The Deterrent Effect of Capital Punishment: Another View

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In a recent paper in this *Review*, Isaac Ehrlich found a negative relationship between the use of the death penalty and homicide rates, over the three and a half decades from 1935–69 in the United States. This empirical finding, in apparent conflict with previous studies on the subject (see Thorsten Sellin, Robert Dann), takes on special meaning because (a) it is the first test of the capital punishment deterrence hypothesis to use econometric estimation techniques, and (b) its publication comes at a time when legislatures and the courts in both the United States and Canada are reshaping public policy on the use of the death penalty. Hence the importance of a second look at Ehrlich's results.

Such a reexamination, described below, suggests that the time-series model and data used by Ehrlich permit no inference about the deterrent effect of capital punishment on homicide. The data indicate that the parameters of Ehrlich's model are extremely sensitive to the choices of included explanatory variables and the functional form of the model; when recast in equally plausible alternative structures, the Ehrlich model fails to generate a deterrent effect for executions. Moreover, Ehrlich's methodological approach to the question, estimation of a single structural equation relating executions to murders, sharply limits the policy implications of the estimated coefficients.

Section I briefly describes Ehrlich's murder rate function and tests the model for parameter stability over the sample period. Section II considers his choice of explanatory variables and functional forms, and examines sensitivity of his estimate to these choices. Section III examines the pitfalls of inferring an execution-murder tradeoff from a single estimated equation.

I

A representative sample of the empirical results reported by Ehrlich in support of the deterrence effect of capital punishment is his equation (1), Table 4, which is displayed as our equation (1) in Table 1. The logarithm of the *U.S.* annual murder rate $(Q/N)^0$ is explained by the logarithm of three deterrence variables (the clearance rate for murder P_a^0, the conviction rate for murder $P_{c/a}^0$, and the ratio of current executions to one-year lagged murder convictions $(PXQ_1)_{-1}$), as well as by the logarithm of five other explanatory variables (the labor force participation rate L, the fraction of the population between 14 and 24 years of age A, an estimate of permanent real per capita income Y_p, the unemployment rate U, and an exponential time trend e^T). The equation is estimated by a two-stage procedure in which P_a^0 and $P_{c/a}^0$ are treated as endogenous variables, and are first regressed on current and lagged values of the predetermined variables, lagged values of all the endogenous variables, and a group of otherwise excluded exogenous variables (real police expenditure per capita $XPOL$, real government expenditure per capita $XGOV$, and the fraction of nonwhites in the population NW). In the second stage an iterative procedure is used to estimate the first-order serial correlation coefficient along with the coefficients of the endogenous and predetermined variables.

Ehrlich presents several versions of this same model (Tables 3 and 4, p. 410), among which the major differences are the use of alternatives to $(PXQ_1)_{-1}$ as empirical sur-

*Columbia University. An early version of this paper was written before the Ehrlich appendix appeared; it uses an alternative data set, available on request from the authors. This paper was listed as a Columbia Workshop discussion paper; it was published in a modified and less technical version in 1976. The conclusion and findings are similar despite the different data set. We would like to thank Phoebus J. Dhrymes and David Kennett for their comments and assistance.

TABLE 1

Equation	Constant	P_a^0	$P_{c/a}^0$	$(PXQ_1)_{-1}$	L	A	Y_p	U	T	P_{63}	C_{63}
(1) 1935–69	−4.060	−1.247	−0.345	−0.066	−1.314	0.450	1.318	0.068	−0.046		
$SSR=.048$	(−1.00)	(−1.56)	(−3.07)	(−3.33)	(−1.49)	(2.20)	(4.81)	(2.60)	(−6.54)		
$\hat{\rho}=.059$											
(2) 1935–69	−5.536	−0.973	−0.375	−0.062	−1.620	0.565	1.363	0.065	−0.046		
$SSR=.049$	(−1.40)	(−1.26)	(−3.10)	(−3.01)	(−1.87)	(2.33)	(4.52)	(2.34)	(−5.86)		
$\hat{\rho}=.204$											
(3) 1935–62	−7.219	0.124	0.236	−0.008	−2.489	0.307	0.795	0.025	−0.029		
$SSR=.019$	(−2.67)	(−0.23)	(−3.04)	(−0.21)	(−3.71)	(1.65)	(3.47)	(1.16)	(−4.09)		
$\hat{\rho}=.048$											
(4) 1935–69	−6.67	−0.491	−0.410	0.055	−2.081	0.545	1.145	0.039	−0.033	−0.112	
$SSR=.045$	(−1.89)	(−0.69)	(−3.41)	(1.03)	(−2.60)	(2.00)	(3.02)	(1.26)	(−2.98)	(−2.00)	
$\hat{\rho}=.524$											
(5) 1935–69	−5.572	−0.698	−0.303	−0.020	−1.803	0.595	1.133	0.054	−0.036	−0.069	−0.113
$SSR=.036$	(−1.70)	(−1.06)	(−3.01)	(−0.41)	(−2.27)	(2.93)	(4.38)	(2.21)	(−4.26)	(−1.36)	(−2.48)
$\hat{\rho}=.013$											
(6) 1935–69	−3.48	−1.138	−0.179	−0.016	−2.321	0.832	1.097	−0.014	−0.0262		
$SSR=.030$	(−1.21)	(−2.35)	(−1.66)	(−0.94)	(−3.81)	(4.91)	(3.11)	(−0.56)	(−2.58)		
$\hat{\rho}=.745$											
(7) 1935–69	−4.698	0.898	−0.425	0.018	−2.009	0.910	1.223	0.041	−0.028		
$SSR=.060$	(−1.10)	(−1.21)	(−2.95)	(0.73)	(−2.29)	(3.18)	(2.41)	(1.15)	(−1.91)		
$\hat{\rho}=.664$											
(8) 1935–69	0.178	−0.00040	−0.00054	−0.00106	−0.264	0.202	0.00012	0.00040	−0.0034		
$SSR=.00015$	(3.25)	(−0.88)	(−3.10)	(−1.26)	(−3.15)	(3.60)	(5.97)	(1.92)	(−6.01)		
$\hat{\rho}=.214$											
(9) 1938–69	0.188	−0.00077	−0.00075	0.0021	−0.200	0.191	0.000091	0.00038	−0.0023		
$SSR=.00014$	(2.79)	(−1.38)	(−2.85)	(1.19)	(−2.20)	(2.82)	(3.22)	(1.41)	(2.80)		
$\hat{\rho}=.216$											

Note: P_a^0 = clearance rate for murder.
$P_{c/a}^0$ = conviction rate for murder.
$(PXQ_1)_{-1}$ = ratio of current executions to one-year lagged murder convictions.
L = labor force participation rate.
A = fraction of population between 14 and 24 (in equation (6) between 18 and 24 years old).
Y_p = permanent income per capita.
U = unemployment rate.
T = time trend.
P_{63} = zero from 1938–62; $(PXQ_1)_{-1}$ from 1963–69.
C_{63} = zero from 1938–62, 1 from 1963–69.
SSR = sum of squared residuals.
$\hat{\rho}$ = estimate of first-order serial correlation coefficient.

rogates for $P_{e/c}$, the subjective conditional probability of execution given conviction. Neither prior judgement nor the estimated coefficients provide much basis for choosing among variant equations. We chose to concentrate on equation (1) because it is the most common form in Ehrlich's tables and because it permits convenient comparisons with the tradeoffs computed by Ehrlich.

Equation (2), Table 1, shows our attempt to replicate equation (1), based on Ehrlich's (1975b) description of the data sources used. Note that the replication is not precise, though the differences are quantitatively small. The source of the differences probably lies either in minor data collection errors or in the use of different computer programs.[1] While these differences could be reconciled were we to use the same numbers and programs as Ehrlich, we feel that the data behind equation (2) are adequate to examine the validity of Ehrlich's conclusions.[2]

Behind the use of time-series estimation is the assumption that the structure and the coefficients to be estimated remain stable over the sample period. In Ehrlich's case it

[1] We used the instruction *TSCORC* of version 2.7 of *TSP* (Time-Series Processor).

[2] This opinion is based on the fact that our examination focuses on factors which dominate the minor differences between equations (1) and (2) such as the murder rate increase in the 1960's and the logarithmic transformation of the execution rate.

is assumed that the behavior of potential murderers is governed by the same variables with the same coefficients over the period 1935–69. If this assumption is in fact not correct, the estimated function would have little use either as an explanation of the causes of murder or of the policy implications of changing the value of an exogenous variable in the structure.

The assumption can be tested.[3] Consider for example the hypothesis that the murder rate function estimated in equation (2) has the same structure from 1935–62 as from 1963–69. Equation (3) with the time-series truncated at 1962 was estimated to test this hypothesis. The F-ratio, computed from the sums of squared residuals in equations (2) and (3) is 6.00, significant even at the 99 percent level. Thus, the hypothesis of structural homogeneity must be rejected. Further, there is nothing special about the shift point chosen for this test. Similar tests were computed[4] for the four possible structural shift points from 1961–64; the F-ratio indicates a significant shift for each of these periods. It is clear therefore that Ehrlich's equation has been estimated over different regimes, a fact which casts considerable doubt on the validity of his estimates.

Since our primary interest is in the deterrent effect of capital punishment, it is important to note that the coefficient of $(PXQ_1)_{-1}$ is very different in equations (2) and (3), turning from -0.062 and significant to -0.008 and insignificant when the sample period is changed. The F-test for the entire equation does not, however, exclude the possibility that changes other than changes in the coefficient of $(PXQ_1)_{-1}$ have generated the statistical significance.

Equations (4) and (5) provide a test of the hypothesis that the coefficient of $(PXQ_1)_{-1}$ is the same over two sample periods under two different sets of assumptions. In equation (4) we add a variable, P_{63}, equal to zero in the years 1938–62 and to $(PXQ_1)_{-1}$ in the years 1963–69. The t-ratio of this variable gives a test of this homogeneity hypothesis, given that all other coefficients are the same over the two periods. The value of the statistic indicates rejection of the hypothesis at the 90 percent level. In equation (5) we add another variable, C_{63}, equal to 0 from 1938–62 and to 1 from 1963–69. The t-ratio of P_{63} in this equation gives a test of the hypothesis of homogeneity of the coefficient of $(PXQ_1)_{-1}$, given that all variables except the intercept are stable over the two periods. The value of this statistic also suggests rejection of homogeneity.

II

Statistical tests for temporal homogeneity in Section I strongly suggest that the coefficients of relevant variables do not remain the same over the 1935–69 period; inclusion of the last few years is vital if one is to infer some deterrent effect for the conditional probability of execution. One casual explanation of this regression result is quite simple. During the 1963–69 period the logarithm of $(PXQ_1)_{-1}$ falls sharply and monotonically (from -0.65 to -3.91, the latter, 2.3 standard deviations below the sample mean) while the logarithm of Q/N increases from its lowest sample value -3.08, to -2.62, the highest sample value. (See Figure 1.) It is possible, of course, that the rise in murder rates is causally linked to the fall

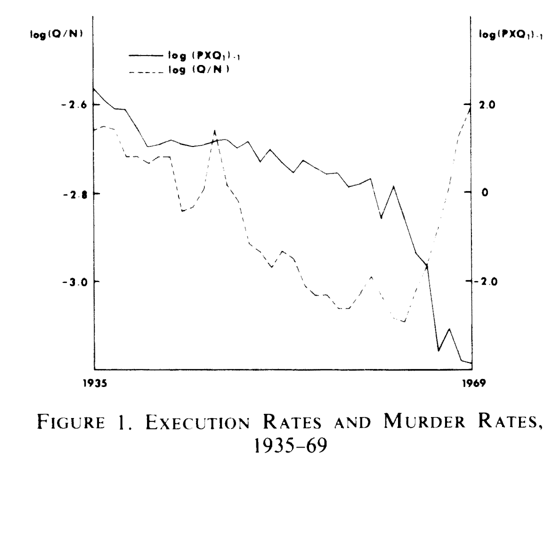

FIGURE 1. EXECUTION RATES AND MURDER RATES, 1935–69

[3]All tests of significance in this paper and in Ehrlich's are based on asymptotic distribution assumptions. Thus what are conventionally called t-ratio or F-ratios in the classical linear regression model will only approximately have the appropriate t or F distribution in these models.

[4]These values are 5.92, 7.07, and 7.36 for the samples ending in 1961, 1963, and 1964, respectively.

in execution rates, as Ehrlich's theory would predict. However the regressions are not in themselves evidence for the existence of such a relationship.

For many observers, alternative explanations of the murder explosion of the 1960's are, a priori, more convincing. As large as increases in murder rates were, the growth rates of other crimes were greater. From 1963 to 1969, per capita reported murders increased 60 percent, robberies by 178 percent, auto theft by 104 percent (see *UCR*, Table 1). Yet few social scientists would choose to connect the increase in auto thefts to the fall in execution rates for murder. Possible nonexclusive explanations for murder rate increases include reduction in the opportunity cost of possessing deadly weapons, racial tension, increases in the difference between economic expectations and opportunities for poor people, reductions in the length of prison sentences. Some of these variables are not easily quantifiable (racial tension, economic frustration, real cost of weapons). Nonetheless their omission from multivariate models of murder rates may so seriously bias the estimated coefficients of included variables that the least squares exercise becomes meaningless. One variable, the expected length of prison sentences given conviction, is not available annually, but is obtainable by state for certain years. It is striking that when the average length of sentences served is included in 1950 and 1960 cross-section regressions, executions lose all explanatory power.[5]

The sensitivity of the estimated coefficient of $(PXQ_1)_{-1}$ to the choice of included variables is notable even for seemingly minor modifications. Ehrlich includes A, the fraction of residential population ages 14–24, to control for shifts in the size of the murder-prone population. Demographic statistics for this age group are easily found in standard reference sources, but the specific choice of the 14–24 year old age group meets no clear theoretical objective. One might plausibly argue on a priori grounds that this age group is unnecessarily broad, young teenagers not being more murder-prone than adults older than 24. Note however that when a narrower target group variable A^*, the fraction of the residential population ages 18–24, excluding armed forces overseas, is substituted for A in Ehrlich's basic equation, the regression results are qualitatively changed.[6] Equation (6) shows the estimated coefficient of $(PXQ_1)_{-1}$ reduced in absolute value and statistically not significantly different from zero.

We do not claim that the major cause of the increase in murders in the 1960's was age group shifts due to the baby boom. This demographic variable may simply be correlated with important omitted variables. What does seem clear, though, is that the data and model employed by Ehrlich do not permit discrimination among numerous plausible explanations of increased murder rates.

Further evidence of sensitivity comes from examining the mathematical transformations of the variables in Ehrlich's model. Theory suggests that an econometric structure should be specified in the mathematical form which conforms most closely to behavioral expectations. In practice, forms are usually chosen which are linear in the parameters to make it easier to interpret the statistical properties of the estimators. And commonly, the logarithmic transformation is chosen to facilitate interpretation of the linear parameter estimates as partial elasticities. In this latter case, the procedure is often justified *ex ante* on theoretical grounds and sometimes *ex post* on statistical grounds. But when the theoretical justification is weak, the results of the estimation are thrown into doubt if they are sensitive to the particular transformation chosen.

In the case of Ehrlich's choice of the logarithmic transformation, the theoretical justification is not convincing. While the elasticity of murder rates with respect to the

[5]See Passell, Tables 1 and 2.

[6]Our source for total residential population is the same as Ehrlich's. The source for the numerator of the fraction was U.S. Bureau of the Census, #114, Table 1 (1933–40), #98, Table 1 (1941–49), #441, #438, Table 4 (1950–69). It was assumed that one-half of all *U.S.* citizens abroad are 18–24, in order to calculate the remaining resident population for the years 1950–69.

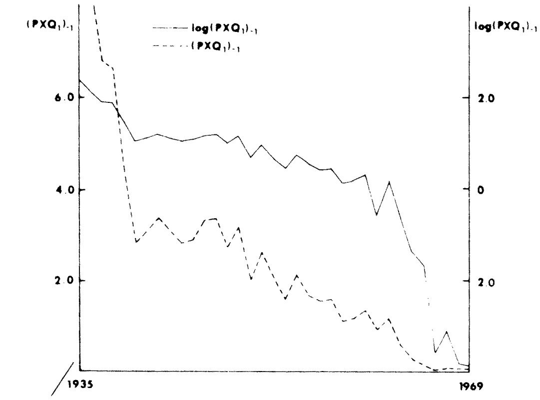

FIGURE 2. EXECUTION RATES, 1935–69; BEFORE AND AFTER *Log* TRANSFORMATION

conditional probability of execution might be approximately constant over some range of the variables, we see no reason why this constant elasticity should hold over the very large range in the observed time-series. However, Ehrlich's finding of significant deterrence effect using 1960's data does appear to be sensitive to the choice of this transformation. Equation (7) is identical to equation (2) with one exception: the data for the conditional probability of execution are employed without transformation to natural *log*s. Note that the coefficient of the execution variables turns positive and statistically insignificant. The intuitive reason for this sensitivity is suggested by the wide difference between the transformed and the untransformed series in Figure 2. Equation (8) uses data for all the variables in untransformed state; the coefficient of execution here is negative, but the *t*-statistic indicates that it is not significantly different from zero.[7]

Given the apparent sensitivity of the model to these transformations, one might be tempted to use statistical criteria to help one choose the correct transformation. But even if these criteria clearly suggested the choice of a particular transformation, one would still question estimation results which were extremely sensitive to this choice in light of the lack of a strong theoretical justification.[8]

III

In this section we abstract from the criticism of Sections I and II to examine another aspect of the analysis. If one were to accept Ehrlich's estimated structure, would it be reasonable to infer a murder-execution tradeoff from the negative coefficient of $P^0_{e/c}$?

Ehrlich argues that this coefficient ($\hat{\alpha}_3$) should be interpreted as an estimate of the partial elasticity of murder rates with respect to the risk of execution. Thus he is able to derive the estimated marginal tradeoff between executions and murders: $\Delta Q/\Delta E = \hat{\alpha}_3(Q/E)$. If one assumes $\hat{\alpha}_3 = -.065$ and Q and E equal to the time-series mean values, $\Delta Q/\Delta E = -7.7$. For $Q = 10{,}920$ and $E - 41$, $\Delta Q/\Delta E = -17.3$.

It is important to note, however, that behind this interpretation of $\hat{\alpha}_3$ lies an important assumption. The coefficient represents the murder-execution tradeoff only if it is possible to alter PXQ_1 without changing the value of any other independent variable in the equation.[9] Yet social scientists (including Ehrlich) interested in economic models of crime typically acknowledge the simultaneity of the system—hence the logic

[7]Sensitivity to functional form is even more delineated when equation (8) is reestimated without the partially extrapolated deterrence data needed to include the years 1935–37. When equation (8) is estimated from 1938–69 the coefficient for $(PXQ_1)_{-1}$ is positive (.0021) and statistically insignificant with a *T*-value of 1.19 (see equation (9)).

[8]One statistical procedure for choosing a transformation has been suggested by G. Box and D. Cox, where the choice is reduced to finding a single parameter α in the transformation $x_t = (x_t^\alpha - 1)/\alpha$, of all the variables in the model. As part of our sensitivity analysis we computed the correlation between the actual murder rates (untransformed) and the predicted murder rates (untransformed) as given by an equation fitted to the Box and Cox transformed variables for 100 values of α between 0 and 1. The highest correlation was at .19 which gave a negative and significant coefficient for the execution variable. However, since the model is not stable over the sample period these estimates provide little insight into the problem.

[9]This may not even be possible if one algebraically interprets the deterrent variables as ratios. If one formally differentiates murder rates with respect to executions in Ehrlich's equation (where Q appears in the denominator of the arrest rate) one finds $\partial Q/\partial E > 0$. For further interpretation of this result see the authors.

of calling criminal behavior functions *supply* functions. For the purposes of estimation, Ehrlich explicitly argues that the probability of arrest and conditional probability of conviction are endogenously determined. Thus one must at the very least account for possible adjustment in these two variables before computing the policy implications of changing the probability of execution.

Traditional methodology offers two alternatives for generating an estimate of the tradeoff. One might estimate the rest of the structural equations in the simultaneous system, or one could estimate the reduced form equation for murder rates. The first alternative is beyond the empirical scope of Ehrlich's paper; no attempt is made to specify the other equation in the system. Ehrlich acknowledges the relevance of the second alternative and does produce negative and statistically significant estimates of the reduced form coefficients of the execution variable for certain specifications of $P_{e/c}$ over the period 1934–69. However our confidence in the value of these estimates is limited (a) by the possible sensitivity to functional form and time period of the estimates, and (b) by the untested assumption that the "modified reduced form" chosen by Ehrlich is not biased by omitted variables.

While it may not be possible to calculate the reduced form murder-execution tradeoff, it is interesting to note the potential sensitivity of the sign of that tradeoff to the elasticity of $P_{c/a}$ with respect to $P_{e/c}$. Many legal experts and social scientists believe that increases in $P_{e/c}$ will reduce $P_{c/a}$, since juries and judges will apply stricter standards for convictions when there is a greater prospect of execution.[10] This widely accepted hypothesis was used successfully as an argument by nineteenth and twentieth century legal reform movement leaders bent on abolishing whole categories of capital crimes and granting juries greater discretion in penalties imposed.[11] By Ehrlich's estimated equation (3) in Table 3, if the absolute value of the elasticity of $P_{c/a}$ with respect to $P_{e/c}$, ϵ_{ce}, were greater than .174, the net impact of an increase in execution probabilities would, perversely, raise murder rates. More generally, the impact will be perverse if $| \epsilon_{ce} | > \alpha_3/\alpha_2$.

[10]See for example, Neil Vidmar; Hugo Bedau; James Bennett; Harry Kalven and Hans Zeisel; Zeisel; Robert Knowlton.

[11]See, for example, Maynard Shipley; John McCloskey.

IV. Conclusion

This examination of Ehrlich's estimates has limited focus. One might wish to examine further the theoretical basis for including or excluding variables in the model, the consistency between the data and alternative hypothetical models, the quality of the data (particularly for the deterrence variables P_a^0, $P_{c/a}^0$, $P_{e/c}^0$) used in the test, and the aggregation problems imposed by the use of national data.

We have essentially confined ourselves to a narrower analysis. First, we have shown that Ehrlich's model does not satisfy the statistical requirement of temporal homogeneity and that the results are sensitive to specification of the variables and transformation of the data. This sensitivity raises grave (and in our own opinion, overwhelming) doubt about the utility of Ehrlich's time-series estimates as partial elasticities. Second, we have argued that even if Ehrlich has captured the essence of the murder rate function in his regression, it is not possible to infer from it that a change in legal institutions which increased $P_{e/c}$ would reduce murder rates. In sum, on the basis of Ehrlich's research, it is prudent neither to accept nor reject the hypothesis that capital punishment deters murder.

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