THE EFFECTS OF THE CRIMINAL JUSTICE SYSTEM ON THE CONTROL OF CRIME: A QUANTITATIVE APPROACH*

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INTRODUCTION

Crime and its prevention has become a much debated issue. Claims and counter claims are made as to the real extent and the possibility of controlling crime.[1] Law makers are considering legislating heavier sentences, which raises questions about the role of prison sentences in crime prevention. Most discussions of crime and its prevention lack a way of generating quantitative estimates of what alternative policies would achieve and what they would cost. A recent paper by one of the authors (Avi-Itzhak and Shinnar, 1973) attempts to develop a mathematical model simple enough to make approximate quantitative estimates based on available statistical information. In this paper we try to simplify the model further and to present it in a way that will make it more accessible to the policy maker and social scientist. We also try to apply it to conditions in New York.

CRIME IN NEW YORK

Analyzing the statistical data about crime in New York City and State,[2] we were struck by two major changes which have occurred over the past few decades. The first is in the way crime

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1. See for example Clarke (1970), Wilson (1973), *Uniform Crime Reports*, Greenberg (1975), etc., Belkin, Blumstein and Glass (1972), etc.

2. Data on crime in New York State and City were obtained from the Uniform Crime Reports and the New York City Police *Statistical Reports*. Data on rates of conviction and commitments were obtained from Hughes (1971), and Reports of the New York State Department of Correction, and from the reports on Prison Statistics of the United States Department of Justice. (For a detailed listing see the list of references.) Data on convictions prior to 1950 were taken from New York City Police *Statistical Reports*.

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affects the average citizen. If the statistics[3] are correct, then twenty years ago the average city dweller had a rather small chance of being the victim of a violent crime. In contrast, at present crime rates, he has a very small chance to escape becoming such a victim. Table 1 gives the probability that a person

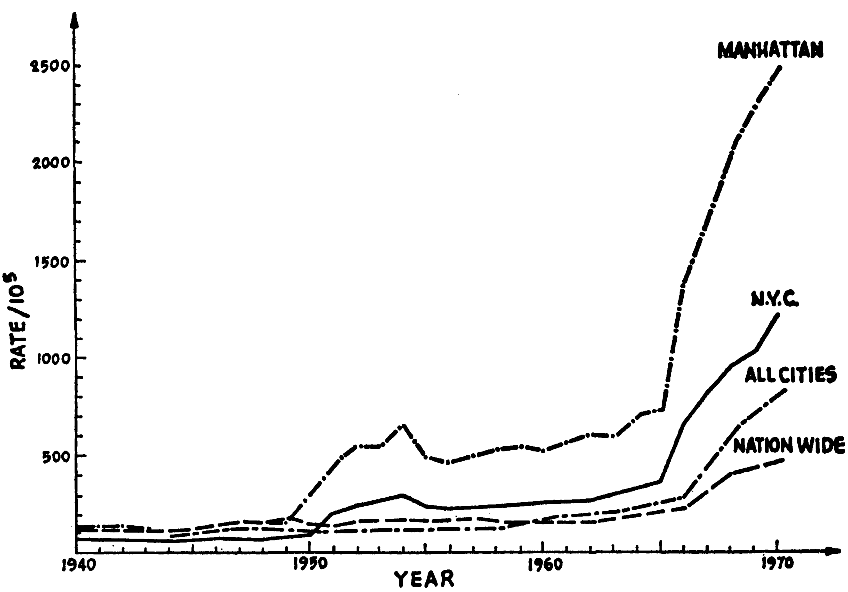
Table 1: Lifetime probability of being affected at least once, and expected number of times being affected during a lifetime, if the crime rate at the years given would have persisted for one's entire lifetime.*

	Violent Offenses: Murder, rape, robbery and assault						Safety Crimes:** Murder, rape, robbery, assault and burglary					
	Lifetime Probability			Expected No. of Times			Lifetime Probability			Expected No. of Times		
Place of Residence	1940	1960	1970	1940	1960	1970	1940	1960	1970	1940	1960	1970
Manhattan	.10	.30	.84	.10	.36	1.8	.14	.59	.99	.15	.89	4.84
Bronx	.03	.14	.57	.03	.15	.85	.05	.31	.91	.05	.38	2.36
Brooklyn	.03	.14	.52	.03	.15	.75	.05	.39	.89	.05	.50	2.21
Queens	.03	.08	.32	.03	.08	.39	.06	.22	.72	.06	.25	1.27
Richmond	.04	.05	.13	.04	.06	.14	.07	.22	.63	.07	.25	1.00

* See Footnote 2 for sources

** Avi-Itzhak (1973) introduced the concept of safety crime as the crimes that affect a person's safety. It includes violent crimes such as homicide, rape, felonious assault, robbery and, in addition, burglary. The latter is included as burglary with forced entry can lead to robbery or homicide if the owner is present. Car theft is excluded, as is larceny.

Figure 1. Violent Crime in the United States 1940-1970



3. There is considerable discussion in the literature as to how accurate crime rates based on police statistics really are. Claims are made that a major source of the increase is a change in either reporting methods or in the fraction of crimes reported to the police. One would not expect such reports to be very accurate but the changes

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living in one of the boroughs of New York City will be the victim of a crime at least once in his lifetime, if present crime rates continue unchanged during his entire life.[4] At the crime rates reported 20 or 10 years ago, an inhabitant of Brooklyn or even Manhattan had a 90% chance of never being the victim of a violent crime. Today this is only true for Staten Island, which is still suburban in character. Similar increases have also occurred in other American cities. In most of Western Europe, crime rates in major cities are still close to those in Staten Island. In Figure 1 the increase in the rate of violent crime in New York City is plotted in comparison with other cities and the United States.

The second major change over the last twenty years occurred in the criminal justice system.[5] The risk that a criminal runs in committing a crime has decreased by a full order of magnitude. One way of defining this risk quantitatively is as the average time a criminal can expect to spend in prison[6] per crime

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are so large that inaccuracies of 20 or 30% would be unimportant. Obviously, it is impossible to prove how much crime is unreported. But one could check claims of manipulation. When the rapid crime increase in the 1960's started in New York (see figure 1), Commissioner Leary declared in 1966 that that year's increase in crimes (60%) was mainly due to changes in reporting procedures introduced by him. We checked this claim by comparing the crime increase in that year to the crime rise in the following four years. (Both total increases in felonies as well as robbery data.) There was no statistical difference between those numbers. The increase in total robberies reported (New York City Police Annual Reports) was 14,610 for 1966, the year of the claim; 12,400 for 1967; 18,471 for 1968; 14,747 for 1969; and 14,950 for 1970. There is clearly no evidence for Mr. Leary's claim in the data, especially as Mr. Leary claimed that the change in reporting procedures was complete in 1966 and predicted a decrease in 1967. Biderman (1966) claimed that the FBI Crime Index is unreliable as the $50 lower limit on larceny is affected by inflation. However, if larceny is taken out of the crime index, the relative change will be the same. Seidman and Couzens (1974) claim that the police can and do manipulate larceny claims. Their data show, however, that such effects are small (20% or less) and the effect on overall crime reporting is negligible. In our study we are mainly concerned with violent crimes and burglary so that the larceny problem is unimportant.

4. If the crime rate per person is α, the probability of never being victimized during an average life of 70 years is $e^{-70\alpha}$. The probability of being a victim at least once is $1-e^{-70\alpha}$, and the average expectation of personal victimizations is 70α (see Avi-Itzhak 1973).

5. We use the term "criminal justice system" to denote the entire complex of institutions and people involved in dealing with crime and criminals. These include the police, the district attorney's office, the judiciary, the parole system and the prisons.

6. The term prison in our paper comprises all institutions in which a criminal is detained, such as prisons, reformatories, mental hospitals, etc. This same definition is used by the New York State Department of Correction. In the way we employ it here jails should also be included. Regretably, statistics on jails are not as accurately reported in detail as those for state institutions and are therefore neglected in our study. This underestimates the length of incapacitation due to each crime. As the relative ratio of jail to prison population has stayed fairly constant, the relative changes predicted by our statistics are correct. A more thorough discussion of this is presented later.

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committed. The average prison stay per reported crime for a given state can be easily measured by a simple balance.

$$\text{average time spent in prison per crime (in years)} = \frac{\text{total number of prisoners in prison}}{\text{total number of crimes reported per year}}$$

Strictly, this is true for a steady state condition only. But the average time spent in prison is less than three years and over three years the number of prisoners does not change that much. In Table 2, the average prison stay per reported crime is given for New York State for 1970 and 1960. We note that from 1960 to 1970 the average prison stay per crime decreased by a factor of six. Over the last thirty years it has decreased by a factor of ten. The length of prison terms has gone down somewhat.

Table 2: Probability of being convicted to jail and length of stay for New York State

	Symbol	Violent Crimes		Safety Crimes		All Felonies	
		1960	1970	1960	1970	1960	1970
Total Number of Crimes*		21,335	122,076	77,780	369,096	175,374	713,453
Number of prisoners committed by the court**		~2,000	~2,500	2,650	2,900	5,186	4,134
Number of persons in prison**		7,500	7,600	~10,000	~9,000	19,500	12,500
Chance of being sent to prison having committed a crime***	qJ	0.09	0.027	0.034	0.008	0.03	0.0058
Average time spent in in prison per crime committed (years)****	qJS	0.35	0.06	0.13	0.029	0.1	0.0175
Average time spent in prison having been committed (years)*****						2.16	1.8

* *Uniform Crime Reports* (1960, 1970; for total number of felonies we list index crimes which underestimates the number.

** New York State Department of Correction, *Characteristics of Inmates under Custody in New York institutions* 1962, 1973, also United States Department of Justice *National Prisoner Statistics* 1960, 1970 and 1972. Detailed statistics for such crimes are used. Only in the last column are our statistics somewhat approximate as we include all court commitments and prisoners. A fraction of these commitments is for misdemeanors, another is for non-index crimes. These estimates are therefore less reliable than those for specific crimes. There are also problems in using these statistics for individual crimes. The crime appearing in prison statistics is the crime stated in the court decision. Due to plea bargaining and other considerations, the reason for commitment may be different and less serious from the real crime committed (Hughes, 1971, J. McKenna, personal communication, 1974, Raab, 1975, Chambers, 1975). This does not affect our conclusion that a major change occurred.

*** Divide line 2 by line 1. This is an approximate estimate only as crimes committed in 1970 may result in a commitment in 1971. As crime rates and commitment rates did not change drastically from 1958-1961 and from 1969-1971, this still gives a good estimate.

**** Divide line 3 by line 1 (for a proof see Krambeck, Katz and Shinnar 1969).

***** New York State Department of Correction personal communication.

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However, the probability of a convicted criminal actually spending time in prison has been drastically reduced and this has profoundly altered the system.

The fact that the decrease in the risk involved in committing a crime parallels the increase in crime does not in itself prove any causal relation. One may, however, speculate that this decrease in prison stay per crime could, by improving the gain-risk ratio for the criminal, make crime more attractive, as was pointed out by Wilson (1973).

However, other aspects of the criminal justice system can be quantitatively analyzed, for example, the incapacitation of criminals due to prison stays. One of the characteristics of the present crime situation is the high rate of recidivism in certain types of crimes, such as mugging, burglary, and robbery. While imprisonment may have little corrective or deterrent effect upon some criminals, it does reduce the crime rate and protect society insofar as criminals cannot commit crimes while in prison and are thereby temporarily deactivated. It is thus to be expected that the rate of crime will strongly depend on the frequency and severity of sentencing even when the corrective and deterrent effects are discounted.

The goal of this paper is to present a quantitative model for the criminal system that elucidates the effect of sentencing rate and prison stay on the overall crime rate and yields quantitative predictions for policy decisions. The model is based on measurable statistical parameters, which are either available[7] or can be measured. These are:

a. The detailed crime rates as reported by the FBI.
b. The fraction of reported crimes which lead to a conviction (which will be called q).
c. Number of criminals committed to prison for each type of crime.
d. Total number of criminals in prison.
e. Their average stay in prison.
f. The fraction of criminals convicted who are first-time offenders.

We propose to show that one can obtain from these data reasonable estimates of the probable results of alternative judicial and legislative actions. As any simplified model, it is at best only an approximation. However, it yields estimates which are

7. See *Uniform Crime Reports* 1939-1970 and United States Department of Justice (1950, 1960, 1970, 1972).

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quite conservative and should provide a quantitative framework within which alternative policies can be compared.

A MODEL OF THE CRIMINAL JUSTICE SYSTEM

We shall now give a brief description of the model we use to predict the incapacitative function of prison sentences. A more detailed and rigorous description of the model and estimating procedures was given in a previous paper by one of the authors (Avi-Itzhak and Shinnar 1973). The assumptions of this model can be described as follows. Consider a criminal population of N criminals. N is considered here to be a constant in time, and an equal number of criminals enter and leave the system.[8] The average length of the criminal career is T, and individual career lengths are exponentially distributed (the fraction of criminals who stay criminals for a time exceeding t is $e^{-t/T}$).

We further assume that during his career a criminal commits crimes in accordance with a Poisson process with rate λ. This rate is uniform for all identified criminals and applies only during the time at which the criminal is free. The main function of prison in the model is to prevent the criminal from committing a crime by temporary incapacitation. Each time he commits a crime he may be arrested and convicted with a probability q, or he may continue undetected with a probabliity 1-q. If convicted he may be committed to prison[9] with a probability J. The probability of going to prison, having committed a crime, is therefore qJ. For each commitment he stays in prison for a time S. S is not the sentence length, but the total time he stays in prison for each conviction. S should therefore include pretrial detention. For each crime he is on the average detained for an average time qJS. If he is convicted of a crime A after having already committed crime B we attribute this conviction to the second crime.[10]

It is immediately apparent that this model contains some simplifications. We shall later discuss in detail how they affect the quality of our estimates. For the present we ask our readers

8. Similar approaches were also formulated by Belkin, Blumstein and Glass (1972) and Ehrlich (1973).

9. As the only function of prison in our model is incapacitation, all institutions such as reformatories, mental hospitals, jails, etc. are included in the term prison stay.

10. The reason for this decision is that in our model the effect of convicting and imprisoning a criminal is to keep him off the streets and prevent him from committing further crimes. Therefore we attribute his conviction to the last crime prior to it.

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to bear with us while we discuss the results of the model. The terms used in our derivation are defined in Table 3. We assume the number of criminals is unaffected by the crime policy. The number of crimes committed by each individual during his criminal career is x. If the criminal justice system does not intervene, the expected value of x is $E(x) = \lambda T$.

Table 3: Definition of Terms

x	=	the number of crimes a criminal commits
S	=	length of a sentence, exponentially distributed with mean S
D	=	number of convictions per criminal
D_J	=	number of times a criminal gets sent to jail
λ	=	crime rate per year per criminal (a constant)
T	=	average length of a criminal career
ϕ	=	expected number of convictions during a criminal career having been convicted once
q	=	probability of getting convicted, having committed a crime, before he commits the next crime
q_A	=	probability of getting arrested having committed a crime, before he commits his next crime
J	=	probability of being committed to jail having been convicted of a crime
J_A	=	probability of being committed, having been arrested for a crime
θ	=	the probability of surviving a sentence (i.e., the probability that after getting out he resumes criminal activities)
p	=	probability of never being convicted again = probability of never being convicted
p_J	=	probability of never being sent to jail again = probability of never being sent to jail
$\pi(t)$	=	probability that a convicted criminal is reconvicted within time t of his release
P(z)	=	probability of event z
E(z)	=	the expected value of the random variable z

If during his life the criminal is convicted of a crime and sent to jail then E(x) is reduced, as during his confinement he does not commit any crimes. His average crime rate is reduced from λ to the new value of E(x) divided by T. If the number of criminals N is constant then the total crime rate is just $N \bullet E(x)/T$. This reduced crime rate is proportional to the fraction of his criminal career that the criminal spends out of prison. Therefore, what we need is an estimate of the magnitude of the fraction. Before giving an exact formula let us first derive a simple estimate for a limiting case. Assume that his criminal career is long as compared to his average prison stay. The time a recidivist criminal spends out of prison is on the average $1/\lambda qJ$. In other words, it is inversely proportional to the frequency with which he commits crimes and the probability of being sentenced to prison having committed a crime. Each time he is sentenced to prison, he spends, on the average, a time S

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in prison. The expected fraction of the time he is free to commit crimes is therefore

$$\frac{\frac{1}{\lambda qJ}}{\frac{1}{\lambda qJ} + S} = \frac{\text{Average time between commitments}}{\text{Average time between commitments + average time in prison}} \quad (1)$$

This relation is essentially the basic relation we use in estimating the incapacitating function of prison. If there were no prisons (or the criminal is never caught) the total number of crimes committed by a criminal has an expected value of

$$E(x) = \lambda T = \text{(length of career)} \times \text{(number of crimes per year)}$$

If he is incapacitated during a fraction of his career, E(x) is reduced to

$$E(x) = \lambda T \bullet \text{(fraction of career spent out of prison)} \quad (2)$$

We should immediately note that the terms in equation (1), average time between commitments and average time in prison, are, at least in theory, directly measurable by looking at detailed records of individual careers and we could thus obtain comparisons between different periods and places or follow the effects of a change in policy.

Equation (1), the fraction of his career a criminal is active, is also the ratio of the number of crimes committed by him under a given policy,[11] to his expected number for zero incapacitation. This ratio can be written explicitly in terms of our model.

$$\frac{E(x) \text{ at a given } qJS}{E(x) \text{ of } qJS \text{ equal to zero}} = \frac{\lambda T/(1+\lambda qJS)}{\lambda T} = \frac{1}{1+\lambda qJS} \quad (3)$$

We can also express the effectiveness of the policy as the number of crimes that are prevented due to the criminal justice system. The effectiveness of crime prevention by incapacitation is then given by

$$\text{Effective reduction} = 1 - \frac{1}{1+\lambda qJS} \quad (4)$$

Equation (3) is only an approximation. We give in the appendix a derivation which is valued for any S and T and the exact expression is

$$E(x) = \frac{\lambda T}{1+\frac{\lambda qJST}{S+T}} \quad (5)$$

If data for q and J are unavailable we can also use q_A, the probability of being arrested for a crime, and J_A, the corresponding

11. By policy we do not necessarily mean a stated conscious behavior of an individual judge, district attorney, etc. but the overall behavior of the system.

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probability of going to prison, having been arrested. It is easy to show that qJS is equal to $q_A J_A S$.[12]

The main effect of incapacitation by prison stay is to make this time as small as possible. Therefore, it is not the length of the sentence that counts, but the actual time spent in prison. Under today's parole system the two are quite different. In Fig. 2 we plot the effectiveness of the policy as a function of qJS for different values of λ. In Fig. 2 we also give historical and present estimates for qJS in order to give the reader a feeling for what is involved. This suggests that safety crimes can be effectively reduced by incapacitation without excessive prison terms. Since qJ and S appear as a product, safety crimes can be prevented either by increasing q or by increasing S. However, for any such policy to be effective at all, J must be close to unity.

Assume that we are ready to accept an average S of three years. Then, if the time between arrests is half a year, incapacitation reduces the crime rate by a factor of seven. If the time is one and a half years, it is reduced by a factor of three. If S is five, the reduction is by a factor of ten in the first case and four in the second. We can also look at this in terms of equation 3. The factor by which crime can be reduced is $1 + \lambda$ qJS. Historically, the best value of qJ ever achieved for career crimes was 0.3. For a value of S of 3, the reduction is a function of λ. If λ is above 2 the possible reduction is again at least a factor of 3. We will later show that for some career crimes a value of $\lambda = 10$ is a more reasonable estimate, which allows a strong reduction.

We should point out here that we really don't know λ, but we can measure qJS rather accurately for each type or class of crime. It is simply the number of criminals confined in all prisons[13] for a specific crime divided by the number of crimes per year. We can also get estimates for λq, from which we estimate λ (see Appendix).

There is another interesting result we can deduce from equation 2. Assume we have an efficient criminal justice system that, by incapacitation, reduces crime by a factor of four. Let us now assume that the number of criminals increases by 30%, but for some reason (lack of space, etc.) we keep the total number of

12. In our experience, legal people have an aversion to using data based on arrests. But here we are not dealing with individual guilt, but with estimates of system parameters. Both $q_A J_A$ and qJ are just the overall probability that a crime will result in a commitment.

13. Including here jails, prisons, mental institutions, and other corrective institutions.

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prisoners constant. Each criminal previously spent 75% of his career in prison and 25% on the outside. We now have to reduce his prison stay by 30%. He will therefore spend only 0.7 x 0.75 = 0.525 of his career in prison and 0.475 of his career on the outside. The effective crime rate of each criminal has doubled (0.4775/0.25) and total crime rate has increased by a factor of $1.3 \times \frac{0.4775}{0.25} = 2.5$. An increase of 30% in the number of criminals has therefore increased effective crime rate by 150% or a factor of 2.5. This is a somewhat unexpected result of the model and shows how sensitive incapacitation effects are to changes in criminal justice system performances. In this case reduction of relative prison population by 30% decreases qJS by a factor of 2. A large increase in qJS can have a large effect on crime rate and a much smaller effect on prison population. On the other hand, if λqJS is small, increasing qJS will initially have significant effects on prison population. Having shown that incapacitation can have major effects on the overall crime rate we now examine the assumptions of our model that led to this conclusion.

ASSUMPTIONS OF THE MODEL

We assume that there is a class of criminals that has a high rate of recidivism, and that furthermore, this class is responsible for a high fraction of the total crimes committed. If the second assumption is not true our model could still predict the reduction of crimes for recidivists, but would not apply to the overall crime rate. We also assume that the number of criminals is not affected by criminal justice system performance, nor is the length of the criminal career. In other words, incapacitation has neither a deterrent nor a rehabilitative effect. We want to make clear that we neither claim that this is correct nor do we ourselves believe it. Deterrence may have a strong effect on the crime rate, affecting both the number of criminals entering careers as well as the length of their careers. Deterrence is hard to measure because the variables that affect it (Ehrlich 1973) are the same as those that affect incapacitation. Rehabilitation is hard to measure, and present studies indicate (Martenson 1972) that recent rehabilitation programs show very little effect compared to prison terms and as yet are not an effective tool.[14]

Our neglect of deterrence or rehabilitation involves certain

14. Rehabilitation, a much more desirable method, and incapacitation can be carried out at the same time and are not mutually exclusive.

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principles of modelling theory. We realize that in such a complex system, exact estimates are impossible. But for purposes of policy making, a lower bound on the effects of incapacitation could be very useful.[15] Deterrence and rehabilitation will decrease the number of criminals and/or reduce their individual crime rate and the length of their career. As long as we can assume that incapacitation does not increase these parameters, the prediction of our model will be conservative in the sense that the reduction in crime will be larger than predicted. Our model is therefore of limited use in predicting what would happen if we would close prisons, as advocated by Clarke (1975). It is more useful for estimating the contribution that reduction in prison sentences (Table 2) has made to the increase in crime rate.

The assumption that λ is uniform is also incorrect. We can, however, show by sensitivity analysis that our model will again give conservative results for any distribution of λ provided λ and q are not negatively correlated in a strong way. (In other words, there is no large group with a very high crime rate who are never caught.) We have already taken care of the fact that a large fraction of those entering a criminal career have a short career by assuming that career length is exponentially distributed.

There are, however, two assumptions which are problematic in terms of a conservative estimate. One is that prison has no criminogenic effect, or equivalently, that T and λ are not increased by prison stay.[16] Actually, we only assume that this increase in $N\lambda T$ due to prison stays is no larger than the decrease in $N\lambda T$ due to deterrence and rehabilitation (which affect both N and T). This assumption is not very crucial. We could separate first time offenders from repeaters and thereby reduce the impact of any possible criminogenic effects.[17] There is another assumption which *is* crucial to our predictions, which is not immediately obvious. In using the measured value of qJS and λq in equations 1 and 3, we made the implicit assumption that the average q for the criminal (or the chance of being convicted for a given crime) is equal to the fraction of crimes solved

15. Techniques using lower (or upper) bounds are common in operational research and engineering design (see, for example, Evangelista, 1967).

16. *Uniform Crime Reports* show no significant effects. There is a slight difference in recidivism between those given suspended sentences and those put into prison, but the two groups are not directly comparable as their crimes were different. This area needs further quantitative research.

17. We would also include criminogenic effects in our model if they were known.

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by conviction (see Avi-Itzhak and Shinnar, 1973). In other words, we attribute the majority of unsolved crimes to criminals who are convicted at least once. (The fraction of criminals in our model which are never convicted is $[1-e^{-qXT}]$. This is crucial. 70% of all safety crimes in the United States are never solved and in New York City this fraction is higher. If most crimes are committed by criminals who are never caught, then no incapacitative policy will work until there are means to catch them at least once. All the other assumptions can be checked by more accurate data and the model can be modified accordingly without too much trouble. It is the last assumption that we have to justify on the basis of available data. But in the end it can only be tested by measuring dynamic trends following increased use of incapacitation.

CHARACTERISTICS OF THE RECIDIVIST CRIMINAL

We outlined our assumptions in the previous section. We will now try to discuss them on the basis of the available literature. The first and most important assumption in our model was that most crimes are committed by recidivists. The evidence is rather convincing that most crimes that are solved by either arrest or conviction are committed by recidivists. One can arrive at this conclusion at several different ways, and it is backed by massive research.[18]

Let us translate this into quantitative terms. The best data on recidivism we have are those based on arrests. (Law enforcement agencies are required to report arrests involving fingerprinting to the FBI, but there is no required recording of disposition of the arrest.) Since prison sentences or other convictions may never be recorded in the convict's file, arrest records are the best personal data we have. This is regrettable for intuitively we hesitate to use arrest data. The literature is full of stories and anecdotal evidence of police overstating the offense during arrest or arresting repeaters without reason. This may be true in some cases, but here, unlike a court, we are not interested in certainty for a specific case, but rather in the reliability of the total population of such arrests. Fortunately, there

18. See *Uniform Crime Reports*, 1962-1970, Hughes (1971). Wolfgang (1972) and Bellein (1972). Also Select Committee on the Administration of Justice (1970). *Parole Board Reform in California*, Administrative Office of the United States Courts (1968), *Persons Under the Supervision of the Federal Probation System 1968* and Christensen (1967).

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are several very extensive studies investigating this problem,[19] each involving several thousand arrests. Both showed that above 90% of the arrests investigated were based on solid evidence, and the reasons charges were dismissed or reduced to misdemeanors were not related to the weight of the evidence but were extraneous (desire to reduce court loads, unwillingness of the witness to appear in court, etc.). Furthermore, depending on the nature of the crime, 65-80% of arrests lead to convictions related to the arrest. Even if we assume that only 70 or 80% of arrests are reliable, then this will not change the results on recidivism.

There are two ways one can perform a study on recidivism. One is to look at an instantaneous sample of arrested offenders. The second is to follow the career of a sample of offenders. The second method has the advantage that it is less affected by the unsteady nature of the system, but has the disadvantage that very long times are needed to provide reasonable accuracy. Both methods are used in the *Uniform Crime Reports* and can therefore be compared. Let us start with the first method. An important simple result given by Avi-Itzhak (1973) is that in any steady state system, the probability of recidivism for arrests is simply equal to the fraction of virgin arrests $P_V(A)$. Similarly, the probability of recidivism for convictions is equal to the fraction of virgin convictions, $P_V(C)$. This is independent of any model and just assumes steady state. The expected number of arrests during a criminal's life is just $\frac{1}{P_V(A)}$. The *Uniform Crime Reports* give these data for a large sample of federal offenders in 1970 (Table 4). We note that the probability of a virgin arrest is 0.316 for all crimes listed and 0.275 for robbery. The average number of arrests per criminal is slightly larger than $1/P_V(A)$, which is expected in a period of increasing crime rate (see Avi-Itzhak, 1973).

19. Feeny (1972) investigating robbery arrests in Oakland, and McKenna (1974 personal communication) on robbery and grand larceny in New York City.

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Table 4—Profile of Offenders Arrested During 1970*
[By last charge in 1970]

	Total	Murder	Aggravated assault	Rape	Robbery	Burglary	Larceny	Auto theft
Total number of subjects	37,884	271	1,746	186	2,273	1,410	3,509	2,592
Average age at last charge	29	29	31	24	24	24	29	26
Average age at first charge	24	23	25	20	20	20	24	21
Average criminal career	5	6	6	4	4	4	5	5
Average number of charges during criminal career	4	4	4	3	4	4	4	5
Frequency of charges (percent of total subjects):								
One	31.6	22.1	31.6	35.5	27.5	31.8	38.2	20.2
Two	19.8	20.3	23.8	21.5	22.1	22.2	19.8	17.3
Three	11.3	14.0	11.6	14.5	10.5	9.1	10.6	11.9
Four or more	37.3	43.6	33.0	28.5	39.9	36.9	31.4	50.6
Frequency of convictions (percent of total subjects):								
One	22.1	23.2	21.1	15.1	20.8	17.5	24.3	22.7
Two	10.3	12.5	9.6	7.0	9.9	7.7	8.5	12.9
Three	5.8	3.7	5.1	4.3	5.4	6.0	3.8	7.9
Four or more	12.5	10.7	9.7	3.8	12.3	11.1	10.0	20.6
Mobility (percent of persons rearrested):								
One State	45.5	40.8	52.6	55.8	55.4	53.8	57.5	24.6
Two States	32.8	41.7	34.8	28.3	28.5	29.2	27.1	37.2
Three States	11.8	10.9	7.4	11.7	9.5	9.2	8.4	17.9
Four or more States	9.9	6.6	5.2	4.2	6.6	7.8	7.0	20.3

Table 4 (continued)

	Forgery	Embezzlement	Fraud	Weapons	Narcotics	Gambling	Stolen property	All other offenses
Total number of subjects	1,706	1,187	1,411	2,166	5,131	867	1,519	11,910
Average age at last charge	29	30	35	31	26	45	30	31
Average age at first charge	23	28	29	25	22	35	24	25
Average criminal career	6	2	6	6	4	10	6	6
Average number of charges during criminal career	5	2	4	4	3	3	5	5
Frequency of charges (percent of total subjects):								
One	21.9	66.0	32.8	30.7	39.7	35.3	25.0	28.2
Two	18.1	17.5	19.4	23.0	21.1	21.1	20.1	18.2
Three	13.1	7.3	12.0	12.3	11.4	12.0	12.5	11.2
Four or more	46.9	9.2	35.8	34.0	27.8	31.6	42.4	42.4
Frequency of convictions (percent of total subjects):								
One	21.7	26.9	23.9	20.8	21.6	19.4	22.5	22.4
Two	12.0	5.1	10.1	10.8	8.0	6.5	10.1	12.3
Three	7.4	1.5	5.2	6.6	4.0	3.8	6.3	7.3
Four or more	18.2	1.5	10.6	8.7	6.2	5.3	13.0	16.8
Mobility (percent of persons rearrested):								
One State	49.0	63.8	43.2	50.7	48.4	62.7	47.9	39.0
Two States	29.0	25.3	33.3	33.7	37.0	28.2	30.9	33.7
Three States	11.3	6.7	11.9	9.7	10.5	6.8	10.6	14.3
Four or more States	10.7	4.2	11.6	5.9	4.1	2.3	10.6	13.0

* *Uniform Crime Reports* (1970) p. 38

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Table 5

Characteristics of Persons Arrested in New York City for Safety Crimes*

Crime	*Sample Size*	*Fraction of Arrests No previous felony arrest*
Homicide	513	35.3**
Robbery	3,106	14.0
Felonious Assault	1,994	50
Burglary	3,450	29.5

* From a study conducted by the New York City Police Department statistical division, January to June 1970, personal communication to the author (1973).

** Only 2% of all persons arrested had been previously arrested for homicide but 40% of all those arrested for homicide had previous arrests for a violent crime (30.5% for felonious assault).

In Table 5 we give the same fractions for New York City.[20] We note that these data predict a high recidivism for arrests. We can use the same type of statistics for courts. Both national and New York State prison statistics show the fraction of prisoners who had no previous commitment to any penal institution to be approximately 0.35, or a total lifetime recidivism rate of 0.65. As commitments to prison are not well recorded, 0.65 is a valuable lower bound on recidivism as measured by new convictions for prison parolees. Estimates based on following careers give very similar results.[21] Three to four year follow-up studies based on arrest give recidivism rates of 60-80% (*Uniform Crime Reports* and Select Committee on the Administration of Justice 1970).

In addition, we can compare these two techniques by computing $\pi(t)$, the chance that a recidivist will be rearrested within a given time t, by our model, and comparing this with the lifetime probability $\pi(T)$ using estimates for T and equation (7) or (8) in the appendix. We can also use the same techniques for data on recommitment or reconviction though here we have to be more careful. There is a long unknown timelag between arrest and conviction (or commitment) and short time follow-ups (less than five years) may be hard to interpret.[22]

20. Data obtained from the New York City Police Department, on file with the authors.

21. *Uniform Crime Reports* and Wolfgang (1972) give the probability of rearrest for juveniles as 0.54 for first arrest, 0.65 for second and 0.8 for subsequent.

22. Historical data based on $P_v(C)$ show good correlations between recidivism based on arrests and commitments. In the last five years the probability of arrest has remained fairly constnt but q and J have drastically changed (mainly by changing felony convictions into misdemeanors regardless of the crime itself, see Hughes [1971].) Thus such follow-up studies would show a drop in recidivism compared to historical data. This does not indicate any change in real recidivism.

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Our model is based on the assumption that criminal careers are long compared with time between arrests. Table 4 gives also an estimate of five years for T, the length of the career. This is an instantaneous estimate, which under-estimates T[23] as it does not include the fraction of the career starting before age 18, or the period before the first arrest. Data for those who have more than one arrest show (*Uniform Crime Reports* 1966, 1969) an average career length of 10 years.

We also need a lower bound for λ. λ can be estimated in several ways. We can look at the rearrest rates of recidivists. In Table 4 if we discount the first times the average number of arrests per criminal during his career is about 1 per year. If we look at the fraction of safety crimes solved in the urban areas q = 0.15-0.2[24]. This would give a λ of 5.7. As part of the recidivist's career was spent in prison λ must be larger than 5. If we estimate historical values of the fraction of time spent in prison or jail as 0.2 to 0.5 then λ is equal to 6-14. Another estimate of λ is given in the appendix.

The data indicate that more than 80% of solved crimes are committed by recidivists. The important question is, who commits the 70% of crimes which are never solved. For reasons we discuss below, the most likely possibility is that they are committed by the same group of recidivists who commit the 30% of crimes which are solved. There are, however, two other possibilities which must be considered. The first is that most of these crimes are committed by amateurs or one-timers, i.e., people who commit only one or two crimes in their lifetime. The second is that these crimes are committed by a highly skilled group of professionals who never get caught. If either of these alternatives is correct then temporary incapacitation policies will only

23. Renewal theory allows us to set bounds for the correct average lifetime of a criminal career based on the measured average in an instantaneous sample. If $f(T_i)$ is the correct lifetime density and $g(A_i)$ is the instantaneous age density then it can be shown that

$$g(A_i) = \frac{1}{E(T)} [1 - \int_o^{A_i} f(T_i) dT]$$

(see Naor and Shinnar, 1963) From this relation we can derive that the expected age $E(A_i)$ is

$$E(A_i) = \frac{1}{2} \frac{1}{E(T_i)} [E^2T_i) + V(T_i)]$$

where V is the variance of the lifetime distribution. For uniform life V(T) is zero, and E(T) = 2E(A) for an exponential distribution E(A) = E(T). For the sample E(A) approximately equals E(T). If only second offenders are considered E(T) increases and career studies show a lifetime for those who stay to be between 10-15 years (*Uniform Crime Reports* [1969]).

24. Clearance rates given in the *Uniform Crime Reports* are higher as our estimate q_A refers to a single arrest for the last offense. Many arrests lead to multiple clearances. An upper bound q_A is the overall clearance rate which is about 0.3.

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affect 30% of the crimes reported and hence not be terribly useful. We now show why both alternatives are rather unlikely.

If most crimes are indeed committed by amateurs, then we are led to some contradictory results. At present crime rates 3.2 safety crimes are committed per resident of New York City during his lifetime. Since more than 80% of safety crimes are committed by males, then if most crimes are committed by amateurs, each male New Yorker must be committing 5 safety crimes. As this figure is considered too high for an amateur, we would be forced to conclude that it is the tourists who make New York unsafe. If on the other hand we make the reasonable assumption that 80% of all male New Yorkers never commit murder, felonious assault, robbery, rape or burglary,[25] then the minimum average number of crimes committed by each criminal is at least 25. In light of Wolfgang's (1972) data that less than 50% of those entering a criminal career become recidivists a more realistic estimate may be 50 crimes per criminal career.

Note that although 50% of the juvenile criminals analyzed by Wolfgang were amateurs or one-timers, they account for a small fraction of the total number of crimes committed by this group. It is important to distinguish between the fraction of crimes committed by recidivists and the fraction of criminals who are recidivists. For example, assume that for every career criminal there are 5 one-timers and we use the estimate of 50 crimes per career criminal. Then although career criminals form only 16% of the criminal population, they could account for more than 90% of the crimes. Hence, the predictions of the model are still valid.

The possibility that a small group of highly skilled professionals who never get caught is responsible for the other 70%, though harder to disprove, is also unlikely for the following reasons. The data show a large number of criminals who get arrested about once a year for 5 to 10 years. It is hard to believe that during a professional career spanning 5-10 years a criminal will commit only one crime per year and get caught every time. Yet this is the conclusion this leads to. If on the other hand, we assume that most unsolved crimes are committed by the same recidivist population which commits the solved crimes, we come up with a figure of 6-14 crimes per year while getting caught once, which seems more reasonable.

25. This assumption does not mean that 80% of New Yorkers are never arrested. We here include only safety crimes and exclude car theft, larceny, non-index crimes and misdemeanors. Detailed studies of identification records could throw further light on this problem.

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One further remark: While we assume a uniform criminal there is obviously no such thing. There are different types of recidivists with different specific crimes. This is not too important for our type of approximate overall estimate. Interestingly enough, both murder and felonious assault are mostly committed by career criminals (65% in New York City, 70% in the FBI study)[26] and could be prevented by incapacitation.

CHANGES IN THE CRIMINAL JUSTICE SYSTEM IN NEW YORK AND THE UNITED STATES: COMPARISON WITH THE MODEL

The results of the preceding chapters can be applied to data on crime in two ways. We can look at the historical data and try to relate the crime rate to judicial policy. We can also examine the present state of affairs and ask what measures, if any, can be taken to make cities safe again. We will put our emphasis on New York (city and state), and compare it to other areas for which there is available data.

Let us first examine the historical data (see Figure 1 and Tables 1, 2, 8 and 9). Over the last 10 years, the crime rate for the United States has gone up. However, the increase was much more pronounced in New York City, especially in Manhattan.[27] Figure 1 shows two major increases in the crime rate. One occurred in the early fifties and then stabilized while the second occurred in the mid-sixties and is still going on. The overall crime rate in the United States has also increased during the same time, but the rate in New York City and some other large cities was larger than in the rest of the country. Manhattan has the dubious distinction of having the highest rate of any American city. To put this in better perspective, we give in Tables 6-9 some more detailed comparisons on personal crime expectancy, crime rates and the chances of conviction for those who have committed a crime.

26. See New York State Department of Corrections (1973) and United States Department of Justice (1972).

27. From the available data it is sometimes hard to dissociate City and State data. In New York State most of the crime is committed in the city, which makes the analysis easier.

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Table 6: Comparison of crime rates, total number of crimes*

		Population	Murder and Manslaughter	Rape	Mugging Robbery	Burglary**
Manhattan	1935	1,876,000	227	298	570	770
	1960		180	518	2,854	12,795
	1965		239	415	3,739	16,761
	1970	1,590,000	394	713	31,738	66,161
New York City	1935	7,187,700	400	582	1,180	2,600
	1960		390	1,296	6,979	35,236
	1970	7,880,000	1,117	2,141	74,102	181,684
New York State not including New York City	1970	10,310,000	322	682	6,539	75,500
England & Wales	1950		391	299	923	3,616
	1968	40,580,000	425	829	4,815	8,846**
West Germany	1964	52,200,000	420	5,500	6,930	
United States	1960	179,323,000	9,000	16,860	107,390	897,000
	1970	203,184,000	15,810	37,270	348,380	2,169,300
Maine, Vermont, New Hampshire	1970	2,174,000	36	152	248	13,009

* Numbers in Table 6 for the United States, New York State and Maine are taken from *Uniform Crime Reports*, for New York City and Manhattan from New York City Police Department *Statistical Reports*, for England from Home Office (1969) *Criminal Statistics England and Wales 1968*, and for West Germany from *FBI Law Enforcement Bulletin* (1966).

** Burglary rates are not directly comparable, as other countries use different classifications.

Table 7:* Personal expectancies. Probability of a person experiencing a crime at least once in his life if crime rates prevailing in a given year remain in force throughout the person's life. (A probability of 0.1 is a 10% chance of being a victim.)

		Murder or Manslaughter	Rape	Robbery (mugging)
Manhattan	1935	0.008	0.018	0.02
	1960	0.008	0.047	0.12
	1970	0.018	0.064	0.76
New York City	1935	0.0038	0.008	0.011
	1960	0.0035	0.023	0.045
	1970	0.010	0.038	0.48
New York State (not including New York City)	1970	0.002	0.0065	0.045
England	1968	0.0007	0.0028	0.0079
Average United States Cities	1970	0.006	0.031	0.153
Average United States	1960	0.0035	0.0130	0.04
	1970	0.00546	0.023	0.122
Maine, Vermont and New Hampshire	1970	0.0012	0.01	0.008

* Personal expectancies are computed from the numbers and references given in Table 6 using the method given in Footnote 4.

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Table 8: Probability of going to prison having committed a crime*

		Murder	Rape	Robbery	Aggravated Assault	Burglary	Larceny
New York State	1960	0.534	0.2	0.11	0.04	0.01	0.014
"	1970	0.4	0.038	0.014	0.0065	0.0016	0.0016
England and Wales	1968	0.57	0.18	0.183	0.034	0.1**	
Maine, Vermont, New Hampshire	1970	0.44	0.28	0.19		0.013	0.02
United States	1960	0.4	0.215	0.07	0.025	0.02	0.04

* This probability is explained in Footnotes to Table 2. Commitment data for individual crimes were used. Those are given in the United States Department of Justice (1960, 1970, 1972) and Home Office (1969) *Criminal Statistics England and Wales 1968.*

Table 9:* Probability of being committed to prison and length of stay: United States total

	1960	1970
Total felonies (index crimes only)	2,019,600	5,581,200
Total number of prisoners	212,953	196,424
Number of prisoners committed by courts	88,575	79,351
qJS average stay in prison per crime	0.105	0.035
qJ chance of being convicted having committed a crime	0.043	0.014

* For sources and explanation of the numbers, see Footnotes to Table 2.

We note that the United States has always had a much higher murder and rape rate than England. The recent increase has magnified this problem. However, the most dramatic effect is in the rise of robbery and mugging. The number of robberies in Manhattan is six times greater than the number for all of England and accounts for almost 10% of all robberies committed in the United States. It is not surprising that consideration of crime rates has started to play an increasingly important role in people's decisions on where to live, study and locate their business.

The decrease in a criminal's chances of being convicted is also not limited to New York State but has a parallel in the United States. However, the trend is more pronounced in New York as can be seen from Table 9. The total number of prisoners remained fairly constant in the United States, but has decreased sharply in New York State. The average prison stay remained constant in the United States and decreased only slightly in New York State, but this is somewhat misleading. In Table 8 we give a breakdown of qJ, the chance of getting committed to prison, as a function of the crime.[28] We note that for murder it stayed

28. The numbers in Table 8 refer to New York State. As most crimes in New York State are committed in New York City (above 75%),

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fairly constant, whereas it decreased sharply for lesser crimes. The fraction of the total prison population committed who are in for murder increased from 6% in 1960 to 17% in 1970. This implies that people are being sent to prison only for more serious offenses than was the case before. The average prison stay for the same crime decreased much more than is indicated by the average prison stay, as can be seen in Table 10. We noted in a previous paper that the fraction of crimes cleared by arrest or by conviction has decreased in recent years, but only by 30% to 50%. The large changes in qJS are therefore mainly due to changes in J, the probability of receiving a jail term once having been convicted.[29] Again these changes are not uniform in the United States as the data for northern New England indicate. Rural areas not only have a lower crime rate, they also still send burglars and muggers to prison. We have no data on qJS for England but we do have data on qJ. In England the overall chance of an arrested robber to go to a long-term prison is 36%; in Manhattan it is less than 10% today. Arrest rates (or clearance rates) for robbery are much higher in England, about 0.5 versus 0.12 in the United States, but the fraction of those arrested who are not convicted later is about the same (60-70%). England not only has a higher clearance rate of safety crimes but also a much higher rate of commitment. The overall rate of commitment is larger by a factor of 10. Northern New England also still has values of qJ close to those of England.

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the numbers for New York State will give reasonable estimates for New York City and probably for the American City. 65-70% of commitments come from New York City. However, qJS varies from county to county. Three counties upstate who together report less than 1% of the index crimes account for 10% of the commitments. There is another source for our error. We exclude here jails. As many felonies do result in a conviction for a misdemeanor this underestimates qJS. Total jail population in New York State was 11,500 for 1960 (119,000 United States total) and 15,000 in 1970 (121,000 United States total). A large portion of this is very short term. This gives a bound on the possible errors in qJS.

29. Hughes (1971), Raab (1975), and Chambers (1975) give data which show that the largest contribution to the reduction in J is due to plea bargaining which reduces a large fraction of the felonies into misdemeanors. The changed bail procedures may also have had significant effects. Not only do these decrease S. They also decrease q as 10-15% of prisoners indicted for felonies in New York City do not appear in court (Gordon, 1975). There are no statistics as to how many are apprehended or as to the nature of their offense or likelihood to be convicted. Such data would be very valuable. The pre-trial release period decreases qJS in another indirect way. Any crimes committed during the period of release are under the same single arrest (or commitment) and, in most cases do not increase S (the real stay in prison). This has the net effect of decreasing q.

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Table 10:* Time, S, served by prisoners before 1st release (median value in years)

	Murder	Robbery
1960	5.0	3.0
1970	2.7	1.7

* See United States Department of Justice (1970) "State Prisoners: Admissions and Releases 1970" and United States Department of Justice (1960) "Characteristics of State Prisoners 1960". 50% of the prisoners stay less than the median value given. Data are given in such a form that the average is difficult to compute.

Why J decreased so much is outside the scope of the present study. Our objective is to investigate the possible effects of the decrease in qJ and qJS, and what can be done to reduce the present crime rate. For this purpose the only important parameter is qJS, the average time actually spent in prison for each crime committed. When we look at qJS, which is the true index of the effectiveness of the criminal justice system, the magnitude of the change becomes apparent. A reasonable historical estimate of qJS for safety crimes based on New York City police statistics for 1940 is 0.3 - 0.5. Table 2 shows that by 1960, qJS = 0.13 and by 1970 it is down to 0.024. If we only look at violent crimes (Table 8), the decrease is equally large as qJS decreased from 0.35 to 0.06.[30] Recall from equation 4 that the effectiveness of the criminal justice system is given by

$$1 - \frac{1}{1+\lambda qJS}$$

For a λ of 10, this means that in 1940 the effectiveness was 75 to 85%, in 1960 it had decreased to 56%, while in 1970 it was down to 20%, and fast approaching zero[31]. In other words, by 1970 the criminal justice system was having very little effect on the crime rate. The United States as a whole experienced a similar reduction in qJS but not nearly as strong as New York City.

Another approach is to look at the period 1960-1970 within which a strong increase in the crime rate occurred and ask what would have happened had the policy of the criminal justice system remained the same. From equation 2 we obtain

30. Our estimates of qJS for safety crimes were biased upwards by including murder which still has a relatively high clearance and commitment rate, and the estimates for qJS in Table 8 indicate that the changes for robbery, assault and rape, the crimes which worry New Yorkers most, were even stronger.

31. Clark (1973) has arrived at a very similar conclusion by a detailed analysis of Wolfgang's data. He estimated that the effect on incapacitation on the solved crimes committed by the cohort was 10-15%. Our simple model would give the same results. The data show a $\lambda q_A J_A S$ of about 0.1, which is not surprising as at the present very few juveniles are committed to incapacitating institutions.

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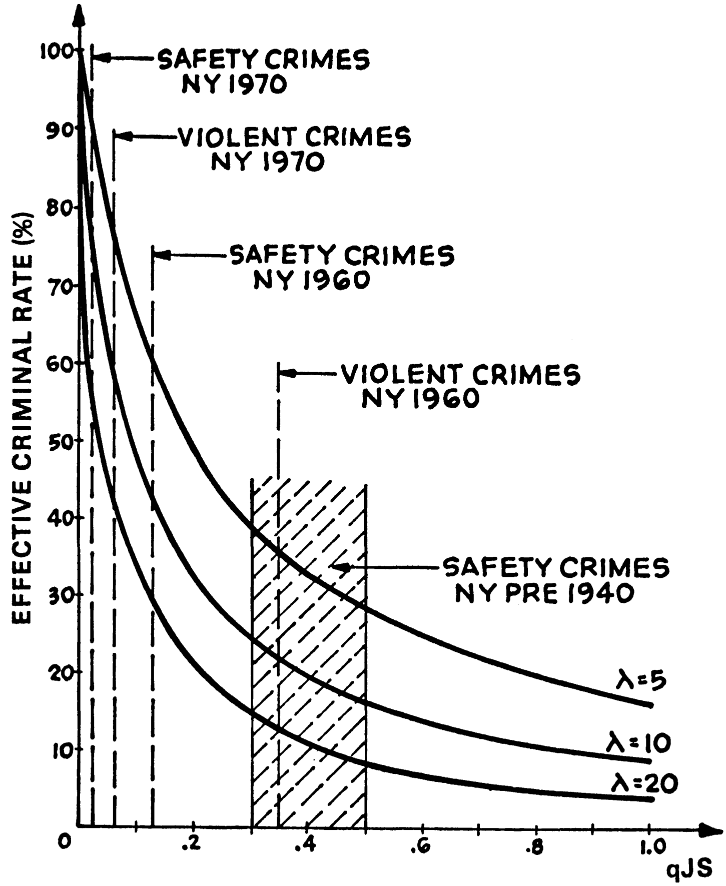
Figure 2. Effect of qJS (prison stay per crime committed) on crime rate (equations 3 and 4). Base rate given as 100. Historical values for qJS given indicated by arrows.



$$\frac{E(x) \text{ at } qJS_{1970}}{E(x) \text{ at } qJS_{1960}} = \frac{1 + \lambda qJS_{1960}}{1 + \lambda qJS_{1970}} = \frac{1 + 10 \text{ x } 0.13}{1 + 10 \text{ x } 0.029} = 1.85$$

This represents the increase in crime rate directly attributable to changes in criminal justice system behavior. In this period, the total crime increase was about a factor of four or 300%. This was partly due to an increased number of criminals, especially juveniles. However, if criminal justice system policy had not changed, the increase would have been only 4/1.85 = 2.15. Of the 300% increase, 185% is attributable to changes in the behavior of the criminal justice system. We concede that statements of this kind can be no more than reasonable estimates. Nevertheless, the estimates we make here are quite conservative. Since

32. This is derived as follows. At the 1960 policy, present crime rate would only be 115% higher than in 1970. As the real increase was 300% the increase due to changes in imprisonment was at least 185% or 60% of the total increase.

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deterrence effects were neglected in our model, it is plausible to attribute a major portion of the recent increases in robbery, rape and mugging to changes in the policies of the criminal justice system.

We can look at the numbers in another way. In the United States the number of persons in the crime prone age (15-30) increased by 40% between 1960-1970 but the total number of prisoners stayed constant. In New York City the increase was only 20%, but if we consider the increase per prison space then the increase in New York City is also close to 40%. We showed before that the model predicts that if the fraction of criminals in this age bracket remained constant, we would expect an increase much larger than 40%. Interestingly, the increase in the United States is approximately what our model predicts. For New York City the increase is higher but we noted before that our model probably underestimates the effects of decreased incapacitation.

We now ask: can we reduce the crime rate sufficiently to make the streets of New York safe again? We noted previously that it takes time before an abrupt change in the crime rate is perceived. This has already happened and we are now seeking measures which will reduce the crime rate in a reasonable length of time. Long range programs to eliminate the underlying causes of crime are, of course, desirable. However, we know very little about them and in any event they would take a long time to bear fruit. In the meantime, how much can we achieve with established methods such as putting criminals in prison? Our simple model indicates that in New York City a reduction by a factor of five within two years should be possible (see Figure 2). This would require an increase of qJS for safety crimes to at least 0.3 and 0.5 - -.0 for violent crimes.

At present, the chance of a mugger being arrested for a given mugging is about 12%, and his chances of imprisonment after being arrested about 10% (Hughes, 1971). His total chance of going to prison is only 0.012 or 1.2%. If we send every convicted mugger and robber to prison for five years, we could reduce this type of violent crime by a factor of five. It will take two to three years for the policy to be effective, for this is the time span needed to convict the majority of recidivists. If we improve police work, and the efficiency of the criminal justice system as a whole, we might increase the probability of a mugger getting convicted for each crime to 20% (the value now prevailing in England). Then, a net prison stay of three years would do the same job. Similar results could be obtained for other types of

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recidivist crime, such as rape. Such a policy would also reduce murder, as 40% of murders are committed by felons with a history of previous violent crimes, (and 65% by recidivists).

With better data and continuous monitoring of the system, the needed value of qJS might be later reduced. A qJS of 0.5 means that for each crime the criminal spends, on the average, half a year in jail. We can obtain this value of qJS in different ways. Either we increase the length of stay (note that length of stay is *not* equivalent to sentence length) or we increase the probability of a criminal getting convicted and sent to prison for every crime he commits. The second alternative is socially preferable, for it gives the criminal a repeated chance to reform. Values of qJS of 0.5 and 1.0 are reasonably obtainable goals. Historically, values of qJ of 0.25 (or 25% of all crimes reported resulting in imprisonment) were obtained in the past and are still obtained in England (see Table 6). An average stay of two years would give a qJS of 0.5, and an average stay of four years would give a value of 1.00. As present conviction rates are lower we would temporarily need longer prison stays. The length of prison stay could also be increased with repetition. What is important, however, is uniform application of penalties for any recidivist offender, regardless of the severity of the second offense, as long as it indicates that he is still pursuing a criminal career. The latter is important, for our chances of convicting a recidivist are small. Obviously, better supervision methods during probation would be highly desirable; but again, only if any indication that he still pursues a criminal career is immediately acted upon.

For a crime policy based on incapacitation to work, it would also have to include youthful offenders who commit an increasing fraction of the crimes. For them, useful utilization of the incapacitation period is even more important and special institutions are needed. But the basic problem is exactly the same. In no way do we want to imply that future crime policies should be based solely on incapacitation. Better rehabilitation would be preferable but rehabilitation must become much more successful before it will have a significant effect.

The effects of such policies on the prison population would be substantial but not extreme. Assuming λ to be between 5-10, we are dealing with a criminal population of 40,000-80,000 in New York State. This means that we need a prison system that can accommodate 40,000-60,000 people for criminals convicted of safety crimes. Its institutions presently can accommodate somewhat less than 35,000 (see Table 7) so that larger facilities would

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be needed. Special facilities would also be needed for youthful and first offenders. There is a good chance that improved sentencing procedures and screening will allow recognition of recidivists and thereby reduce the number of spaces needed by selectively increasing their sentences as shown in the California Study (Select Committee on the Administration of Justice, 1970). Larger facilities would be needed, but their cost would be negligible compared to the present cost of crime.

What our model shows is that incapacitation offers such an alternative. Unfortunately, it would be very difficult to introduce these policies, or for that matter, any other effective anticrime policies by legislation. The fundamental problem is that there is no policy-making authority with the power to implement a comprehensive crime prevention policy. Recent New York City history provides an excellent case in point. There was never a formal decision to change the sentencing rate or the time actually spent in prison. Individual judges still have full authority to impose sentences as stiff as those of 30 years ago. By some general consensus, however, most of them do not. Recent efforts by the legislature to remedy the situation have had little effect. The independence of the three branches of government makes it very difficult to achieve a unified policy to deal with crime. Nevertheless, unilateral decisions of one branch may have profound effects which were not necessarily foreseen. Hence, a quantitative approach to the problem of crime control is needed.

CONCLUSION

The paper has analyzed the present state of crime control in New York. We tried to show by simple quantitative arguments that there is a strong correlation between increased crime rates and recent changes in the criminal justice system which sharply reduced the chances of a criminal going to prison as well as the length of his stay there. It was shown that one of the main effects of prison is simply temporary incapacitation. It was also shown that any factor that decreases the chance of a criminal to get convicted has a direct effect on increasing crime rate in an almost proportional way. We submit that a policy of uniform prison sentences for convicted criminals could under present conditions reduce *safety* crime by a factor of four to five. This would require net prison stays of five years for muggers and robbers and other violent crimes, and three years for burglars. (As we have pointed out, it is only net prison stay which is important and not sentence length.) This would also reduce the

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number of murders since most murders are committed by career criminals. If we could increase police effectiveness and change court practices so that 20% of all crimes end in a conviction, we could reduce the average prison stay needed to three years with the same results. The total number of prisoners in New York State would probably increase by 20,000. Such a policy would also have some deterrent effect and the number of crimes would decrease in the future.

What is needed is a carefully designed overall policy. In addition to uniform sentencing policies, there is a need to investigate how the rate at which crimes are solved can be increased. We must also recognize that a significant fraction of crimes is committed by juveniles, and search for sensible integrated approaches. When dealing with crime, it is hard to get accurate data or make exact predictions. However, it is clear that any factor or judicial decision that decreases the efficiency of the criminal control system has a direct and almost proportional effect on increasing the crime rate. We are convinced that with reasonable, carefully designed policies, the crime rate could be significantly reduced in a short time. Despite their limitations existing data allow reasonable estimates as to how effective a policy of incapacitation could be. In the end, as in any complex system, the only real proof would be to try such policies out and evaluate their results.

Derivation of the Model

We wish to derive E(x) the expected number of crimes per criminal. Since this will depend on the amount of time he will spend in jail we start by computing his chances of getting convicted.

Let us first compute P, the probability of not getting convicted again. Since convictions are independent this is also equal to the probability of never getting convicted. This is given by

$$P = P(D=O) = \sum_{x=o}^{\infty} (1-q)^x \left(\frac{\lambda T}{\lambda T + 1}\right)^x \frac{1}{(\lambda T + 1)} = \frac{1}{1 + \lambda qT} \qquad (1)$$

It follows that the probability of a criminal getting convicted at least once is

$$1 - P = \frac{\lambda qT}{1 + \lambda qT} \qquad (2)$$

Similarly P_J, the probability of not being sent to prison and $1-P_J$ are given by

$$P_J = P(D_J=0) = \sum_{x=o}^{\infty} (1-qJ)^x \left(\frac{\lambda T}{\lambda T + 1}\right)^x \frac{1}{(\lambda T + 1)} = \frac{1}{1 + \lambda qJT} \qquad (1a)$$

and

$$1-P_J = \frac{\lambda qJT}{1 + \lambda qJT} \qquad (2a)$$

We now derive, in a non-rigorous, intuitive fashion a simple expression for E(x), the expected number of crimes in a criminal career. The same results can be obtained rigorously and the interested reader

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is referred to (7) where this is done for a similar but more general case. Intuitively

$$E(x) = \frac{1}{q} E(D) \quad \text{or}$$
$$E(x) = \frac{1}{q\,J} E(D_J) \tag{3}$$

where E(D) and (ED_J) are the expected number of convictions and the expected number of jail sentences per criminal respectively. 1/q and 1/qJ are the average number of crimes committed per conviction and jail sentence respectively. For reasons of simplicity, it is easier to use the second expression. The expected value of the random variable D_J is given by

$$E(D_J) = \sum_{n=o}^{\infty} P(D_J > n)$$

Recall that

$$P_J = P(D_J = 0) = \frac{1}{1 + \lambda qJT} \tag{1a}$$

This implies that $P(D_J > O) = 1 - P_J$.

Let us assume that a criminal has already been convicted once. Then the probability that he will be convicted a second time is the probability that his criminal career will not end with his first jail term, multiplied by the probability that he will be convicted again and sent to jail. If we assume that the length of criminal careers are exponentially distributed, this is $(1\text{-}P_J)$. Therefore,

$$P(D_J \geq 2) = (1 - P_J)^2\Theta$$

The probability that he will survive his prison term or, in other words, that his criminal career will not end during his prison term is given by

$$\Theta = \int_o^{\infty} c^{-s/T} dF_s(s)$$

where F_s ( ) is the distribution function of S. For the exponential case, however, Θ becomes

$$\Theta = \frac{T}{S + T}$$

Any deterrence or rehabilitation effects will manifest themselves by changing Θ, and are therefore included in T. It is easily seen that the probability $P(D_J \geq n)$ for higher n is given by

$$P(D_J \geq n) = (1 - P_J) \prod_{i\text{-}1}^{n} (1 - P_J)\,\Theta = (1 - P_J)\,[(1 - P_J)\Theta]^n$$

where $\prod_{i\text{-}1}^{n} (1 - P_J)$ represents the probability of getting sentenced n times and surviving the n^{th} jail term. $1 - P_J$ represents the probability of getting sentenced to jail at least once more. We can now write down an expression for E(x)

$$E(x) = \frac{1}{qJ} E(D_J) = \frac{1}{qJ} \sum_{n=0}^{\infty} P(D_J > n) = \frac{1\text{-}P_J}{qJ} \sum_{n=1}^{\infty} [(1 - P_J)\Theta]^n$$
$$= \frac{1\text{-}P_J}{qJ} \cdot \frac{1}{1 - (1 - P_J)\Theta} \tag{4}$$

Substituting for Θ and P_J yields

$$E(x) = \frac{1\text{-}P_J}{qJ} \cdot \frac{1}{1\text{-}(1\text{-}P_J)\Theta} = \frac{\lambda T(S + T)}{S\text{+}T + \lambda qJST} = \frac{\lambda T}{1 + \frac{\lambda qJST}{S\text{+}T}} \tag{5}$$

for T large with respect to S this becomes approximately

$$E(x) = \frac{\lambda T}{1 + \lambda qJS} \tag{6}$$

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The variables q, J, and S are directly measurable. The only parameters that we can't measure and therefore need to estimate are λ and T. Based on criminal records experts estimate T, the average criminal career length, to be between 10 and 15 years (ref. 1). Our estimates are insensitive to T as long as it is greater than 5 years which seems to be a reasonable assumption.

We can estimate λ from other directly measurable parameters such as $\pi(t)$, the probability of a criminal being reconvicted after a conviction or a release from jail within a fixed time t. Estimates of this type are available for many types of crime and for safety crimes π(3 yrs) varies from 0.6-0.85. From this we can estimate λ as follows. In the model

$$\pi(t) = \int_0^t \lambda q e^{-\lambda q x} e^{-x/T} dx = \frac{\lambda q T}{1+\lambda q T}\left[1 - e^{-(\lambda q + 1/T)t}\right] \qquad (7)$$

For high values of T and λq with which we are dealing, this becomes approximately

$$\pi(t) = 1 - e^{-\lambda q T} \qquad (8)$$

from which λ can be estimated.

We can now investigate the sensitivity of our estimate of λ to T. This is shown in Table A1 for typical values of π (3 years) and reasonable values of T. When T varies from ∞ to 5, λq varies by a factor of two, but as λq is a difficult variable to estimate this is still a very reasonable bound. For policy considerations it is often sufficient to know that λ is either high or low and a lower bound is very important. If values are available for both three and five years, this estimate would be improved.

Table A1: Sensitivity of the Estimate of λq to T

T	π(3 years)	λq
∞	0.8	0.59
10	0.8	0.7
5	0.8	0.95
∞	0.6	0.3
10	0.6	0.45

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