CRIMINAL DETERRENCE IN THE REDUCED FORM: A NEW PERSPECTIVE ON EHRLICH'S SEMINAL STUDY

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Ehrlich [1973] is perhaps the best known and most influential study of criminal deterrence. Ehrlich's structural estimation of a three-equation simultaneous system found large and significant direct deterrent effects of penalties on crime rates. However, recent theoretical results show that higher penalties may indirectly increase crime rates by reducing the probability of conviction. Hence, a reduced-form model is needed to learn the total effect of penalties on crime rates. Using such a model, we find that the marginal deterrent effects reported by Ehrlich vanish. This result generates much different policy implications than those widely adopted following Ehrlich's publication.

I. INTRODUCTION

Perhaps the best known and most influential econometric analysis of the deterrent effect of criminal penalties is Isaac Ehrlich's [1973] "Participation in Illegitimate Activities: A Theoretical and Empirical Analysis." He reported large and significant marginal deterrent effects of penalties for a wide range of crimes. Ehrlich's work was heavily criticized on methodological grounds, and many subsequent studies have contradicted his results, while still others have not.[1] Nonetheless, Ehrlich's work remains an important hallmark in the study of criminal deterrence.

This note is motivated by recent research that indicates that penalties may have indirect consequences that could reduce their deterrent effect. Higher penalties could, for instance, encourage a criminal to spend more effort avoiding detection and prosecution (Malik [1990], and Snyder [1990]). For instance, as Lott [1987; 1992] shows, higher penalties may increase the amount of money criminals spend on legal defense.[2] This means that higher penalties could reduce the probability of apprehension and conviction. In addition, a feature of the legal system may generate another way for higher penalties to reduce the probability of punishment. This feature is that judges and juries must apply the reasonable doubt test to their decision to convict a defendant. Assume that jurors establish the level of doubt which is "reasonable" by finding the threshold that will minimize expected (social) losses. If juries, like criminals, have a forecast of likely penalties, then as the

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1. Since Blumstein, Cohen and Nagin [1978] researchers have emphasized that studies based on individuals (or that are aggregated at a low level, such as by city, community, or neighborhood) will avoid difficult identification problems inherent in highly aggregated data, such as that used by Ehrlich. For recent work in this area see Bursik et al. [1990], Grogger [1991], Klepper and Nagin [1989], Myers [1983], Schmidt and Witte [1984], Votey [1984], and Witte [1980].

2. Lott goes on to argue that this has the beneficial effect of increasing the penalty (which includes defense expenditures) even though it may reduce the probability of conviction.

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expected penalty rises, the cost of an incorrect conviction also rises. This means the juror's threshold level of reasonable doubt will rise as well. The effect is to reduce the probability that a given defendant will be convicted (Andreoni [1991]). If either the "avoidance" or the "reasonable doubt" effect is significant, then this will mitigate the direct deterrent effect of penalties on crime rates.

Reexamining Ehrlich's work we see that his prime objective was to identify a single equation in a three-equation simultaneous equations system, that being the equation predicting crime rates. He found significant negative coefficients on penalties, which he took as evidence for his theoretical model of criminal behavior in which criminals could be deterred by higher penalties. If more recent theories are correct in claiming that higher penalties may also decrease the chance of conviction, then Ehrlich's estimation of the single equation will not tell a complete story. In particular, we must estimate a reduced-form model which will capture both the direct and indirect effects of penalties on crime rates.

This paper will address these questions using Ehrlich's original data. Replicating Ehrlich's regressions, we find strong direct deterrent effects of penalties. However, we also find that increased penalties have a significant negative affect on the probability of conviction, as predicted by the theoretical studies. We combine these effects by examining the reduced-form equations for both crime rates and probabilities of conviction. We find that the total effect of penalties on crime rates is approximately zero for all twelve crime categories considered but that the effects of penalties on probabilities of conviction remain negative and significant in the reduced-form equations.

This note allows for two general conclusions. First, we provide some evidence for theoretical models that predict that penalties may reduce the probability that criminals will be convicted. Second, and more importantly, despite one's views on the many widely discussed methodological issues surrounding Ehrlich's seminal work, when generalized to account for possibilities that higher penalties may reduce the probability of conviction, his data generate much different policy implications than those widely adopted at the time of his paper's publication.

II. SPECIFICATION

This section discusses the specification of the structural equations for Ehrlich's original study. Every attempt is made to honor Ehrlich's original specifications, data, and intentions. The original data set used by Ehrlich was published in Vandaele [1978]. This data is a cross section of forty-seven states for 1960.[3] Table I lists the variables used, along with their definitions and means. All of the crime rate, probability, and sentence length variables are available for a total of twelve crime categories.

Ehrlich outlined a simultaneous equations model with three endogenous variables: crime rates *CrimeRate*, probabilities of apprehension and conviction *Prob*, and police expenditures *Expend*. He clearly specified the crime rate equation in his (4.1) as[4]

3. While Ehrlich also considered data from 1940 and 1950, those data were not available for this study. This is not constraining, since Ehrlich was primarily concerned with the 1960 data.

4. Ehrlich also tested for the effects of unemployment, labor-force participation and age composition. He augmented his equation (4.1) to become

$$\ln CrimeRate = \alpha_0 + \alpha_1 \ln Prob + \alpha_2 \ln Sentence + \alpha_3 \ln Income + \alpha_4 \ln PctPoor + \alpha_5 \ln PctNonWhite + \alpha_6 \ln Unempl_{14\text{-}24} + \alpha_7 \ln L_{14\text{-}24} + \alpha_8 \ln Age_{14\text{-}24} + \varepsilon_1',$$

which is his equation (4.4). We also estimate systems with equation (1') and find results similar to those reported in this paper. For brevity we do not present these here. Tables containing these results are available from the author upon request.

$$(1)\quad \ln CrimeRate = \alpha_0 + \alpha_1 \ln Prov + \alpha_2 \ln Sentence + \alpha_3 \ln Income + \alpha_4 \ln PctPoor + \alpha_5 \ln PctNonWhite + \varepsilon_1.$$

The primary predictions are that the coefficients on the probability, ln *Prob*, and the time served in prison, ln *Sentence*, should be negative. Predictions for the other coefficients can be found in Ehrlich [1973].

Ehrlich specified one equation for the aggregate "effectiveness of law enforcement" in his (4.5). This equation is

$$(2)\quad \ln Prob = \beta_0 + \beta_1 \ln CrimeRate + \beta_2 \ln Expend + \beta_3 \ln Population + \beta_4 \ln SMSA + \beta_5 \ln PctPoor + \beta_6 \ln PctNonWhite + \beta_7 \ln Edu + \beta_8 \ln Age_{14-24} + \beta_9 South + \varepsilon_2.$$

This is the only specification Ehrlich gives for the structural equation on *Prob*, and will be taken as his intended specification for this equation. Several recent studies indicate that perhaps (2) should also include the potential penalties *Sentence*. One reason, suggested by Lott [1987] and Malik [1990], is that higher penalties may lead some criminals to spend more resources on "avoidance," that is evading detection, or pursuing more vigorous criminal defense. Andreoni [1991] argues that higher penalties may also lead judges and jurors to increase the standards of proof required to convict "beyond a reasonable doubt," leading to fewer convictions.[5] For this reason we also estimate an equation which includes ln *Sentence* on the right-hand side:

$$(2')\quad \ln Prob = \beta_0 + \beta_1 \ln CrimeRate + \beta_2 \ln Expend + \beta_3 \ln Population + \beta_4 \ln SMSA + \beta_5 \ln PctPoor + \beta_6 \ln PctNonWhite + \beta_7 \ln Edu + \beta_8 \ln Age_{14-24} + \beta_9 South + \beta_{10} \ln Sentence + \varepsilon_{2'},$$

where the coefficient on ln *Sentence* is predicted to be negative.

The final equation, on expenditures, was not explicitly specified by Ehrlich. In his equation (3.8) Ehrlich presented a partial adjustment model of expenditures that, in log form, is

$$(3)\quad \ln Expend = Z\gamma + \gamma^* \ln CrimeRate + (1-\gamma^*) \ln Expend_{t-1} + \varepsilon_3$$

where Z is a vector of exogenous variables intended to represent, in part, the expected loss due to crime. Ehrlich (footnote 34) indicates that one way to proxy for this is to include lagged crime rates, $CrimeRate_{t-1}$, in Z. There are two remaining exogenous variables used in Ehrlich's two-stage least-squares estimates that have not yet entered any structural equation, the unemployment rate of males, $Unempl_{35-39}$, and the percentage of the population that is male, *PctMales*. We must assume that Ehrlich also meant to include these in the expenditures equation. However, Ehrlich made no attempt to estimate equation (3) due to a lack of variables needed to fully specify this equation. Since we have no additional data here, we also will not attempt to estimate this equation.

5. See Snyder [1990] for empirical evidence of this effect in the enforcement of antitrust laws.

TABLE I
Definition and Means of Variables
Used in Ehrlich's [1973] Study*

Variable	Description	Mean
CrimeRate	Crime rate: known offenses per 100,000 people; all crimes.	905.07
$CrimeRate_{t-1}$	*CrimeRate* lagged one year; all crimes.	817.93
Prob	Probability of apprehension and imprisonment: number imprisoned per offenses known; mean for all crimes.	.047
Sentence	Average time served by offenders in state prisons; mean for all crimes.	26.60
Expend	Per capita expenditures on police, fiscal 1960.	8.50
$Expend_{t-1}$	Per capita expenditures on police, fiscal 1959.	8.02
Income	Median income of families.	5253.8
Population	Population of the state in 1960, 100,000s.	36.518
PctPoor	Proportion of families below one-half the median income.	.19
PctNonWhite	Percent of non-whites in the population.	10.11
Age_{14-24}	Percent of all males of age 14 to 24.	13.86
$Unemph_{14-24}$	Urban unemployment rate for males aged 14 to 24.	9.54
$Unemph_{35-39}$	Urban unemployment rate for males aged 35 to 39.	3.40
L_{14-24}	Labor force participation rate for urban males aged 14 to 24.	.56
Edu	Mean years of education for those over 25.	10.56
SMSA	Percent of population in SMSAs.	48.40
PctMales	Number of males per 100 females.	98.30
South	Dummy variable for southern states.	.34

*More detailed descriptions can be found in Ehrlich [1973] or Vandaele [1978].

III. RESULTS

Equations (1), (2) and (2′) were estimated for all twelve crime categories. Space constraints will not allow all of the regression results to be reported, but for illustration the structural parameters for these three equations for the "all crimes" category are listed in Table II.[6] The first thing to note from Table II is that the coefficient on the penalty ln *Sentence* in equation (1) is −1.063 and is highly significant (t = −4.49). This indicates a large direct deterrent effect of penalties. Turning to equations (2) and (2′), we see that the coefficient on ln *Sentence* in (2′) is −.858, and is also highly significant (t = −4.21). Moreover, the addition of ln *Sentence* to equation (2) significantly increases the R^2 of the regression.[7] This is consistent

6. One should note that computational errors made by Ehrlich were discovered during Vandaele's [1978] replication. These errors do not change Ehrlich's qualitative finding. However, they do imply that the coefficients we report on the crime rate equations will not be identical to those published by Ehrlich, but instead will match those found by Vandaele [1978].

7. A standard F-test for the significance of additional regressors is $F(1,37)=18.5$, which is highly significant.

TABLE II
Structural Coefficients and Standard Errors for the All Crime Category

Equation Variable	(1) ln *CrimeRate*	(2) ln *Prob*	(2′) ln *Prob*
Constant	−2.169 (3.581)	1.489 (2.477)	4.702* (2.191)
ln *CrimeRate*		−.854** (.226)	−.674** (.192)
ln *Prob*	−.937** (.156)		
ln *Expend*		.219 (.358)	−.169 (.311)
ln *Sentence*	− 1.063** (.237)		−.858** (.204)
ln *Income*	1.383** (.471)		
ln *PctPoor*	1.779** (.408)	1.094 (.623)	.724 (.525)
ln *PctNonWhite*	.261** (.050)	.267** (.092)	.257** (.077)
ln *Population*		−.226** (.076)	−.063 (.074)
ln *SMSA*		−.059 (.039)	−.045 (.033)
ln *Edu*		2.370* (.898)	1.498 (.774)
ln Age_{14-24}		−1.074 (.817)	−1.036 (.678)
South		.428* (.189)	.298 (.160)
R^2	.736	.787	.858

**Significant beyond the .01 level
*Significant beyond the .05 level

with a substantial avoidance or reasonable-doubt effect of penalties on probabilities of conviction. Hence, it is reasonable to expect that the structural parameter on ln *Sentence* reported from equation (1) will overstate the total deterrent effect of penalties.

Table III reports the parameters on ln *Sentence* in the structural equations (1) and (2′) as well as in the reduced-form equations for crime rates, ln *CrimeRate*, and probabilities of conviction ln *Prob*. The reduced-form coefficients are obtained from the ordinary-least-squares regres-

TABLE III
Reduced Form Reanalysis of Ehrlich's Data
The Structural and Reduced Form Coefficients
(standard errors) on ln *Sentence*

	Structural Equations		Reduced Form	
Crime Category	ln *CrimeRate*	ln *Prob*	ln *CrimeRate*	ln *Prob*
All	−1.063**	−.858**	.012	−.842**
	(.237)	(.204)	(.069)	(.220)
Burglary	−1.069**	−1.125**	−.135	−1.063**
	(.227)	(.212)	(.079)	(.213)
Larceny	−.546	−1.464**	−.061	−1.515**
	(.290)	(.508)	(.072)	(.541)
Auto Theft	−.249	−.424	.030	−.483
	(.147)	(.278)	(.070)	(.306)
Larceny & Auto Theft	−.614**	−1.028**	.011	−1.008**
	(.215)	(.353)	(.065)	(.390)
Property	−.874**	−.846**	−.083	−.857**
	(.205)	(.231)	(.076)	(.253)
Assault	−.950*	−1.021*	.108	−1.220**
	(−.416)	(.394)	(.107)	(.449)
Murder	−.086	.095	.005	.111
	(.126)	(.121)	(.079)	(.148)
Rape	−.351	−.432*	−.062	−.278
	(.189)	(.191)	(.100)	(.189)
Murder & Rape	−.342**	−.280*	.009	−.202
	(.108)	(.113)	(.059)	(.121)
Robbery	−.346	−.188	−.034	−.328
	(.255)	(.208)	(.128)	(.248)
Person	−.483**	−.315*	.100	−.410**
	(.143)	(.151)	(.074)	(.177)

**Significant beyond the .01 level
*Significant beyond the .05 level

sions conducted as the first stage to the two-stage least-squares procedure. We see from the first column of Table III that Ehrlich's main finding is replicated. For seven of the twelve categories there is a significant direct deterrent effect of penalties. However, we also see from column 2 that in nine of twelve categories the penalty has a significantly negative effect on the probability of conviction. While the data is not precise enough to clearly identify the avoidance or reasonable doubt models, this coefficient is consistent with their predictions. In the final two columns we can see the total effect of penalties in the reduced-form equations. In all of the twelve categories the total effect of penalties on crime rates collapses to almost

zero. The point estimate is actually positive in seven of the categories, although in no category is the effect significant. By contrast, the coefficients on ln *Sentence* in the ln *Prob* (probability of conviction) equations remain negative and largely significant in the reduced form.

Although the coefficient on ln *Sentence* was never seen to have a significant effect on crime rates, other variables were often significant in the reduced-form equation. These include ln $CrimeRate_{t-1}$, as well as demographic variables such as ln *Income*, ln *Population*, ln *PctPoor*, ln *PctNonWhite*, ln *PctMales* and *South*. Surprisingly, lagged expenditures on law enforcement, ln $Expend_{t-1}$, was only significant in the reduced-form equation for larceny, with a coefficient of −0.292 (*s.e.* = 0.135). It is likely, however, that the lack of significance is due to measurement problems and the difficulty of making meaningful comparisons across states.

IV. CONCLUSION

Ehrlich's [1973] paper remains one of the best known and most influential studies of criminal deterrence. This paper notes that Ehrlich only discussed the partial effect of penalties by estimating just one of the structural equations of his three-equation model. Penalties that affect crime rates directly may have indirect effects via other endogenous variables. To measure the total effect, we reconsider Ehrlich's data but estimate the reduced-form coefficients.

In reanalyzing Ehrlich's model, we find that the parameters in the structural equations are broadly consistent with economic models of crime. First, penalties have a direct and significant negative effect on crime. This is consistent with a direct deterrent effect of penalties. Second, penalties have a direct and significant negative effect on probabilities of conviction. This suggests the existence of possible "avoidance" or "reasonable doubt" effects in which players in the legal process, such as judges and jurors, make decisions that mitigate the impact of sentencing policies. Combining these effects in the reduced-form parameters yields marginal deterrent effects of approximately zero for all twelve crime categories, and none of the effects is significant. Nonetheless, the reduced-form effects of penalties on probabilities of conviction remain negative and significant.

This paper now puts Ehrlich's seminal work in a new light. When generalized to account for the fact that penalties may reduce the probability of conviction, Ehrlich's data generate much different policy implications than those widely adopted at the time of its publication.

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