CAPITAL PUNISHMENT AND
THE DETERRENCE HYPOTHESIS:
SOME NEW INSIGHTS AND EMPIRICAL EVIDENCE

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Economists have made repeated efforts through both theoretical modeling and empirical testing to understand the deterrent effect of capital punishment. By and large, they have found a negative and statistically significant effect of capital punishment on the act of murder (that is, the death penalty deters murder). Ehrlich (1975) provides the first systematic analysis of the relationship between capital punishment and murder along with the first empirical test of the deterrence hypothesis concerning not only capital punishment but also other deterrent measures. His results suggest that on the average eight murder victims might have been saved as a result of one execution for the sample period 1953-87 in the United States. Although Ehrlich's work was criticized by scholars such as Waldo (1981) and Forst (1983), many subsequent studies, using independent time-series and cross-section data from the United States (Ehrlich, 1977; Layson, 1985; Cluninger, 1992; Ehrlich and Liu, 1996; Denhaksh, et al., 2000), Canada (Layson, 1980) and the UK (Walpin, 1978), have offered corroborating evidence consistent with the deterrence hypothesis.

There is, however, a largely unexplained empirical regularity in the United States: murder rates appear to be higher in states where the death penalty is legal and actually imposed than in states where the death penalty has been abolished either by law or in practice. Some have taken this as testimony against the deterrence hypothesis. By no means can this regularity be held as evidence that the introduction of the death penalty encourages the act of murder and its abolition helps to reduce murder. This is essentially because the abolition or reinstatement decision on the death penalty itself is endogenous, associated mainly with the public sentiments for and against the death penalty. This suggests that there exists a possible simultaneous relationship between the murder rate and the death-penalty status. Surprisingly, none of the existing studies take this simultaneity issue into account. Furthermore, it has been commonly assumed that the effects of deterrent measures and socioeconomic factors on murder rates are independent of the death-penalty status. This is disputable on both theoretical and econometric grounds.

In the next section, we present a simple model to show that the effects of certain deterrence differ between retentionist and abolitionist states. An increase in a deterrence measure in retentionist states, say, the conditional probability of conviction given arrest, reduces the expected gains from committing murder by increasing both

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the probability of imprisonment and the unconditional probability of execution for murder. In abolitionist states, however, a similar increase in the deterrence measure raises only the probability of imprisonment and therefore would yield a smaller deterrent effect on murder. An important insight the model offers is that abolishing the death penalty not only discards capital punishment as a valuable deterrent but also diminishes the deterrent effects of other deterrents. The empirical implication of the model is that the estimation of murder supply function must be conducted separately for these two types of states. Moreover, to the extent that the death-penalty status is endogenously determined, ordinary or generalized least-squares (OLS or GLS) estimates of the effects of deterrent measures on murder based on stratified samples would suffer from selection bias and are, therefore, inconsistent. Accordingly, we propose an econometric model that takes such bias into account. The econometric model, consisting of two structural equations of murder supply and a decision equation determining the death-penalty status, falls in the general class of switching models. We use a well-known U.S. data set to test the implications of the theoretical model. The results indicate that the selection bias is substantial, justifying our proposed econometric formulation. The results are consistent with our theoretical predictions and robust to alternative specifications, and lend support to the deterrence hypothesis. Concluding remarks are offered in the last section.

THE MODEL

We introduce a simple model to analyze how offenders respond to changes in deterrence measures with and without the presence of the death penalty. The model is an extension of the one analyzed in Ehrlich [1975]. The point of departure is that we consider offenders’ behavior in retentionist and abolitionist states separately.

Formally, assume that person o’s utility depends on his/her own consumption $c_i$ and the consumption of others $c_j$, $i = 1, \ldots, n$.

$$U_i = U_i(c_i, c_j)$$

where the direction in which o’s utility is affected by others’ consumption is given by $\frac{\partial U_i}{\partial c_j}$. In the event of a willful murder of person o by person o, the latter is assumed to set person o’s consumption to zero and run the risk of incurring losses in states of the world involving apprehension, conviction, and punishment by imprisonment or by death, if capital punishment is legal. Let three possible consumption prospects be: (1) $c_i(c_o = c_i, c_o = 0)$, when person o is apprehended but not convicted; (2) $C_i(c_o = c_i, c_o = 0)$, when o is convicted and punished by imprisonment; and (3) $c_i(c_o = c_i, c_o = 0)$, when o is convicted and punished by death in a retentionist state. These consumption prospects are in a descending order, $(c_i < C_i)$. Assuming person o, a potential murderer, behaves to maximize expected utility, a necessary and sufficient condition for murder to occur is that o’s expected utility from committing murder exceeds his/her expected utility from any alternative action including committing a lesser crime.

$$U^* = (1 - P^a_i)[U_i(C_i) + P_i(1 - P^a_i)[U_i(C_i) + P^a_i a_i(U_i) > U^*],$$

where $U^*$ and $U^*$ denote, respectively, o’s utility if he/she commits murder or takes an alternative action, $P_i$ denotes the probability of conviction, and $P^a_i a_i$ denotes the conditional probability of execution given conviction.

Equation (2) implies that an increase in the probability or severity of various punishments for murder decreases the expected utility from murder and, hence, reduces the incentive to commit murder (deters murder). Differentiating equation (2) with respect to $P_i$ and $P^a_i a_i$, we obtain the partial elasticities of the expected utility from crime with respect to these probabilities as follows:

$$\varepsilon_{P_i} = \left| \frac{\partial U^*}{\partial P_i} \right| \frac{U_i^*}{1 - P_i}{P_i[U_i(C_i) - U_i(C_i)] + P^a_i a_i[U_i(C_i) - U_i(C_i)]}$$

and

$$\varepsilon_{a_i} = \left| \frac{\partial U^*}{\partial a_i} \right| \frac{U_i^*}{1 - P_i}{P_i[U_i(C_i) - U_i(C_i)]}.$$
more, if the average probability of conviction is greater in retentionist states than in abolitionist states, \( P_c \), the following cross-rank condition ensures:

\[ c_n > c_k. \]

A one percent increase in \( P_c \) is expected to have a greater deterrent effect in retentionist states than in abolitionist states. The economic intuition is that an increase in \( P_c \) in retentionist states decreases the expected utility from committing murder by increasing both the probability of imprisonment and the unconditional probability of execution \( (P_c + P_r) \) for murder, whereas a similar increase in \( P_c \) in abolitionist states reduces the expected utility from murder by raising the probability of imprisonment only. This implies that the supply of murders is more responsive to changes in \( P_c \) in retentionist states than in abolitionist states. If there exists a positive monotonic relation between an average person’s subjective evaluations of \( P_c \) and \( P_r \) and the objective values of these variables, and between an average person’s expected utility from committing murder and the actual murder rate in the population, equations (5) and (8) would become two testable propositions regarding the partial elasticities of the murder rate in a given period with respect to objective measures of \( P_c \) and \( P_r \). The former has been tested and confirmed in Ehrlich (1975, 1977) and Wolpin (1978), among others. The latter, however, is a unique insight of the current study.

Whether the average probability of conviction is greater in retentionist states than in abolitionist states depends on reasons underlying the abolition decision: ideology or economics. A simple model of defense against murder can be used to illustrate the point. Following Becker (1968), we assume that law enforcement agencies seek to maximize a social welfare function by minimizing the per capita loss from murder. Let the social loss be summarized by:

\[ L = L(q, P_c, P_{tr}, T), \]

where \( q \) denotes the rate of murder in the population and \( T \) denotes the length of imprisonment. Let \( P^{*}_c, P^{*}_r \), and \( T^{*} \) denote the optimal values for \( P_c, P_{tr}, \) and \( T \) respectively. If a state abolishes the death penalty on the ideological ground, the optimal law enforcement requires an increase in the value of \( P_c \) above the level had execution been an option and utilized. In this case, the probability of conviction, as a substitute for the conditional probability of execution, will be greater in abolitionist states than in retentionist states. (\( P^{*}_c > P_c \)). Equation (8), therefore, may not apply.

On the contrary, if the death penalty is abolished when the optimal value for \( P^{*}_c \) is zero (that is, when the marginal cost of executing the very first convicted murderer exceeds the marginal social benefit of the execution) the probability of conviction, as a complement for the conditional probability of execution, must be lower in abolitionist states than in retentionist states. This is because a reduction in the severity of damages from murder that leads to \( P^{*}_c = 0 \) or abolishing the death penalty decreases the marginal social benefits not only from the execution but also from the probability of conviction. Optimal law enforcement ensures a reduction in the optimal values of

\[ P_{tr}, \] as well as \( P_c \). Therefore, the probability of conviction is at least as great in retentionist states as in abolitionist states (\( P^{*}_c > P_c \)). Equation (8) is then, guaranteed to hold.

**ECONOMETRIC MODEL AND DATA**

The death-penalty status is likely to be endogenously determined. It relates systematically to the public sentiments for and against the death penalty, which are largely a function of socioeconomic characteristics and pervasiveness of homicide incidence in a state. If these relationships depend on unobserved state characteristics, the distribution of these characteristics in either retentionist or abolitionist states is not representative of the distribution in these two types of states as a whole. Moreover, since our analysis in the previous section suggests that the structure of murder supply function varies with the status of capital punishment, OLS estimates of the supply function based on even the stratified sample will be subject to sample selection bias. Consistent estimates require simultaneous estimations of the murder supply function and the mechanism associated with the decision to abolish or reintroduce the death penalty. Taking into account the restrictions posited by the theoretical analysis in the previous section, we propose an econometric model that contains a system of three equations:

\[ q_x = X_1 \beta_1 + u_x, \]

\[ q_{tr} = X_2 \beta_2 + u_{tr}, \]

\[ I = Z_2 \gamma + \epsilon, \]

where \( q_x \) and \( q_{tr} \) are the murder rates in retentionist and abolitionist states, respectively; \( X_1 \) and \( X_2 \) are row vectors of exogenous variables, including deterrence and socioeconomic variables; \( I \) denotes the propensity of state \( i \) to have the death penalty; and \( Z_2 \) is a row vector of exogenous variables that determine this propensity. \( \epsilon \) is not observable. We observe, however, its realization: \( I = I_1 \) if \( I > 0 \) and \( I = 0 \) if \( I < 0 \). The error terms, \( u_x, u_{tr}, \) and \( \epsilon \), are assumed to have trivariate normal distribution, with a mean vector zero and a covariance matrix

\[ \Sigma = \begin{pmatrix}
\sigma_{11} & \sigma_{12} & \sigma_{1n} \\
\sigma_{21} & \sigma_{22} & \sigma_{2n} \\
\sigma_{1n} & \sigma_{2n} & \sigma_{nn}
\end{pmatrix}. \]

The model fails in the general class of switching models with endogenous switching as suggested by Maddala and Nelson (1977). Such models have been widely implemented in numerous contexts and in various forms.
The Supply-of-Murder Function

Following Ehrlich (1977), we specify the supply of murder function in logarithmic form as,

\[ \ln q = \alpha + \beta_1 \ln T + \beta_2 \ln P_r + \beta_3 \ln P_{cr} + \beta_4 \ln NW + \beta_5 \ln W + \beta_6 \ln X \\
+ \beta_7 \ln Age + \beta_8 \ln Urb + \beta_9 D40 + u \]

The theoretical justifications for including these variables (defined in Table 1) and the log functional form are provided in Ehrlich (1975; 1977) and, therefore, will not be repeated here for the sake of brevity. Note, equation (13) is the specification we adopt for equation (10), that is, the structural equation for retentionist states. The structural equation for abolitionist states or equation (11) is similarly specified, except that the term \( \beta_8 \ln P_{cr} \) is dropped from equation (13).

**Determination of Death-Penalty Status**

Each state faces two choices regarding the death penalty: legalize capital punishment or abolish capital punishment either by law or in practice.\(^{11}\) If we assume that policies emerge as reactions to problems or to public demand, the death-penalty status is largely determined by public sentiments for and against the death penalty. Although there is no theory that suggests what ought to be included in Z, opinion polls conducted in the United States have invariably suggested the importance of the following factors: pervasiveness of murders, electoral ideology, racial composition, affluence, urbanization, religion, and region of the country. A brief discussion of each of these seven factors is in order.

**The Pervasiveness of Murders.** Crime problems affect death penalty decisions. Proportionally high rates of murder and non-negligent homicide and increasing rates for those crimes are likely to increase the support for capital punishment from the society at large. This is consistent with the notion that the support for the death penalty is a utilitarian response to rising crime rates. We measure the pervasiveness of murder incidence by the accumulated murder rates in the four years preceding our sample years (AMR).

**Electoral Ideology.** Previous research shows a strong relationship between public opinion regarding capital punishment in the 1950s and state policies on the issue (Erikson, 1979). In general, ideological conservatism is likely to increase state receptivity to the death penalty. In this sense, Republicans are more likely than Democrats to favor the death penalty. To measure the dominant electoral ideology in a state, we use a dummy variable, DEM, which equals one if the state voted for the Democratic presidential candidate in the most recent elections and zero otherwise.
**Urbanization.** The degree of urbanization also has an ambiguous effect on the death penalty. Some public opinion polls suggest that rural residents are particularly supportive of the death penalty. Alternatively, the impersonality of metropolitan life may lead to greater apprehensions for crime and more pressure on the government to take action to relieve these apprehensions. By this perspective, more urbanized states should be more sympathetic to the death penalty. We use the percent of urban population (Urb) in a state to measure the degree of urbanization.

**Religion and Region of the Country.** The level of support for the death penalty also varies by religious groups. The 1953 opinion poll, the survey nearest our sample years that contains responses by religious affiliation, shows a combined approval rate for capital punishment from Protestants and Catholics that is higher than for the population at large. Though some variation occurs from year to year, overall, the South has been least likely to support the death penalty. The empirical measures of these two factors are Religion, the percent of population belonging to a church, and South, a dummy variable identifying the southern states.

Obviously, this list is not complete. Other important variables are crucial to reinstating the death penalty but are either unavailable in or inapplicable to our sample period. The occurrence of lynching or unusual murder cases, for instance, is believed to be the principal factor prompting the reinstatement of the death penalty in several states during early 1960s. The incidence of legal challenges to the death penalty on constitutional grounds may also affect the public sentiment for capital punishment. For instance, during the period prior to the Furman decision, public support for the death penalty dropped significantly.

The death penalty status equation (the criterion function that determines which of the murder supply equations is applicable) is therefore specified as a probit model:

\[
I = f_{\text{AMR, DEM, NW, W, Urb, Religion, South, } H},
\]

where \( I = 1 \) for retentionist states, \( I = 0 \) for abolitionist states, and \( H \) represents those variables (except the conditional probability of execution \( P_X \), that are included in equation (13) but are not discussed in this section. In principle, since equation (14) is a non-linear function, it can have the same set of independent variables as the murder supply equations without causing any identification problems [Maddala, 1983].

But including extra identification variables in the criterion function would add strength to the resulting estimates. Note that equation (14) contains one variable that are not in the murder supply equations: AMR, DEM, Religion, and South. The lagged accumulated murder rates (AMR) and the ideology variable (DEM) in particular justifiably do not belong in the murder supply equations.\(^11\)

**Data**

Our estimation is based on state-level data from 1940 and 1960.\(^{11}\) Between these two sample years, five states (Delaware, Montana, New Hampshire, Utah, and Wyoming) changed from retentionist to abolitionist status, while four states (Kansas, Nebraska, New Mexico, and South Dakota) switched from abolitionist to retentionist status. Table 1 lists the variables used and states in the sample. Ehrlich [1977] and Ehrlich and Liu [1989] also use this data set. The former contains a more detailed description of the data set as well as the construction of the variables. McManus [1985] and McAleer and Veall [1988], among others, use only part of the data set—namely the subset for 1960.

**RESULTS**

Equations (10), (11), and (12) are estimated using the Two-Stage Method proposed by Lee [1976].\(^7\) We begin with the discussion of the basic results presented in Tables 2 and 3, and then examine the robustness of the results to alternative model specifications as well as alternative hypotheses. We also offer some supplementary evidence that is consistent with the theoretical arguments.

**The Status of the Death Penalty**

Table 2 reports the maximum likelihood probit estimates of the death-penalty decision equation. Note first that AMR, DEM, and T are statistically significant determinants. A high frequency of murder incidence in preceding years increases the propensity for a state to have the death penalty, indicating that states tend to resort to the death penalty as a means to combat the crime of murder when the latter becomes a serious threat to the society. States that punish murder convicts with longer prison terms are also inclined to adopt the death penalty. This is consistent with the optimal response of law enforcement agencies to changes in the severity of damages from crime, which is to increase the optimal values of all deterrence measures.\(^{18}\) It may seem surprising that the estimate for the ideology variable (DEM) is positive because ideological conservatism tends to increase the propensity for the death penalty. Note, however, that during our sample periods, (1940 and 1950) the Democrats...
and the Republicans had more similarities than differences in the realm of politics and ideology. Urbanization (Urb) and Religion are shown to have marginally significant influences on the death-penalty status. A high degree of urbanization increases the propensity for a state to have the death penalty, whereas a high concentration of religious groups reduces this propensity. The estimates for the remaining variables are statistically insignificant. As discussed earlier, racial composition and affluence may have conflicting impacts on receptivity to the death penalty. It is somewhat surprising, however, that South has a negative coefficient, because a large number of executions were actually carried out in southern states.

The estimated probit model is highly significant, with a likelihood ratio test of the hypothesis that the coefficients are zero based on a chi-squared value of 41.62 with 12 degrees of freedom. The model correctly predicts 86 percent of the observations. The likelihood ratio index is 0.44, suggesting quite a good fit of the model.

Estimates of the Elasticities of Murder with Respect to Deterrents

Table 3 reports the estimates of the murder supply functions for retentionist and abolitionist states. For ease of comparison, we report selection-bias-unadjusted estimates in the first two columns. Columns 3 and 4 are selection-bias-adjusted estimates. First of all, the selectivity variables in both columns 3 and 4 are highly significant, indicating that conspicuous correlations exist between the death-penalty decision equation and the supply-of-murder equations. This strongly justifies our econometric formulation and thus suggests that the GLS estimates in columns 1 and 2 as well as those reported in previous studies are inconsistent. Second, all three deterrence variables are negatively and significantly related to the murder rate, confirming the deterrence hypothesis. Third, consistent with the theoretical prediction concerning the ranking order of elasticities of the murder rate with respect to deterrence variables (in absolute terms), the estimated elasticity of the probability of conviction, -0.623, is greater than and statistically different from its counterpart in abolitionist states, -0.360. The elasticity estimates for the severity of punishment (T) are also ranked the same way and the difference between them is statistically different from zero.

There are three evident differences between the selection-bias-adjusted and selection-bias-unadjusted estimates. The first and more important is with respect to the

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<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Murder Supply Functions (GLS/Selection Bias Adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>(1) Retentionists</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>Constant</td>
<td>4.047</td>
</tr>
<tr>
<td>T</td>
<td>(1.284)</td>
</tr>
<tr>
<td>-0.897</td>
<td>(3.305)</td>
</tr>
<tr>
<td>P_c</td>
<td>(-4.217)</td>
</tr>
<tr>
<td>P_T</td>
<td>-0.897</td>
</tr>
<tr>
<td>P_sc</td>
<td>(-7.955)</td>
</tr>
<tr>
<td>N</td>
<td>0.392</td>
</tr>
<tr>
<td>NW</td>
<td>(0.478)</td>
</tr>
<tr>
<td>X</td>
<td>(9.771)</td>
</tr>
<tr>
<td>W</td>
<td>0.867</td>
</tr>
<tr>
<td>Age</td>
<td>0.105</td>
</tr>
<tr>
<td>Sel</td>
<td>(-0.658)</td>
</tr>
<tr>
<td>D0</td>
<td>1.917</td>
</tr>
<tr>
<td>Selectivity Variable</td>
<td>0.425</td>
</tr>
<tr>
<td>R2</td>
<td>0.80</td>
</tr>
<tr>
<td>Number of observations</td>
<td>61</td>
</tr>
</tbody>
</table>

All regressions are weighted by the square root of urban population to account for heteroskedastic variations in the regression models. (Ellrich, 1977; see Table 1.)

The estimate for T in the abolitionist subsample as shown in column 2, without correcting for selection bias, this estimate is positive and insignificant. The selection-bias-adjusted estimate is negative, however, indicating that the severity of punishment deters murder. Apparently, the selection bias is the underlying reason causing the sign reversal. Second, the estimated elasticities associated with the deterrence variables are generally lower when the selection bias is fully accounted for. The changes in these estimated elasticities range from 3 to 30 percent, with the largest reduction occurring in the coefficient on the probability of conviction pertaining to the abolitionist states. Marked changes also appear in the estimates for some of the socioeconomic variables. The third noticeable change is the improvement of the goodness of fit. The adjusted R-squares are higher for the selection-bias-adjusted models than for the selection-bias-unadjusted ones. The improvement is particularly sizable for the model pertaining to abolitionist states.
Accounting for Simultaneity

We have so far treated deterrent variables as exogenous variables. The market model of crime suggests, however, that these measures are simultaneously determined along with the murder rate and public expenditures on enforcement. On the one hand, higher murder rates may lower the probability of apprehending and convicting offenders due to a crowding effect on the efficacy of law enforcement activity if enforcement budgets are constant. On the other hand, optimal law enforcement requires that enforcement budgets and willingness for the society to resort to harsher penalties increase in response to a higher risk of victimization. In the following analysis we treat the probability of conviction ($P_c$) and the conditional probability of execution ($P_e$) as endogenous variables.¹²

In addition to the murder supply function, our underlying econometric structure includes production and demand functions for private protection and public enforcement against murder. The production functions governing the probabilities of apprehension and punishment are usually specified to include real expenditures on law enforcement and technical variables influencing the productivity of these expenditures, such as population density and the volume of crime itself. The demand for enforcement activity, and therefore production of apprehension and punishment probabilities, depends on the perceived risk of, and losses from, victimization. The perceived risks and losses are determined by the crime rate in the population and by population wealth. The conditional probability of execution is also influenced by legislative and judicial decisions.

Besides the exogenous variables in the murder supply equation and selection equation, we have used the total number of police per 100,000 population (POL), the state population, the accumulated rates of all crimes and violent crimes (excluding murder) in the 4 years prior to the sample years in the reduced form equation. The variable POL serves as a proxy for enforcement efforts directed against all crimes. Because murder is only a small fraction of the total crime, POL can be considered exogenous in the regression. The same holds for accumulated flows of total offenses and violent crimes over the preceding 4-year period, which induces a demand for both law enforcement and self-protection by potential victims.

Table 4 presents the two-stage least squares (2SLS) estimates. The first two columns are selection-bias-unadjusted estimates, whereas columns 3 and 4 are selection-bias-adjusted estimates. These results are highly consistent with our theoretical expectations. A few findings are worth highlighting. First, the estimated elasticities of the murder rate with respect to the probability of conviction and the conditional probability of execution given convictions are statistically significant and larger than their GLS counterparts in Table 3. There are two potential sources of simultaneity bias. One is the crowding effect associated with higher crime rates, which affects the estimated deterrent effects in a negative direction. The other is the optimal demand for enforcement in response to higher risks of victimization, which affects the estimated deterrent effects in a positive direction. The 2SLS estimates suggest that the latter bias is stronger. Second, the estimated elasticities of the murder rate with respect to the probability of conviction are significantly larger than the corresponding elasticities with respect to the conditional probability of execution in states with the death penalty. Third, the estimated elasticities of the murder rate with respect to the conviction risk are significantly greater in retributionist states than in abolitionist states. The same ranking order holds for the estimated elasticities related to the length of imprisonment. Fourth, the selectivity variables in columns 3 and 4 of Table 4 remain statistically significant. This implies that selection bias associated with the endogenous death-penalty status persists in the empirical estimation even after we overcome the simultaneity bias concerning certain deterrence variables.

### Table 4

<table>
<thead>
<tr>
<th>Variables</th>
<th>Selection Bias Unadjusted</th>
<th>Selection Bias Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)Rejectionists</td>
<td>(2)Abolitionists</td>
</tr>
<tr>
<td>Constant</td>
<td>0.303</td>
<td>-22.030</td>
</tr>
<tr>
<td>$T$</td>
<td>(1.56)</td>
<td>(-2.54)</td>
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<tr>
<td>$P_c$</td>
<td>-0.438</td>
<td>0.094</td>
</tr>
<tr>
<td>$P_e$</td>
<td>-0.243</td>
<td>0.145</td>
</tr>
<tr>
<td>$P_{ee}$</td>
<td>-1.057</td>
<td>-0.534</td>
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<tr>
<td>$P_{ew}$</td>
<td>-1.01</td>
<td>-2.28</td>
</tr>
<tr>
<td>$P_{ew}$</td>
<td>-0.81</td>
<td>-3.04</td>
</tr>
<tr>
<td>$P_{ew}$</td>
<td>-0.72</td>
<td>-3.04</td>
</tr>
<tr>
<td>$N_W$</td>
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<td>0.017</td>
</tr>
<tr>
<td>$X$</td>
<td>7.555</td>
<td>0.003</td>
</tr>
<tr>
<td>$W$</td>
<td>0.014</td>
<td>2.070</td>
</tr>
<tr>
<td>$A_{pr}$</td>
<td>1.71</td>
<td>0.505</td>
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<td>$A_{pr}$</td>
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<td>2.82</td>
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<td>$A_{pr}$</td>
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<td>$A_{pr}$</td>
<td>1.141</td>
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<td>$U_{ev}$</td>
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<td>$S_{ev}$</td>
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<td>1.023</td>
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<td>$S_{ev}$</td>
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<tr>
<td>Selectivity Variable</td>
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</tr>
<tr>
<td>B²</td>
<td>0.68</td>
<td>0.74</td>
</tr>
<tr>
<td>Number of observations</td>
<td>67</td>
<td>25</td>
</tr>
</tbody>
</table>

See Table 3.

### Controlling for Heterogeneity

States that have the death penalty may differ systematically, in both observable and unobservable ways, from states that do not. For example, there may be substantial heterogeneity among potential criminals in different states, and therefore in the average effect that a particular state law would have on the behavior of offenders. If this is the case, the results in Tables 3 and 4 that rely on cross-state variations may
largely reflect this difference rather than the effects of law change or changes in perceived conviction or execution risk. To resolve the heterogeneity issue in a general way, we implement fixed-effects regressions. In addition to capturing the effects of state-specific observable and unobservable factors, the fixed-effects model eliminates the bias caused by systematic measurement errors in the difference variables across states in any one year, because the estimated coefficients on all regressors are based strictly on within-state variations in these regressors.

Since we need to have at least two full observations per state, the sample is reduced to 64 with 50 observations for the retentionist states and 14 for the abolitionist states. Since it is impossible to run the fixed-effects regression with 8 observations, we focus on the subset of retentionist states and assess the effects of heterogeneity by comparing the fixed-effects estimates with their corresponding counterparts in Tables 3 and 4. Table 5 presents the results.

The fixed-effects estimates of elasticities of the murder rate with respect to the probability of conviction and conditional probability of execution given conviction all have the correct sign and are statistically significant at the 5 percent level or higher. This indicates that the mechanism governing the decision to abolish or retain the death penalty is an important factor affecting the statistical properties of the elasticity estimates. Ignoring the selection bias would result in inconsistent estimates. Second, simultaneity bias associated with deterrence measures matters. 2SLS estimates are larger than their GLS counterparts. Third, the ranking order concerning the elasticities of the murder rate with respect to the conviction and execution risk continues to hold.

While introducing state dummies does not alter the estimates for the deterrence variables, it does bring about dramatic changes in the estimates for the socioeconomic variables. The estimated coefficients on all these variables, except for D40, lose statistical significance, indicating that there are very small within-state variations in these variables.

**Alternative Explanations**

We have attributed the difference in the estimated elasticity of the murder rate with respect to the probability of conviction between retentionist and abolitionist states to the presence or absence of the death penalty. There are likely to be other differences between these two types of states, however, that would also predict a greater responsiveness of the murder rate to the conviction risk. One such factor that has recently received considerable attention is the conditions of state prisons. An increase in prison population is expected to reduce crime through two channels. One is the incapacitation effect: imprisonment incapacitates convicted offenders from participating in criminal activities. The other is the deterrence effect: lengthy prison terms increase the "price of crime" for all offenders. 48 The conditions in prisons matter as well. Crowded or dangerous conditions may serve as an independent deterrent. If the conditions in prisons are much worse in retentionist states than in abolitionist states, the conviction risk may also generate a greater deterrent effect on murder in the former than in the latter states.

This concern is potentially relevant for this study because, historically, southern states are among retentionists and have had higher incarceration rates. 49 Prison conditions have also historically been worse in southern states than in northern states. For example, southern states account for a disproportionate share of states that have had their entire prison system under court order because of overcrowding at some point between 1971-1990 (Levitt, 1998). Although we do not have a direct measure for prison populations or conditions, the dummy variable, South (one for southern states and zero for northern states) seems to be a reasonable proxy. We conduct two types of regression analysis to discriminate the death-penalty effect from the crowded-prison effect.
First, we reestimate all models in Tables 3-5, adding South as an additional regressor to control for prison populations or conditions. The results show that adding South has little impact on the elasticity estimates, especially those pertaining to the conviction risk. The estimated coefficients on South are generally negative, consistent with the hypothesis that prison populations reduce crime, but statistically insignificant. These results are in accordance with the one reported in Levitt [1996] for murder.27

Second, we run separate regressions for retentionist states in the South and North, and compare the elasticity estimates from the two subsets. Both the GLS and 2SLS estimates of the elasticity of the murder rate with respect to the conviction risk are quantitatively (not statistically) larger for northern states than for southern states.29 There is, therefore, no empirical evidence that prison populations or conditions are competing forces with the death penalty that affect the marginal productivity of increased conviction risk in reducing the murder rate.

One indirect piece of evidence supporting the argument that the death penalty raises the elasticity of the murder rate with respect to the conviction risk comes from examining two other violent crimes: robbery and assault. Since robbery and assault are generally not capital crimes in any states, our model predicts that the presence of the death penalty should not affect the elasticity of the incidence of robbery or assault with respect to the conviction risk associated with the crime.30 However, if there are any factors other than the death penalty that are responsible for the results we have obtained so far, we would expect them to have a similar effect on the elasticity estimates for robbery and assault.

Complete data concerning the deterrence variable for robbery and assault, however, are available only for 1980. We restrict our sample accordingly. We estimate the supply functions for robbery and assault. The incidence of robbery (assault) per 100,000 population is specified as a function of the average length of imprisonment, the probability of conviction, and the socioeconomic variables included in equation (13). We allow for possible systematic differences in the elasticities associated with prison terms and the conviction risk by introducing their interaction terms with a dummy variable, which equals one and zero for states with and without the death penalty, respectively. The analysis, therefore, boils down to F-tests for significance of these two interaction terms jointly. The relevant F-statistics are 0.0062 and 0.7285 for robbery and assault supply functions, respectively. This fails to reject the null hypothesis that the elasticities of the incidence of robbery (assault) with respect to the length of imprisonment and the conviction risk are the same for retentionist and abolitionist states.31 More general tests that allow the structural coefficients in the supply functions to be different in the subsets of states with and without the death penalty also lead to the same result in the subsets of states with and without the death penalty. In other words, the death penalty is not serving as a proxy for some other crime-reducing force in the state.

Equations (15) and (16) constitute two testable propositions. If the frequency of execution and length of imprisonment for convicted murderers differ systematically among retentionist states, we should observe commensurate difference in the elasticity estimates with the conviction risk. To test these propositions, we divide the retentionist states into two subsamples using alternative criteria, and then estimate the murder supply function separately for each subset.

Before we report the results, it is important to emphasize that these tests are intended to serve as consistency checks against the main findings of the paper. If higher conditional probabilities of execution given conviction and longer prison terms increase the deterrent effect of the conviction risk among retentionist states, it would only be logical for us to expect that the introduction of the death penalty (raising $P_r$ from zero to some positive values) would produce a similar, if not greater, increase in the effect of the conviction risk on murder. After all, death is the most feared punishment of all.32

Table 6 reports the results.33 Panel A of Table 6 presents GLS (in row 1) and 2SLS (in row 2) estimates of elasticity of the murder rate with respect to the probability of conviction. In column 1, the sample is segmented at the median $P_r$ (6 percent). So, the high and low executing-frequency groups comprise an equal number of observations. In column 2, the sample is segmented at $P_r$ = 10 percent where the difference in $P_r$, between any two consecutive observations is the largest. In this case, the high executing-frequency group contains about 28 percent of the sample. Panel B reproduces the analysis of panel A, using the length of prison terms to divide
the retentionist states into long- and short-imprisonment groups. Columns 1 and 2 use, respectively, the median T (125 months) and the T (161 months) where the largest gap in T between two consecutive observations occurs. The long-imprisonment subset consists of about one third of the sample.

In general, the results in Table 6 strongly support the propositions underlying equations (15) and (16). The estimated elasticities of the murder rate with respect to the conviction risk are greater in states with high frequency of execution than those in states with low frequency of execution in all cases, and are greater in long-imprisonment states than in short-imprisonment states in three of the four cases reported. In a few instances, the difference in the elasticity estimates across the two groups of states is statistically significant (see column 5 of panel A). Consistent with the results of the previous subsections, the 2SLS estimates are generally larger than their GLS counterparts.

CONCLUSION

We have shown that the effect of deterrence measures other than capital punishment on murder is systematically related to the status of the death penalty. The elasticity of the murder rate with respect to the probability of conviction is larger in states with the death penalty than in states without the death penalty. Abolishing the death penalty, therefore, not only discards a valuable deterrent but also lowers the marginal productivity of other possible deterrents in reducing murder. The implication of the theoretical analysis is that the structure of the murder supply function depends on the status of the death penalty. This, along with the fact that the death penalty status in a state is endogenously determined, calls for separate estimations of the murder supply function for states with and without the death penalty, which take into account the selectivity bias associated with the decision to retain or abolish the death penalty.
data suggests, a full implementation of the complete system is impossible. Therefore, all existing studies have relied on the estimation of only the supply function. We do the same.

10. Lee (1976), and Willis and Roe (1979) are just two early and more prominent applications.

11. We consider a statute of limitations of more than 4 years to be equivalent to abolishing the death penalty. Although a false classification of states into three categories (legal and imposed, legal but not imposed, and illegal, but more determinable, the small number of states that fall in the latter two groups makes such improvements operationally impossible.

12. A state-specific influence measure is not available. The median income is used as a proxy for affluence.


15. Religion and South may be in the supply equilibrium equations. We exclude them in order to conform with the specifications adopted in Rohlfs (1977). However, when Religion and South are added to the supply equilibrium, they do not alter the estimation results in the next section. Excluding AMR and LSM from the specification equations does not change the basic results either.

16. It might be desirable to construct a panel from more recent years. However, since the Bureau of Justice Statistics stopped collecting conviction information associated with murder cases after the mid-1970s, we are unable to compute the probability of conviction (P_D) — the key variable in our specification. We omit the 1970s because our estimates are based on the conviction rates available from 1970 onwards.

17. Although a maximum likelihood method may be desirable to increase the efficiency of the estimates, it proves unsatisfactory in our case because the procedure fails to converge. The problem occurs quite similarly in frequent types of empirical studies, and is not peculiar to our data.

18. This also shows the simultaneous relations between offense and defense. In the estimates of the deterrent effects of conviction and execution must be obtained using suitable simultaneous equation techniques. However, this is not feasible in the present context. Because our sample is quite small, the predicted values for P_D and P_E, through reduced form regressions and the selectivity equation via the probit regression are highly correlated. Such strong intercorrelations render the 2SLS estimates imprecise and unreliable.

19. The two parties were almost equally supportive of the death penalty in the 40s and 50s. See John.

20. Note that the median length of time served by convicted murderers first released from prisons in 1951 is similar to 40 years for the imprisonment variable in both 1940 and 1950.

21. Homicide data for the 1 percent level) the null hypothesis that P_D and P_E are jointly uncorrelated. In principle, the implication of this hypothesis is that all the variables are independent of the effective date of the specific crime — is precluded. This is supported by an independent examination of the hypothesis that T is an exogenous variable, conditional on P_D and P_E. Being Hessian test of the hypothesis T is an exogenous variable, conditional on P_D and P_E, being equal to zero is valid.

22. The direction of bias is ambiguous. If criminals in execution states are less responsive to incentives than those in abolishment states, the existence of such heterogeneity would result in a downward bias in the estimated deterrent effects.

23. Scientists in the 1940s and 1950s, we have to drop T from the murder supply equation in the fixed-effects model to avoid perfect collinearity. See footnote 21.

24. These fixed-effects selection bias-adjusted estimates (in columns 8 and 9 of Table 5) should be taken with a grain of salt for two reasons. First, different selection specifications are used for the selection equations, with a grain of salt. Second, the fixed-effects specification is applied to the selection equations only where the supply equation is specified as a fixed-effects model; the fixed-effects selection bias-adjusted estimates are not. As a result, we can only compute the selection bias-adjusted estimates in the first stage of the estimation, this selection bias-adjusted estimates in the second stage of the estimation, thus making it difficult to accurately estimate the fixed-effects model estimates of the model supply equation will also be inconsistent. We also run a fixed-effects model estimates of the model supply equation will also be inconsistent. We also run a fixed-effects model 2SLS estimates insignificant and unable to use this instrument because the first instrument was fitted in early 1950s after our sample periods.

25. The 1972.3.38 elasticity estimates for the probability of conviction are -0.059 (-4.14) and -0.768 (-1.76) for northern states, and -0.174 (-5.09) and -0.901 (-9.91) for northern states. Numbers in parentheses are r-values.


27. The critical value for these tests is F = 2.64 and 2.25 corresponding to the 5 percent level of significance.

28. The results are not sensitive to the inclusion of the conditional probability of conviction for murder, the critical value, F = 3.07; for robbery and assault, respectively. These numbers are smaller than the critical value, F = 3.07, 2.25 corresponding to the 5 percent level of significance.

29. Note that P_D - P_E > 0.

30. There is much evidence that death row inmates appeal for commutation of the death sentence to life imprisonment.

31. To conserve space, we report only the elasticity estimates for P_D. The full version of the table is available from the author upon request.

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WAITING TO EXECUTE:
AN OPTIMAL STOPPING MODEL OF CAPITAL PUNISHMENT STAYS

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INTRODUCTION

In the summer of 1986, the Supreme Court upheld the section of the Antiterrorism and Effective Death Penalty Act of 1996 that strictly limited the federal appeals by state death row inmates (Greenhouse, 1996). More recently, the American Bar Association recommended a moratorium on capital punishment (New York Times, 1997). In February 2000, Governor George Ryan of Illinois, a moderate Republican, imposed a moratorium on executions in that state, citing a record of convicting and sentencing innocent people to death (Johnston, 2000). Liebman et al. (2000) find that the overall error rate in capital cases in Illinois is not unusually high, and is in fact, slightly below the national average. The fact that this move met with little criticism from either major political party indicates some change in political will regarding capital punishment. Support for the death penalty remains high, but is at its lowest point in 19 years (Holmes, 2000). Liebman et al., 2000). According to a poll by the Charlotte (North Carolina) Observer, when life without the possibility of parole is offered as an alternative, support for the death penalty falls below 50 percent. Since Governor Ryan announced the moratorium on capital punishment in Illinois, support for change to the current system has grown even among political conservatives (Holmes, 2000).

The major emphasis of economic research regarding capital punishment has focused on execution as a deterrent to future crime (Ehrlich, 1975; 1977; Cover and Thistle, 1988; McAlister and Veall, 1988; Cloninger, 1991). Contrasting with this focus, others ask, are there economic justifications for capital punishment delays? If so, what is the optimal length of capital punishment stays? At one extreme, McAlister and Spenowits (1976) use principles from welfare economics to argue that capital punishment is not justifiable. In their analysis, the implementation of capital punishment fails to meet the Kaldor test for a Pareto improvement. Reynolds (1977) notes that...