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Participation in Illegitimate Activities: An Economic Analysis

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INTRODUCTION

Much of the search in the criminological literature for a theory explaining participation in illegitimate activities seems to have been guided by the predisposition that since crime is a deviant behavior, its causes must be sought in deviant factors and circumstances determining behavior. Criminal behavior has traditionally been linked to the offender's presumed unique motivation which, in turn, has been traced to his allegedly unique inner structure, to the impact of exceptional social or family circumstances, or to both (for an overview of the literature see, e.g., Taft and England, 1964).

Reliance on a motivation unique to the offender as a major explana-

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tion of actual crime does not, in general, render possible predictions regarding the outcome of objective circumstances. We are also unaware of any persuasive empirical evidence reported in the literature in support of theories using this approach. Our alternative point of reference, although not necessarily incompatible, is that even if those who violate certain laws differ systematically in various respects from those who abide by the same laws, the former, like the latter, do respond to incentives. Rather than resort to hypotheses regarding unique personal characteristics and social conditions affecting respect for the law, penchant for violence, preference for risk, or in general preference for crime, one may separate the latter from measurable opportunities and see to what extent illegal behavior can be explained by the effect of opportunities, given preferences.

In recent years a few studies attempted to investigate the relation between crime and various measurable opportunities. For example, Fleisher (1966) studied the relation between juvenile delinquency and variations in income and unemployment conditions via a regression analysis, using inter- and intracity data relating to the United States in 1960. Smigel-Leibowitz (1965) and Ehrlich (1967) used several regression methods to study the effect of the probability and severity of punishment on the rate of crime across states in the United States in 1960. In his significant theoretical contribution to the study of crime in economic terms, Becker (1968) has developed a formal model of the decision to commit offenses which emphasizes the relation between crime and punishment. Stigler (1970) also approaches the determinants of the supply of offenses in similar terms. Following these studies, and particularly my 1970 study, an attempt is made in this paper to formulate a more comprehensive model of the decision to engage in unlawful activities and to test it against some available empirical evidence. My analysis goes beyond that of Becker and other previous contributions in several ways. First, it incorporates in the concept of opportunities both punishment and reward—costs and gains from legitimate and illegitimate pursuits—rather than the cost of punishment alone, and attempts to identify and to test the effect of their empirical counterparts. Specifically, it predicts and verifies empirically a systematic association between the rate of specific crimes on the one hand, and income inequality as well as law enforcement activity on the other. Second, it links formally the theory of participation in illegitimate activities with the general theory of occupational choice by presenting the offender's decision problem as an optimal allocation of resources under uncertainty to competing activities both inside and outside the market sector, rather than as a choice between mutually exclusive activities. The model developed can be used to predict not only the *direction*, but also the relative *magnitude* of the response of specific offenders to changes in various observable opportunities. In addition, the analysis distinguishes between the deterrent and preventive effects of punishment by imprisonment on the rate of crime (by the latter is meant the reduction in criminal activity due to the temporary separation of imprisoned offenders from potential victims) and permits an empirical verification of the former effect alone. Finally, in the context of the empirical implementation, I analyze the interaction between offense and defense—between crime and (collective) law-enforcement activity through police and courts—and employ a simultaneous-equation econometric model in estimating supply-of-offenses functions and a production function of law-enforcement activity. The results of the empirical investigation are then used to provide some tentative estimates of the effectiveness of law enforcement in deterring crime and reducing the social loss from crime.

The plan of the paper is as follows: In Section I, I develop a model of participation in illegitimate activities and derive some behavioral implications. In Section II those implications are applied in developing supply-of-offenses functions. Section III is devoted to an econometric specification of a simultaneous-equation model of crime and law enforcement, and in Section IV, I present and discuss the results of the empirical investigation.

I. THE CRIMINAL PROSPECT

In spite of the diversity of activities defined as illegal, all such activities share some common properties which form the subject matter of our analytical and empirical investigation. Any violation of the law can be conceived of as yielding a potential increase in the offender's pecuniary wealth, his psychic well-being, or both. In violating the law, one also risks a reduction in one's wealth and well-being, for conviction entails paying a penalty (a monetary fine, probation, the discounted value of time spent in prison and related psychic disadvantages, net of any direct benefits received), acquiring a criminal record (and thus reducing earning opportunities in legitimate activities), and other disadvantages. As an alternative to violating the law one may engage in a legal wealth- or consumption-generating activity, which may also be subject to specific risks. The net gain in both activities is thus subject to uncertainty.

A simple model of choice between legal and illegal activity can be formulated within the framework of the usual economic theory of choice under uncertainty. A central hypothesis of this theory is that if, in a given period, the two activities were mutually exclusive, one would choose between them by comparing the expected utility associated with each alone.[1] The problem may be formulated within a more general context, however, for the decision to engage in illegal activity is not inherently an either/or choice: offenders are free to combine a number of legitimate and illegitimate activities or to switch from one to another during any period throughout their lifetime.[2] The relevant object of choice to an offender may thus be defined more properly as his optimal activity mix: the optimal allocation of his time and other resources to competing legal and illegal activities.[3] Allowing explicitly for varying degrees of participation in illegitimate activity, we then develop behavioral implications concerning entry into, and optimal participation in, such activity.

A. Optimal Participation in Illegitimate Market Activities: A One-Period Uncertainty Model

For the sake of a simple yet general illustration, assume that an individual can participate in two market activities: i, an illegal activity, and l, a legal one, and must make a choice regarding his optimal participation in each at the beginning of a given period. No training or other entry costs are required in either activity, neither are there costs of movement between the two. The returns in both activities are monotonically increasing functions of working time. Activity l is safe in the sense that its net returns are given with certainty by the function $W_l(t_l)$, where t denotes the time input. Activity i is risky, however, in the sense that its net returns are

1. Such formulation is used in Ehrlich (1967) and Becker (1968), included in this volume.

2. The standard literature on occupational choices usually assumes specialization in a single activity, rather than multiple-job holding. An important incentive for such specialization arises from time dependencies generated by specific training, for wages in activities involving training stand in some positive relation to the total amount of time previously spent there training or learning by doing. Multiple-job holding also entails various costs of movement between jobs that may offset potential gains due, say, to the increased returns on time spent in each. Specialization in a single market activity may thus be optimal, at least during periods of intensive training. Nevertheless, in the case of market activities involving a large measure of risk, there may be an incentive for diversifying resources among several competing activities. We propose that such an incentive exists in the case of illegitimate activities, especially those that do not require specific training.

3. In addition, an offender's probability of being apprehended and convicted of a specific charge is not determined by society's actions alone, but is modifiable through his deliberate actions (self-protection). For an analysis of an offender's simultaneous decision to allocate resources to illegal and legal activities as well as to self-protection, see Appendix 2 to this section.

conditional upon, say, two states of the world: a, apprehension and punishment at the end of the period, with (subjective) probability p_i, and b, escaping apprehension, with probability $1 - p_i$. If successful, the offender reaps the entire value (pecuniary and nonpecuniary) of the output of his illegitimate activity, net of the costs of purchased inputs (accomplices' and accessories' services), $W_i(t_i)$.[4] If apprehended and punished, his returns are reduced by an amount $F_i(t_i)$: the discounted (pecuniary and nonpecuniary) value of the penalty for his entire illegitimate activity and other related losses, including the possible loss of his loot. It is assumed that the probability of apprehension and punishment is independent of the amount of time spent in i and l,[5] and that time is proportionally related to any other direct inputs employed in the production of market returns.

The individual is assumed to behave as if he were interested in maximizing the expected utility of a one-period consumption prospect.[6] For analytical convenience, let the utility in any given state of the world s, be given by the function

$$U_s = U(X_s, t_c), \tag{1.1}$$

where X_s denotes the stock of a composite market good (including assets, earnings within the period, and the real wealth equivalent of nonpecuniary returns from legitimate and illegitimate activity), the command over which is contingent upon the occurrence of state s; t_c is the amount of time devoted to consumption or nonmarket activity; and U is an indirect

4. In large measure, the pecuniary returns from crime are positively related to the amount of transferable goods and assets and other wealth possessed by potential victims. More important, these returns may be subject to uncertainty due in large measure to varying degrees of self-protection provided by potential victims. (For a theoretical analysis of private self-protection, see Ehrlich and Becker, 1972.) For analytical simplicity, and in view of the limited data available for an empirical estimation of illegitimate returns (see Sect. III, B), we here treat W_i as a single-valued function of t_i.

5. This assumption is relaxed in Appendix 2 to this section, where we have allowed p_i to be a positive function of t_i (or the number of offenses committed), and a negative function of the degree of self-protection provided by the offender, which, in turn, is expected to be positively related to t_i. The behavioral implications of the more simple model are shown to hold in this more general case, as well.

6. This may be compatible with the assumption that the individual wishes to maximize the expected utility of his lifetime consumption, since it is possible, in general, to represent his decision problem at any given period in terms of maximizing a derived one-period utility function, which is explicitly a function of current variables, but which also summarizes realized past consumption and the results of optimal decisions at relevant subsequent periods for all possible future events. For an elaborate discussion of this proposition, see Fama (1970).

utility function that also converts X_s and t_c into consumption flows. Denoting all earnings within the period in real terms, that is, in terms of the composite good X, there exist under the foregoing assumptions regarding the earning functions in i and l only two states of the world with respect to X. Either

$$X_b = W' + W_i(t_i) + W_l(t_l) \tag{1.2}$$

is obtained with probability $1 - p_i$, or

$$X_a = W' + W_i(t_i) - F_i(t_i) + W_l(t_l) \tag{1.3}$$

is obtained with probability p_i, where W' denotes the real value of the individual's assets (net of current earnings), including his borrowing opportunities against earnings in future periods, and is assumed to be known with certainty, given the state of the world in the beginning of each period. The expected utility which is generally given by

$$EU(X_s, t_c) = \sum_{s=a}^{n} \pi_s U(X_s, t_c) \tag{1.4}$$

where π_s denotes the probability of state s, reduces in this case to

$$EU(X_s, t_c) = (1 - p_i)U(X_b, t_c) + p_i U(X_a, t_c). \tag{1.4a}$$

The problem thus becomes that of maximizing equation (1.4a) with respect to the choice variables t_i, t_l, and t_c, subject to the wealth constraints given by equations (1.2) and (1.3), a time constraint,

$$t_0 = t_i + t_l + t_c, \tag{1.5}$$

and nonnegativity requirements,

$$t_i \geqslant 0; \quad t_l \geqslant 0; \quad t_c \geqslant 0. \tag{1.6}$$

Substituting equations (1.2) and (1.3) in equation (1.4a), the Kuhn-Tucker first-order optimality conditions can be stated as follows:

$$\begin{gathered} \frac{\partial EU}{\partial t} - \lambda \leqslant 0, \\ \left(\frac{\partial EU}{\partial t} - \lambda\right) t = 0, \\ t \geqslant 0, \end{gathered} \tag{1.7}$$

where t stands for the optimal values of each of t_i, t_l, and t_c, and λ is the marginal utility of time spent in consumption. It can easily be shown that

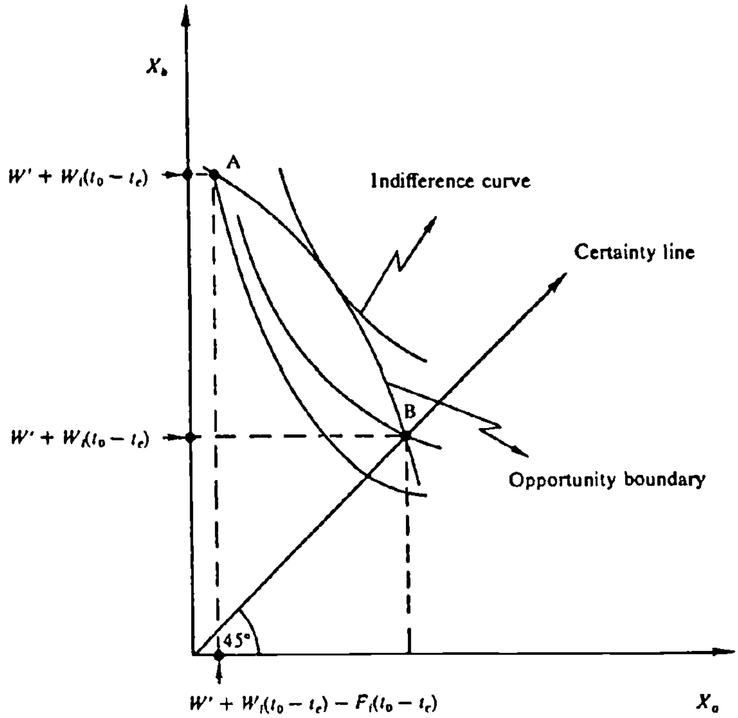

FIGURE 1

given the amount of time allocated to consumption t_c, the optimal allocation of working time between i and l, in case of an interior solution, must satisfy the first-order condition,

$$-\frac{w_i - w_l}{w_i - f_i - w_l} = \frac{p_i U'(X_a)}{(1 - p_i)U'(X_b)}, \tag{1.8}$$

where $w_i = (dW_i/dt_i)$, $f_i = (dF_i/dt_i)$, and $w_l = (dW_l/dt_l)$. The term on the left-hand side of equation (1.8) is the slope of an opportunity boundary, the production transformation curve of the composite good X between the two states of the world considered in this example (by condition [1.6] it is defined only between points A and B in Figure 1), and the term on the right is the slope of an indifference curve (defined along $dU^* = 0$). In an equilibrium position involving participation in both i and l, they must be the same. Clearly, a necessary prerequisite for equation (1.8) is that the potential marginal penalty, f_i, exceed the differential marginal return from illegitimate activity, $w_i - w_l$, for otherwise the marginal opportunities in i would always dominate those in l.[7] The imposition of concurrent

7. This paraphrases and modifies a well-known argument that "the evil of punishment must be made to exceed the advantage of the offense" (see Bentham, 1931, p. 325).

imprisonment terms for several offenses committed by the same offender is thus shown to create an incentive for offenders to specialize in illegitimate activity. Equation (1.8) would be necessary and sufficient for a strict global maximum involving participation in both i and l if the indifference curve is strictly convex to the origin (which implies diminishing marginal utility of real wealth) and the opportunity boundary is linear or strictly concave (which is consistent with, say, diminishing marginal wages and constant or increasing marginal penalties).[8]

Figure 1 and equation (1.7) can be used to analyze the range of possible combinations of illegitimate and (safe) legitimate activities. A *sufficient* condition for entry into i—regardless of attitudes toward risk—is that the absolute slope of the opportunity boundary exceed the absolute slope of the indifference curve at the position where the total working time is spent in legitimate activity (point B on the certainty line) or $-(w_i - w_l)/(w_i - f_i - w_l) > p_i/(1 - p_i)$. This requires, in turn, that the marginal expected return in i exceed that in l. For risk avoiders or risk-neutral persons, this is also a necessary condition for entry into i, and its converse would imply their specialization in l.

If the opportunity boundary were concave to the origin, as in Figure 1 (or if the probability of apprehension and punishment were a positive function of t_i), participation in both legitimate and illegitimate activity may be consistent with constant or increasing marginal utility of wealth. Assuming that the opportunities available to offenders were independent of their attitudes toward risk, it can then be shown that a risk-neutral offender will spend more time in illegitimate activity relative to a risk avoider, and a risk preferrer will spend more time there relative to both.[9] Moreover, if the opportunity boundary were linear (and p_i were constant),

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8. The second-order condition for a (strict) local maximum in this case is

$$\Delta = (1 - p_i)U''(X_b)(w_i - w_l)^2 + p_iU''(X_a)(w_i - f_i - w_l)^2$$
$$+ (1 - p_i)U'(X_b)\left(\frac{dw_i}{dt_i} + \frac{dw_l}{dt_l}\right)$$
$$+ pU'(X_a)\left(\frac{dw_i}{dt_i} - \frac{df_i}{dt_i} + \frac{dw_l}{dt_l}\right) < 0. \qquad (1.8a)$$

9. By equation (1.8) in an equilibrium position, $-(1 - p_i)(w_i - w_l)/p_i(w_i - f_i - w_l) \gtreqless 1$; that is, $E(w_i) = (1 - p_i)w_i + p_i(w_i - f_i) \gtreqless w_l$, as $U'' \gtreqless 0$. Since the opportunity boundary is concave to the origin, the equilibrium position of a risk preferrer must be to the left of that of a risk neutral, and even further to the left of that of a risk avoider (i.e., closer to the X_b axis).

offenders who are risk preferrers would necessarily specialize in illegitimate activity, since the optimality conditions imply a corner solution in this case. In contrast, offenders who are risk avoiders are likely to combine a relatively safe legitimate activity with their illegitimate activity to hedge against the relatively greater risk involved in a full-time pursuit of the latter. Whether offenders are likely to specialize in illegitimate acitvity thus becomes an aspect of their attitudes toward risk, as well as their relative opportunities in alternative legitimate and illegitimate activities [10] (the latter including, by definition, nonpecuniary costs and returns). Also, whether in equilibrium crime pays in terms of expected (real) marginal returns is simply a derivative of an offender's attitude toward risk, since in equilibrium the expected marginal returns from crime would exceed, be equal to, or fall short of the marginal returns from legitimate activity, depending on whether the offender were a risk avoider, risk neutral, or a risk preferrer, respectively.[11]

Although our model has been illustrated for two states of the world, the analysis generally applies to n states—various combinations of contingencies in legitimate and illegitimate activities. For example, if returns in i and l are (each) subject to a single trial binomial probability distribution due to success or failure in i and employment or unemployment in l throughout a given period, the necessary condition for an interior solution with respect to the allocation of working time between i and l that maximizes equation (1.4) becomes

$$(1 - p_i)(1 - u_l)U_a'(w_i - w_l) + (1 - p_i)u_lU_b'w_i + p_i(1 - u_l)U_c'(w_i - f_i - w_l) + p_iu_lU_d'(w_i - f_i) = 0, \quad (1.9)$$

where u_l is the probability of unemployment in l and a, b, c, and d are the four relevant states of the world.[12] The basic implications of the

10. At present, no reliable statistics exist which indicate to what extent crimes are committed by full-time criminals. Studies of prisoners in federal, state, and local correctional institutions in the United States show that a majority of these offenders did have legitimate occupational experience—mainly in unskilled occupations—prior to their apprehension, and that only a small fraction never worked. Other available data indicate that professional criminals are responsible for a large proportion of major thefts (see PCL, 1967 (b), p. 47).

11. A proof is given in n. 9. Some evidence as to whether crime pays in the monetary sense alone is discussed in Appendix 2 to Section IV.

12. In deriving eq. (1.9), we have implicitly assumed that legitimate wage rates in case of unemployment are zero. Note that losses from unemployment may be insured via market insurance, whereas no such insurance is available against punishment for crime. This is one reason for expecting l to be a safer activity relative to i.

preceding analysis hold with some modifications in this more general case as well (see Appendix 1 to this section).

The model developed in this section can be used to explain why many offenders, even those convicted and punished, tend to repeat their crimes. Given the offender's opportunities and preferences, it may be optimal for him to commit several offenses in any given period. Moreover, even if there were no systematic variations in preferences for crime from one period to another (these may in fact intensify), an offender is likely to repeat his illegitimate activity if the opportunities available to him remain unchanged. Indeed, legitimate earning opportunities of convicted offenders may become much more scarce relative to their illegitimate opportunities because of the criminal record effect and the effect of long imprisonment terms on legitimate skills and employment opportunities. Recidivism is thus not necessarily the result of an offender's myopia, erratic behavior, or lack of self-control, but may rather be the result of choice dictated by opportunities.

B. Some Behavioral Implications

Equation (1.7), and, more specifically, equation (1.8) or (1.9), identify the basic factors determining entry into and optimal participation in illegitimate activities. We now turn to derive some comparative statics implications associated with these factors and start by considering their effects on the allocation of working time $(t_0 - t_c)$ between competing legitimate and illegitimate activities in the market sector.

An increase in either p_i or f_i with no change in the other variables entering equation (1.8) or (1.9) reduces the incentive to enter and participate in illegitimate activity because it increases the expected marginal cost of punishment, $p_i f_i$. If an offender had a neutral attitude toward risk, and thus were interested only in the expected value of his wealth prospect, the magnitude of his response to a 1 per cent increase in either p_i or f_i would be the same, for equal percentage changes in each of these variables have the same effect on $p_i f_i$. Equal percentage changes in p_i and f_i may have quite different effects on the expected utility from crime, however, if one has nonneutral attitudes toward risk. The deterrent effect of a 1 per cent increase in the marginal or average penalty per offense can be shown to exceed or fall short of that of a similar increase in the probability of apprehension and punishment if the offender is a risk avoider or a risk preferrer, respectively. Moreover, if the offender was a risk preferrer and yet partly engaged in legitimate activity, an increase in the average penalty per offense might not deter his participation in crime. Such participation might even increase.[13] This result is not inconsistent with an assertion often made by writers on criminal behavior regarding the low, or even positive effect of punishment on the criminal propensities of *some* offenders. Such behavior is here found to be consistent with preference for risk and need not be interpreted as evidence of an offender's lack of response to incentives.

Similarly, an increase in the marginal or average differential return from illegal activity, $w_i - w_l$, resulting from an increase in (real) illegitimate payoffs or a decrease in (real) legitimate wages with no change in the other variables entering equation (1.8) or (1.9), can be shown generally to increase the incentive to enter into or allocate more time to illegitimate activity: since the opportunity boundary in Figure 1 becomes steeper about point B, some persons who initially specialized in legitimate activity would now find it optimal to allocate some time to an illegitimate activity (more general proofs are given in Ehrlich, 1970, under some restrictive assumptions regarding absolute risk aversion). However, an increase in the *probability* of unemployment, u_l (if unemployment is viewed as an uncertain event in the beginning of a given period), has a more ambiguous effect on the incentive to assume the greater risk involved in additional illegitimate activity if offenders are risk avoiders.[14]

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13. The effect of a 1 per cent increase in p_i on the optimal fraction of working time allocated to i, $t_i^* - W'$, w_i, w_l, f_i, and t_c held constant—can be found, for example, by differentiating eq. (1.8) with respect to $\ln p_i$: $(\partial t_i^*/\partial p_i)p_i = (1/\Delta)[-U_a'(w_i - f_i - w_l)p_i + U_b'(w_i - w_l)p_i] = (+)/(-) < 0$, where Δ is defined in eq. (1.8a) in n. 8. Similarly, the partial effect of a 1 per cent increase in all the penalty rates, f_i, hence in the average rate, $f = (F/t_i)$, would be given by $(\partial t_i^*/\partial f)f = (1/\Delta)[U_a'p_i f_i + U_a''(w_i - f_i - w_l)p_i f t_i^*]$. If $U'' \leqslant 0$, the preceding equation would always be negative. The result would be ambiguous, however, if $U'' > 0$, and would depend on opposite wealth and substitution effects. Moreover, it can easily be verified that

$$-\frac{\partial t_i^*}{\partial p_i} p_i \gtreqless -\frac{\partial t_i^*}{\partial f} f, \text{ as } U'' \gtreqless 0, \tag{1.10}$$

where the right-hand side of eq. (1.10) represents the effect of a 1 per cent change in either the marginal or the average penalty for crime. This result can also be shown to apply under some restrictive assumptions to the relative effects of probability and severity of punishment on the *absolute* amount of time allocated to i. Moreover, it holds unambiguously for the relative effects of these variables on the incentive to enter (or exit from) illegal activity (proofs are given in Appendix 1 to this section).

14. The reason is that the increase in the probability of the least desirable state of the world (unemployment in l and failure in i) increases the demand for wealth in this state and might decrease the incentive to participate in i since the latter decreases the potential wealth in this state (see Appendix 1 to this section). However, the partial effect of an increase in u_l on entry into i is unambiguously positive and symmetrical to that of an increase in p_i.

A pure wealth effect may be defined as the effect of an equal proportional increase in wealth in every state of the world with no change in the probability distribution of states. Such may be the case when legitimate and illegitimate returns increase by the same proportion, and punishment for crime is by imprisonment (an empirical implementation of this case is considered below in Sec. III, B). Whether the optimal allocation of working time between i and l changes would then depend on whether an offender has increasing or decreasing relative risk aversion.[15] Increasing relative risk aversion thus implies that the rich have a lesser incentive to participate in crimes punishable by imprisonment relative to the poor.

Note, finally, that a decrease in the amount of time allocated to nonmarket activities (including schooling), due to a change in factors other than those considered in the preceding analysis, is likely to generate a positive scale effect on participation in i and l: since more time is spent in market activities, more time would be spent in both legal and illegal market activities, provided that the reduction in t_c did not affect one's relative allocation of working time between the latter activities.

We have so far considered the effects of changes in various indicators of the opportunities available in legitimate and illegitimate activities on the fraction of working time allocated to these activities. The behavioral implications of the preceding analysis would strictly apply to the absolute level of participation in i and l if changes in market opportunities did not affect the demand for time in nonmarket activities due, say, to offsetting wealth and substitution effects. This may not be true in general. For example, wealth-compensated changes in legitimate and illegitimate opportunities generate a pure substitution effect on the demand for consumption time. A partial increase in w_i is then expected to increase both the fraction of working time devoted to i as well as its absolute level, due to a complementary scale effect on working time. In contrast, a partial increase in w_l would lead to a decrease in the absolute level of participation in i only if the resulting substitution effect within the market sector exceeds an opposite scale effect on working time. This analysis shows that the effect of compensated and even uncompensated changes in legitimate market wages on the extent of participation in i may be lower than that of changes in illegitimate payoffs. A further implication is that the effect of uncompensated changes in various legitimate and illegitimate opportunities on the extent of participation in illegitimate activities is generally

15. For an elaborate discussion of this result, see Ehrlich and Becker (1972).

expected to be greater on offenders who participate in such activities on a part-time basis than on those who specialize in such activities. To illustrate, if an offender specializes in i—a boundary solution obtains—his objective opportunities will not be affected at all by small changes in legitimate employment opportunities, and he may not respond even to changes in illegitimate opportunities if such uncompensated changes have no effect on the demand for consumption time.[16] Thus, the extent of (initial) participation in illegitimate activity may be an important determinant of the *magnitude* of the response of specific offenders to changes in various market opportunities. Full-time or hard-core offenders may be less deterred in absolute magnitude by, say, an increase in law-enforcement activity, relative to part-time or occasional offenders, simply because of their greater involvement in illegitimate activity.

C. MARKET OPPORTUNITIES AND CRIMES AGAINST THE PERSON

Unlike crimes involving material gains that may be motivated largely by the offender's desire for self-enrichment, crimes against the person may be motivated primarily by hate or passion: phenomena involving interdependencies in utilities among individuals whereby the utility of one is systematically affected by specific characteristics of another.[17] It may thus be appropriate to consider crimes against the person nonmarket activities, that is, activities that directly meet needs, as distinct from market or wealth-generating activities.

Since those who hate need not respond to incentives any differently from those who love or are indifferent to the well-being of others, the analysis of the preceding sections would apply, with some modifications,

16. More generally, let the total time spent in illegitimate activity be given by the identity $i \equiv t_0 - c - l$, where i, c, and l denote the number of hours an offender spends in i, c, and l, respectively. Let the subscripts p and f distinguish between relatively part-time and full-time offenders. By assumption, then, $i_f > i_p$ and $l_p > l_f \geqslant 0$. If α is a parameter that improves the relative opportunities in i, the effect of an uncompensated increase in α on i_p and i_f will be denoted by $E_{p\alpha} = (\partial i_p/\partial\alpha)(\alpha/i_p)$ and by $E_{f\alpha} = (\partial i_f/\partial\alpha)(\alpha/i_f)$, respectively. Assuming, now, that the partial elasticities of l and c with respect to α, $\sigma_{l\alpha} = -(\partial l/\partial\alpha)(\alpha/l)$ and $\sigma_{c\alpha} = -(\partial c/\partial\alpha)(\alpha/c)$, are the same for both groups of offenders, then it can easily be shown that $D \equiv E_{p\alpha} - E_{f\alpha} = \sigma_{l\alpha}(l_p/i_p - l_f/i_f) + \sigma_{c\alpha}(c_p/i_p - c_f/i_f)$ is necessarily positive if $\sigma_{l\alpha} \geqslant \sigma_{c\alpha} \geqslant 0$.

17. Indeed, the empirical evidence lends support to such a proposition, for it shows that crimes against the person, unlike crimes against property, occur most frequently among people known to exercise close and frequent social contact and whose utilities are likely to be interdependent. For a more elaborate discussion, see Ehrlich (1970).

to crimes against the person as well as to crime involving material gains. Specifically, an increase in the probability and severity of punishment would deter crimes against the person for the same reasons it was expected to deter participation in crimes against property. Moreover, independent changes in legitimate market opportunities may also have a systematic effect on participation in crimes against the person. For example, given the total time spent in nonmarket activities, t_c, an increase in w_l that was fully compensated by a reduction in other income would reduce the demand for time-intensive consumption activities (for this concept, see Becker, 1965) because of the increase in their relative costs; some crimes against the person might fit into this category.[18] In contrast to crimes against property, however, a decrease in t_c due to specific exogenous factors is likely to produce a negative scale effect on participation in crimes against the person simply because less time could then be spent on all nonmarket activities, legitimate, as well as illegitimate. Accordingly, an improvement in legitimate earning opportunities that increases the total amount of time spent at work may reduce participation in crimes against the person even if it did not increase the cost of such crimes relative to other nonmarket activities. Some empirical evidence pertaining to these implications is discussed in Sec. IV, B.

II. THE SUPPLY OF OFFENSES

A. THE BEHAVIORAL FUNCTION

Given the validity of our analysis and the behavioral implications developed in the preceding section, we may now specify a behavioral function relating a person's actual participation in illegal activity in a given period to its basic determinants. Because in many illegal activities crime is comprised of discrete actions, or offenses, the dependent variable could be generally specified in terms of the directly observable number of offenses one commits, q_{ij}, rather than as the amount of time and other resources one devotes to such activities, assuming that all these variables are monotonically related:

$$q_{ij} = \psi_{ij}(p_{ij}, f_{ij}, w_{ij}, w_{lj}, u_{lj}, \pi_j). \tag{2.1}$$

18. This is likely particularly in view of the prospect of imprisonment associated with these crimes. If the length of incarceration, rather than the full cost of imprisonment, f_i, is held constant, as in the empirical implementation of our model, an increase in w_l is likely to increase the cost of crimes against persons relative to legitimate consumption activities.

The argument π_j is introduced in equation (2.1) to denote other variables that may affect the frequency of offenses committed by a specific individual, j, in addition to those discussed in the preceding section. These include his personal or family level of wealth, his efficiency at self-protection, the amount of private insurance provided by his family (or a criminal organization), and other factors that may affect the demand for time spent in nonmarket activities. In addition, the variable π includes costs and gains in other specific illegal activities which are close substitutes or complements to the illegal activity, (i).[19] Finally, π accounts for the form of the penalty: imprisonment, a fine, or a combination of the two. The importance of this latter distinction is discussed below in Sec. II, C.

B. THE AGGREGATE FUNCTION

If all individuals were identical, the behavioral function (2.1), except for change in scale, could also be regarded as an aggregate supply function in a given period of time. In general, however, none of the variables entering (2.1) is a unique quantity, since people differ in their legitimate and illegitimate earning opportunities and hence in their opportunity costs of imprisonment (if punishment assumes such form). Therefore, the behavioral implications derived in Section I apply here for independent changes in the level of the entire distributions of these variables, or for changes in the mean variables within specific communities, holding all other parameters of the distributions constant:

$$Q_i = \Psi_i(P_i, F_i, Y_i, Y_l, U_l, \Pi_i), \tag{2.2}$$

where P_i, F_i, etc., denote the mean values of p_{ij}, f_{ij}, etc., and Π includes, in addition to environmental variables, all the moments of the distributions of p, f, etc., other than their means.

Our general expectations concerning the effect of exogenous shifts in various opportunities on the number of offenses committed may hold with fewer qualifications in the aggregate than in the case of individual offenders. The aggregate supply curve of offenses can be conceived of as the cumulative distribution of a density function showing variations across persons with respect to the minimum expected net gain that is sufficient to induce them to enter an illegal activity (their entry payoffs)

19. In Section I we considered the choice between single legitimate and illegitimate activities, but the analysis could easily be extended and applied to a choice among several competing legitimate and illegitimate activities. Participation in i might, in general, be affected by the opportunities available in some related illegal activities, as well as in l.

as well as the extent of response of active offenders to changes in net gains. Variations in entry payoffs across persons reflect different attitudes toward risk (as well as different psychic net benefits if the net gain is defined to include monetary elements only). People with preference for risk or a penchant for violence may enter crime even when their expected monetary gains are negative. Others, risk averters or law abiders, may enter crime only when the expected monetary gains are very high. A positive elasticity of the aggregate supply of offenses with respect to an increase in net gains from an offense may thus be expected, even if all individual supply curves were infinitely elastic—that is, if all offenders specialized in illegitimate activity and did not respond to such change at all—because the higher net gains would induce the entry of new offenders into illegitimate activity.

C. The Preventive Effect of Imprisonment

The set of hypotheses spelled out in Sections I, B and I, C regarding the effect of various opportunities on individuals', and hence the aggregate, supply of offenses, follows from our basic thesis that offenders respond to incentives. However, an increase in the probability and severity of punishment by imprisonment might reduce the total number of offenses even in the absence of any deterrent effect on offenders, because at least those imprisoned are temporarily prevented from committing further crimes. While both deterrence and prevention may serve equally well the basic purpose of law enforcement, which is to reduce total crime, they involve different costs. Moreover, the preventive effect of imprisonment may be partly offset by the enhanced incentive for recidivism generated through the possible adverse effect of imprisonment on legitimate relative to illegitimate skills and employment opportunities. It is therefore important (and challenging) to establish the existence of an independent deterrent effect of imprisonment on crime, both to verify the validity of our theory and to determine the effectiveness of penal modes that may have a deterrent effect only.

An estimation of the preventive effect of imprisonment can be derived through the following reasoning. Suppose that offenders constituted a noncompeting group that does not respond to incentives, the constant proportion of which $\bar{S} = S/N$, is determined by nature, and let punishment be imposed solely in the form of imprisonment. In this model, where no deterrent effect of imprisonment (or other factors) is assumed, the rate (per capita) of flow of offenses in any given period,

$k = Q/N$, would be a positive function of the rate of offenders at large (those free to commit offenses), $\bar{\theta} = \theta/N$, or

$$k_t = \zeta\bar{\theta}_t, \tag{2.3}$$

where ζ is the number of offenses committed by an average offender in a given period and is assumed to be constant. The rate of offenders at large in the population is in turn identically equal to the rate of the offenders' subpopulation net of the rate of those in jail, or

$$\bar{\theta}_t = \bar{S}_t - \bar{J}_t. \tag{2.4}$$

Let the fraction of offenders apprehended and imprisoned in any period (the probability that an offender is apprehended and jailed in t) be P, and let the average duration of time spent in jail by each convict be T periods. It can then be shown that in a steady state the rate of offenders in jail would be

$$\bar{J} = \frac{\bar{S}P \sum_{\tau=1}^{T} (1+g)^{-\tau}}{1 + P \sum_{\tau=1}^{T} (1+g)^{-\tau}}, \text{ for } P < 1,\text{[20]} \tag{2.5}$$

where g is a constant rate of growth (per period) of both the total population and the offender subpopulation. Substituting equations (2.5) and (2.4) in (2.3) yields

$$k = \frac{\zeta\bar{S}}{1 + p \sum_{\tau=1}^{T} (1+g)^{-\tau}} \approx \frac{\zeta\bar{S}}{1 + PT} \text{ for } g \approx 0. \tag{2.6}$$

Since ζ, g, and $\bar{S}$ are assumed given constants, the rate of offenses committed in a steady state would be a negative function of PT, the expected

20. The number of offenders jailed in the beginning of each period is identically equal to the total number of offenders apprehended and jailed in the preceding T periods, or

$$J_t \equiv \sum_{\tau=1}^{T} P(S_{t-\tau} - J_{t-\tau}).$$

Given that $S_t = S_0(1+g)^t$ and $N_t = N_0(1+g)^t$, the identity above can be expressed as a linear difference equation of the Tth degree,

$$\bar{J}_t + P(1+g)^{-1}\bar{J}_{t-1} + \cdots + P(1+g)^{-T}\bar{J}_{t-T} = P\bar{S} \sum_{\tau=1}^{T} (1+g)^{-\tau}. \tag{2.5a}$$

Equation (2.5) is the particular integral of eq. (2.5a). The condition $P < 1$ (if $g \geq 0$) can be shown to be a sufficient condition for the general solution of (2.5a) to converge toward the equilibrium value of its particular integral.

length of imprisonment for an offender. In particular, the absolute value of the elasticity of the rate of offenses per period with respect to changes in probability and severity of imprisonment would be approximately the same: [21]

$$\sigma_{kP} \approx \sigma_{kT} \approx \frac{PT}{1+PT} \text{ for } g \approx 0. \tag{2.7}$$

Clearly, σ is independent of the value of ζ and is positively related to PT.[22] Therefore, the preventive effect of imprisonment may be relatively small for less serious crimes. Equation (2.7) establishes the important point that the preventive effect of P and T is in principle distinguishable from the deterrent effect: not only is the latter compatible with, say, $\sigma_{kT} \geqslant 1$, it is also compatible with $\sigma_{kT} \gtreqless \sigma_{kP}$.[23] The existence of a deterrent effect can thus be inferred from empirical estimates of the absolute and relative values of σ_{kP} and σ_{kT}.

III. AN ECONOMETRIC SPECIFICATION OF THE MODEL

A. The Supply-of-Offenses Equation

The variables entering the behavioral function (2.1) have been generally defined in terms of the real wealth equivalent of both monetary and psychic elements. Since psychic elements cannot be accounted for explicitly in an empirical investigation, it will be useful to modify equations (2.1) and (2.2) by separating quantifiable from nonquantifiable variables. A simple form of a mean (group) supply-of-offense function

21. An increase in P may have a greater preventive effect than an equal proportional increase in T in the short run, however, because the latter does not have any immediate impact on the number of offenders at large, whereas an increase in P does. Indeed, that may have led some criminologists to believe the probability of punishment to be of greater importance than severity of punishment in preventing crime (see Becker, 1968, included in this volume, p. 9, n. 12). A comparison of the exact values of σ_{kP} and σ_{kT} in eq. (2.7) shows that a relatively greater effect of P may persist, to a limited extent, even in a steady state, if $g > 0$ and $T > 1$.

22. This implies a potential variation across states in the coefficients (elasticities) b_1 and b_2 of the regression eq. (3.2), for states with relatively higher values of PT might have higher elasticities of offenses with respect to P and T. However, the variation in PT of specific crimes across states is found to be quite small in practice.

23. In terms of our model (see eq. [1.10] in n. 13), $\sigma_{kF} > \sigma_{kP}$ indicates risk aversion on the part of the average offender. Since $\sigma_{kT} \leqslant \sigma_{kF}$ (see Appendix 1 to Section III, item 3), this conclusion may be strengthened if $\sigma_{kT} > \sigma_{kP}$.

which is consistent with this modification is

$$\left(\frac{Q}{N}\right)_i = P_i^{b_{1i}} F_i^{b_{2i}} Y_i^{c_{1i}} Y_l^{c_{2i}} U_l^{d_i} V^{c_i} Z_i, \tag{3.1}$$

where $(Q/N)_i$ denotes the number of offenses of crime category i committed by the average person in a community (crime rate); F_i, Y_i, and Y_l are arithmetic means of the monetary components of f_{ij}, w_{ij}, and w_{lj} in eq. (2.1); V is a vector of environmental variables; and Z summarizes the effect of psychic and other nonquantifiable variables on the crime rate.[24]

To the extent that individuals' taste for crime was either proportional to some of the quantifiable variables affecting crime, or uncorrelated in the natural logarithms with all the explanatory variables, it is possible to specify a stochastic function of the form

$$\left(\frac{Q}{N}\right)_i = A P_i^{b_{1i}} F_i^{b_{2i}} Y_i^{c_{1i}} Y_l^{c_{2i}} U_l^{d_i} V^{e_i} \exp\,(\mu_i), \tag{3.2}$$

where A is a constant, and μ_i stands for random errors of measurement and other stochastic effects and is assumed to have a normal distribution. In this paper we apply equation (3.2) in a cross-state regression analysis.[25]

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24. The mean supply-of-offenses function given by eq. (3.1) can be derived by integrating individual supply-of-offenses functions of the same form if the individual elasticities b_{1ij}, b_{2ij}, etc., are the same for all. The variables entering eq. (3.1) would then be the geometric means of the corresponding variables entering eq. (2.1). However, if the density function of, say, $p_{ij} - g(p_{ij}P_i)$—were equal across states and homogeneous of degree minus one in p_{ij} and P_i (the arithmetic mean), and similarly for all the explanatory variables entering eq. (2.1) then eq. (3.1) could be specified in terms of arithmetic rather than geometric means, with an appropriate modification of the constant term Z (for proofs see Tobin, 1950, or Chow, 1957). Note, however, that to the extent that the variation in the rate of crime across communities is due to changes in the average offender's participation in crime, and not only to entry and exit of offenders, the coefficients of eq. (3.2) may vary systematically with Q/N, as our discussion in the last paragraph of Sec. I, B indicates; the regression equation may not, then, be strictly linear in the parameters. This problem is ignored in our analysis.

25. The cross-state regression analysis does not control spillovers or displacement effects due to a possible migration of individuals from one state to another in response to differences in opportunities across states. To the extent that such effects exist, the estimated coefficients associated with P_i, F_i, and Y_i would be overstated, while those associated with Y_l and U would be understated, relative to their values in closed communities. We implicitly assume, however, that there is no perfect mobility of resources across states because of considerable costs of migration. Different states can thus be viewed essentially as different markets.

B. CRIME, INCOME INEQUALITY, AND AFFLUENCE

In Section I, B it was shown that the extent of individual participation in crime, and hence the crime rate in each state, is a positive function of the absolute differential returns from crime $(Y_i - Y_l)$.[26] Information concerning such monetary differential returns is at present unavailable on a statewide basis, and alternative income opportunities cannot be estimated unless one is able to identify a control group representing potential offenders and study its alternative income prospects. The difficulty may be met, in part, by making some plausible assumptions regarding the occupational characteristics of activities such as robbery, burglary, and theft, which are actually investigated in our empirical analysis. We postulate that payoffs on such crimes depend, primarily, on the level of transferable assets in the community, that is, on opportunities provided by potential victims of crime, and to a much lesser extent on the offender's education and legitimate training. The relative variation in the average potential illegal payoff, Y_i, may be approximated by the relative variation in, say, the median value of transferable goods and assets or family income across states which we denote W.[27] The preceding postulate also implies that those in a state with legitimate returns well below the median have greater differential returns from property crimes and, hence, a greater incentive to participate in such crimes, relative to those with income well above the median. The variation in the mean legitimate opportunities available to potential offenders across states, Y_l, may therefore be approximated by that of the mean income level of those below the state's median. Partly because of statistical considerations, we have chosen to compute the latter somewhat indirectly as the

26. The *elasticity* of offenses with respect to Y_i need not be equal to that with respect to Y_l (see the final paragraph in Sec. I, B). We have therefore introduced both variables in eq. (3.2) (rather than the difference $Y_i - Y_l$), allowing for their coefficients c_1 and c_2 to be different.

27. More precisely, the assumption is that, given the relative distribution of family income in a state, variations in average potential payoffs on property crimes can be approximated by the variation in the level of the *entire* distribution. If the income distribution were of the log-normal variety, it can be shown that variation in its level would be reflected by an equal proportional variation in its *median* value. Note that the relative variation in *potential* payoffs on property crimes may be an unbiased estimator of the relative variation in the realized gross payoffs if self-protection (of property) by potential victims were proportionally related to their wealth.

percentage of families below one-half of the median income in a state, which we denote X (income inequality).[28]

Since X is a measure of the *relative* distance between legitimate and illegitimate opportunities, changes in W, X held constant, would amount to equal percentage changes in the absolute wage differential, $Y_i - Y_l$. Given the probability and severity of punishment, an increase in W might have a positive effect on the rate of property crimes similar to that of X. In our empirical implementation, the severity of punishment, F, is measured by the effective incarceration period of offenders, T. If punishment were solely by imprisonment, an increase in W, with X and T constant, might increase $Y_i - Y_l$ and F (the opportunity cost of imprisonment) by the same proportion, and its net effect could be nil (see our discussion of pure-wealth effects in Sec. I, B). In contrast, an increase in X would imply in this case a decrease in both Y_l and F. In practice, however, a major proportion of offenders is punished by means other than imprisonment (see Ehrlich, 1970, Table 1). Consequently, we may expect the median income level (affluence) as well as income inequality to be positively related to the incidence of property crimes. Note that an advantage of introducing W and X in equation (3.2) in lieu of $Y_i - Y_l$ is that the former can be treated as exogenous variables, whereas the actual differential gain from crime may be a function of both the crime rate and private expenditure on self-protection (see our discussion in footnotes 4 and 29).

28. Let the average legitimate income of those with income below and above the average be w_p and w_r, respectively. Our measure of income inequality X (originally used by Fuchs, 1967, as an index of poverty) can be regarded as inversely related to w_p/W. If median income, W, were held constant, the effect of an increase in X on the rate of property crimes $k = Q/N$ would be given by $\sigma_X = -d \ln k/d \ln (w_p/W) = \eta_p + \eta_r \, d \ln w_r/d \ln w_p$, where $\eta_p = -\partial \ln k/\partial \ln (w_p/W)$ and $\eta_r = -\partial \ln k/\partial \ln (w_r/W)$. By our assumptions η_r is much smaller than η_p. A 1 per cent increase in X might therefore have approximately the same effect as a 1 per cent decrease in legitimate opportunities available to potential offenders, or $\sigma_X \approx \eta_p$. In contrast, if the income effect on the supply of malice and acts of hate were the same for rich and poor alike, $\eta_p = \eta_r = \eta$, then an increase in income inequality—mean and median income held constant—can be shown to have a positive effect on the incidence of crimes against the person only if the income effect were negative ($\eta > 0$), for then $\sigma_X = \eta[1 - (w_p/w_r)] > 0$. Precisely the same result applies in reference to the impact of an increase in X on crime through its opposing effects on self-protection by potential victims. One reason for employing X rather than w_p in the regression analysis is that its correlation with W is relatively lower.

C. CRIME AND LAW ENFORCEMENT: A SIMULTANEOUS-EQUATION MODEL

Equation (3.2) defines the rate of a specific crime category $(Q/N)_i$ as a function of a set of explanatory variables, including the probability and severity of punishment. In general, both P and F may not be exogenous variables, since they are determined by the public's allocation of resources to law-enforcement activity and, as will be argued below, by the level of crime itself. The expenditure on law enforcement, in turn, is likely to be affected by the rate of crime and the resulting social loss. In order to insure consistent estimates of equation (3.2), it is desirable to construct a simultaneous-equation model of crime and law enforcement.[29]

To simplify matters, we assume that the severity of punishment is in practice largely unaffected by the joint determination of Q/N and P.[30] Our model consists of a supply-of-offenses function, as discussed above, a production function of direct law-enforcement activity by police and courts, and a (public) demand function for such activity.

An increase in expenditure on police and courts, E/N, can be expected to result in a greater proportion of offenders apprehended and convicted of crime. However, the productivity of these resources is likely to be lower at higher levels of criminal activity because more offenders must then be apprehended, charged, and tried in court in order to achieve a given level of P. Thus, with a given level of expenditure devoted to law-enforcement activity, the rate of crime and the probability of appre-

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29. Simultaneous relations may also exist between the rate of crime, the average payoff from crime, Y_i, and *private* self-protection against crime that can be expected to have an adverse effect on both (see our discussion in n. 4). We do not elaborate on these relations here because in our empirical investigation we use indirect estimates of Y_i (see Sec. III, B above) that can be considered largely exogenous to our system of equations and because of the lack of reliable data on private self-protection.

30. Bureau of Prisons statistics from 1940, 1951, 1960, and 1964 show little variation in the median time served in state prisons by felony offenders over the past few decades. For example, the median time served for burglary (T_b) in the United States in 1940 and 1964 was virtually identical: 20.6 and 20.1 months, respectively, even though the national burglary rates in those 2 years (based on unpublished FBI data) were 285.6 and 630.3 per 100,000 civilian population, respectively, and the number of prisoners received from court in federal and state institutions for the crime of burglary (based on unpublished Bureau of Prisons data) rose from 7,434 in 1942 to 21,600 in 1962. Furthermore, there had been relatively little change in the distribution of T_b across states: in 35 out of 44 states in our sample, changes in T_b between 1940 and 1964 were in the order of magnitude of ± 6 months, with the number of increases approximately matching the number of declines.

hension and punishment for crime might be negatively related, with the causality running in an opposite direction from that predicted by our analysis: for example, in a riot, the probability of apprehension for individual rioters, as well as for offenders committing other crimes, falls considerably below its normal level due to the excessive load on local police units. (This is a source of external economies in criminal activity.) Population size and density may also be negatively related to P because of the relative ease with which an offender could elude the police in densely populated areas. A natural way to summarize these relations is via a production function of the Cobb-Douglas variety:

$$P = B\left(\frac{E}{N}\right)^{\beta_1}\left(\frac{Q}{N}\right)^{\beta_2} Z^{\delta} \exp(\xi) \tag{3.3}$$

with $\beta_1 > 0$ and $\beta_2 < 0$,[31] where B is a constant, Z is a vector of environmental variables (productivity indicators), and ξ is a random variable.[32]

The demand for law-enforcement activity may be viewed to be essentially a negative demand for crime or, conversely, a positive demand for defense against crime. In general, potential victims may wish to self-protect against victimization, both privately and collectively. Our present discussion is confined to collective self-protection via law-enforcement activity and ignores private self-protection and other collective methods of combating crime, since data exigencies rule out a comprehensive analysis of social defense against crime. (A theoretical analysis of self-protection by victims is implicit, however, in Ehrlich and Becker, 1972.) For a simple exposition, assume the following probability distribution of losses from crime to the ith person in a given period: he has either a potential real wealth I_i^c with probability $1 - k_i$, or a lower wealth, $I_i^c - L_i$, with probability k_i, where L_i is his potential loss from crime and k_i the probability of victimization. If the number of persons in the community were large enough, and their probabilities of victimization largely independent, their actual per capita wealth would be known with certainty and

31. The elasticity of P with respect to Q/N, β_2, is not likely to be lower than -1, however, since this would imply that, given E/N, an increase in Q/N reduces the absolute number of offenses cleared by conviction, and not only their proportion among all offenses.

32. Since $0 < P < 1$, the natural logarithm of P is bounded between $-\infty$ and 0, and its distribution cannot be assumed normal. Nevertheless, the normal distribution may approximate that of $\ln P$ over its observed range of variation. For example, the observed mean and standard deviation of our measures of $\ln P$ of all offenses in 1960 are -3.1670 and 0.5365, respectively. Moreover, since our regression estimates are derived by method of two-stage least-squares, they are asymptotically unbiased.

would equal the expected personal wealth, $Y = I - kL$, where

$$k = \frac{1}{N}\sum_{i=1}^{N} k_i = \frac{Q}{N},\ I = \frac{1}{N}\sum_{i=1}^{N} I_i, \text{ and } L = \frac{\sum_{i=1}^{N} k_i L_i}{\sum_{i=1}^{N} k_i}. \tag{3.4}$$

Effective law enforcement by police, courts, and legislative bodies is expected to reduce the crime rate (i.e., the objective probability of victimization to a person) by increasing the probability and severity of punishment for crime. In addition, such activity may also reduce the actual loss to victims by recovering stolen property, guarding property, and other related actions. Consequently, we may write $k = k(r, j)$ and $L = L(r, j)$, where $r = E/N$ is real per capita expenditure on direct law enforcement and j represents expenditure on the determination and actual implementation of imprisonment or other punitive measures, private expenditure on self-protection against crime, and other outlays affecting the level of criminal activity in a state. Both k and L are assumed to have continuous first- and second-order derivatives with respect to r, so that $k'(r)$ and $L'(r)$ are negative and $k''(r)$ and $L''(r)$ are positive in sign. To further simplify matters, we ignore any functional dependence between r and j and treat j as an exogenous variable. If the public were interested in maximizing the expected utility of the average person,[33] optimal per capita expenditure, r^*, would be derived under the foregoing assumptions by maximizing the expected personal wealth,

$$Y = I - k(r)L(r) - r - j, \tag{3.5}$$

with respect to r. The first-order optimality condition can be written

$$r^* = (e_1 + e_2)L(r^*)k(r^*), \tag{3.6}$$

where $e_1 = -k'(r^*)(r^*/k)$ and $e_2 = -L'(r^*)(r^*/L)$ are assumed constant. Optimal expenditure on apprehending and convicting offenders, $r^* =$

33. Collective self-protection may be viewed as a voluntary pooling of resources by potential victims of crime (all members of the community) to provide a common service—decreasing the probabilities of (private) states of the world involving victimization—the benefits of which are to be divided among all members. Maximization of the utility of an average member would then be the appropriate decision rule. Note that the loss to a victim of crime, even in the case of property crimes, is a net social loss, not just a transfer payment: if criminal activity were competitive, and offenders' risk neutral, then the potential marginal payoff to an average offender would equal the marginal value of the foregone resources he would devote to achieve it, including his marginal expected opportunity costs of imprisonment (see our analysis in Sec. I, A).

$(E/N)^*$, is thus seen to be proportional to the resulting crime rate and potential loss to a victim of crime. The latter may be forecast in practice as the actual crime rate and the average loss to a victim. The demand function for law-enforcement expenditure may thus be specified as

$$\left(\frac{E}{N}\right)^* = \Gamma \frac{Q}{N} L. \tag{3.7}$$

Equation (3.7) shows the desired level of per capita expenditure on law enforcement in the absence of adjustment costs. In practice, one may expect only partial adjustment of public expenditure on law enforcement to its desired level in a given period due to positive costs of adjustment in a relatively short run. If the ratio of current to lagged expenditure were a power function of the ratio of the desired to lagged expenditure, the relevant demand function could be written as

$$\frac{E}{N} = \Gamma L^{\gamma} \left(\frac{Q}{N}\right)^{\gamma} \left(\frac{E}{N}\right)_{t-1}^{1-\gamma} \exp(\epsilon), \tag{3.8}$$

where $0 < \gamma < 1$ is an adjustment coefficient and ϵ is assumed a normally distributed random variable. Equations (3.2), (3.3), and (3.8)[34] form the structure of our simultaneous-equation model of law enforcement and crime.[35]

34. Available information regarding expenditure on police relates to fiscal years, whereas the other variables used in the regression analysis relate to calendar years. The appropriate forecasts of $k(r^*)$ and $L(r^*)$ may therefore be defined as weighted geometrical means of current and lagged crime rates and average losses. At present no data on losses to victims of crime are available on a statewide basis, and no serious attempt has been made to estimate eq. (3.8). Lagged crime rates are included in the reduced-form regression equations.

35. Stability conditions associated with this system of equations require that the product of the elasticities b_1 and β_2 in eqq. (3.2) and (3.3)—both assumed negative in sign—does not exceed unity. This arises because when solving for the value of Q/N in terms of reduced-form variables, lagged expenditure $(E/N)_{t-1}$, for example, is raised to the power $[(1-\gamma)b_1\beta_1]/(1-b_1\beta_2-\gamma b_1\beta_1)$. This coefficient would be negative for all possible values of γ—the simultaneous-equation system would have a stable solution—if the denominator were positive. A sufficient condition is $b_1\beta_2 < 1$. Note that unlike Becker's optimality conditions for the minimization of the social loss from crime (see Becker, 1968, included in this volume, pp. 14–18), our stability conditions do not require that $|b_2| < 1$ or that $|b_2| < |b_1|$: they do not require that in equilibrium offenders must be, on balance, risk preferrers. Indeed, some of our empirical estimates of $|b_{2i}|$, exceed those of $|b_{1i}|$ (see Sec. IV below).

IV. ANALYSIS OF CRIME VARIATIONS ACROSS STATES IN THE UNITED STATES

We have applied the economic and econometric framework developed in the preceding sections in a regression analysis of variations of index crimes across U.S. states in 1960, 1950, and 1940.[36] A short description of the variables used in the empirical investigation as counterparts of the theoretical constructs entering equations (3.2), (3.3), and (3.8) are given in Table 1, and the interested reader is referred to Appendix 1 to Section

TABLE 1
LIST OF VARIABLES USED IN REGRESSION ANALYSIS

$\left(\frac{Q}{N}\right)_i, \left(\frac{Q_i}{N}\right)_{t-1}$	= current and 1-year lagged crime rate: the number of offenses known per capita
$\left(\frac{C}{Q}\right)_i = P_i$	= estimator of probability of apprehension and imprisonment: the number of offenders imprisoned per offenses known
T_i	= average time served by offenders in state prisons
W	= median income of families
X	= percentage of families below one-half of median income
NW	= percentage of nonwhites in the population
A_{14-24}	= percentage of all males in the age group 14–24
U_{14-24}, U_{35-39}	= unemployment rate of civilian urban males ages 14–24 and 35–39
L_{14-24}	= labor-force participation rate for civilian urban males ages 14–24
Ed	= mean number of years of schooling of population 25 years old and over
$SMSA$	= percentage of population in standard metropolitan statistical areas
$\frac{E}{N}, \left(\frac{E}{N}\right)_{t-1}$	= per capita expenditure on police in fiscal 1960, 1959
M	= number of males per 100 females
D	= dummy variable distinguishing northern from southern states (south = 1)

NOTE.—Variables are time- and state-specific; i denotes a specific crime category.

36. Due to data exigencies, the empirical investigation deals with only seven felony offenses (index crimes) punishable by imprisonment. The data regarding (and definitions of) these crimes are available in the *Uniform Crime Reports* of the FBI. Samples from 1960 include 47 state observations and those from 1950 include 46. The 1940 sample sizes vary between 36 and 43.

III for a more elaborate analysis and discussion of this list. Since data on police expenditure across states are available for 1960, but not for 1950 and 1940, crime statistics relating to earlier decennial years are used only to derive ordinary-least-squares (OLS) estimates of supply-of-offenses functions. Data from 1960 are also used to derive two-stage least-squares (2SLS) and seemingly unrelated (SUR) estimates of supply-of-offenses functions and a production function of law-enforcement activity.

A. Supply-of-Offenses Functions: The Effect of Probability and Severity of Punishment, Income and Income Inequality, and Racial Composition

Despite the shortcomings of the data and the crude estimates of some of the desired variables (see Appendix 1 to Section III), the results of the regression analysis lend credibility to the basic hypotheses of the model. The major consistent findings are:

1. The rate of specific crime categories, with virtually no exception, varies inversely with estimates of the probability of apprehension and punishment by imprisonment, $P = C/Q$, and with the average length of time served in state prisons, T.

2. Crimes against property (robbery, burglary, larceny, and auto theft) are also found to vary positively with the percentage of families below one-half of the median income (income inequality), X, and with the median income, W; in contrast, these variables are found to have relatively lower effects on the incidence of crimes against the person, particularly murder and rape. Also, the regression coefficients associated with X and W have relatively high standard errors in the case of crimes against the person.

3. All specific crime rates appear to be positively related to the percentage of nonwhites in the population, NW. (For the reasons for including this, and other demographic variables, see Appendix 1 to Section III.) These findings hold consistently across samples from 1960, 1950, and 1940, independently of the regression technique employed or the specific set of (additional) variables introduced in the regression analysis. We therefore present them separately from other results.[37]

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37. The FBI's estimates of crime rates across states in 1950 and 1940 relate to urban areas, whereas no such data are available in 1960. Also, our estimates of income inequality in 1940 are derived from a sample of wage and salary workers, whereas in 1960 they are derived from a census of family income. Because of these differences we have not integrated the three samples for a more comprehensive regression analysis. Also, the point estimates of the regression coefficients are not exactly comparable across the different samples.

OLS ESTIMATES

Tables 2 and 3 present a summary of weighted OLS estimates of elasticities associated with P, T, W, X, and NW. The regression equation used is a natural logarithmic transformation of equation (3.2):

$$\ln\left(\frac{Q}{N}\right)_i = a + b_{1i} \ln P_i + b_{2i} \ln T_i + c_{1i} \ln W + c_{2i} \ln X + e_{1i} \ln NW + \mu_i,^{38} \quad (4.1)$$

with the weighting factor being the square root of the population size.[39]

The OLS estimates of the elasticity of offenses with respect to P_i and T_i, $\hat{b}_{1i}$, and $\hat{b}_{2i}$, respectively, are generally lower than unity in absolute value. Also, the difference $|\hat{b}_{1i}| - |\hat{b}_{2i}|$ exceeds twice its standard error in regressions dealing with murder, rape, and robbery, while the converse holds in the case of burglary in 1960. However, estimates of b_{1i} are likely to be biased in a negative direction relative to those of b_{2i} (provided that the true absolute values of b_{1i} were lower than unity) because of a potential negative correlation between $(Q/N)_i$ and $P_i = (C/Q)_i$ arising from errors of measurement in Q_i[40] (see our discussion in Appendix 1 to Section III). In addition, the OLS estimates of b_{1i} and b_{2i} may be subject to a simultaneous-equation bias. More reliable estimates are therefore provided by our simultaneous-equation estimation methods.

The estimated elasticities of specific crimes against property with respect to both W and X, $\hat{c}_{1i}$ and $\hat{c}_{2i}$, respectively, are positive, statistically

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38. When grouping specific crime categories in broader classes, the probability and severity of punishment, P_u and T_u, were measured as weighted averages of the P's and T's associated with the single categories:

$$P_u = \left(\sum_{i=1}^{g} C_i\right) \Big/ \left(\sum_{i=1}^{g} Q_i\right) \text{ and } T_u = \sum_{i=1}^{g} C_i T_i \Big/ \sum_{i=1}^{g} C_i.$$

It should be pointed out that the coefficient b_{2i} in eqq. (4.1) and (4.3) below is expected to be lower than b_{2i} in eq. (3.2) by a positive constant factor (see our discussion in Appendix 1 to Section III, item 3).

39. A residual analysis of unweighted regressions generally showed a negative correlation between the absolute value of estimated residuals and the population size. This apparent heteroscedasticity is consistent with the assumption that unspecified random variables which affect participation in crime are homoscedastic at the individual level. Thus, $\sqrt{N}$ may be an appropriate weighting factor.

40. Since the variances of errors of measurement in Q_i are likely to be greater in 1950 and 1940 than in 1960, the bias in the difference between b_{1i} and b_{2i} is likely to be relatively large in regressions using data from the former 2 years. Indeed, this may explain why the differences $|b_{2i}| - |b_{1i}|$ in regressions concerning burglary and larceny in 1960 are positive and significant, while in 1940 they are negative but insignificant.

TABLE 2

OLS (WEIGHTED) REGRESSION ESTIMATES OF COEFFICIENTS ASSOCIATED WITH SELECTED VARIABLES IN 1960, 1950, AND 1940: CRIMES AGAINST THE PERSON AND ALL OFFENSES (DEPENDENT VARIABLES ARE SPECIFIC CRIME RATES)

Offense and Year	Estimated Coefficients Associated with Selected Variables: a Intercept	b_1 with ln P_i	b_2 with ln T_i	c_1 with ln W	c_2 with ln X	e_1 with ln NW	Adj. R^2
Murder:							
1960	−0.6644 [a]	−0.3407	−0.1396 [a]	0.4165 [a]	1.3637 [a]	0.5532	.8687
1950 [b]	−0.7682 [a]	−0.5903	−0.2878	0.6095 [a]	1.9386	0.4759	.8155
Rape:							
1960 [b]	−7.3802 [a]	−0.5783	−0.1880 [a]	1.2220	0.8942 [a]	0.1544	.6858
Assault:							
1960	−13.2994	−0.2750	−0.1797 [a]	2.0940	1.4697	0.6771	.8282
1950	−0.7139 [a]	−0.4791	−0.3839	0.5641 [a]	0.9136 [a]	0.5526	.8566
1940	−0.2891	−0.4239	−0.6036	0.7274 [a]	0.5484 [a]	0.7298	.8381
Murder and rape:							
1960 [b]	−1.8117	−0.5787	−0.2867	0.6773 [a]	0.9456	0.3277	.6948
Murder and assault:							
1950 [b]	1.0951 [a]	−0.7614	−0.3856	0.3982 [a]	1.1689 [a]	0.4281	.8783
Crimes against persons:							
1960 [b]	−4.1571 [a]	−0.5498	−0.3487	1.0458	0.9145	0.4897	.8758
All offenses:							
1960	−7.1657	−0.5255	−0.5854	2.0651	1.8013	0.2071	.6950
1950	−1.5081 [a]	−0.5664	−0.4740	1.3456	1.9399	0.1051	.6592
1940	−5.2711	−0.6530	−0.2892	0.5986	2.2658	0.1386	.6650

NOTE.—The absolute values of all regression coefficients in Tables 2 and 3, except those marked [a], are at least twice those of their standard errors; [b] indicates regressions in which the absolute difference $(\hat{b}_1 - \hat{b}_2)$ is at least twice the value of the relevant standard error $S(\hat{b}_1 - \hat{b}_2)$.

TABLE 3

OLS (WEIGHTED) REGRESSION ESTIMATES OF COEFFICIENTS ASSOCIATED WITH SELECTED VARIABLES IN 1960, 1950, AND 1940: CRIMES AGAINST PROPERTY (DEPENDENT VARIABLES ARE SPECIFIC CRIME RATES)

Offense and Year	Estimated Coefficients Associated with Selected Variables						
	a Intercept	b_1 with $\ln P_i$	b_2 with $\ln T_i$	c_1 with $\ln W$	c_2 with $\ln X$	e_1 with $\ln NW$	Adj. R^2
Robbery:							
1960[b]	−20.1910	−0.8534	−0.2233[a]	2.9086	1.8409	0.3764	.8014
1950[b]	−10.2794	−0.9389	−0.5610	1.7278	0.4798	0.3282	.7839
1940	−10.2943	−0.9473	−0.1912[a]	1.6608	0.7222	0.3408	.8219
Burglary:							
1960[b]	−5.5700[a]	−0.5339	−0.9001	1.7973	2.0452	0.2269	.6713
1950	−1.0519[a]	−0.4102	−0.4689	1.1891	1.8697	0.1358	.4933
1940	−0.6531[a]	−0.4607	−0.2698	0.8327[a]	1.6939	0.1147	.3963
Larceny:							
1960	−14.9431	−0.1331	−0.2630	2.6893	1.6207	0.1315	.5222
1950	−4.2857[a]	−0.3477	−0.4301	1.9784	3.3134	−0.0342[a]	.5819
1940	−10.6198	−0.4131	−0.1680[a]	0.6186	3.7371	0.0499[a]	.6953
Auto theft:							
1960	−17.3057	−0.2474	−0.1743[a]	2.8931	1.8981	0.1152	.6948
Burglary and robbery:							
1960	−9.2683	−0.6243	−0.6883	2.1598	2.1156	0.2565	.7336
1950	−3.0355[a]	−0.5493	−0.4879	1.3624	1.6066	0.1854	.5590
Larceny and auto theft:							
1960	−14.1543	−0.2572	−0.3339	2.6648	1.8263	0.1423	.6826
1950	−3.9481[a]	−0.3134	−0.4509	1.9286	2.9961	−0.0290[a]	.5894
Crimes against property:							
1960	−10.1288	−0.5075	−0.6206	2.3345	2.0547	0.2118	.7487
1950	−2.8056	−0.5407	−0.4792	1.5836	2.2548	0.0755	.6253

NOTE.—Same references as in Table 2.

significant, and generally greater than unity. Note, however, that $\hat{c}_{1i}$ may reflect, in part, the effect of "urbanization" (the percentage of the population in standard metropolitan statistical areas, SMSA), since W and $SMSA$ are highly correlated.[41] This may explain why the absolute values of $\hat{c}_{1i}$ in regressions using 1940 and 1950 data are lower than their estimates in the 1960 regressions: the dependent variables in the 1940 and 1950 regressions are urban crime rates, while in 1960 they are state crime rates. The fact that variations in X and W are found to have a lower effect on the incidence of crimes against the person relative to crimes against property supports our selection of them as indicators of the relative opportunities associated with these latter crimes. Moreover, the introduction of X and W in the regression analysis helps to obtain significant results concerning the effect of T, which is to be expected since variations in these variables presumably account in large part for the variation in the opportunity costs of imprisonment.

The positive correlation between the percentage of nonwhites, NW, and the rate of specific crimes is found to be independent of a regional effect tested via the introduction of a dummy variable distinguishing northern and southern states: the dummy variable loses its statistical significance when NW is also introduced in the regression analysis. Moreover, virtually the same elasticities of crime rates with respect to NW have been derived in an OLS regression analysis including northern states only. The significant effect of NW on the rate of specific crimes may essentially reflect the effect of the relatively inferior legitimate market opportunities (and lower opportunity cost of imprisonment) of nonwhites, since our measures of average relative legitimate opportunities in a state do not fully reflect opportunities available to nonwhites.

The simple multiple regressions appear to account for a large part of the variation in crime rates across states: the adjusted R^2 statistics range from .87 for murder to .52 for larceny in 1960. Apparently, the ranking of the R^2 statistics by crime categories is negatively related to the ranking of these crimes by the extent of their underreporting errors and by the extent to which they involve punishment other than imprisonment. The R^2 statistics may partly reflect, however, the extent of negative correlation between $(Q/N)_i$ and P_i, due to measurement errors in Q_i. This may

41. Urbanization may serve as a measure of accessibility to (lower direct costs of engaging in) various criminal activities due, for example, to the concentration of business activity, the massive communication networks, and the density of the population in metropolitan areas. The positive simple-regression coefficient associated with SMSA becomes insignificant, however, when P and W are also introduced in regressions concerning specific crimes against property.

explain why the R^2 statistics associated with the 1940 regressions are not lower than those associated with the 1960 ones.

THE 2SLS AND SUR ESTIMATES

The set of equations (4.1) has also been estimated via a 2SLS procedure, applying our simultaneous-equation model and using data from 1960. The set of exogenous and predetermined variables introduced in the reduced-form regression analysis has been

$$\begin{aligned}\ln P_i = a_0 + a_{1i} \ln T_i + a_{2i} \ln \left(\frac{E}{N}\right)_{t-1} \\ + a_{3i} \ln \left(\frac{Q_i}{N}\right)_{t-1} + a_{4i} \ln W + a_{5i} \ln X \\ + a_{6i} \ln U_{35-39} + a_{7i} \ln NW + a_{8i} \ln A_{14-24} \quad (4.2) \\ + a_{9i} \ln \mathrm{SMSA} + a_{10i} \ln M \\ + a_{11i} \ln N + a_{12i} D + a_{13i} \ln Ed + \mu_i.\end{aligned}$$ [42]

Estimates of specific regression equations are presented in Tables 4, A, and 5, A.

The 2SLS estimates do not take account of disturbance correlations. However, random changes (disturbance terms) relating to the rate of, say, burglary may be positively associated with those relating to the rate of robbery if these crimes were complements. To derive efficient estimates of the supply-of-offenses functions we have also employed an asymptotically efficient simultaneous-equation estimation method proposed by Zellner (1962) for estimating seemingly unrelated regression equations (SUR).[43] Such estimates have been derived separately for crimes against property and crimes against the person and are presented in Tables 4, B, and 5, B.

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42. It should be pointed out that the coefficients associated with $(E/N)_{t-1}$ in the reduced-form regressions are generally found to be statistically insignificant (a few having wrong signs), presumably because of a multicollinearity between $(E/N)_{t-1}$ and $(Q_i/N)_{t-1}$. Similar weak results were obtained in the reduced-form regression analysis when $\ln (Q/N)_i$ were regressed on the set of independent variables included in eq. (4.2). The presumed existence of multicollinearity in these regressions should not bias the computed (expected) values of both $(Q/N)_i$ and P_i, however, and should not affect the consistency of the estimates of our structural coefficients.

43. We have not attempted to derive 3SLS or FIML estimates of eq. (4.1) because of the absence of data requisite for estimating eqq. (3.3) and (3.8) in the case of specific crime categories; in particular, data are lacking for police expenditure on combating *specific* crimes and for average losses from crime to victims.

TABLE 4

2SLS and SUR (Weighted) Regression Estimates of Coefficients Associated with Selected Variables in 1960: Crimes against Property

Offense	a Intercept	b_1 with $\ln \hat{P}_i$	b_2 with $\ln T_i$	c_1 with $\ln W$	c_2 with $\ln X$	e_1 with $\ln NW$
	A. 2SLS Estimates					
Robbery:						
$\hat{\beta}$	−11.030	−1.303	−0.372	1.689	1.279	0.334
$\hat{\beta}/S\hat{\beta}$	(−1.804)	(−7.011)	(−1.395)	(1.969)	(1.660)	(4.024)
Burglary:						
$\hat{\beta}$	−2.121	−0.724	−1.127	1.384	2.000	0.250
$\hat{\beta}/S\hat{\beta}$	(−0.582)	(−6.003)	(−4.799)	(2.839)	(4.689)	(4.579)
Larceny:						
$\hat{\beta}$	−10.660	−0.371	−0.602	2.229	1.792	0.142
$\hat{\beta}/S\hat{\beta}$	(−2.195)	(−2.482)	(−1.937)	(3.465)	(2.992)	(2.019)
Auto theft:						
$\hat{\beta}$	−14.960	−0.407	−0.246	2.608	2.057	0.102
$\hat{\beta}/S\hat{\beta}$	(−4.162)	(−4.173)	(−1.682)	(5.194)	(4.268)	(1.842)
Larceny and auto:						
$\hat{\beta}$	−10.090	−0.546	−0.626	2.226	2.166	0.155
$\hat{\beta}/S\hat{\beta}$	(−2.585)	(−4.248)	(−2.851)	(4.183)	(4.165)	(2.603)
Property crimes:						
$\hat{\beta}$	−6.279	−0.796	−0.915	1.883	2.132	0.243
$\hat{\beta}/S\hat{\beta}$	(−1.937)	(−6.140)	(4.297)	(4.246)	(5.356)	(4.805)
	B. SUR Estimates					
Robbery:						
$\hat{\beta}$	−14.800	−1.112	−0.286	2.120	1.409	0.346
$\hat{\beta}/S\hat{\beta}$	(−2.500)	(−6.532)	(−0.750)	(2.548)	(1.853)	(4.191)
Burglary:						
$\hat{\beta}$	−3.961	−0.624	−0.996	1.581	2.032	0.230
$\hat{\beta}/S\hat{\beta}$	(−1.114)	(−5.576)	(−4.260	(3.313)	(4.766)	(4.274)
Larceny:						
$\hat{\beta}$	−10.870	−0.358	−0.654	2.241	1.785	0.139
$\hat{\beta}/S\hat{\beta}$	(−2.52)	(−2.445)	(−1.912)	(3.502)	(2.983)	(1.980)
Auto theft:						
$\hat{\beta}$	−14.860	−0.409	−0.233	2.590	2.054	0.101
$\hat{\beta}/S\hat{\beta}$	(−4.212)	(−4.674)	(−1.747)	(5.253)	(4.283)	(1.832)

Note.—The underlying regression equation is

$$\ln\left(\frac{Q}{N}\right) = a + b_{1i} \ln \hat{P}_i + b_{2i} \ln T_i + c_{1i} \ln W + c_{2i} \ln X + e_{1i} \ln NW + \mu_i. \quad (4.3)$$

TABLE 5

2SLS AND SUR (WEIGHTED) REGRESSION ESTIMATES OF COEFFICIENTS ASSOCIATED WITH SELECTED VARIABLES IN 1960: CRIMES AGAINST THE PERSON AND TOTAL OFFENSES

Offense	a Intercept	b_1 with $\ln \hat{P}_i$	b_2 with $\ln T_i$	c_1 with $\ln W$	c_2 with $\ln X$	e_1 with $\ln NW$
	Coefficient (β) Associated with Selected Variables					
	A. 2SLS Estimates					
Murder:						
$\hat{\beta}$	0.316	−0.852	−0.087	0.175	1.109	0.534
$\hat{\beta}/S\hat{\beta}$	(0.085)	(−2.492)	(−0.645)	(0.334)	(1.984)	(8.356)
Rape:						
$\hat{\beta}$	−0.599	−0.896	−0.399	0.409	0.459	0.072
$\hat{\beta}/S\hat{\beta}$	(−0.120)	(−6.080)	(−2.005)	(0.605)	(0.743)	(0.922)
Murder and rape:						
$\hat{\beta}$	2.703	−0.828	−0.350	0.086	0.556	0.280
$\hat{\beta}/S\hat{\beta}$	(0.732)	(−6.689)	(−3.164)	(0.172)	(1.188)	(5.504)
Assault:						
$\hat{\beta}$	−7.567	−0.724	−0.979	1.650	1.707	0.465
$\hat{\beta}/S\hat{\beta}$	(−1.280)	(−3.701)	(−2.301)	(2.018)	(2.111)	(3.655)
Crimes against the person:						
$\hat{\beta}$	1.635	−0.803	−0.495	0.328	0.587	0.376
$\hat{\beta}/S\hat{\beta}$	(0.380)	(−6.603)	(−3.407)	(0.570)	(1.098)	(4.833)
All offenses:						
$\hat{\beta}$	−1.388	−0.991	−1.123	1.292	1.775	0.265
$\hat{\beta}/S\hat{\beta}$	(−0.368)	(−5.898)	(−4.483)	(2.609)	(4.183)	(5.069)
	B. SUR Estimates					
Murder:						
$\hat{\beta}$	−1.198	−0.913	−0.018	0.186	1.152	0.542
$\hat{\beta}/S\hat{\beta}$	(−0.033)	(−3.062)	(−1.710)	(0.361)	(2.102)	(8.650)
Rape:						
$\hat{\beta}$	0.093	−0.930	−0.436	0.333	0.425	0.065
$\hat{\beta}/S\hat{\beta}$	(0.019)	(−6.640)	(−2.318)	(0.502)	(0.692)	(0.841)
Assault:						
$\hat{\beta}$	−6.431	−0.718	−0.780	1.404	1.494	0.460
$\hat{\beta}/S\hat{\beta}$	(−1.103)	(−4.046)	(−2.036)	(1.751)	(1.871)	(3.801)

NOTE.—Same reference as in Table 4.

The results of the 2SLS and SUR regression analyses strongly support the qualitative results of the simple regressions analyzed in the preceding discussion. They show that the rates of all specific crimes are inversely and significantly related to the appropriate P_i and T_i and directly related to NW, the estimated regression coefficients generally exceeding twice their standard errors. Crimes against property are found to be positively and significantly related to W and X, whereas the estimated elasticities of crimes against the person with respect to these variables are relatively lower—and their standard errors relatively higher—especially those associated with W in the regressions concerning murder and rape.[44] Moreover, estimates derived via the 2SLS and SUR methods are similar in magnitude, the latter generally having lower standard errors. However, these estimates only have the desirable large-sample property of consistency, and their small-sample properties are for the most part unknown.[45]

Unlike the OLS estimates of the elasticities of specific crimes with respect to P_i, the elasticities derived via 2SLS and SUR methods are expected to be free of a potential negative bias (due to measurement errors in Q_i) between current values of $(Q/N)_i$ and $P_i = (C/Q)_i$, since $\hat{P}_i$ is a linear combination of a set of variables that does not include (current) $(Q/N)_i$.[46] Nevertheless, estimates of both b_{1i} and b_{2i} appear even higher than those reported in Tables 3 and 4. It is interesting to note that the absolute values of the estimated elasticities of crimes against the person with respect to probability and severity of punishment are not lower on the average than those associated with crimes against property. This suggests that law enforcement may not be less effective in combating crimes of hate and passion relative to crimes against property.[47]

44. To some extent crimes against the person may be complementary to crimes against property since they may also occur as a by-product of the latter. This is particularly true in the case of assault, for it is generally agreed that some incidents of robbery are classified in practice as assault. This may be one reason why assault exhibits a greater similarity to crimes against property in its estimated functional form, and why the incidence of murder is positively correlated with W and X.

45. See Zellner (1970). A more elaborate analysis of this problem in the context of this study is given in Ehrlich (1970).

46. The 2SLS estimates might still be affected by spurious correlation if errors of measurement in $(Q/N)_i$ were serially correlated in each state. We have therefore derived alternative 2SLS estimates of the supply-of-offenses functions by excluding $(Q_i/N)_{t-1}$ from the reduced-form regressions. The results, reported in Ehrlich (1970, Table 15 of Appendix R), are nevertheless highly consistent with those reported in Tables 4 and 5.

47. Note, however, that this may be partly due to the preventive effect of imprisonment which is expected to be generally higher for crimes against the person (see Sec. II, C).

The absolute values of b_{1i} in Tables 4 and 5 are found to exceed those of b_{2i} in the case of murder, rape, and robbery, while they fall short of b_{2i} in the case of burglary and larceny (the differences exceeding twice the value of their standard errors). It should be emphasized, however, that the various T_i are less than proportionally related to the discounted cost of imprisonment and, therefore, our estimates of b_{2i} necessarily understate the true elasticities of the various crimes with respect to severity of punishment, F_i—especially in the case of crimes punishable by long imprisonment terms (see our discussion in item 3 of Appendix 1 to Section III). In view of these results we may venture the conclusion that burglars and thieves are risk avoiders (see the analysis in Sec. I, B). Whether other offenders are risk preferrers cannot be determined unambiguously, however, without knowledge of offenders' discount rates: the higher the latter, the larger would be the absolute values of our revised estimates of b_{2i}.[48] Following our analysis in Section I, A, we can therefore expect that in a real income sense, crime does pay at the margin to burglars and thieves, while it may not pay to robbers.[49]

It is difficult to determine accurately on the basis of available data to what extent the estimated values of b_{1i} and b_{2i} are attributable to a preventive effect of imprisonment (see eq. [2.7]) because the absolute values of our estimates of P_i may not be accurate.[50] Since our 2SLS and SUR cross-states estimates of b_{1i} and b_{2i} appear to differ significantly in the case of murder, rape, robbery, burglary, and larceny (some of these estimates approach or even exceed unity in absolute value), the independent deterrent effect of law enforcement appears to be confirmed because the preventive effect of probability and severity of imprisonment,

48. We have computed estimates of correction factors $1/\lambda$ (where λ is defined in Appendix 1 to Section III) based on arithmetic mean values of T_i and alternative arbitrary discount rates. We find that only when using a yearly rate of 36 per cent do the revised estimates of b_{2i} for murder and rape (but not for robbery) approach our estimates of b_{1i} associated with the same crimes.

49. We have attempted to test these implications directly by calculating the net monetary gains associated with an average robbery, burglary, larceny, and auto theft. Surprisingly, our crude estimates of the expected net gains are compatible with their predicted values according to the regression results discussed above, for the net gain is estimated to be negative in the case of robbery and positive in the case of burglary and larceny (see Appendix 2 to this section).

50. Estimates of σ based on our estimates of P and T are found to account for less than 10 per cent of the magnitude of the 2SLS estimates of b_1 and b_2 associated with all offenses. The latter may be regarded as estimates of steady state elasticities of the crime rate with respect to P and T, because the variation in these variables across states is likely to exhibit persistent differences.

P_i and T_i, is expected to be virtually identical, and, in view of the available information regarding average values of T_i and reasonable estimates of P_i in the United States, considerably lower than unity.

B. SUPPLY-OF-OFFENSES FUNCTIONS: THE EFFECT OF UNEMPLOYMENT, LABOR-FORCE PARTICIPATION, AND AGE COMPOSITION

We have also investigated in our regression analysis the partial effects of unemployment and labor-force participation rates of urban males in the age groups 14–24, U_{14-24} and L_{14-24}, respectively, as well as the effect of the variation in the proportion of all males belonging to that age group, A_{14-24}, by adding these variables to the regression equations (4.1) and (4.3). The expanded regression equation is

$$\ln\left(\frac{Q}{N}\right)_i = a_i + b_{1i}\ln P_i + b_{2i}\ln T_i + c_{1i}\ln W + c_{2i}\ln X + d_{1i}\ln U_{14-24} + d_{2i}\ln L_{14-24} + e_{1i}\ln NW + e_{2i}\ln A_{14-24} + \mu_i, \tag{4.4}$$

and the results concerning these variables are shown in Table 6.[51]

The partial effect of age is found to be inconclusive in the regressions dealing with crimes against property. The signs of e_{2i} vary across different crimes with their values falling short of their standard errors, especially when estimates are derived via a 2SLS procedure. Possibly, then, not age per se, but the general opportunities available to offenders determine their participation in crimes against property. The percentage of young age groups does appear to be positively correlated with the rate of crimes against the person in 1960, independently of the regression method employed.

The results concerning the partial effect of the unemployment rate U_{14-24} are generally disappointing: the signs of d_{1i} are not stable across different regressions and do not appear significantly different from zero. One reason may be that variations in U_{14-24} across states reflect considerable variation in voluntary unemployment due to the search for desirable employment, since this source of unemployment is particularly important among young workers. Indeed, we have achieved somewhat

51. We have generally excluded A_{14-24} from eq. (4.4) whenever the ratio of e_2 to its standard deviation fell short of 1. In the 2SLS regressions, P_i were replaced by estimates of specific probabilities of imprisonment, $\hat{P}_i$, derived through a modified version of the reduced-form regression eq. (4.2), including U_{14-24} and L_{14-24}, in addition to the explanatory variables entering eq. (4.2), and excluding U_{35-39}.

TABLE 6

ALTERNATIVE ESTIMATES OF ELASTICITIES OF OFFENSES WITH RESPECT TO UNEMPLOYMENT AND LABOR-FORCE PARTICIPATION OF YOUNG AGE GROUPS IN 1960
(DEPENDENT VARIABLES ARE SPECIFIC CRIME RATES)

Crime Category	Ordinary Least-Squares (OLS)						Two-Stage Least-Squares (2SLS)					
	Unweighted			Weighted			Unweighted			Weighted		
	d_1	d_2	e_2	d_1	d_2	e_2	d_1	d_2	e_2	d_1	d_2	e_2
Robbery:												
$\hat{\beta}$	0.148	−0.346	–	−0.297	−0.431	–	−0.634	−0.793	–	−0.749	−0.920	–
$\hat{\beta}/S\hat{\beta}$	(−0.383)	(−1.145)	–	(−0.838)	(−1.208)	–	(−1.281)	(−2.006)	–	(−1.968)	(−1.754)	–
Burglary:												
$\hat{\beta}$	−0.078	0.059	0.9092	−0.084	0.216	–	−0.306	−0.136	–	−0.033	0.334	–
$\hat{\beta}/S\hat{\beta}$	(−0.333)	(0.301)	(1.4150)	(−0.380)	(0.944)	–	(−1.115)	(−0.559)	–	(−0.154)	(1.107)	–
Larceny:												
$\hat{\beta}$	0.186	0.573	–	0.091	0.430	–	0.214	0.487	–	−0.103	−0.033	–
$\hat{\beta}/S\hat{\beta}$	(0.955)	(2.056)	–	(0.326)	(1.395)	–	(0.711)	(1.188)	–	(−0.306)	(−0.067)	–
Auto theft:												
$\hat{\beta}$	0.147	0.435	1.062	−0.137	0.373	–	0.516	0.401	–	−0.315	0.174	–
$\hat{\beta}/S\hat{\beta}$	(0.534)	(1.984)	(1.328)	(−0.553)	(1.360)	–	(0.188)	(1.396)	–	(−0.365)	(0.519)	–
Murder:												
$\hat{\beta}$	−0.132	−0.656	1.803	−0.178	−0.602	1.622	−0.151	−1.510	2.072	−0.324	−0.822	1.293
$\hat{\beta}/S\hat{\beta}$	(−0.388)	(−2.264)	(1.875)	(−0.636)	(−2.018)	(2.043)	(−0.268)	(−2.456)	(1.298)	(−0.227)	(−1.966)	(1.698)
Rape:												
$\hat{\beta}$	0.238	−0.728	1.339	0.222	−0.654	1.605	0.286	−0.851	1.430	0.209	−0.576	2.043
$\hat{\beta}/S\hat{\beta}$	(0.853)	(−3.232)	(1.660)	(0.828)	(−2.363)	(2.080)	(0.428)	(−3.366)	(1.603)	(0.774)	(−1.902)	(2.583)
Assault:												
$\hat{\beta}$	−0.073	−0.325	2.792	−0.083	−0.314	2.164	−0.132	−0.162	3.403	−0.389	−0.168	1.345
$\hat{\beta}/S\hat{\beta}$	(−0.219)	(−1.044)	(2.885)	(−0.268)	(−0.903)	(2.431)	(−0.283)	(−1.370)	(2.492)	(−0.938)	(−1.272)	(1.938)
All offenses:												
$\hat{\beta}$	0.037	0.159	1.044	0.049	0.275	1.157	−0.129	−0.481	1.386	−0.169	0.004	–
$\hat{\beta}/S\hat{\beta}$	(0.172)	(0.768)	(1.709)	(0.262)	(1.264)	(2.051)	(−0.421)	(−1.288)	(1.606)	(−0.806)	(0.012)	–

better results when using the unemployment rates of urban males in the age group 35–39 in lieu of U_{14-24}. Another reason may be that the effect of variations in the true probability of involuntary unemployment is impacted in the effect of income inequality, X, since a decline in legitimate market opportunities leading to an increase in involuntary unemployment is likely to affect disproportionately those with lower schooling and training and may therefore increase income inequality. Finally, it may be noted that our theoretical analysis indicates some ambiguity regarding the effect of an increase in the probability of unemployment on offenders engaging in both legitimate and illegitimate activities, if unemployment is regarded as an uncertain event (see footnote 14).

Interesting results have been obtained with respect to the partial effect of labor-force participation on the rate of specific crimes. The effect of L_{14-24} is somewhat inconclusive in the case of crimes against property but is found consistently negative and significantly different from zero in the case of specific (as well as all) crimes against the person. Are these results compatible with the theory developed in Section I of this paper?

One important question is what do variations in labor-force participation rates indicate in the context of this investigation? On the one hand, if all offenders specialized in crime and also chose to register as not in the labor force, then L_{14-24} could be viewed as a rough index of time spent in *legitimate* market activities by young persons in a state: movements in L_{14-24} would then be likely to reflect opposite movements in the rate of participation in crimes against property. On the other hand, if most offenders were partly engaged in legitimate market activities, L_{14-24} would be an index of time spent by the average young person in *all* market activities, legitimate as well as illegitimate.

Traditional economic theory predicts that labor-force participation is a function of real income, the market wage rate if employed, and the probability of unemployment. If variations in these variables were effectively accounted for by the variation in W, X, and U_{14-24}, the variation in L_{14-24} would mainly capture the effect of exogenous factors determining labor-force participation of young age groups (e.g., the rate of school enrollment or the degree of enforcement of child labor laws). Assuming that L_{14-24} is an index of total time spent in market activities by the average young person, variations in L_{14-24} would then produce a pure scale effect on participation in crime. We have expected such a scale effect to be positive in the case of crimes against property and negative in the case of crimes against the person (see our discussion in Secs. I, B, and I, C). However, since variations in legitimate wage rates available to potential young offenders are only indirectly accounted for by the variation in family income inequality, X, they, too, are likely to be reflected by the variation in L_{14-24}. Specifically, with the distribution of family income held constant, an increase in legitimate wages available to young workers is expected to reduce their incentive to participate in all crimes. This negative substitution effect is likely to offset the positive scale effect of an increase in L_{14-24} on the rate of crimes against property, but may reinforce the negative scale effect of an increase in L_{14-24} on the rate of crimes against the person, as our analysis in the last paragraphs of Sections I, B, and I, C, predicts. The results reported in Table 6 are compatible with these expectations.

It should be pointed out that the introduction of A_{14-24}, U_{14-24}, and L_{14-24} in the regression analysis has had virtually no effect on the estimated elasticities and only a marginal impact on the extent of the R^2 statistics reported in Tables 2 and 3.[52]

C. THE EFFECTIVENESS OF LAW ENFORCEMENT: SOME TENTATIVE ESTIMATES

Is law enforcement effective in combating crime? Is there at present too much or too little enforcement of existing laws against felonies? The answer to these questions can be obtained, in principle, by considering two related issues. First, what would be the effect of an increase in the probability and severity of punishment on the level of felony offenses and the resulting social loss? Second, to what extent would an additional expenditure on law-enforcement agencies increase their effectiveness in apprehending and punishing felons?

Our empirical estimates of supply-of-offenses functions provide consistent results pertaining to the first issue. In addition, an attempt has

52. The regression models employed thus far have implicitly assumed that specific illegal activities, i, were independent of each other. Specific crimes may be substitutes (or complements) in the sense that an increase in opportunities available in one crime would have opposite (or similar) effects on the rate of related crimes. (For example, offenders charged for robbery are often convicted of burglary; an increase in the penalty for burglary might then deter participation in both crimes.) To test interdependencies among specific crimes, we have introduced in the regression eq. (4.3) the (estimated) probability and severity of imprisonment relating to subsets of these crimes, $\hat{P}_g$ and T_g, respectively, in addition to own variables. The 2SLS estimates of the regression coefficients associated with $\hat{P}_g$ and T_g indicate that robbery and burglary are complements, and that burglary and theft are substitutes, but the absolute values of the coefficients associated with these variables are found to be quite low relative to their standard errors. Moreover, the estimated coefficients of the explanatory variables introduced in eq. (4.3) are virtually unaffected by the introduction of these other variables (see Ehrlich, 1970, pp. 86–89).

been made to estimate the effectiveness of public outlays on police in determining the probability of apprehending and punishing felons, P, by estimating an aggregate production function of law-enforcement activity (equation (3.3) defined for all felony offenses) via a 2SLS weighted-regression procedure using state data from 1960. In the first stage of the analysis, the rate of all felony offenses, Q/N, and per capita expenditure on police, E/N, were regressed on the set of exogenous and predetermined variables specified in the reduced-form regression equation (4.2). In the second stage, P was regressed on values of $\hat{Q}/N$ and $\hat{E}/N$ computed from the estimated reduced-form regression equations, and on other environmental variables, some of which were discussed in connection with equation (3.3). The results are given in equation (4.5) below (the numbers in parentheses denote the ratios of the regression coefficients to their standard errors).[53]

$$\begin{aligned}\ln P = \underset{(0.601)}{1.489} + \underset{(0.611)}{0.219} \ln \left(\frac{\hat{E}}{N}\right) - \underset{(-3.784)}{0.854} \ln \left(\frac{\hat{Q}}{N}\right) - \underset{(-2.980)}{0.226} \ln N \\ - \underset{(-1.505)}{0.059} \ln \text{SMSA} + \underset{(1.755)}{1.094} \ln X + \underset{(2.893)}{0.267} \ln NW + \underset{(2.637)}{2.37} \ln Ed \\ - \underset{(-1.313)}{1.074} \ln A_{14-24} + \underset{(2.268)}{0.428} D. \qquad (4.5)\end{aligned}$$

As expected, the probability of apprehending and convicting felons is found to be positively related to the level of the current expenditure on police and negatively related to the crime rate, the estimated elasticities being $\hat{\beta}_1 = 0.219$ and $\hat{\beta}_2 = 0.854$, respectively. The productivity of law-enforcement activity is found to be negatively affected by the size and density of the population, as indicated by the negative signs of the coefficients associated with N and SMSA, and positively affected by the extent of relative poverty, the schooling level of the adult population, and the proportion of nonwhites, as indicated by the positive signs of the co-

53. The reader may note that the results reported in equation (4.5) of this essay, as well as other calculations in this section which are based on these results, differ to some extent from the corresponding results in my original article in the *Journal of Political Economy*. Subsequent to the publication of my article it was discovered that the computer program used to derive the latter results did not weight the dummy variable, D, by the weighting factor applied to all other variables. There is, of course, little technical justification for such an incomplete weighting procedure. The qualitative conclusions reached here on the basis of the new results are consistent, however, with those reached in my original article.

efficients associated with X, Ed, and NW.[54] Also, P appears to be greater in southern states and lower in states with a greater proportion of juveniles.[55] Note, however, that the standard error of the coefficient associated with E/N is 0.358 which implies, for example, that the lower and upper 95 per cent confidence limits of $\hat{\beta}_1$ (calculated from the normal distribution) are -0.483 and 0.920, respectively. Put differently, the probability that $\hat{\beta}_1$ takes on a *positive* value, given that β_1 is normally distributed with mean 0.219 and standard deviation 0.358, is only .7291. This somewhat weak result may be attributed both to measurement errors in E/N and aggregation biases involved in estimating an aggregate production function of law-enforcement activity. First, E/N measures all expenditures on police activity, including, for example, traffic control, but not on criminal courts. The latter is presumably an important determinant of felony conviction rates. (Also see our discussion of item 6 in Appendix 1 to Section III.) Second, monetary expenditure on police is an imperfect measure of the real outlays on police activity across states because of possible regional differences in the rates of pay to policemen across states that are not due to differences in productivity. Finally, to the extent that the coefficients of the production function of law-enforcement activity against *specific* crimes differ for different crime categories (in particular, crimes against the person as against crimes against property), the estimated coefficients in equation (4.5) may be subject to aggregation biases, since the distribution of specific crimes among total felonies (especially crimes against property) varies significantly across states.[56] This implies, of course, that all the estimated coefficients in equation (4.5), not only $\hat{\beta}_1$, must be viewed with caution.

Assuming for a methodological purpose the validity of our estimates of the aggregate production function (4.5), we may now combine these

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54. The positive association between P and both X and NW suggests that those with lower income spend less resources on legal counsel and legal defense. The positive (partial) effect of Ed on P, given E/N, is interesting, for it may reflect the degree and effectiveness of private self-protective efforts and other assistance provided by victims and law-enforcement agents in bringing about the apprehension and conviction of offenders (also see Appendix 1 to Section III, item 6).

55. One reason why P—the probability of punishment by imprisonment—may be negatively related to A_{14-24} is that many young convicts are sent to reformatories and other correctional institutions rather than to state and federal prisons.

56. Indeed, the value of the coefficient associated with E/N is found to exceed twice the value of its standard error in a regression analysis estimating a production function of law-enforcement activity that relates to crimes against the person only (see Ehrlich, 1970, p. 92). In general, estimates of both β_1 and β_2 have been found to be quite sensitive to the specification of the reduced-form regression equation.

with estimates of the aggregate supply-of-offenses function to derive a preliminary estimate of the effectiveness of public expenditure on law enforcement in a given year in reducing the rate of crime in that year. Substituting equation (3.3) in equation (3.2), it is easily seen that the elasticity of the crime rate, Q/N, with respect to current expenditure, E/N, is $e = (b_1\beta_1)/(1 - b_1\beta_2)$. In terms of our 2SLS estimates of b_1, β_1, and β_2, e is, then, estimated at -1.42: a 1 per cent increase in expenditure on direct law enforcement would result in about a 1.4 per cent decrease in all felony offenses. However, the standard error of this estimate calculated through a Taylor's series approximation of e as a function of b_1, β_1 and β_2 is found to be 3.8. This implies that the probability that $\hat{e}$ takes on a negative value, given that e is asymptotically normally distributed with mean -1.42 and standard deviation 3.8, is only .6443.

The total social loss from crimes against property and crimes against the person in 1965 has been estimated in monetary terms at \$5,968 million (see PCL, 1967(b), p. 44), which is probably an underestimate of the true social loss due to these crimes. On the other hand, total expenditure on police, courts, prosecution, and defense in 1965 was \$3,178 million (see PCL, 1967(b), p. 54), which obviously is an overestimate of the public expenditure devoted to combating these crimes alone. Nevertheless, if one accepted the tentative estimate of $e = -1.42$, one would conclude that in 1965 the marginal cost of law enforcement against felonies fell short of its marginal revenue, or that expenditure on direct law enforcement was less than optimal.[57] In view of the imperfections inherent in our estimate of e, however, this result cannot be considered very reliable. More accurate and specific data on expenditure on various kinds of law-enforcement activity, on payoffs on specific crimes against property, on private self-protection against crime, and on the private losses from crime would be required in order to derive more reliable simultaneous-equation estimates of production functions of law-enforcement activities

57. Assuming that the social loss from crime is proportionally related to the number of offenses committed, an increase in the expenditure on police and courts in 1965 by \$32 million (1 per cent of \$3,178 million) could have reduced the loss from felonies by about \$83 million (1.4 per cent of \$5,968 million). Furthermore, our tentative estimates of β_1 and e indicate that a 1 per cent increase in the expenditure on police and courts might have reduced the flow of offenders committed to prisons, $C/N = P(Q/N)$ and thus the total costs of their imprisonment by $\beta_1 + e = 1.2$ per cent. Since expenditures on state adult institutions in 1965 amounted to \$385 million (see PCL, 1967(b), p. 54; this represents approximately the total costs of imprisonment of a yearly flow of offenders committed to state prisons throughout their effective prison terms), the additional cost of law enforcement associated with a 1 per cent increase in the expenditure on police and courts in 1965 might have amounted to about \$27 million only (\$32 million less \$4.6 million savings in imprisonment costs).

and the effectiveness of these activities in reducing specific crimes and the resulting social losses.

CONCLUSION

The basic thesis underlying our theory of participation in illegitimate activities is that offenders, as a group, respond to incentives in much the same way that those who engage in strictly legitimate activities do as a group. This does not necessarily imply that offenders are similar to other people in all other respects, or that the extent of their response to incentives is the same. Indeed, our theory suggests that the extent of individual offenders' response to incentives may vary (negatively) with the extent of their specialization in illegitimate activity and so may not be uniformly high or low. We do emphasize, however, the role of opportunities available in competing legitimate and illegitimate activities in determining the extent of an offender's participation in the latter and thus, indirectly, also in determining the extent of his response to incentives.

The results of our regression analysis of variations in the rate of index crimes across states in the United States are not inconsistent with this basic thesis. In spite of the shortcomings of the crime statistics used, the indirect estimates of some of the theoretical constructs, and the somewhat stringent econometric specification of functional relationships, the signs and alternative point estimates of the coefficients of specific regression equations exhibit a remarkable consistency with the theoretical predictions, as well as with one another, across independent samples. The rate of specific felonies is found to be positively related to estimates of relative gains and negatively related to estimates of costs associated with criminal activity. In particular, and contrary to some popular arguments, the absolute magnitudes of the estimated elasticities of specific crimes with respect to estimates of probability and severity of punishment are not inconsistent with the hypothesis that law-enforcement activity has a deterrent effect on offenders that is independent of any preventive effect of imprisonment. Moreover, the elasticities associated with crimes against the person are not found to be lower, on the average, than those associated with crimes against property.

Viewing the decision to participate in crimes involving material gains as an occupational choice is not inconsistent with the evidence concerning the positive association between income inequality and the rate of crimes against property. Moreover, the relative magnitude of estimates of the elasticities of burglary and larceny with respect to probability and severity of punishment indicate that burglars and thieves are risk avoiders. These findings indicate, in turn, that many crimes against property, not unlike legitimate market activities, pay in the particular sense that their expected gains exceed their expected costs at the margin. This approach may be useful in explaining not only variations in the rate of felonies and many other types of crime across states or over time, but also a variety of specific characteristics associated with individual offenders: for example, why many appear to be relatively young males with little schooling and other legitimate training; why some are occasional offenders who combine legitimate and illegitimate market activities, while others specialize in crime; and why many continue their participation in illegitimate activities even after being apprehended and punished. Such characteristics, the analysis suggests, may be largely the consequence of the relative opportunities available to offenders in legitimate and illegitimate activities rather than the result of their unique motivation.

More important, the analytical and econometric framework developed in this paper appears useful in evaluating the effectiveness of public expenditure on law-enforcement activity. Some tentative estimates of the effectiveness of police and court activity against felonies in 1965 indicate that such activity paid (indeed, "overpaid") in the sense that its (partial) marginal revenue in terms of a reduced social loss from crime exceeded its (partial) marginal cost. Our empirical investigation also indicates that the rates of all felonies, particularly crimes against property, are positively related to the degree of a community's income inequality. This suggests a social incentive for equalizing training and earning opportunities across persons, which is independent of ethical considerations or any social welfare function. Whether it would pay society to spend more resources in order to enforce existing laws would then depend not only on the effectiveness of such expenditure in deterring crime, but also on the extent to which alternative methods of combating crime pay. Our ability to analyze these important issues would undoubtedly improve as more and better data concerning the frequency of illegitimate activities, self-protection by both offenders and victims, and alternative private and collective methods of combating crime became available.

APPENDIX 1 TO SECTION I: THE ALLOCATION OF TIME TO ILLEGITIMATE ACTIVITIES

A.

The expected utility associated with a one-period consumption prospect can be written generally as

$$EU = U^* = \sum_{s=a}^{n} \pi_s U(X_s, t_c), \tag{A.1}$$

where s denotes the state of the world and π_s its probability. If returns from i were contingent upon the occurrence of only two events: "no punishment," with probability $(1-p)$, and "apprehension and punishment," with probability p, and if the returns from l were fully insured, then (A.1) would reduce to

$$U^* = (1-p)U(X_b, t_c) + pU(X_a, t_c), \tag{A.2}$$

where

$$X_b = W' + W_i(t_i) + W_l(t-t_i),$$

$$X_a = W' + W_i(t_i) - F_i(t_i) + W_l(t-t_i),$$

and

$$t = t_i + t_l \equiv t_o - t_c$$

is the amount of "working time." Given the value of t_c, hence t, the value of t_i that maximizes this function in case of an interior solution must satisfy the first-order condition

$$(1-p)U'(X_b)(w_i - w_l) + pU'(X_a)(w_i - w_l - f_i) = 0, \tag{A.3}$$

where $w_k = (dW_k/dt_i^*)k = i, l$; $f_i = (dF_i/dt_i^*)$; and t_i^* denotes the optimal value of t_i. Clearly, equation (A.3) may be satisfied only if

$$w_i - f_i > w_l. \tag{A.4}$$

The second-order condition is

$$\Delta = (1-p)U''(X_b)(w_i - w_l)^2 + pU''(X_a)(w_i - w_l - f_i)^2$$
$$+ (1-p)U_b'\left(\frac{dw_i}{dt_i} + \frac{dw_l}{dt_l}\right) + pU_a'\left(\frac{dw_i}{dt_i} - \frac{df_i}{dt_i} + \frac{dw_l}{dt_l}\right) < 0. \tag{A.5}$$

If the rates of change in w_i, f_i and w_l were constant, equation (A.5) would always be satisfied if everywhere $U'' < 0$. However, if w_i and w_l were a decreasing function of "working time" and f_i were not a decreasing function of t_i (if the production transformation curve were concave to the origin as in Figure 1), (A.5) would also be satisfied if everywhere $U'' = 0$ and might be satisfied even if $U'' > 0$. In the following analysis it is therefore assumed that equation (A.5) is satisfied regardless of attitudes toward risk, and that equilibrium is consistent with regular interior maxima with the values of both t_i and t_l being positive.

The partial effects of equal percentage changes in p and $f = F/t_i$ on the value of t_i^* in case the latter is positive have been analyzed in Section I, B, and in footnote 13 in the text. However, the theorem presented in equation (1.10) in footnote 13 concerning the relative elasticity of t_i^* with respect to p and f_i is more general, since it also holds in case of a boundary solution in which a person specializes in legitimate activity. To prove this proposition note, first, that for any given value of t_c, a person would be indifferent between entering i or devoting his full working time to l if the expected utility from a single offense were the same as that from the marginal unit of time allocated to l; that is, if

$$U_i^* \equiv (1-p)U(W+w_i) + pU(W+w_i-f_i) = U_l^*(W+w_l), \qquad \text{(A.6)}$$

where $W = W' + w_l(t-dt)$, and $t = t_o - t_c$. Clearly,

$$\frac{\partial U_i^*}{\partial p} = -[U(X_b) - U(X_b - f_i)] < 0,$$

and (A.7)

$$\frac{\partial U_i^*}{\partial f_i} = -pU'(X_b - f_i) < 0,$$

where $X_b = W + w_i$. An increase in either p or f_i decreases the incentive to *enter* i. Furthermore, by the set of equations (A.7) the relative effects of equal percentage changes in p and f_i on the incentive to enter or exit from i can be summarized as follows:

$$-\frac{\partial U_i^*}{\partial p} p \gtreqless -\frac{\partial U_i^*}{\partial f_i} f_i,$$

as

$$U(X_b) - U(X_b - f_i) \gtreqless U'(X_b - f_i) f_i. \qquad \text{(A.8)}$$

Applying Taylor's theorem around the point $X_b - f_i$ one can write

$$U(X_b) = U(X_b - f_i) + f_i U'(X_b - f_i) + \frac{f_i^2}{2!} U''(X_b - f_i + \theta f_i),$$

where $0 < \theta < 1$. Hence, $U(X_b) - U(X_b - f_i) \gtreqless U'(X_b - f_i)f_i$, as $U'' \gtreqless 0$. Equation (A.8) thus implies that a 1 per cent change in p has a greater effect on the incentive to enter i than a 1 per cent change in f_i if a person is risk preferring, and a relatively lower effect if a person is risk avoiding. A geometrical proof for this result is given in Becker (1968), included in this volume.

The effect of an equal proportional increase in the wage rates obtained in i, hence in the average wage $\bar{w}_i$ with p, f_i, w_l and W' held constant, would be given by

$$\frac{dt_i^*}{d\bar{w}_i}\bar{w}_i = \frac{(A+B)\bar{w}_i}{\Delta}, \qquad \text{(A.9)}$$

where

$$A = -(1-p)U_b' - pU_a'$$

and

$$B = -(1-p)U_b''(w_i - w_l)t_i^* - pU_a''(w_i - w_l - f_i)t_i^*.$$

Because the value of A is always negative, equation (A.9) would have a positive value if $U''=0$ or if B did not have an algebraic sign opposite to that of A. Substituting equation (A.3) in B it can be shown that B would equal zero if

$$-\frac{U_a''}{U_a'}=-\frac{U_b''}{U_b'}, \tag{A.10}$$

i.e., there is constant absolute risk aversion (or preference).[58] This assumption also guarantees that a reduction in $\bar{w}_l$ would always increase participation in i since then

$$-\frac{dt_i^*}{d\bar{w}_l}\,\bar{w}_l=\frac{(A-C)w_l}{\Delta}=\frac{(-)}{(-)}>0, \tag{A.11}$$

where

$$C=-(1-p)U_b''(w_i-w_l)t_l^*-pU_a''(w_i-w_l-f_i)t_l.$$

If we now relax the assumption that legitimate earnings are known for certain and assume that earnings in l, too, were contingent upon the occurrence of two events: "employment" with probability $(1-u)$, and "unemployment" with probability u, and if the probability of unemployment were independent of the probability of apprehension and conviction, then equation (A.1) would become

$$U^*=(1-p)(1-u)U(X_a,t_c)+(1-p)uU(X_b,t_c)$$
$$+p(1-u)U(X_c,t_c)+puU(X_d,t_c), \tag{A.12}$$

where

$$X_a=W'+W_i(t_i)+W_l(t-t_i),$$
$$X_b=W'+W_i(t_i)+W_l(t-t_i)-D_l(t-t_i),$$
$$X_c=W'+W_i(t_i)-F_i(t_i)+W_l(t-t_i),$$
$$X_d=W'+W_i(t_i)-F_i(t_i)+W_l(t-t_i)-D_l(t-t_i),$$

and D_l denotes the reduction in real earnings due to unemployment. Given the value of t_c, the first-order optimality condition is

$$\frac{dU^*}{dt_i^*}=(1-p)(1-u)U_a'(w_i-w_l)+(1-p)uU_b'(w_i-w_{l2})$$
$$+p(1-u)U_c'(w_{i2}-w_l)+puU_d'(w_{i2}-w_{l2})=0, \tag{A.13}$$

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58. See the discussion in Ehrlich and Becker (1972). Since both absolute and relative risk aversion are constant along the certainty line (Ehrlich and Becker, op. cit.), equations (A.9) and (A.11) would always have a positive sign when most working time is spent in l. Of course, both might have a positive sign even when there is increasing or decreasing absolute risk aversion.

where $w_{i2} = w_i - f_i$ and $w_{l2} = w_l - d_l$, and the second-order condition is

$$\frac{d^2U^*}{dt_i^{*2}} = \Sigma < 0. \tag{A.14}$$

If $w_i > w_l$ equations (A.13) and (A.14) would be satisfied by the same conditions satisfying equations (A.3) and (A.5).[59]

The effects of changes in p, f_i, w_i and w_l on the value of t_i^* discussed above can be shown to apply in this more general case as well. In particular,

$$\frac{dt_i^*}{dp} = \frac{1}{\Sigma}[(1-u)U_a'(w_i - w_l) + uU_b'(w_i - w_{l2}) + S] = \frac{(+)}{(-)} < 0, \tag{A.15}$$

since $S = -(1-u)U_c'(w_{i2} - w_l) - uU_d'(w_{i2} - w_{l2})$ must have a positive sign for equation (A.13) to be satisfied. On the other hand, the effect of an increase in u on t_i^* would be given by

$$\frac{dt_i^*}{du} = \frac{1}{\Sigma}[(1-p)U_a'(w_i - w_l) - (1-p)U_b'(w_i - w_{l2}) + pU_c'(w_{i2} - w_l) - pU_d'(w_{i2} - w_{l2})]. \tag{A.16}$$

The sign of equation (A.16) would always be positive if $U'' = 0$, since then equation (A.16) reduces to $-(U'd_l/\Sigma) = (-)/(-) > 0$. If $U'' < 0$ and $w_{i2} - w_{l2} \geqslant 0$ it also can be seen that (A.16) would be positive. In contrast, if $w_{i2} - w_{l2} < 0$, which would be the case if $f > w_i$ and $d \leqslant w_l$, equation (A.16) would have a positive sign only if p were small and U were not too concave. It is then possible, in principle, that an increase in the probability of unemployment will not induce offenders to allocate more time to i, essentially because an increase in u increases the demand for wealth in the less desirable states of the world. Note, however, that regardless of attitudes toward risk, an increase in u would always increase the incentive to enter i, since as a result of this change the expected utility from the marginal unit time spent in l would decrease relative to the expected utility from entering i. This can be easily shown by differentiating the term U_i^* in equation (A.6) above with respect to u.[60]

59. A necessary condition for entry into i is that the expected utility from entering i would exceed the expected utility from "full-time" participation in l. If earnings in l are known for certain, it has been shown in the text that this condition would be satisfied for a risk avoider if the expected wage in i, $E(w_i)$, exceeded w_l. Since earnings in l are here assumed subject to uncertainty, then given that the variance of earnings in i is greater than that in l, a risk avoider would enter i only if $E(w_i)$ were initially sufficiently greater than $E(w_l)$.

60. Equation (A.16) shows the partial effect of u on t_i^* when the extent of punishment is held constant. If punishment were by imprisonment, an increase in u that was expected to persist over a sufficiently long period might also imply a reduction in the expected opportunity costs of imprisonment, provided these were largely determined by the expected legitimate earnings. In this case, an increase in u might unambiguously induce a greater participation in crime.

So far we have assumed in our analysis that the probability of being apprehended and punished in a given "period," p, was independent of the amount of time spent in i. This assumption may be justified in part in view of the opposite effects an increase in t_i may have on p. On the one hand, an increase in the number of offenses committed within a given period may increase the likelihood that the offender will be apprehended on any one offense committed.[61] However, an increase in t_i is also likely to enhance an offender's ability to elude apprehension and punishment through "learning by doing."[62] The net effect of t_i on p is therefore not clear a priori. However, even if p were positively related to t_i at the margin, the results derived in the preceding discussion would essentially be unaffected.

Given that $\partial p/\partial t_i^* = p'(t_i^*) > 0$, equation (A.3) becomes

$$[1 - p(t_i^*)]U_b'(w_i - w_l) + p(t_i^*)U_a'(w_i - w_l - f_i) - p'(t_i^*)[U_b - U_a] = 0, \quad \text{(A.17)}$$

and equation (A.15) becomes

$$\Delta' = \Delta - p''(t_i^*)(U_b - U_a) - p'(t_i^*)[U_b'(w_i - w_l) - U_a'(w_i - w_l - f_i)], \quad \text{(A.18)}$$

where Δ is defined as in equation (A.5). As Δ has been assumed negative in value, Δ' would be negative in value—the second-order equilibrium condition would be satisfied—if $p''(t) \geqslant 0$, and $f > w_i - w_l$.

Since p is a function of the amount of time spent in i,[63] a 1 per cent increase in p may generally be interpreted as a 1 per cent increase in both $p(t_i^*)$ and $p'(t_i^*)$. In this case, holding the value of all the other parameters constant, the effect on t_i^* would be

$$\frac{dt_i^*}{dp}p = \frac{[-U_a'(w_i - w_l - f_i)p + U_b'(w_i - w_l)p] + p'(t_i^*)(U_b - U_a)}{\Delta'}$$
$$= \frac{(+)}{(-)} < 0. \quad \text{(A.19)}$$

Similarly, the effect of a 1 per cent increase in all the penalty rates, hence in the aggregate rate f, would be

$$\frac{dt_i^*}{df}f = \frac{[U_a'pf_i + U_a''(w_i - w_l - f_i)] + p'(t_i^*)U_a'ft_i^*}{\Delta'} = \frac{(+)}{(-)} < 0 \quad \text{(A.20)}$$

if $U'' \leqslant 0$. The implications of equation (1.10) in footnote 13 are thus shown to hold in this case as well. Moreover, the implications of equation (A.18) also hold

61. If the probability of being apprehended on a single offense π were independent of the number of offenses committed, t, then the probability of being apprehended on any one offense committed would be $\tau = 1 - (1 - \pi)^t$. Clearly, then, $\partial\tau/\partial t > 0$.

62. Moreover, it is shown in Appendix 2 to Section I that an increase in t_i is likely to enhance the offender's expenditure on self-protection and thus decrease at least the probability of apprehension and punishment for a single offense.

63. Formally, $p(t_i^*) = \int_0^{t_i^*} p'(t_i)dt_i$.

in this case. Note, first, that in equilibrium $X_a = X_b - F^*$, where $F^* = ft_l^*$. Using a theorem summarized by equation (A.8) above, given the value of t_c,

$$U(X_b) - U(X_b - F^*) \gtreqless U'(X_b - F)F,$$

as $U'' \gtreqless 0$. Therefore, the second term in the numerator of equation (A.19) exceeds, is equal to, or falls short of, the second term in the numerator of (A.20) as U'' is greater than, equal to, or lower than, zero. Exactly the same condition determines the relative magnitudes of the first terms in the numerators of equations (A.19) and (A.20), as was shown in footnote 13 in the text. The results summarized in equation (1.10) in footnote 13 therefore hold unambiguously in this case as well.[64]

B.

The analysis so far has focused on effects of changes in exogenous factors on the allocation of working time, $(t_o - t_c)$, between i and l. In this section, the assumption of t_c being constant is relaxed in order that behavioral implications can be developed regarding the absolute, as well as the relative, allocation of time to i and l. In general, the effect of changes in legitimate and illegitimate costs and returns on the absolute magnitude of t_c^*, hence of t_i^* and t_l^*, are ambiguous because of competing wealth and substitution effects. Also, changes in the overall amount of time allocated to market activities, $t_o - t_c$, may have systematic effects on the incentive to participate in either i or l. Abstracting from such possible effects, it can be shown, however, that the same implications discussed in Part A of this appendix hold also in reference to the absolute allocation of time to i and l. In the following analysis, this assertion is demonstrated with regard to effects of exogenous changes in p and f.

For methodological convenience, let us define $t_i \equiv s(t_o - t_c)$, and $t_l = (1 - s) \times (t_o - t_c)$, where s and $(1 - s)$ denote the fractions of working time devoted to i and l, respectively. Optimal values of t_i, t_l, and t_c may thus be determined through an unconstrained maximization of equation (A.2) with respect to the independent variables s and t_c. It is assumed throughout the analysis that the utility function, U, is strongly separable in t_c and $X_j j = a,b$, so that $\partial U/\partial X;\ \partial t_c = 0$. It is also assumed that $\partial U^*/\partial s \partial t_c = 0$, so that the relative allocation of working time between i and l is independent of the scale of working time itself. Values of s and t_c that maximize equation (A.2) locally in case of an interior solution under these assumptions must satisfy the following necessary conditions:

$$U_s^* = (1 - p)U'(X_b)(w_i - w_l)(t_o - t_c^*) + pU'(X_a)(w_i - f_i - w_l)(t_o - t_c^*) = 0, \quad \text{(A.21)}$$

64. The results discussed in reference to equations (A.10) and (A.11) can also be shown to hold with some modifications in this more general case.

and

$$U_t^* = U'(t_c) - (1-p)U'(X_b)[w_i s^* + w_l(1-s^*)] \\ - pU'(X_a)[(w_i - f_i)s^* + w_l(1-s^*)] = 0, \quad \text{(A.22)}$$

where U_s^* and U_t^* denote $\partial U^*/\partial s$ and $\partial U^*/\partial t_c$, respectively, $U'(X_j) = \partial U/\partial X_s$, and $U'(t_c) = \partial U/\partial t_c$. The variables w_i, w_l and f_i were defined in Part A above. The set of sufficient conditions in this case requires that

$$U_{ss}^* = (1-p)U''(X_b)(w_i - w_l)^2(t_o - t_c^*)^2 \\ + pU''(X_a)(w_i - f_i - w_l)^2(t_o - t_c^*)^2 + (1-p)U'(X_b)\left(\frac{dw_i}{dt_i} + \frac{dw_l}{dt_l}\right)(t_o - t_c^*) \\ + pU'(X_a)\left(\frac{dw_i}{dt_i} - \frac{df_i}{dt_i} + \frac{dw_l}{dt_l}\right)(t_o - t_c^*) < 0, \quad \text{(A.23)}$$

$$U_{tt}^* = U''(t_c) - (1-p)U''(X_b)[w_i s^* + w_l(1-s^*)]^2 \\ - pU''(X_a)[(w_i - f_i)s^* + w_l(1-s^*)]^2 \\ + (1-p)U'(X_b)\left[\frac{dw_i}{dt_i}(s^*)^2 + \frac{dw_l}{dt_l}(1-s^*)^2\right] \\ + pU'(X_a)\left[\left(\frac{dw_i}{dt_i} - \frac{df_i}{dt_i}\right)(s^*)^2 + \frac{dw_l}{dt_l}(1-s^*)^2\right] < 0, \quad \text{(A.24)}$$

and

$$U_{ss}^* U_{tt}^* - (U_{st}^*)^2 > 0. \quad \text{(A.25)}$$

Clearly, values of s^* and t_c^* that satisfy equations (A.23) and (A.24) also satisfy equation (A.25) since, by assumption, $U_{st}^* = \partial U^*/\partial s \partial t_c = 0$.

Consider, now, the effects of an exogenous increase in p on s^* and t_c^* with w_i, f_i, w_l and W' held constant. These effects are summarized in equations (A.26) and (A.27) as follows:

$$\frac{\partial s^*}{\partial p} = \frac{1}{U_{ss}^*}\left\{(t_o - t_c^*)[U'(X_b)(w_i - w_l) - U'(X_a)(w_i - f_i - w_l)]\right\} = \frac{(+)+(+)}{(-)} < 0, \quad \text{(A.26)}$$

and

$$\frac{\partial t_c^*}{\partial p} = \frac{1}{U_{tt}^*}\left\{-U'(X_b)[w_i s^* + w_l(1-s^*)] + U'(X_a)[(w_i - f_i)s^* + w_l(1-s^*)]\right\} \\ = \frac{(-)+(-)}{(-)} > 0, \quad \text{(A.27)}$$

provided that $(w_i - f_i)s + w_l(1-s) < 0$. The latter condition requires that the punishment imposed on the offender exceed his current income from both legitimate and illegitimate activity, which is likely to be satisfied in the case of most felonies. This analysis shows that an increase in p increases t_c^* and decreases s^*. Thus, it decreases unambiguously the absolute amount of time spent in illegitimate activities.

Similarly, the effects of an exogenous increase in all the penalty rates dF_i/dt_i, hence in the average penalty f, on s^* and t_c^*, with p, w_i, w_l, and W' held constant, are given by

$$\frac{\partial s^*}{\partial f} = \frac{1}{U_{ss}^*}[pU'(X_a)(t_o - t_c^*) + pU''(X_a)(w_i - f_i - w_l)s^*(t_o - t_c^*)^2]$$
$$= \frac{(+) + (+)}{(-)} < 0, \text{ if } U'' \leqslant 0, \quad \text{(A.28)}$$

and

$$\frac{\partial t_c^*}{\partial f} = \frac{1}{U_{tt}^*}\Big\{- pU'(X_a)s^* - pU''(X_a)[(w_i - f_i)s^*$$
$$+ w_l(1 - s^*)]s^*(t_o - t_c^*)\Big\} = \frac{(-) + (-)}{(-)} > 0 \text{ if } U'' \leqslant 0. \quad \text{(A.29)}$$

Furthermore, the effect of a 1 per cent increase in p on t_c^* can be easily shown to exceed that of a 1 per cent increase in f if a person were a risk avoider, with the converse holding for a person who was a risk preferrer. Formally, by equations (A.27) and (A.29),

$$\frac{\partial t_c^*}{\partial p}p = \frac{1}{U_{tt}^*}\Big\{- pU'(X_a)f_i s^* + p[U'(X_a) - U'(X_b)][w_i s^*$$
$$+ w_l(1 - s^*)]\Big\} \gtrless \frac{\partial t_c^*}{\partial f}f = \frac{1}{U_{tt}^*}\Big\{- pU'(X_a)f_i s^*$$
$$- pU''(X_a)[(w_i - f_i)s^* + w_l(1 - s^*)]s^*(t_o - t_c^*)f_i\Big\} \text{ as } U'' \gtrless 0. \quad \text{(A.30)}$$

The theorem summarized in equation (A.29) has already been shown in equation (1.10) in footnote 13 to hold unambiguously in reference to the relative effects of equal percentage changes in p_i and f_i on the relative allocation of working time between i and l, indicated by s^*. Thus, under the assumptions imposed in this analysis, equation (1.10) in footnote 13 holds in reference to the effects of p and f (or f_i) on the absolute as well as the relative allocation of time to i and l.

APPENDIX 2 TO SECTION I: CRIME AND SELF-PROTECTION

The maximization of equation (A.2) in Appendix 1 has been carried out on the assumption that both the probability and severity of punishment are independent of an offender's actions. This assumption is not always true; for example, an offender can reduce the probability of being apprehended and punished by spending resources on "covering" his illegal activity, by fixing policemen and witnesses, by disposing of stolen goods through selected fences, or, in general, by providing self-protection. An explicit analysis of self-protection may be useful primarily because decisions concerning participation in illegal activity are generally influenced by the extent to which the former is provided; some behavioral implications should therefore be developed within the context of a more comprehensive decision problem.

Assuming for simplicity that expenditure on self-protection only affects the probability of apprehension and conviction, and that self-protection does not involve the use of an offender's time, we may write

$$p = p(r, s), \tag{B.1}$$

where r is public expenditure on law enforcement and s is an offender's total expenditure on self-protection, with $\partial p/\partial r > 0$ and $\partial p/\partial s = p'(s) \leq 0$.

Given the value of time spent in nonmarket activities, t_c, and the value of r, equation (A.2) can be written as a function of t_i and s:

$$U^* = [1 - p(s)]U[X_b(t_i) - s] + p(s)U[X_a(t_i) - s]. \tag{B.2}$$

The values of t_i and s that maximize this function in the case of an interior solution must satisfy the first-order conditions

$$U^*_{t_i} = (1 - p)U'_b(w_i - w_l) + pU'_a(w_i - w_l - f_i) = 0, \tag{B.3}$$

and

$$U^*_s = -p'(s)[U_b - U_a] - (1 - p)U'_b - pU'_a = 0. \tag{B.4}$$

The second-order conditions are

$$U^*_{t_it_i} = (1 - p)U''_b(w_i - w_l)^2 + pU''_a(w_i - w_l - f_i)^2$$
$$+ (1 - p)U'_b\left(\frac{dw_i}{dt_i} - \frac{dw_l}{dt_l}\right) + pU'_a\left(\frac{dw_i}{dt_i} - \frac{df_i}{dt_i} + \frac{dw_l}{dt_l}\right) < 0, \tag{B.5}$$

$$U^*_{ss} = -p''(s)(U_b - U_a) + 2p'(s)(U'_b - U'_a) + (1 - p)U''_b + pU''_a < 0, \tag{B.6}$$

and

$$\Sigma = U^*_{t_it_i}U^*_{ss} - (U^*_{t_is})^2 > 0, \tag{B.7}$$

which are assumed to be satisfied regardless of the sign of U''.[65]

Equation (B.4) implies that the incentive to provide self-protection is related to the level of participation in i, for the marginal gain from self-protection, given

65. A more detailed discussion of these optimality conditions and other related issues can be found in Ehrlich and Becker (1972) in reference to the joint determination of self-insurance and self-protection.

by $-p'(s)(U_b - U_a)$, is a positive function of the difference between income in different states, which is positive if $t_i > 0$. Moreover, an exogenous increase in t_i is expected to increase the amount spent on self-protection because its main effect is to widen the differences between income in different states:

$$\frac{ds}{dt_i} = \frac{-U^*_{st_i}}{U^*_{ss}} = \frac{(-)}{(-)} > 0, \tag{B.8}$$

where

$$U^*_{st_i} = -p'(s)[U'_b(w_i - w_l) - U'_a(w_i - w_l - f_i)] - (1-p)U''_b(w_i - w_l) - pU''_a(w_i - w_l - f_i) > 0,$$

provided that U'' and U' do not have opposite signs if $U'' \leqslant 0$, and that they do not have the same signs if $U'' > 0$.[66] This analysis provides an explanation for the fact that professional criminals—those who engage in crime on a relatively full-time basis—also tend to exercise more self-protection relative to other offenders[67] (see PCL, 1967(b), p. 97). Furthermore, it predicts that the proportion of professional offenders (and, generally, those who are relatively efficient in providing self-protection due to age, experience, or appropriate training) among those arrested and convicted of crime would understate their share in the total number of crimes committed.

Since self-protection and illegitimate activity are generally seen to be complements, the direction of the effect of changes in exogenous factors on the extent of participation in crime when self-protection is available would be the same as that predicted in the absence of such protection only if the direct effects of these changes on t_i and s are not in opposite directions, but might be different otherwise. For example, an increase in expenditure on law enforcement—f_i, w_i, w_l, $\bar{W}'$, and $p'(s)$[68] held constant—would reduce the optimal values of both t_i and

66. Note that by equation (B.3): $(1-p)(w_i - w_l) \gtreqless -p(w_i - w_l - f_i)$; i.e., $E(w_i) \gtreqless w_l$ as $U'' \lesseqgtr 0$, respectively.

67. Given the value of s, if p were positively related to t_i equation (B.3) would become (A.17) and equation (B.6) would become (A.18). U_{st_i} would then have a positive sign if in addition to the assumptions made above $\partial p'(s)/\partial t_i \geqslant 0$, i.e., the marginal productivity of a given expenditure on self-protection does not increase with more offenses committed within a given period. The results discussed in reference to equations (B.9) to (B.12) can then be shown to hold in this more general case as well.

68. If part of the increased expenditure on law enforcement is directed to combating collaboration of law-enforcement agents with offenders and other means of self-protection employed by offenders, then

$$-A_2 = -\frac{\partial p'(s)}{\partial r}[U_b - U_a] + [U'_b - U'_a]\frac{\partial p}{\partial r},$$

where $-\partial p'(s)/\partial r < 0$ and $-A_2$ is defined following equation (B.10) below. In this case $-A_2$ has a negative sign even if $U'' = 0$; the incentive to exercise self-protection would be smaller and, consequently, the decrease in t_i would be greater.

s, provided that $U'' \leq 0$, since then

$$\frac{dt_i}{dr} = \frac{A_1 U^*_{ss} - A_2 U^*_{st_i}}{\Sigma} = \frac{(-)}{(+)} < 0, \tag{B.9}$$

and

$$\frac{ds}{dr} = \frac{A_2 U^*_{t_i t_i} - A_1 U^*_{st_i}}{\Sigma} \leq 0, \tag{B.10}$$

where

$$-A_1 = -[U_b'(w_i - w_l) - U_a'(w_i - w_l - f_i)] \frac{\partial p}{\partial r} < 0,$$

and

$$-A_2 = [U_b' - U_a'] \frac{\partial p}{\partial r} \leq 0 \text{ if } U'' \leq 0.$$

In contrast, an exogenous increase in the severity of punishment on the optimal values of t_i and s, with $p'(s)$, r, w_i, w_l, and W' held constant, and with $U'' \leq 0$, is generally ambiguous:

$$\frac{dt_i}{df} = \frac{B_1 U^*_{ss} - B_2 U^*_{st_i}}{\Sigma}, \tag{B.11}$$

and

$$\frac{ds}{df} = \frac{B_2 U^*_{t_i t_i} - B_1 U^*_{st_i}}{\Sigma}, \tag{B.12}$$

where

$$-B_1 = -pU_a' - pU_a'' t_i(w_i - w_l - f_i) < 0 \text{ if } U'' \leq 0,$$

while

$$-B_2 = -p'(s)U_a' t_i + pU_a'' t_i > 0 \text{ if } U'' \geq 0.$$

The direct effect of an increase in punishment on the incentive to self-protect would be positive if $U'' = 0$ and may be positive even if $U'' < 0$, provided U was not too concave. This effect would at least partly offset the deterrent effect on t_i. Therefore, the observation that efforts to apprehend and convict offenders have a greater deterrent effect on some offenders relative to an increase in the severity of punishment may be explained simply by the interaction between self-protection and crime, and may be consistent with neutral (or even negative) attitudes toward risk.[69]

In analogy to the incentive offenders have to self-protect against the hazard

69. Note that the results derived in Appendix 1 to Section I (as well as in the text) regarding the relative deterrent effect of the probability and the severity of punishment refer to the partial effect of p and f when either alone changes. The analysis above is concerned with the effect of a change in f when r, not p, is held constant. It does not affect, therefore, the results summarized in equation (A.8) in Appendix 1 to Section II, and in equation (1.10) in footnote 13 in the text, or the corresponding hypotheses tested in the empirical investigation.

of apprehension and punishment, potential victims of crime have an incentive to self-protect against the hazard of becoming victims to crime. For example, the probability of becoming a victim to burglary or robbery can be reduced by installing security locks and burglar alarm systems, or by keeping watchdogs; that of becoming a victim to assault or rape can be lowered by using appropriate means of transportation and escorts when traveling at certain locations and hours. Another option available to individuals is to reduce the potential size of their losses if victimized (self-insurance), for example, the loss from a house burglary can be reduced by keeping money in saving accounts and valuables in safe deposit boxes. Since the formal analysis of these methods of shifting risks is virtually identical to that presented in Ehrlich and Becker (1972) the interested reader is referred to this source for a detailed discussion of the behavioral implications. An example of aggregate self-protection by potential victims through law enforcement activity is discussed in Section IV, C, of this paper.

APPENDIX 1 TO SECTION III: THE EMPIRICAL COUNTERPARTS OF OUR THEORETICAL CONSTRUCTS

The empirical counterparts of our constructs can be itemized as follows:

1. $(Q/N)_i$, the crime rate of a specific crime category, is measured as the number of offenses known to the police to have occurred in a given year per 100,000 (state) population. Statistics of offenses known are based on a count of complaints of crimes filed with the police by victims and other sources and subsequently substantiated. Since reporting a crime is time consuming and may involve psychic and other disadvantages, an underreporting of crime is expected, especially in the case of milder offenses where the various costs of reporting may exceed its benefits (the potential recovery of stolen property, the collection of insurance benefits, or vengeance).[70] If relative underreporting of specific crimes did not differ systematically across states and percentage reporting errors were random, the relative variation in the rate of offenses known would serve as an unbiased approximation to that of the true crime rate (see Appendix 1 to Section IV).

2. P_i, an average offender's subjective probability that he will be apprehended and punished for his engagement in a specific crime category in a given year, may be approximated by the objective probability that a single offense will be cleared by the conviction of an offender.[71] At present, no judicial statistics on

70. Evidence consistent with this argument is presented in PCL, 1967(b), pp. 18, 19.

71. If the probability that an offender will be apprehended and convicted of his criminal activity in a given year were independent of the amount of time he devoted to illegal activity, as our model has assumed for simplicity, an objective measure of P would be the ratio of the number of offenders convicted, C', to the number of active offenders in the same year, or $P_i = (C'/\theta)_i$. This ratio would be the same as the ratio of offenses cleared by conviction to the total number of offenses committed, or K/Q, if those convicted committed the same number of offenses per period, ζ, as other offenders in the same state, or $(K/Q) = (\zeta C'/\zeta\theta)$.

the number of convictions are available on a statewide basis. Instead, we have computed the ratio of the number of commitments to state (and in the case of auto theft also federal) prisons in a given state to the number of offenses known to have occurred in the same year, $(C/Q)_i$.[72] Of course, not all those convicted are committed to prisons; some (especially young offenders) are sent to correctional institutions or released on probation. To the extent that the proportion of such convicted offenders did not differ systematically across states, the relative variation in $(C/Q)_i$ could serve as an efficient approximation to that in P_i.

It is possible that a purely statistical exaggeration of the expected negative sign of the regression coefficient associated with $(C/Q)_i$ in equation (4.1), b_{1i}, would result from spurious correlation. Recall that the dependent variable is $(Q/N)_i$. If Q_i were not measured appropriately, the errors in the numerator of the dependent variable and in the denominator of the probability measure would move in the same direction. This spurious correlation would bias b_{1i} to a higher (absolute) value if and only if the absolute value of the true regression coefficient were lower than unity (a proof is given in Appendix 1 to Section IV).[73] A spurious correlation may also exist in an opposite direction, however, for if the recovery of stolen merchandise or vengeance played an important role in determining the reporting of an offense, or if the fraction of reported offenses were positively related to law enforcement activity, a low probability of apprehending and convicting offenders would be associated with a low rate of *reported* crimes, thus biasing the correlation between $(Q/N)_i$ and $(C/Q)_i$ toward a positive value. A similar argument can be made regarding the correlation between the severity of punishment and reported crime.

3. F_i, the average cost of punishment for a specific crime category, is measured by the average time actually served by offenders in state prisons for that crime before their first release, T_i. As with our measure of P_i, if the relative variation in T_i also reflected the relative variation in the severity of other punitive measures imposed for the same crime, and if, in addition, current values of T_i in different states indicate effectively the long-run levels of these variables, as forecast by potential offenders in those states, then T_i would serve as an efficient indicator of F_i. Note, however, that T_i is not proportionately related to F_i. For example, the opportunity costs of imprisonment, F', which may be assumed to be proportionally related to the total cost of punishment, would be measured under a continuous discounting process as $F' = \int_0^T \omega e^{-rt}\, dt$, where ω denotes an average prisoner's (constant) foregone value of time per period of imprisonment and r is the relevant discount rate. The elasticity of crime rates with respect to T, σ_{kT}, can therefore be expected to be consistently lower than that with

72. Data for both this and the following variable, T_i, are collected from the National Prisoner Statistics. These variables were first used by Smigel-Leibowitz (1965).

73. If the number of offenses committed by the average offender, ζ, were positively related to the crime rate, then our probability measure C/Q would underestimate the relative level of the true probability in states with higher crime rates. This might inject a further negative bias on the regression estimates of b_1.

respect to F, σ_{kF}, the difference being particularly significant in the case of crimes punishable by long imprisonment terms.[74]

4. As indicators of differential returns in property crimes we use W and X (see the discussion in Sec. III, B).

5. U, the average probability of unemployment in legitimate activities in a given year, is measured by census estimates of yearly unemployment rates in the civilian labor force. The variation in unemployment rates may not fully capture the variation in the average unemployment duration across states, for which data were not available in our sample years, and thus it may not reflect the true variation in the relevant probability of unemployment with sufficient accuracy. One way to minimize potential biases is by narrowing the base of the unemployment index to apply to relatively homogeneous groups of labor-force participants. Alternative estimates used have been the unemployment rate of urban males in the age group 14–24, U_{14-24}, and 35–39, U_{35-39}. Another way is by introducing census estimates of labor-force participation rates jointly with unemployment rates. We have actually used the labor-force participation rate of civilian urban males in the age group 14–24, L_{14-24}.

6. E/N, the per capita amount of resources allocated to law-enforcement activity in a given year, is measured as the per capita yearly expenditure on police activity by state and local governments (collected from *Governmental Finances in 1960*). Data on expenditures on courts by local governments, which bear the bulk of these expenditures, are not available on a statewide basis. To the extent that the proportion of total expenditure on direct law enforcement devoted to courts did not differ systematically across states (the production functions (3.3) were homogeneous with respect to police and court activity[75] and the ratio of factor costs were constant), and if, in addition, the absolute prices of the relevant factors were constant, the relative variation in our measure of E/N would approximate its true variation. However, the absence of data on private expenditure on self-protection might bias our estimates of equation (3.3) if the former had a direct effect on apprehending and convicting offenders and were not related proportionally to the per capita expenditure on police. To some extent,

74. Assuming that losses due to the criminal record effect and other disadvantages of punishment for crime are proportionally related to F', it is easily shown that $(d \ln F)/(d \ln T) = (rTe^{-rT})/(1 - e^{-rT}) = \lambda < 1$. This implies that the coefficient b_{1i} in eqq. (4.1) and (4.3) is lower than b_{1i} in eq. (3.2) by a constant proportion, λ. Clearly, λ tends to zero as T tends to infinity. Another difficulty with the use of T is that it measures the average penalty per offender, not per offense. To the extent that the number of offenses committed by the average offender was positively related to the crime rate across states, estimates of b_2 might be biased toward positive values.

75. By definition, the probability of apprehension and conviction is $P \equiv P_a \cdot P_{c|a}$, where P_a is the probability of apprehension and $P_{c|a}$ is the conditional probability of conviction, given apprehension. If $P_a = g(E'_p)$ and $P_{c|a} = h(E'_c)$ were homogeneous with respect to real per capita expenditure on police (E'_p) and courts (E'_c), so would P be with respect to both.

we may have accounted for the variation in private self-protection by the variation in the schooling level of the adult population across states, *Ed*. The latter can be shown to be positively related to optimal expenditures on the former (see Ehrlich and Becker, 1972).

7. The percentage of young males aged 14–24, A_{14-24}, and the percentage of nonwhites in the population, NW, are introduced in the regression analysis to account for variations in the demographic composition of the population. One reason for standardizing the observations for age and racial composition is to increase the efficiency of our estimators of probability and severity of punishment. For example, there is likely to be a positive correlation between the age of offenders and the use of punitive methods other than imprisonment across states. In addition, since the variation in differential returns from criminal activities is only indirectly accounted for in the regression analysis via X and W, the effect of both A_{14-24} and NW may partly reflect the effect of such differential returns, or a lower opportunity cost of imprisonment, for the legitimate employment opportunities of young age groups and nonwhites are well below the average, whereas their returns from illegitimate activity may not be significantly different. (For a more detailed discussion of schooling, age, race, and crime, see Ehrlich, NBER and Carnegie Commission on Higher Education (1974).) Given P and T, both NW and A_{14-24} may thus be positively related to all crime rates. Other demographic variables used in some of the cross-state regressions are listed in Table 1.

APPENDIX 1 TO SECTION IV: ANALYSIS OF MEASUREMENT ERRORS

This discussion analyzes the impact of errors of measurement in the crime rates and the probabilities of apprehension and conviction on the least-squares estimates of the coefficients of the supply of offenses function. We start with the simple stochastic equation:

$$\left(\frac{Q^o}{N}\right)_i = A_{oi}\left(\frac{C^o}{Q^o}\right)_i^{\beta_i} e^{\epsilon_i}, \tag{C.1}$$

where Q_i^o denotes the true number of offenders engaged in crime category i (the latter subscript will henceforth be omitted), C^o is the number of offenders convicted of such crimes, N is the state population, A_o is a constant term, e is the base of natural logarithms, and ϵ is a stochastic variable, independently and identically distributed, with a zero mean and a constant variance. Equation (C.1), thus, relates the crime rate to the probability of apprehension and conviction.

If the number of reported offenses, Q, and the number of convicts entering state prisons, C, were related to Q^o and C^o by

$$Q = Q^o(1-g)e^{w}, \tag{C.2}$$

and

$$C = C^o(1 - d)e^{\mu}, \tag{C.3}$$

where g and d are constants and w and μ are measurement errors, each a random variable independently and identically distributed, with a zero mean and a constant variance, then (C.1) could be written in terms of Q and C as

$$\left(\frac{Q}{(1 - g)e^{w}N}\right) = A_o \left(\frac{C(1 - g)e^{w}}{Q(1 - d)e^{\mu}}\right)^{\beta} e^{\epsilon}. \tag{C.4}$$

The regression model would thus be

$$(q - n) = \alpha_o + \ln (1 - g)(1 + \beta) - \ln (1 - d)\beta + \beta(c - q) + [\epsilon + (1 + \beta)w - \beta\mu], \tag{C.5}$$

where q, n, c, and α_o are the natural logarithms of Q, N, C, and A_o, respectively, and $\alpha_1 = \ln (1 - g)(1 + \beta) - \ln (1 - d)\beta$ is an additional constant term.[76]

The least-squares estimates of (C.5) are both biased and inconsistent. Note, first, that

$$\operatorname*{plim}_{N\to\infty} (\hat{b} - \beta) = \text{var } (c - q)^{-1} \text{ cov } [(c - q), (\epsilon + (1 + \beta)w - \beta\mu)] \tag{C.6}$$

is not zero. Specifically, if ϵ, w, μ, q^o, and c^o were mutually uncorrelated, (C.6) would equal

$$\operatorname*{plim}_{N\to\infty} (\hat{b} - \beta) = -\text{var } (c - q)^{-1}[(1 + \beta) \text{ var } (w) + \beta \text{ var } (\mu)]. \tag{C.7}$$

The direction of bias in $\hat{b}$ cannot be determined unambiguously, however, without making specific assumptions regarding the value of β and the relative magnitudes of var (w) and var (μ). If var (μ) were zero, (C.7) would imply that

$$\begin{aligned} &\text{plim } \hat{b} < \beta \text{ if } \beta \geqslant 0, \\ &\text{plim } \hat{b} \leqslant \beta \text{ if } 0 > \beta \geqslant -1, \\ &\text{plim } \hat{b} > \beta \text{ if } 0 > \beta < -1. \end{aligned} \tag{C.8}$$

Put differently, the absolute magnitude of the regression coefficient $\hat{b}$ is likely to be biased upward if the absolute value of β were lower than unity, and downward if the latter were greater than unity (provided that $\beta < 0$). In general, var (μ), hence the second term on the right-hand side of (C.7), are positive. Consequently, plim $\hat{b}$ may be smaller than β in absolute value, even if $\beta \geqslant -1$. Moreover, since (C.7) is a weighted average of var (w) and var (μ), the weights being $(1 + \beta)$ and β, respectively, the importance of var (μ) in determining the direction of bias in $\hat{b}$ would increase as the value of β was closer to -1.

Finally, the direction of bias in $\hat{b}$ also determines the direction of bias in the

76. Note that if $\beta > -1$, a_1 would be negative in sign, since g and d are, in general, lower than 1.

least-squares estimate of the intercept $\alpha = \alpha_0 + \alpha_1$, since $\operatorname{plim}_{N \to \infty} \hat{\alpha} = \alpha + (\beta - \operatorname{plim} \hat{b})E(c - q)$.

Errors of measurement in Q/N and C/Q affect not only α and β in (C.5), but, in general, all the regression coefficients in the multiple regression regarding the supply-of-offenses function. To evaluate these effects, the foregoing discussion may be generalized following a model developed by Lindley and applied for a similar problem by Chow (1957). Let y^o be a vector $(N \times 1)$ of the natural logarithms of the true crime rates $(q^o - n)$ and let $X^o = [x_1^o, x_2^o, \ldots, x_k^o]$ be a matrix $(N \times p)$ of p predetermined variables of which x_k^o designates the true probability of apprehension and punishment $(c^o - q^o)$. It is assumed that the regression of y^o on all the x^o's is linear, that is,

$$y^o = X^o\beta + \epsilon. \tag{C.9}$$

Hence

$$\operatorname{cov}(X^o)\beta = \operatorname{cov}(X^o, y^o), \tag{C.10}$$

where $\operatorname{cov}(X^o)$ designates the variance-covariance matrix of X^o in the population. If y^o and X^o were related to their measured values by

$$y = y^o + w, \tag{C.11}$$

and

$$X = X^o + U \tag{C.12}$$

where w and U are an $(n \times 1)$ vector and an $(n \times p)$ matrix of measurement errors, respectively, and if all errors of measurement were random variables, independently and identically distributed, independent of y^o and all the X^o's and normally distributed, Lindley shows that the regression of y on the X's would be linear provided that the latter have a multivariate normal distribution. In this case, therefore,

$$\operatorname{cov}(X)b = \operatorname{cov}(X, y), \tag{C.13}$$

where

$$b = \operatorname{plim}_{N \to \infty} \hat{b}.$$

Substituting for the x^o's and the y^o their values from (C.11) and (C.12) equation (C.10) becomes

$$\operatorname{cov}(X - U)\beta = \operatorname{cov}[(X - U), (y - w)]. \tag{C.14}$$

Since $\operatorname{cov}(XU) = \operatorname{cov}(U)$, and using equation (C.13), (C.14) reduces to

$$\operatorname{cov}(X)(b - \beta) = -[\operatorname{cov}(U)\beta - \operatorname{cov}(U, w)], \tag{C.15}$$

or

$$b - \beta = -\operatorname{cov}(X)^{-1}[\operatorname{cov}(U)\beta - \operatorname{cov}(U, w)]. \tag{C.16}$$

Henceforth, the analysis is a straightforward application of Chow's development (op. cit.). Assuming that only $x_k = (c - q)$ was subject to a measurement error: $e = (\mu - w)$, and denoting cov $(e) = e^2 =$ cov (μ) + cov $(w) = \mu^2 + w^2$ it can be shown that

$$b_k - \beta_k = -\frac{w^2}{s^2 + e^2}(1 + \beta_k) - \frac{\mu^2}{s^2 + e^2}\beta_k, \tag{C.17}$$

and

$$b_{p(\neq k)} - \beta_p = d_{kp}\left[\frac{w^2}{s^2 + e^2}(1 + \beta_k) + \frac{\mu^2}{s^2 + e^2}\beta_k\right], \tag{C.18}$$

where d_{kp} is the partial regression coefficient of x_k on $x_{p(\neq k)}$ in the multiple regression of the former on all the other x_p's ($p \neq k$); ($s^2 + e^2$) is the variance of the residual term in the same regression; and s^2 is the variance of the residual term in the regression of x_k^0 on all the x_p's. Clearly, (C.17) has the same implications as (C.7). In addition (C.18) implies the following generalization: the least-squares estimates of the regression coefficients of variables other than x_k would be biased in the same direction as $\hat{b}_k$ if d_{kp} were *negative*, and in an opposite direction if d_{kp} were *positive*.[77]

APPENDIX 2 TO SECTION IV: DOES CRIME PAY?

Crime always pays, according to the assumption underlying our model, if the variety of all monetary and psychic costs and returns offenders derive from engaging in crime as well as their utility from assuming risk are taken into ac-

77. Simple least-squares estimates of d_{kp} associated with the basic explanatory variables in the supply of offenses functions in 1960 are shown below in Table A.1.

TABLE A.1
THE PROBABILITY OF IMPRISONMENT FOR VARIOUS FELONIES REGRESSED AGAINST SELECTED VARIABLES

Estimate of d_{kp} Associated with p				
k = Probability of Punishment for:	T_i	W	X	NW
Murder	−0.2468	−0.7297	−0.6373	−0.1532
Rape	−0.1818	−2.1461	−1.3940	−0.2800
Assault	−1.2165	−0.7502	0.5878	−0.4885
Robbery	−0.3715	−1.9805	−0.9631	−0.0997
Burglary	−1.0511	−1.5533	0.1415	0.0790
Larceny	−1.1913	−0.4920	2.2799	0.0324
Auto theft	−0.5098	0	2.1744	−0.0531

count, and if offenders act rationally. Since psychic costs and gains cannot be measured directly, one may attempt to measure the monetary costs and returns from a single offense in those crimes in which the payoff is measurable in monetary terms. Whether crime pays in the monetary sense alone, however, would, in general, depend on the importance of the monetary relative to the nonmonetary aspects of crime. In particular, if psychic costs and returns average out to a constant magnitude, equal for the property crimes considered in this discussion (auto theft is excluded in this analysis), the algebraic value of the net expected gain on a single offense at the margin would indicate the relative premium required by offenders in order to compensate themselves for assuming the risk involved in these crimes. An independent test for the offenders' attitudes toward risk may thus be obtained for the three property crimes considered (robbery, burglary, and larceny).

The expected net monetary return on a single crime against property is

$$E(w_i) = (1 - p)w_i + p[(1 - d)w_i - f],$$

or

$$E(w_i) = (1 - dp)w_i - pf,$$

where w_i, w_l and f_i are here defined to include monetary elements only, and d denotes the conditional probability that the stolen property would be recovered by the police if the offender were apprehended.

In the following calculations of the expected net monetary returns, w_i is measured by the average reported value of property stolen in a single offense type i.[78] The cost of conviction on a single offense is measured by the average disposable income foregone while serving an actual prison term T_i in state prisons in 1960. Disposable income is computed on the basis of the median income of males with eight years of schooling, net of the average income tax actually paid in 1960, with the data being corrected for the age and race of those sent to state prisons and for the likelihood of being unemployed in legitimate markets.[79] Finally, the expected cost of conviction is calculated as the product of the latter statistic and the probability of being punished by imprisonment

78. The relevant statistic should be the market value of stolen property in each crime category, which may be considerably lower than its reported value. No information is given in the UCR on the market value of stolen merchandise by type of crime. It is possible, however, that the discount rates charged by fences when purchasing stolen goods are approximately the same except for auto-theft, which is why auto-theft is excluded from property crimes whose expected net pecuniary returns are compared below.

79. The available information concerns income rather than earnings, although the latter statistic may be a more appropriate measure of market opportunity costs of incarceration. No attempt is made to measure the nonmarket opportunity costs of incarceration, the criminal record effect, or the value of direct benefits received during imprisonment, nor to discount the value of earnings foregone in relatively distant incarceration periods.

(approximated by $(C/Q)_i$), with the expected cost of other forms of punishment omitted.[80]

The results are presented in Table A.2.

TABLE A.2
PECUNIARY COSTS AND RETURNS ON CRIMES OF THEFT

Crime	Average Gross Return [a]	Average Expected Cost
Robbery	$256	$620
Burglary	183	102
Larceny	178 [b]	83

[a] Estimates of the conditional probability that stolen property would be recovered by the police, d_i, are not broken down by these specific crimes. UCR estimates of the percentage of stolen property recovered by the police range below 10 per cent for all goods except autos.

[b] Average gross return on larceny over and under $50 is only $74 in 1960. However, since the measures of the probability of imprisonment and the average time served in prisons for larceny (C/Q) may essentially relate to larceny over $50 (data on the number of larcenies relate to larcenies over $50 only, and offenders committed to prisons for larceny are presumably mainly those convicted of more serious larcenies), the average gross return on larceny over $50 has been estimated on the basis of data provided by the UCR for 1965.

80. The true expected cost of conviction is pf, where p is the probability of being convicted of an offense and f is the "average punishment" imposed in the case of conviction. Assuming that the various forms of punishment are mutually exclusive,

$$p = p_1 + p_2,$$

where p_1 is the probability of being punished by imprisonment and p_2 is the probability of being put under probation, released into parents' custody, and so on. Similarly,

$$f = \frac{p_1}{p} f_1 + \frac{p_2}{p} f_2,$$

where f_1, f_2 are the monetary losses associated with the two forms of punishment discussed. It follows that

$$pf = p_1 f_1 + p_2 f_2,$$

which is approximated by $p_1 f_1$ on the assumption that f_2 is small.

Even though expected cost of punishment $p_1 f_1$ in each class of offenses is computed for a single offender rather than for a single offense $p_1' f_1'$, these two measures may be approximately equal. Assume that each offender committed ζ offenses. Then the relevant probability and severity of punishment estimates may be, according to n. 71,

$$p_1' = \frac{\zeta C'}{Q}, \text{ and } f_1' = \frac{f_1}{\zeta},$$

assuming the actual punishment to the offender is proportional to the number of offenses committed. Thus,

$$p_1' f_1' = p_1 f_1.$$

The estimated probabilities of punishment employed in Table A.2 above are based on the ratio of commitments over the *reported* number of offenses. If these probabilities were calculated adjusting for the percentage of unreported crimes in each crime category according to estimates from the President's Commission on Law Enforcement and Administration of Justice (1967(a), p. 22), average expected costs would become:

TABLE A.3
REVISED ESTIMATES OF PECUNIARY COSTS AND RETURNS IN CRIMES OF THEFT

Crime	Average Gross Return	Average Expected Cost
Robbery	$256	$459
Burglary	183	71
Larceny	178	59

Given the estimates of costs and returns reported in Table A.3, the expected net gain in robbery appears negative, while the expected net gains in burglary and larceny appear positive. Clearly in view of serious omissions of various nonpecuniary costs and returns in our calculations the absolute values of these estimates are unreliable. However, if the same percentage errors applied to all specific estimates of costs and gains respectively, the *ranking* of the three property crimes investigated above might not be affected. By this ranking robbers appear to be risk preferrers *relative* to burglars and thieves.

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