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THE DETERRENT EFFECT OF CAPITAL PUNISHMENT:

A QUESTION OF LIFE AND DEATH

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THE DETERRENT EFFECT OF CAPITAL PUNISHMENT: A QUESTION OF LIFE AND DEATH

by

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"A punishment to be just should have only that degree of severity which is sufficient to deter others."

(Beccaria (1764), p. 117)

The debate over the legitimacy or propriety of the death penalty may be almost as old as the death penalty itself and, in view of the increasing trend towards its complete abolition, perhaps as outdated. Not surprisingly, and as is generally recognized by contemporary writers on this topic, the philosophical and moral arguments for or against the death penalty have remained remarkably unchanged since the beginning of the debate (see Sellin (1959), p. 17 and Bedau (1967), pp. 120-214). One outstanding issue has become, however, the subject of increased investigation, especially in recent years, due to its objective nature and the dominant role it has played in shaping the analytical and practical case against the death penalty. That issue is the deterrent effect of capital punishment, a reexamination of which, in both theory and practice, is the object of this paper.

The multifaceted opposition to capital punishment relies partly upon ethical and aesthetic considerations. It arises also from recognition of the risks of errors of justice inherent in a legal system, errors occasionally aggravated by political, cultural and personal corruption under certain social regimes. Such errors are, of course, irreversible upon application of this form of punishment. But the question of deterrence is separable from subjective preferences among alternative penal modes and can be studied independently of any such preferences. Of course, the verification or estimation of the magnitude of the deterrent effect of the death penalty--the determination of the expected tradeoff between the execution of a murderer and the lives of potential victims it may help save--can, in turn, influence the evaluation of its overall desirability as a social instrument under varying circumstances, even if such evaluation is largely subjective. This may be the reason why the issue is being consistently raised and reexamined by most public bodies investigating the relative merits of the death penalty.

In recent studies (see Becker (1968), Stigler (1970) and Ehrlich (1970, 1972, 1973)), economic theory has been used to present some analytical considerations and empirical evidence that support the notion that offenders respond to incentives and, in particular, that punishment and law enforcement deter the commission of specific crimes. Curiously, two of the most effective opponents of capital punishment, Beccaria in the 18th century and Sellin in recent years, have never, to my knowledge, questioned analytically the validity of the deterrent effect of punishment in general; Beccaria even recognizes explicitly the existence of such a general effect. What has been questioned by these scholars is the existence of a differential deterrent effect of the death penalty over and above its most common practical alternative--life imprisonment. But if the imposition of life imprisonment upon convicted murderers can deter potential felons from committing murders, why cannot the death penalty be expected to have an even greater deterrent effect? Beccaria uses a logical argument to explain his apparently inconsistent viewpoint:

> It is not the intenseness of the pain that has the greatest effect on the mind, but its continuance. . . . The death of a criminal is a terrible but momentary spectacle and therefore a less efficacious method of deterring others. Perpetual slavery . . . has in it all that is necessary to deter the most hardened and determined, as much as the punishment of death. I say it has more. There are many who can look upon death with intrepidity and firmness; some through fanaticism, and others through vanity . . . others from a desperate resolution to get rid of their misery, or to cease to live; but fanaticism and vanity foresake the criminal in slavery, in chains and fetters, in an iron cage; and despair seems rather the beginning than the end of their misery. (Beccaria (1767), pp. 115-117)

Sellin, in the same general spirit, mentions cases showing that "the desire to be executed has caused persons to commit a capital crime" (Sellin (1959), p. 65) and implicitly considers imprisonment for life a more adequate substitute (ibid., pp. 69-79). More important, however, Sellin has presented extensive statistical data that he and others have interpreted to imply, by and large, the lack of a differential deterrent effect of capital punishment (see Sellin (1959, 1961, 1967)).

Whether the death penalty constitutes for the average potential criminal a more severe form of punishment than life imprisonment cannot be settled on purely logical grounds, although crime control legislation, ancient and modern, clearly answers this question affirmatively. Indeed, the fact that convicted offenders almost universally seek and welcome the commutation of a death sentence to life imprisonment is consistent with an intuitive ranking of the death penalty as the harshest of all punishments.

The validity of the differential deterrent effect of capital punishment still remains an open empirical issue, however, both in view of alleged evidence denying its existence and because of the need to verify a distinct deterrent effect that is independent of any preventive effects associated with this form of punishment. (See Ehrlich (1973); by the latter is here meant the total prevention of any future crimes by those executed for capital offenses.) The importance of a unique preventive effect of the death penalty may not be very large in practice because actual imprisonment for life can provide in principle an identical service and because the risk of recidivism among those convicted for murder may be relatively low. But the differential deterrent effect of capital punishment on the incidence of capital offenses may also be partly offset by the added incentive it may create for those who actually commit such offenses to eliminate policemen and witnesses who can bring about their apprehension and subsequent conviction and execution. Moreover, if an offender's subjective probability of being executed approaches unity following his involvement in murder, his incentive to commit additional murders may be enhanced because the marginal cost of additional crimes would then approach zero.

In spite of these somewhat conflicting intuitive expectations concerning the differential deterrent effect of capital punishment this investigation, although by no means definitive, does indicate its independent existence. Two related arguments are offered in this context of which only the second shall be elaborated upon in this paper. First, it may be argued that the statistical methods used by Sellin and others to infer the nonexistence of the deterrent effect of capital punishment do not provide an acceptable test of such an effect and consequently do not warrant such inferences.[1] Second, it is argued that the application of the economic approach to criminality permits a more systematic test of the existence of a differential deterrent effect of capital punishment. Moreover, the theoretical analysis provides some a priori predictions concerning the absolute magnitude and importance of the effect of capital punishment relative to apprehension and conviction. Since the empirical analysis, in spite of many deficiencies in data, allows a quantitative estimation of these effects in practice and is found to be remarkably consistent with theoretical expectations, the paper further elaborates upon analytical and practical implications that are related to the empirical findings.

I. An Economic Approach to Murder and Defense Against Murder

A. Factors Influencing Acts of Murder and Other Crimes Against Persons

The basic propositions underlying the approach here to murder and other crimes against the person are that these crimes are committed largely as a result of hate, jealousy, and other interpersonal conflicts involving pecuniary and nonpecuniary motives or as a by-product of crimes against property, and that the propensity to perpetrate such crimes is influenced by the prospect of gains and losses associated with their commission. The abhorrent, cruel and occasionally pathological nature of murder notwithstanding the empirical evidence concerning its circumstances is at least not inconsistent with these basic propositions. Victimization data reveal that most murders, as well as other crimes against the person, occur within the family or among relatives, friends, acquaintances and members of the same race, and are not committed as a rule by strangers on the street (see PCL, pp. 14, 15, 81, and 82 and Table 1). Indeed, hate and other interdependencies in utility across persons are likely to develop among groups that exercise a relatively close and frequent social contact, rather than among groups that exercise little or no contact. There is no a priori reason to expect those who hate, or, for that matter, those who love other persons to be less responsive to changes in costs and gains associated with activities they may wish to pursue in accordance with their preferences than persons who are indifferent toward the well-being of others.

More formally, assume that persons o's utility from a consumption prospect in a given period is a function of his own consumption c_o and consumption activities involving other persons (with or without o's direct participation), $\underline{c}_j$, $j = 1, \ldots, n$,

$$U_o(C_o) = U_o(c_o, \underline{c}_j) \tag{1}$$

and the sign of $\partial U_o/\partial c_j$ indicates the direction in which o's utility is affected by consumption activities pursued by others. For simplicity, let us conceive of c_o and c_j as activities that are produced by varying combinations of a composite market good x representing, in effect, individual real wealth, and time available for nonmarket activities, t, as follows:

$$c_o = c_o(x_o, t_0) \tag{2}$$

$$c_j = c_j(x_j, x_{oj}, t_j, t_{oj}; E_{oj}) \tag{3}$$

where $x_{oj} \geq 0$ and $t_{oj} \geq 0$ indicate the amounts of goods (wealth) and time allocated by o to affect consumption activities involving other persons, and E_{oj} stands for environmental factors accounting for social and geographic proximity and other opportunities for social interactions between o and j. The unique feature of this multi-person consumption model[2] is that it allows one person (here identified with o) to modify the consumption level enjoyed by others simultaneously with determining his own consumption level through positive or negative transfers of his own time and goods. Such modifications are constrained by the production functions specified in equations (2) and (3), by person o's and all other persons' endowments of x and t in a given period which, in turn, are assumed to be determined separately through optimal production decisions, and by potential "awards" or "penalties" that are conditional upon person o's benevolent or malevolent actions with varying degrees of uncertainty. The focus of the present analysis shall remain actions which harm others.[3]

The preceding framework can be applied to analysis of the incentive to commit murder and other crimes against the person by extending the model to incorporate explicitly the uncertainty associated with the prospective punishments for crime. Specifically, murder can be considered a deliberate action intended by an offender, o, to inflict severe harm on a victim, v, by setting c_v equal to, say, zero at some direct costs of planning and executing the crime and mainly at the risk of incurring detrimental losses in states of the world involving apprehension, conviction, and punishment.[4] By the usual theory of behavior under uncertainty, a necessary and sufficient condition for murder to occur is that o's expected utility from crime exceed his expected utility from an alternative (second best) action:

$$U_o^*(C_o^m | c_v = 0) \equiv \sum_{s=a}^{S} \pi_s U_o(c_{os}) > U_o^*(C_o^\ell | c_v = c_v^\ell) \quad , \qquad (4)$$

where $s = a, \ldots, S$, denote a set of mutually exclusive and jointly exhaustive states of the world including all the possible outcomes of murder;

c_{os} denote the offender's consumption levels, net of potential punishments and other losses, that are contingent upon these states; π_s denote his subjective evaluation of the probabilities of these states; and C_o^m and C_o^ℓ denote, respectively, his consumption prospect in the event he commits murder or takes an alternative action.

To illustrate the behavioral implications of the model via a simple, yet sufficiently general example, assume the existence of just four states of the world associated with the prospect of murder as summarized in Table 2. In Table 2, Pa denotes the probability of the event of apprehension and 1 - Pa denotes its complement--the probability of getting away with crime; Pc|a denotes the conditional probability of conviction of murder given apprehension and 1 - Pc|a denotes it complement--the probability of conviction of a lesser offense (including acquittal); finally, Pe|c and 1 - Pe|c denote, respectively, the conditional probabilities of execution and of other punishments given conviction of murder. An implicit assumption is that none of these states is an empty state--all are relevant for the offender's decision. The (subjective) probabilities of these states are equal, by definition, to the relevant products of conditional probabilities of sequential events that lead to a more final set of states. The last column in Table 2 lists the consumption levels that are contingent upon the occurrence of this set of states. Economic intuition suggests that these consumption levels can be ranked according to the severity of punishment imposed on the offender; that is, $C_a > C_b > C_c > C_d$.

In the preceding discussion the incidence of murder has been viewed to be motivated by hate. As hinted earlier in the discussion, however, murder could also be a by-product, or more generally, a complement of other crimes against persons and property. Since the set of states of the world

TABLE 2

Event		State s	Probabilities π_s	Consumption Prospect C_s
apprehension →	conviction of murder →	execution	$Pa Pc\|a Pe\|c$	$C_d:(c_o=0;c_v=0)$
		imprisonment for murder	$Pa Pc\|a(1 - Pe\|c)$	$C_c:(c_o=c;c_v=0)$
	conviction of a lesser offense or acquittal →	other punishment	$Pa(1 - Pc\|a)$	$C_b:(c_o=b;c_v=0)$
no apprehension →		no punishment	$1 - Pa$	$C_a:(c_o=a;c_v=0)$

underlying the outcomes of these other crimes also includes punishment for murder, the decision to commit these would also be influenced by factors determining the probability distribution of outcomes considered in Table 2. In turn, the incidence of murder would be influenced by factors directly responsible for related crimes. In general, behavioral implications concerning the effect of various opportunities on the incidence of murder ought to be analyzed within a framework that includes related crimes as well. For methodological simplicity and because data exigencies rule out a comprehensive empirical implementation of such a framework,[5] the following discussion emphasizes the effect of factors directly related to murder and the direct effect on murder of general economic factors like income and unemployment. In practice, however, the effect of these latter factors on murder may largely be due to their systematic effects on particular crimes against property.

1. The Effects of Probability and Severity of Punishment

An immediate implication of the model that is independent of the specific motives and circumstances leading to an act of murder is that an increase in the probability of severity of various punishments for murder decreases, relative to the expected utility from an alternative activity, the expected utility from murder or from activities that may result in murder. These implications have been discussed in detail elsewhere (see Ehrlich (1970, 1973)) but the somewhat more detailed formulation of the model adopted in this paper makes it possible to derive more specific predictions concerning the relative magnitudes of the deterrent effects of apprehension, conviction, and execution that expose the theory to a sharper empirical test. Specifically, given the ranking of the consumption levels in states of the world involving execution, imprisonment, other punishment, and no punishment for murder as assumed in the preceding illustration, and given the level of the probabilities of apprehension and the conditional probabilities of conviction and execution, it can be shown that the partial elasticities of the expected utility from crime with respect to these probabilities can be ranked in a descending order as follows:

$$\epsilon_{Pa} > \epsilon_{Pc|a} > \epsilon_{Pe|c} \quad , \tag{5}$$

where $\epsilon_P = -\partial \ln U^*/\partial \ln P$ for $P = Pa, Pc|a, Pe|c$.[6] The interesting implication of equation (5) is that the more general the event leading to the undesirable consequences of crime, the greater the deterrent effect associated with its probability: a one percent increase in the (subjective) probability of apprehension, Pa, given the values of the conditional probabilities $Pc|a$ and $Pe|c$, reduces the expected utility from murder more than a one percent increase in the conditional (subjective) probability of conviction of murder, $Pc|a$ (as long as $Pc|a < 1$), essentially because an increase in Pa increases the overall, i.e., unconditional, probabilities of two undesirable states of the world: conviction of murder and conviction of a lesser offense, whereas an increase in $Pc|a$ raises the unconditional probability of the latter state only. A fortiori, a one percent increase in $Pc|a$ is expected to have a greater deterrent effect than a one percent increase in $Pe|c$ as long as $Pe|c$ is less than unity. If there exists a positive monotonic relation between an average person's subjective evaluations of Pa, $Pc|a$, and $Pe|c$ and the objective values of these variables and between an average person's expected utility from crime and the actual crime rate in the population, equation (5) would then amount to a testable theorem regarding the partial elasticities of the murder rate in a given period with respect to objective measures of Pa, $Pc|a$, and $Pe|c$. On the basis of this analysis, it can be predicted that while the execution of guilty murderers deters the acts of murder, ceteris paribus, the apprehension and conviction of guilty murderers is likely to have an even larger deterrent effect.

Another important theorem associated with the effects of probabilities of apprehension, conviction, and execution for murder is that the absolute magnitudes of their deterrent effects on the murder rate are increasing functions of the levels of Pa, $Pc|a$, and $Pe|c$ and, hence, of the level of the unconditional probability of execution, $Pe \equiv PaPc|aPe|c$. More formally,[7]

$$\frac{\partial \epsilon_P}{\partial P} > 0, \quad P = Pa,\ Pc|a,\ Pe|c \quad . \tag{6}$$

A somewhat surprising implication is that the extent of the deterrent effect of execution as well as of apprehension and of conviction is not independent of the overall frequency with which capital punishment is enforced in practice: the higher the latter, the greater the deterrence from apprehension, conviction, and execution.[8]

Analogously to the effects of the probabilities of various punishments for murder, an increase in the severity of these punishments, their probabilities held constant, decreases the expected utility from murder and so discourages its commission.[9] Furthermore, a change in the severity of a specific mode of punishment for murder is expected to affect the elasticity of the murder rate with respect to both the probability and the severity of that punishment and with respect to other punishments as well. To illustrate the latter propositions, consider a decrease in the severity of imprisonment for murder. This decrease implies an increase in an offender's consumption level in the event he is punished by imprisonment (C_c in Table 2). It also enlarges the difference between the prospective consumption levels that are contingent upon imprisonment and execution, respectively ($C_c - C_d$)--the source of the differential deterrent effect of execution (see equation (5.3) in footnote 6). A decrease in the severity of imprisonment and other related punishments for murder with no change in the severity of punishment by execution can thus be expected to increase the differential deterrent effect of execution as represented by the elasticity of the murder rate with respect to the conditional probability of execution, $\epsilon_{Pe|c}$.

2. Effects of Employment Opportunities, Income and Demographic Variables

Further theoretical development in this section suggests that the incentive to commit murder or other crimes that may result in murder would be enhanced by an increase in relative opportunities to extract material gains via illegal activities or by an increase in what might be termed social interaction between individuals. Predictions regarding the effects of a social interaction variable appear limited because of difficulty in identifying empirical measures of such a variable (see, however, the discussion in footnote 27). In contrast, variations in legitimate and illegitimate earning opportunities may be approximated by movements in the rates of unemployment and of labor force participation and in the distribution of permanent income within the population.

Given the distribution of permanent income, an increase in the unemployment rate, U, or a reduction in the labor force participation rate, L, are unambiguously expected to lessen legitimate employment and earning opportunities. These effects, in turn, would precipitate a relative increase in the gains from crimes involving material gains. Further, they imply a reduction in the opportunity costs of the time expended in crimes of hate and passion and even a decrease in the opportunities costs of relatively short imprisonment terms. Thus, changes over time in the rate of murder and other related crimes may be expected to be anticyclical either because of the direct effects of employment opportunities on the incentive to commit murder or because of the indirect effects of these opportunities on the incentive to commit crimes against property of which murder is often a by-product.

An increase in the level of permanent income, Y_P, may have a direct effect on offenders' incentives to commit various crimes through the association between income and preference for crime or between income and the willingness to assume the risk of punishment for crime. The analysis of income effects becomes more difficult to decipher when changes in the level of permanent income are associated with changes in the distribution of personal income. Conceivably, increases in the permanent income level of potential offenders may not have the same effect on their propensities to harm other persons as would changes in potential victims' income. The theoretical ambiguity with respect to the precise effect of pure changes in income does not justify, of course, the exclusion of income or income inequality from the list of the major determinants of murder and other crimes against the person. Moreover, it has been demonstrated elsewhere (see Ehrlich (1973)) that positive shifts in the level of the entire income distribution or in the degree of income inequality, the extent of law enforcement activity held constant, should be expected on the average to increase the incentive to commit crimes against property. Since murder may be committed partly as a by-product of these other crimes, one may expect in practice a positive correlation between the frequency of murder and, say, the level of permanent income in the population even if murder as an expression of hate were a neutral or an inferior good.

Variations in the age structure of the population may also exert an independent effect on the frequency of murder and of related crimes. Abstracting from any systematic differences in the propensity to commit crimes against persons and property across different age groups, it may be argued that the opportunity cost of imprisonment may be relatively low for young and sometimes for old persons who are part of the labor force because their expected market wages, hence, their opportunity costs of time, are relatively low. Also, law enforcement agencies tend to treat apprehended and convicted offenders of young age groups less harshly than older age groups. To the extent that variations in the probability and severity of punishments imposed on young offenders are not fully accounted for in an empirical investigation, it is important to "control" for the variations in the percentage of this age group in the population in order to estimate more efficiently the effects of other variables. The partial correlation between the murder rate and the percent of young age groups might in such cases be positive. Similar arguments may apply when considering a systematic empirical investigation of the partial correlation between the murder rate and the racial composition of the population or other demographic variables.

B. Defense Against Murder

The hazard of murder creates an incentive for potential victims to protect their lives both privately and collectively. This section deals with specific aspects of social defense via law enforcement that seem particularly relevant in the context of this study. Since the main concern here is the establishment and estimation of the causal relations between the incidence of murder and the enforcement of capital punishment or other punishments for murder, the major determinants of these latter activities must also be identified in light of the economic approach to criminality in order that these determinants and the interactions among them may be adequately accounted for in the empirical investigation.

1. Factors Determining Law Enforcement Activity Concerning Murder

Following the approach adopted in Becker (1968), I shall attempt to derive implications concerning optimal law enforcement activity against murder on the assumption that law enforcement agencies behave as if they seek to maximize a social welfare function by minimization of the per-capita loss from murder.[10] Losses accrue from three main elements: harm to victims net of gains to offenders, the direct costs of law enforcement by police and courts and the net social costs associated with penalties. The behavior of enforcement agencies is assumed to be in accordance with the general implications of the deterrent theory of law enforcement.

For methodological simplicity murder is considered here a uniquely defined capital crime that is punishable in practice, however, by either execution or imprisonment. It is further assumed that public expenditures on law enforcement against murder do not affect the private incentive to provide self-protection against murder (for this concept, see Ehrlich and Becker (1972)) or public expenditures on combatting other crimes, so that optimal law enforcement activity concerning murder can be determined independently of these other activities. The per capita loss function is then assumed to be of the special form

$$L = D(Q) + C(Q, Pc) + (b_1\lambda_1 + \beta_1\lambda_2)PcPe|c\, dQ + (b_2\lambda_1 + \beta_2\lambda_2)Pc(1 - Pe|c)mQ \quad . \tag{7}$$

The first term in equation (7), $D(Q)$, represents the net social damage resulting from the death of murder victims and other related losses. It is assumed to be a continuous, increasing, and twice differentiable function of the rate of murder in the population, Q/N (here referred to as Q) such that $D_o = \frac{\partial D}{\partial Q} > 0$ and $D_{oo} = \frac{\partial^2 D}{\partial Q^2} > 0$.

The function $C(Q, Pc)$ represents the cost of appehending, indicting, prosecuting, and convicting offenders. The aggregate output of this activity can be summarized by the fraction of all murders that are "cleared" or solved by the conviction of their alleged perpetrators. This fraction, θ, may be viewed as an objective indicator of the probability that a perpetrator of murder will be convicted of his crime, $Pc = PaPc|a$,[11] with one qualification: since the probability of legal error, α--that of convicting an innocent defendant--is presumably greater than nil, Pc will exceed θ as long as the probability of legal error is lower than the conditional probability of convicting the guilty. For methodological simplicity, it is henceforth assumed, however, that Pc and θ are proportionally related and that $C_p = \frac{\partial C}{\partial Pc} > 0$ and $C_{pp} = \frac{\partial^2 C}{\partial Pc^2} > 0$, given $0 < Pc < 1$.[12] The rate of murder Q is introduced as a separate variable in C because of the argument and evidence that the costs of producing a given value of θ are higher the higher Q was, for more suspects must then be apprehended, charged and convicted in order to achieve that value of θ. Thus, it is assumed that $C_o = \frac{\partial C}{\partial Q} > 0$, and $C_{oo} = \frac{\partial^2 C}{\partial Q^2} > 0$.

The remaining expressions in equation (7) represent the per capita social costs of punishing guilty and innocent convicts through execution or imprisonment, respectively, where λ_1 and λ_2 are coefficients relating

Pc to the fractions of guilty and innocent convicts, respectively, and $Pe|c$ is assumed to be identically equal to the fraction of all convicts who are subsequently executed. The terms d and m denote the private costs to convicts and their relatives from execution and conviction, and the multipliers b and β indicate the presence of additional costs or gains to the rest of society from administering and otherwise bearing the penalties of execution or imprisonment to guilty and innocent convicts, respectively. Presumably $\beta > b$--the social costs of imprisoning or executing innocent persons are greater than the costs of imposing these punishments on guilty ones if only because of the greater probability of recidivism on the part of the latter.[13] However, the signs of each of these multipliers could in principle be positive or negative depending upon the relative magnitudes of transaction costs involved in meting out penalties including mandatory appeals and commutations of death sentences, on the one hand, and benefits of retribution to victims, accomplishing "justice" by adequately punishing the guilty, and other considerations. The signs of the "social prices" of execution and imprisonment, $\gamma_1 = \lambda_1 b_1 + \lambda_2 \beta_1$ and $\gamma_2 = \lambda_1 b_2 + \lambda_2 \beta_2$, are also a function of the implicit probabilities of apprehending and charging innocent persons as well as the probabilities of legal error tolerated in murder trials. As will be shown later in this section, the magnitudes of γ_1 and γ_2 play an important role in determining optimal law enforcement against murder.

Equation (7) can also be specified as

$$L = D(Q) + C(Q, Pc) + \gamma_1 Pc\ f\ Q \tag{8}$$

where $f = Pe|c\ d + \frac{\gamma_2}{\gamma_1}(1 - Pe|c)m$ is a measure of the expected social costs of punishment for murder. Equation (8) is a generalized version of the loss function considered in Becker (1968). It identifies the relevant set of control variables underlying law enforcement activity as the unconditional probability of conviction, Pc, or the tolerable probability of legal error (see the discussion in footnote 12), the conditional probability of execution, $Pe|c$, the harshness of the method of execution, hence the level of d, and the length of imprisonment, hence the magnitude of m. The following analysis illustrates some behavioral implications of the model by formally considering the choice of optimal values of Pc and $Pe|c$ assuming that values of d and m have been fixed at predetermined levels.

The values of Pc and $Pe|c$ that locally minimize equation (8) must satisfy the following pair of necessary conditions,[14]

$$[D_o + C_o + C_p \frac{1}{Q_p} + \gamma_1 Pc\ f(1 - Ep)]Q_p = 0 \tag{9}$$

$$[D_o + C_o + \gamma_1 Pc\ f(1 - Ef)]Q_f f_e = 0 \tag{10}$$

where

$$Ep \equiv - \frac{\partial Pc}{\partial Q} \frac{Q}{Pc} \equiv \frac{1}{\epsilon_{Pc}}, \quad Ef \equiv - \frac{\partial f}{\partial Q} \frac{Q}{f} \equiv \frac{1}{\epsilon_f} \quad ,$$

$$f_e \equiv \frac{\partial f}{\partial Pe|c} = (d - \frac{\gamma_2}{\gamma_1} m) \quad ,$$

and the subscripts p, f, and e associated with the variables C and Q denote the partial derivatives of the latter with respect to Pc, f, and $Pe|c$, respectively. The product $\gamma_1 f_e$ indicates the difference between the social costs of execution and imprisonment.

Equations (9) and (10) reproduce the general proposition of economic theory that in equilibrium the net marginal gains from convictions and executions must be nil. For example, given the optimal probability of conviction, the probability of execution must be set so as to equal the marginal revenue from execution, $-(D_o + C_o)Q_p f_e$, with its marginal cost, $\gamma_1 Pc\ f(1 - Ef)Q_p f_e$. The former term represents essentially the value of the lives of potential victims saved, and the reduced costs of apprehension and conviction due to the differential deterrent effect of an additional execution on the frequency of murders in the population; the latter term represents essentially the differential value to society of the life of a person executed at a given probability of legal error, including all the various costs of effecting his execution, net of imprisonment costs thereby "saved." Because, in equilibrium, the two must be equated, the optimal probability of execution given conviction of murder need not be unity--capital punishment may not always be imposed even when it is legal--and would depend on the magnitude of the various parameters entering equation (10). A similar interpretation applies to equation (9).

Inspection of the equilibrium conditions given by equations (9) and (10) reveals a number of interesting results. First, it may be noted that if an increase in $Pe|c$ is assumed to unambiguously raise the expected social costs of punishment for murder, that is, if $\gamma_1 f_e = \gamma_1 d - \gamma_2 m > 0$, then it can be shown as an implication of the present model, that, in equilibrium, the deterrent effect associated with capital punishment must be less than unity, or $\epsilon_{Pe|c} < \epsilon_f < 1$.[15] Put differently, executions must only decrease the rate of murders in the population but not the rate of persons executed, for otherwise the marginal cost of execution would be negative and a corner solution would be achieved at $Pe|c = 1$. In contrast, equation

(10) does not have a similar implication regarding the value of ϵ_{Pc}. More specifically, equation (10) shows that the marginal costs of conviction, $[C_p \frac{1}{Q_p} + \gamma_1 Pc\ f(1 - E_p)]Q_p$, include the marginal costs of apprehending and prosecuting offenders in addition to the marginal costs of punishing those convicted of murder. Therefore, the marginal revenue from convictions must also be relatively higher. Indeed, by combining equations (9) and (10) it can readily be shown that in equilibrium $\epsilon_{Pc} > \epsilon_f > \epsilon_{Pe|c}$;[16] that is, the deterrent effect associated with the unconditional probability of conviction must be larger than the differential deterrent effect associated with the conditional probability of execution. This proposition is essentially the same as that derived regarding the response of offenders to changes in Pc and Pe|c (see equation (5)). The compatibility of the implications of optimal offense and defense under the assumption that both offenders and law enforcement agencies regard execution to be more costly than imprisonment or other punishments for murder insures the stability of equilibrium with respect to both activities. It also provides the basis for a sharp empirical test of the theory.

The analysis thus far has been restricted to the assumption that minimization of the per capita costs of crime and law enforcement is the sole objective of law enforcement acvtivity. An additional possible target of social policy, and one which received much emphasis in the Supreme Court decision in 1972 on the constitutionality of capital punishment in the United States, is the minimizing of <u>ex post</u> discrimination among offenders. Clearly, equally guilty offenders do not receive equal punishments: some are executed, others are imprisoned, and still others escape legal sanctions altogether. A concern for equal treatment of all offenders can be expressed formally by introducing into equation (8), as an additional source of social loss, the variance of the actual punishments borne by different offenders (d, m, or, say, zero). This variance is given by

$$v = PcPe|c(1 - PcPe|c)d^2 + Pc(1 - Pe|c)[1 - Pc(1 - Pe|c)]m^2 - 2\,Pc^2Pe|c(1 - Pe|c)dm \;.$$

In this more general model equation (8) ought be rewritten as $L' = L + \Psi(v)$, with $\Psi'(v) > 0$, and equations (9) and (10) should be modified to incorporate the effects of Pc and of Pe|c on L', $\Psi'(v)\left(\frac{\partial v}{\partial Pc}\right)$ and $\Psi'(v)\left(\frac{\partial v}{\partial Pe|c}\right)$, respectively.[17]

As can be easily shown, a separate increase in Pc or in Pe|c will always increase v and hence raise the marginal social costs of convictions and executions if the values of Pc or Pe|c are lower than one-half. At higher values of both variables, an increase in Pc or Pe|c is generally expected to lower v.[18] The magnitudes of $\partial v/\partial Pc$ and $\partial v/\partial Pe|c$ are found to be decreasing functions of Pc and Pe|c, respectively; that is, v is a strictly concave function in each of these variables. In addition, the magnitude of $\partial v/\partial Pe|c$ is found to be always a decreasing function of m and, more generally, an increasing function of (d - m) if $Pe|c \leq \frac{1}{2}$. However, the same is not true in general for the effect of (d - m) on $\partial v/\partial Pc$ if $Pc \leq \frac{1}{2}$. These observations imply that concern for equality of punishment creates an incentive to lower the optimal values of Pc and Pe|c if these variables are lower than one-half and, particularly, when they approach zero. Furthermore, the incentive to lower the optimal value of Pe|c is generally increased when the difference (d - m) increases. It is thus possible that the steady decrease over time in the severity of imprisonment relative to execution, and the relatively infrequent imposition of capital punishment in the United States in recent decades, had precipitated the trend toward the practical abolition of this punishment that culminated in the Supreme Court's decision in 1972 to declare it "cruel and unusual" in violation of the eighth and fourteenth amendments.

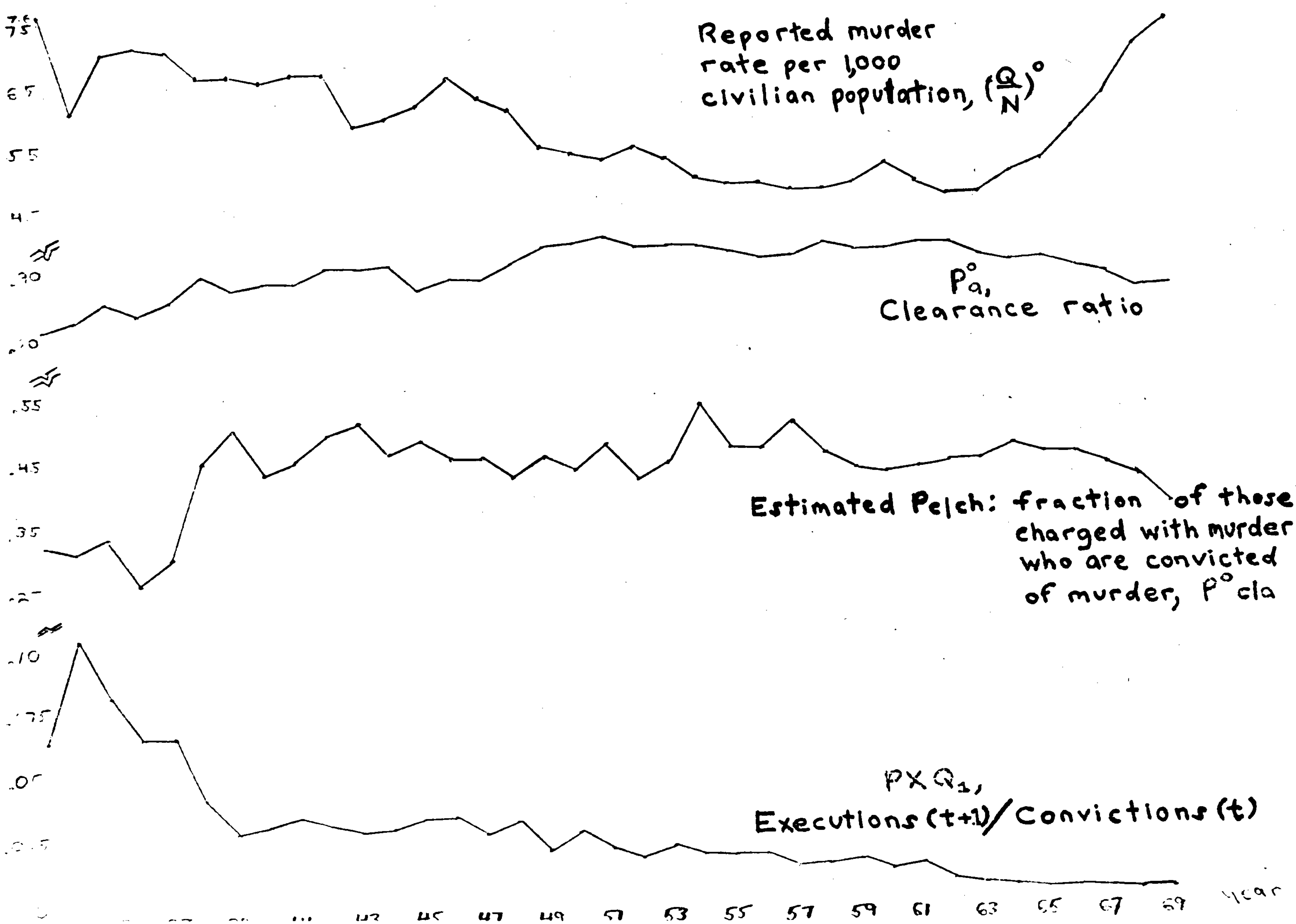
2. The Interdependencies between the Murder Rate and the Probabilities of Conviction and Execution

Although the preceding analysis concerned the determinants of the optimal values of Pc and $Pe|c$, the same framework can be used to derive implications regarding optimal punishments for murder and other factors determining the social cost of murder. The present analysis will continue, however, to focus upon implications concerning the former variables, since only these **have been amenable to empirical investigation.**

Further consideration of equations (9) and (10) indicates that an exogenous decrease in the severity of punishment for murder via a decrease in the conditional probability of execution increases the optimal value of the probability of conviction, Pc, because it tends to decrease the marginal costs of conviction and increase its marginal revenue (proofs of this and other assertions made in this section are given in a mathematical appendix available from the author upon request). But the relation between Pc and $Pe|c$ can be stated more meaningfully if it is assumed that both are subject to control. Given the values of d and m, an increase in social aversion toward capital punishment or simply toward punishment in general, measured by an increase in γ_1 or by an equal proportional increase in both γ_1 and γ_2, can be shown to produce a decline in the optimal value of $Pe|c$ and a simultaneous increase in the optimal value of Pc. This analysis is consistent with an argument often made regarding the greater reluctance of courts or juries to convict defendants charged with murder when the risk or their subsequent execution is relatively high. Conviction and execution can thus be considered substitutes in regard to changes in the shadow price of execution, including the costs of mandatory appeals or, <u>a fortiori</u>, in regard to changes in legal procedures like the compulsory appointment of public defenders that make apprehensions and convictions more costly to achieve. The empirical investigation reveals that at least over the period between 1933 and 1969, in which the estimated annual fraction of convicts executed for murder in the United States, denoted by PXQ_1, fell from roughly 8 percent to nil, the national clearance ratios of reported murders, denoted by $P^o a$, and the fraction of persons charged with murder who were convicted of murder, denoted by $P^o c|a$, on the whole, moved in an opposite direction (see Figure 1). Indeed, the zero-order correlation coefficient between PXQ_1 and $P^o a$ is found to be -0.028, while that between PXQ_1 and $P^o c|a$ is found to be -0.19. (In principle, the product of $P^o a$ and $P^o c|a$ approximates the value of Pc.) The general implication of this analysis is that the simple correlation between estimates of the rate of murder and the conditional probability of execution cannot be accepted as an indicator of the true differential deterrent effect of capital punishment, even if movements in $Pe|c$ are considered to be the result of changes in exogenous factors like public attitudes toward execution, because the simple correlation is then likely to confound the offsetting effects of opposite changes in Pc and possibly also in the severity of alternative punishments for murder.

Just as convictions and executions are expected to be substitutes with respect to changes in the shadow cost of each activity, they can be expected to be complementary with respect to changes in the severity of damages from crime, essentially because such changes increase the marginal revenues from both activities. Since an increase in the rate of murder due

Figure 1


Reported murder rate per 1,000 civilian population, $(\frac{Q}{N})^o$
P_a^o, Clearance ratio
Estimated Pelch: fraction of those charged with murder who are convicted of murder, P^ocla
PXQ_1, Executions (t+1)/Convictions (t)
.55
.45
.35
.10
53
55
57
59
61
63
67
year

to factors outside the control of law enforcement agencies is expected to increase the marginal social damage, D_o, and the marginal costs of apprehension and conviction, C_o, it may also induce an increase in law enforcement activity and hence in the optimal values of both Pc and $Pe|c$. This analysis demonstrates the simultaneous relations between offense and defense and suggests that the deterrent effects of conviction and execution on the incidence of murder must be identified empirically through appropriate statistical techniques. These may be particularly important to pursue if the magnitude of the probabilities of conviction and execution are low, because in such cases the deterrent effect of capital punishment and even the deterrent effect of conviction are expected to be relatively low by equation (6).

II. New Evidence on the Deterrent Effect of Capital Punishment

A. The Econometric Model

The preceding analysis suggests that the differential deterrent effect of capital punishment can be tested empirically via a statistical identification and estimation of a "supply of murders" function within a simultaneous equation regression model that incorporates the major determinants of the frequency of murder, including the conditional probability of execution, and accounts for the simultaneous relations among the endogenous variables of the model. Specifically, the analysis suggests that statistical applications should consider the rate of murder, murder combatting activities, the probabilities of apprehension, conviction, and execution, and even the severity of punishment as endogenous variables, jointly determined by a system of simultaneous equations.

A simple econometric model of crime and law enforcement has been devised and partially tested in my analysis of variations in the rate of murders and other major felonies across states in the United States in 1960. However, due to data shortcomings, the cross-sectional investigation did not include a test of the deterrent effect associated with the conditional probability of execution. In this investigation, an attempt is made to apply essentially the same econometric framework in the analysis of data on the time trends of murders and executions in the United States in the period 1933-1969. Since data limitations appear to rule out the estimation of structural equations relating to law enforcement activities or private defense against murder, the following discussion deals only with the specification of the supply of murders function actually estimated in this study. A more general discussion of some of the underlying structural relations can be found in Ehrlich (1973).

1. The Supply of Murders Function.

Following the analysis of Section I.A, and the specification of the model used in my analysis of crime variations across states (<u>ibid</u>.), it is assumed that the supply of murders function as well as the functions explaining other endogenous varibles are of a Cobb-Douglas variety in the arithmetic means of all the relevant variables. The supply of murders function estimated here is specified as follows:

$$\left(\frac{Q}{N}\right) = K\, Pa^{\alpha_1}\, Pc|a^{\alpha_2}\, Pe|c^{\alpha_3}\, U^{\beta_1}\, L^{\beta_2}\, Y_p^{\beta_3}\, A^{\beta_4} (\exp)^{v} \quad , \qquad (11)$$

where K is a constant term, (exp) denotes the base of natural logarithms, α_i and β_j denote constant coefficients (elasticities), and v is a stochastic variable with zero mean and a finite variance. The regression equation used to estimate the parameters of equation (11) and the reduced form regression equation used to estimate the systematic parts of the endogenous variables entering equation (11) (see the statistical appendix) can thus be derived upon a natural logarithmic transformation of the relevant variables. Equation (11) becomes

$$y_1 = Y_1A_1' + X_1B_1' + v_1 \quad , \tag{12}$$

where y_1, Y_1, and X_1 denote, respectively, the natural logarithms of the dependent variables, other endogenous variables, and all the exogenous variables entering equation (11); A_1 and B_1 are coefficient vectors.[19] The following section discusses the empirical counterparts of these and other variables used in the regression analysis. The method of estimation is outlined in the statistical appendix.

2. Variables Used and Their Limitations

The dependent variable of interest $\left(\frac{Q}{N}\right)$ is the true rate of capital murders in the population in a given year. The statistic actually used, $\left(\frac{Q}{N}\right)^{o}$, is the number of murders and nonnegligent manslaughters **reported by** the police per 1,000 civilian population as computed from data reported by the FBI (UCR)[20] and the Bureau of the Census. This statistic can serve as an efficient estimator of the true $\left(\frac{Q}{N}\right)$ if the two were related by

$$\left(\frac{Q}{N}\right) = k\left(\frac{Q}{N}\right)^{o} (\exp)^{\mu} \quad , \tag{13}$$

where k indicates the ratio of the true number of capital murders committed in a given year relative to all murders reported to the police and μ denotes random errors of reporting or identifying murders. It should be noted, however, that the fraction of capital murders among all murders may have been subject to a systematic trend over time. Indeed, the theory developed in Section I.A, suggests that the decrease in the tendency to apply the death penalty in the United States over time may have led to an increase in the fraction of capital murders among all murders. More important, the number of reported murders may have decreased systematically over time because of the decrease in the fraction of all attempted murders resulting in the death of the victims due to the continuous improvement in medical technology. To account for such possible trends, the term k in equation (13) can be defined as $k = \delta(\exp)^{\lambda T}$, where δ and λ are constant terms and T denotes chronological time. Upon substitution of $(\frac{Q}{N})^{o}$ for $(\frac{Q}{N})$ in equation (11), the inverse values of δ and μ would be subsumed under the constant term, K, and the stochastic variable, v, respectively, and $(\exp)^{-\lambda T}$ would emerge as an additional explanatory variable. Thus, the natural value of T is introduced in equation (12) as an independent exogenous variable.[21]

The matrix of endogenous variables associated with Y_1 in equation (12) includes the conditional probabilities that guilty offenders be apprehended, convicted, and executed for murder. These probabilities have been approximated by computing objective measures of the relevant fractions of offenders who are apprehended, convicted, and executed. However, problems of measurement and interpretation warrant a more detailed discussion of these measures.

Pa is measured by annual national "clearance rates" as reported by the FBI (UCR), which are estimates of the percentage of all murders cleared by the arrest of a suspect. Clearance rates, denoted by $P^{o}a$, would serve as efficient estimates of Pa in the context of the regression equation (12) if the true probabilities of apprehension for capital and noncapital murders were identical or proportionally related and if both the proportion of innocent persons arrested for murder and the ratio of the total number of murders to the number of murder perpetrators remained constant over time.

However, random deviations in these latter ratios would inject downward biases on the estimated elasticity associated with $P^{o}a$.

$Pc|a$ is identically equal to $Pch|a \cdot Pc|ch$--the product of the conditional probabilities that a person who committed murder be charged once arrested and that he be convicted once charged. Again, it is assumed that this probability is the same for both capital and noncapital murders. Statistical exigencies preclude the estimation of a complete series of $Pch|a$, but $Pc|ch$ is estimated here by the fraction of all persons charged with murder who were convicted of the same offense in a given year as reported by the FBI (<u>UCR</u>). This fraction is denoted by $P^{o}c|a$. $P^{o}c|a$ may serve as an efficient estimator of the overall true probability, $Pc|a$, provided that the missing conditional probability of being charged with murder, $Pch|a$, were either constant over time or proportionally related to the probability of arrest Pa. There is, however, a more fundamental problem associated with the use of $P^{o}c|a$ as an indicator of the true $Pc|a$. The implicit assumption underlying the interpretation of the fraction of those charged who were convicted of murder as an estimator of the probability that a guilty offender be convicted of crime is that court decisions are probabilistic in the same sense as are the outcomes of throwing a die. But if court decisions were perfectly efficient so that the guilty were always convicted and the innocent always acquitted, then variations in $P^{o}c|a$ would merely represent variations in the proportion of innocent persons among those charged. In that case, the estimated elasticity of $\left(\frac{Q}{N}\right)^{o}$ with respect to $P^{o}c|a$ might be nil. It would be more realistic to assume, however, that the probabilities of both type I errors (convicting the innocent) and type II errors (acquitting the guilty) are positive. If, in addition, these latter probabilities were proportionally related (see the discussion in footnote 12) and the fraction of innocent persons charged with murder were constant over time, $P^{o}c|a$ and the true $Pc|a$ would be proportionally related[22] and the estimated elasticity associated with $P^{o}c|a$ would reflect the deterrent effect of conviction, as predicted by the theory.

The actual measures of $Pe|c$ consist of alternative estimates based on the expected fraction of persons convicted of murder in a given year who were subsequently executed, $P^{o}e|c = \left|\frac{E}{C}\right|^{o}$. This fraction must be estimated because there are no complete statistics on the disposition of murder convicts in a given year by type of punishment. Instead, $P^{o}e|c$ must be estimated indirectly by matching annual time series data on convictions and executions. Mandatory appeals and other various requirements of due process generate a time lag between conviction and execution. Since over most of the period considered in this investigation (up to 1962) executions appear to lag convictions by 12 to 16 months on the average, an objective measure of $P^{o}e|c$ in year t may therefore be the ratio of the number of persons executed in year $t + 1$ to the number convicted in year t or $PXQ_1 = E_{t+1}/C_t$.[23]

One problem in connection with the use of PXQ_1 as a measure of the true $Pe|c$ is that the fraction of convicts executed for murder may merely represent the fraction of those convicted of capital murders among all murder convicts. Deviations in PXQ_1 might then be entirely unrelated to the likelihood that a convict liable to be punished by the death penalty will be actually executed, and the expected elasticity of the overall murder rate, including both capital and noncapital murders, with respect to PXQ_1, might be nil. However, the significant downward trend in PXQ_1 between 1933 and 1967 suggests, especially during the 1960's, that it may serve as a useful indicator of $Pe|c$, since it seems reasonable to assume that the fraction of capital offenders among all those convicted of murder has been essentially constant and may have even increased over time due to the decline in the tendency to impose capital punishment.

A related problem is due to a particular aggregation bias. The relative variation in the reported national murder rate, $\left|\frac{Q}{N}\right|^{o}$, relates to the United States as a whole whereas the relative variation in PXQ_1 (or alternative estimates of $P^{o}e|c$ discussed below) relates to only a subset of states which retained and actually enforced capital punishment throughout the period considered in this investigation. The fraction of (de facto) abolitionist states remained virtually constant up to 1960 (8 out of 49 states including D. C. until the late 1950's; the fraction then rose to 10 out of 51 with Alaska and Hawaii joining the Union). However, the estimated elasticities of the national murder rate with respect to estimates of $P^{o}e|c$ necessarily understate the true elasticities of the murder rate in retentionist states alone.

Another difficulty associated with the use of PXQ_1 as an estimator of $Pe|c$ is that E_{t+1}, the number of persons executed in year $t + 1$, and hence the ratio E_{t+1}/C_t is, of course, unknown in year t and must be forecast by potential murderers. Even if expectations with respect to PXQ_1 in any given year were unbiased on the average, the actual magnitude of PXQ_1 is likely to deviate randomly from its expected magnitude in time t. The effect of such random noise would be to bias the coefficient associated with PXQ_1 toward zero. I have therefore constructed four alternative forecasts of the desired variable, based on past data on convictions and executions: $PXQ_{1_{-1}} = E_t/C_{t-1}$; $PXQ_2 = E_t/C_t$; TXQ_1 = the systematic value of PXQ_1 computed via a linear distributed lag regression of PXQ_1 on three of its lagged values; and PDL_1 = the systematic part of PXQ_1

computed via a second degree polynomial distributed lag function relating PXQ_1 and four of its lagged values.[24] The advantage of using these alternative estimates (with the exception of PXQ_1) is that they may be treated as predetermined rather than as endogenous variables on the assumption that the random components of current murder rates are uncorrelated with lagged executions and convictions. Alternatively, PXQ_1 is treated as an endogenous variable along with $P^o a$ and $P^o c|a$ and its systematic portion is computed via the reduced form regression equation.

The matrix of exogenous variables associated with X_1 in equation (12) includes annual census estimates of the labor force participation rate of the civilian population 16 years and over (calculated by excluding the armed forces from the total noninstitutional population), L, the unemployment rate of the civilian labor force, U, Professor Friedman's estimate of per capita permanent income (extended through 1969),[25] Y_p, the percentage of residential population in the age group 14-25, A, and chronological time, T. These variables have been discussed briefly in Section II.A, and the relevance of T has been stressed above in the discussion of the dependent variable $\left(\frac{Q}{N}\right)^o$. Other exogenous variables assumed to be associated with the complete simultaneous equation model of murder and law enforcement, X_2, are one year lagged estimates of real expenditure on police per capita, $XPOL_{-1}$, and annual estimates of real expenditure by local, state, and federal governments per capita, XGOV. Real expenditures are computed by deflating Survey of Current Business estimates of current expenditures by the implicit price deflator for all governments. In addition, X_2 includes the size of the total residential population in the United States, N, and the percent of nonwhites in residential population, NW. The reason for including NW in the list of variables subsumed under X_2 is discussed below in Section II.B. A list of all the variables used in the regression analysis is given in Table 3.

B. The Empirical Findings

An interesting finding which poses a challenge to the validity of the analysis in Section I is that over the period 1933-1969, the simple correlation between the reported murder rate and estimates of the objective risk of execution given conviction of murder is positive in sign. For example, the simple (zero-order) correlation coefficients between $\left(\frac{Q}{N}\right)^{o}$ and PXQ_1, $PXQ_{1_{-1}}$, and PXQ_2 are found to be 0.140, 0.096 and 0.083, respectively. However, the results change substantively and are found to be in accordance with the theoretical predictions and statistically significant when the full econometric framework developed in the preceding section is implemented against the relevant body of data from the same period. The numerous limitations inherent in the empirical counterparts of the desired theoretical constructs notwithstanding, the regression results reported in Tables 4-7 uniformly exhibit a significant negative elasticity of the murder rate with respect to alternative measures of the probability of execution. More importantly, the regression results also corroborate the specific theoretical predictions regarding the effects of the probabilities of apprehension and conviction, unemployment, and labor force participation.

Table 4 shows that the estimated elasticity of the murder rate with respect to the conditional probability of execution is lowest in absolute magnitude when the objective measure of $Pe|c$, PXQ_1, is treated in the regression analysis as if it were a perfectly forecast and strictly exogenous variable. The elasticity associated with PXQ_1 is -0.039 with upper and lower 95 percent confidence limits (calculated from the normal distribution) of 0.008 and -0.086. The elasticities associated with the alternative measures of $Pe|c$, $PXQ_{1_{-1}}$, TXQ_1, PXQ_1, and PDL_1, vary between -0.049 and -0.068 with upper and lower 10 percent confidence limits ranging between -.01 and -0.10. These results have been anticipated by the analysis of Section II.A.2. The regression coefficient associated with PXQ_1 is likely to be biased toward zero due to the effect of random errors of prediction associated with $PXQ_1 \equiv \frac{E_{t+1}}{C_t}$ when this variable is treated as a perfectly forecast statistic in year t. $PXQ_{1_{-1}}$, TXQ_1, and PDL_1 may be relatively free of such errors if expectations concerning the true value of $Pe|c$ in year t are formed on the basis of past information. In addition, since the analysis of optimal social defense against murder suggests that an exogenous change in $\left(\frac{Q}{N}\right)$ may change the socially optimal value of $Pe|c$ in the same direction, the coefficient associated with PXQ_1 may be biased toward a positive value because of a potentially positive correlation between $\left(\frac{Q}{N}\right)$ and the unsystematic part of PXQ_1. This simultaneous equation bias is expected to be eliminated when the systematic part of PXQ_1 is estimated via the reduced form regression equation ($\widehat{PXQ}_1$). It is noteworthy that the estimated elasticities of $\left(\frac{Q}{N}\right)^o$ with respect to alternative measures of $Pe|c$ are found generally to be low in absolute magnitude--not an unexpected result with the average conditional risk of execution given conviction over the period investigated being estimated at about 2.1 percent and the average unconditional risk of execution estimated at only about 0.8 percent.[26] This, perhaps, is the principle reason why previous studies into the effect of capital punishment on murder using simple correlation techniques and rough measures of the conditional risk of execution have failed to identify a systematic association between murder and the risk of execution. Table 5 indicates the particular importance of introducing into the regression equations measures of Pa, $Pc|a$, L, U, and the time trend, T.

The regression results regarding the effects of P^oa, $P^oc|a$ and $P^oe|c$ constitute perhaps the strongest findings of the empirical investigation. Not only do the signs of the elasticities associated with these variables conform to the general theoretical expectations, but their ranking, too, is consistent with the predictions in Section I. Table 4 shows that the elasticities associated with P^oa range between -1.0 and -1.5, whereas the elasticities associated with $P^oc|a$ in the various regression equations range between -0.4 and -0.5. And, as indicated in the preceding paragraph, the elasticities associated with $P^oe|c$ are lowest in absolute magnitude. It is, of course, possible that the observed ranking of these elasticities is a consequence of the varying degrees of noise associated with P^oa, $P^oc|a$, and $P^oe|c$. However, there is no compelling reason to expect the degree of noise inherent in the empirical counterpart of $Pc|a$ to be lower than that indigenous to the empirical counterpart of $Pe|c$.

The estimated values of the elasticities associated with U, L, and Y_p in Table 4 are not inconsistent with the theoretical expectations discussed in Section I.A. Of particular interest is that the effects of equal percentage changes in $P^oe|c$ and U are found to be nearly alike in absolute magnitude. In part, the positive effect of U on $\left(\frac{Q}{N}\right)^o$ may be attributed to the effect of the reduction in legitimate earning opportunities on the incentive to commit crimes involving material gains, because murder is often a by-product of these crimes. Indeed, preliminary time series regression results show that the elasticities of robbery and burglary rates with respect to the unemployment rate are even larger in magnitude than the corresponding elasticities of the murder rate. These results conform more closely to theoretical expectations than do the results in the cross-state regression analysis (see Ehrlich (1973) and Table 8). The reason, presumably, is that, due to their higher correlation with cyclical variations in the demand for labor, changes in U over time measure the variations in both involuntary unemployment and the duration of such unemployment more effectively than do variations in U across states at a given point in time. The estimated negative effect of variations in the labor force participation rate on the murder rate can be explained along similar lines. Theoretically, variations in L are likely to reflect opposing income and substitution effects of changes in market earning opportunities. However, with measures of both permanent income, Y_p, and the rate of unemployment introduced in the regression equation as independent explanatory variables, changes in L may reflect a pure substitution effect of changes in legitimate earning opportunities on the incentive to commit both crimes against persons and property.[27] Finally, the positive association between Y_p and $\left(\frac{Q}{N}\right)^o$ need not imply a positive income elasticity of demand for hate and malice since changes in the level of the personal distribution of income may be strongly correlated with payoffs on crimes against property. If legitimate employment opportunities are effectively accounted for by U and by L, changes in Y_p may be highly correlated with similar changes in the incidence of crimes against property. Such a partial correlation is indeed observed across states (Ehrlich (1973) and Table 8) and in a time series regression analysis of crimes against property now in progress. Of note, perhaps, is that changes in Y_p exhibit a trend which is similar to the trend in urbanization for which no complete time series data are available. The effect of Y_p may thus represent in part the effect of increased urbanization on the overall crime rate in the United States.

The positive effect of variations in the percentage of the population in the age group 15-24, A, on the murder rate is consistent with the cross-state evidence concerning the correlation between these variables (see Table 8). A possible explanation for this finding was already offered in Section II.A.2. However, in some of the regressions, the standard errors of the estimated elasticities associated with A exceed the absolute value of the elasticities. The effect of the percentage of nonwhites in the population, NW, is found to be statistically insignificant when the time trend, T, is introduced as an independent explanatory variable in the regression equation and is therefore excluded from the regressions estimating the supply of murders function (see Table 5). This result stands in sharp contrast to the ostensibly positive effect of NW on the murder rate across states (see Table 8). I have argued elsewhere in this context that the apparently higher participation rate of nonwhites in all criminal activities may largely be the result of the relatively poor legitimate employment opportunities available to them (see Ehrlich (1973)). Since, over time, variations in these opportunities may be effectively accounted for by the variations in U and L, the estimated independent effect of NW may indeed be nil. The negative partial effect of T on $\left|\frac{Q}{N}\right|^{o}$ reported in Tables 4-7 may indicate a rising proportion of capital murders among all murders, k, as predicted by the analysis of Section II.A.2. For if k was related to T by $k = \delta(\exp)^{\lambda T}$, then T would enter the regression equation (12) with a negative coefficient, $-\lambda$. However, the effect of T is likely to confound the effect of the continuously improving medical technology on the number of attempted murders resulting in the death of victims and actually identified as murders, as well as the effect of other relevant missing variables which may exhibit a systematic trend; hence no conclusive inferences may be drawn from the negative association between T and $(\frac{Q}{N})^{o}$.

The regression results are found to be robust with respect to the functional form of the regression equation. Running the regressions reported in Table 4 (using the same estimation procedure) by introducing the natural values of all the relevant variables instead of their natural logarithms does not change the qualitative results reported therein. In addition, running the regressions by introducing the levels of the relevant variables rather than their modified first differences (that is, assuming no serial correlation in the error terms) artificially reduces the standard errors of the regression coefficients as would be expected on purely statistical grounds (see Table 7 , equation (3)). The results are further insensitive as to the specific estimates of expenditures on police used in the reduced form regression equation. The data for this variable are not available for all the odd years between 1933 and 1951 and the missing statistics were interpolated either via a reduced form regression analysis ($XPOL_{-1}$) or via a simple smoothing procedure. The results are virtually identical (compare equations (1) and (2) in Table 7 with equations (3) and (4) in Table 4). The introduction of a dummy variable distinguishing the Second World War years (1942-1945) from other years in the sample has no discernible effect on the regression results, while the effect of the dummy variable itself appears to be statistically insigifnicant.

Of more importance, the qualitative results reported in Table 4 are insensitive to changes in the specific interval of time investigated in the regression analysis, as indicated by the results reported in Table 7. However, the absolute magnitudes of some of the estimated elasticities, especially those associated with P^oa, $P^oc|a$, U, and L do change when estimated from different subperiods. One reason for this sensitivity of the regression results follows from the theorem summarized by equation (6), namely, that the absolute magnitudes of the elasticities associated with Pa, $Pc|a$, and $Pe|c$ are increasing functions of the levels of these variables. There is some indication that the regression results are compatible with this theorem. For example, the average values of P^oa and $P^oc|a$ in 1941-1969 were distinctly higher than in 1935-1969 and estimates of the elasticities associated with these variables are indeed higher in equations (6) and (7) of Table 7 than in equations (3) and (4) of Table 4. In contrast, the elasticities associated with estimates of $Pe|c$, expected to be an increasing function of the unconditional probability of execution, $Pe = Pa \cdot Pc|a \cdot Pe|c$, do not exhibit an unambiguous decline across the two subperiods, perhaps because the differences between the magnitudes of the corresponding estimates of the unconditional probability of execution, Pe, are not as substantial as the differences between the mean values of $P^{o}a$ and $P^{o}c|a$. Alternatively, it is possible that the imprisonment terms actually served by capital offenders decreased during this period. The analysis of Section I.A.1, indicates that the magnitude of the elasticity of $\frac{Q}{N}$ with respect to $Pe|c$ is negatively related to the severity of punishment by imprisonment.

Another reason for the sensitivity of the absolute magnitudes of the regression coefficients to different sample subperiods is due to changes in the accuracy of empirical estimates of Pa, $Pc|a$, and $Pe|c$. It is generally asserted that more recent UCR data are relatively more reliable than earlier compilations. Indeed, the national sample size from which the values of $P^{o}a$ and $P^{o}c|a$ were computed by the UCR has increased steadily over time. In addition, the variations in $P^{o}a$, $P^{o}c|a$, and $P^{o}e|c$ were more pronounced during the 1960's than in other decades. These considerations may explain why the elasticities associated with the latter variables are relatively lower when estimated from the 1935-1966 subsample than from the 1935-1969 subsample.[28] In contrast, the variations in U and L were largest during the 1930's. Indeed, the standard errors of the regression coefficients associated with these variables are lower when estimated from the 1935-1969 sample rather than the 1941-1969 subsample.

Last, but not least, the time series estimates of the supply of murders function appear to be generally consistent with independent estimates derived through a cross-state regression analysis using data from 1960. The set of explanatory variables used in the separate investigations is not identical due to the lack of comrehensive data for the length of imprisonment for murder and for inequality in the personal distribution of income in the time series analysis and because of the absence of separate information on $P^{o}a$, $P^{o}c|a$, and $P^{o}e|c$ across states. To make the separate regression estimates more comparable, the product of $P^{o}a$ and $P^{o}c|a$, $P^{o}ac$, a proxy for the true $Pc \equiv Pa \cdot Pc|a$, was introduced in the time series regression analysis instead of $P^{o}a$ and $P^{o}c|a$ since the variable P in the cross-state analysis has been constructed as a proxy for the unconditional probability of imprisonment (see Ehrlich (1973)). The results reported in Tables 7 and 8 are quite compatible. The elasticity associated with P in Table 8 lies between estimates of the separate elasticities associated with $P^{o}a$ and $P^{o}c|a$ in Table 4 and is similar to, albeit somewhat higher than, the elasticities associated with $P^{o}ac$ in Table 7. The general compatibility of the qualitative results associated with other variables introduced in Tables 7 and 8 has been discussed in the preceding paragraphs.

III. Some Implications

A. The Apparent Effect of Capital Punishment: Deterrence or Prevention?

It has already been hinted in the introduction to this paper that an apparent negative effect of the conditional probability of execution on the murder rate may merely reflect the relative preventive impact of the death penalty which eliminates categorically the possibility of recidivism on the part of those executed. The argument is more general, however, and may apply in part to all forms of punishment involving the incarceration or detention of perpetrators of crime. To the extent that offenders have a positive probability of recidivism once free to commit crimes outside of prisons and if incarceration _per se_ does not enhance considerably that probability, imprisonment as well as execution would reduce the actual murder rate by reducing the number of offenders at large.

An estimation of the differential preventive effect of execution relative to imprisonment for capital murders can be attempted through an application of a general analysis of the preventive effect of imprisonment developed in Ehrlich (1973). The theoretical model assumes that offenders constitute a unique group of persons unresponsive to incentives and who compose a constant fraction of the population that is determined by forces exogenous to the social system. An average offender is assumed to commit ζ offenses per year (ζ may be less than one) if not imprisoned or executed, but none otherwise. Thus, by this model, the effects on the murder rate of increases in the fractions of _potential_ offenders who are imprisoned or executed, $P^o m \equiv P^o a P^o c|a(1 - P^o e|c)$ and $P^o e \equiv P^o a P^o c|a P^o e|c$, respectively, exhibit the pure preventive effects of imprisonment or execution.[28a] **In this application** of the model, execution is identified analytically with an imprisonment term, Te, which is equal in length to the life expectancy of an average offender imprisoned for murder. Under these assumptions, the absolute magnitude of the elasticity of the murder rate with respect to the fraction of those convicted of murder who were punished by execution, $P^o e|c$, can be shown to equal

$$\sigma_{P^o e|c} = \frac{P^o e \left[\sum_{\tau=1}^{Te} (1+g)^{-\tau} - \sum_{\tau=1}^{Tm} (1+g)^{-\tau} \right]}{1 + P^o m \sum_{\tau=1}^{Tm} (1+g)^{-\tau} + P^o e \sum_{\tau=1}^{Te} (1+g)^{-\tau}} < 1 \quad , \qquad (14)$$

where g denotes the natural rate of growth of the general population as well as the stock of potential murderers over time and Tm denotes the effective average time spent in prison by those convicted of capital murders. The method used in deriving equation (14) can be inferred from the analysis given in Ehrlich (1973, p. 536).

Tentative calculations of $\sigma_{Pe|c}$ relating to the period 1935-1969 are based upon estimates of the average values of Te, Tm and g, and upon **estimates of P^oe and P^om computed on the extreme assumption that an average** offender at large commits murders at the frequency of one per year. This yields estimates of $\sigma_{Pe|c}$ ranging from slightly less than a third to a little more than half of the empirical estimates of elasticities of the murder rate with respect to alternative measures of $P^oe|c$, $\hat{\alpha}_3$, reported in Section III.B.[29] Thus, even under the extreme assumption that $\zeta = 1$, the empirical findings are inconsistent with the notion that executions have a preventive effect only. Moreover, according to the preventive theory of law enforcement, the partial elasticity of the murder rate with respect to the fraction of offenders apprehended for murder, P^oa, is expected to be identical to the partial elasticity of the murder rate with respect to the fraction of those apprehended or charged with murder who were convicted of murder, $P^oc|a$; that is,

$$\sigma_{P^oa} = \sigma_{P^oc|a} = \frac{P^om \sum_{\tau=1}^{Tm} (1+g)^{-\tau} + P^oe \sum_{\tau=1}^{Te} (1+g)^{-\tau}}{1 + P^om \sum_{\tau=1}^{Tm} (1+g)^{-\tau} + P^oe \sum_{\tau=1}^{Te} (1+g)^{-\tau}} < 1. \quad (15)$$

(Equation (15) is a straightforward generalization of equation (2.7) in Ehrlich (1973).) The reason, essentially, is that equal percentage changes in either P^oa or $P^oc|a$ have the same effect on the fractions of offenders who are incapacitated through incarceration or execution, $P^o m$ and $P^o e$, respectively, and thus should have virtually equivalent preventive effects on the murder rate. This prediction is ostensibly at odds with the significant positive difference between empirical estimates of the elasticity of the murder rate with respect to $P^o a$ and $P^o c|a$. In contrast, the latter findings are consistent with implications of the deterrent theory of law enforcement (see equation (5)). In light of these observations one cannot reject the hypothesis that punishment, in general, and execution, in particular, exert a unique deterrent effect on potential murderers.

B. Tentative Estimates of the Tradeoff Between Executions and Murders

The regression results concerning the partial elasticities of the reported murder rate with respect to various measures of the expected risk of execution given conviction in different subperiods, $\hat{\alpha}_3$, can be restated in terms of expected tradeoffs between the execution of an offender and the lives of potential victims that might thereby be saved. For illustration, consider the regression coefficients associated with $\widehat{PXQ_1}$ and $PXQ_{1_{-1}}$ in equations (6) and (3) of Table 4 . These coefficients, -0.06 and -0.065, respectively, may be considered consistent estimates of the average elasticity of the national murder rate, $\left(\frac{Q}{N}\right)^o$, with respect to the objective conditional risk of execution, $P^o e|c = \left(\frac{E}{C}\right)^o$, over the period 1935-1969. Evaluated at the mean values of murders and executions over that period, $\bar{Q} = 8965$ and $\bar{E} = 75$, the marginal tradeoffs, $\frac{\Delta Q}{\Delta E} = \hat{\alpha}_3 \frac{Q}{E}$, are found to be 7 and 8, respectively. Put differently, an additional execution per year over the period in question may have resulted, on average, in 7 or 8 fewer murders. Curiously, approximately the same tradeoffs are found to exist at the middle year of the sample, 1952, in which the numbers of murders and executions were 8,260 and 71, respectively. In contrast, the tradeoffs corresponding to the average values of murders and executions over the period 1960-1967 ($Q = 10{,}958$ and $E = 22$, respectively) and to the elasticities -0.06 and -0.065 are found to be 1 for 30 and 1 for 32, respectively. The weakness inherent in these predicted magnitudes, especially those relating to the more recent years of the sample, is that they may be subject to relatively large prediction errors. More reliable point estimates of the expected tradeoffs should be computed at the mean values of all the explanatory variables entering the regression equation (hence, also the mean value of the dependent variable) because the confidence interval of the predicted value of the dependent variable is there minimized. The mean values of the dependent variable and the explanatory variable used to calculate the value of $\hat{\alpha}_3$ in equation (3) of Table 4 are found to be nearly identical with the actual values of these two variables in 1966 and 1959, respectively. The corresponding values of murders and executions in these two years were $Q(1966) = 10{,}920$ and $E(1959) = 41$; the marginal tradeoffs between executions and murders based on the latter magnitudes and the elasticity $\hat{\alpha}_3 = -0.065$ is found to be 1 to 17.

It should be emphasized that the expected tradeoffs computed in the preceding illustration mainly serve a methodological purpose since their validity is conditional upon that of the entire set of assumptions underlying the econometric investigation. In addition, it should be pointed out that the 90 percent confidence intervals of the elasticities used in the preceding illustrations vary approximately between 0 and -0.10 implying that the corresponding confidence intervals of the expected tradeoffs in the last illustration range between limits of 0 and 24. It is particularly important to recall that the validity of both the regression results and the expected tradeoffs in question rests on the assumption that the effective length of imprisonment for murder, which is expected to have a direct effect on both the rate of murder and its elasticity with respect to the conditional probability of execution, $\hat{\alpha}_3$, were not subject to any systematic trends. As the above illustrations indicate, however, although the estimated elasticities ($\hat{\alpha}_3$) reported in Tables 4-7 are low in absolute magnitude, the tradeoffs between executions and murders implied by these elasticities are not negligible, especially when evaluated at relatively low levels of executions and relatively high levels of murder.[30]

Finally, it should be emphasized that the tradeoffs discussed in the preceding illustrations were based upon the partial elasticity of $\left|\frac{Q}{N}\right|^o$ with respect to measures of $P^o e|c$ and thus, implicitly, on the assumption that the values of all other variables affecting the murder rate are held constant as the probability of execution varies. In practice, however, the values of the endogenous variables, Pa and $Pc|a$, may not be perfectly controllable. The theoretical analysis in Section II.B suggests that exogenous shifts in the optimal values of $Pe|c$ may generate offsetting changes in the optimal values of Pa and $Pc|a$. Indeed, consistent estimates of the elasticities of the reported murder rates with respect to alternative measures of $P^o e|c$ that were derived through a reduced form regression analysis using as explanatory variables only the exogeneous and predetermined variables included in the supply of offenses function and other structural equations (X_1 and X_2 in Table 3) are found to be generally lower than the elasticities reported in Table 4.[31] The actual tradeoffs between executions and murders thus depend partly upon the ability of law enforcement agencies to control the values of all the parameters characterizing law enforcement activity while, at the same time, setting new guidelines for the application of capital punishment.

IV. Conclusion

This paper has attempted to present a systematic analysis of the relation between capital punishment and the crime of murder. The analysis rests on the presumption that offenders respond to incentives. Not all those who commit murder may respond to incentives. But for the theory to be useful in explaining aggregate behavior, it is sufficient that at least some so behave.

Previous investigations, notably those by Thorsten Sellin, have developed evidence used to unequivocally deny the existence of any deterrent or preventive effects of capital punishment. This evidence stems by and large from what amounts to informal tests of the sign of the simple correlation between the legal status of the death penalty and the murder rate across states and over time in a few states. Studies performing these tests have not considered systematically the actual enforcement of the death penalty, which may be a far more important factor affecting offenders' behavior than the legal status of the penalty. Moreover, these studies have generally ignored other parameters characterizing law enforcement activity against murder, such as the probabilities of apprehension and conviction, which appear to be systematically related to the probability of punishment by execution. The sign of the simple correlation between the murder rate and the legal status, or even the effective use of capital punishment, cannot provide conclusive evidence for or against the existence of the deterrent effect of capital punishment since it may capture effects of other determinants of the murder rate as well.

The basic strategy I have attempted to follow in formulating an adequate analytic procedure has been to develop a simple economic model of murder and defense against murder, to derive on the basis of this model a set of specific behavioral implications that could be tested against available data and, accordingly, to test those implications statistically. The theoretical analysis provided sharp predictions concerning the signs and the relative magnitudes of the elasticities of the murder rate which respect to the probability of apprehension and the conditional probabilities of conviction and execution for murder. It suggested also the existence of a systematic relation between employment and earning opportunities and the frequency of murder and other related crimes. Although in principle the negative effect of capital punishment on the incentive to commit murder may be partly offset, for example, by an added incentive to eliminate witnesses, the results of the empirical investigation are not inconsistent with the hypothesis that, on balance, capital punishment reduces the murder rate. But even more significant is the fact that other specific theoretical predictions, too, are found to be consistent with the empirical results. The elasticity of the murder rate with respect to the probability of apprehension is found greater in absolute magnitude than its elasticity with respect to a measure of the conditional probability of conviction. The latter elasticity, in turn, is found to exceed the elasticity of the murder rate with respect to alternative measures of the conditional probability of punishment by execution. The murder rate is also found negatively related to the labor force participation rate and positively to the rate of unemployment. None of these results is compatible with a hypothesis that offenders do not respond to incentives. In particular, the results concerning the effects of the estimates of the probabilities of appehension, conviction and execution are not consistent with the hypothesis that execution or imprisonment decrease the rate of murder only by incapacitating or preventing apprehended offenders from committing further crimes.

These observations do not imply that the empirical investigation has proved the existence of the deterrent or preventive effect of capital punishment beyond conventional statistical qualifications. The results may be biased by the absence of data on the severity of alternative punishments for murder and by other missing variables in the regression analysis. The use of national data in the regression analysis creates potential aggregation biases, partly because the national statistics incorporate data from both retentionist and abolitionist states. Although the estimation procedure attempts to correct potential simultaneous equation regression biases and biases due to autoregressiveness in the residual terms of the regression equation, the constant elasticity format used in this analysis may be inappropriate due to considerations spelled out in Section II. Most important, perhaps, the empirical counterparts of the conditional probabilities of conviction and execution for capital murders may not be efficient estimators of the true variables as the discussion in Section II.A.2 suggests. Future investigations into the issues raised in this paper that may use superior data and/or more satisfactory measures of the theoretical constructs would undoubtedly reach different quantitative conclusions.

At the same time it is not obvious whether the net effect of all the shortcomings noted above necessarily exaggerates the regression results in favor of the theorized results. For example, the aggregation of data from abolitionist and retentionist states indicates that the regression coefficients associated with measures of the conditional probability of execution are likely to be biased downward because the latter measures relate, in principle, to retentionist states only. Also, the results of the time series analysis of variations in the national murder rate are compatible with results from regression analysis of variations in murder rates and other crimes across states in the United States. In view of this new evidence one cannot reject the hypothesis that law enforcement activities in general and executions in particular do exert a deterrent effect on acts of murder. Strong inferences to the contrary drawn from earlier investigations appear to have been premature.

As the analysis of Section I.A.1 demonstrates, the magnitudes of the partial derivatives and the elasticities of the murder rate with respect to the conditional probability of execution reflect the differential effects of execution over alternative punishments imposed on convicted offenders. Thus, the observed partial effect of capital punishment on the rate of murder during the period studied in this investigation is partly a function of the actual severity of imprisonment and of other penalties imposed on capital offenders. These punishments have been less severe than actual imprisonment for life and a far cry from the severity of punishments other than execution which were imposed on offenders in the time of Beccaria, as indicated by the excerpt cited from his treatise in the introduction to this paper. It may not be surprising, therefore that the magnitude of the differential deterrent effect of execution over imprisonment in recent decades has been ostensibly higher than what Beccaria believed it to be in the eighteenth century.

Even if one accepts the results concerning the partial effect of the conditional probability of execution on the murder rate as valid, these results do not imply that capital punishment is necesarily a desirable form of punishment. Specifically, whether the current level of application of capital punishment is optimal cannot be determined independently of the question of whether the levels of alternative punishments for murder or other decision variables affecting the murder rate are optimal. If the severity of punishments by means other than execution had been greater in recent years, the apparent elasticity of the murder rate with respect to the conditional probability of punishment by execution would have been lower, thereby making capital punishment ostensibly less efficient in deterring or preventing murders. Again, this observation need not imply that the effective period of incarceration imposed on convicted capital offenders should be raised. Given the validity of the analysis pursued above, incarceration or execution are not exhaustive alternatives for effectively defending against murders.[32] Indeed, these conventional punishments may be considered inefficient means of deterrence from an economic point of view because the high "price" they exact from convicted offenders is not transferrable to the rest of society. Adequate monetary fines seem eminently more efficient alternatives because they may provide, in principle, an equivalent deterrent to potential offenders, an adequate punishment to the guilty, and retribution as well as compensation to the families of victims. These alternative punishments may be too costly to administer in some instances, but their relative expediency as a penal instrument in criminal cases has not been sufficiently explored. Moreover, the results of the empirical investigation indicate that the rate of murder and other related crimes may also be reduced through increased employment and earning opportunities. The range of effective means of defense against murder thus goes beyond conventional means of law enforcement and crime prevention. There is no unambiguous method for determining whether capital punishment should be utilized as a legal means of punishment without considering at the same time the optimal values of all other choice variables that can affect the level of capital crimes.

TABLE 1

MURDER BY CIRCUMSTANCE IN 1966 AND 1969 (PERCENT DISTRIBUTION).

Region	Year	Spouse Killing Spouse	Parent Killing Child	Other Family Killings	Romantic Triangle and Lovers' Quarrels	Other[a] Arguments	Known[b] Felony Type	Suspected Felony Type
Northeastern States	1966	15.3	6.1	7.0	9.4	36.1	16.6	9.5
	1969	10.7	5.4	4.7	5.2	37.9	22.6	13.5
North Central States	1966	15.4	4.3	8.4	8.5	41.4	15.4	6.6
	1969	13.0	3.5	9.3	6.0	40.3	22.5	5.4
Southern States	1966	16.1	2.5	8.9	8.6	46.1	11.6	6.2
	1969	14.1	2.2	10.1	8.5	46.1	13.5	5.5
Western States	1966	19.7	6.6	7.5	7.2	30.7	21.3	7.0
	1969	13.5	6.0	6.9	6.9	34.4	25.5	6.8
Total	1966	16.3	4.2	8.3	8.5	40.9	14.8	7.0
	1969	13.1	3.7	8.[illegible]	7.0	41.3	19.3	7.2

[a]Persons participating in these arguments were most frequently acquainted prior to the fatal act.

[b]Felony murders are those resulting from robberies, sex motives, gangland slayings and other felonies.

Source: Uniform Crime Reports, (1966, 1969).

TABLE 3

VARIABLES USED IN THE REGRESSION ANALYSIS
ANNUAL OBSERVATIONS 1933-1969

(Means and Standard Deviations in Natural Logarithms)

	Variable	Mean	Standard Deviation
y_1	$(\frac{Q}{N})^o$ = Crime rate: offenses known per 1,000 civilian population.	-2.857	0.156
Y_1	$P^o a$ = Probability of arrest: clearance rates	4.997	0.038
	$P^o c \mid a$ = Conditional probability of conviction: fraction of those charged who were convicted of murder.[a]	3.741	0.175
	$P^o e \mid c$ = Conditional probability of execution. PXQ_1 = the no. of executions for murder in year t+1 as a percent of the total number of convictions in year t.[b]	0.176	1.749
X_1	L = Labor force participation rate of the civilian population.	-0.546	0.030
	U = Unemployment rate of the civilian labor force	1.743	0.728
	A = Fraction of residential population in the age group 14-24.	-1.740	0.118
	Y_p = Friedman's estimate of permanent income per capita	6.870	0.338
	T = Chronological time (years)		
X_2	NW = Percent of nonwhite residential population.	-2.212	0.063
	N = Civilian population in 1,000's.	11.944	0.161
	XGOV = Per capita (real) expenditures on all governments in million dollars.	-7.661	0.501
	$XPOL_{-1}$ = Per capita (real) expenditures on police in dollars lagged one year.[a]	2.114	0.306

Table 3 (Cont'd.)

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[a]The figures for $P^{o}c|a$ (1933-1935) and XPOL (all the odd years 1933-1951) were interpolated via an auxiliary regression analysis.

[b]The actual number of executions in 1968, 1969 and 1970 was zero. However the numbers were assumed equal to 1 in each of these years in constructing the value of PXQ_1 in 1967-1969.

TABLE 4

MODIFIED FIRST DIFFERENCES OF MURDER RATES (IN NATURAL LOGARITHMS)
REGRESSED AGAINST CORRESPONDING MODIFIED FIRST DIFFERENCES OF SELECTED VARIABLES SET I (1933-1969)

($\hat{\beta}/s_{\hat{\beta}}$ in parentheses)

Effective Period / D. W. Statistic	$\hat{\rho}$(CORC) / $\hat{\sigma}_e$	C (Constant)	$\Delta^*\hat{P}^o a$	$\Delta^*\hat{P}^o c\|a$	Alternative $\Delta^* P^o e\|c$: $\Delta^* PXQ_1$	$\Delta^* PXQ_2$	$\Delta^* PXQ_{1_{-1}}$	$\Delta^* L$	$\Delta^* A$	$\Delta^* Y_p$	$\Delta^* U$	$\Delta^* T$
1. 1935-1969 / 1.84	0.257 / 0.052	-3.176 (-0.78)	-1.553 (-0.78)	-0.455 (-3.58)	-0.039 (-1.59)			-1.336 (-1.36)	0.630 (2.10)	1.481 (4.23)	0.067 (2.00)	-0.047 (-4.63)
2. 1935-1969 / 1.82	0.135 / 0.042	-4.190 (-1.25)	-1.182 (-1.83)	-0.386 (-3.85)		-0.068 (-3.69)		-1.277 (-1.59)	0.480 (2.19)	1.318 (4.86)	0.062 (2.38)	-0.047 (-6.61)
3. 1935-1969 / 1.81	0.077 / 0.045	-4.419 (-1.25)	-1.203 (-1.78)	-0.374 (-3.59)			-0.065 (-3.29)	-1.405 (-1.63)	0.512 (2.26)	1.355 (4.88)	0.068 (2.55)	-0.04? (-6.5?)
					$\Delta^* TXQ_1$	$\Delta^* PDL_1$	$\Delta^* P\hat{X}Q_1$					
4. 1937-1969 / 2.00	0.291 / 0.046	-2.447 (-0.61)	-1.461 (-2.03)	-0.487 (-3.38)	-0.049 (-2.26)			-1.393 (-1.58)	0.524 (1.94)	1.295 (3.90)	0.063 (2.09)	-0.044 (-4.93)
5. 1939-1969 / 2.15	-0.207 / 0.050	6.868 (1.39)	-2.225 (-3.04)	-0.850 (-4.124)		-0.062 (-3.82)		-0.457 (-0.50)	0.059 (1.23)	0.580 (1.70)	0.014 (0.43)	-0.032 (-4.09)
6. 1935-1969 / 1.86	0.081 / 0.051	-3.503 (-0.85)	-1.516 (-1.93)	-0.424 (-3.37)			-0.060 (-1.73)	-1.368 (-1.38)	0.489 (1.42)	1.455 (4.25)	0.064 (1.93)	-0.050 (-4.87)

The estimation procedure is outlined in the statistical appendix. All variables, except T, are in natural logarithms denoted by lower case letters. The definitions of these variables are given in Table 3. Δ^*X denotes the linear operation $X - \hat{\rho}X_{-1}$. The value of $\hat{\rho}$ is estimated via the Cochrane-Orcutt iterative procedure (CORC). $\hat{\sigma}_e$ is defined in the statistical appendix. $\Delta^*\hat{P}a$ and $\Delta^*\hat{P}c|a$ in equations 1-5 a computed via a reduced form regression equation including: C(constant), $\frac{Q}{N}_{-1}$, Pa_{-1}, $Pc|a_{-1}$, $P^o e|c$, L, A, Y_p, U, T, $P^o e|c_{-1}$, L_{-1}, A_{-1}, Y_{p-1}, U_{-1}, $XPOL_J$, XGOV, NW, N. $\Delta^*\hat{P}a$, $\Delta^*\hat{P}c|a$ and $\Delta^*\hat{P}XQ_1$ in equation 4 are computed via the same reduced form with PXQ_1 ($P^o e|c$) excluded.

TABLE 5

MODIFIED FIRST DIFFERENCES OF MURDER RATES (IN NATURAL LOGARITHMS) REGRESSED AGAINST CORRESPONDING MODIFIED FIRST DIFFERENCES OF SELECTED VARIABLES, SET II: ALTERNATIVE SETS OF EXPLANATORY VARIABLES
($\beta/S_{\hat{\beta}}$ in parentheses)

Effective Period / D. W. Statistic	$\hat{\rho}$(CORC) / $\hat{\sigma}_e$	C (Constant)	$\Delta^* P^o a$	$\Delta^* P^o c\|a$	$\Delta^* P^o e\|c$ / $\Delta^* PXQ_{1_{-1}}$	$\Delta^* L$	$\Delta^* A$	$\Delta^* NW$	$\Delta^* Y_p$	$\Delta^* U$	$\Delta^* T$
1. 1935-1969 1.18	0.838 0.056	-5.568 (1.44)			-0.024 (-0.99)	-2.139 (-2.23)	0.834 (1.92)	-2.080 (-1.76)	-0.282 (-0.62)	-0.038 (-0.93)	0.022 (1.30)
2. 1935-1969 1.73	0.073 0.045	-4.385 (-1.22)	-1.395 (-1.84)	-0.357 (-3.37)	-0.063 (-3.11)	-1.413 (-1.62)	0.502 (2.18)	-0.791 (-0.75)	1.187 (3.42)	0.050 (1.40)	-0.037 (-2.62)
3. 1935-1969 1.75	0.117 0.059	4.831 (1.00)	-3.65 (-3.83)	-0.084 (-0.57)	-0.056 (-2.69)	-0.717 (-0.62)		-3.075 (-4.27)	0.272 (1.42)		
4. 1935-1969 1.77	0.508 0.051	0.563 (0.14)	-1.173 (-1.25)	-0.273 (-1.86)	-0.047 (-2.36)	-0.854 (-1.03)	0.435 (1.76)	-1.446 (-2.54)			
5. 1935-1969 1.56	0.700 0.054	-0.175 (-0.05)	-0.195 (-0.22)	-0.414 (-2.44)	-0.010 (-0.62)	-1.879 (-2.33)	0.713 (2.40)				

Note: Some references as in Table 4 but the reduced form used to compute $\Delta^*\hat{P}^o a$ and $\Delta^*\hat{P}^o c|a$ is adjusted so as to include the specific set of exogeneous variables introduced in each of the structural (supply of murders) functions reported in Table 5.

TABLE 6

MODIFIED FIRST DIFFERENCES OF MURDER RATES (IN NATURAL LOGARITHMS) REGRESSED AGAINST CORRESPONDING MODIFIED FIRST DIFFERENCES OF SELECTED VARIABLES SET III: ALTERNATIVE TIME PERIODS AND OTHER TESTS

($\hat{\beta}/S_{\hat{\beta}}$ in parentheses)

Effective Period	$\hat{\rho}$(CORC)	C			$\Delta^* P^o e\|c$							
D. W. Statistic	$\hat{\sigma}_e$	(Constant)	$\Delta^* \hat{P}^o a$	$\Delta^* \hat{P}^o c\|a$	$\Delta^* PXQ_{1_{-1}}$	$\Delta^* TXQ_1$	$\Delta^* L$	$\Delta^* A$	$\Delta^* Y_p$	$\Delta^* U$	War Years Dummy (1942-45)	$\Delta^* T$
1. 1935-1969 1.80 (a)	0.059 0.044	-4.060 (-1.00)	-1.247 (-1.56)	-0.345 (-3.07)	-0.066 (-3.33)		-1.314 (-1.49)	0.450 (2.20)	1.318 (4.81)	0.068 (2.60)		-0.046 (-6.54)
2. 1937-1969 1.99 (a)	0.287 0.046	-2.568 (-0.61)	-1.435 (-1.87)	-0.474 (-3.22)		-0.049 (-2.31)	-1.388 (-1.57)	0.526 (1.94)	1.289 (3.91)	0.063 (2.10)		-0.044 (-4.96)
3. 1937-1969 1.49 (b)	- 0.046	-3.608 (-1.02)	-1.385 (-2.12)	-0.345 (-3.25)		-0.064 (-3.52)	-1.218 (-1.40)	0.482 (2.13)	1.348 (4.94)	0.068 (2.59)		-0.047 (-5.69)
4. 1935-1969 1.84	0.061 0.046	-4.882 (-1.32)	-1.172 (-1.73)	-0.383 (-3.20)	-0.069 (-3.22)		-1.487 (-1.61)	0.477 (1.89)	1.393 (4.30)	0.077 (1.95)	0.018 (0.31)	-0.043 (-5.79)
5. 1937-1969 2.08	0.250 0.048	-2.086 (-0.51)	-1.634 (-2.16)	-0.508 (-2.83)		-0.055 (-2.36)	-1.444 (-1.51)	0.406 (1.23)	1.334 (3.73)	0.077 (1.80)	0.035 (0.50)	-0.045 (-4.72)
6. 1941-1969 2.21	-0.164 0.048	3.025 (0.57)	-1.744 (-2.21)	-0.714 (-3.70)	-0.074 (-3.70)		-1.008 (-1.04)	0.141 (0.56)	0.734 (2.06)	0.028 (0.91)		-0.036 (-4.40)

Table 6 (Cont'd.)

Effective Period / D. W. Statistic	$\hat{\rho}$(CORC) / $\hat{\sigma}_e$	C (Constant)	$\Delta^* \hat{P}^o a$	$\Delta^* \hat{P}^o c\|a$	$\Delta^* P^o e\|c$: $\Delta^* PXQ_{1_{-1}}$	$\Delta^* P^o e\|c$: $\Delta^* TXQ_1$	$\Delta^* L$	$\Delta^* A$	$\Delta^* Y_p$	$\Delta^* U$	War Years Dummy (1942-45)	$\Delta^* T$
7. 1941-1969 2.13	-0.029 0.048	3.752 (0.68)	-1.947 (-2.38)	-0.723 (-3.69)		-0.066 (-3.34)	-0.962 (-0.99)	0.152 (0.55)	0.771 (2.00)	0.0311 (0.96)		-0.036 (-4.13)
8. 1933-1966 1.90	0.061 0.033	-5.678 (-2.21)	-0.564 (-1.10)	-0.265 (-3.49)	0.055 (-3.72)		-2.111 (-3.18)	0.283 (1.65)	0.922 (4.16)	0.036 (1.74)		-0.036 (-6.30)
9. 1939-1966 1.96	0.016 0.037	-2.601 (-0.598)	-0.946 (-1.38)	-0.360 (-1.984)		-0.051 (-3.23)	-1.766 (-2.254)	0.212 (1.03)	0.780 (2.920)	0.027 (1.11)		-0.033 (-4.99)

Note: same references as in Table 4 but the reduced form used to compute $\Delta^* \hat{P}^o a$ and $\Delta^* \hat{P}^o c|a$ does not include N.

[a] Same as equations 3 and 4 in Table 4 with the missing data pertaining to $XPOL_{-1}$ interpolated via a smoothing procedure.

[b] Same as equation 4 in Table 4, with $\hat{\rho}$ assumed to be zero (level regression).

TABLE 7

MODIFIED FIRST DIFFERENCES OF MURDER RATES (IN NATURAL LOGARITHMS)
REGRESSED AGAINST CORRESPONDING MODIFIED FIRST DIFFERENCES OF SELECTED VARIABLES
SET IV: TESTING THE EFFECT OF THE OVERALL PROBABILITY OF CONVICTION

($\hat{\beta}/S_{\hat{\beta}}$ in parentheses)

Effective Period / D. W. Statistic	$\hat{\rho}$(CORC) / $\hat{\sigma}_e$	C Constant	$\Delta^*\hat{P}^o ac$	Alternative $\Delta^*P^o e\|c$: Δ^*PXQ_1	Δ^*PXQ_2	Δ^*PXQ_{-1}	Δ^*TXQ_1	Δ^*L	Δ^*A	Δ^*Y_p	Δ^*U	Δ^*T
1. 1935-1969 1.79	0.304 0.052	-10.050 (-4.61)	-0.549 (-5.08)	-0.040 (-1.63)				-1.705 (-1.81)	0.809 (2.93)	1.525 (4.30)	0.067 (1.97)	-0.047 (-4.52)
2. 1935-1969 1.76	0.158 0.043	-9.545 (-5.75)	-0.454 (-5.71)		-0.073 (-4.03)			-1.585 (-2.10)	0.581 (2.82)	1.358 (5.00)	0.063 (2.35)	-0.048 (-6.73)
3. 1935-1969 1.76	0.094 0.045	-9.961 (-5.85)	-0.449 (-5.52)			-0.071 (-3.68)		-1.777 (-2.24)	0.607 (2.82)	1.407 (5.06)	0.069 (2.53)	-0.049 (-6.76)
4. 1937-1969 1.75	0.334 0.046	-10.360 (-5.05)	-0.473 (-4.58)				-0.055 (-2.60)	-1.893 (-2.26)	0.703 (2.89)	1.490 (4.44)	0.067 (2.20)	-0.048 (-5.27)

Note: Some references as in Table 4 with Pac = PaPc|a replacing Pa, Pc|a .

TABLE 8

MURDER RATES REGRESSED AGAINST SELECTED VARIABLES:
A CROSS-STATE REGRESSION ANALYSIS, 1960 (48 STATES)

($\hat{\beta}/S_{\hat{\beta}}$ in parentheses)

Method \ Variable	C Constant	$\ell n\ \hat{P}$	ℓn T	ℓnW	ℓnX	ℓn NW	ℓnA	ℓn U 15-24	ℓn L 15-24
2SLS	0.316	-0.852	-0.087	0.175	1.109	0.534			
	(0.085)	(-2.492)	(-0.645)	(0.334)	(1.934)	(8.356)			
SUR	-1.198	-0.913	-0.018	0.186	1.152	0.542			
	(-0.033)	(-3.062)	(-1.710)	(0.361)	(2.102)	(8.650)			
2SLS	-7.284	-0.8515	-0.421	0.457	0.860	0.501	1.293	-0.324	-0.822
	(-1.486)	(-2.578)	(-0.333)	(0.903)	(1.597)	(7.921)	(1.698)	(-1.227)	(-1.966)

The variables included in the analysis are: P = probability of imprisonment for murder (number of commitments to state prisons divided by the number of offenses known); T = average time served in state prisons for murder; W = median family income in a state; X = proportion of families with income less than 1/2W; A = fraction of males in the age group 15-24; U = unemployment rate of urban males in the age group 15-24; L = labor force participation rate of urban males in the age group 15-24. The symbol ℓn denotes a natural logarithm. $\hat{P}$ denotes the regression estimate of P computed via a reduced form regression analysis. The abbreviation 2SLS indicates that the regression equation was estimated by a two-stage least-squares procedure. SUR indicates that the regression equation was estimated by applying Zellner's method of estimating seemingly unrelated equations simultaneously. The other (seemingly unrelated) equations refer to the crimes of rape and aggravated assault.

Source: Ehrlich (1973).

STATISTICAL APPENDIX

From a purely econometric point of view the problem underlying the empirical investigation is assumed to be that of estimating a simultaneous equation model with first order serially correlated disturbances

$$YA' = XB' + V \qquad \text{(A1)}$$

where

$$V = V_{-1}R' + E \quad . \qquad \text{(A2)}$$

Y and X are matrices of endogeneous and exogeneous or predetermined variables, V and E are matrices of disturbance terms; A and B are coefficient matrices and R is a diagonal matrix with elements between -1 and +1. The subscript -1 denotes one period lagged values of the relevant terms. The equation of interest is the supply of murders equation which is, say, the first equation in (A1). It can be written as

$$y_1 = Y_1A_1' + X_1B_1' + w_1 \quad , \qquad \text{(A3)}$$

where

$$v_1 = \rho_{11}v_{1_{-1}} + e_1 \quad . \qquad \text{(A4)}$$

Equations (A3) and (A4) can be written for any value of ρ_{11}, $\hat{\rho}$, as

$$y_1 - \hat{\rho} y_{1_{-1}} = (Y_1 - \hat{\rho} Y_{1_{-1}})A_1' + (X_1 - \hat{\rho} X_{1_{-1}})B_1' + [(\rho_{11} - \hat{\rho})v_{1_{-1}} + e_1] \ . \quad \text{(A5)}$$

Equation (A5) is estimated in this study via a nonlinear estimation procedure proposed by R. C. Fair (1970), which is based on the following three-round procedure. In the first stage predicted values of Y_1, denoted by $\hat{Y}_1$, are derived via a reduced form regression analysis that includes as instruments $y_{1_{-1}}$, $Y_{1_{-1}}$, $X_{1_{-1}}$ and a sufficient number of exogeneous or predetermined variables associated with other structural equations in (A1), X_2. A list of variables subsumed under X_2 is included in Table 3 and the rationale for including these variables in the model follows, generally from the specification of the simultaneous equation model of crime and law enforcement discussed in Ehrlich (1973). In the second stage, equation (A5) is then estimated for any given value of ρ by classical least squares, using the modified difference $\hat{Y}_1 - \hat{\rho}\, Y_{1_{-1}}$ in place of $Y_1 - \hat{\rho}\, Y_{1_{-1}}$. Equation (A5) thus becomes

$$y_1 - \hat{\rho} y_{1_{-1}} = (\hat{Y}_1 - \hat{\rho} y_{1_{-1}})A_1' + (X_1 - \hat{\rho} S_{1_{-1}})B_1' + [(\rho_{11} - \hat{\rho})v_{1_{-1}} + e_1 + \hat{W}_1 A_1'] \quad \text{(A6)}$$

where $\hat{W}_1 = Y_1 - \hat{Y}_1$. This second stage is then repeated for various values of $\hat{\rho}$ between -1 and +1 through an iterative procedure (I have here used the Cochran-Orcutt method (CORC)), and the estimation procedure stops at the choice of that value of $\hat{\rho}$ and the corresponding values of A_1 and B_1 which yield the smallest sum of squared residuals of the second stage regression. The values of A_1 and B_1 thus estimated are shown in Fair (1970) to be consistent statistically. These estimates along with $\hat{\rho}$ and the estimated standard error of e_1, denoted $\hat{\sigma}_e$, are reported in Section II.B.

FOOTNOTES

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[1]A detailed discussion of the evidence of Sellin is contained in an unpublished version of this paper (dated July 1973). Omitted here due to space considerations, that discussion will be made available in a future publication. A few remarks on this evidence are contained in the final section of this paper.

[2]Essentially the same formulation of consumption decisions in the presence of interdependencies in utility across persons has been developed and illustrated in Becker (1969). For a related analysis see Hochman and Rodgers (1969).

[3]It might be argued that although the wish to harm other persons cannot be rejected on economic grounds, nonetheless the execution of such desires (as opposed to benevolent actions) must be considered irrational in the sense of violation of Pareto optimality conditions. If there were no

bargaining, transfer or enforcement costs associated with mutually acceptable and enforceable contracts between a potential offender (o) and his potential victim (v), and if v's wealth constraint were not binding, then it would always be optimal for v to offer compensation to o for not committing a crime against him and for o to seek such compensation or extortion. The reason is that a reduction in v's consumption level is thus achieved by o simultaneously with a net increase in his own consumption level, rather than an expected decrease, due to the direct costs of committing a crime and the prospective cost of legal sanctions. Indeed, there exists some range of compensations that would increase both o's and v's utilities relative to their expected utilities if crime is committed by o against v. Many crimes against persons, and some cases of property crimes as well, may occasionally be avoided by such arrangements--successful extortions involving kidnapping or hijacking constitute obvious examples. Yet in many situations compensations may be too costly to pursue or to enforce just as fully effective private or public protection against murder may be too costly to provide. (This may be especially true in the case of crimes against property where the victim-offender relationship underlying such crimes is less enduring.) The incidence of murder must then be expected on purely economic grounds.

[4]The case in which crime is committed in pursuit of material gains has been analyzed explicitly in Ehrlich (1973). Note that in such a case the victims' level of consumption need not directly enter the offender's utility function.

[5]In particular, the introduction of specific explanatory variables relating to other crimes against person and property in the supply of murders regression equation has been avoided in the empirical investigation in view of the relatively small sample size and the relatively large number of variables that must then be introduced in the reduced form regression analysis.

[6]Differentiating equation (4) with respect to Pa, Pc|a, and Pc|c, using the contingent outcomes of murder as illustrated in Table 2 , it can easily be demonstrated that

$$\epsilon_{Pa} = - \frac{\partial U_o^*}{\partial Pa} \frac{Pa}{U_o^*} = \frac{1}{U_o^*} \{Pa(1 - Pc|a)[U(C_a) - U(C_b)] \qquad (5.1)$$

$$+ PaPc|a(1 - Pe|c)[U(C_a) - U(C_c)]$$

$$+ PaPc|aPe|c[U(C_a) - U(C_d)]\} > 0 \quad ;$$

$$\epsilon_{Pc|a} = - \frac{\partial U_o^*}{\partial Pc|a} \frac{Pc|a}{U_o^*} = \frac{1}{U_o^*} \{PaPc|a(1 - Pe|c)[U(C_b) - U(C_c)] \qquad (5.2)$$

$$+ PaPc|aPe|c[U(C_b) - U(C_d)]\} > 0 \quad ;$$

$$\epsilon_{Pe|c} = - \frac{\partial U_o^*}{\partial Pe|c} \frac{Pe|c}{U_o^*} = \frac{1}{U_o^*} \{PaPc|aPe|c[U(C_c) - U(C_d)] > 0 \quad . \qquad (5.3)$$

Clearly, $\epsilon_{Pa} > \epsilon_{Pc|a} > \epsilon_{Pe|c} > 0$.

[7]For example, differentiating equation (5.3) in footnote 6 with respect to Pe|c we obtain

$$\frac{\partial \epsilon_{Pe|c}}{\partial P_{e|c}} = \frac{1}{(U_o^*)^2} \{U^*PaPc|a[U(C_c) - U(C_d)]$$

$$- PaPc|aPe|c[U(C_c) - U(C_d)]\frac{\partial U_o^*}{\partial Pe|c}\} > 0$$

since by equation (5.3) $\frac{\partial U_o^*}{\partial Pe|c} < 0$. Analogous results can be demonstrated by differentiation of ϵ_{Pa} and $\epsilon_{Pc|a}$ with respect to, say, Pa or Pc|a.

[8]This implication of the theory supports a line of reasoning advanced by Mr. Justice Stewart in connection with the Supreme Court's important ruling in the case of Furman v. Georgia (1972, p. 312). "Common sense and experience tell us," said Mr. Stewart, "that seldomly enforced laws become ineffective measures for controlling human conduct and that the death penalty, unless imposed with sufficient frequency, will make little contribution to deterring crimes for which it may be exacted."

[9]

$$\frac{\partial \epsilon_{Pe|c}}{\partial C_c} = \frac{1}{(U^*)^2} [PeU'_c - PeU'_c \ \epsilon_{Pe|c}] > 0$$

$$\text{iff. } \epsilon_{Pe|c} < 1 \ .$$

In Section I.B, it is shown that the optimal value of $\epsilon_{Pe|c}$ must be less than 1 if execution is regarded as inflicting a net social cost. Therefore, an increase in the value of C_c caused by a reduction in the severity of imprisonment can be expected to increase the differential deterrent effect of capital punishment.

[10]Per capita loss from murder is employed here as the relevant target function in lieu of the aggregate social loss considered in Becker (1968) because the latter is not known with certainty whereas the former can be specified as a unique magnitude, assuming that the risks of victimization, conviction, or execution are largely independent across a large number of offenders and victims.

[11]More generally $Pc \equiv Pa \cdot Pch|a \cdot Pc|ch$, where $Pch|a$ denotes the conditional probability that a suspect be charged with murder once arrested, and $Pc|ch$ denotes the conditional probability that he be convicted

once charged. The costs of "producing" each of these probabilities are of course different, and optimal social policy may require their separate determination. For simplicity, attention here is focused upon the determination of the overall or unconditional probability of apprehension and conviction, Pc, as a unique means of deterrence.

[12]Pc and θ would be proportionally related if both α and the probability that innocent persons be apprehended and indicted remained constant as more resources were spent on enforcement activity through arrests and prosecutions. Alternatively, it might be argued that Pc and θ are highly (positively) correlated because of the well-known proposition that at any given level of evidence presented in court in reference to the defendants' guilt or innocence, the probability of legal or type I error, α (that of convicting the innocent), is negatively related to the probability of type II error, β (that of acquitting the guilty), and hence α might be negatively correlated with $Pc|ch \equiv 1 - \beta$. (This argument is discussed more elaborately in Arichai and Ben-Zion (1972).) However, the assumption that Pc and θ, or $Pc|ch$ and α, are mutually dependent is made mainly for methodological convenience without affecting the basic implications of the following analysis. More generally, the direct costs of law enforcement activity, C, may be specified as a function including Pc and the unconditional probability of legal error as independent arguments so that optimal values of these probabilities may be determined separately via appropriate expenditures. Note that in this more general case changes in Pc need not affect the social costs of punishment due to punishing innocent persons (see the discussion in the following paragraph).

[13]It is tempting to argue that an increase in the rate of innocent persons who are convicted of murder may produce the additional social cost

of encouraging murder or other crimes, because the costs of legitimate behavior are thereby increased. The opposite effect is perhaps more likely, since there would now be an incentive to engage in a subset of "strictly legitimate" activities, particularly those promoted by the revealed preferences of enforcement agencies, as a means of self-protection against arbitrary arrests and convictions. This argument suggests that conviction of innocent as well as guilty persons can produce some discouraging effect on offenders. Regardless of the specific impact errors of justice may have on legitimate or illegitimate behavior, however, these errors necessarily increase the social costs associated with law enforcement activity since they distort the optimal allocation of individuals' resources to productive pursuits.

[14]Sufficient conditions are analyzed in a mathematical appendix to this paper that is available upon request.

[15]By definition,

$$\epsilon_{Pe|c} \equiv -(\partial Q/\partial Pe|c)(Pe|c/Q) \equiv \epsilon_f(\partial f/\partial Pe|c)(Pe|c/f) \equiv \epsilon_f \epsilon_{fe} \quad .$$

Clearly,

$$\epsilon_{fe} = Pe|c[d - (\gamma_2/\gamma_1)m]/\{(\gamma_2/\gamma_1)m + Pe|c[d - (\gamma_2/\gamma_1)m]\}$$

is lower than unity if $[d - (\gamma_2/\gamma_1)m] > 0$. Under this condition, and the condition that $\gamma_1 > 0$, $\epsilon_{Pe|c} < \epsilon_f < 1$.

[16]By like reasoning and some simplifying assumptions it can also be shown that, in equilibrium, $\epsilon_{Pa} > \epsilon_{Pc|a} > \epsilon_{Pe|c}$.

[17]Since the modified equation (9) now includes the additional term $\Psi'(v)(\partial v/\partial Pe|c)$, the value of $\epsilon_{Pe|c}$ may exceed unity in equilibrium if that term is positive in sign. However, the theorem that in equilibrium $\epsilon_{Pc} > \epsilon_{Pe|c}$ need not be affected. Note that the analysis here and pursuant implications differ from a related analysis in Becker (1968) where the coefficient of variation of actual punishments imposed on offenders is assumed to be the source of additional social costs rather than the variance of the punishments.

[18]For any value of $0 < Pe|c < 1$ v reaches a minimum (zero) at $Pc = 0$. Similarly, for any value of $0 < Pc < 1$ v reaches a minimum, $Pe|c(1 - Pe|c)m^2$, at $Pe|c = 0$. In the special case where $Pc = 1$, $v = Pe|c(1 - Pe|c)(d - m)^2$ and $\partial v/\partial Pe|c = (1 - 2Pe|c)(d - m)^2 \gtreqless 0$ as $Pe|c \lesseqgtr 1/2$. Similar results hold in cases when $Pe|c$ is either zero or unity.

[19]It should be pointed out that equation (12) may not be strictly linear in the parameters associated with Pa, Pc|a, and Pe|c. For example, equation (6) implies that the elasticity of murder with respect to Pe|c is positively related to the absolute level of $Pe \equiv PaPc|aPe|c$. The same problem arises, however, in the context of a regression equation that introduces the natural values of y_1, Y_1, and X_1 instead of their natural logarithms, as can easily be inferred from the analysis developed in foonotes 9 and 10. The double-log format of the regression analysis is chosen partly because many of the variables used as proxies for the desired theoretical constructs are expected to be proportionally related to the latter variables (see Section II.A.2 below).

[20]I am indebted to the Uniform Crime Reporting Section of the Federal Bureau of Investigation for making available to me their revised annual

estimates of the total number of murder and other index crimes in the United States during the period 1933-1965.

[21]Another important reason for introducing chronological time as an exogenous variable in equation (12) is to account for a possible time trend in missing variables, in particular, the average length of imprisonment for both capital and noncapital murders for which no complete time series is available. Scattered evidence shows rising trends in the median value of prison terms served by all murder convicts over a large part of the period considered in this investigation, but this increase may have been largely technical. With executions being imposed less frequently over time, the frequency of life imprisonment sentences for murder convicts may have risen accordingly, thus increasing the mean or median time spent in prisons by these convicts.

[22]Let $P^o c|a = \frac{C}{A}$, where C denotes the number of persons convicted, and A the number of those charged. Also let $A = G + I$ and $C = C_g + C_i$, where G and I, and the subscripts g and i, represent guilty and innocent persons, respectively. Then

$$P^o c|a \equiv \frac{G}{A} \cdot \frac{C_g}{G} + \frac{I}{A} \cdot \frac{C_i}{I} = \lambda\ Pc|ch + (1 - \lambda)\alpha \quad ,$$

where $\alpha \equiv \frac{C_i}{I}$ denotes the probability of legal error. Clearly, if $\lambda \equiv \frac{G}{A}$ were constant, and if $Pc|ch$ and α were proportionally related, $P^o c|a$ and $Pc|ch$ would also be proportionally related. In other cases, variations in $P^o c|a$ may either overstate or understate the variation in $Pc|ch$.

[23]Execution figures are based on NPS statistics. Conviction figures are derived by $C_t = Q^o_t\ P^o a_t\ P^o c|a_t$. Statistics on the time elapsed between sentencing and execution can be found in NPS numbers 20 and 45.

[24]

$$TXQ_1 = \underset{(5.954)}{.9593}\, PXQ_{1_{-1}} + \underset{(1.973)}{.4266}\, PXQ_{1_{-2}} + \underset{(-2.405)}{.4155}\, PXQ_{1_{-3}}$$

(t-values in parentheses).

$$PDL_1 = \underset{(5.233)}{.8053}\, PXQ_{1_{-1}} + \underset{(3.977)}{.5574}\, PXQ_{1_{-2}} + \underset{(0.8007)}{.1109}\, PXQ_{1_{-3}} - \underset{(-3.222)}{.5341}\, PXQ_{1_{-4}}$$

The coefficients associated with lagged values of PXQ_1 in the last equation were estimated via the Almon method (Almon, 1965) which constrains the coefficients of the distributed lag equation to lie along a polynomial of a chosen degree (here degree 2).

[25]I am indebted to Edi Karni for making available to me his calculations of Y_p.

[26]The regression coefficients associated with estimates of $Pe|c$ are found to be even lower in absolute magnitude when all variables are represented in the regression equation by their natural numbers rather than by their natural logarithms. For example, the regression coefficient associated with the natural value of PXQ_1 in the context of equation (1) in Table 4 is -0.00385 with a standard error of 0.00127.

[27]The partial effect of L on the rate of murder as well as other crimes against the person was also found to be negative across states (see Ehrlich (1973) and Table 8), but its partial effect on the frequency of crimes against property across states was found to be inconclusive. A possible explanation for the significant negative association between L and particularly crimes against the person is that interpersonal frictions and social interactions leading to acts of malice occur mostly in the nonmarket or

home sector rather than at work. An increase in the total time spent in the nonmarket sector (a reduction in L) might then generate a positive scale effect on the incidence of murder. This ad hoc hypothesis is nevertheless supported by UCR evidence on the seasonal pattern of murder. This crime rate peaks twice a year: around the holiday season (December) and around the summer vacation season (July-August) in which relatively more time is spent out of work. It is also supported by evidence that the frequency of murders on weekends is significantly higher than on weekdays (see William F. Graves, "The Deterrent Effect of Capital Punishment in California," reprinted in Bedau (1967), p. 327).

[28] In addition, it is also possible that the severity of imprisonment had also decreased during the period of practical abolition of capital punishment, which would have contributed to the increase in the differential deterrent effect of capital punishment in this subperiod. The interval of time 1962-1969 is found to be particularly important in the regression analysis, mainly because of the greater variability exhibited in this subperiod by P^oa, $P^oc|a$, and $P^oe|c$. Indeed, regression results pertaining to the effect of these variables in the subperiod 1935-1962 or 1937-1962 are found to be generally weak compared to the results reported in Table 6. Note that in view of the large number of variables used in the reduced form regression analysis, experimentation with different intervals of time is constrained to subperiods including a sufficient number of observations.

[28a] The reader should note that P^oa, P^om and P^oe here refer to the fractions of all potential murderers who are apprehended, imprisoned and executed in a given year, respectively, rather than to the corresponding fractions of actual perpetrators of murder who are apprehended, imprisoned and executed. The latter have constituted my original definitions of P^oa, P^om and P^oe. The alternative definitions of the symbols in question would be identical, of course, if the number of murders committed by an average murderer

in a given year, ζ, were greater than or equal to unity. More generally, these alternative definitions would be proportionally related if ζ were constant. Under the latter assumption the qualitative prediction summarized by equation (15) holds for equal percentage changes in P^oa and $P^oc|a$, regardless of the exact definition of P^oa.

[29]The average value of Te is estimated at about 40 years, which is the life expectancy of an average person whose age is the same as the age of an average offender committed to state prisons for the crime of murder (33 according to NPS (1960), p. 64). Tm is estimated to be between 10 and 16 years (see Sellin (1959), pp. 74-75), and g is found to be roughly 1.25 percent per annum. P^om is estimated at 0.38, which is the average value of the product $P^oa \cdot P^oc|a\ (1 - P^oe|c)$. (These variables are defined in Section II.A.2, with $P^oe|c$ being approximated by PXQ_1.) Finally, P^oe, the fraction of all potential murders who are executed in a given year, is estimated as .008, the ratio of all persons executed during 1935-1969 to the total number of murders reported in that period. Both P^om and P^oe are constructed on the extremely unrealistic assumption that any offender at large commits one murder each and every year. Under this assumption $^{o}Pe|c$ is estimated to lie between .020 and .037, depending upon the specific value of Tm assumed in its calculation.

[30]A decrease in the number of executions in 1960 from 44 to 2 (the actual number of executions in 1967), which implies a decline of 95 percent in the value of $Pe|c$ in that year, would have increased the murder rate that same year by about 6.2 percent from 0.05 to 0.053 per 1,000 population if the true value of α_3 were equal to 0.065. The implied increase in the actual number of murders in 1960 would have been from 9,000 to 9,558. For comparison, note that the actual murder rate in 1967 was 0.06 per 1,000 population and the number of murders was 12,100. The values of other explanatory variables associated with the supply of murders function were, of course,

quite different in these two years. By this tentative and rough calculation, the decline in Pe|c alone might have accounted for about 25 percent of the increase in the murder rate between 1960 and 1967.

[31]The elasticities associated with PXQ_1, $PXQ_{1_{-1}}$, TXQ_1, and PDL_1 in this modified reduced form regression analysis relating to the period 1934-1969 are found equal to -0.0269 (-0.83), -0.0672 (-2.29), -0.0414 (-1.99), and -0.052 (-5.81), respectively, where the numbers in parentheses denote the ratios of the coefficients to their standard errors.

[32]Ironically, the argument that capital punishment should be abolished because it has no deterrent effect on offenders might serve to justify the use of capital punishment as an ultimate means of prevention of crime, since the risk of recidivism that cannot be deterred by the threat of punishment is not eliminated entirely even inside prison walls. In contrast, since the results of this investigation support the notion that execution exerts a pure deterrent effect on offenders, they can be used to suggest that other punishments, even those which do not have any preventive effect, can, in principle, serve as substitutes.

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