identified the following variables as having a nonlinear relationship to Crime: the labor force participation rate of civilian urban males aged 14-24 (LF), the percentage of nonwhites in the population (NW), and average time in months served by offenders in state prisons before their first release (Time). We created linear splines with one knot point for LF, NW and Time, and determined the location of each knot point by the shape of the Loess curve. The the association between Time and Crime was not statistically significant ($\beta = 8.179$, $P = 0.315$), but there was a statistically significant negative association between Prob and log-transformed Crime ($\beta = -7270.6$, $P = 0.003$). Similarly, the association between Time and log-transformed Crime was not statistically significant ($\beta = 0.008$, $P = 0.339$), but there was a statistically significant negative association between Prob and log-transformed Crime ($\beta = -7.447$, $P = 0.004$).

Multivariate Analyses

For the base model of crime, the additional predictors identified by the stepwise model selection procedure include the percentage of males aged 14–24 in the state population (M), mean years of schooling of the population aged 25 years or over (Ed), per capita expenditure on police protection in 1960 (Po1), number of males per 100 females (MpF), labor force participation rate of civilian urban males aged 14-24 (LF), linear spline of LF, unemployment rate ratio of urban males aged 35-39 and urban males aged 14-24 (Ur), and income inequality (Ineq). For the base model of log-transformed crime, the additional predictors identified by the stepwise model selection procedure include the percentage of males aged 14–24 in the state population (M), mean years of schooling of the population aged 25 years or over (Ed), per capita expenditure on police protection in 1960 (Po1), unemployment rate ratio of urban males aged 35-39 and urban males aged 14-24 (Ur), wealth (Wealth) and income inequality (Ineq). We chose the adjusted model of log-transformed Crime given by the stepwise model selection procedure because it was more parsimonious and simpler to interpret than the adjusted model of Crime given by the stepwise model selection procedure. VIF values were calculated for the covariates of the model of log-transformed Crime to identify potentially problematic collinearity. Wealth and Ineq were identified as potentially collinear with VIF > 5. The F-test was used to evaluate whether to keep Wealth or Ineq or both. The results of the F-test suggested that Wealth was not significant predictor so we excluded Wealth from the model ($P > 0.05$). The absence of potential confounding by the percentage of nonwhites in the population (NW) was confirmed by adding NW to the model and observing that this did not result in a meaningful change (< 10%) in the slopes of Prob or Time. Effect modification by the indicator variable for a southern state (So) was assessed by interacting So with Time and Prob. We found that So modified the effect of Time on log-transformed Crime since the interaction between So and Time was statistically significant ($\beta = -0.044$, $P = 0.002$). However, So did not modify the effect of Prob on log-transformed Crime because the interaction between So and Prob was not statistically significant ($\beta = 5.120$, $P = 0.257$). The F-test was used to evaluate whether to include So and its interaction with Time in the model. The results of the F-test indicated that So and its interaction with Time were significant predictors so we kept them in the model ($P < 0.05$).

In the final model, there was one point with crime rate 750 that was an outlier based on the studentized residuals. This outlier was not a high leverage point because there were no points greater than four times the mean of the hat values. This outlier was also not a high influence point because there were no points greater than the Cook's distance threshold of 12/47. We decided to keep the outlier in the model because it was neither a high leverage point nor a high influence point and we were concerned with overfitting given the limited number of data points ($n = 47$) included in our analyses. According to the final model, crime rate in 1960 decreased by 2% for each 1,000 unit increase in average time served by offenders in state prisons before their first release if all other covariates are constant, and crime rate in 1960 decreased by 6% for each 1% increase in probability of imprisonment if all other covariates are constant (see Table 3).

Table 1 Summary Statistics of Variables

Variables	**Mean (SD)**

Percentage of males aged 14-24 in total state population (M)	13.9 (1.3)
Southern state, n(%) (So)	16 (34)
Mean years of schooling of the population aged 25 years or over (Ed)	10.6 (1.1)
Per capita expenditure on police protection in 1960 (in $) (Po1)	8.5 (3.0)
Per capita expenditure on police protection in 1959 (in $) (Po2)	8.0 (2.8)
Labour force participation rate of civilian urban males in the age-group 14-24 (LF)	0.6 (0.04)
Number of males per 100 females (MpF)	98.3 (2.9)
State population in 1960 in hundred thousands (Pop)	36.6 (38.1)
Percentage of nonwhites in the population (NW)	10.1 (10.3)
Unemployment rate of urban males 14-24 (U1)	0.1 (0.02)
Unemployment rate of urban males 35-39 (U2)	3.4 (0.8)
Wealth: median value of transferable assets or family income (in $) (Wealth)	5253.8 (964.9)
Income inequality: percentage of families earning below half the median income (Ineq)	19.4 (4.0)
Probability of imprisonment: ratio of number of commitments to number of offenses (Prob)	0.05 (0.02)
Average time in months served by offenders in state prisons before their first release (Time)	26.6 (7.1)
Crime rate: number of offenses per 100,000 population in 1960 (Crime)	905.1 (386.8)

Table 2 Univariate Analysis

	Log(Crime)	
Variables	**Estimate**	**p-value**

Percentage of males aged 14-24 in total state population (M)	-0.01839	0.707
Southern state, n(%) (So)	-0.02825	0.826
Mean years of schooling of the population aged 25 years or over (Ed)	0.11102	0.039
Per capita expenditure on police protection in 1960 (in $) (Po1)	0.09055	5.99e-07
Per capita expenditure on police protection in 1959 (in $) (Po2)	0.09369	1.46e-06
(Po1+Po2)/2	0.09240	8.8e-07
Labour force participation rate of civilian urban males in the age-group 14-24 (LF)	1.7570	0.246
Number of males per 100 females (MpF)	0.02067	0.3203
State population in 1960 in hundred thousands (Pop)	0.003643	0.0204
Percentage of nonwhites in the population (NW)	0.002761	0.645
Unemployment rate of urban males 14-24 (U1)	-1.7070	0.617
Unemployment rate of urban males 35-39 (U2)	0.08148	0.261
U2/U1	0.025432	0.0129
Wealth: median value of transferable assets or family income (in $) (Wealth)	1.817e-04	0.00279
Income inequality: percentage of families earning below half the median income (Ineq)	-0.01563	0.309
Probability of imprisonment: ratio of number of commitments to number of offenses (Prob)	-7.4465	0.00402
Average time in months served by offenders in state prisons before their first release (Time)	0.008270	0.339

TABLE 3 Multivariable Logistic Regression of Crime Rates				
Variable	Crime			
	Foundation Model		Full Model	
	Effect on log Crime	Effect on linear Crime	Effect on log Crime	Effect on linear Crime
States evaluated, n	47		47	
Adjusted R2, %	13.4		71.7	
Probability of imprisonment: ratio of number of commitments to number of offenses (Prob)				
β-estimate (P) | % change in Crime Rate	-7.808 (0.007)	-99.959	-5.814 (0.005)	-99.7
95% CI	-13.365 to -2.251	-99.999 to -89.472	-9.737 to -1.89	-99.99 to -84.905
Average time in months served by offenders in state prisons before their first release (Time)				
β-estimate (P) | % change in Crime Rate	-0.003 (0.765)	-0.265	-.00002 (0.997)	-.002
95% CI	-0.020 to 0.015	-2.028 to 1.528	-0.011 to 0.012	-1.162 to 1.172
Percentage of males aged 14-24 in total state population (M)				
β-estimate (P) | % change in Crime Rate	-----	-----	.141 (<.001)	15.1
95% CI	-----	-----	0.071 to 0.211	7.348 to 23.478
Mean years of schooling of the population aged 25 years or over (Ed)				
β-estimate (P) | % change in Crime Rate	-----	-----	.239 (<.001)	27.0
95% CI	-----	-----	0.139 to 0.340	14.882 to 40.463
Per capita expenditure on police protection in 1960 (in $) (Po1)				
β-estimate (P) | % change in Crime Rate	-----	-----	.098 (<.001)	10.3
95% CI	-----	-----	0.066 to 0.130	6.867 to 13.889
Unemployment Rate Ratio: (ur) U2/U1				
β-estimate (P) | % change in Crime Rate	-----	-----	.018 (0.019)	1.8
95% CI	-----	-----	0.003 to 0.033	.310 to 3.325
Income inequality: percentage of families earning below half the median income (Ineq)				
β-estimate (P) | % change in Crime Rate	-----	-----	.076 (<.001)	7.9
95% CI	-----	-----	0.046 to 0.107	4.663 to 11.297
Indicator variable for a southern state (So)				
β-estimate (P) | % change in Crime Rate	-----	-----	1.193 (0.002)	330
95% CI	-----	-----	0.480 to 1.906	162 to 673
Interaction of Time x So				
β-estimate (P) | % change in Crime Rate	-----	-----	-.044 (0.002)	-4.3
95% CI	-----	-----	-0.072 to -0.017	-6.927 to -1.652