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ANNOTATION:

ANALYSIS OF THE FLOW OF OFFENDERS THROUGH THE SYSTEM- POLICE, COURTS, AND CORRECTIONS.

ABSTRACT:

ONE PROBLEM IN IMPROVING LAW ENFORCEMENT IS THE NEED TO EXAMINE THE TOTAL CRIMINAL JUSTICE SYSTEM - POLICE, PROSECUTION, COURTS, AND CORRECTIONS AGENCIES - IN AN INTEGRATED WAY. ANY SUCH ANALYSIS MUST REFLECT THE FEEDBACK INTO SOCIETY OF OFFENDERS RELEASED AT VARIOUS STAGES IN THE SYSTEM. A MODEL IS FORMULATED FOR THE CRIMINAL JUSTICE SYSTEM IN ONE PARTICULAR STATE. THE MODEL DEPICTS THE FLOW OF ARRESTED PERSONS THROUGH THE SYSTEM AS A FUNCTION OF TYPE OF CRIME, AND PROVIDES A BASIS FOR APPORTIONING COSTS TO SYSTEM COMPONENTS AND TO TYPE OF CRIME. AN IMPORTANT PART OF THE MODEL IS THE FEEDBACK FEATURE, WHICH REFLECTS THE PROBABILITY OF REARREST AS A DECREASING FUNCTION OF AGE, AND A CRIME-TRANSITION MATRIX REFLECTING THE SUCCESSIVE-CRIME DISTRIBUTION. THE RESULTS WITH THE MODEL INCLUDE A COST DISTRIBUTION BY CRIME TYPE, CRIMINAL-CAREER COSTS, AND AN EXAMINATION OF THE COURSE OF CRIMINAL CAREERS, AND AN EXAMINATION OF THE SENSITIVITY OF COST AND OFFENDER FLOW WITHIN THE SYSTEM TO CHANGES IN THE SYSTEM'S CONTROLLABLE VARIABLES. (AUTHOR ABSTRACT)

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PAPER P-480

MODELS OF A TOTAL CRIMINAL JUSTICE SYSTEM

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November 1970

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PAPER P-480

MODELS OF A TOTAL CRIMINAL JUSTICE SYSTEM

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November 1970

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PREFACE

The main body of this report is essentially the paper, "Models of a Total Criminal Justice System," which appeared in Operations Research, Vol. 17, pp. 199-232, March-Arpil 1969. The appendices to this report contain the detailed back-up technical material, input data, and output results that are summarized in the paper. In addition, some ancillary analyses are included as appendices.

ACKNOWLEDGMENTS

The suggestions and contributions of Ronald A. Christensen and Sue Johnson, the programming assistance of Charles McBride, and the cost estimates of P.A. Donvito are gratefully acknowledged. We also thank J. Navarro, J. Taylor, and C. Vickery for comments on an earlier draft.

The basic work for this report was supported by the Law Enforcement Assistance Administration of the U.S. Department of Justice. That support is appreciated.

ABSTRACT

One central problem in improving law enforcement is the need to examine the total criminal justice system, comprising police, prosecution, courts, and corrections agencies, in an integrated way. Any such analysis must reflect the feedback into society of offenders released at various stages in the system. In this paper, a model is formulated for the criminal justice system in one particular state. The model depicts the flow of arrested persons through the system as a function of type of crime, and provides a basis for apportioning costs to system component and to type of crime. An important part of the model is the feedback feature, which reflects the probability of rearrest as a decreasing function of age, and a crime-transition matrix reflecting the successive-crime distribution. The results with the model include a cost distribution by crime type, criminal-career costs, an examination of the course of criminal careers, and an examination of the sensitivity of cost and offender flow within the system to changes in the system's controllable variables.

CONTENTS

I. INTRODUCTION AND SUMMARY

A. INTRODUCTION

The criminal justice system (CJS), comprising agencies of the police, prosecution, courts, and corrections, has remained remarkably unchanged through the significant social, technological, and managerial changes of recent decades. This stability results partly from the insularity of these institutions and their relative freedom from external examination and influence; but it also results from the independence of the individual components of the system, each of which operates within a set of prescribed rules to attain its own suboptimized objective. Nowhere is there a single manager of a CJS with control over all the constituent parts.*

In the past few years, there has been an increasing trend toward examining the interactions among the parts of the CJS. The report of the President's Commission on Law Enforcement and Administration of Justice (Ref. 1) urged much closer relationships among the parts of the system. The Omnibus Safe Streets and Crime Control Act of 1968 (Ref. 2) provides Federal funds to State planning agencies to develop "a comprehensive statewide plan for the improvement of law enforcement throughout the State" (Ref. 2, Sec. 203(b)(1)). Federal subsidy grants are to be provided on the basis of these plans. Thus, there is developing an especially strong need for models that would permit study of a total CJS. This is needed only partly for reasons of resource

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*The closest approach to this is the Federal CJS, in which the police (Federal Bureau of Investigation), prosecutors (U.S. Attorneys), and corrections (Federal Bureau of Prisons) all report to the Attorney General. The courts, however, are completely independent. We do not suggest here that a single manager would be desirable. There are strong checks-and-balances reasons for retaining the institutional independence.

allocation; perhaps even more importantly, such total system models could provide a tool for examining the effects on crime of actions taken by the CJS, for most crimes are committed by people who have previously been arrested. Thus, examination of the feedback process is central to an improvement in the system's performance. In the present state of extensive ignorance on the cause-and-effect relationships, the model of this study will at least identify the data needs and the research questions that will permit analyses of the crime consequences of the actions taken.

B. SUMMARY

This paper* describes means of modeling the CJS--both in a detailed way with the linear model and in a more aggregated way using feedback to account for recidivism. Clearly, the focus of this study is on the CJS itself, so neither the many public and private means outside the CJS (by which criminal behavior is controlled) nor the deterrent effects of the CJS are addressed. Our goal has been to describe in a quantitative way the operation of the system which tries to apprehend, adjudicate, and rehabilitate offenders and to assess some of the effects of this system on their future criminal behavior. Within the constraints of the available data, these models allow us to study questions regarding the CJS, its costs, workloads and resource requirements, and the effects of alternative rehabilitative procedures on criminal careers.

Future studies could include more realistic assumptions within the framework of these models and more complete and accurate data for performing the calculations. The end goal of such studies would be to improve the management of the system, including appropriate allocation of public resources to minimize the total social and dollar costs of crime and its control. The models also provide a research tool for examining the behavior of the CJS in order to understand its impact on the problem of crime.

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* The work on this paper was done under contract SD-50.

II. DESCRIPTION OF THE CRIMINAL JUSTICE SYSTEM

The CJS comprises those public agencies concerned with apprehending and dealing with persons, both adults and juveniles, who violate the criminal law. The basic structure* of the CJS is depicted in Fig. 1. In society, there are former offenders (recidivists), and those not previously so identified, who will commit criminal acts. Of all crimes which are detected (and many like shoplifting go largely undetected) and reported to the police (and many go unreported**), only a fraction lead to arrest of a suspect.

An arrested person may simply be admonished at the police station and returned home, or he may be referred to some social service agency outside the CJS. An arrested adult is usually brought before a magistrate who may dismiss the case or formally accuse the suspect of the original or lesser charge and set his bail.

The district attorney, who is responsible for prosecution of an accused adult, may dismiss the complaint against the defendant at any time prior to the trial. Those defendants who are not dismissed may plead guilty or stand trial either by a jury or a judge. Those who are not acquitted can receive a sentence by a judge that can be of various forms, usually one of the following:

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*This, of course, is a highly simplified version of a very complicated procedure. For a more detailed description, see McIntyre (Ref. 3), or for a more condensed version, Hazard (Ref. 4).

**A Crime Commission survey in three Washington, D.C., precincts found a victimization rate three to ten times (depending on type of crime) that reported to the police (Ref. 5).

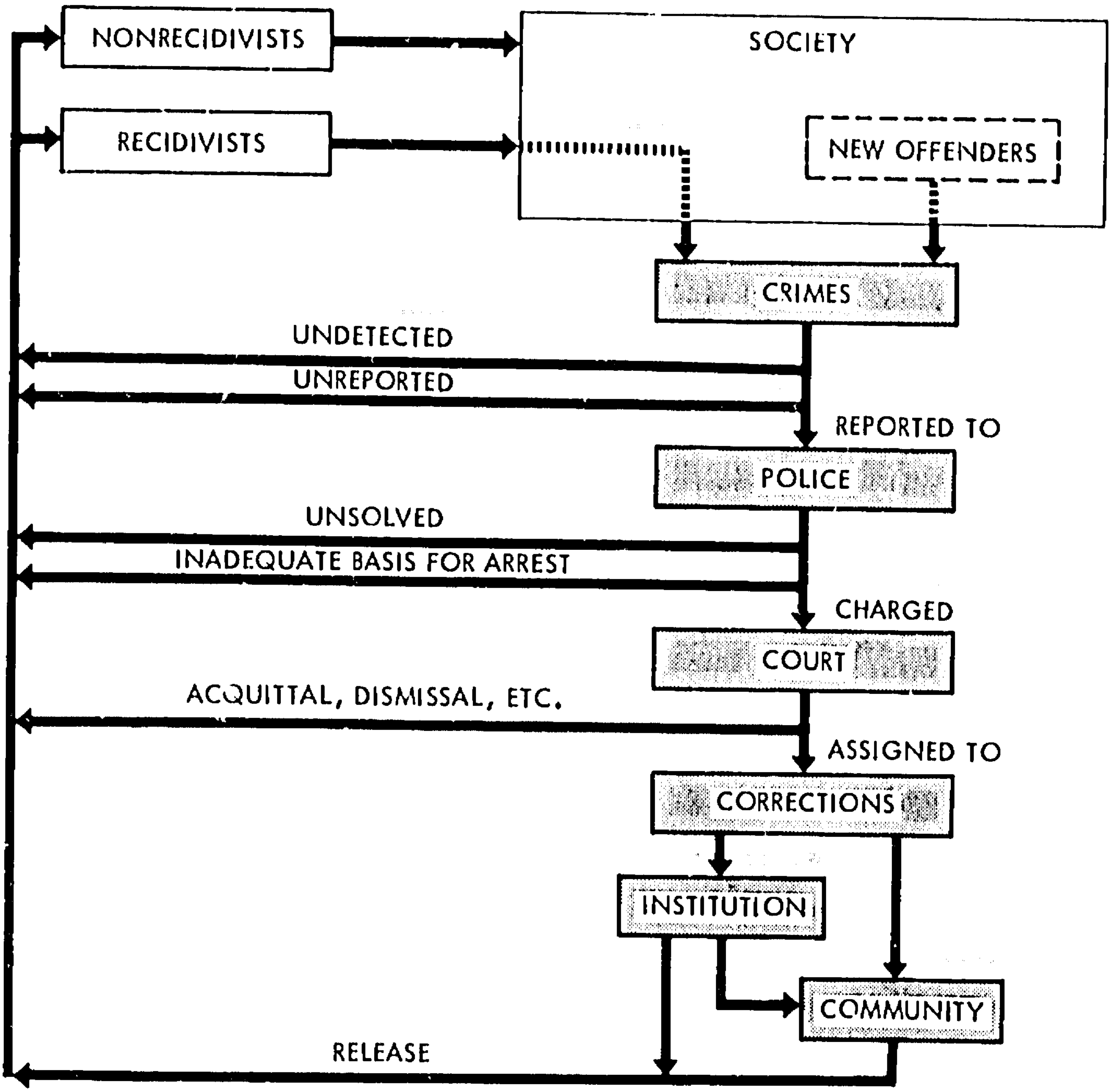

FIGURE 1. The Criminal Justice System

(1) A monetary fine,

(2) Probation (usually with a suspended sentence),

(3) Probation (following a fairly short jail term),

(4) Assignment to a State Youth Authority,

(5) A jail term (usually of less than one year),

(6) A prison term (usually of no less than one year at a state institution), and

(7) Civil commitment for some specified treatment.

In addition to newly sentenced offenders from court, prisons can also receive probation and parole violators. Release from prison is usually under parole supervision. Parole violators, if returned to prison, may subsequently be released either on another period of parole, or unconditionally if their sentence has been served.

The processing of juveniles is similar to that of adults but is much less formal than that of adults, with far more freedom of choice exercised by the juvenile authorities.

This processing by the CJS typically involves a series of stages, with the alternatives of returning to the community or entering into the next stage of the CJS. Since virtually all offenders return to society eventually, temptation affords them repeated opportunities for recidivism followed by recycling through the CJS.

This cursory description suggests two approaches to modeling the CJS. First, there is the simple production process, in which the principal concerns are the flow through the system and the accumulation of costs from a single arrest. Such a linear model provides an opportunity (1) to examine at each stage the workload, the personnel requirements that result, and the associated costs; (2) to attribute these to types of crimes; and (3) to project all of these planning variables as functions of future arrest rates.

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*Some preliminary discussion of such models has been given by Roy (Ref. 6).

The second is a feedback model, which considers the recidivism probability associated with each released defendant, and his subsequent processing for future arrests after he has once been released by the CJS. Such a feedback model, building on the work of the Space-General Corporation (Ref. 7), permits estimating the costs of a total criminal career (considering the succession of rearrests of an individual) and estimating the consequences of alternative actions within the CJS to lower recidivism probabilities.

Some preliminary results with these two models on aggregated U.S. data have been reported previously (Ref. 8). This study and accompanying appendices provide some of the details of the form of those models and present results for California, the single state that comes closest to having an adequate data base. Hopefully, as the use of such models increases, more complete data will become available.

III. THE LINEAR MODEL

A steady-state, linear model is used to compute the costs and workloads at the various processing stages and to establish manpower requirements to meet the anticipated workloads.*

The flow of persons through each processing stage is described by a vector whose ith component represents the yearly flow associated with characteristic type i (i = 1, ..., I). These characteristics can be any attribute associated with individual offenders, their crimes, or their previous processing by the CJS. In most of our studies, there have been seven characteristics (i.e., I = 7), corresponding to the seven index** crimes.

The independent flow vector to the model, which must be specified as input, is the number of crimes reported to police during one year.*** The outputs are the computed flows, costs, and manpower requirements that would result if the input and the system were in steady state.

Each processing stage is characterized by vector cost rates (per unit flow) and branching probabilities (or branching ratios). The input flow at each processing stage is partitioned into the appropriate

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*Workload is the annual demand for service at the various processing stages (e.g., courtroom hours, detective manhours). Manpower requirement is derived from workload by dividing by the annual working time per man (or other resource). Total operating costs are allocated to offenders by standard cost accounting procedures. These allocated costs are then assumed to be variable costs.

**The seven index crimes which the FBI annually tabulates (Ref. 9) to get an "index" of crime in the United States are willful homicide, forcible rape, aggravated assault, robbery, burglary, larceny of $50 or over, and auto theft.

***Hereafter, unless stated otherwise, all computed variables and data are considered as seven-component vectors. The flow variables represent annual flow rates.

output flows by element-by-element vector multiplication of the input flow and the branching probability (e.g., $F_{i,n} = F_{i,m} P_{i,mn}$), where

$F_{i,n}$ = number of offenders associated with crime type i following route n out of processing stage m

$F_{i,m}$ = number of offenders associated with crime type i entering processing stage m during one year

$P_{i,mn}$ = probability that an offender associated with crime type i input at stage m will exit through route n $\left(\sum_n P_{i,mn} = 1\right)$

A simple processing stage, representing the verdict of jury trial, is depicted in Fig. 2. The input N_{t_1} is the number of defendants who receive a jury trial. The outputs N_{tg_1} and $N_{t\bar{g}_1}$ are the numbers found guilty and not found guilty, respectively. The branching probability P_{tg_1} is the probability that a jury trial defendant will be found guilty. With seven crime types, the seven components of P_{tg_1} are required as input data for this stage.*

Describing the entire model in detail is not warranted here. To illustrate the details, however, we briefly discuss the prosecution and courts submodel. The flow diagram is given in Fig. 3. The input to this part of the model is the vector, N_{ad_1}, the number of adult arrestees who are formally charged with index crimes. This submodel produces seven output vectors corresponding to the seven sentence types. These provide the inputs to the subsequent processing stages. In addition, there are four intermediate output vectors characterizing defendants who never reach the sentencing stage, namely:

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*A more general model would define each branching probability as a function of an offender's prior path through the system and other information which had become known since arrest. The branching probabilities describing the sentencing decision, for instance, would depend on whether the defendant had pleaded guilty, had a jury trial, or a bench or transcript trial. In effect, the possible number of characteristics that could be associated with a flow variable could grow exponentially with the depth of system penetration. The demands for data, of course, grow comparably.

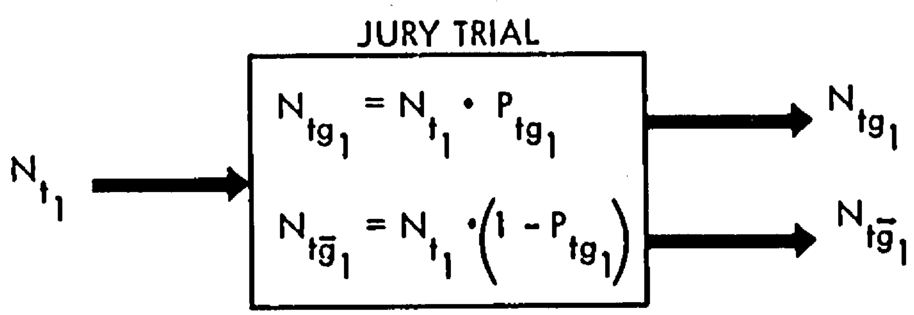
(1) $N_{\bar{f}}$ = number of adults formally charged who do not reach trial stage

(2) N_{td} = number of defendants whose cases are dismissed or placed off calendar at the trial stage

(3) $N_{t\bar{g}_1}$ = number of jury trial defendants not found guilty

(4) $N_{t\bar{g}_2}$ = number of bench and transcript trial defendants not found guilty

Clearly, any other intermediate flows can also be calculated, if desired.



DEFINITIONS:

N_{t_1} = NUMBER OF DEFENDANTS WHO RECEIVE JURY TRIALS

N_{tg_1} = NUMBER OF JURY TRIAL DEFENDANTS FOUND GUILTY

$N_{t\bar{g}_1}$ = NUMBER OF JURY TRIAL DEFENDANTS NOT FOUND GUILTY

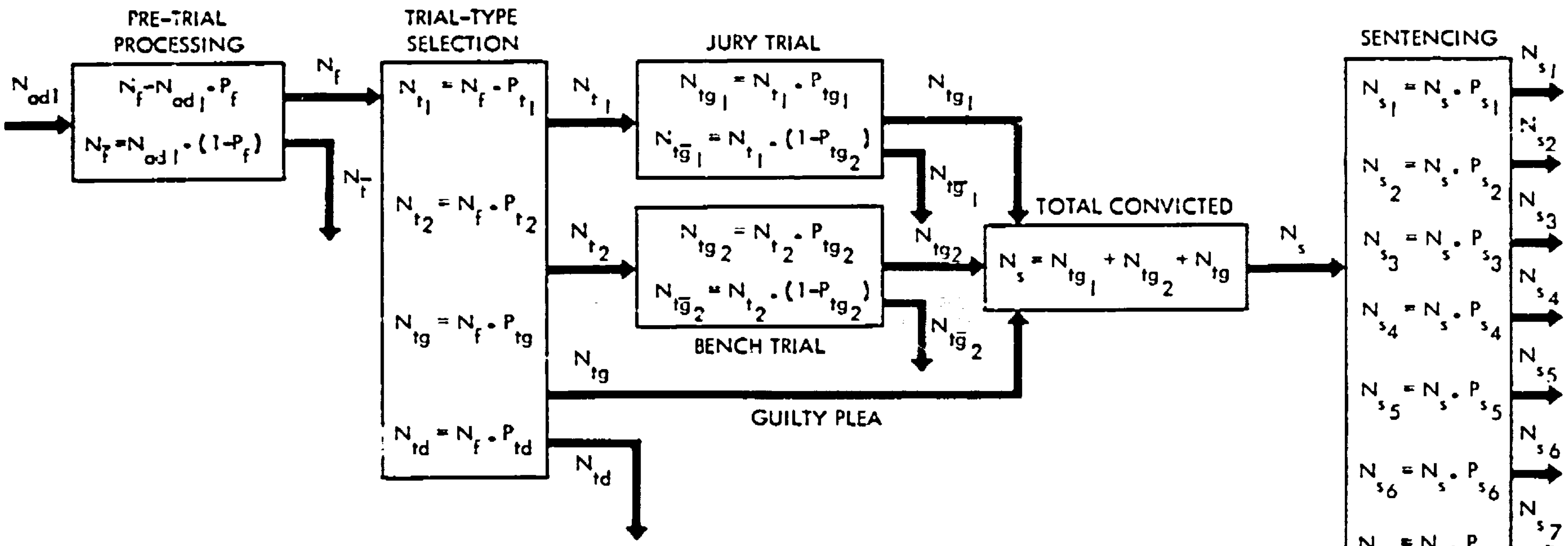
P_{tg_1} = PROBABILITY THAT A JURY TRIAL DEFENDANT IS FOUND GUILTY

FIGURE 2. Jury Trial Stage

This submodel calls for four classes of branching probabilities. These refer to:

(1) Whether the defendant reaches the trial stage,

(2) The type of trial (or whether dismissed at trial stage),



NOTE: SEE TABLE 1 FOR DEFINITION OF SYMBOLS

FIGURE 3. Prosecution and Courts Flow Model

(3) The trial verdict, and

(4) The sentencing decision.

The definitions of all the flow and branching probability variables of Fig. 3 are given in Table 1.

TABLE 1. DEFINITIONS OF FLOWS AND BRANCHING PROBABILITIES IN THE PROSECUTION AND COURT SUBMODEL[a]

N_{ad_1}	The number of adult arrestees who are formally charged by the magistrate.
(N_f, P_f)	The number of adults formally charged who reach the trial stage.
$(N_{\bar{f}}, 1\text{-}P_f)$	The number of adults formally charged who do not reach the trial stage.
(N_{t_1}, P_{t_1})	Number of defendants who reach trial stage and who receive <u>jury</u> <u>trials</u>.
(N_{t_2}, P_{t_2})	Number of defendants who reach trial stage and who receive <u>bench</u> or <u>transcript</u> <u>trials</u>.
(N_{tg}, P_{tg})	Number of defendants who reach trial stage and who plead guilty.
(N_{td}, P_{td})	Number of defendants who reach trial stage and who are dismissed or placed off calendar.
(N_{tg_1}, P_{tg_1})	Number of defendants who receive jury trials who are found guilty.
$(N_{t\bar{g}_1}, 1\text{-}P_{tg_1})$	Number of defendants who receive jury trials who are not found guilty.
(N_{tg_2}, P_{tg_2})	Number of defendants who receive bench or transcript trials who are found guilty.
$(N_{t\bar{g}_2}, 1\text{-}P_{tg_2})$	Number of defendants who receive bench or transcript trials who are not found guilty.
N_S	The number of defendants who are sentenced.
(N_{Sj}, P_{Sj})	The number of sentenced defendants who receive sentence type j (j = 1, 2, ..., 7).

[a]Output flows and corresponding branching probabilities are given as matched pairs. Only the definition of the flow is stated.

Having determined the flow through each processing stage, total costs are determined simply as the product of unit costs and flow rates. Costs are separated into pre-trial and trial costs, and for each, court and prosecutor's costs.* In addition, there is a cost of pre-trial detention.

The flows through the appropriate processing states permit calculating annual workloads in terms of total trial-days for jury and bench (i.e., judge) trials and man-days for pre-trial detention in jail. The annual manpower requirements (e.g., the required number of prosecutors, judges, and jurors) are then calculated on the basis of unit productivity (e.g., annual trial days available per prosecutor).

Some illustrative results were developed based on data principally from California (Ref. 10); these are discussed in Section V. In some cases, where California data were unavailable, data from other jurisdictions were invoked. The input data are presented in Table 2.

It is interesting to note, for instance, that P_{t_1}, the probability that a defendant will receive a jury trial,** increases with the severity of the offense, but never exceeds 0.20. Regardless of crime type, a majority of those who reach trial plead guilty. Probabilities of being found guilty in a trial are roughly three-quarters.

Table 2 also shows time and cost data. The average jury trial length, T_1, ranges between 4.3 and 1.7 days,*** depending on type of crime. The average cost per day of a jury trial was computed by first allocating the total court costs to "judgeships," and then dividing the judgeship annual cost by the annual number of judge working days spent in trial.† This obviously simplified cost allocation procedure clearly needs much more refinement when the necessary cost data become available.

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*Much of the court costs data were estimated from other jurisdictions, particularly Washington, D.C., and the Federal Court System.

**The numerical estimate of P_{t_1} is formed by computing the ratio (number of jury trial defendants/total number of defendants) for a given year.

***A trial day is typically five hours in length.

†There are additional court costs to the prosecutor and to police investigators, attributed before and during trial.

TABLE 2. CALIFORNIA INPUT DATA TO THE PROSECUTION AND COURTS MODEL

	Homicide	Robbery	Assault	Burglary	Larceny	Auto Theft	Rape
P_{t_1}	0.20	0.18	0.12	0.07	0.06	0.03	0.11
P_{t_2}	0.20	0.13	0.25	0.17	0.20	0.16	0.21
P_{tg}	0.57	0.61	0.52	0.67	0.66	0.75	0.58
P_{tg_1}	0.81	0.81	0.75	0.78	0.68	0.83	0.54
P_{tg_2}	0.68	0.71	0.77	0.71	0.89	0.75	0.61
T_1	4.3	2.4	2.4	1.7	2.2	2.0	4.0
C_j	2580	1440	1440	1020	1320	1200	2400
T_2	0.6	1.5	1.0	1.3	1.5	2.0	1.0
C_b	222	555	370	481	555	740	370

T_1, T_2 = Average number of jury (T_1) and bench trial (T_2) days/case.

C_j, C_b = Average jury (C_j) and bench trial (C_b) cost/trial.

However complex this model may appear, it is still a gross simplification of reality. Each processing stage represents a number of detailed processing stages in the real system; the description could have been made more detailed, but the finer data were not available, and little but complexity would have been gained.

The unit costs at each processing stage have been calculated simply by dividing current total yearly cost by current yearly workload. This implied linear relationship between flow and cost (i.e., all costs are variable) ignores the fact that many costs are fixed and independent of flow (e.g., the cost of courthouses). However, this simplification also avoids the problem of having to identify which costs are fixed and which are variable, since many costs that are fixed over a slight variation in flow become variable if there is a large variation in flow. By this costing procedure, certain facilities which may currently be operating well below capacity (e.g., rural courts) would show an excessively high unit cost.

The variables in the model are assumed to be constant over time (a steady-state assumption) and independent of each other or of exogenous variables. There undoubtedly are interactions that limit the validity of this simplification. Certain service times (e.g., detention time) and branching ratios (e.g., probability of prison sentence) are probably a function of the magnitude of demands. Such interactions need further examination.

Despite these limitations, the model does permit a reasonable first estimate of costs, workload, and flows and allocation of these to crime type and processing stage. Furthermore, these planning variables can be projected into the future if the crime or arrest rate can be projected, and if the branching probabilities are either constant or can be projected.

IV. SENSITIVITY ANALYSES

An important phase of the analysis is to determine the effect of changes in one subsystem on the workload, costs, and manpower requirements of another subsystem. For instance, if there were indications that an improved fingerprint recognition system would increase the burglary arrest rate (i.e., arrests per burglary), it would be necessary to plan for the increased cost and workload effect on the subsequent court and corrections subsystems. In addition, the allocation of costs to various subfunctions is of interest in considering possible reallocation of resources. A sensitivity analysis permits an examination of this distribution.

Given any two system flows, C_i and N_i ($i = 1, 2, \ldots, I$) we find it useful to define the following two quantities:

$\dfrac{\partial C_i}{\partial N_i}$ = incremental change in C_i per unit change in N_i (first partial derivative of C_i with respect to N_i)

$\left(\dfrac{\partial C_i/C_i}{\partial N_i/N_i}\right)$ = incremental fractional change in C_i per unit fractional change* in N_i ("elasticity" of C_i with respect to N_i)

To indicate the interpretation of these two quantities, suppose C_i represents the cost at stage 12 associated with processing individuals charged with crime i. Consider that N_i represents the flow of persons into stage 6. In terms of N_i, suppose C_i is linearly related to N_i, i.e., it can be written as follows:

$$C_i = A_i + B_i N_i$$

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*A "unit fractional change" could be, for instance, a 1 percent change.

Then,

$$\frac{\partial C_i}{\partial N_i} = B_i$$

= Average additional cost incurred for processing at stage 12 per additional individual charged with crime i inserted at stage 6.*

$$\left(\frac{\partial C_i/C_i}{\partial N_i/N_i}\right) = \frac{B_i\ N_i}{A_i + B_i\ N_i}$$

= Average fractional increase in cost incurred at stage 12 for processing individuals charged with crime i per unit fractional increase in individuals charged with crime i inserted at stage 6.

More succinctly, the first partial derivative in this case is an incremental cost per person and the elasticity is the fractional increase in cost per unit fractional increase in the number of persons.

As an example, we may be interested in the incremental change in total system direct operating cost C_t due to the addition of one robbery defendant in the flow N_{ad_1}, the number of adults who are charged with a felony in magistrate's court. For this case, the incremental cost per additional robbery defendant (i.e., $\partial C_t/\partial N_{ad_1}$ robbery) is calculated to be \$4800. This means that an average robbery defendant who has just been charged by a magistrate's court will cost the system \$4800 (for the current offense) in addition to costs already incurred in previous stages. The value of \$4800 is the expected value of the total subsequent costs (i.e., the sum of each of the unit costs after magistrate's court weighted by the probability that the defendant passes through each particular processing stage).

If C_i is a flow, then $\partial C_i/\partial N_i$ is an incremental flow per additional person inserted. For instance, if we let C_i be the number of jury trials for robbery defendants (the robbery component of N_{t_1}) and

*This cost could be calculated directly as the product of the unit cost of processing at stage 12 and the probability that an individual inserted at stage 6 will reach stage 12. That probability is not explicitly calculated.

N_i be the robbery component of N_{ad_1} (the number of adults charged with a felony in magistrate's court), then the incremental number of robbery jury trials per additional robbery defendant from magistrate's court is calculated to be 0.10. This figure can also be interpreted as the probability that a randomly selected robbery defendant from magistrate's court will proceed to the next stage and have a jury trial.

Now let us consider an example involving elasticity. Suppose that C_i is the number of burglary defendants placed on straight probation, the burglary component of N_{s_1}, and that N_i is the number of defendants found guilty of burglary in jury trials, the burglary component of N_{tg_1}. We calculate that $(\partial C_i/C_i / \partial N_i/N_i) = 0.07$. This means that a 1 percent increase in the number of burglary defendants found guilty in jury trials would cause a 0.07 percent increase in the number of burglary defendants placed on straight probation.

Other illustrative calculations made for the 1965 California CJS system are shown in Tables 3 and 4. Table 3 shows various incremental costs per additional reported crime. Of the crimes presented,* robbery costs are highest ($1084), primarily because of the high increment in corrections cost. The incremental costs for burglary are lowest. These calculated costs combine many factors including the probability of apprehending a suspect, the dismissal probabilities along the way, and the costing procedure.**

*No entries are given for homocide or larceny because of the lack of uniformity of definition of these two crimes in the various processing stages. For instance, police report the incidence of "grand theft, except auto" whereas most (but not all) other processing stages report the number of defendants associated with "theft except auto," a larger category which includes petty theft with prior and receiving stolen property offenses. (See Ref. 10, 1965, pp. 207-209). Even for the five crime types considered here there are minor deviances of definitions in various parts of the system.

**The procedure for calculating police costs was a product of time components and time pay rates. For detectives, the time components were preliminary investigation, arrest, and case development. Cost assignment for the police patrol force is somewhat more troublesome. The force spends a large fraction of its time on "preventive patrol," and it is difficult to apportion this time to individual crimes. In the current model, a lower bound on patrol costs was used. The time allocated to crimes was taken as twice the average time to service a call.

TABLE 3. INCREMENTAL COSTS PER REPORTED CRIME
(In Dollars)

	Robbery	Assault	Burglary	Auto Theft	Rape
C_t	1084	433	153	155	957
C_{co}	843	215	86	58	607
C_{ct}	63	45	12	15	153
C_p	70	44	32	22	106
C_{pd}	60	37	21	14	92

C_t = total system cost
C_{co} = cost of the corrections system
C_{ct} = cost of the prosecution and courts system
C_p = cost of police
C_{pd} = cost of police detectives

TABLE 4. INCREMENTAL FLOWS PER ARREST
(Including Juvenile Arrests)

	Robbery	Assault	Burglary	Auto Theft	Rape
N_I	0.41	0.09	0.09	0.04	0.16
N_P	0.10	0.02	0.03	0.02	0.03
N_{Bt}	0.02	0.04	0.02	0.02	0.06
N_{Pg}	0.12	0.07	0.09	0.08	0.16
N_C	0.19	0.14	0.14	0.11	0.28

N_I = number of adult-years served in prison
N_P = number of adults sentenced to prison directly from Superior Court
N_{Bt} = number of adults having bench trials
N_{Pg} = number of adults who plead guilty
N_C = number of adults who receive a Superior Court disposition

Table 4 presents incremental flows resulting from one additional arrest. The entry in the first row (additional number of adults in prison) is the average man-years served in prison per additional arrest. This can also be interpreted to be the incremental prison population per additional arrest. All other entries have a probabilistic interpretation; for instance, entries in the second row indicate that 10 percent of those arrested for robbery are sentenced to prison from Superior Court as compared to only 2 percent of those arrested for assault.

V. ESTIMATION OF FUTURE REQUIREMENTS

Administrators of the CJS at all levels, from state attorneys general, crime commissions, and budget directors to planners in the various local agencies, require projections of future workloads, costs, and manpower requirements. These projections are needed for earlier decisions which must be made in anticipation of future changes in workload. For instance, new buildings (e.g., courts or correctional institutions) can be designed and constructed or additional personnel can be hired and trained.

In this section, we report two applications of the model, using data from the State of California. First, we investigate the degree to which the branching probabilities are constant. Following that, we project for California workloads, costs, and manpower requirements into the year 1970 on the basis of data collected through 1965. Since the number of reported crimes is a basic input to the model, we must independently predict the number of crimes that will be reported; a linear extrapolation is used for that prediction. Then we develop estimates of the number of arrests per year and use the model to obtain predictions of CJS workloads, costs, and manpower requirements.

A. TREND IN THE NUMBER OF ARRESTS PER REPORTED CRIME

A comparison of system branching ratios over a five-year period indicated that system workload is most sensitive to changes in the average number of arrests per reported crime.

The branching probabilities P_{ac} (the number of arrests per reported crime*) for California in the years 1961 through 1965 are shown in Fig. 4 for aggravated assault, robbery, auto theft, grand theft,** and burglary. (The crimes of homicide and rape are not included because the definition of these crimes changes from the crime report to the arrest stages.) Each rate exhibits a negative slope, with robbery showing the greatest rate of decrease. Indeed, arrests for robbery have shown a marked decline of about 32 percent from 0.83 per reported crime in 1961 to 0.57 per reported crime in 1965. Burglary arrest probability has decreased by approximately 20 percent.*** The general downward trends could be caused by a combination of several factors:

(1) More frequent reporting of crimes to or by police;

(2) More accurate police classification of reported crimes;

(3) Fewer arrests of individuals not associated with the crimes;

(4) Saturation of limited police manpower resources; and

(5) Greater difficulty in solving crimes, due to such problems as mobility of criminals, lowered citizen cooperation, etc.

Many other possible reasons could be advanced. Without having to attribute cause, however, it is possible to project P_{ac} somewhat into the future. This parameter describes the system's first processing stage of arrest and its value linearly affects workloads and costs in all other system stages.

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*Numerical values for P_{ac} are computed simply by dividing the total number of arrests (adults and juveniles) by the total number of crimes reported. Strictly speaking it is an estimate of the average number of arrests per reported crime. We often refer to it as the "arrest probability," knowing that some crimes generate more than one arrest and that the suspect arrested may not be the perpetrator of the particular reported crime of interest.

**In California, "grand theft" is larceny of $200 or more.

***More recent data which have since become available indicate a continuation in these trends. For the year 1966, the number of arrests per reported robbery dropped to 0.52, per burglary to 0.21, and per assault to 0.59. Auto theft and grand theft probabilities remained about constant.

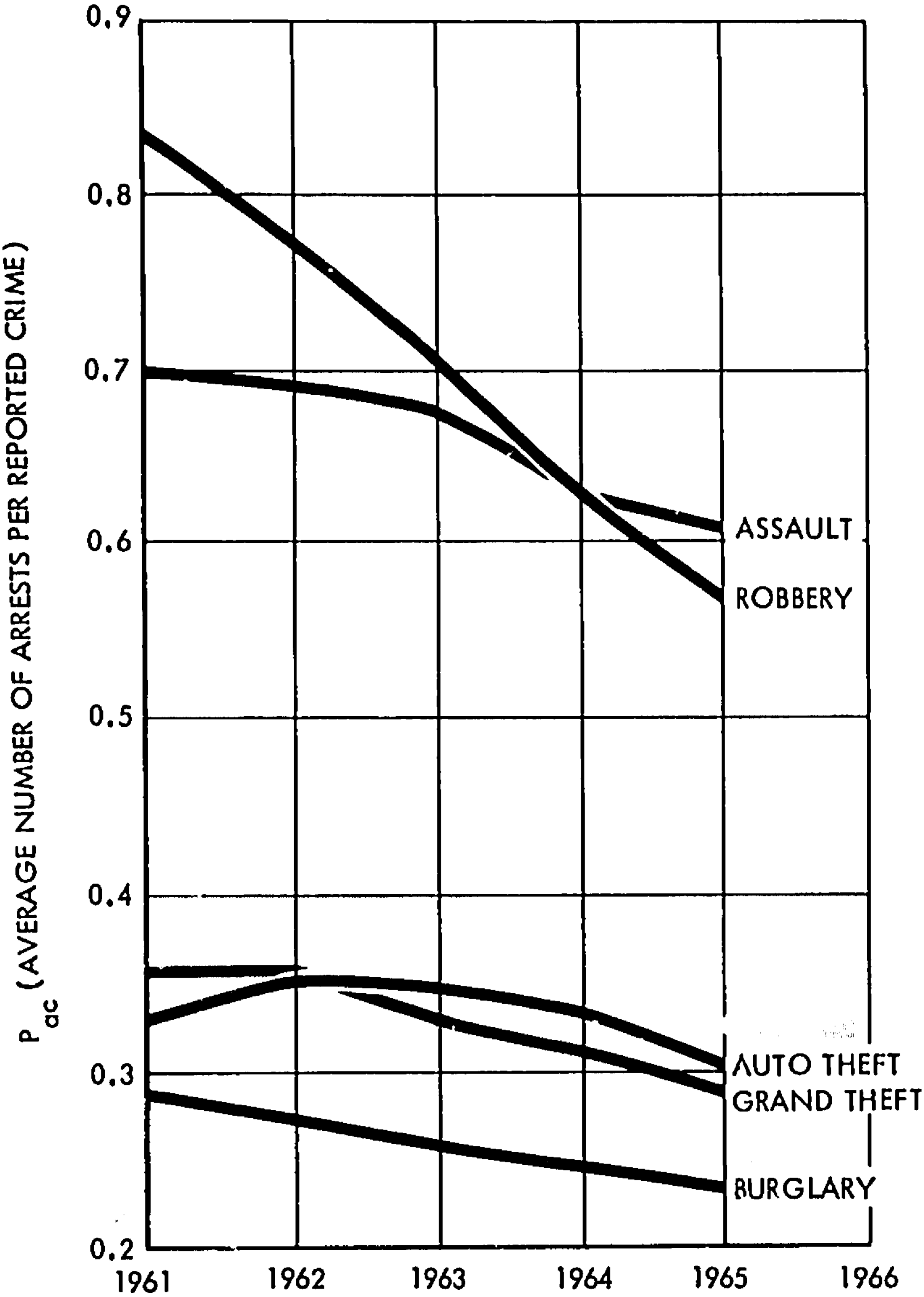

FIGURE 4. P_{ac} Versus Time

B. TRENDS IN FINAL DISPOSITION PERCENTAGES

To further test the constancy of the branching ratios, a linear extrapolation was performed to estimate trends in the other branching ratios for California. Specifically, for each of the years 1960 through 1965, the ratios of final disposition of adult felony arrests to total arrests were investigated. The final dispositions were:

(1) Released

(2) Assigned to other jurisdiction

(3) Dismissed

(4) Acquitted

(5) Misdemeanor prosecution

(6) Superior court conviction

- (a) Civil commitment
- (b) Prison
- (c) Youth Authority
- (d) Probation
- (e) Jail and fine

The most significant* trend ($t = 5.3$)** was found in the fraction receiving probation. During 1960 through 1965, a fraction of approximately 0.13 of felony arrests received probation at the sentencing stage and this value is increasing 0.00631 per year. No other trends were significant (at the 0.05 level) and none was as important as the trend in P_{ac}.

Although not all of the individual branching ratios were examined in detail, the steady-state assumption appeared justified for all important branching ratios except P_{ac} and those relating to the probation decision.

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*Significance was tested with a student's t-test of the difference from zero of the linear time term.

**This value of t causes us to reject, even at the $\alpha = 0.001$ level of significance, the hypothesis that there is no linear time trend in the fraction receiving probation.

In making projections with the model, it was especially important to consider the downward trend in P_{ac} since changes in this fraction propagate throughout the entire system. It was felt that for short-range projections, it would not be necessary to adjust the probation or other branching ratios.

For short-range projections, it was decided to compute output in two ways:

(1) To extrapolate linearly the trends in P_{ac} and use the resulting projection of P_{ac}, and

(2) To use the 1965 value of P_{ac}.

These two projections can be expected to bound the actual future values. In our calculations, we use the average of the two projections.

C. CRIME PROJECTION

The future numbers of crimes reported to police were projected using a linear time extrapolation of the reported crimes for the years 1958 through 1966.* The results of this analysis are shown in Table 5. All the correlation coefficients except for the crime of forcible rape** exceed 0.95, indicating that the linear fit is a good one. Particularly important to CJS administrators are the yearly growth coefficients given in the last column. Note that the number of reported burglaries is increasing by the largest magnitude at 16,534 per year.***

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*Uniform Crime Reports' figures for California were used. The definitions of some of the seven crimes are different from the "seven major offenses" of California. Most notably, larceny of $50 and over is counted by the FBI as an index offense whereas "grand larceny" in California requires theft of property values at $200 and over.

**In contrast to a simple linear relationship, the number of reported rapes was found to remain approximately constant (about 3000 per year) until 1964 when it jumped to 3621, and then to 4432 in 1966.

***With 95 percent confidence, the yearly growth coefficient is between 13,000 and 20,000 burglaries per year.

TABLE 5. LINEAR PROJECTION OF INDEX CRIMES
REPORTED TO POLICE IN CALIFORNIA

Offense	Mean No. of Reported Crimes 1958-1966 (N=9)	Standard Deviation of Reported Crimes 1958-1966	Standard Error of Linear Estimate	Correlation Coefficient of Estimating Equation	Constant Term in Equation	Linear Coefficient in Equation (Yearly Increment)	T-Value of Linear Term
Criminal Homicide	677.6	128.2	42.47	0.956	440	47	8.656
Forcible Rape	3309.3	528.0	302.0	0.863	2427	177	4.528
Robbery	16501.2	3402.7	1144.5	0.955	10209	1259	8.518
Aggravated Assault	21724.2	4402.5	1046.4	0.978	13338	1667	12.341
Burglary	168022.7	43403.8	8310.9	0.983	85351	16534	14.373
Grand Larceny	97146.1	27735.6	7948.9	0.968	45060	10417	10.151
Auto Theft	62059.7	14957.6	4565.2	0.953	34163	5579	9.467

Data Source: Uniform Crime Reports for 1958 through 1966.

D. ARREST PROJECTION

Using the predictions of reported crimes from the regression analysis, the approximate upper and lower estimates (keeping P_{ac} constant and projecting its trend, respectively) for the number of arrests in 1970 is given in Table 6. The results are expressed as percentages of the numbers of arrests in 1965. The upper estimate indicates about a 30 percent increase in system workload during this five-year interval while the lower estimate indicates that the increasing trend in reported crimes is about compensated by the decreasing trend in arrest probability, and so system workloads will remain about constant (with some fluctuations by crime type, of course). If the declining trend in robbery arrest probability were to continue, the robbery arrest workload in 1970 would be about half that of 1965. On the other hand, it appears that the arrest probability for auto theft has almost kept pace with the increasing number of reported auto thefts; auto theft exhibits the largest lower estimate in Table 6.

TABLE 6. PROJECTED NUMBER OF ARRESTS BY CRIME TYPE IN 1970
(Expressed as a Percentage of the Number of Arrests in 1965)

	Homicide	Forcible Rape	Robbery	Aggravated Assault	Burglary	Grand Larceny	Auto Theft
Upper Estimate	129.6	124.2	129.8	132.0	138.0	140.4	134.2
Lower Estimate	-	-	55.7	109.0	100.0	93.5	121.0

To project a numerical value for arrests in 1970, we arbitrarily average the upper and lower bounds in Table 6. These results are as follows:

Crime Type	Projected Number of Arrests in 1970, Expressed as a Percentage of the Number of 1965 Arrests
Homicide	129.6
Forcible rape	124.2
Robbery	92.7
Aggravated assault	120
Burglary	119
Grand larceny	117
Auto theft	128

E. PROJECTIONS OF SYSTEM VARIABLES

Using these arrest projections we can compute, using the steady-state model, projected values of system variables in 1970. Several of these calculations are shown in Table 7. We see that a projected total of 119 additional detectives and 73.9 additional patrolmen will be required to handle increases in the seven major crimes. A projected total of 1403 additional defendants will be placed on probation in 1970. The additional yearly cost to California's criminal justice agencies for increases in the seven major crimes is computed to be

$17.3 million. About 41.6 percent of this additional cost is due to additional burglary workloads, about 22.5 percent to additional auto theft workloads. In the 1965 calculations, burglary costs accounted for 31 percent of the total and auto theft costs 10 percent. Grouping auto theft, burglary, and larceny as the "property crimes," they accounted for 54 percent of the cost in 1965 but are projected to account for 57 percent in 1970.

TABLE 7. PROJECTED INCREASES IN VALUES OF CJS VARIABLES IN CALIFORNIA FROM 1965 TO 1970

	Homicide	Rape	Robbery	Assault	Burglary	Theft	Auto Theft	Total
N_{adl}	900* +270	1700 +400	4200 -300	4600 +920	13700 +2600	4400 +750	4400 +1200	33900 +5840
M_d	24 +7	22 +5	85 -6	65 +13	310 +60	115 +19	75 +21	696 +119
U_p	3600 +1000	4500 +110	35000 -2600	31000 +6200	415,000 +78000	45000 +7400	115,000 +32000	649,100 +122,110
N_{t_1}	210 +60	100 +25	420 -30	260 +53	500 +94	195 +33	77 +22	1762 +257
M_p	2.1 +0.6	5.3 +1.3	21 -[illegible].5	18 +4	240 +46	26 +4.5	67 +19	379.4 +73.9
N_{t_2}	140 +40	190 +50	290 -20	570 +110	1200 +220	700 +120	410 +115	3500 +635
N_s	670 +200	700 +170	1950 -140	1800 +360	5900 +1200	3000 +520	2300 +640	16320 +2950
N_{s_1}	100 +30	280 +70	95 -7	600 +120	1200 +230	1000 +170	500 +140	3775 +753
N_{s_2}	160 +50	150 +40	290 -20	420 +75	1400 +270	660 +110	440 +125	3520 +650
N_{s_4}	370 +110	110 +30	1200 -85	340 +70	1450 +280	420 +70	400 +110	4290 +585
C_t ($ Million)	8.1 +2.4	3.3 +0.8	23 -1.7	11 +2.2	38 +7.2	15 +2.5	14 +3.9	112.4 +17.3

*For each pair of entries, the projected increase is given below the 1965 value.

Definitions for Table 7:

N_{ad_1} = Number of adult felony arrests which result in a felony charge

M_d = Total number of detectives required

U_p = Total number of patrolman man-hours allocated (to these crimes)

M_p = Total number of patrolmen required (for these crimes)

N_{t_1} = Number of jury trial defendants

N_{t_2} = Number of bench or transcript trial defendants

N_s = Number of convicted defendants

N_{s_1} = Number of convicted defendants granted straight probation

N_{s_2} = Number of convicted defendants granted probation with jail as a condition

N_{s_4} = Number of convicted defendants sentenced to state prison

C_t = Total system direct operating costs

F. EXTENSIONS AND FURTHER ANALYSES WITH THE LINEAR MODEL

These projections can be expected to deviate from the future observations. The differences will result from inadequacies of the current model, errors and incompleteness in the reported data, and basic change in the operation of the California CJS. As actual results are compared with past projections, calibration of the model and the data sources will result, leading to an improved projection methodology.

As the model is improved, other useful analyses can be performed. The effects on CJS operations of significant changes in system branching ratios can be explored. For instance, introduction of new police hardware (e.g., an electronic automobile license plate scanner or automated fingerprint files) might dramatically change one or more branching ratios (e.g., the probability of arrest for auto theft or burglary) and thus affect the workloads at subsequent stages. More widespread provision of free defense counsel, especially for juveniles as a result of recent court decisions, might provide additional strain on prosecution and court workloads. Greater use of nonadjudicative treatment (e.g., use of social service agencies as an alternative to prosecution) will require the introduction of additional flow routes in the model and can be expected to reduce court workloads. A change in sentencing policies (e.g., more use of community treatment or longer sentences) might affect decisions on construction of new correctional facilities or hiring and training of additional parole and probation personnel.

Crime projections can be improved by taking into account changes in such demographic characteristics as age, income, education, and urbanization. Similarly, since many of the branching ratios also depend on these characteristics, they can be used for more accurate estimation throughout the system.

In our model, the branching ratios were assumed to be mutually independent. In a number of cases, interaction can be expected. For instance, if the number of convictions increases, and if prisons operate near capacity, one might expect a reduction in probability of prison sentence or the time served. Such interaction must be explored to improve the model.

VI. FEEDBACK MODEL

This section summarizes a feedback model which describes the recycling through the CJS during the course of an individual's criminal career. The model has several important applications. First, given the age of an offender at first arrest and the crime for which he is arrested, the model computes his expected criminal career profile (i.e., the expected crimes for which he will be arrested at each age). Second, using the cost results of the linear model, the average costs incurred by the CJS over a criminal career are computed. Third, recidivism parameters (e.g., rearrest probabilities) can be varied to assess how each parameter affects criminal careers and cost. For instance, we can study the effect of an intensive rehabilitative program that reduces rearrest probability by a specified amount. Fourth, and most fundamental, the model provides a unified framework in which to study the process of recidivism and in which to test the effects on recidivism of proposed alternative CJS policies.

A. OVERALL STRUCTURE OF THE MODEL

As in the linear model, flows are distinguished by crime type. In addition, each flow variable is broken down by the offender's age. Input to the model, rather than crimes reported to police, is the numbers of arrests during a year, by crime type and by age, of individuals who have never previously been arrested for one of the crimes being considered. In the model, these "virgin" arrests are added to recidivist arrest (i.e., arrests of individuals who have previously been arrested) to obtain the total arrests during the year.* The total arrests then proceed through the CJS just as they do in the linear model.

Since the offender flows comprise individuals who cycle back into the system after dismissal or release from the CJS, it is necessary to compute the number that do recycle, when they are rearrested, and for what crime. At each possible dismissal point, the offender is characterized by a probability of rearrest which is, in general, a function of his age and his prior criminal record. The expected number who will be rearrested at some later time is computed by multiplying the number in the flow by the appropriate rearrest probability. Then, the age at rearrest is computed using the distribution of delay between release and the next arrest. Finally, the crime type of the next arrest is computed from a rearrest crime-transition matrix where the matrix element p_{ij} is the conditional probability that the next arrest is for crime type j, given that rearrest occurs and the previous arrest was for crime type i ($1 \le i, j \le I$). A flow diagram of the model is given in Fig. 5.

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*Although reported crimes are a more adequate variable upon which to compute police workloads and the overall magnitude of the crime problem, arrest is the first event linking crime to a specific individual. Statistics describing recidivism often use arrest as the index of recidivism, even though the arrest may not necessarily indicate that one or more crimes have been committed by the individual arrested. In this model, recidivism is consistently measured by rearrest. Using arrest as the basis for measuring recidivism introduces two types of error: crimes for which no offender is arrested are not counted, and offenders who are erroneously arrested are counted. Using a later stage for counting (e.g., conviction) would introduce the additional, more serious error of omitting the many crimes for which evidence is insufficient to warrant conviction. In much of the criminological literature, where the concern is principally on the corrections process (e.g., Glaser (Ref. 11)), recidivism is often defined in terms of the imprisonment-to-imprisonment cycle. It should be clear that, for the same amount of crime repetition, the measured probability of recidivism decreases as one measures it at stages of successively deeper involvement into the CJS. Thus, FBI estimates (UCR/1966) of rearrest recidivism of about three-quarters are consistent with Glaser's (Ref. 11) estimate of reimprisonment recidivism of about one-third due to the arrests which do not result in imprisonment. A simple Markov model, using a reasonable value of 0.75 for arrest-to-imprisonment attrition probability, shows this compatibility.

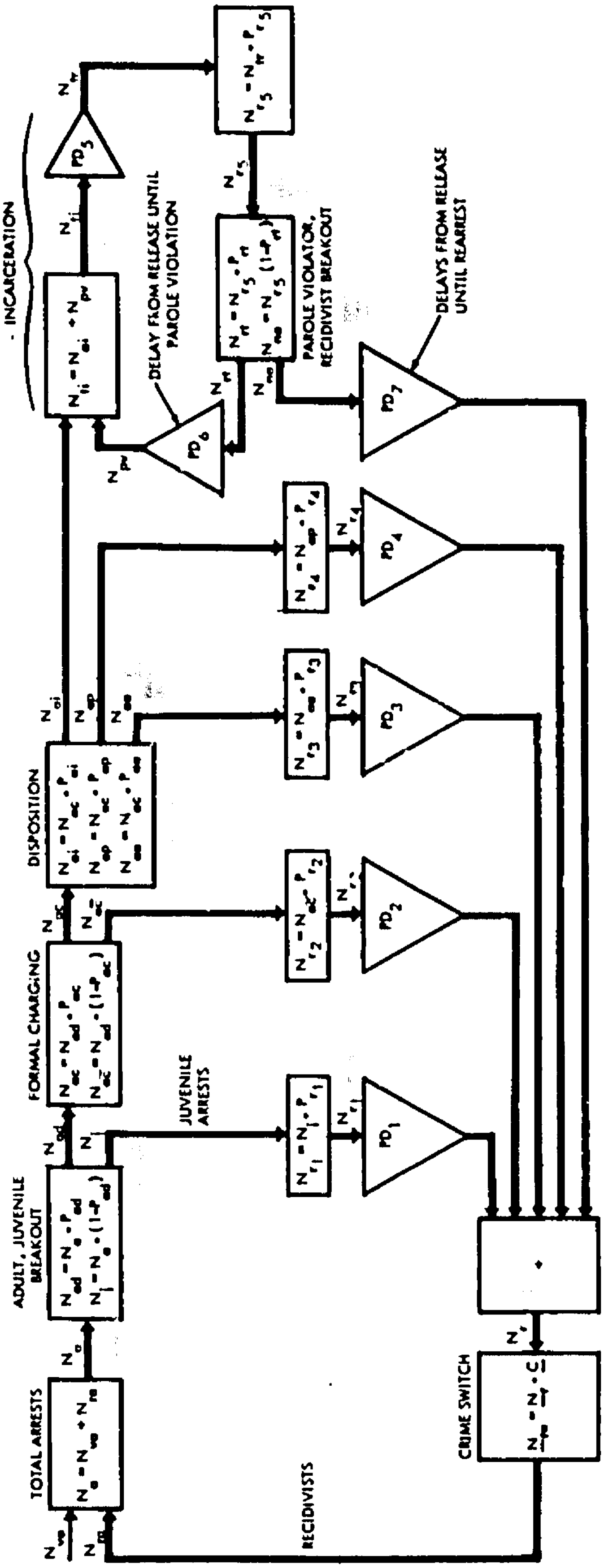


FIGURE 5. Flow Diagram of the Feedback Model

DEFINITIONS OF SYMOBLS IN FIGURE 5

VARIABLE OR PARAMETER NAME	DEFINITION
N_{va}	NUMBER OF VIRGIN ARRESTS
N_{ra}	NUMBER OF RECIDIVIST ARRESTS
N_a	TOTAL NUMBER OF ARRESTS
N_{ad}, P_{ad}	NUMBER (PROPORTION) OF ARRESTS WHICH ARE ADULT ARRESTS
N_j	NUMBER OF ARRESTS WHICH ARE JUVENILE ARRESTS
N_{ac}, P_{ac}	NUMBER (PROPORTION) OF ADULT ARRESTS FORMALLY CHARGED
$N_{\bar{ac}}$	NUMBER OF ADULT ARRESTS NOT FORMALLY CHARGED
N_{ai}, P_{ai}	NUMBER (PROPORTION) OF CHARGED ADULTS INCARCERATED
N_{ap}, P_{ap}	NUMBER (PROPORTION) OF CHARGED ADULTS GRANTED PROBATION
N_{aa}, P_{aa}	NUMBER (PROPORTION) OF CHARGED ADULTS RELEASED OR ACQUITTED
N_{ti}	TOTAL NUMBER OF ADULTS WHO ARE INCARCERATED
N_{tr}	NUMBER OF ADULTS RELEASED FROM INCARCERATION
N_{r_1}, P_{r_1}	NUMBER (PROPORTION) OF ARRESTED JUVENILES WHO ARE REARRESTED
N_{r_2}, P_{r_2}	NUMBER (PROPORTION) OF ADULTS ARRESTED BUT NOT FORMALLY CHARGED WHO ARE REARRESTED
N_{r_3}, P_{r_3}	NUMBER (PROPORTION) OF ADULTS RELEASED OR ACQUITTED WHO ARE REARRESTED

VARIABLE OR PARAMETER NAME	DEFINITION
N_{r_4}, P_{r_4}	NUMBER (PROPORTION) OF ADULTS GRANTED PROBATION WHO ARE REARRESTED
N_{r_5}, P_{r_5}	NUMBER (PROPORTION) OF ADULTS RELEASED FROM INCARCERATION WHO RECIDIVATE*
N_{rr}, P_{rr}	NUMBER (PROPORTION) OF ADULTS RELEASED WHO VIOLATE PAROLE AND ARE REINCARCERATED
N_{pv}	NUMBER OF ADULT PAROLE VIOLATORS WHO REENTER PRISON
N_{na}	NUMBER OF ADULT RELEASES WHO ARE REARRESTED
N_r	TOTAL NUMBER OF THOSE WHO WILL BE REARRESTED
$\underline{C}$	REARREST CRIME -TRANSITION MATRIX
PD_1	DISTRIBUTION OF TIME UNTIL REARREST OF JUVENILE RECIDIVISTS
PD_2	DISTRIBUTION OF TIME UNTIL REARREST OF ADULTS NOT FORMALLY CHARGED AND WHO ARE REARRESTED
PD_3	DISTRIBUTION OF TIME UNTIL REARREST OF ADULTS ACQUITTED OR RELEASED AND WHO ARE REARRESTED
PD_4	DISTRIBUTION OF TIME UNTIL REARREST OF ADULTS GRANTED PROBATION AND WHO ARE REARRESTED
PD_5	DISTRIBUTION OF TIME FROM ENTRANCE UNTIL RELEASE FROM PRISON
PD_6	DISTRIBUTION OF TIME FROM PRISON RELEASE UNTIL PAROLE VIOLATION, FOR THOSE ADULTS WHO VIOLATE PAROLE
PD_7	DISTRIBUTION OF TIME UNTIL REARREST OF ADULTS RELEASED FROM PRISON AND WHO ARE REARRESTED

*ADULTS RELEASED FROM INCARCERATION WHO RECIDIVATE EITHER VIOLATE PAROLE OR ARE REARRESTED.

There are two different interpretations of the computed flows: as a cohort-tracing model or as a population-simulation model. In the first, a cohort of virgin arrests can be inserted at some age and the aggregate criminal career of that cohort can be traced. For a 15-year old cohort, for instance, the model will compute the expected number of arrests by crime type incurred at ages 16, 17, etc. Alternatively, in the second case, we can input as virgin arrests the total present distribution of such arrests, by age and by crime type; in this case, invoking a steady-state assumption, the computed flows represent the current distribution of all individuals (including recidivists) processed by the CJS. With this interpretation, the computed number of arrested 20 year olds, for instance, represents arrests of both virgins and recidivists. If the virgin-arrest distribution were known for the U.S., this use of the model would be a good check on the validity of the model.

B. BRANCHING RATIOS

Many details explicitly treated in the linear model are aggregated in the feedback model. Only four branching probabilities are required to determine flows through the trial stage:

(1) P_{ac} = probability that an arrested adult is formally charged with a felony

(2) P_{ai} = probability that an adult who is charged will be incarcerated in a state correctional institution

(3) P_{ap} = probability that an adult who is charged will be placed on probation or in a local jail

(4) P_{aa} = probability that an adult who is charged is dismissed before or during trial or is acquitted.

The values of these probabilities that were used in the current model are given in Table 8, based on California statistics (Ref. 10).

One of the facts noted from these data is that assault charges, most of which result from attacks on relatives or acquaintances, frequently result in dismissal and only rarely in incarceration. A similar situation exists for rape charges. Larceny charges, probably many of which are against first offenders, most often lead to probation.

TABLE 8. BRANCHING RATIOS FOR RECIDIVISM MODEL

	Homicide	Robbery	Assault	Burglary	Larceny	Auto Theft	Rape
P_{ac}	0.68	0.41	0.34	0.50	0.53	0.42	0.59
P_{ai}	0.43	0.35	0.09	0.15	0.12	0.17	0.10
P_{ap}	0.29	0.22	0.31	0.27	0.55	0.35	0.30
P_{aa}	0.28	0.43	0.60	0.58	0.33	0.48	0.60

Reference: Approximated from 1965 California data (Ref. 10).

C. REARREST PROBABILITIES

Rearrest probabilities are specified at each point of dismissal and are functions of age and crime of last arrest.* The variation with age of the offender is typically a gradual decrease after about 30 years of age. To approximate this decrease, we allowed the rearrest probability to be the following function of age:

$P_R(a)$ = probability that an offender dismissed at age $\underline{a}$ would be rearrested for an index crime

$$= P \text{ Min} \left\{1, \frac{1}{T-C} \text{ Max}(T-a,0)\right\}$$

This function is plotted in Fig. 6. The three parameters of this function have intuitive definitions:

P = probability of rearrest of individuals released who are less than C years of age at time of release.

*Rearrest probability data (e.g., the data on criminal careers in UCR/1966) exhibit a marked variation by type of crime of the last arrest and the type of disposition.

C = age at which the rearrest probability starts declining linearly to zero

T = age beyond which rearrest does not occur.

The values of these parameters are shown in Table 9 for two types of dispositions:

(1) Adults who are formally charged but not found guilty, and

(2) Adults who are found guilty and who are placed on probation or in a local jail.

These values were estimated from data presented in UCR/1966, pp. 32-42. There is a marked decrease in likelihood of recidivism for those placed on probation, even though they were found guilty.*

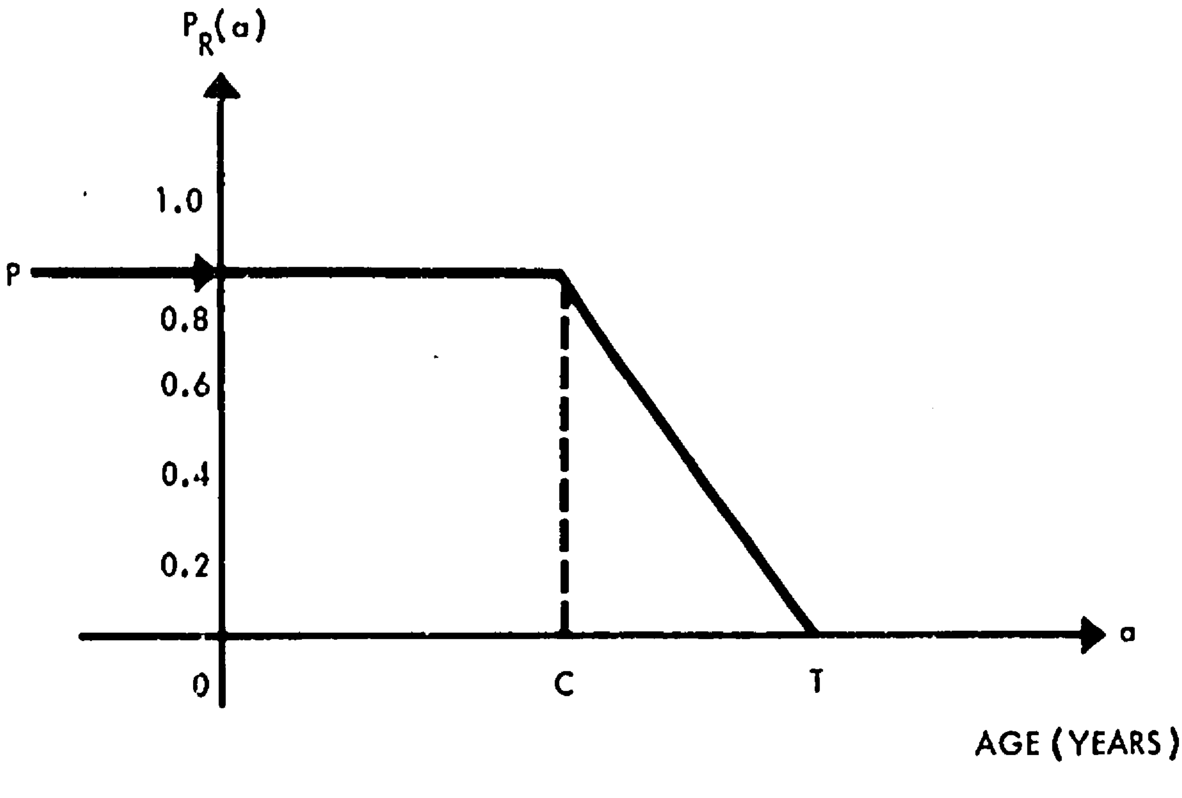


FIGURE 6. Rearrest Probability as a Function of Age

*It may be that supervision during the probationary period provided a relatively successful rehabilitative environment. Part of the effect noted, however, must be attributed to the selection of probationers since those granted probation were judged good risks during the pre-sentence investigation.

TABLE 9. PARAMETER VALUES FOR THE REARRL . PROBABILITY FUNCTION

		Homicide	Robbery	Assault	Burglary	Larceny	Auto Theft	Rape
Disposition 1	P	0.65	0.80	0.785	0.833	0.770	0.833	0.65
	C	40	35	40	35	40	60	25
	T	100	80	65	80	75	100	55
Disposition 2	P	0.25	0.573	0.375	0.572	0.539	0.675	0.33
	C	35	30	30	30	35	40	25
	T	100	80	64	75	75	100	55

Disposition 1: Adults who are formally charged but not found guilty.

Disposition 2: Adults who are found guilty and who are placed on probation or in a local jail.

D. TIME BETWEEN RELEASE AND REARREST

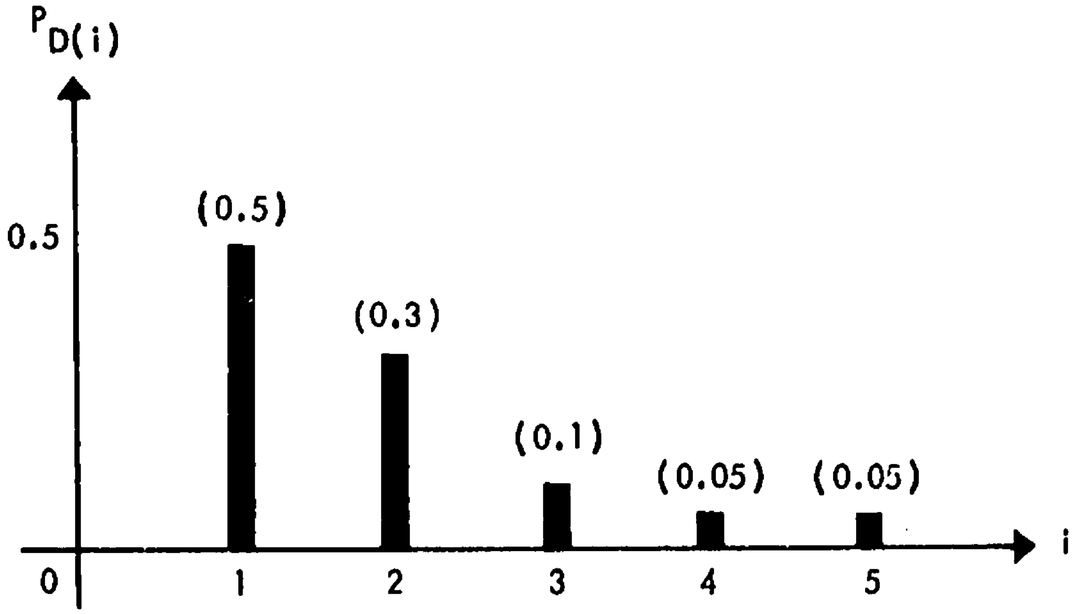
Data describing time between release and rearrest are sketchy, at best, and the distributions which were used were chosen to have a mean of about two years.* An illustrative delay distribution function of this time interval is given in Fig. 7.

E. REARREST CRIME-TRANSITION MATRIX

In the present model, the same crime-transition matrix is used for all recidivists, regardless of age and number of prior arrests. Even with this simplification, 42 independent probability estimates are required to specify the matrix for seven types of crime. Thus, a relatively large sample of recidivists is required for accurate estimation.

*A mean of two years was chosen to match the UCR/1966 statistics which showed that about 0.5 index arrests per year occurred from the start of an individual's criminal career. Delay distribution data for time from release on parole until parole suspension for parole violation are published for California (Ref. 12). These data, because of many unique characteristics about the parole process, are inadequate for the model.

Those few studies which have reported data from which a crime-transition matrix can be developed have either had an inadequate sample size or their sample was biased in some important sense. Table 10 presents the rearrest crime-transition matrix which was used in most of our studies. This matrix was based primarily on a sample of about 500 recidivists who were studied by the Minnesota Department of Corrections.* In this matrix, none of the on-diagonal terms is greater than 0.50, indicating a strong tendency to commit (or at least to be arrested for) different types of crimes.



$P_{D(i)}$ = PROBABILITY THAT THE DELAY FROM DISMISSAL UNTIL REARREST IS i YEARS, GIVEN THAT REARREST OCCURS (i IS A POSITIVE INTEGER).

FIGURE 7. Illustrative Distribution of Delay from Dismissal Until Rearrest

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*The data were obtained from Crime Revisited (Ref. 13), Minnesota Department of Corrections. The estimates for murder and nonnegligent manslaughter, forcible rape, and aggravated assault were best estimates based on inadequate data. The Federal Bureau of Prisons statistical tables (Ref. 14) for fiscal year 1965, were also used in estimating the matrix where the Minnesota sample was too small.

TABLE 10. REARREST CRIME-TRANSITION MATRIX 1[a]

	If arrested again for an Index crime, the probability it will be for --						
Last Index Arrest for	Murder and Nonnegligent Manslaughter	Forcible Rape	Robbery	Aggravated Assault	Burglary	Larceny ($50 and over)	Auto Theft
Murder and Nonnegligent Manslaughter[b]	0.025	0.025	0.150	0.400	0.200	0.100	0.100
Forcible Rape[b]	0.020	0.150	0.110	0.260	0.200	0.140	0.120
Robbery	0.015	0.010	0.350	0.060	0.350	0.115	0.100
Aggravated Assault[b]	0.025	0.040	0.150	0.300	0.085	0.200	0.200
Burglary	0.010	0.020	0.135	0.063	0.459	0.282	0.031
Larceny ($50 and over)	0.010	0.020	0.140	0.025	0.400	0.275	0.130
Auto Theft	0.010	0.027	0.045	0.028	0.390	0.222	0.278

[a] Based on data from _Crime Revisited_: Minnesota Department of Corrections; 1965 _Uniform Crime Reports_, pp. 29-31; and Federal Bureau of Prisons statistical tables, fiscal year, 1965.
[b] Best estimates based on inadequate data.

Table 11 presents a rearrest crime-transition matrix based on a sample of several thousand recidivists; it was computed primarily from the Federal Bureau of Prisons statistical tables for the years 1961 through 1965* (Ref. 14). The sample was biased in the sense that a disproportionate number of offenders had been arrested for federal offenses, the definitions of which often differ from those of local jurisdictions.** In this matrix, the on-diagonal terms for both burglary and auto theft are greater than 0.50, the burglary probability being higher at 0.63. We will compare results computed from the model using each of these matrices to see how the matrix affects the criminal careers depicted.

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*The entries for robbery, burglary, grand larceny, and auto theft were calculated from the Federal Bureau of Prisons statistical tables for the years 1961-65. The entries for forcible rape and aggravated assault were estimated from Ref. 15. The row for murder and nonnegligent manslaughter was set equal to the row for aggravated assault.

**An example is interstate auto theft, the perpetrator of which is prosecuted under the Federal Dyer Act.

TABLE 11. REARREST CRIME-TRANSITION MATRIX 2

	If arrested again for an Index crime, the probability it will be for --						
Last Index Arrest for	Murder and Nonnegligent Manslaughter	Forcible Rape	Robbery	Aggravated Assault	Burglary	Larceny ($50 and over)	Auto Theft
Murder and Nonnegligent Manslaughter[a]	0.03	0.03	0.12	0.31	0.26	0.14	0.11
Forcible Rape[b]	0.03	0.10	0.08	0.30	0.21	0.20	0.08
Robbery[c]	0.03	0.00	0.41	0.06	0.33	0.04	0.11
Aggravated Assault[b]	0.03	0.03	0.12	0.31	0.26	0.14	0.11
Burglary[c]	0.02	0.00	0.15	0.04	0.63	0.04	0.12
Larceny ($50 and over)[c]	0.01	0.01	0.12	0.06	0.40	0.15	0.25
Auto Theft[c]	0.01	0.00	0.10	0.03	0.29	0.06	0.51

[a] Set equal to the row for Aggravated Assault.

[b] Forcible Rape and Aggravated Assault based on District of Columbia data, Ref. 3, Appendix, p. 605.

[c] Robbery, Burglary, Grand Larceny and Auto Theft based on Bureau of Prisons statistical tables for the years 1961, 1962, 1963, 1964, 1965.

F. SIMPLIFYING THE ASSUMPTIONS OF THE CURRENT MODEL

Before this feedback model can be used confidently to make decisions regarding rehabilitative programs and overall allocation of resources, appropriate data must be collected and analyzed. Limitations of existing data have required that we make a number of simplifying assumptions in our model such as the following:

(1) Future criminal behavior is determined solely by the age of the offender, the crime for which he was last arrested, and the disposition of his last arrest.

(2) The arrest-transition matrix depends only on the crime type of the last arrest, not upon age, disposition, or otherwise upon prior criminal career.

(3) CJS branching ratios are not a function of age or prior criminal career.

(4) Delay until rearrest is a function only of disposition.

Because of these assumptions, the numerical results must still be treated with caution. The model, however, has identified the required data and provides the framework in which to use them once they become available.

VII. SOME RESULTS FROM THE FEEDBACK MODEL

Recognizing these limitations, some illustrative results were computed using the feedback model. In the first set of runs, 1000 20-year olds are first arrested for crime i (i = 1, 2, ..., 7) and their criminal careers are traced. Table 12 presents the mean number of subsequent career arrests for crime type j (the columns) among the population of 1000 people first arrested at age 20 for crime type i (the rows). This matrix was computed using the rearrest crime-transition matrix of Table 10.

TABLE 12. CAREER MATRIX FOR 20-YEAR OLD NEW ARRESTEES
(Using Rearrest Crime-Transition Matrix 1)

Crime of Original Arrest	Total Number of Career Arrests							Total Career Arrests per Person	CJS Direct Operating Costs, $
	Homicide	Robbery	Assault	Burglary	Theft	Auto Theft	Rape		
Homicide	1039	330	426	645	412	262	57	3.17	8100
Robbery	28	1486	154	816	427	230	41	3.19	4500
Assault	43	379	1402	687	561	395	78	3.55	3600
Burglary	28	371	176	2021	634	200	56	3.49	3500
Theft	26	336	128	900	1574	261	51	3.28	4000
Auto Theft	31	309	157	1034	657	1455	70	3.76	3500
Rape	34	296	326	656	437	269	1144	3.16	3[illegible]00

Those who are initially arrested for auto theft have the greatest average number of career arrests (3.76) and represent the only type of initial arrests which has an off-diagonal term greater than one (i.e., those first arrested for auto theft will be arrested for an average of

1,084 burglaries). Table 12 also presents the total average number of career arrests for the seven crimes, the career costs using results from the linear model.

For comparative purposes, in Table 13 we show the career arrest matrix for the same cohorts, but using the rearrest crime-transition matrix of Table 7. Overall, the total number of career arrests appears to be only slightly greater; the number of career grand theft and rape arrests appears to be significantly less. As we would expect, the total numbers of arrests (which depend principally on the rearrest probability) are much less sensitive to the crime-transition matrix than are the crime-type distributions.

TABLE 13. CAREER MATRIX OF 1000 20-YEAR OLD NEW ARRESTEES (Using Rearrest Crime-Transition Matrix 2)

Crime of Original Arrest	Total Number of Career Arrests							Total Arrests per Person	CJS Direct Operating Costs, $
	Homicide	Robbery	Assault	Burglary	Theft	Auto Theft	Rape		
Homicide	1052	338	353	860	209	404	32	3.25	8100
Robbery	52	1569	145	909	117	384	5	3.18	4400
Assault	61	395	1413	1035	245	472	37	3.63	3500
Burglary	52	435	148	2385	138	475	5	3.64	3400
Theft	39	365	151	1060	1211	576	13	3.42	3900
Auto Theft	46	416	146	1162	177	1993	5	3.95	3400
Rape	52	302	355	810	256	377	1081	3.23	3400

In another run, 1000 15-year old virgin arrestees were taken as the cohort. The distribution of initial arrests, by crime type, was made to approximate the actual distribution of total 12-year old arrests reported in UCR/1965. Because of low age, this distribution is probably based largely on virgin arrests. The output distributions are shown in Table 14 for ages 16 and 20. Also shown in Table 14 is the arrest distribution* of all arrests of 20-year olds as reported in the UCR/1965. Even though the model-derived distribution is only for those with five-year-old criminal careers, and the UCR distribution includes all arrestees, we would expect a similarity in the two distributions to be a modest validation check. We see that the distributions are roughly similar, with only the fraction which are assaults deviating significantly from the UCR value.

TABLE 14. ARREST DISTRIBUTIONS OVER CRIME TYPE FOR A 15-YEAR OLD COHORT

	Age 15 Input Distribution from UCR/1965	Model-Derived Distributions for Ages		Arrest Distributions for all 20-Year-Old Arrests
		16	20	
Homicide	0.002	0.011	0.01	0.01
Robbery	0.047	0.115	0.15	0.11
Assault	0.045	0.054	0.07	0.14
Burglary	0.335	0.398	0.39	0.35
Grand theft	0.246	0.248	0.24	0.19
Auto theft	0.317	0.149	0.11	0.17
Rape	0.008	0.024	0.02	0.03

The recidivism model also permits examination of a crucial question confronting CJS administrators: How does reduction of recidivism probability affect a criminal career? Many experimental programs have been run to try to discover how various rehabilitative programs affect recidivism probability. For instance, one study of youthful offenders, which was part of the California Community Treatment Project, included randomly separated treatment and control groups. During a 24-month period, the institutionalized control group had a failure probability of 0.61 and the Community Treatment Group had a rate of 0.38, or about a one-third reduction in recidivism probability (Ref. 16). To

*This distribution is made up of virgin arrestees as well as recidivists with various lengths of prior criminal careers.

investigate what a factor of a one-third reduction of recidivism probability implies in terms of criminal careers, the model was run with 20-year olds first arrested for crime type i and with the rearrest crime-transition matrix of Table 10. The results are given in Table 15. The total career arrests are reduced by about a factor of 2 by reducing recidivism probability by one-third.

TABLE 15. CAREER MATRIX FOR 1000 20-YEAR OLD NEW ARRESTEES

Original Arrest	Total Number of Career Arrests							Total	Career Cost, $ Per Arrestee
	Homicide	Robbery	Assault	Burglary	Larceny	Auto Theft	Rape		
Homicide	1017	124	223	205	128	95	22	1813	6600
Robbery	11	1223	55	301	136	85	13	1824	2900
Assault	19	142	1202	188	200	168	33	1952	1300
Burglary	10	136	63	1400	248	57	20	1934	1800
Larceny	9	123	38	340	1222	102	18	1851	2400
Auto Theft	11	88	46	402	239	1209	27	2021	1600
Rape	14	103	159	209	145	103	1079	1811	1900

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APPENDIX A

APPENDIX A

CONTENTS

APPENDIX A

DESCRIPTION OF A STATEWIDE CRIMINAL JUSTICE SYSTEM

The Criminal Justice System (CJS) for any state is a loosely organized collection of many separate, somewhat independent agencies: municipal police departments, municipal courts, county court systems and probation offices, local jails and state prisons, and other related government departments and agencies, all distributed throughout the state. For purposes of this paper a statewide CJS comprises only those public agencies concerned with apprehending and dealing with those persons--adults and juveniles--who are believed to have violated the criminal law.*

Because of its complexity, no description of a CJS can ever be complete. Any characterization must necessarily be a significant simplification. The CJS described here is presented in detail only to the degree necessary to relate it to the subsequent development of the linear model in Appendix B.

A highly aggregated flow diagram of a general CJS is shown in Fig. A-1. Individual systems differ in such details as the sequence of stages in the court process, the sentencing alternatives available and, of course, the individual parameters characterizing those parts that may even be identical in structure.

The system to be described here and modeled in Appendix B closely resembles the California CJS, from which many of the data estimates

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*Other agencies, not part of the CJS, also come into the picture. Many referrals of juveniles to local probation authorities originate from parents, churches, or school authorities. In turn, the juvenile may be remanded to the custody of his parents. In this paper, the primary focus is on the agencies of police, prosecution and courts, and correction; excluded are welfare agencies, local church or school authorities, civic groups, and others.

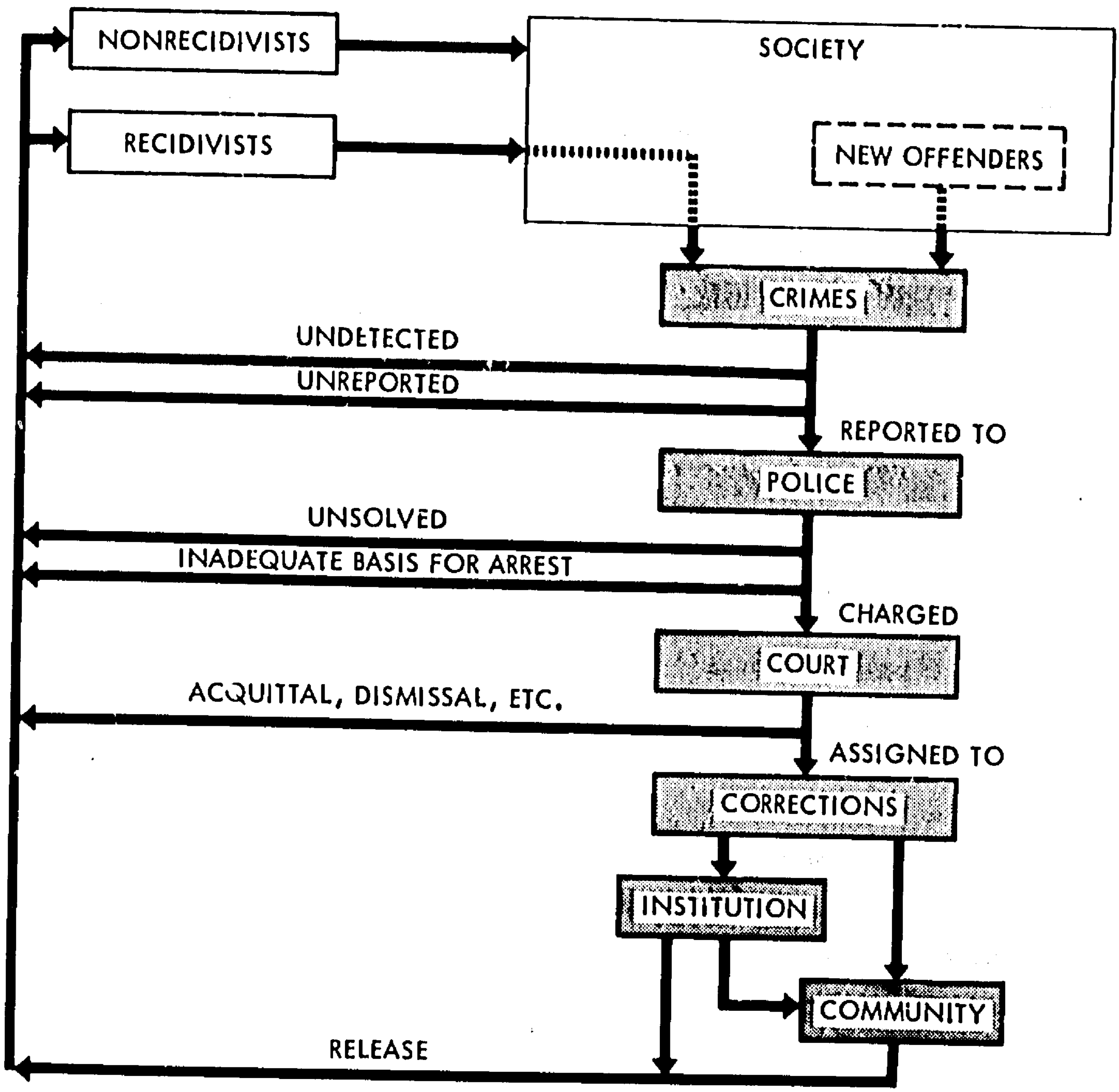

FIGURE A-1. The Criminal Justice System

were obtained.* Since the focus is on the CJS, we begin with crimes reported to the police. Then, we will examine how an individual progresses through the system through a sequence of "processing" stages that may be followed to a subsequent processing stage, always including the possibility of dropping the individual from further processing by the CJS.

A. THE POLICE SUBSYSTEM

Our initial focus is on the numbers of "major crimes" (usually felonies)** reported to police. Those reports which are classified as "unfounded" are discounted.*** Of necessity, those crimes which are committed but not reported to the police are not counted.

Some reported crimes lead to arrests by the police. One suspect may be arrested for one or more crimes, and several suspects might be arrested for one crime.† Individuals arrested may have committed and/or been charged with crimes other than the specific one which initially motivated the arrest.††

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*The reader who wishes more detail is urged to consult the annual publications of the Bureau of Criminal Statistics, State of California Department of Justice.

**The "major crimes" are willful homicide, forcible rape, robbery, aggravated assault, burglary, grand theft, and auto theft. (See Appendix C, Table C-1.)

***Crime in California, State of California Department of Justice, p. 25, 1964.

†"Arrest" is used to mean formal arrest and booking. Informal questioning followed by release without booking is not counted as "arrest."

††Police have attempted a solution to the problem of linking individuals to crimes by defining the "clearance rate" which, for a particular crime, is the percentage of reported crimes for which the police believe they know the offender. The suspected offender need not be convicted or even arrested for the crime to be "cleared." When the reporting department closes a crime investigation by arrest and prosecution of an offender, the offense is shown as "cleared by arrest." Offenses are also cleared other than by arrest. These clearances

(footnote continued)

Because the same individual can be arrested more than once during a single year, it is necessary to make the distinction between "total police arrests" and "total number of individuals arrested," the latter quantity being smaller than the former. In order to generate workloads and costs, total arrests rather than total individuals arrested will be of greater interest.*

The processing of juvenile arrests is quite different from that of adult arrests. "Differences in concepts, arrest practices, and disposition procedures..."** cause us to consider separately the police procedures related to juvenile arrests and to adult arrests. In fact, it will be necessary to separate juvenile arrests from total arrests and to treat juveniles separately from adults throughout the entire CJS.***

For adult arrests, the arrestee must be brought before a magistrate "without unnecessary delay" at which time a complaint or charge must be filed, or the individual must be released. A representative from the district attorney's office is responsible for issuing a felony complaint if the information on the defendant substantiates such action. After reviewing the evidence, the district attorney may decide to file a misdemeanor rather than a felony complaint against the person originally arrested and booked on a felony charge. If neither a felony nor misdemeanor complaint is filed, the arrested

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†would include those cases where offenders are sentenced on charges in other jurisdictions. (Crime in California, 1964, p. 27.) The wide variation in published clearance rates suggests that different operational definitions are being used. We will not use the concepts of clearance to describe individual flow in our models.

*Of course, for many questions of interest including the number of criminal career arrests, recidivism probabilities, etc., the number of arrested individuals is the variable of interest.

**Crime in California, 1964, p. 43.

***For the age category 18 to 21, arrestees may be treated either as adults or as juveniles in California.

suspect must be released. The police or magistrate might decide to turn over the arrestee (defendant) to another jurisdiction where there might be an outstanding warrant for his arrest.

This first major processing stage after arrest is called "police disposition." Police disposition occurs before a magistrate in a magistrate's court, a municipal court, or a justice court. The possible dispositions are grouped into four categories:

(1) Felony complaint filed,
(2) Misdemeanor complaint filed,
(3) Released, no further action required, or
(4) Transferred to another jurisdiction.

B. PROSECUTION AND COURTS SUBSYSTEM

In our felony flow model, we are concerned with defendants formally charged with a felony as a result of police disposition. The defendant's case is then in the hands of the district attorney who may at any time prior to trial date decide to dismiss the complaint issued against the defendant. Most of these dismissals occur between the magistrate's court appearance and filing of the case in the superior court. After a felony complaint has been filed in a magistrate's court, a preliminary hearing is usually held to determine if there is probable cause to hold the defendant for trial in the superior court. If no probable cause is found, the complaint is dismissed and the defendant discharged. In some cases a decision may be made to charge the defendant with a misdemeanor offense which can be disposed of in the lower court. Even if a defendant is held for trial in the superior court, the prosecutor may elect to replace the original charge in favor of other (usually less serious) charges. He may also bring about a dismissal;* about 20 percent of the felony complaints filed (out of

*Crime in California, 1964, p. 101.

magistrate's court) were reported by California authorities as dismissed prior to superior court filing.* The reasons for dismissal are as follows:**

(1) Further prosecution not feasible,
(2) Referred to juvenile court,
(3) Prosecuted in a municipal or justice court on a misdemeanor complaint, or
(4) Prosecuted in superior court on a different felony complaint.

We can aggregate into a single event, "opportunity for dismissal prior to court appearance," the various opportunities and causes for dismissal between the initial felony charge in magistrate's court and eventual superior court disposition. Thus, we can consider the pre-court activity is aggregated into a single processing stage with two possible dispositions:

(1) Hold the defendant for felony trial and eventual disposition in the superior court (i.e., filing), and
(2) Do not hold the defendant for felony trial in the superior court (i.e., no filing).

Superior court filings are generated by bills of information, certifications (certified confessions), and indictments. In the model, we do not distinguish among these various types of filing procedures. The choice of trial type can be represented by a separate

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* Crime and Delinquency in California, 1965, p. 53.

** These recorded dismissals account for about 85 percent of the difference between the number of defendants charged with a felony and the number of superior court filings. This difference should represent all dismissals, but present records procedures result in some dismissals not being accounted for. Felony filings in California superior courts present a difficult counting problem in any system model. Some defendants on a single filing are charged with multiple offenses. An "offense" counting system would include some duplication of defendants. In addition, some defendants have multiple filings issued against them, each one of which may include several offenses. Thus, a "filing" counting system may also be redundant. The California Bureau of Criminal Statistics has chosen to use felony filings as a unit of count.

processing stage. A felony defendant may proceed through the California Superior Court in one of several ways:

(1) Jury trial,
(2) Court trial or court trial on transcript,
(3) Guilty plea, and
(4) Dismissal or placed off the court calendar.

Following trial type, the defendant may be convicted of the charge placed, of a lesser felony charge, of a misdemeanor, or he may be acquitted. Arrival at a verdict can thus be treated as a separate processing stage. The sentencing procedure can be viewed as the final processing stage in the court subsystem. There are seven basic types of sentences which can be imposed on convicted felony defendants:

(1) Straight probation (suspended sentence),
(2) Probation with jail (suspended sentence),
(3) Jail,
(4) State prison,
(5) Youth Authority,
(6) Fine, or
(7) Civil commitment.

C. CORRECTIONS SUBSYSTEM

As a result of the sentencing decision the convicted felon may enter the corrections subsystem. It is convenient to consider the following correctional institutions separately:

(1) Prisons of the State Department of Corrections,
(2) State-supervised parole,
(3) County probation agencies, and
(4) County jails.

The defendant granted probation is under the supervision of local probation authorities for approximately three years. Probation violators may be resentenced and sent to prison, jail, or the Youth Authority (if between the ages of 18 and 21).

The State Department of Corrections operates the California prison system. Defendants senteced to prison are committed to the director of the department under an indeterminate sentence.*

Nearly all felons sentenced to prison are parolled at least once rather than given a mandatory release at the end of the maximum term specified by law.** Parolees remain on parole for up to five years. Any violation of parole will cause the violator to be recommitted to prison.

Local jails are used to incarcerate convicted felons who have been given sentences of less than one year and those who have been given a small jail sentence followed by probation.

Figure A-2 shows an aggregated flow diagram of the adult CJS, combining the previous discussion of the police, prosecution and courts, and corrections subsystems.

D. JUVENILE PROCESSING

All arrests of individuals under 18 years of age are designated juvenile arrests. Persons between the ages of 18 and 21 are handled either as juveniles or as adults. Juvenile arrests are distinguished either as law violations or as delinquent tendencies. Law violations include the major offenses (including the seven major crimes) and minor offenses.

Police disposition of juvenile cases allows one of three possible decisions to be made:

(1) Handled within the department (presumably admonished in the department and returned home),

(2) Referred to the county probation department, or

(3) Referred to agencies other than the county probation department.***

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*Exceptions include those few defendants given the death penalty or a natural life sentence, chiefly in cases of first-degree murder.

**By maximum term, we include time subtracted for good behavior.

***This accounts for juveniles arrested in one locality who are wanted in other localities or counties.

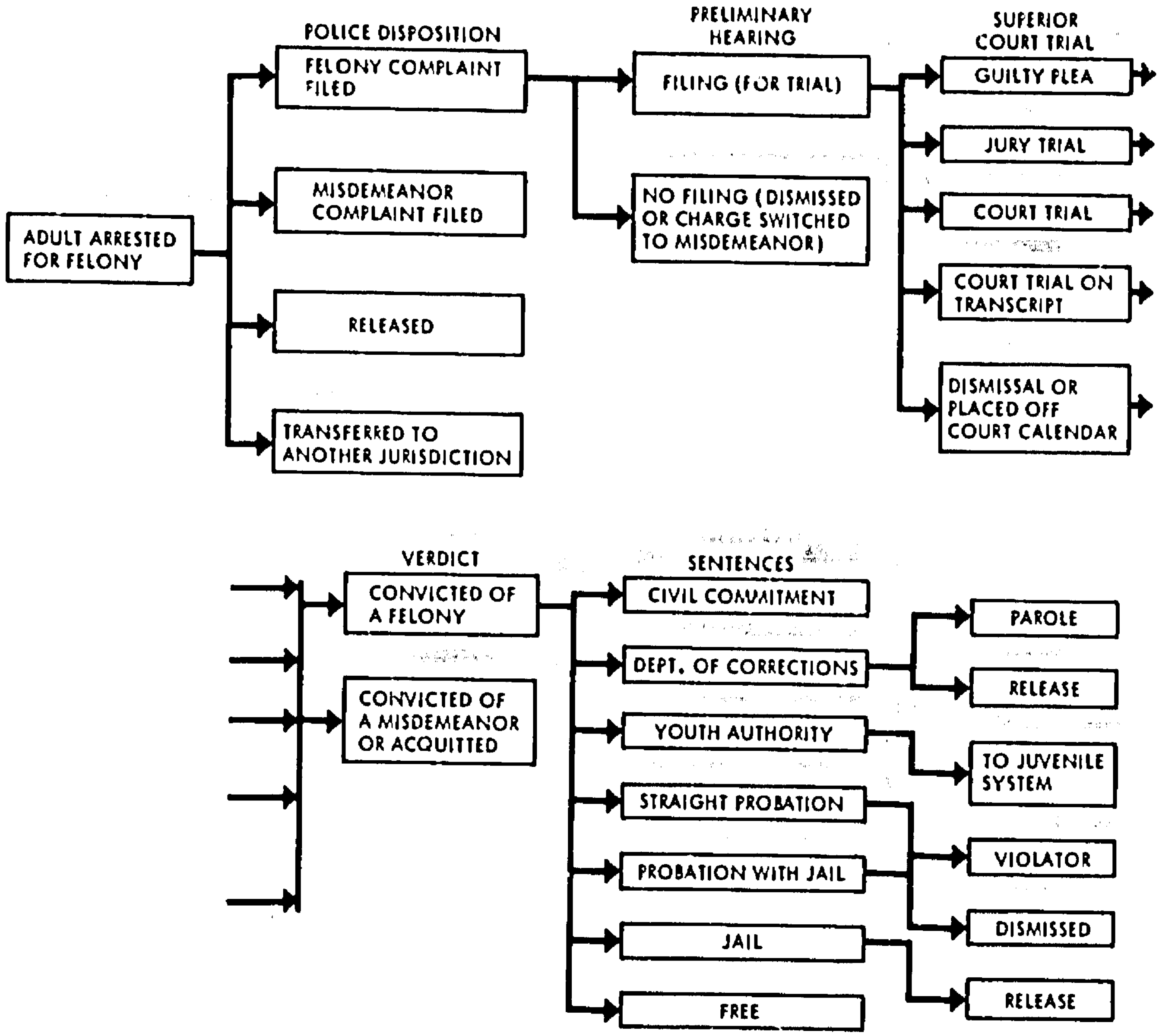

FIGURE A-2. The Adult Criminal Justice System

The juvenile probation department is the administrative branch of the juvenile court. Referrals to this department are transferred to the jurisdiction of the juvenile court. Referrals can be received from parents and from church and school authorities, as well as from police agencies.*

The first referral of each juvenile to the department receives one of the following initial determinations:

(1) Case closed after interview or investigation,
(2) Case referred to other agency,
(3) Case placed under informal (noncourt) supervision, or
(4) Case filed for court action.

Subsequent referrals of juveniles are treated somewhat differently, and records of determinations of re-referrals are often incomplete.

Juveniles whose cases are filed for court action and who have not previously been before the juvenile court receive one of the following <u>initial dispositions</u>:**

(1) Case dismissed,
(2) Case assigned to "local supervision" (as a ward or nonward),
(3) Juvenile incarcerated as a ward, or
(4) Juvenile committed to the California Youth Authority.

Only a small fraction of the Youth Authority intake is due to initial dispositions; most commitments result from later supplemental hearings. Those committed to the Youth Authority are eventually released on parole. Parole violations may cause recommitment to the Youth Authority.

An aggregated flow diagram of the juvenile CJS is summarized in Figure A-3.

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*Although the fractions of such referrals for the major crimes are relatively small, they do cause problems in the interpretation of currently available data.

**In addition to these dispositions, small fractions of cases are transferred to other counties or are remanded to adult court.

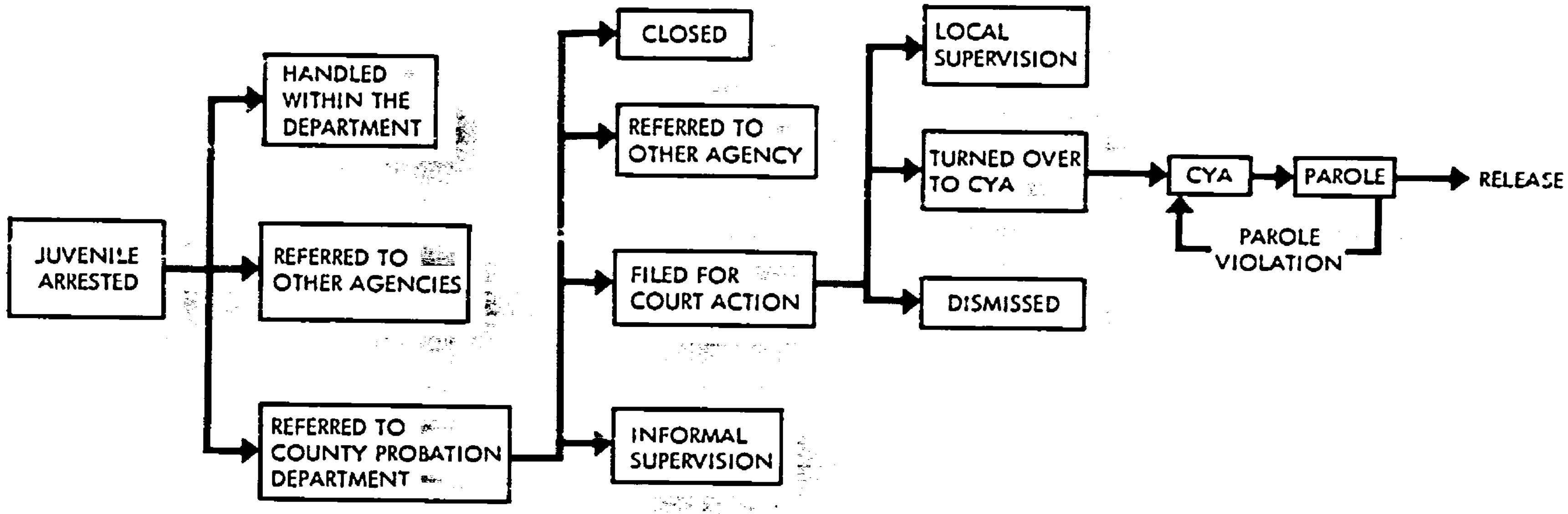


FIGURE A-3. The Juvenile Criminal Justice System

APPENDIX B

APPENDIX B

CONTENTS

APPENDIX B

FORMULATION OF THE LINEAR MODEL

Based on the description of the California CJS in Appendix A, a computer model was formulated. This model permits estimation of flow rates through the CJS by crime type, the apportionment of costs to types of crime and to components of the CJS, and the estimation of workload and personnel requirements for various parts of the system. This Appendix describes the computational details of that model, first in general structural terms and then with the specifics of the individual segments of the model. Appendix D adds the feedback aspects of the process by which recidivism can be examined.

Although the model is formulated specifically for the California CJS, it should be clear that the formulation is sufficiently general to permit its application to any other CJS--national, state, or local--with only slight modification. The most difficult part is the collection of the appropriate data, a subject covered in Appendix C for California.

A. GENERAL STRUCTURE AND PROPERTIES OF THE MODEL

For purposes of developing the model, the CJS is considered as a sequence of processing stages or decision-making steps. At each such stage, a suspect, defendant, or offender is somehow "processed" or treated, and then routed to any one of a number of possible subsequent stages. The essence of the model is the determination of the flow along these alternative routes and the evaluation of the costs, workloads, and manpower requirements at each of the processing stages.

1. Branching Ratios and the Partitioning of the Flow at a Processing Stage

We present here the basic process by which the flows out of a processing stage are partitioned among the possible exit routes by means of a set of branching ratios.

For an individual processed at processing stage k, we associate a crime type j $(1 \le j \le J)$, the most serious crime type with which he is charged. Let there be D_k $(D_k \ge 2)$ decision alternatives at stage k. Let the integer d_k $(1 \le d_k \le D_k)$ represent the d_kth decision alternative at processing stage k. We consider the same set of alternatives for all crime types at each processing stage.

The mechanism by which one among the D_k alternatives is selected is based on a probability estimate. Consider a fixed past time interval (say a year) during which a population of $N_k(j)$ offenders charged with crime type j were processed through stage k. Let $N_k(j, d_k)$ $[0 \le N_k(j, d_k) \le N_k(j)]$ be the number of persons charged with crime type j, who received the d_kth decision alternative at stage k during that interval. If an individual is selected randomly from the entire population $N_k(j)$, then the probability that he received decision alternative d_k is simply equal to the relative frequency of d_k type decisions made during that time interval. Thus, if

$p_k(d_k|j)$ = probability that a randomly selected individual from the population $N_k(j)$ will receive decision d_k

then,

$$p_k(d_k|j) = \frac{N_k(j,d_k)}{N_k(j)} \quad .$$

The matrix of these probabilities

$$\underline{P}_k = \| \, p_k \, (d_k \mid j) \, \| \qquad (1 \le d_k \le D_k;\ 1 \le j \le J)$$

will be called the set of branching ratios associated with the k^{th} processing stage. These branching ratios represent the probability of following each of the possible branches out of a processing stage.

The quantity N_k (j, d_k) is known as the flow of individuals through state k associated with crime type j who receive decision alternative d_k. Unless otherwise specified, flow rates are discussed as an annual rate.

As an illustration, a generic processing stage is diagrammed in Fig. B-1 for J = 2 types of crime, D_k = 3 decision alternatives.

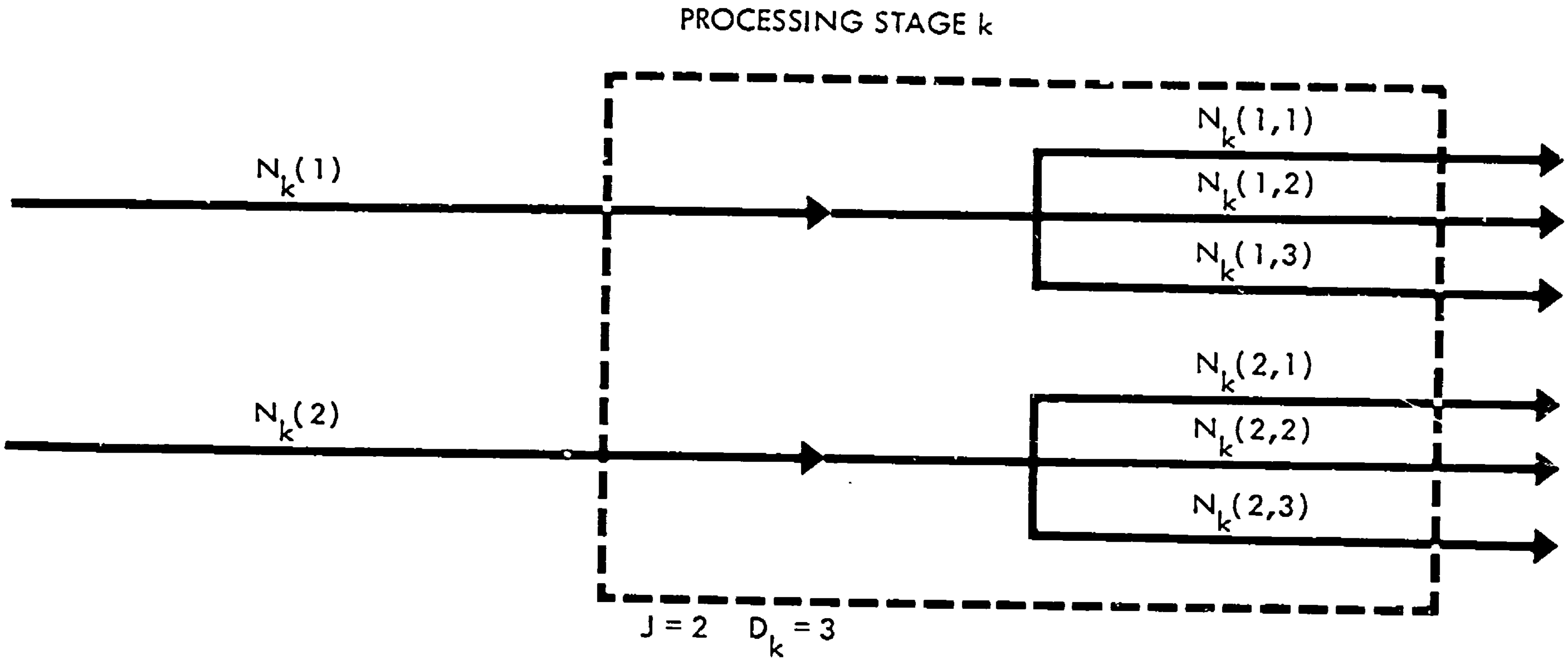
To facilitate the discussion, flow variables are represented by descriptive letter symbols rather than the numeric matrix notation (e.g., N_a represents the number of arrests). Furthermore, since all flow variables represent J parallel flows for the J crime types, all flow variables and their associated branching ratios are J-component vectors (so that, for example, N_a denotes the vector [$N_a(1)$, $N_a(2)$, ..., $N_a(J)$]). Each output flow from a stage and its associated branching ratio are designated by a common subscript notation. For instance, the pair (P_{ad_1}, N_{ad_1}) represents two J-component vectors denoting the proportion* and number, respectively, of adult felony arrests which result in a felony charge.

Using these ideas, it is more convenient to represent a block diagram of a typical processing stage (a jury trial) as in Fig. B-2. The multiplication represents element-by-element multiplication of the N and P vectors (not the conventional inner product of vectors) to obtain the J-component output vectors.

2. Branching Ratio Estimation and Projection

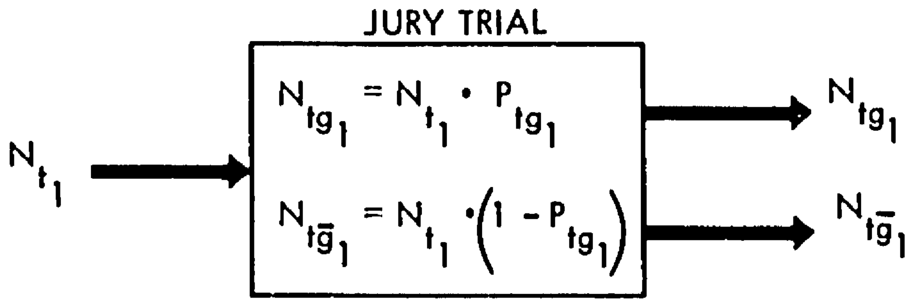
The branching ratios have been defined in terms of flows which have occurred in the past. We would like to be able to use such computed branching ratios to project future system behavior.

*When referring to branching ratios, we will interchangeably use the probabilistic interpretation (i.e., the probability that a randomly selected individual will receive a certain decision) and the relative proportion interpretation (i.e., that if the branching ratio is p for a particular decision alternative, then p is the proportion of offenders who receive that corresponding decision alternative).



$$\underline{P}_k = \begin{bmatrix} \frac{N_k(1,1)}{N_k(1)} & \frac{N_k(1,2)}{N_k(1)} & \frac{N_k(1,3)}{N_k(1)} \\ \frac{N_k(2,1)}{N_k(2)} & \frac{N_k(2,2)}{N_k(2)} & \frac{N_k(2,3)}{N_k(2)} \end{bmatrix}$$

FIGURE B-1. Block Diagram c˜ a Generic Processing Stage



DEFINITIONS:

N_{t_1} = NUMBER OF DEFENDANTS WHO RECEIVE JURY TRIALS

N_{tg_1} = NUMBER OF JURY TRIAL DEFENDANTS FOUND GUILTY

$N_{t\bar{g}_1}$ = NUMBER OF JURY TRIAL DEFENDANTS NOT FOUND GUILTY

P_{tg_1} = PROBABILITY THAT A JURY TRIAL DEFENDANT IS FOUND GUILTY

FIGURE B-2. The Jury Trial Stage

The simplest way of doing this is to assume that there is some constant underlying probability of each decision alternative being selected. Ratios computed from past operations provide estimates of the underlying probabilities, and they provide very good estimates when the flow through each decision alternative is suitably large (say, 100 or greater). If the underlying probability does not change from year to year, the computed ratios in each year should be very nearly equal and no observable trend should be apparent. If this behavior is validated, the system is said to be in "steady state," i.e., system parameters are not changing over time.

However, in a system as complex and dynamic as the CJS, it would be surprising indeed to find all system branching ratios exhibiting no changes over time. When such changes are observed they must be accounted for in projecting future system behavior. There are many ways to perform such projections and we shall use one such method in Appendix D.

Initially, prior to using the model to make projections, we shall focus on the steady-state characteristics.

3. Workloads, Costs, and Manpower Requirements

The three principal kinds of quantities of interest calculated from the model are:

(1) Workloads. The workload is the annual demand for service at various processing stages. Examples are detective man-hours per year, jury-trial-days per year and prison man-years per year necessary to maintain in prison those sentenced.*

(2) Costs. A cost is the product of a flow quantity and the unit cost of processing one unit (e.g., a case, an offender) in that flow. (All costs in the model are calculated directly proportional to a flow quantity.)

(3) Manpower Requirements. A manpower requirement specifies the number of personnel necessary to satisfy a particular workload requirement. It is calculated by dividing the workload by the time (per year) that one individual can spend on that task. The computations required to obtain the workloads, costs, and manpower requirements for a processing stage are given in Table B-1.

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*The calculation of certain workloads also gives estimates of populations at various processing stages. We will use the number of prison man-years required per year to accommodate defendants sentenced to prison to illustrate this concept. If $N_p(j)$ is the number of individuals sentenced to prison each year for type j crimes, and if $T_p(j)$ is the mean time spent in prison by each, and if $N_p(j)$ and $T_p(j)$ are constant from year to year, then the product $N_p(j) \cdot T_p(j)$ is the workload in terms of prison man-years. This workload can also be interpreted as the mean prison population at any given time. That is,

$$N_p(j) \cdot T_p(j) = \text{mean prison population at any given time of those convicted of j-type offenses.}$$

For a deterministic model we can see this as follows: During each incremental time interval $\Delta T_p(j)$, a number, $N_p(j) \cdot \Delta T_p(j)$, are sentenced to prison and a number $N_p(j) \cdot \Delta T_p(j)$, who were sentenced $T_p(j)$ years previously are released from prison. All those who were sentenced in the interim still remain in prison. But the interim is $T_p(j)$ years, during which time $N_p(j) \cdot T_p(j)$ were sentenced.

Once the values of the branching ratios are chosen and the input flow distribution is specified for the first processing stage, the model gives as outputs all subsequent flows of individuals, workloads, costs, and manpower requirements. Each of the output quantities is a number, not a distribution, and represents the expected number of individuals, dollars, or personnel required (i.e., the model is an expected value model).

TABLE B-1. COMPUTATIONS OF WORKLOADS, COSTS, AND MANPOWER REQUIREMENTS

Costs:

$N_k(j) \cdot C_k(j)$ = Yearly cost for processing at stage k individuals charged with crime type j

Workloads:

$N_k(j) \cdot T_k(j)$ = CJS time units (e.g., man-hours) per year necessary to process at stage k individuals charged with crime type j

Manpower Requirements:

$$\frac{N_k(j) \cdot T_k(j)}{H_k}$$ = Number of CJS personnel required per year to process at stage k individuals charged with crime type j

where:

$N_k(j)$ = Yearly number of offenders processed through stage k associated with crime type j

$C_k(j)$ = Average cost of processing each individual charged with crime type j at stage k

$T_k(j)$ = Average amount of time per CJS personnel at stage k required to process each individual charged with crime type j through stage k

H_k = Amount of time available per year from each CJS person assigned to stage k

4. Incremental Quantities

Here we will consider two incremental quantities, which will later be used in the sensitivity analyses of the model. Let $Y_\ell(j)$ be any calculated variable (individuals, dollars, etc.) for crime type j at processing stage ℓ. Let us concentrate on incrementally changing the flow variable $N_k(j,d_k)$, the number of individuals processed at stage k charged with crime j during a year who receive decision d_k.

Define

$$\frac{\partial Y_\ell(j)}{\partial N_k(j,d_k)}$$ = Incremental change in $Y_\ell(j)$ per unit change in $N_k(j,d_k)$
= First partial derivative* of $Y_\ell(j)$ with respect to $N_k(j,d_k)$

$$\frac{\partial Y_\ell(j)/Y_\ell(j)}{\partial N_k(j,d_k)/N_k(j,d_k)}$$ = Incremental fractional change in $Y_\ell(j)$ per given fractional change in $N_k(j,d_k)$
= "Elasticity" of $Y_\ell(j)$ with respect to $N_k(j,d_k)$

To indicate the interpretation of these two quantities, suppose $Y_\ell(j)$ is a cost at stage ℓ associated with processing individuals charged with crime j. Assume that $Y_\ell(j)$ is linearly related to $N_k(j,d_k)$, so that $Y_\ell(j)$ can be written as follows:

$$Y_\ell(j) = A_\ell(j) + B_\ell(j) \quad N_k(j,d_k)$$

Then,

$$\frac{\partial Y_\ell(j)}{\partial N_k(j,d_k)} = B_\ell(j)$$
= Average additional cost incurred at stage ℓ for processing individuals charged with crime j, per additional individual inserted at stage k, charged with crime j and given decision alternative d_k.

*The flows $N_k(j,d_k)$ will not be constrained to integers so that derivatives are well defined and so that output flows can be estimated by simple multiplications of input flows and branching ratios (i.e., no integer truncation is required.)

$$\frac{\partial Y_\ell(j)/Y_\ell(j)}{\partial N_k(j,d_k)/N_k(j,d_k)} = \frac{B_\ell(j)N_k(j,d_k)}{A_\ell(j) + B_\ell(j)\ N_k(j,d_k)}$$

= Average fractional increase in cost incurred at state ℓ for processing individuals charged with crime j, per fractional increase in individuals inserted at stage k, charged with crime j and given decision alternative d_k.*

More succinctly, in this example the first derivative is an incremental cost per person and the elasticity is the fractional increase in cost per given fractional increase in the number of persons.

5. Summary of Assumptions of the Linear Model

In this linear model of the CJS, we have initially assumed the following:

(1) The system is operating in the steady state. That is, the branching ratios do not change significantly from year to year.

(2) The flow at a particular processing stage is described adequately by the distribution by crime type of individuals processed at that stage, independent of the prior history of those individuals.

(3) Unit costs can meaningfully be assigned to flow quantities.

(4) No feedback mechanism is allowed where individuals who repeat crimes can be recycled through the system.

The linear model, being an expected value model, does not include effects due to stochastic fluctuations in demands and in the servicing of those demands. For applications where such random fluctuations

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*The elasticity can also be interpreted to be that fraction of the current value of the cost $Y_\ell(j)$ which is directly attributable to the number of persons $N_k(j,d_k)$.

are important, for instance in congestion problems, an extension of the linear model would be required. The extended model might take the form of a Monte Carlo simulation model, in which both branching paths and processing times of individual offenders are generated from measured probability distributions. The data requirements for such a model far exceed the already taxing requirements of the linear model.

In Appendix D, we develop in detail a feedback model which avoids assumption 4, and which is an extension of the linear model already discussed.

B. DESCRIPTION OF THE LINEAR MODEL

The description of the linear model here parallels the description of the CJS in Appendix A. For each CJS subsystem, flow, workload, and cost models are presented in order.

1. The Police Subsystem

a. Flow Model. The input to the linear model is the number of major crimes reported to police (N_c). The number of felony arrests (N_a) is linearly related to N_c by

$$N_a = N_c \cdot N_{a/c} ,$$

where $N_{a/c}$ is the number of arrests per reported crime. Arrests are broken down as "adult arrests" (N_{ad}) and "juvenile arrests" (N_{aj}), with the fraction P_{ad} of N_a being adult arrests. Thus,

$$N_{ad} = \text{number of adult arrests} = N_a \cdot P_{ad}$$

$$N_{aj} = \text{number of juvenile arrests} = N_a \cdot (1 - P_{ad}).$$

(The flow of juvenile arrests will be continued in Section B-4 of this Appendix.)

Adult arrestees receive one of four possible police dispositions:

(1) Felony complaint filed,

(2) Misdemeanor complaint filed,

(3) Released, no further action required, or

(4) Transferred to another jurisdiction.

We define (P_{adi}, N_{adi}) to be the proportion and number, respectively, of adult arrests which receive the $i^{\underline{th}}$ (i = 1,2,3,4) police dispostion.

A block diagrm of the police flow model is given in Fig. B-3, with the variables and parameters defined in Table B-2.

b. The Police Workload and Cost Model. The police workload and cost model shown in Fig. B-4 (with definitions in Table B-3), consists of patrol and detective parts. These are the only police costs considered. Furthermore, since we only consider the operating costs directly attributable to the specified reported crimes, the resulting cost figures probably represent lower bounds for the true costs.*

Patrol officers must respond to all reported crimes; if an arrest is not readily made, they often initiate a follow-up investigation. Here, the average patrol force workload is assumed proportional to the number of crimes reported (N_c). Associated with each reported crime are two patrol workloads:

T_{p_1} = average time required to service a reported crime.

T_{p_2} = average time spent in "preventive patrol" trying to deter that crime for each hour of direct service time.**

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*These directly attributable costs are good estimates of the variable costs associated with changes in the number of crimes.

**The value assigned to T_{p_2} is largely subjective for cost allocation purposes or for patrol scheduling purposes. We will note later that total costs can be quite sensitive to its value.

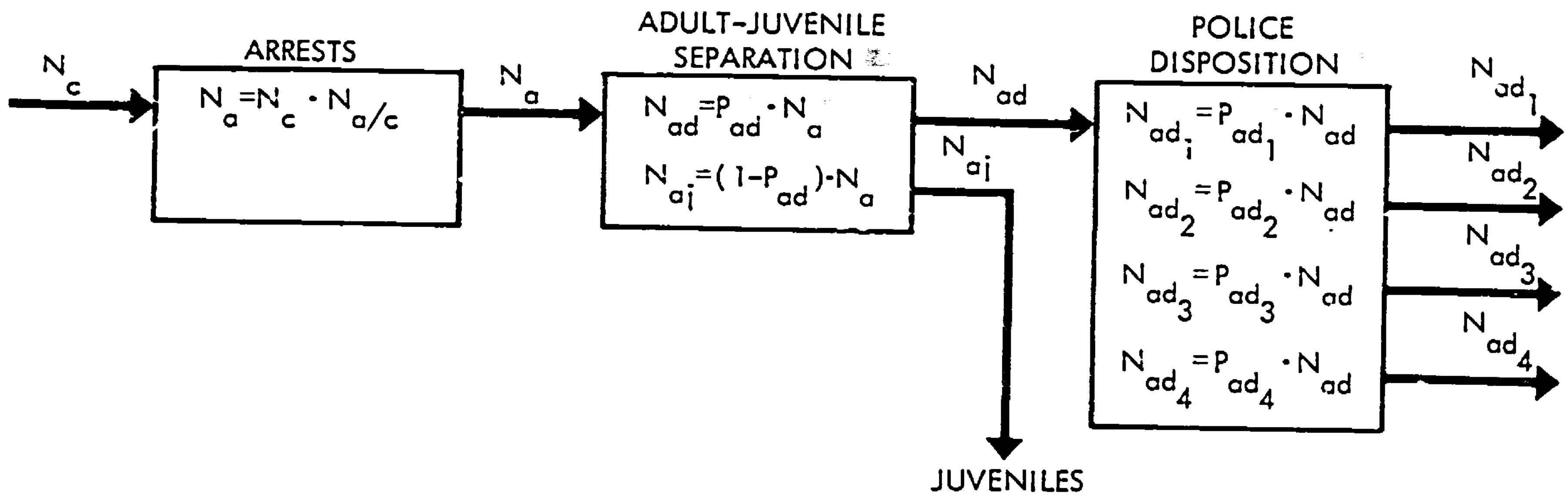

FIGURE B-3. The Police Flow Model

TABLE B-2. ADULT FELONY SUBSYSTEM FLOW CHART DEFINITIONS

POLICE SUBSYSTEM

N_c	Number of major offenses reported
$N_{a/c}$	Number of arrests for general classification crimes per major offense reported.
N_a	Number of felony arrests for general classification crimes, $$N_a = N_c \cdot N_{a/c}$$
P_{ad} , N_{ad}	Proportion and number, respectively, of felony arrests which are adult arrests, $$N_{ad} = N_a \cdot P_{ad}$$
N_{aj}	Number of felony arrests which are juvenile arrests, $$N_{aj} = N_a - N_{ad}$$
P_{ad_1} , N_{ad_1}	Proportion and number, respectively, of adult felony arrests which result in a felony charge
P_{ad_2} , N_{ad_2}	Proportion and number, respectively, of adult felony arrests which result in a misdemeanor charge
P_{ad_3} , N_{ad_3}	Proportion and number, respectively, of adult felony arrests which result in release
P_{ad_4} , N_{ad_4}	Proportion and number, respectively, of adult felony arrests which result in transfers to other jurisdictions, $$N_{adk} = N_{ad} \cdot P_{adk} \ (k = 1,2,3,4)$$

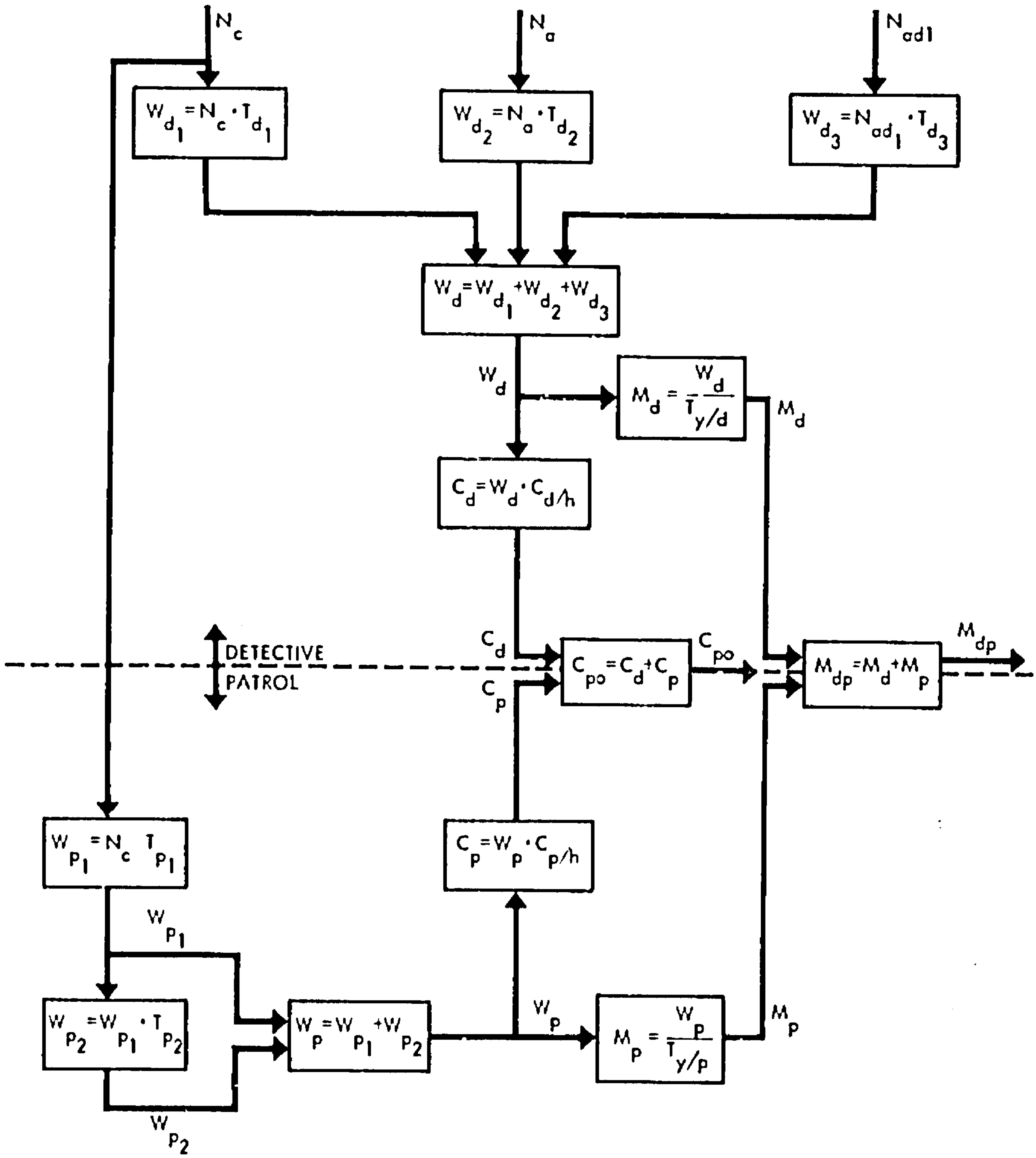

FIGURE B-4. The Police Workload and Cost Model

TABLE B-3. POLICE SUBSYSTEM WORKLOAD DEFINITIONS

N_c	Number of major offenses reported
T_{d_1}	Detective man-hours required per major offense reported
W_{d_1}	Detective workload for major offenses reported, $$W_{d_1} = N_c \cdot T_{d_1}$$
N_a	Number of felony arrests for general classification crimes
T_{d_2}	Detective man-hours required per felony arrest
W_{d_2}	Detective workload for felony arrests, $$W_{d_2} = N_a \cdot T_{d_2}$$
N_{ad_1}	Number of adult felony arrests which result in a felony charge
T_{d_3}	Detective man-hours required per adult felony charge
W_{d_3}	Detective workload for adult felony charges, $$W_{d_3} = N_{ad_1} \cdot T_{d_3}$$
W_d	Total detective man-hours required to service felony crime, $$W_d = W_{d_1} + W_{d_2} + W_{d_3}$$
$T_{y/d}$	Detective man-hours available per year per detective
M_d	Total number of detectives required to service felony crimes, $$M_d = \frac{W_d}{T_{y/d}}$$
T_{p_1}	Patrol man-hours required to service major offenses reported

(table continued)

W_{p_1} Patrol workload for major offenses reported,

$$W_{p_1} = N_c \cdot T_{p_1}$$

T_{p_2} Number of preventive patrol man-hours apportioned per patrol man-hour of service time for major offenses reported

W_{p_2} Patrol workload for maintaining preventive patrols against major offenses,

$$W_{p_2} = W_{p_1} \cdot T_{p_2}$$

W_p Total patrol man-hours spent on felony crimes.

$$W_p = W_{p_1} + W_{p_2}$$

$T_{y/p}$ Patrolman man-hours available per year per patrolman

M_p Total number of patrolmen required to service felony crimes,

$$M_p = \frac{W_p}{T_{y/p}}$$

M_{dp} Total number of police officers required to service felony crimes,

$$M_{dp} = M_d + M_p$$

$C_{p/h}$ Cost per hour per patrolman

$C_{d/h}$ Cost per hour per detective

C_d Total cost of detective force to service felony crimes,

$$C_d = W_d \cdot C_{d/h}$$

C_p Total cost of patrol force to service felony crimes,

$$C_p = W_p \cdot C_{p/h}$$

C_{po} Total cost of police due to major crimes,

$$C_{po} = C_d + C_p$$

Thus, the patrol workload W_p is given by

$$W_p = N_c \cdot T_{p_1} + N_c \cdot T_{p_1} \cdot T_{p_2} .$$

If $C_{p/h}$ is the cost per hour of patrol time, then the cost of patrol due to felonies (C_p) is

$$C_p = W_p \cdot C_{p/h} .$$

If each patrol officer spends $T_{y/p}$ hours per year on patrol, then the number of patrolmen required due to felony crimes is

$$M_p = W_p/T_{y/p} .$$

The average amount of detective time expended per reported crime depends upon whether or not a suspect is arrested, and whether or not an arrested suspect is formally charged with a felony at the magistrate's court. Thus, in the model we associate different times with with cases for which no arrest is made (T_{d_1}), an arrest is made but no charge is filed ($T_{d_1} + T_{d_2}$) and both an arrest and charge are made ($T_{d_1} + T_{d_2} + T_{d_3}$). Here, an average amount of detective time (T_{d_1}) is spent on each reported crime, with T_{d_2} being the additional detective times required to obtain an arrest and T_{d_3} being the time to help in preparing a case for Superior Court.* The remainder of the detective model is identical to the patrol model.

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*The detective time data were developed by the Los Angeles Police Department (LAPD) by calculating the average time per case for the three types of cases and then subtracting to infer the additional time incurred due to arrest and to charge.

The total police costs and manpower requirements are obtained by summing the costs and manpower requirements of partolmen and detectives, respectively.

2. The Prosecution and Courts Subsystem

a. The Flow Model. The diagram for the prosecution and court model is shown in Fig. B-5, with the variables defined in Table B-4. The input to the prosecution and courts subsystem is N_{ad_1}, the number of adult felony charges. A fraction P_f of these individuals reach the trial stage; others avoid felony processing before trial. That is,

$$N_f = \text{number of adults charged with a felony who obtain a court disposition}$$

$$= N_{ad_1} \cdot P_f$$

The defendant may proceed through the Superior Court in one of four ways:

(1) Jury trial,

(2) Court trial (including court trial on transcript),

(3) Guilty plea, or

(4) Dismissal or placed off the court calendar.

For those who go through trials, the outcome is either "defendant guilty" or "defendant not guilty." Those who plead guilty or are found guilty by trial are then sentenced. The seven sentence alternatives have associated probabilities P_{si} $(i=1,\ldots,7)$ $(\Sigma_i\ P_{si} = 1)$ for the probability that a guilty defendant will receive the $i^{\underline{th}}$ from among the following seven alternative sentences:

(1) Straight probation,

(2) Probation with jail as a condition,

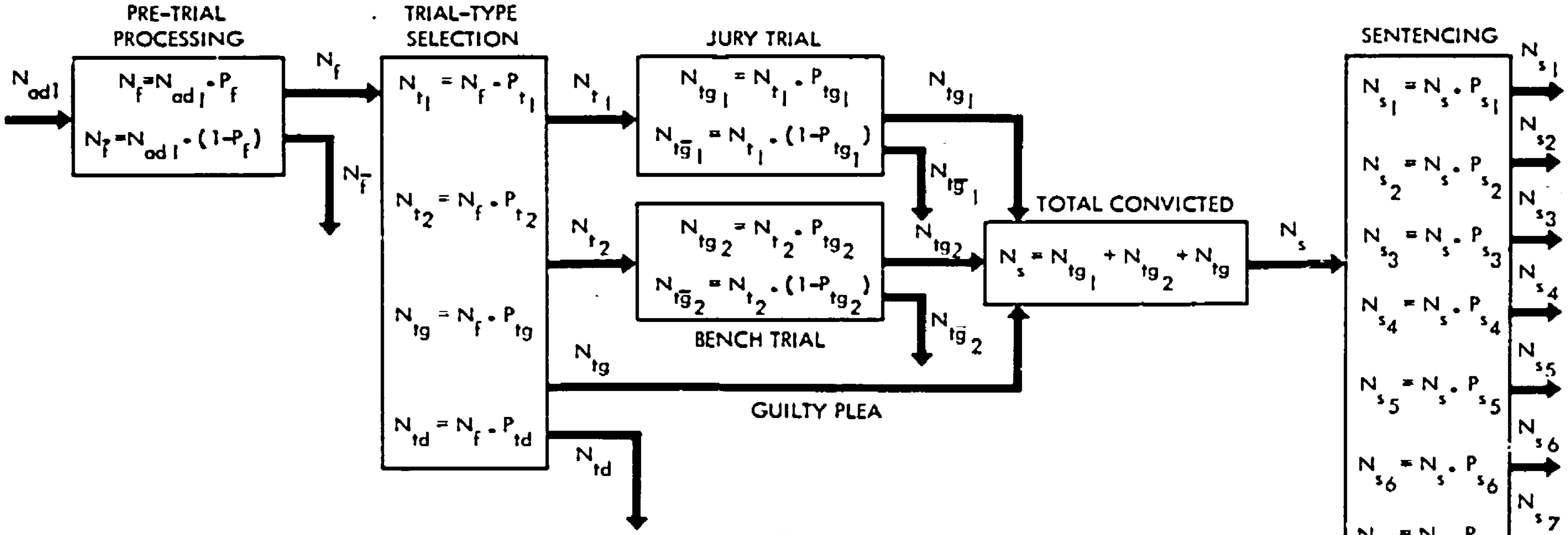
(3) Jail,

(4) State prison,

(5) Referred to Youth Authority,

(6) Fined, or

(7) Referred to other civil commitment.



NOTE: SEE TABLE B-4 FOR DEFINITION OF SYMBOLS

FIGURE B-5. The Prosecution and Courts Flow Model

TABLE B-4. DEFINITIONS OF FLOWS AND BRANCHING PROBABILITIES IN THE PROSECUTION AND COURT SUBMODEL*

Prosecution and Courts Subsystem

N_{ad_1} — The number of adult arrestees who are formally charged by the magistrate

$(N_f\ ,\ P_f)$ — The number of adults formally charged who reach the trial stage,

$$N_f = N_{ad_1} \cdot P_f$$

$(N_{\bar{f}},\ 1-P_f)$ — The number of adults formally charged who do not reach the trial stage,

$$N_{\bar{f}} = N_{ad_1} - N_f$$

$(N_{t_1}\ ,\ P_{t_1})$ — Number of defendants who reach trial stage and who receive jury trials,

$$N_{t_1} = N_f \cdot P_{t_1}$$

$(N_{t_2}\ ,\ P_{t_2})$ — Number of defendants who reach trial stage and who receive bench or transcript trials,

$$N_{t_2} = N_f \cdot P_{t_2}$$

$(N_{tg}\ ,\ P_{tg})$ — Number of defendants who reach trial stage and who plead guilty,

$$N_{tg} = N_f \cdot P_{tg}$$

$(N_{td}\ ,\ P_{td})$ — Number of defendants who reach trial stage and who are dismissed or placed off calendar,

$$N_{td} = N_f \cdot P_{td}$$

$(N_{tg_1}\ ,\ P_{tg_1})$ — Number of defendants who receive jury trials who are found guilty,

$$N_{tg_1} = N_{t_1} \cdot P_{tg_1}$$

*Output flows and corresponding branching probabilities are given as matched pairs. Only the definition of the flow is stated.

(table continued)

$(N_{t\bar{g}_1}, 1-P_{tg_1})$	Number of defendants who receive jury trials who are not found guilty, $$N_{t\bar{g}_1} = N_{t_1} - N_{tg_1}$$
(N_{tg_2}, P_{tg_2})	Number of defendants who receive bench or transcript trials who are found guilty, $$N_{tg_2} = N_{t_2} \cdot P_{tg_2}$$
$(N_{t\bar{g}_2}, 1-P_{tg_2})$	Number of defendants who receive bench or transcript trials who are not found guilty, $$N_{t\bar{g}_2} = N_{t_2} - N_{tg_2}$$
N_S	The number of defendants who are sentenced
(N_{Sj}, P_{Sj})	The number of sentenced defendants who receive sentence type j (j=1,2,...,7):

$$N_S = N_{S_1} + \dots + N_{S_7}$$

$N_{S_1} = N_S \cdot P_{S_1}$ (straight probation)

$N_{S_2} = N_S \cdot P_{S_2}$ (probation with jail as a condition)

$N_{S_3} = N_S \cdot P_{S_3}$ (jail)

$N_{S_4} = N_S \cdot P_{S_4}$ (state prison)

$N_{S_5} = N_S \cdot P_{S_5}$ (referred to Youth Authority)

$N_{S_6} = N_S \cdot P_{S_6}$ (fined)

$N_{S_7} = N_S \cdot P_{S_7}$ (civil commitment)

b. The Cost and Workload Model. The prosecution and courts workload is computed just on the number of Superior Court dispositions and does not include workloads due to those released prior to Superior Court. (This restriction is due to the incompleteness of the available data and is discussed further in Appendix C.) To determine workloads and costs, the model treats jury trials and bench (or transcript) trials separately. The workload outputs are the numbers of judges and of trial prosecutors required for all trials and the number of jurors required for jury trials.

Costs are assigned for pre-trial detention as well as for pre-trial and trial efforts. These latter two costs are broken down by prosecutor and court costs. Total trial costs are directly proportional to the duration of the trial. Total prosecution and courts cost includes total trial costs, pre-trial costs, and pre-trial detention costs.

A diagram of the model is given in Fig. B-6, with definitions given in Table B-5.

3. The Adult Corrections Subsystem

The following flows from the prosecutions and courts submodel are taken as inputs to the corrections submodel:*

N_{s_1} = Number of adults granted straight probation.

N_{s_2} = Number of adults granted probation with jail as a condition.

N_{s_3} = Number of adults sentenced to straight jail.

N_{s_4} = Number of adults sentenced to prison.

We will discuss the three parts of the corrections system (probation, jail, prison and parole) separately and calculate the steady-state population of each for costing purposes.

*Those who are referred to the Youth Authority (N_{s_5}) are treated separately in the juvenile system. Those fined (N_{s_6}) are not further considered in the model. Those given a civil commitment (N_{s_7}) are not further considered, since the model deals with the criminal process.

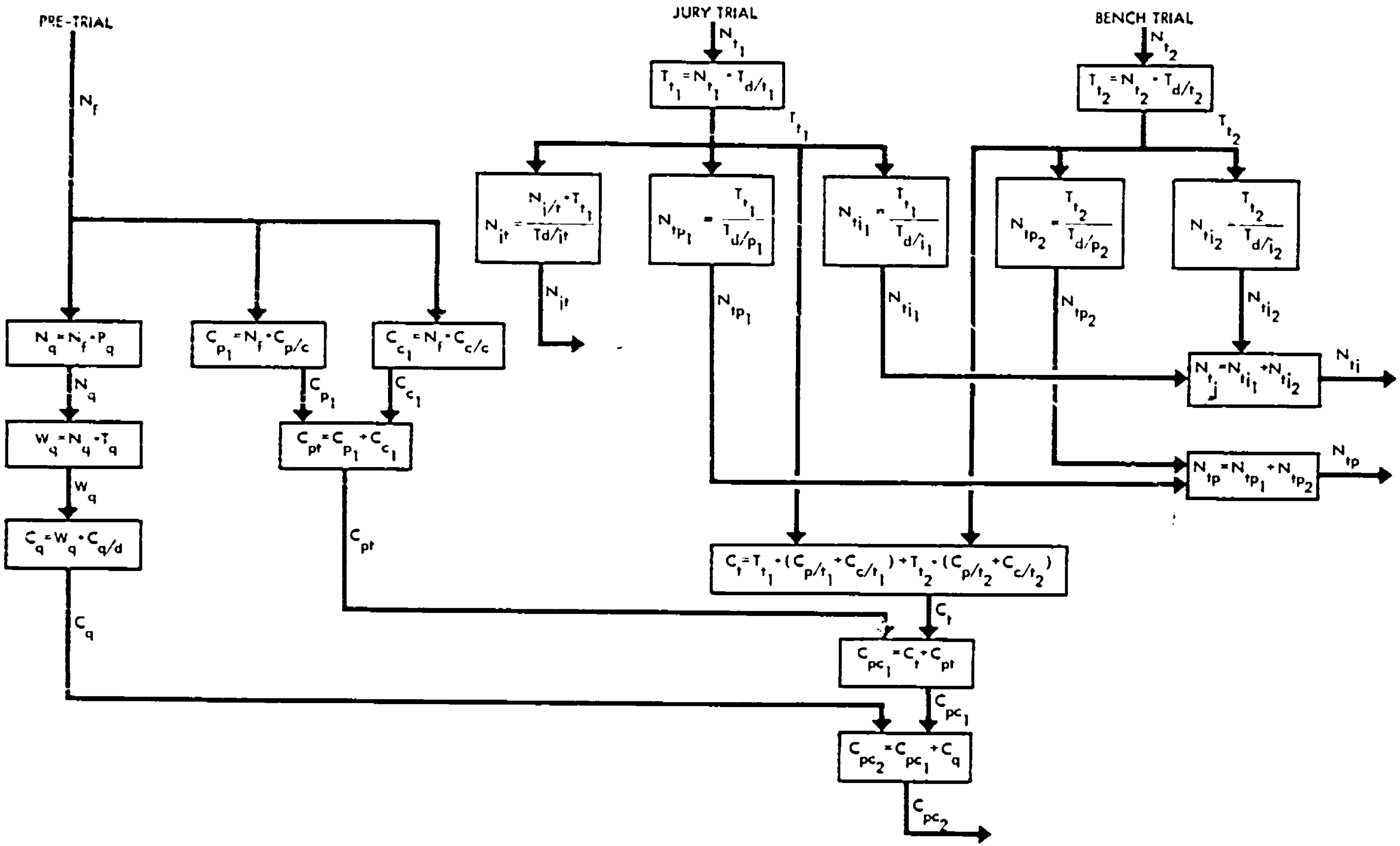


FIGURE B-6. Prosecution and Courts: Cost and Workload Model

TABLE B-5. COSTS AND WORKLOAD

Prosecution and Courts Subsystem

N_f	Number of adults charged with a felony who receive a court disposition (defendants)
P_q, N_q	Probability and number, respectively, of charged defendants detained in jail pending court disposition, $$N_q = N_f \cdot P_q$$
T_q	Average number of pre-trial days spent in jail by those detained in jail
W_q	Jail workload (total detainee days per year) due to pre-trial felony defendants, $$W_q = N_q \cdot T_q$$
$C_{q/d}$	Cost of jail per day per detainee
C_q	Total pre-trial jail costs, $$C_q = W_q \cdot C_{q/d}$$
$C_{p/c}$	Prosecutor (district attorney) cost per case prior to trial
C_{p_1}	Total prosecutor cost prior to trial, $$C_{p_1} = N_f \cdot C_{p/c}$$
$C_{c/c}$	Court cost per case prior to trial
C_{c_1}	Total court cost prior to trial, $$C_{c_1} = N_f \cdot C_{c/c}$$
C_{pt}	Total pre-trial costs, $$C_{pt} = C_{p_1} + C_{c_1}$$
N_{t_1}	Number of defendants who receive jury trials

(table continued)

T_{d/t_1}	Number of jury trial days per trial
T_{t_1}	Total number of jury trial days, $$T_{t_1} = N_{t_1} \cdot T_{d/t_1}$$
$N_{j/t}$	Number of jurors per trial
$T_{d/jt}$	Number of trial days per juror
N_{jt}	Number of jurors required for jury trials, $$N_{jt} = \frac{N_{t_1} \cdot T_{d/t_1} \cdot N_{j/t}}{T_{d/jt}}$$
T_{d/p_1}	Number of jury trial days per trial prosecutor per year
N_{tp_1}	Number of trial prosecutors required for jury trials, $$N_{tp_1} = \frac{N_{t_1} \cdot T_{d/t_1}}{T_{d/p_1}}$$
T_{d/j_1}	Number of jury trial days per judge per year
N_{tj_1}	Number of judges required for jury trials, $$N_{tj_1} = \frac{N_{t_1} \cdot T_{d/t_1}}{T_{d/j_1}}$$
N_{t_2}	Number of defendants who receive bench or transcript trials
T_{d/t_2}	Number of bench trial days per trial
T_{t_2}	Total number of bench trial days, $$T_{t_2} = N_{t_2} \cdot T_{d/t_2} \cdot$$

(table continued)

T_{d/p_2}	Number of bench and transcript trial days per trial prosecutor per year,
N_{tp_2}	Number of trial prosecutors required for bench and transcript trials

$$N_{tp_2} = \frac{N_{t_2} \cdot T_{d/t_2}}{T_{d/p_2}}$$

T_{d/j_2}	Number of bench and transcript trial days per judge per year
N_{tj_2}	Number of judges required for bench and transcript trials,

$$N_{tj_2} = \frac{N_{t_2} \cdot T_{d/t_2}}{T_{d/j_2}}$$

N_{tj}	Total number of judges required for trials,

$$N_{tj} = N_{tj_1} + N_{tj_2}$$

N_{tp}	Total number of trial prosecutors required,

$$N_{tp} = N_{tp_1} + N_{tp_2}$$

C_{p/t_1}	Prosecutor cost per day of jury trial
C_{p/t_2}	Prosecutor cost per day of bench trial
C_{c/t_1}	Court cost per day of jury trial
C_{c/t_2}	Court cost per day of bench trial
C_t	Total trial costs.

$$C_t = T_{t_1} (C_{p/t_1} + C_{c/t_1}) + T_{t_2} (C_{p/t_2} + C_{c/t_2})$$

(table continued)

C_{pc_1} Total prosecution and court costs, excluding pre-trial detention costs,

$$C_{pc_1} = C_t + C_{pt}$$

C_{pc_2} Total prosecution and court costs, including pre-trial detention costs,

$$C_{pc_2} = C_{pc_1} + C_q$$

a. Probation. A block diagram of the flow model for probation is given in Fig. B-7 with definitions in Table B-6. The total number placed on probation during a year is the sum of those placed on probation directly from Superior Court, N_{s_1}, and those placed on probation after serving a short (less than one year) jail sentence. The steady-state assumption implies that the annual output from jail onto probation is equal to the annual input to jail N_{s_2}. Thus, the total placed on probation per year is

$$N_b = N_{s_1} + N_{s_2} .$$

Each probationer has probability P_{bv} of becoming a probation violator. Even though there is a (random) delay until violation, in the steady-state the number of probation violators is $N_b \cdot P_{bv}$. Thus, during a given year, the violators do not represent the same individuals as are placed on probation. A fraction P_{bs} of probation violators are resentenced, with the sentencing alternatives of jail, prison, or Youth Authority.

The total number on probation at any given time is the number placed on probation during a year multiplied by the average number of years on probation. This number (W_b) is used to compute a probation cost.

b. Jail. A block diagram of the jail model is given in Fig. B-8, with definitions in Table B-7. Only the steady-state population is computed here. In the corrections subsystem, inputs to jails are of three types:

(1) Those given straight jail sentences (N_{s_3}),

(2) Those given jail sentences as a condition of probation (N_{s_2}), and

(3) Those returned to jail because of probation violations (N_{bs_1}).

Each of the above three flows is multiplied by the corresponding average time in jail to compute the number in jail in that flow category. These numbers are summed to obtain the population of convicted felons in jail.

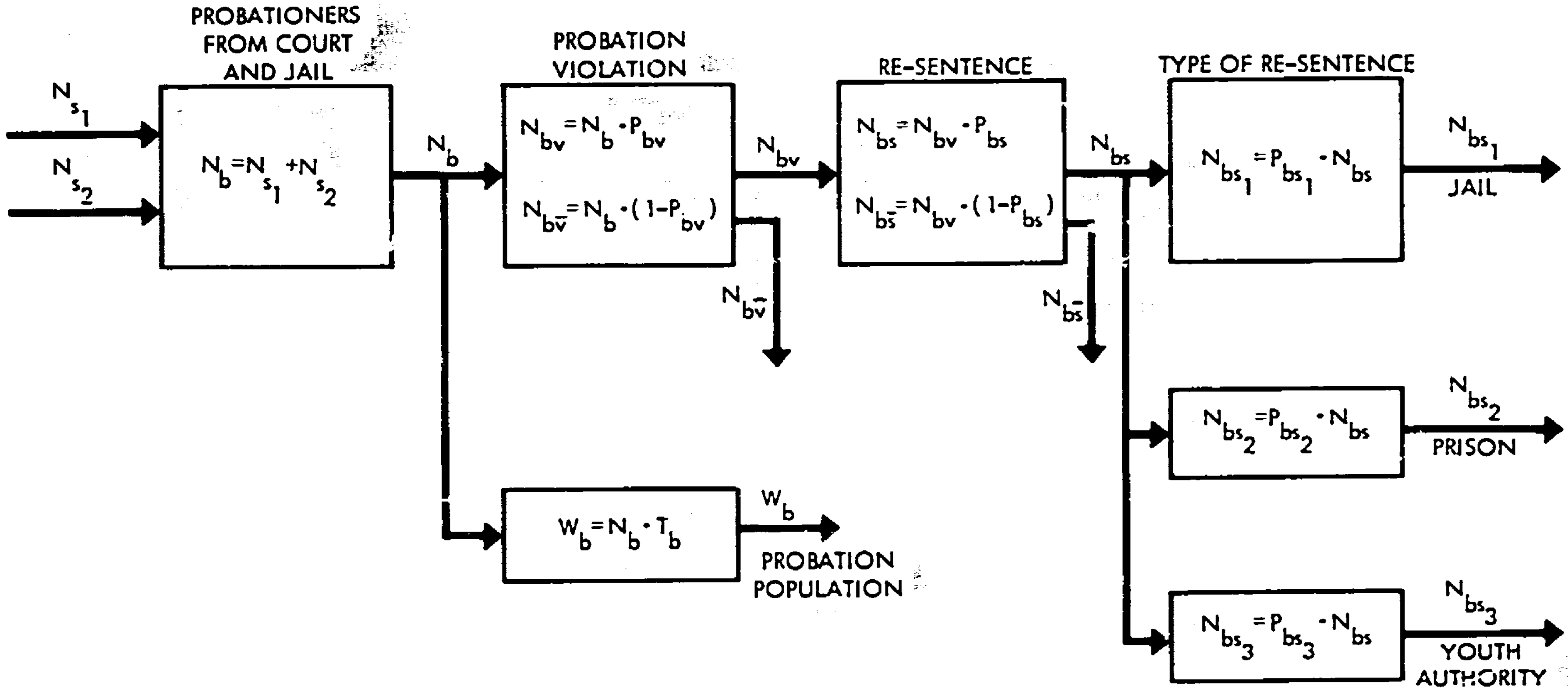
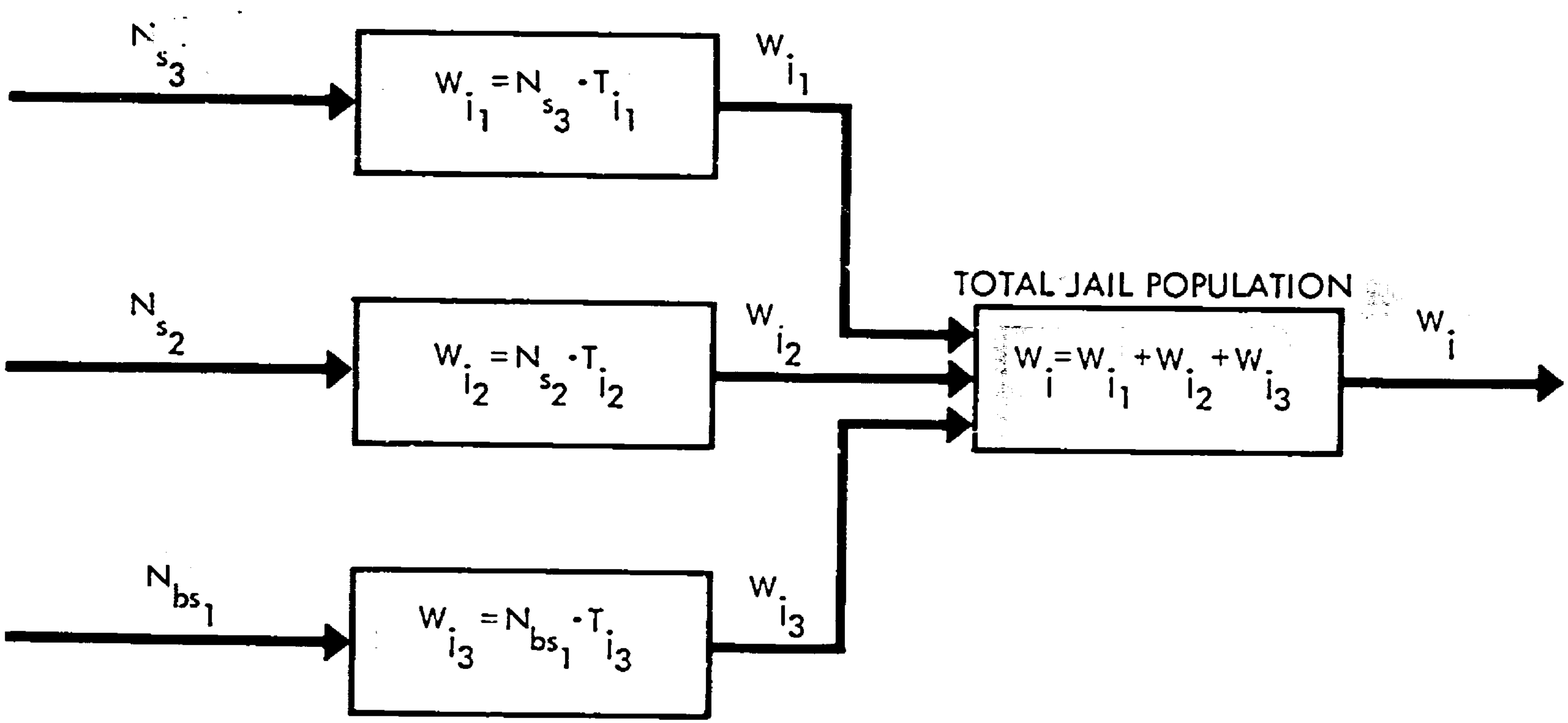


FIGURE B-7. A Flow Model of Adults Placed on Probation

TABLE B-6. COSTS AND WORKLOAD

N_b	Total number of adults placed on probation in a year, $$N_b = N_{s_1} + N_{s_2}$$
P_{bv}, N_{bv}	Probability and number, respectively, of adult probation violators, $$N_{bv} = N_b \cdot P_{bv}$$
$N_{b\overline{v}}$	Number of adults who do not violate probation, $$N_{b\overline{v}} = N_b - N_{bv}$$
P_{bs}, N_{bs}	Proportion and number, respectively, of adult probation violators who are resentenced
$N_{b\overline{s}}$	Number of adult probation violators who are <u>not</u> resentenced
P_{bs_1}, N_{bs_1}	Proportion and number, respectively, of adult probation violators who are resentenced to jail
P_{bs_2}, N_{bs_2}	Proportion and number, respectively, of adult probation violators who are resentenced to prison
P_{bs_3}, N_{bs_3}	Proportion and number, respectively, of adult probation violators who are resentenced to Youth Authority referral, $$N_{bs_k} = N_{bs} \cdot P_{bs_k} \quad (k = 1,2,3) .$$
T_b	Average time probationers spend on probation
W_b	Number of adults on probation at any given time, $$W_b = N_b \cdot T_b$$



NOTE:
POPULATION COMPUTED BY FLOW CATEGORY.

FIGURE B-8. The Jail Population Model

TABLE B-7. CORRECTIONS STAGE - JAIL

N_{s_3}	Number of guilty defendants sentenced to straight jail sentences
T_{j1}	Average time spent in jail by N_{s_3}
W_{j_1}	Number of adults in jail at any given time due to straight jail sentence, $$W_{j_1} = N_{s_3} \cdot T_{j_1}$$
N_{s_2}	Number of guilty defendants granted probation with jail as a condition,
T_{j_2}	Average time spent in jail by N_{s_2}
W_{j_2}	Number of adults in jail at any given time due to granting of probation with jail as a condition, $$W_{j_2} = N_{s_2} \cdot T_{j_2}$$
N_{bs_1}	Number of probation violators resentenced to jail
T_{j_3}	Average time spent in jail by resentenced probation violators
W_{j_3}	Number of probation violators in jail at any given time due to resentencing, $$W_{j_3} = N_{bs_1} \cdot T_{j_3}$$
W_j	Number of adults in jail at any given time, $$W_j = W_{j_1} + W_{j_2} + W_{j_3}$$

c. Prison and Parole. A flow diagram of the prison and parole model is given in Fig. B-9, with the definitions in Table B-8. Not including parole violators, the total yearly prison input (N_{w_3}) is the sum of those committed directly from Superior Court (N_{s_4}) and those committed following a probation violation (N_{bs_2}). A fraction (P_r) of that committed receive a first parole. A fraction P_{rv} of those on first parole become parole violators and are recommitted to prison either under a new charge ("new commitment") or under the old charge ("not new commitment"). Theoretically, this process of recommitment - reparole - recommitment - reparole could be treated as an infinite sequence. For simplicity we terminate the sequence after the first reparole.

Time spent in prison and on parole depends on method of release (parole or not parole) and whether the individual has previously been a parole violator. A similar statement applies to time on parole. The prison population is considered in terms of four subpopulations:

(1) Those who do receive a first parole.

(2) Those who do not receive a first parole.

(3) Those who are recommitted under a new offense.*

(4) Those who are recommitted under the old offense.

The steady-state population of each of these four groups is the product of the mean time spent in prison and the yearly flow into that group.

Similarly, the parole population consists of three subpopulations, (first-parole parolees, new offense reparolees, old offense reparolees), whose numbers are computed in the same manner.

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* A problem of consistency of interpretation confronts us when considering violators recommitted under a new offense. The violator might have been arrested by police and thus be counted as an arrest statistic and be an input to our model; but, in the model we still classify such an offender as being in the corrections subsystem and associated with the former crime which might have been a different type of crime. This complexity is typical of many which the current model, both because of its limited scope and the limitations of available data, does not take into account.

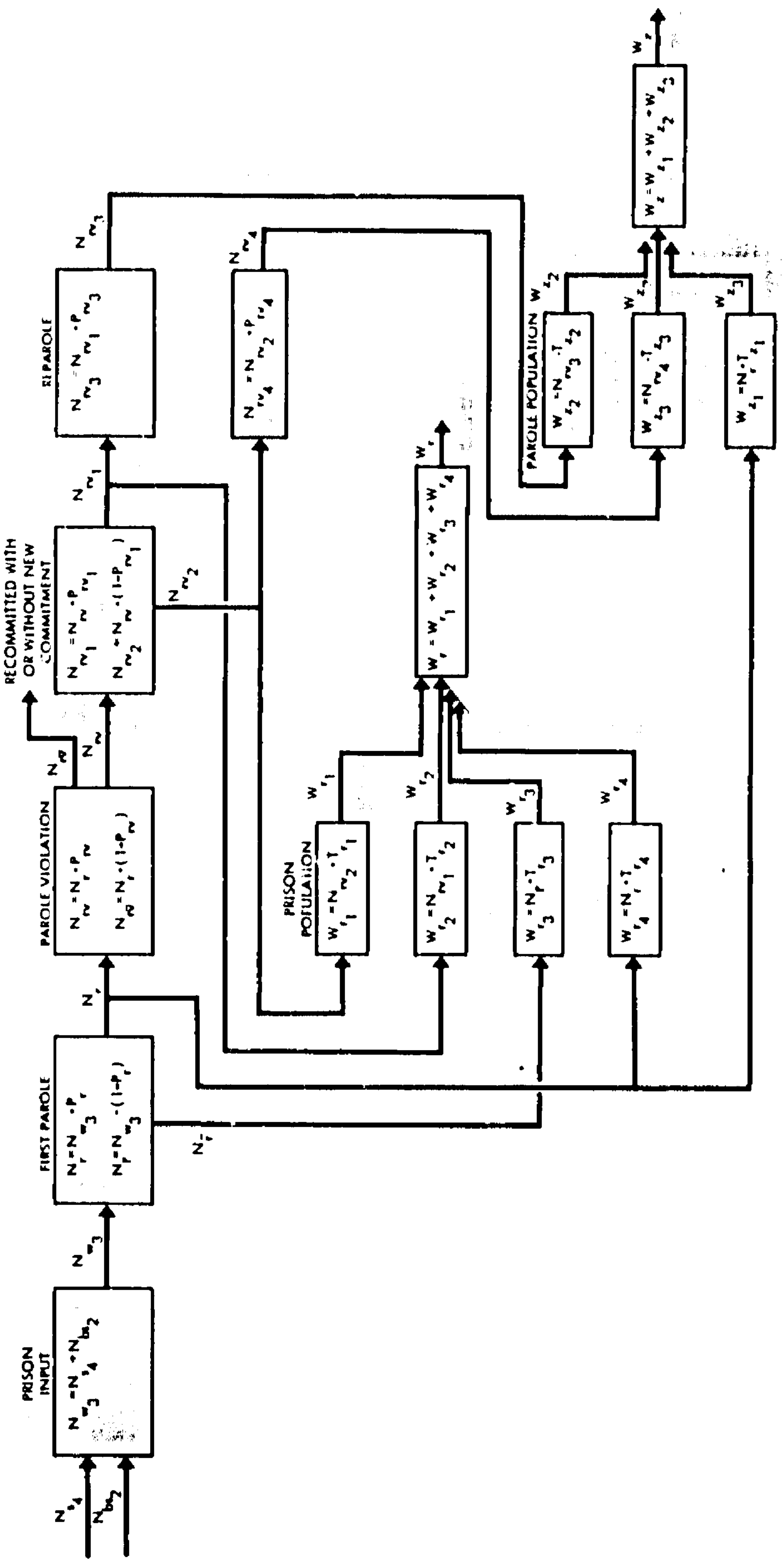

FIGURE B-9. The Prison and Parole Model

TABLE B-8. THE PRISON AND PAROLE MODEL

N_{s_4}	Adults committed to prison directly from Superior Court
N_{bs_2}	Adults committed to prison following a probation violation
N_{w_3}	Total number of adults sent to prison in a year, $$N_{w_3} = N_{s_4} + N_{bs_2}$$
P_r, N_r	Proportion and number, respectively, of adult prisoners who are given at least one parole, $$N_r = N_{w_3} \cdot P_r$$
$N_{\bar{r}}$	Number of adult prisoners who are <u>not</u> given at least one parole, $$\bar{N}_r = N_{w_3} - N_r$$
P_{rv}, N_{rv}	Proportion and number, respectively, of first parole adult prisoners violating first parole, $$N_{rv} = N_r \cdot P_{rv}$$
$N_{r\bar{v}}$	Number of first-parole adult prisoners who do <u>not</u> violate first parole, $$N_{r\bar{v}} = N_r - N_{rv}$$
P_{rv_1}, N_{rv_1}	Proportion and number, respectively, of adult first-parole violators who are returned to prison for a new offense, $$N_{rv_1} = N_{rv} \cdot P_{rv_1}$$

(table continued)

N_{rv_2}	Number of adult first-parole violators who are returned to prison under old offense, $$N_{rv_2} = N_{rv} - N_{rv_1}$$
P_{rv_3} , N_{rv_3}	Proportion and number, respectively, of first-parole <u>new</u> offense parole violators reparoled, $$N_{rv_3} = N_{rv_1} \cdot P_{rv_3}$$
P_{rv_4} , N_{rv_4}	Proportion and number, respectively, of first-parole <u>old</u> offense parole violators reparoled, $$N_{rv_4} = N_{rv_2} \cdot P_{rv_4}$$
T_{r_1}	Mean time spent in prison by N_{rv_2} until next release
W_{r_1}	Number of prisoners at any given time consisting of first-parole violators returned to prison under <u>old</u> offense, $$W_{r_1} = N_{rv_2} \cdot T_{r_1}$$
T_{r_2}	Mean time spent in prison by N_{rv_1} until next release
W_{r_2}	Number of prisoners at any given time consisting of first-parole violators returned to prison for a <u>new</u> offense, $$W_{r_2} = N_{rv_1} \cdot T_{r_2}$$
T_{r_3}	Mean time spent in prison by $N_{\bar{r}}$
W_{r_3}	Number of prisoners at any given time consisting of prisoners who do not receive at least one parole, $$W_{r_3} = N_{\bar{r}} \cdot T_{r_3}$$

(table continued)

T_{r_4} Mean time spent in prison by N_r prior to granting of first parole

W_{r_4} Number of prisoners at any given time consisting of prisoners who receive a first parole,

$$W_{r_4} = N_r \cdot T_{r_4}$$

W_r Prison population at any given time,

$$W_r = W_{r_1} + W_{r_2} + W_{r_3} + W_{r_4}$$

T_{z_1} Time spent on first parole by first-parole parolee

T_{z_2} Time on reparole of N_{rv_3}

T_{z_3} Time on reparole of N_{rv_4}

W_z Total number on parole at any given time

W_{z_1} Number on parole at any given time consisting of first-parole parolees,

$$W_{z_1} = N_r \cdot T_{z_1}$$

W_{z_2} Number on parole at any given time consisting of new offense reparolees,

$$W_{z_2} = N_{rv_3} \cdot T_{z_2}$$

W_{z_3} Number on parole at any given time consisting of old offense reparolees,

$$W_{z_3} = N_{rv_4} \cdot T_{z_3}$$

d. Corrections Costs. We consider here the costs of each of the three corrections subsystems previously described. The costing procedure, in general, is very simple once we have computed the populations defined above. There is typically a cost per person in a population (e.g., prison population) per year, and the cost assigned to that population is just the total population multiplied by the yearly unit cost.

The cost model is depicted in Fig. B-10, with definitions in Table 9. The total corrections cost (C_{co}) is the sum of the costs due to probation (C_b), jail (C_j), prison (C_r), and parole (C_z).

4. The Juvenile Model

a. Juvenile Flows. The juvenile flow model is developed in a straightforward manner from the discussion in Appendix A, Section F. The model is given in Fig. B-11; with definitions in Table B-10. A fraction P_{jr} of the arrested juveniles (N_{aj}) is referred to juvenile probation authorities. For each police referral, there is a total of P_{je} referrals ($P_{je} \geq 1$), giving N_{je} total referrals per year. There are three possible probation department dispositions·

(1) Petition filed in juvenile court
(2) Informal probation
(3) Case closed or referred to another agency.

If a petition is filed in juvenile court, there are five possible outcomes:

(1) The juvenile is incarcerated under Youth Authority supervision.
(2) The case is dismissed.
(3) The juvenile is assigned to local supervision as a non-ward.
(4) The juvenile is placed under local supervision as a ward.
(5) The juvenile is incarcerated as a ward.

Inputs to Youth Authority detention halls (N_{ya}) are received from juvenile courts, from Superior Court, and as a result of (adult) probation violation. The Youth Authority population is the product of

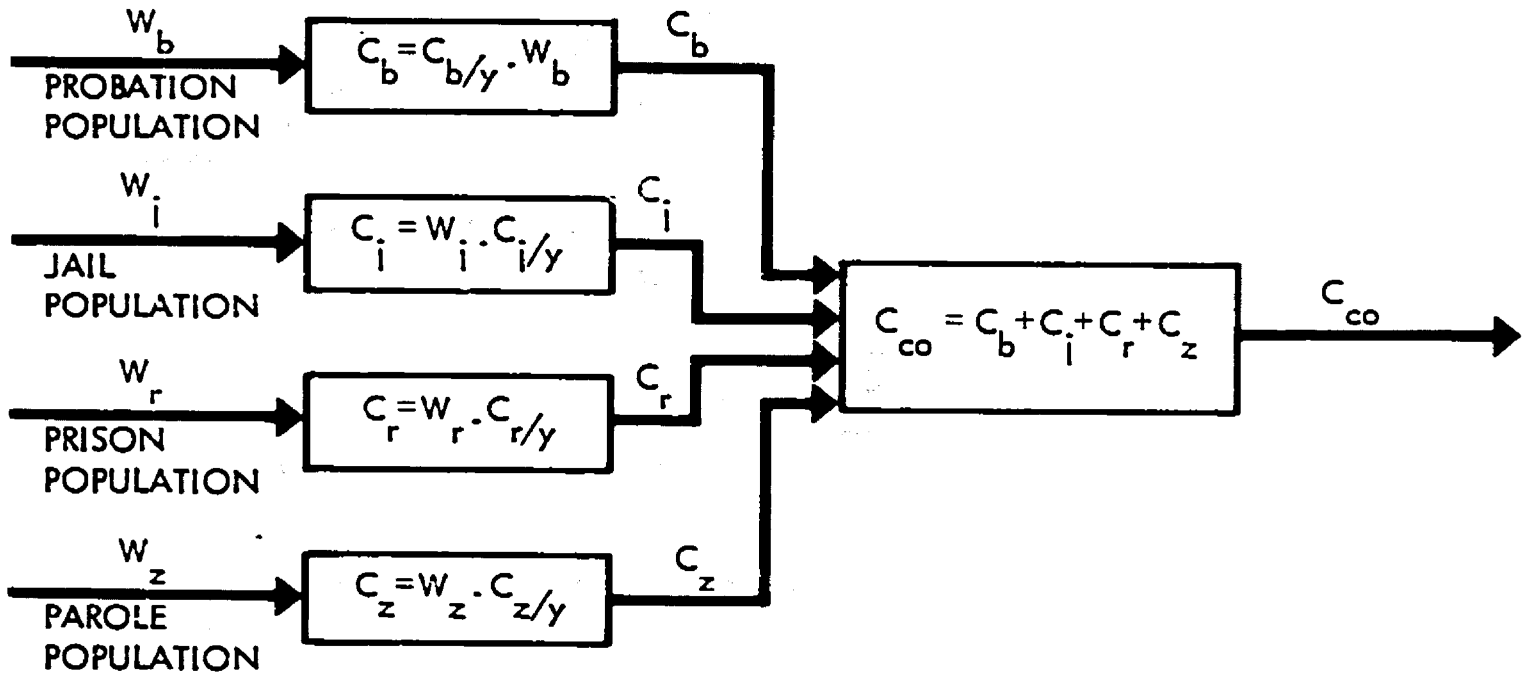

FIGURE B-10. Corrections Costs

TAPLE B-9. CORRECTIONS COSTS

$C_{b/y}$	Cost per person per year on probation
C_b	Total cost for probation, $$C_b = C_{b/y} \cdot W_b$$
$C_{j/y}$	Cost per person per year in jail
C_j	Total cost for jail, $$C_j = C_{j/y} \cdot W_j$$
$C_{r/y}$	Cost per person per year in prison
C_r	Total cost for prison, $$C_r = C_{r/y} \cdot W_r$$
$C_{r/y}$	Cost per person per year for parole
C_z	Total cost for parole, $$C_z = C_{z/y} \cdot W_z$$
C_{co}	Total corrections cost, $$C_{co} = C_b + C_j + C_r + C_z$$

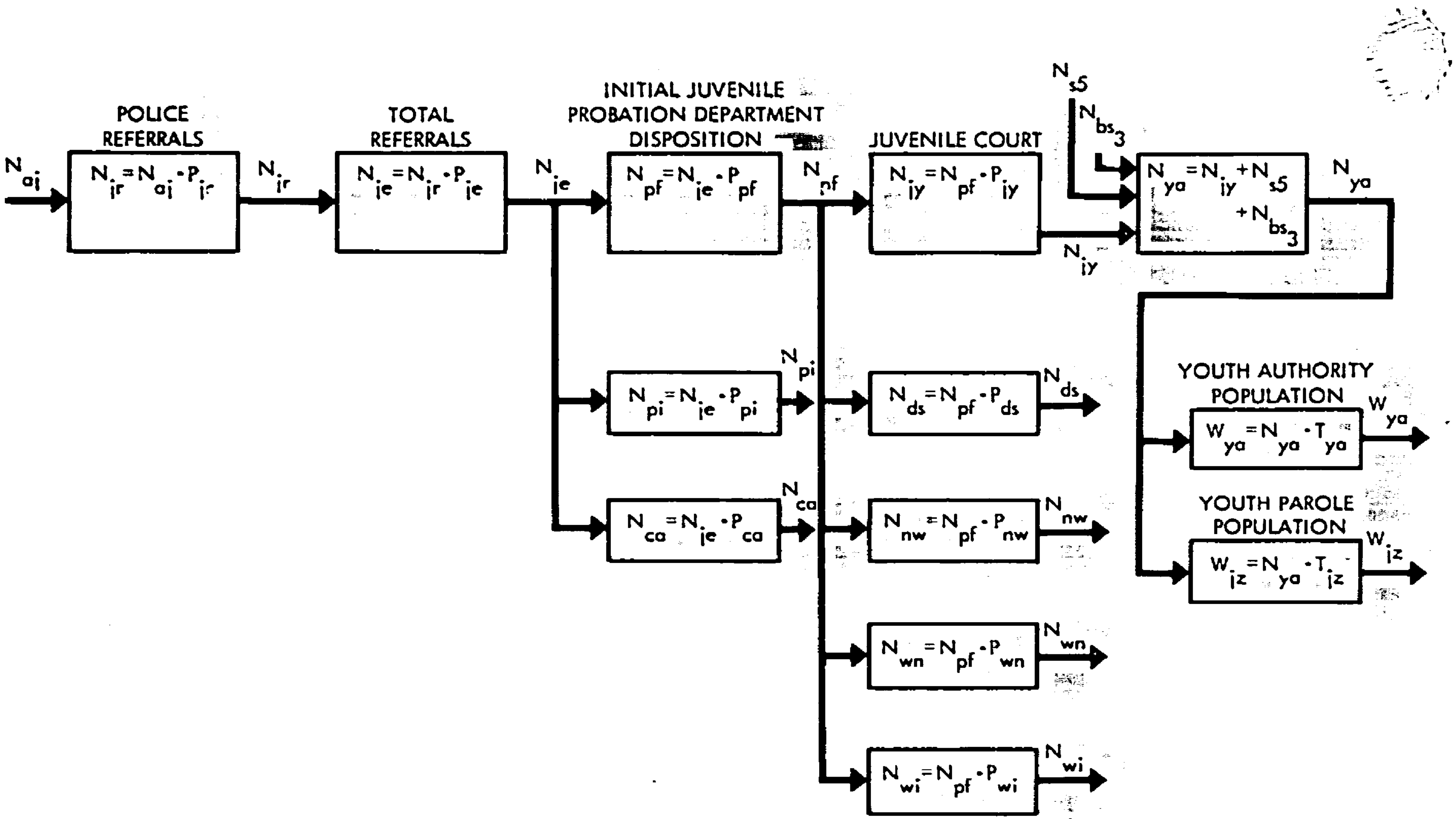

FIGURE B-11. The Juvenile Flow Model

TABLE B-10. DEFINITIONS FOR FLOW MODEL

N_{aj}	Number of arrested juveniles
N_{jr}, P_{jr}	Number and proportion of arrested juveniles referred to the juvenile probation authorities, $$N_{jr} = P_{jr} \cdot N_{aj}$$
P_{je}	Number of referrals per police referral ($P_{je} \geq 1$)
N_{je}	Total referrals per year, $$N_{je} = N_{jr} \cdot P_{je}$$
N_{pf}, P_{pf}	Number and proportion of referrals who have a petition filed in juvenile court
N_{pi}, P_{pi}	Number and proportion of referrals who are given informal probation
N_{ca}, P_{ca}	Number and proportion of referrals who have the case closed or are referred to another agency, $$N_{pk} = N_{je} \cdot P_{pk} \ (k = f, i, \text{or } a)$$
N_{jy}, P_{jy}	Number and probability that the juvenile referred to juvenile court is incarcerated under the Youth Authority
N_{ds}, P_{ds}	Number and probability that the case is dismissed by the juvenile court
N_{nw}, P_{nw}	Number and probability that the case is under local supervision as a non-ward
N_{wn}, P_{wn}	Number and probability that the case is under local supervision as a ward
N_{wi}, P_{wi}	Number and probability that juvenile is incarcerated as a ward
N_{ya}	Number of juveniles sent to Youth Authority halls, $$N_{ya} = N_{jy} + N_{s5} + N_{ls3}$$
T_{ya}	Mean time incarcerated under Youth Authority

(table continued)

W_{ya} Youth authority population at any given time,

$$W_{ya} = N_{ya} \cdot T_{ya}$$

T_{jz} Mean time on parole after release

W_{jz} Youth parole population at any given time,

$$W_{jz} = N_{ya} \cdot T_{jz}$$

N_{ya} and the mean time incarcerated. Similarly, the youth parole population is computed as was done in the previous section for adults.

b. Juvenile Costs. We will encounter data problems with the juvenile model which will be discussed further. Because of these problems, juvenile costing is difficult. We will attempt to assign a yearly cost for each probation referral, juvenile court disposition, Youth Authority incarceration and parole, and local supervision (as ward). No cost is assigned for detention of juveniles in local (not state supervised) detention houses. This omission is caused by lack of data describing numbers of juveniles in local detention and duration of stay.

The structure of the juvenile cost model is given in Fig. B-12; Table B-11 gives the definitions for the model. In all respects, it is similar to but somewhat simpler than the cost structure of the adult model.

5. Misdemeanors

The model does not include the processing of those arrested and charged with misdemeanors or those whose charge is dropped from a felony to a misdemeanor. Still, we include a system cost for those who are arrested for a felony and who are charged with a misdemeanor at the magistrate's stage. This cost C_m is the total average cost incurred by CJS agencies due to post-magistrate processing of a defendant whose charge has been dropped to a misdemeanor at the magistrate's stage.

6. Total Direct Operating Costs

The total direct operating cost C_t of the CJS due to the seven major crimes is the sum of five costs:

(1) Cost of police (C_{po});
(2) Cost of prosecution, courts, and pre-trial detention (C_{pc_2});
(3) Cost of the corrections system (C_{co});
(4) Cost incurred by agencies processing youthful offenders (C_y); and

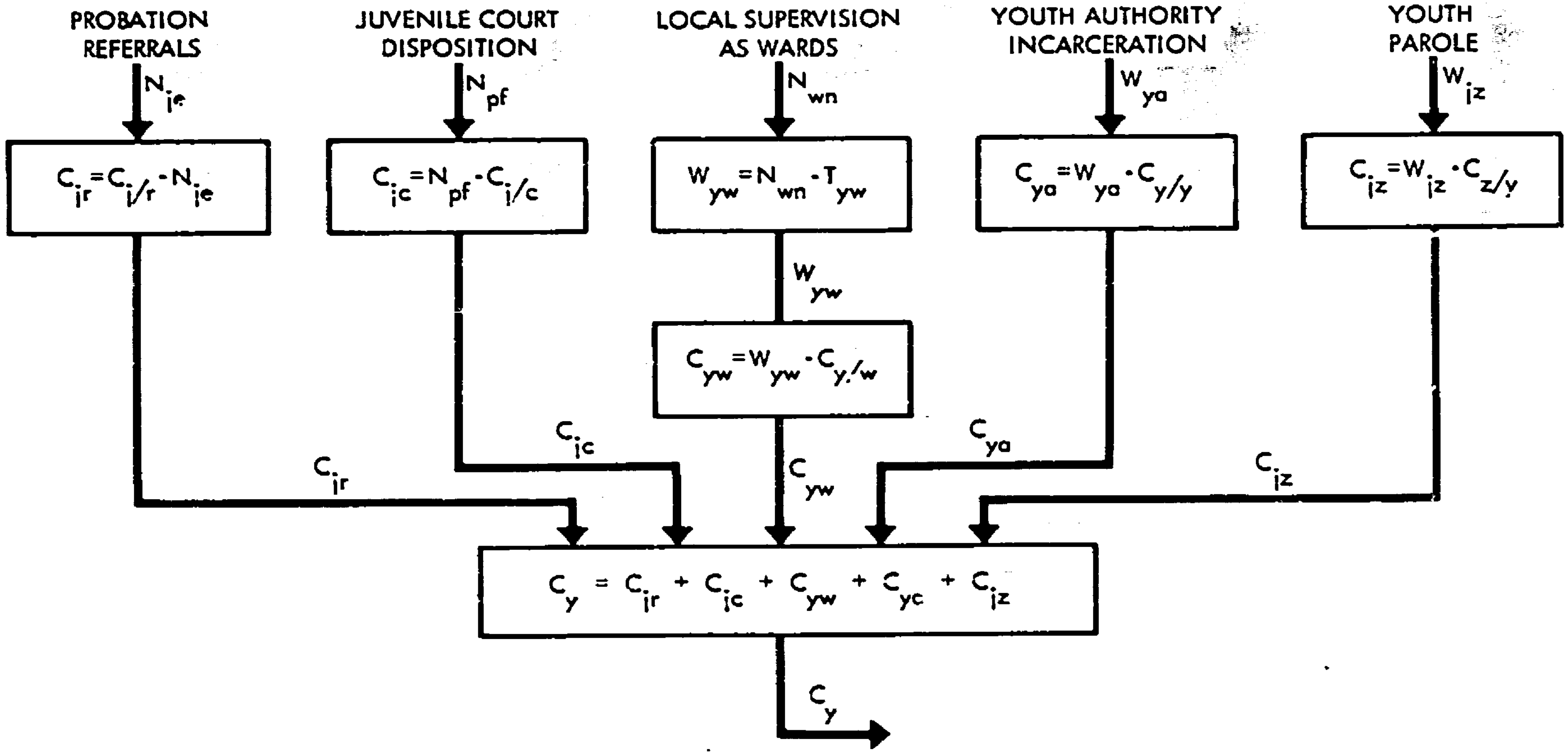

FIGURE B-12. The Juvenile Cost Model

TABLE B-11. DEFINITIONS FOR THE JUVENILE COST MODEL

N_{je}	Number of probation referrals per year
$C_{j/r}$	Cost per probation referral
C_{jr}	Total cost per year for probation referrals, $C_{jr} = C_{j/r} \cdot N_{je}$
N_{pf}	Number of juvenile court dispositions per year
$C_{j/c}$	Cost per court disposition per year
C_{jc}	Total cost per year for court disposition, $C_{jc} = C_{j/c} \cdot N_{pf}$
N_{wn}	Number of local supervision as ward cases per year
T_{yw}	Mean time as ward under local supervisor
W_{yw}	Total number of wards at any given time, $W_{yw} = N_{wn} \cdot T_{yw}$
$C_{y/w}$	Yearly cost per ward for local supervision
C_{yw}	Total cost per year for local supervision, $C_{yw} = C_{y/w} \cdot W_{yw}$
W_{ya}	Number of Youth Authority incarcerations per year
$C_{y/y}$	Cost per incarceration per year
C_{ya}	Total cost per year for incarceration, $C_{ya} = W_{ya} \cdot C_{y/y}$
W_{jz}	Number of youths on parole per year
$C_{z/y}$	Cost per youth parolee per year

(table continued)

C_{jz} Total cost per year for youth parole,

$$C_{jz} = W_{jz} \cdot C_{z/y}$$

C_y Total juvenile costs,

$$C_y = C_{jr} + C_{jc} + C_{yw} + C_{ya} + C_{jz}$$

(5) Cost due to post-magistrate processing of misdemeanor cases for which the defendant was originally arrested for a felony (C_m).

The sum of the first three costs is the adult CJS operating cost. The sum of the first four costs is the total (adult and juvenile) CJS operating cost for felonies, exclusive of post-magistrate cost of misdemeanor cases.

The cost model is given in Fig. B-13, with definitions in Table B-12.

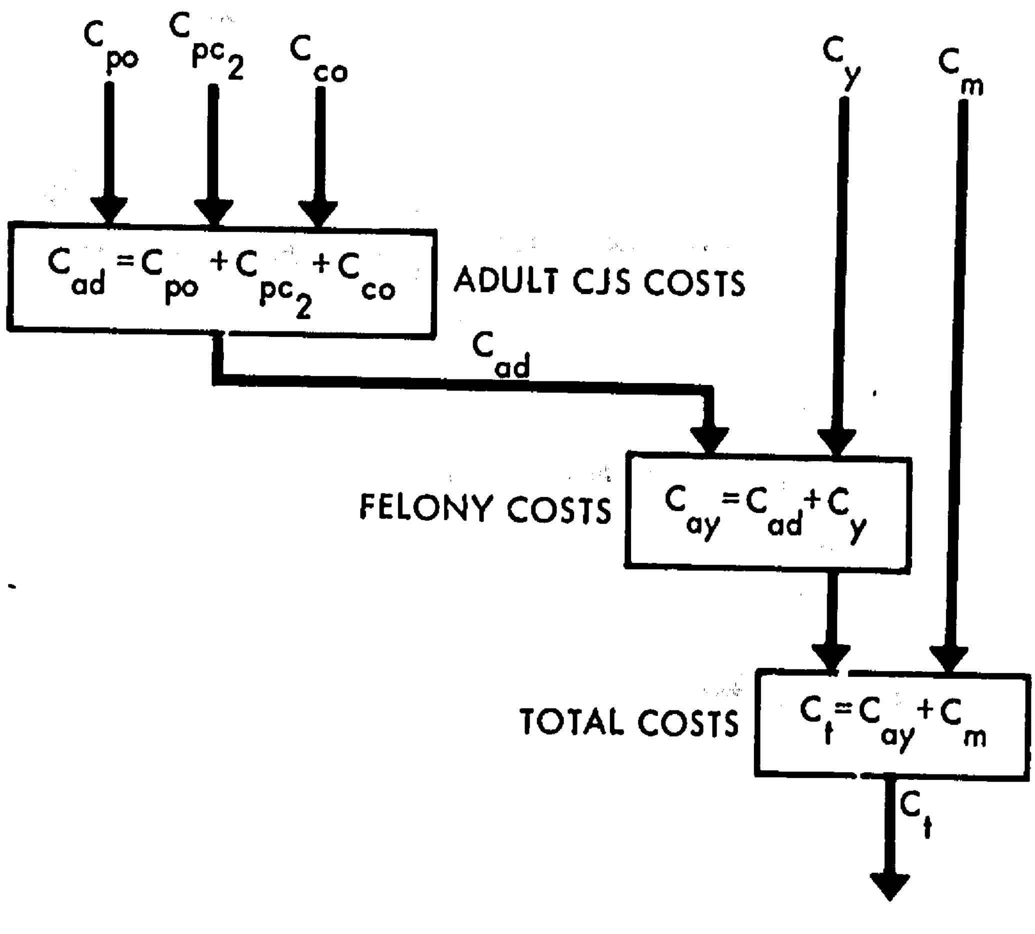

FIGURE B-13. The Total Direct Operating Cost Model

TABLE B-12. COMPONENTS OF TOTAL DIRECT OPERATING COST

C_{po}	Cost of police
C_{pc_2}	Cost of prosecution, courts, and pre-trial detention
C_{co}	Cost of the corrections system.
C_{ad}	Adult CJS operating cost, $C_{ad} = C_{po} + C_{pc_2} + C_{co}$
C_y	Cost incurred by agencies processing youthful offenders,
C_{ay}	Total CJS operating cost, exclusive of post-magistrate costs of misdemeanor cases $C_{ay} = C_{ad} + C_y$
C_m	Cost due to post-magistrate processing of misdemeanor cases,
C_t	Total direct operating cost of the CJS due to the seven major crimes $C_t = C_{ay} + C_m$

APPENDIX C

APPENDIX C

CONTENTS

APPENDIX C

ESTIMATED VALUES OF INPUT DATA TO LINEAR MODEL

This Appendix contains the numerical values of the branching ratios, costs, and other input data used in the linear model. It was originally hoped that the data from California would be sufficiently complete to permit a reasonably accurate representation of the California CJS for 1965, the year for which the data were collected. The data requirements of the model are sufficiently extensive, however, that even California, which has the best statistics available, could not provide all the needs. In computing the branching ratios, reference had to be made to special reports and studies by California CJS personnel which often reported values for years other than 1965. In other computations, data from specific cities within California, from cities outside the state, or from other states, had to be used. We appreciate, therefore, that our numbers are only crude approximations. But with the current state of information, even these crude approximations are needed to gain some initial insights and to point the way to further refinement and data collection.

The most troublesome problem in computing the branching ratios is the use of different definitions of the seven "major crimes" by the various reporting agencies within California. Two sets of definitions which are encountered frequently are the "seven major offenses" and the "general classification offenses." These definitions are contrasted in Table C-1. The "major" offenses comprise a subset of the "general classification" offenses. For instance, the homicide category in the seven major offense list is called "willful homicide," and "includes only murder and excludes negligent manslaughter." However, the corresponding crime category in the general offenses list is called "criminal homicide" and "includes all degrees of murder and all types of manslaughter, including vehicular."

TABLE C-1. CONTRAST BETWEEN "SEVEN MAJOR OFFENSES" AND "GENERAL CLASSIFICATION OFFENSES"

List I. Seven Major Offenses

1. Willful Homicide. Includes only murder and excludes negligent manslaughter.
2. Robbery. Same as General Classification (List II).
3. Aggravated Assault. Same as General Classification, with the exception of wife or child beating.
4. Burglary. Same as General Cl-ssification, with the exception of "burglary from locked vehicle."
5. Grand Theft, Except Auto. Excludes petty theft with prior and receiving stolen property offenses.
6. Auto Theft. Same as General Classification.
7. Rape. Includes only forcible rape. Excludes statutory rape.

List II. General Classification*

1. Criminal Homicide. Includes all degrees of murder and all types of manslaughter, including vehicular.
2. Robbery. Includes all offenses in which property is taken from the person or immediate presence of another through means of force or violence or by putting in fear. Includes assault with intent to rob and attempt to commit robbery.
3. Aggravated Assault. Includes:
   (a) Assaults and attempted assaults which might result in severe bodily injuries to the victim or in death.
   (b) Attempted murder and all assaults and attempted assaults with the exception of assault to commit robbery or rape.

---

*Also included in the general classification list are forgery and checks, sex except rape, violations of the narcotic drug laws, and several miscellaneous offenses.

4. Burglary. Includes:

   (a) All offenses in which any building or structure is broken into or entered with the intention of committing a felony or any theft therein at any time, either day or night.
   (b) Attempt to commit burglary.
   (c) Theft from locked vehicle and shoplifting. (It should be noted that these offenses are often looked upon as petty theft by law enforcement agencies and therefore are not always reported to the state bureau as felonious acts.)

5. Theft Except Auto. Includes:

   (a) All felonious offenses of stealing which are committed under circumstances not amounting to robbery or burglary and attempts to commit such thefts. (Any theft involving a value of over $200 is felonious, as in the theft of certain specified fruits and nuts having a value of over $50. In addition, the theft of any horses, cattle, swine, sheep or goats, is felonious regardless of value.)
   (b) Buying and receiving or possession of stolen property.
   (c) Attempts at any of the above offenses.

6. Auto Theft. Includes:

   (a) All offenses in which a motor vehicle is stolen or driven away and abandoned by someone not having lawful access thereto.
   (b) Attempt to commit auto theft.

7. Rape. Includes:

   (a) Forcible rape, statutory rape, and assault with intent to rape.
   (b) Attempt to commit any of these offenses.

The predominant motivation for the "major offenses" list is that these offenses "... are most likely to be reported to the police and uniformly accounted for." (See Ref. 1, p. 207.) California summary statistics of crimes reported to the police include only crimes defined in the major offense list and omit some of the less serious crimes included in the broader general classification list. Thus, in the model as well, the offenses reported to the police include only the major offenses: however, most of the later flows (e.g., in courts and corrections) are defined on the basis of the broader general offense list. This causes problems in interpretation of some of the results. For instance, we would like to divide the number of offenders convicted by the total number of crimes reported to approximate the probability of a reported crime resulting in conviction. If the number of convictions is defined on the basis of the general classification list, and the number of crimes reported is based on the major offenses list, the computed probability will be an overestimate of the actual value.

Occasionally a reporting agency will deviate slightly from the definitions of the general classification crimes and, where possible, we report this deviation. For convenience, we will refer to the major offense list as List I and the general classification list as List II (Table C-1). Other lists used are shown as Lists III through VII in Table C-2.

In order to give the reader an estimate of the "hardness" of the data, we have a very subjective scale ranging from 1 to 5, the lower numbers assigned to the harder data. Data which are given a scale value of 5 are simply estimates, based on little or no statistical evidence, while those with a scale value of 1 can easily be duplicated by the reader by referring to the indicated sources. We do not here question the validity of those basic sources.

When referring to a specific component of a data vector, we will use the following convention: If the data vector is Z, the $i^{\underline{th}}$ ($1 \le i \le 7$) component of Z is Z(i). For instance, the average number

TABLE C-2. ALTERNATE CRIME CATEGORY DEFINITION LISTS

List III

1. Homicide
2. Robbery
3. Aggravated assault
4. Burglary
5. Grand theft, except auto
6. Auto theft
7. Rape

List IV

1. Homicide--Murder 1st
Murder 2nd
Manslaughter
2. Robbery--Robbery 1st
Robbery 2nd
Attempted robbery
3. Assault with a deadly weapon
4. Burglary--Burglary 1st
Burglary 2nd
Attempted burglary 2nd
5. Theft--(1) Grand theft, except auto
(2) Petty theft with prior and receiving stolen property offenses
6. Auto theft
7. Rape

List V

1. Homicide--Murder 2nd
Manslaughter
2. Robbery--Robbery 1st
Robbery 2nd
3. Assault with a deadly weapon
4. Burglary--Burglary 1st
Burglary 2nd
5. Theft--Grand theft, except auto
6. Auto theft
7. Rape

List VI

1. Homicide--Murder
Manslaughter
2. Robbery
3. Assault--Aggravated
Assault simple
Assault
4. Burglary
5. Theft, except auto
6. Auto theft
7. Sex offenses

List VII

Same as List VI, except

7. Forcible rape

of robbery arrests per reported robbery is referred to as $N_{a/c}(2)$, i = 2 corresponding to the robbery component of the vector $N_{a/c}$.

The data values* are reported roughly in the order in which they were defined in Appendix B.

A. THE POLICE SUBSYSTEM

1. Flow Model Data

There are three types of branching ratios required for the police flow model. These are (1) $N_{a/c}$ (the average number of arrests per reported crime); (2) P_{ad} (the proportion of arrests which are adult arrests); and (3) P_{ad_i} (i = 1,2,3,4) (the branching ratios describing police disposition).

Data values for the police flow model are reported in Table C-3. All of these values were computed from Crime and Delinquency in California, 1965 (Ref 1).**

The problem of crime definition consistency arises early. Lists I and III are both used to compute the number of arrests per reported crime. The logical relationships among Lists I, II, and III are shown in Fig. C-1. The number of reported crimes is based on the most narrow list, the major offenses (List I). Adult arrests, which are tabulated separately from juvenile arrests, are reported according to

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* Numerical values are usually given to two significant figures only, whereas in the model four significant figures were often used in order that the 1965 computed flows would closely approximate the actual flows. (This served as a check for the flow model.) Some of the sets of branching ratios, when rounded to two significant figures, do not add to one; to correct this, typically one of the numerical values has been rounded to the second closest one-hundredth so that the probabilities in the set do add to one. (This was not done in the computer runs of the model, where four significant figures were used.) Where this type of rounding is used, the datum will be given the superscript (R).

** The computation of these values is given in the last column in Table C-3. The following convention is used: (Reference number, table number, column number in the table, page number of the table, crime category list number). Thus, for instance, (Ref. 1, Table III-4, 3, p. 46, III) refers to the third column of Table III-4, p. 46; the values are reported according to List III.

TABLE C-3. POLICE FLOW MODEL DATA VALUES

DATA NAME	HOMICIDE (1)	ROBBERY (2)	ASSAULT (3)	BURGLARY (4)	THEFT (5)	AUTO THEFT (6)	RAPE (7)	SCALE VALUE	COMPUTATION
$N_{a/c}$	1.59	0.57	0.61	0.23	0.28	0.30	0.90	1	[(Ref. 1, Table III-1, 4, p. 43, III) + (Ref. 1, Table VIII-1, 4, p. 142, I)] / (Ref. 1, Table II-1, 4, p. 37, I)
P_{ad}	0.94	0.85	0.85	0.54	0.83	0.43	0.90	1	(Ref. 1, Table III-1, 4, p. 43, III) / [(Ref. 1, Table III-1, 4, p. 43, III) + (Ref. 1, Table VIII-1, 4, p. 142, I)]
P_{ad_1}	0.68	0.41	0.34	0.50	0.53	0.42	0.59	1	(Ref. 1, Table III-4, 6, p. 46, III) / (Ref. 1, Table III-4, 2, p. 46, III)
P_{ad_2}	0.04	0.14	0.37	0.19	0.18	0.11	0.12	1	(Ref. 1, Table III-4, 5, p. 46, III) / (Ref. 1, Table III-4, 2, p. 46, III)
P_{ad_3}	0.22	0.38	0.27	0.26	0.23	0.29	(R) 0.25	1	(Ref. 1, Table III-4, 3, p. 46, III) / (Ref. 1, Table III-4, 2, p. 46, III)
P_{ad_4}	0.06	0.07	0.02	0.05	(R) 0.06	0.18	0.09	1	(Ref. 1, Table III-4, 4, p. 46, III) / (Ref. 1, Table III-4, 2, p. 46, III)

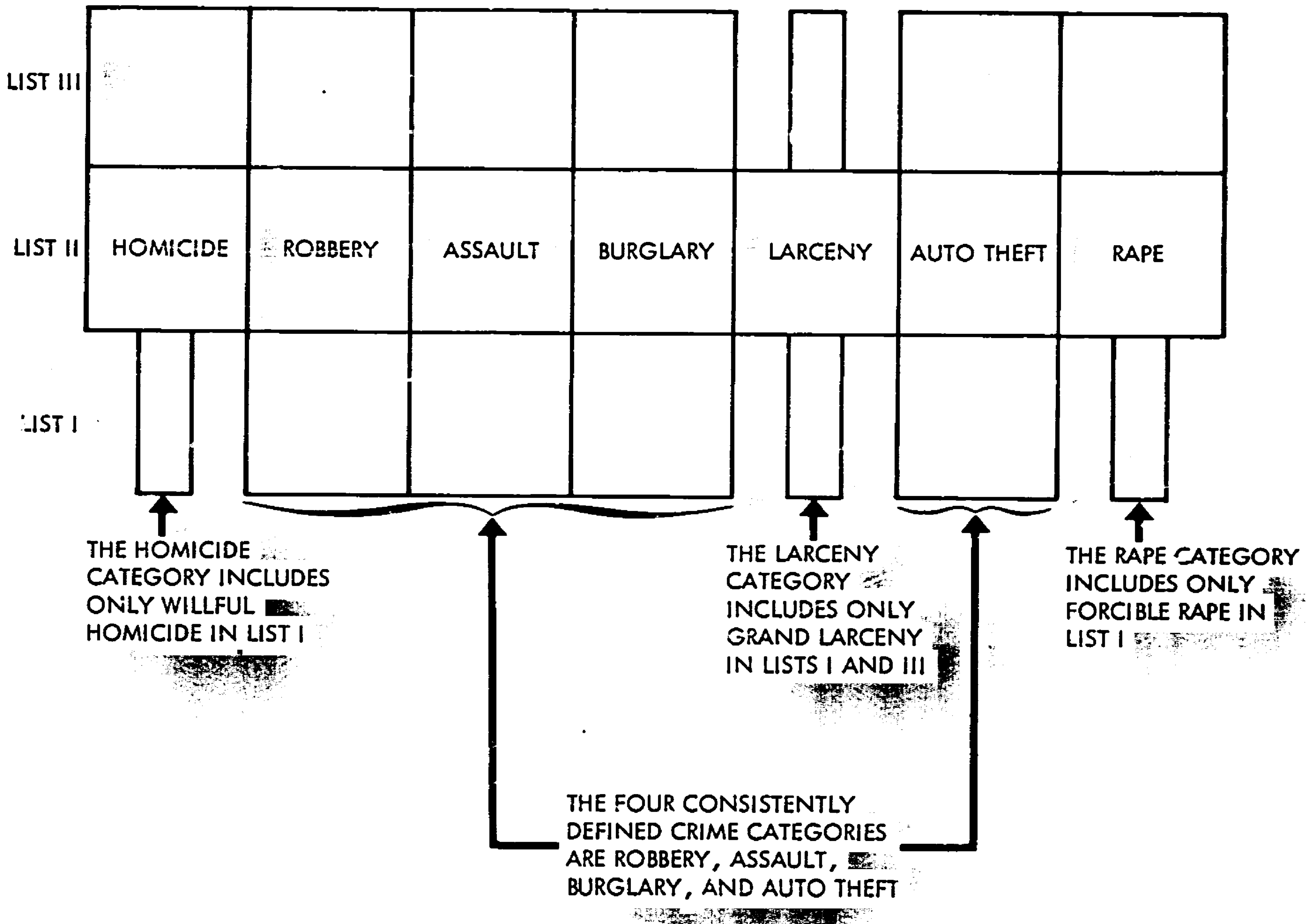

FIGURE C-1. Logical Relationships Among Crime Category Lists I, II, and III

List III. On the other hand, arrest statistics for juveniles are reported by the major offense list only (List I). Thus, in comparing adult arrest data to those of juveniles, the relative number of adult arrests is greater than if the lists were defined on identical crime categories. This problem is reflected in the computations of P_{ad} (the proportions of arrests which are adult arrests), the magnitude of which tends to understate the extent of juvenile involvement with police. We should also add at this point that circumstances involving criminal behavior of a juvenile--for which an adult would be arrested--often do not lead to the arrest of the juvenile. The system seems less formal and more flexible when dealing with juvenile offenders, and the stigma of an arrest record is considered when taking police action.

Of the four consistently defined crimes (robbery, aggravated assault, burglary, and auto theft), Table C-3 shows that the two crimes against person, robbery and assault, show the greatest arrest probability, 0.57 and 0.61, respectively. These comparatively high arrest probabilities are perhaps due to the seriousness of the offenses and the fact that, since a victim is directly involved in the crime, a suspect can often be named or at least described. Reported auto thefts are only one-half as likely as robbery or assault to lead to an arrest, and reported burglaries lead to an arrest with an even smaller probability of 0.23. Examining $N_{a/c}(5)$ (the number of arrests for grand theft per reported grand theft), we observe the comparatively low value of 0.28. This would probably be even lower if the category were all thefts, not just grand theft.

The values of $N_{a/c}(1)$ (number of homicide arrests per willful homicide) and $N_{a/c}(7)$ (number of rape arrests per reported forcible rape) tend to exaggerate the likelihood of arrest for each of these reported crime types. This occurs because the crime reporting definitions are more exclusive than the arrest definitions for each crime type. (See Fig. C-1.) That is, since a large fraction of the reported homicides are not willful homicides, the number 1.59 arrests per reported willful homicide is misleading and difficult to interpret. In a like manner, the figure 0.90 for rape does not mean that with 0.90 probability an arrest will occur for each reported rape.

Looking at the fraction of arrests which are adult arrests (P_{ad}), we see that for the crimes-against-person (homicide, rape, assault), arrests are typically adult arrests (85 percent for each are adult arrests), while for the less serious property crimes (burglary, theft, auto theft) arrests are approximately evenly divided between adults and juveniles.

The adult police disposition probabilities (P_{ad_1}, P_{ad_2}, P_{ad_3}, and P_{ad_4}) do not cause any problems of consistency of crime definition since all computations were made from the same table in Ref. 1 Those arrested for homicide are most likely to be charged with a felony at the magistrate's level ($P_{ad_1}(1) = 0.68$) and those arrested for assault have the lowest probability ($P_{ad_1}(3) = 0.34$). Typically, one-half of those adults arrested for a felony are charged with that felony at the magistrate's stage. Assault arrests are most likely to have their charge reduced to a misdemeanor ($P_{ad_2}(3) = 0.37$). Robbery arrests are most likely to be released ($P_{ad_3}(2) = 0.38$). Auto theft arrests, as we might expect due to the mobility of the automobile, are most likely to be turned over to other jurisdictions ($P_{ad_4}(6) = 0.18$).

2. Police Workload and Cost Data

Reported crimes generate workloads for two types of police officers--patrolmen and detectives.* Computation of the average time spent per case is a relatively straightforward task for detective personnel. Detectives are primarily a reactive force, spending most of their time investigating crimes which have already occurred. There are, of course, special squads such as detective patrols (designed to intercept crimes in progress) and detective intelligence units. But for our purposes here, since we are limiting the model to the seven serious offenses, the concept of detective workload per reported crime is operationally meaningful.

The model distinguishes three types of cases involving detective man-hour considerations:

(1) Crime reported but no arrest;

*See Ref. 2.

(2) Crime reported, arrest occurs, but no formal charge;

(3) Crime reported, arrest occurs, and a formal charge is brought.

The Los Angeles Police Department (LAPD) has computed the average time spent by detectives for each of the above types of cases for each of the seven crime types of interest. If the time spent on Type 1 cases is subtracted from the time for Type 2 cases, the difference can be called the additional time spent due to arrest. In a like manner, if the time spent on Type 2 cases is subtracted from the time for Type 3, the difference can be called the additional time spent due to charge. Much of this latter time is spent gathering evidence and in assisting the District Attorney to construct a case.

The computations for detective workload (in man-hours) are presented in Table C-4. Note that detective time per reported crime (T_{d_1}) ranges from 0.6 hour for auto theft to 15.1 hours for homicide; the typical time is 2 hours. The additional time spent per arrest (T_{d_2}) does not vary so widely among crime types, ranging from a low of 2.1 hours for auto theft to 5.2 hours for theft. Finally, the additional time spent due to charge (T_{d_3}), i.e., the case buildup time, ranges from 3.5 hours for assault to 23.4 hours for homicide. Thus, a total of 43.5 detective hours is spent per homicide case brought to court, compared to a low value of 8.1 hours per assault case brought to court.

The times spent by patrol in the servicing of each reported crime (T_{p_1}) were computed from a study performed in Boston, Massachusetts, in June 1966. (See Ref. 3, App. I.) The times spent by patrolmen per reported crime vary from 0.6 hour for assault and theft to 1.2 hours for rape and 2.0 hours for homicide. Unlike the times for detectives, the data for patrol times are not broken down by reported crime-arrest-charge.

A critical workload assignment in the model is the method of assigning preventive patrol time to the seven major crimes. This assignment is reflected in the value of the parameter T_{p_2}, the average number of preventive patrol man-hours apportioned per patrol man-hour

TABLE C-4. DETECTIVE WORKLOAD PER REPORTED CRIME AND PATROL WORKLOAD PER REPORTED CRIME

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
T_{d_1}	15.1	2.8	2.0	1.3	2.3	0.6	2.1	1	Ref. 2
T_{d_2}	5.0	4.0	2.6	2.7	5.2	2.1	3.1	1	Ref. 2
T_{d_3}	23.4	8.9	3.5	7.3	13.4	6.1	11.7	1	Ref. 2
Totals	43.5	15.7	8.1	11.3	20.9	8.8	16.9		
T_{p_1}	2.0	0.8	0.6	0.9	0.6	0.7	1.2	1	Ref. 3, p. 172
T_{p_2}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5	

required to service reports of crimes. Typically, a patrolman spends from 50 to 90 percent of his time performing preventive patrol and inspection duties. A fundamental purpose of this type of patrol is to deter and prevent major crimes, including, of course, the seven crimes in the model.* Thus, whatever the cost allocation procedure for preventive patrol, it is unfortunate that (1) it will be an arbitrary allocation, and (2) the police costs are fairly sensitive to the particular allocation.

In the current model, we allocate one hour of preventive patrol for each hour spent servicing a call for a reported crime, regardless of crime type. (That is, we have set $T_{p_2}(i) = 1.0$ for $i = 1, \ldots 7$.) Although arbitrary, this workload assignment probably represents a conservative lower bound estimate of the patrol effort which can be associated with the seven major crimes. An assignment of all preventive patrol time to these crimes would represent an upper bound and typically would amount to 50 to 90 percent of the patrolman's efforts.

The number of working hours per year per officer (patrolman or detective) was set at 1700 hours. The LAPD estimates that a patrolman is available for work 63 percent of the days in a year. (See Ref. 6.) Assuming about 7.5 hours of work per man per shift, we calculate that each policeman works 1723 hours per year. This was rounded to 1700 hours.

The variable cost per hour worked by detectives was set at \$10.30. The variable hourly cost of patrolmen was set at \$6.50. Included in

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* The determination of the "need" for a given quantity of preventive patrol, based on historical crime distributions and other data, has been a topic of wide concern in the police literature. O.W. Wilson discusses the problem at length and concludes that "...preventive patrol needs cannot presently be determined analytically due to a lack of studies linking preventive patrol with crime incidence and prevention, yet the very real dilemma exists that most of a patrolman's time is spent on preventive patrol." (See Ref. 4, pp.256-258.) R. Dean Smith (Ref. 5) assigns a given number of hours of preventive patrol per reported crime on the basis of seriousness and preventability.

these figures are indirect costs, e.g., costs of administrators, support personnel, equipment, and contracted services; these indirect costs were distributed to the operating divisions on the basis of the number of uniformed personnel in each division. For instance, the calculation for the patrol division was made by dividing the total yearly budget associated with the patrol division (for the LAPD in 1964, about $19 million for salaries and about $0.8 million for equipment and other expenses) by the number of uniformed personnel in the division (about 2740 in the LAPD in 1964) to obtain a cost-per-patrol division officer per year (about $7200). Similar computations were performed for the detective division and the traffic division.* Then, administrative and other costs were aggregated and apportioned to each of the three divisions on the basis of the number of uniformed personnel in each division. These calculations resulted in an annual cost per man of $11,000 for patrol personnel and $17,500 for detectives. Dividing by 1700 hours per year, we obtained the hourly cost figures reported above.

B. THE PROSECUTION AND COURT SUBSYSTEM

1. Flow Model Data

As discussed in Appendix B, Section B-2, the model aggregates all pre-trial activity into one processing stage. Either a defendant receives a court disposition (including dismissal and off calendar) or the defendant is dismissed from the system at the single processing stage prior to court disposition. The values of P_f, the proportion of the defendants charged with a felony from magistrate's court who receive a court disposition, are given in Table C-5. These values were computed by dividing the number of adult felony defendants who received a Superior Court disposition in 1965 by the number of adult felony arrests for whom a felony complaint was filed. In addition to the complications indicated in the previous chapter concerning the

*The traffic division was separated out because it has little to do here with the seven crimes of interest and a proportion of the overhead costs should be assigned to these personnel.

TABLE C-5. PROPORTION OF DEFENDANTS CHARGED IN MAGISTRATE'S COURT WHO RECEIVE A COURT DISPOSITION AND TYPED TRIAL OR OTHER DISPOSITION

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_f	0.79	0.54	0.49	0.51	0.78	0.59	0.53	2	$\frac{\text{(Ref. 1, Table V-5, 4, p. 69, II)}}{\text{(Ref. 1, Table III-4, 6, p. 46, III)}}$
P_{t_1}	0.25	0.18	0.12	0.07	0.06	0.03	0.11	1	$\frac{\text{(Ref. 1, Table V-5, 7 + 12, p. 69, II)}}{\text{(Ref. 1, Table V-5, 4, p. 69, II)}}$
P_{t_2}	0.18	0.13	0.25	0.17	0.20	0.16	0.21	1	$\frac{\text{(Ref. 1, Table V-5, 8+9+13+14, p. 69, II)}}{\text{(Ref. 1, Table V-5,4, p. 69, II)}}$
P_{t_g}	0.50	0.61	0.52	0.67	(R) 0.65	0.75	(R) 0.57	1	$\frac{\text{(Ref. 1, Table V-5, 11, p. 69, II)}}{\text{(Ref. 1, Table V-5, 4, p. 69, II)}}$
P_{t_d}	0.07	0.08	0.11	0.09	0.09	0.06	0.11	1	$\frac{\text{(Ref. 1, Table V-5, 6, p. 69, II)}}{\text{(Ref. 1, Table V-5, 4, p. 69, II)}}$

interpretation of these numbers, there are at least two other problems. First, a number of the "adults" charged with a felony as a result of police disposition are presumably in the 18 to 21 age group, and some of their cases are referred to juvenile courts; these relatively few cases are not included in the model. Second, and probably more important, the court disposition statistics reported by the California Bureau of Criminal Statistics are apportioned by the crime for which the defendant was found guilty (if found guilty) or charged (if acquitted or dismissed). From the magistrate's court stage there are many opportunities for change in the charge, usually charge reduction. These changes may be within the same crime category (e.g., from assault 1 to assault 2) or they may jump crime categories (e.g., from rape to assault). A detailed description of this process is not available from recorded data and is not included in the model. Thus, the set of individuals who receive a court disposition for a particular crime may not be composed entirely of a subset of those individuals charged with that type of crime at the magistrate's stage. One way future models could include this behavior, which is an important descriptor of the "plea-bargaining" process, is to include a "charge-switch matrix" in the flow just before the court disposition stage.

Here again, we run into problems due to the lack of consistency of crime definitions. The value of $P_f(5)$ in Table C-5 is the number of theft dispositions per defendant charged with grand theft at the magistrate's court. Each of the other probabilities is computed on consistent crime definitions from magistrate to Superior Court.

From the Table, we note that the fraction who receive dispositions (P_f) ranges from a low of 0.49 for assault to 0.79 for homicide. Robbery, burglary, and rape probabilities are also all near one-half. Thus, typically, about one-half of those adults charged with a felony at the magistrate's stage receive a Superior Court disposition. Referring back to arrests, about one-fourth of those adults arrested for a felony receive a final Superior Court disposition for that felony, and only a fraction of these dispositions find the defendant guilty.

Examining the trial stage, we see that guilty pleas are the most likely method of disposition. Over all crime types, at least 50 percent of all dispositions are pleas of guilty or nolo contendere. The fraction of defendants receiving a trial is greatest for homicide cases (43 percent) and lowest for auto theft cases (19 percent). None of the three property crime cases (burglary, theft, auto theft) has a trial probability greater than 0.26 (for theft cases). Jury trials are quite rare among the property crimes; the largest fraction of cases which are tried by jury (one-quarter) are homicide cases. Averaged over all of the seven crimes, 8.9 percent of defendants received jury trial, 18.0 percent bench or transcript trials, and 64.2 percent submitted a plea of guilty or nolo conterdere; all others were dismissed and placed off calendar.

Probabilities of being found guilty in each of the two types of trials are given in Table C-6. Except for defendants charged with rape, probabilities of being found guilty in jury trail (P_{tg_1}) are never less than 0.68 (for theft) and reach 0.83 (for auto theft). The associated probability for rape is 0.54. The probability of being found guilty in a court or transcript trial (P_{tg_2}) ranges from 0.61 for rape (again, this crime category has the lowest probability) to 0.89 for theft. Averaged over all of the seven crimes, the probability of being found guilty in a jury trial is 0.76, whereas the corresponding probability for court or transcript trial is 0.75.

Sentencing probabilities are given in Table C-7. The probability of being sentenced to prison (P_{s_4}), given the defendant is sentenced, exceeds 0.25 (burglary) only for the violent crimes of homicide (0.55) and robbery (0.62). The probability of a prison sentence is lowest for theft defendants (0.14). The straight jail sentence is infrequently used for homicide and robbery defendants but is used in about 20 percent of the other cases. Probation (P_{s_1}) and probation with jail probabilities are greatest for defendants found guilty of rape (0.62) and lowest for those found guilty of robbery (0.20). Averaged over all seven crimes, the fractions of sentenced defendants granted probation or probation with jail is 0.45. Relatively few defendants

TABLE C-6. PROBABILITIES OF BEING FOUND GUILTY IN EACH OF THE TWO TYPES OF TRIALS

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{tg_1}	0.81	0.81	0.75	0.78	0.68	0.83	0.54	1	$\frac{\text{(Ref. 1, Table V-5,12, p.69, II)}}{\text{(Ref. 1, Table V-5,12+7, p. 69, II)}}$
P_{tg_2}	0.68	0.71	0.77	0.71	0.89	0.75	0.61	1	$\frac{\text{(Ref. 1, Table V-5,13+14, p. 69, II)}}{\text{(Ref. 1, Table V-5,8+9+13+14, p. 69, II)}}$

TABLE C-7. SENTENCING PROBABILITIES

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{s_1}	0.15	0.05	0.33	0.21	0.34	0.22	0.40	1	(Ref. 1, Table V-13, 9, p. 81, II) / (Ref. 1, Table V-13, 2, p. 81, II)
P_{s_2}	0.24	0.15	0.23	0.24	0.22	0.19	0.22	1	(Ref. 1, Table V-13, 10, p. 81, II) / (Ref. 1, Table V-13, 2, p. 81, II)
P_{s_3}	(R) 0.02	0.02	0.20	0.18	0.24	0.25	0.12	1	(Ref. 1, Table V-13, 11, p. 81, II) / (Ref. 1, Table V-13, 2, p. 81, II)
P_{s_4}	0.55	0.62	0.19	0.25	0.14	(R) 0.18	0.16	1	(Ref. 1, Table V-13, 7, p. 81, II) / (Ref. 1, Table V-13, 2, p. 81, II)
P_{s_5}	0.04	0.14	0.04	0.10	0.04	0.15	0.07	1	(Ref. 1, Table V-13, 8, p.81, II) / (Ref. 1, Table V-13, 2, p.81, II)
P_{s_6}	0.00	0.00	0.01	0.00	0.01	0.00	0.00	1	(Ref. 1, Table V-13, 12, p. 81, II) / (Ref. 1, Table V-13, 2, p.81, II)
P_{s_7}	0.00	(R) 0.02	0.00	0.02	0.01	0.01	0.03	1	(Ref. 1, Table V-13, 3 + 4, p. 81, II) / (Ref. 1, Table V-13, 2, p. 81, II)

are committed to the Youth Authority and very few are fined or given a civil commitment.

2. Cost and Workload Data - Prosecution and Courts

Cost and workload data for courts are perhaps more difficult to obtain than similar data for the other subsystems. Police, for instance, maintain fairly good records on manning assignments and can calculate the total working days per year per officer; they also know quite accurately the total numbers of incidents handled in a year. Correction officials can easily compute workloads by taking a prison census and by recording parole and probation officer caseloads. In prosecution and courts, however, the system at times is not as neatly defined as are the other systems. Cases which are dismissed prior to trial or are settled by a plea of guilty represent some workload on prosecution, but it is difficult to estimate how much. It is not possible to follow individual cases from the data currently compiled by the Bureau of Criminal Statistics. Those cases in which the charge is dropped to misdemeanor after the magistrate but before final disposition are impossible to trace.

Assigning costs which are proportional to flow variables is even more difficult and the cost assignments given here should be considered rough estimates at best. However, since the overall CJS costs are dominated by police and corrections costs, the rough estimates made here for the courts system do not greatly affect the total system costs.

We have separated costs by pre-trial and trial costs and by prosecution and court cost; in addition, there is a cost due to pre-trial detention. Not all the data required for costing purposes were available from California, so estimates were made from other jurisdictions.

The defendant, prior to trial, may either be released if he can post bail, be released on his own recognizance, or be placed in jail (i.e., pre-trial detention) if bail cannot be posted. Only the last category causes the CJS to incur direct costs; that is, the cost of detaining the defendant in jail. Unfortunately, for California no data are available for the proportion of defendants, by crime type, who are detained in jail. Nationwide, the bail system is most often used, with relatively infrequent release of the defendant on his own recognizance. The Courts Task Force of the National Crime Commission reports that in 9 counties distributed throughout the nation, the percentage of felon defendants unable to make bail ranges from 93 percent to 6 percent.* There seemed to be no typical value, indicating that local practices can vary widely.**

In addition to the probability of pre-trial detention, the model requires data on the mean time spent in jail by those who are detained. This is not available for the state of California. The President's Commission on Crime in the District of Columbia reports that the median time between indictment and disposition for all cases in the District Court in 1966 was 4.8 months. The "time v..ied considerably, however, by type of disposition, growing longer as accused persons

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*Ref. 7, p. 37. The detailed breakdown was as follows:

	Felony Defendants Unable to Make Bail (percent)
Large Counties	
Cook (Chicago)	75
Hennepin (Minneapolis)	71
Jefferson (Louisville)	30
Philadelphia (Philadelphia)	14
Small Counties	
Brown, Kansas	93
Rutland, Vermont	83
Putnam, Missouri	36
Anchorage, Alaska	28
Catoosa, Georgia	6

**Studies have shown that a defendant's later court disposition, including determination of guilt and sentencing, is dependent on whether or not he was detained in jail prior to trial. (See Ref. 7, p. 38 for several references.) Thus, a detailed flow model would establish separate branching ratios for those detained and those not detained. This has not been attempted here.

exercised their rights to jury trial. Persons acquited by the jury waited 5.6 months for verdict, and it required 6.3 months to convict those found guilty by the jury."* Appealed cases required years to determine guilt or innocence. For use in the model, pre-trial detention probabilities and mean time served in jail by those detained are given in Table C-8. These values should be considered exemplary and are inserted solely to include the order-of-magnitude effect of pre-trial detention in the cost of the overall system. The cost per day of detention was set at a conservative $2.87, in accordance with the value reported by the Corrections Task Force. (See Ref. 9, p. 164.)

To establish jury and court trial workloads, it is necessary to know T_{d/t_1}, and T_{d/t_2}, the mean number of trial days for jury trials and for bench (or transcript) trials, respectively. Again we must resort to another jurisdiction to obtain estimates for these data. We use data compiled for criminal cases of the U.S. District Courts and compiled yearly by the Administrative Office of the United States Courts. (See Refs. 10 and 11.) The results computed here are based on the federal definitions of the seven major crimes, a federal auto theft, for instance being one that the automobile is driven across state lines. Thus the severity of the offenses, within each crime category, will not be the same as that for an average statewide jurisdiction, where the felony definitions are different. The mean numbers of trial days required per case computed from the Federal data are given in Table C-9. Note that the mean length of jury trials varies from 4.6 days for homicide cases to 1.6 days for auto theft. Bench trials are of generally shorter duration, ranging from 1.1 days for homicide, robbery, and theft to 0.8 day for rape.

From the data describing the mean lengths of trials, it is necessary to compute judicial workloads. This computation is complicated by the fact that judges must spend more time out of court looking up

*Ref. 8, p. 245. See Table 7, p. 246, for the disposition and median time interval from filing to termination--U.S. District Court. See Table 14, p. 260, for the median times elapsed between detailed points in the criminal process (i.e., indictment to that disposition, conviction to sentence).

TABLE C-8. PRE-TRIAL DETENTIONS

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_q	0.3	0.7	0.5	0.5	0.5	0.7	0.8	5	---
T_q (days)	60	60	60	60	60	60	60	5	---

TABLE C-9. THE MEAN NUMBER OF TRIAL DAYS PER CASE COMPUTED

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
T_d/t_1	4.6	3.1	2.3	2.2	3.0	1.6	2.9	2	Ref. 10, Table C.8, pp. 206-207. Weighted Average
T_d/t_2	1.1	1.1	1.0	1.0	1.1	1.0	0.8	2	

precedent cases and reviewing the current case for bench trials than for jury trials. James McCafferty (Ref. 12) agrees that the court workload measure should be proportional to the average lengths of the cases involved.* In facing the problem of additional judge time spent out of the courtroom for bench trials, McCafferty assigns an additional judge day per trial (out of court) for each day spent in court (Ref. 12, p. 4). We will follow this procedure in the model.

There are six cost figures required by the prosecution and courts submodel. These represent a cost per case (which receives a disposition) prior to trial incurred by the courts ($C_{c/c}$) and the prosecution ($C_{p/c}$) and a cost per day of trial for jury trials (C_{c/t_1}, C_{p/t_1}), and for bench (or transcript) trials (C_{c/t_2}, C_{p/t_2}). The data serving as the basis of the costs were obtained primarily from Los Angeles County. The components of costs considered included those of (1) judgeships, (2) prosecution, (3) juries and witnesses, and (4) grand jury.

First we estimate jury and witness costs. In 1965, the Los Angeles County Superior Court budget for jury and witness expenses was $1.7 million. There were 6489 civil trials completed and 5964 criminal trials completed. Apportioning costs equally to each trial, whether civil or criminal, we obtain an allocation of $814,000 to criminal trials. There were 1127 criminal jury trials in 1965. Assuming the average criminal jury trial lasts 2.8 days, there were

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* McCafferty (Chief of Research and Evaluation Branch, Division of Procedural Studies and Statistics, Administrative Office of the United States Courts) developed a weighted caseload concept in which the weights were proportional to the time of the case by type. "In the study of the courts it was obvious that the amount of trial time and the proportion of cases disposed of varied considerably and in a sense were directly related to the type of case. In other words, some cases might take very little trial time and, therefore, very little of the court's time, whereas other cases took considerable trial time and proportionately a considerable amount of the court's time. In 1962, the weighted case values were published and we have continued to use them with a minor revision in 1964. The weight system in simplest terms is taking the proportion of court trial time used and dividing this by the proportion of such cases terminated." (See Ref. 12, p. 3.)

3156 jury trial days required. Each of the 12 jurors is allotted a $10 daily fee plus $10 for subsistence and travel. Thus, a cost of $20 per juror per day implies a daily cost of $240 just for the 12 jurors. Multiplying by the total number of trial days, we obtain $757,400 allocated to jurors. The balance ($814,000 - $757,000) of the $57,000 can be assigned to witnesses. Dividing the balance by the number of criminal trials, we obtain a cost of about $10 per day for witnesses--for jury and court trials.* (This last computation assumes an equal use of witnesses in both jury and non-jury trials.)

We now attempt to estimate daily court costs due to judgeships. The 1965 Los Angeles County budget (Ref. 13) for Superior Courts was $8,340,000. This budget, less $1,700,000 for jury and witness expenses, is $6,640,000. In 1965 there were 120 judgeships in Los Angeles County Superior Courts. Dividing 6,640,000 by 120, we obtain $55,333 as the annual cost per judgeship, excluding jury and witness costs. In addition, there is a $15,000 California State subsidy for each judge (Ref. 14). The total cost allocation per judgeship is then $55,333 + $15,000 = $70,333. Assuming 220 working days per annum, we obtain a figure of $70,333/220), or about $320 per judgeship per day. Adding $10 per day for witness expenses, we obtain a cost of <u>$330 per day for court trials</u>. Adding (in addition to the witness costs) $240 per day for jury expenses, we obtain a cost of <u>$570 per day for jury trials</u>. Similar computations were performed (for purposes of comparison) for Sacramento County Superior Courts (Ref. 15) and a cost of $236 per judgeship per day was computed (excluding jury and witness expenses).

The Los Angeles County budget in 1965 allocated only $148,000 to Grand Jury costs. Typically only about 3 percent of the felony filings

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*This calculation is very crude because of two assumptions. First, we assign jury and witness costs equally to criminal and to civil trials. Second, the $58,600 allocated to witness costs is the result of a subtraction of a (comparatively) large number from another large number, and a small error in, for instance, the mean number of trial days per jury trial could cause the daily witness costs to vary by a factor of 2 or 3.

on defendants in Los Angeles County are by grand jury indictment; the remainder are based on filing by bills of information (typically about 90 percent) and on certified pleas of guilty from the lower courts (about 7 percent). Although the additional cost per case processed by the grand jury may be considerable, the use of indictment is so infrequent that we will not consider it in our cost estimates.*

We now develop a daily cost factor for prosecuting attorneys. From the 1965 Los Angeles City budget, the Office of the District Attorney was given a $3.0 million appropriation. There were 120 attorneys provided for in the budget, resulting in $25,000 per attorney per annum. Dividing by 220 working days per year, we obtain a daily cost factor of <u>$115 per attorney per day</u>. (It is interesting that the identical figure is obtained using the above procedures to compute a daily cost for attorneys assigned to the California State Department of Justice, Division of Criminal Law.) It is estimated that for each day in court, a prosecuting attorney on the average spends another day in preparation for trial. Therefore, <u>the $115 per day cost factor for prosecutors is doubled ($230) for cost allocations to trial days</u>.

The final court costs to be computed are the non-trial costs per case incurred by prosecution and by the courts. These costs could be considered to be those miscellaneous costs incurred by all cases receiving final dispositions and which are incurred outside of trial. For instance, they are the only costs associated with cases for which the plea is guilty. We roughly approximate this cost as follows: The judges' schedule for the Los Angeles County Superior Court provides for one hour each day for the consideration of pleas of guilty, sentencing and other types of activities, not including trials. Los Angeles County data indicate that 10,251 cases were handled during this allotted hour in 1965 by 30 judges, implying about 1.5 such

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*The California Bureau of Criminal Statistics reports "...the number of indictments in California is so small as to relegate this type of filing to a relatively little-used procedure." (See Ref. 16, p. 103.)

actions per day per judge. Recall court costs per judgeship (excluding jury and witness costs) are estimated at $320 per day. An hourly allocation based on 6 hours per day would represent $53.33 per hour, ($320 divided by 6 hours). With 1.5 such actions per hour, one such case would on the average, require 2/3 hour or $36 (2/3 x 53) for judgeship costs per case.

An allocation of this cost for the prosecuting attorney is also required. Considering that 2/3 hour court time is required, and assuming again that on the average a prosecuting attorney required the same amount of time for preparation as is required in court, the total time requirement is $2 \cdot \frac{2}{3} = \frac{4}{3}$ hours per case. The $\frac{4}{3}$ hours of prosecution time at $115 per day (computed on an 8-hour day) is about $19. We will assume that every case which receives a final disposition is charged with these incurred court and prosecution costs in addition to those incurred during trial.

In summary, then, the prosecution and court costs are estimated as follows:

<u>Non-Trial</u>

Court Cost, $C_{c/c}$ = $36

Prosecutor Cost, $C_{p/c}$ = $19

<u>Jury Trial</u>

Court Cost, C_{c/t_1} = $570

Prosecutor Cost, C_{p/t_1} = $230

<u>Bench Trial</u>

Court Cost, C_{c/t_2} = $330

Prosecutor Cost, C_{p/t_2} = $230

In the present model, costs of pre-sentence investigations (usually performed by probation officials) have not been included.

C. THE CORRECTIONS SUBSYSTEM

1. Probation Data

From the number granted probation each year, the first calculation required by the model is the number of probation removals by violation of the conditions of probation. We may assume that an individual, when granted probation, is characterized by the probability P_{bv}, the probability of probation violation (specifically, probation removal by violation). Even though the lengths of probation terms and the times until termination vary among individuals, in the steady state the random delays until removal can be ignored, and the fraction of those granted probation who are removed by violation is P_{bv}. In the real system, however, the steady state is not an entirely valid assumption. Also, we would expect random fluctuations from year to year in the numbers granted probation, removed by violation, etc. Thus, the preferred way to compute P_{bv} would be to follow a large cohort of individuals from moment of granting of probation until each of the cohorts has been removed from probation, either by termination or violation. This procedure would remove effects of yearly flow fluctuation and, perhaps, fluctuations in parameter values. The available data, however, are not reported in this manner and we must resort to using yearly flow data instead of data on individuals. Specifically, P_{bv} was estimated, for each crime type, by dividing the number removed from probation (due to violation) in 1965 by the total number granted probation (both with and without a jail term as a condition).* These calculations are reported in Table C-10. Note that the probation violation probability, as computed, varies from a low of 0.12 for homicide to a high of 0.48 for auto theft and 0.45 for robbery. These probabilities could be used as a measure of the recidivism tendencies of those placed on probation, by crime type.

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*A possible bias in this procedure that should be further investigated is that probation probabilities have been increasing, and the delay until removal would cause a relatively smaller population of possible violators than there would be in the steady state. If this is in fact true, then the figures reported here are low biased estimates of the probation violation probabilities.

TABLE C-10. PROBATION FLOW DATA

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{bv}	0.12	0.45	0.21	0.39	0.31	0.48	0.42	2	$\frac{\text{(Ref. 1, Table VI-15,3, p. 117, II)}}{\text{(Ref. 1, Table V-13,9+10, p.81, II)}}$
P_{bs}	0.59	0.28	0.41	0.38	0.36	0.38	0.43	1	$\frac{\text{(Ref. 17, Table V-20,6+7+8+9, p. 192, II)}}{\text{(Ref. 17, Table V-20, 3, p. 192, II)}}$
P_{bs_1}	0.65	0.11	0.69	0.39	0.59	0.50	0.64	1	$\frac{\text{(Ref. 17, Table V-20, 9, p. 192, II)}}{\text{(Ref. 17, Table V-20,6+7+8+9, p. 192, II)}}$
P_{bs_2}	0.25	0.77	0.26	0.43	0.33	0.30	0.25	1	$\frac{\text{(Ref. 17, Table V-20, 6, p. 192, II)}}{\text{(Ref. 17, Table V-20,6+7+8+9, p. 192, II)}}$
P_{bs_3}	0.00	0.07	0.04	0.13	0.04	0.18	0.11	1	$\frac{\text{(Ref. 17, Table V-20, 8,p. 192, II)}}{\text{(Ref. 17, Table V-20,6+7+8+9, p. 192, II)}}$

Also reported in Table C-10 are the probabilites associated with resentencing of probation violators (P_{bs}). For these figures we referred to Ref. 17, Delinquency and Probation in California, 1964.* Table V-20 in this publication reports the number of adult defendants removed from probation by California Superior Courts (1964) by convicted offense and type of removal. The probability of resentencing was approximated to be the number of defendants whose probation was revoked and who were resentenced in 1964 divided by the total number removed from probation.** Note that the computed numbers range from a high of 0.59 for homicide to a low of 0.28 for robbery. (Apparently those who were last arrested for robbery are most successful at eluding bench warrants for their rearrest.)

The resentence decision is broken out by jail, prison, and Youth Authority, respectively. The estimates of the associated probabilities are also given in Table C-10.*** In general, jail is the most frequent type of resentence; however, for robbery defendants, prison (P_{bs_2} (2) = 0.77) is much more frequently used. Youth Authority commitments are highest (P_{bs_3} (6) = 0.18) for probationers originally found guilty of auto theft.

The mean time T_b spent on probation was estimated to be three years, regardless of crime type. In both Delinquency and Probation in California 1964 (p. 186) and in Crime and Delinquency in California 1965 (p. 111), the modal probation term imposed on adults who were granted probation by Superior Courts during those years was 3 years. In 1965, for instance, 51.3 percent of the terms imposed were for 3

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* This booklet was last published in 1964 and not all of the data reported therein are carried over in the expanded Crime and Delinquency in California (Ref. 1).

** The group whose probation was revoked but who were not sentenced was composed largely of probationers who had absconded and had bench warrants outstanding for their arrest. Some of these were receiving sentences in other jurisdictions. (See Ref. 17, p. 190.)

*** A certain small number were committed to the California Rehabilitation Center as addicts. This flow was not computed and accounts for the fact that, in general, the resentencing probabilities do not add to one.

years; 79.7 percent were for 3 years or less. Unfortunately, these figures are not broken down by crime type and do not report actual time served on probation, only the term imposed. Early removals can occur either by termination or violation.

2. Data on Jail Terms

The only data required for defendants sentenced to jail are the mean times spent in jail. Reference 1 reports a distribution, by offense and by the length of the terms in months, of the term imposed on felony defendants sentenced to jail from California Superior Courts, 1965. Separate distributions are given for defendants sentenced to straight jail and for those whose jail term is a condition of probation. The means of these distributions were computed to provide estimates for T_{j_1} and T_{j_2} and are given in Table C-11. The average jail term imposed is at least 118 days, which holds for defendants charged with auto theft and whose jail term is a condition of probation. Straight jail terms for homicide and robbery defendants are greatest, 273 days and 264 days, respectively. For each crime category the term is shorter for the case in which jail is a condition of probation, ranging from 111 days shorter for homicide to 24 days for theft.

No data were available describing lengths of jail terms of those resentenced to jail as a result of probation removal by violation. The entries for T_{j_3} shown in Table C-11 are simply arithmetic averages of T_{j_1} and T_{j_2}.

3. Prison and Parole Data

Prison data consist of times spent in prison by those who are paroled and by those not paroled. First we report estimates of the relevant parole branching probabilities and then the times spent in prison and on parole. The data source for much of the parole and prisoner data is the booklet published early in 1964, California Prisoners 1961, 1962, 1963 (Ref. 18).*

* Apparently this publication is not regularly issued by the Department of Corrections and, in particular, it was not possible to obtain data values specifically for the year 1965. Often weighted averages of several previous years were used.

TABLE C-11. JAIL TERM DATA

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
T_{j_1} (days)	273	264	168	195	154	160	177	1	Ref. 1, p. 85, Table V-16. The mean was calculated.
T_{j_2} (days)	162	218	130	139	130	118	131	1	Ref. 1, p. 85, Table V-16. The mean was calculated.
T_{j_3} (days)	217.5	241	149	167	142	139	154	4	Average of T_{j_1} and T_{j_2}

Examining Table C-12, we see that the parole probability is very close to one for every crime type. This probability (P_r) was computed by dividing the number released on first parole, by crime type, for the years 1959 to 1963 by the sum of first parolees and those first released from prison by discharge at expiration of sentence. Persons committed for the crime categories of homicide, robbery, assault, and rape apparently are always paroled at least once. The crime categories of burglary, theft, and auto theft include a small number of offenders (never in excess of 20 percent of the total) who do not receive at least a first parole.

The probability of unsuccessful parole was computed from a special study entitled "Number and Percent of Men Returned to California Prison with a New Commitment or Without a New Commitment During 24 Months after Parole Date by Offense Class at Date of Parole," (Ref. 19) The tabulation in this publication is done for each year 1955 through 1959 for adult males paroled to California supervision during those years. A weighted average was used to compute the branching ratios given in Table C-12. Since the study was truncated at 24 months, these values can be considered to be lower bound estimates of the true probabilities. Note that the probability of unsuccessful parole varies from 0.17 for homicide to 0.46 for auto theft. A typical value seems to be about one-third. It is interesting to compare these probabilities to the probabilities of unsuccessful probation reported in Table C-10. With probationers also, those charged with auto theft have the highest "failure" probability (0.48 for probationers compared to 0.46 for parolees) and those charged with homicide the lowest (0.12 for probationers compared to 0.17 for parolees). However, within the extremes, "failure" probabilities are quite different for probationers and parolees.

Parole violators will be recommitted either under the old offense or charged with a new offense. Values for P_{rv_1}, the probability that a parole violator is recommitted under a new offense, are also given in Table C-12. These computations were also made from the special study (Ref. 19). Those originally charged with burglary are most

TABLE C-12. PAROLE AND REPAROLE PROBABILITIES

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_r	1.0	1.0	1.0	0.92	0.93	0.80	1.0	2	~~(Ref. 18, Table 31A, see text, p. 105, IV)~~ (Ref. 18, Table 31A, see text, p. 105, IV, and Table 33, see text, p. 113, IV)
P_{rv}	0.17	0.35	0.36	0.43	0.33	0.46	0.22	2	Ref. 19.
P_{rv_1}	0.26	0.53	0.54	0.57	0.51	0.53	0.23	2	Ref. 19.
P_{rv_3}	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5	Estimate
P_{rv_4}	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5	Estimate

likely to be recommitted for a new offense (P_{rv_1} (4) = 0.57), the new offense probably being burglary, and those charged with rape or homicide have the lowest probabilities of being recommitted under a new offense (P_{rv_1} (7) = 0.23, P_{rv_1} (1) = 0.26).

It was not reported what fractions of those recommitted are re-paroled and this was estimated to be 0.5 for both P_{rv_3} and P_{rv_4}, for all crime types.

Median times spent in prison vary widely over crime category, as can be seen by examining Table C-13. For those who are paroled at least once the median time spent in prison before first parole varies from 1.54 years for auto theft to 5.4 for homicide. A finer breakdown within each category indicates even greater variation.* Of those who are not paroled (only a small number of those charged with burglary, theft, or auto theft), the typical time spent in prison before release is about 2 years.

Of those recommitted, either under a new offense or under the former offense, the median time until next release was not reported by crime type. For those recommitted under a new offense, we approximate the mean time spent in prison until next release to be 3.3 years; this is based on data reported in Ref. 18, aggregated by crime type. The mean time spent in prison by those recommitted under the old offense was, in a like manner, estimated from Ref. 18 to be 1.5 years, regardless of crime category.

Reference 18 reports, by offense, the median time served on parole before discharge for male felons discharged from first parole in 1961, 1962, and 1963. Since only offense groups with 25 or more cases are reported, there are no entries for murder list, attempted robbery, attempted burglary 2nd, and petty theft with prior. We are thus forced

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* Those committed for first degree murder remain for a median term before first parole 11.7 years, those committed for manslaughter, 3 years. The three categories of robbery (robbery 1st, robbery 2nd, and attempted robbery) have associated median times of 3.26 years, 2.35 years, and 2.44 years, respectively. For the individual burglary categories (burglary 1st, burglary 2nd, and attempted burglary) the associated times in prison are 2.9 years, 1.9 years, and 1.7 years, respectively.

TABLE C-13. TIMES SPENT IN PRISON

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
T_{r_1} (years)	5.4	2.95	2.69	2.02	1.70	1.54	3.17	1	Ref. 18, Table 31, p. 105, List IV. The median (not the mean) was given in Table 31. A weighted average was computed for the years 1959-1963.
T_{r_2} (years)	---	---	---	2.5	1.7	2.1	---	2	Ref. 18, Table 33, p. 113. A weighted average was computed for the years 1959-1963.
T_{r_3} (years)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	4	Estimated from Ref. 18, Table 32A, p. 110. (Data in Ref. 18 are aggregated over crime category.)
T_{r_4} (years)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	4	Estimated from Ref. 18, Table 32A, p. 110. (Data are aggregated over crime category.)

to define a crime category List V, as given in Table C-2. Weighted averages of the median times spent on first parole are given in Table C-14. The values reported in Ref. 18 allow us to approximate T_{z_3}, the mean time spent on first parole. Values for T_{z_1} and T_{z_2}, the mean time spent on reparole for those recommitted under a new offense and under the old offense, respectively, were not reported and were arbitrarily estimated to be equal to T_{z_3}. Note that the time spent on parole does not vary significantly by crime category, ranging from 1.65 years for auto theft to 3.27 years for homicide. The typical value is about 2 years.

4. Corrections Costs

Corrections costs are computed by multiplying the yearly unit cost per individual in a particular correctional population by the number in that population. The four populations of interest are the individuals on probation, in jail, in prison, and on parole.

The yearly cost per probationer was set at $200. This figure is $50 more than that derived from figures reported by the Corrections Task Force* and $80 less than a proposed figure reported in Correction in the United States.** The importance of the probation cost is found not in its exact amount but in comparison to yearly costs of imprisonment.

The annual per-person jail cost was set at $1044, simply the daily cost of $2.86 reported earlier*** multiplied by 365, the number of days in a year.

The annual cost of prison per inmate depends, of course, on the type of prison, particularly the number of inmates per prison staff

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*Ref. 9, p. 27. According to the National Survey of Corrections and special tabulations provided by the Federal Bureau of Prisons and the Administrative Office of the U.S. Courts, 257,755 felons were on probation in 1965 and the associated annual cost was $37,937,808.

**Ref. 20, p. 175. "If the present estimated $31,507,204 cost of probation were increased to around $89,000,000 (+184 percent) to meet current standards, then the cost for investigation would be about $25,000,000 a year and the annual cost for supervision would be about $64,000,000. At current low salary levels, the annual cost per case...would be about $280 per year..."

***Section B.2 of this Appendix.

TABLE C-14. TIMES SPENT ON PAROLE

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
T_{z_1} (years)	3.27	2.51	2.15	2.05	2.00	1.65	2.55	4	Estimate. Assumed to be same as T_{z_3}.
T_{z_2} (years)	3.27	2.51	2.15	2.05	2.00	1.65	2.55	4	Estimate. Assumed to be same as T_{z_3}.
T_{z_3} (years)	3.27	2.51	2.15	2.05	2.00	1.65	2.55	2	Ref. 18, Table 46A, p. 139. List V. A weighted average of medians was computed. Only offense groups with 25 or more cases were reported.

member and whether there are special training programs given in the institution. In addition, some state prisons "sell" a large quantity of manufactured goods each year* which, of course, reduces the direct taxpayers' cost of prison. The 1965 budget for the California correctional system includes a calculation of per capita costs. Administrative costs were not included in the calculations, however. Total administrative costs for the California corrections systems are budgeted at $11,500,000 for 1965. The total California prison population (in the state system) is 28,000 inmates. Prorating the administrative costs equally among the inmates yields a proration of $410 per inmate for administrative costs.

Per capita costs of several particular institutions are given as follows:

San Quentin	$1,851
California Conservation Center	2,941
Sierra Conservation Center	2,745
Rehabilitation Center	2,740
Vocation Institute	2,884

The average of these five costs is $2632.** Including the $410 administrative proration, we round off and set the prison cost at $3000 per inmate per year.

Yearly parole cost per parolee was set at $391. This figure was obtained from the California State Budget, 1965. It should be mentioned that the figure of $391 represents conventional parole only, and that more specialized supervision, particularly work unit supervision and

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* The Illinois State Budget provided $5,000,000 for Joliet Penitentiary. During a year, Joliet sells to other state institutions $2.5 million of industrial products and $371 thousand in agricultural products.

** Actually, a weighted average should be used to account for the relatively greater use of standard penitentiaries, such as San Quentin, which show significantly lower annual per inmate costs.

non-felon addict supervision, costs more than conventional parole ($591 for work unit supervision and $860 for non-felon addict supervision). In Correction in the United States, the typical figure spent by a state per parolee per year is about $250 (Ref. 20, p. 219).

D. DATA ON THE JUVENILE SYSTEM

1. Juvenile Probation Referral

The model of the juvenile subsystem, although relatively easy to structure, is very difficult to provide with a consistent set of data. The heart of the problem is that juvenile agencies act in a much more informal manner when handling juveniles than do the regular CJS agencies in dealing with adults. For instance, California juvenile agencies, in reporting statistics, often classify crimes associated with juveniles either as major law violations (these usually reflect Penal Code violations of a felony nature), minor violations (which largely reflect Penal Code violation of a misdemeanor nature), and other acts of delinquency which are denominated "delinquent tendencies." (Reference 1, p. 141. Delinquent tendencies include incorrigible, runaway, waywardness, and improper associations.) The seven crimes of interest for the model are included in the major law violations. Police statistics break out the major and minor violations by crime type, thus providing useful information on initial juvenile processing by police within each crime category. Juvenile probations and court records are not reported in this manner, however, initial referrals to juvenile probation are well documented; but the referral of juveniles (that is, the referral of those whose cases are currently active) is not very well documented, and these re-referrals account for much of the juvenile court workload.*

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*Some of the problems of re-referrals are illustrated in the following paragraph which is taken from Ref. 17, p. 113:

> "Generally, all but the smallest probation departments have established some sort of intake units around which have developed standard procedures for the recording of new cases coming to the attention of the departments, regardless of the method of their

(Footnote continued next page)

The probabilities P_{jr} that an arrested juvenile will be referred to juvenile probation authorities are given in Table C-15. These referral probabilities are quite high, ranging from 0.71 for burglary and auto theft arrests to 0.90 for forcible rape arrests. Typically, about three-quarters of the juvenile arrests for major offenses are referred to juvenile probation.

We are now forced to link up the police data and those of the juvenile agencies. Table C-16 presents the numbers of police referrals of arrested juveniles to the probation departments for which the arrest is for one of the seven major offenses. The second column of the table lists the numbers of initial referrals of juveniles to probation departments for which the juvenile was arrested for one of the general offenses. (Rape was not reported.) Due again to the lack of consistency of crime category definition, only three of the rows in the table are directly comparable--the rows corresponding to robbery, burglary, and auto theft. We see, for instance, that 11,564 of the 16,840 burglary referrals (or 69 percent) were initial referrals from the police. For robbery, 56 percent were initial referrals and for auto theft, 75 percent were initial referrals. On the other hand,

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initiation (by juvenile hall lock-up or otherwise). In routine fashion, essentially all new cases are documented whether petitions are filed or not. However, recurring activity in cases already under jurisdiction may not be recorded in the same systematic manner. Such data are available and empirical formulations suggest that this lapse is particularly true of cases that (a) are originated other than by law enforcement agencies, (b) are reported because of the commission of minor types of offenses or technical violations, or (c) are disposed of without court action. Hence, in a situation where the probation officer is advised by a foster parent that a runaway has occurred, and the case is adjusted without resort to court action, it is highly likely in some areas that there will be no statistical recording made of the incident. And, indeed, some occurrences of this general nature are on the borderline of definition of what constitutes a re-referral as differentiated from some regulative activity that might derive from a routine supervisory contact.

TABLE C-15. DATA ASSOCIATED WITH JUVENILE PROBATION REFERRAL

NAME DATA	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{jr}	0.85	0.80	0.76	0.71	0.75	0.71	0.90	1	(Ref. 1, Table VIII-4,6, p. 144, I)
N_{je}	3.05	1	2.51	1	17.4	1	1	4	See text. Crime category list VII.

TABLE C-16. NUMBER OF REFERRALS OF JUVENILES TO PROBATION DEPARTMENTS

Crime Category	Number of Police Referrals of Arrested Juveniles to Probation Departments for Major Offenses*	Crime Category	Number of Initial Referrals of Juveniles to Probation Departments for General Offenses**
Willful Homicide	75	Homicide	176
Robbery	1,482	Robbery	833
Aggravated Assault	1,794	Assault	3,460
Burglary	16,840	Burglary	11,564
Grand Theft, Except Auto	1,275	Theft, Except Auto	17,089
Auto Theft	9,889	Auto Theft	7,369
Forcible Rape	291		

*Reference 1, Table VIII-4, p. 144.

**Reference 1, Table IX-5, p. 161.

there is a total of 1275 referrals (initial and re-referrals) of juveniles arrested for "grand theft, except auto," whereas there are more than ten times as many (17,089) initial referrals for the broader category of "theft, except auto."

The problem is that probation departments do not report total referrals by crime type within a year. Thus, for the crimes of homicide, assault, "theft, except auto," and rape, we must use a scale factor to estimate the total number of referrals in each of these categories. In addition, the referrals reported by police do not constitute all referrals of juveniles to the probation department. The great majority (87.2 percent) of initial referrals of all juveniles were from primary law enforcement agencies, but the remainder were from criminal courts or other juvenile courts, from the family, schools, welfare departments, private agencies, and attorneys (Ref. 1, p. 161). Thus, even the police data on referrals for robbery, burglary, and auto theft do not represent total inputs to the juvenile model.

The re-referrals add to this already difficult data problem. A re-referral is a currently active case which is referred again to a probation department, regardless of whether or not a status change results from the re-referral. The individuals whose cases are re-referred are delinquent wards who violate probation (or commit subsequent offenses) and are continued under local supervision, with or without a change in placement. The data on initial referrals are usually much more complete than those on re-referrals.*

Due to these data limitations, and the fact that in its handling of juvenile offenders the CJS usually defies any systematic description, many of these problems are circumvented in order to provide some form of first, simple model of the juvenile system. First, re-referrals are not treated explicitly; they may be included implicitly in some of the police referrals. Second, initial referrals are not singled out,

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*There is a good discussion of the issues relevant to counting of referrals, re-referrals, and the numbers of individuals involved in Ref. 17, pp. 112-120.

primarily because they are not singled out by police. Thus, we compute the input to the juvenile probation departments in the following ways:

(1) For robbery, burglary, and auto theft, we use the police figures on the number of juvenile referrals as the input to probation.

(2) For homicide, assault and theft (except auto), we multiply the probation department figures on numbers of initial referrals by a scale factor that depends on crime type. This factor approximately accounts for the total referrals compared to the initial referrals for the crime categories of robbery, burglary, and auto theft.

(3) We assume the total number of forcible rape referrals is equal to the police figure (291 in 1965). Branching ratios for forcible rape are computed from category 7 ("sex offenses") in crime List VI.

These procedures give rise to the values of N_{je} reported in Table C-15. A new crime category list (List VII) had to be defined to include forcible rape and exclude other sex offenses from List VI. The entry of 17.4 under the theft category is particularly bothersome since it implies that one police referral of a juvenile arrested for grand theft results in 17.4 total referrals for the broader theft category. Hopefully, these problems will come under control as consistent crime categories are used throughout the system.

2. Initial Probation Department Determinations

Cases referred to juvenile probation can have one of three initial determinations:

(1) Petition filed for juvenile court action,
(2) Informal probation, or
(3) Case closed or referred to other agency.

Data describing these determinations by crime type are not usually reported. We rely on the special study (Ref. 21) issued by the Bureau of Criminal Statistics in November 1966. As computed from this study, initial probation determination probabilities are given in Table C-17. Homicide referrals are most likely ($P_{pf}(1) = 0.87$) to lead to a filing of a petition; theft cases are least likely ($P_{pf}(5) = 0.23$). Informal probation is not used very often, theft referrals being the most likely type to receive, and there $P_{pi}(5) = 0.16$. Theft referrals are also most likely to have the case closed or referred to another agency. The fact that theft probabilities are so different than the others at this processing stage is probably due to the large number of petty theft referrals, petty theft being the least serious crime in the list.

3. Initial Juvenile Court Dispositions

There are five possible initial juvenile court dispositions:

(1) Dismissal,
(2) Non-ward,
(3) Wards, no incarceration,
(4) Wards, incarceration, or
(5) California Youth Authority.

Due to initial Youth Authority commitments resulting from re-referrals, the branching ratios for initial juvenile court disposition cannot be used directly to generate Youth Authority intake. That is, for some of the crime categories, it is necessary to scale up the probability of initial Youth Authority commitment (P_{jy}) so that the model-computed Youth Authority intake per year is approximately equal to that reported by the Youth Authority. These scaled probabilities plus the other juvenile court branching ratios are given in Table C-18. It was necessary to change $P_{jy}(3)$ (assault) from 0.04 to 0.12, $P_{jy}(5)$ (theft) from 0.01 to 0.07, and $P_{jy}(6)$ (auto theft) from 0.02 to 0.08; since rape cases are included in "sex offenses" by the Youth Authority, no direct comparison was possible and no scaling was performed. Note that the most likely disposition in each crime category is "ward, no incarceration;" this probability varies from 0.25 for homicide to 0.64 for burglary. Typically, 20 percent of the referrals are dismissed, 15 percent become non-wards, and 5 percent wards with incarceration. Except for homicide ($P_{jy}(1) = 0.19$) and robbery ($P_{jy}(2) = 0.12$), initial commitments to the Youth Authority are rare.

TABLE C-17. BRANCHING RATIOS FOR JUVENILES PROBATION DEPARTMENT DISPOSITION

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{pf}	0.87	0.74	0.63	0.53	0.23	0.55	0.52	1	$\frac{\text{(Ref. 21, Table 5, p. 5, VI)}}{\text{(Ref. 21, Table 2, p. 5, VI)}}$
P_{pi}	0.02	0.06	0.05	0.14	0.16	0.09	0.10	1	$\frac{\text{(Ref. 21, Table 4, p. 5, VI)}}{\text{(Ref. 21, Table 2, p. 5, VI)}}$
P_{ca}	0.11	0.20	0.32	0.33	0.61	0.36	0.38	1	$\frac{\text{(Ref. 21, Table 3, p. 5, VI)}}{\text{(Ref. 21, Table 2, p. 5, VI)}}$

TABLE C-18. BRANCHING RATIOS FOR JUVENILE COURT DISPOSITION

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE	SCALE VALUE	COMPUTATION
P_{ds}	0.19	0.20	0.21	0.09	0.16	0.11	0.17	1	$\frac{\text{(Ref. 21, Table 2,6, p. 6, VI)}}{\text{(Ref. 21, Table 2,2, p. 6, VI)}}$
P_{nw}	0.17	0.03	0.16	0.15	0.19	0.14	0.12	1	$\frac{\text{(Ref. 21, Table 2,7, p. 6, VI)}}{\text{(Ref. 21, Table 2,2, p. 6, VI)}}$
P_{wn}	0.25	0.45	0.50	0.64	0.58	0.60	0.60	1	$\frac{\text{(Ref. 21, Table 2,8, p. 6, VI)}}{\text{(Ref. 21, Table 2,2, p. 6, VI)}}$
P_{wi}	0.04	0.06	0.03	0.04	0.02	0.05	0.03	1	$\frac{\text{(Ref. 21, Table 2,9, p. 6, VI)}}{\text{(Ref. 21, Table 2,2, p. 6, VI)}}$
P_{jy}	0.19	0.12	0.12	0.02	0.07	0.08	0.02	1	$\frac{\text{(Ref. 21, Table 2,10, p. 6, VI)}}{\text{(Ref. 21, Table 2,2, p. 6, VI)}}$

The time spent under local supervision of probation agencies (i.e., the time of wardship) was not available by crime type and was estimated to be 1.09 years (Ref. 1, Table IX-11, p. 170).

4. Youth Authority* Commitments

The yearly input to the Youth Authority, as defined in the model, is composed of those received from juvenile courts, criminal (adult) courts, and those received as a result of probation removal by violation. There are several problems encountered in matching the yearly input to that reported by the Youth Authority (Refs. 22 and 23). First, the Youth Authority reports data on first commitments each year and on the total population at the end of the year. However, the criminal court dispositions, for instance, do not distinguish individuals who have not previously been adjudicated. In addition, those who are committed to the Authority as a result of probation violation may be counted elsewhere as a court disposition as well. Second, the majority of the commitments are received from the juvenile courts and many of these are the result of re-referrals, which is not explicitly included in the model. Third, a large fraction of the Youth Authority ward population is composed of those recommitted after a parole violation, either with or without a new commitment. Thus, the model in this case must be viewed as a very crude approximation to the real system.

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*The California Youth Authority was created by an act of the Legislature in 1941 to provide a state authority responsible for the training and treatment of young persons found guilty of public offenses by means of correction and rehabilitation as opposed to retributive punishment. Under the Act, persons under 21 at the time of the commission of an offense may be referred to the Authority by juvenile or criminal courts and if the referral is accepted such persons are under commitment to the Authority. Jurisdiction exists over those committed as juveniles until age 21; those committed as felons until age 25. The department operates diversified institutions for care of wards committed to them and, in addition, has the authority to place wards in the most appropriate institutions maintained by the Departments of Corrections and Mental Hygiene, or in county jail facilities. (See Ref. 1, p. 197.)

Instead of modeling the recycling phenomenon of incarceration/parole/parole violation/incarceration as we do for the adult model, we simply compute a mean total time spent as a Youth Authority ward in Authority institutions and on parole. The mean times spent incarcerated in Youth Authority institutions were computed as the ward population (for each commitment offense) measured at a particular time (specifically December 31, 1966) divided by the average yearly intake of first commitments to the Youth Authority. That is, we make use of the fact that, in the steady state, if N persons are admitted to an institution per year and each stays an average of T years, the steady state institution population is NT. Thus, if we divide the measured population (NT) by the yearly intake (N), we have an estimate of the mean time (T) spent per person. The number of first commitments per year was computed as an average of the first commitments received (by individual offense category) for each of the years 1964, 1965, and 1966. The time estimates are given in Table C-19. These times are interpreted to be the mean time spent in Youth Authority institutions per first commitment associated with a particular offense category T_{ya}. A fraction of the 1.5 years given for robbery, for instance, is caused by recommitments of individuals who were not first committed for robbery. The greatest estimated time is 2.2 years for homicide; the shortest duration of incarceration is 1.0 year for burglary and for auto theft. These times compare to an average time per commitment (over all crime categories) of about 7 or 8 months before parole (Ref. 1, p. 198).

Also given in Table C-19 are the estimated mean times spent on parole per ward, T_{jz}. These were computed in a similar manner. By commitment offense, the total parole population on December 31, 1966, including those on first or subsequent parole, was divided by the average number of new commitments per year. Again this average was computed for the years 1964, 1965, and 1966. These estimated total times on parole (by first commitment offense) do not vary greatly by crime type, ranging from 2.3 years for homicide to 2.9 years for sex offenses.

TABLE C-19. ESTIMATED MEAN TIMES SPENT BY WARD ON FIRST COMMITMENT IN YOUTH AUTHORITY INSTITUTION AND ON PAROLE

DATA NAME	HOMICIDE	ROBBERY	ASSAULT	BURGLARY	THEFT	AUTO THEFT	RAPE[a]	SCALE VALUE	COMPUTATION
Mean Time in Youth Authority Institution, T_{ya}	2.2	1.5	1.3	1.0	1.1	1.0	1.2	3	$\frac{\text{(Ref. 22, Table 1A, 2, p. 1, VI)}}{\text{(Ref. 23, Table 1A, 10+11+12, p. 3, VI)}}$
Mean Time on Parole, T_{jz}	2.3	2.8	2.6	2.8	2.7	2.6	2.9	3	$\frac{\text{(Ref. 22, Table 4A, 2, p. 25, VI)}}{\text{(Ref. 23, Table 1A, 10+11+12, p. 3, VI)}}$

[a] Sex offenses.

5. Juvenile Costs

There are five costs in the model which are specifically related to juvenile processing. These are costs due to:

(1) Probation determination of juvenile referrals,
(2) Juvenile court,
(3) Local supervision of juveniles on probation,
(4) Juvenile incarceration, and
(5) Juvenile parole.

The cost per referral to the juvenile probation department was estimated to be $50 per referral, regardless of crime category. The cost of juvenile court was estimated to be $100 per court disposition regardless of crime type. Each of these very crude estimates should be refined in later studies.

Juveniles released under local supervision were considered to be on probation and the annual per case cost was set at $330. This figure was derived from tabulations reported by the Corrections Task Force (Ref. 9, p. 27).

The only juvenile incarceration costs considered in the model are those incurred within the California Youth Authority. Per capita Youth Authority costs appear to be significantly greater than comparable costs for adults (in State correctional institutions). These costs, as reported in the California State budget, are directly related to the ward/employee ratio. Four examples of actual 1966-1967 expenditures indicate the possible variation in costs:

Facility	Ward/ Employee Ratio	Per Capita* Cost
Youth Training School	3.0 to 1	$3905
Fred C. Nelles School for Boys	2.2 to 1	4904
Fricot Ranch School for Boys	1.7 to 1	6225
Northern California Youth Center	1.2 to 1	8697

*Ref. 24, p. 191.

(These costs would be increased slightly if Youth Authority central administrative expenses were to be prorated to the individual wards.) The Youth Training School is for boys between 17 and 21 years of age and the school's program is designed to give wards pre-employment training in the various vocational fields and to provide an opportunity for completion of the requirements for high school graduation. The ratio of wards to employees can be comparatively high since many auxiliary functions associated with institutional administration are performed by wards (Ref. 24, p. 187). The Fricot Ranch School for Boys, on the other hand, is for delinquent boys primarily between 8 and 13 years of age. The institution places major emphasis upon a program of academic education and counseling and requires a relatively smaller ward/employee ratio. The average population per capita cost incurred in fiscal 1966-67 was $5063. We set C_{ya} (the annual Youth Authority cost per ward) at a value of $5000, a figure nearly twice the magnitude of the comparable adult incarceration cost.

Youth parole costs are also higher than those of adults and can fluctuate, depending on the type of supervision, by a greater percentage than youth incarceration costs. We give three examples (Ref. 24, p. 190):

Program	Cost Per Parolee Per Year
Regular Parole Supervision	$ 346
Community Treatment Project	2327
Part Way Home Program	4464

The Community Treatment Project is a parole program that is concerned with testing the feasibility of the treatment of delinquent wards within the community without long-term institutionalization. The more intensive treatment received by wards in this program includes individual counseling or psychotherapy, group therapy, natural and foster parent group meetings, school tutoring, etc. The Part Way Home Program, operated on a contractual basis with private agencies, actually places wards in homes* for an average of 90 days in residence at which time they are offered group counseling and are provided with employment placement information. During 1966-67, about 95 percent of the parolees were paroled under regular parole supervision. We set C_{jf} (the annual cost per parolee) equal to $375, recognizing that changes in programs could alter this figure markedly. We can compare this figure to one reported in Correction in the United States (Ref. 20, p. 101). An average computed from 40 states which responded to a national survey showed that $320 are spent per year per case in State-supervised juvenile aftercare programs.

6. Misdemeanors

The model does not consider misdemeanors explicitly. Costs and workloads associated with misdemeanor arrests are not included, primarily due to the lack of data describing the extent of misdemeanor arrests and subsequent prosecutions. It was felt, however, that since such a large fraction (about 20 percent) of those adults originally arrested for one of the seven offenses of interest (List III definitions) are charged at the police disposition stage with a misdemeanor, some attempt should be made to assign an aggregated cost to each of these individuals. This cost would represent direct CJS operating costs received for all later processing--courts, detention, probation, etc. Some of the problems encountered in trying to account for these costs are discussed in Correction in the United States in the chapter on "Misdemeanant Probation." In a survey reported in that chapter (Ref. 20, pp. 115-117), cost estimates were made for municipal court charges of misdemeanor in one eastern city for six months. Summing the cost of the judges (1 chief judge and 14 associate judges), probation,

*Ref. 24, p. 105. "The Part Way Home Program is used as a resource for the placement of wards who have no homes to go to, or whose homes are so destructive that it would be harmful to their rehabilitation to place them there."

psychiatric services, and detention, and dividing the sum by the total number of probation charges, we obtain about \$28 per misdemeanor charge incurred after police handling (i.e., this figure does not include pro-rated police costs). About \$22 of the \$28 is due to detention costs, assigned at \$2.35 per day. Although these costs are not significant when compared to other CJS costs, we will include a cost per misdemeanor charge (for those adults originally arrested for one of the List III offenses) of \$30 per charge. That is, C_{pm} will be set to \$30, regardless of crime category of the original arrest.

APPENDIX D

APPENDIX D

CONTENTS

APPENDIX D
SOME RESULTS OF RUNS WITH THE CALIFORNIA MODEL

In this appendix we present some computed results derived from the model of Appendix B and using the data of Appendix C.

First, using the distribution of reported crimes in California in 1965 as the input to the model, we compute flows and costs at various stages within the California CJS. While many of the computed quantities are derived from the model itself and were not specifically reported by California agencies, a reasonable check on the model's validity is provided by the fact that some flows are directly comparable to reported statistics.

Second, we make an estimate of crimes at a future time and use the model to estimate future CJS flows, costs, and workload requirements.

A. ATTRITION IN FLOW OF ADULTS

A basic question in studying a criminal justice system is the relationship between the flow through the early stages of processing and the flow through the later stages.

Figure D-1 depicts the computed flow at seven successive CJS stages, from systems input (number of reported crimes) to the final output to state correctional institutions. It is clear that the rate of attrition or "dropout" from beginning to end is relatively large.

Figure D-1 must be interpreted in the context of the crime category definitions at each stage. Reported crimes are defined in terms of the exclusive "seven major offenses" list, as discussed in Appendix C. Arrests are defined on a combination of lists (see

STAGE		GRAPHIC DECLINE	NUMBER	CUMULATIVE PERCENTAGE DROPPED
NUMBER OF REPORTED CRIMES	(N_c)		386,708	0
NUMBER OF ARRESTS	(N_a)		118,067	70
NUMBER OF ADULT ARRESTS	(N_{ad})		74,186	81
NUMBER OF ADULT CHARGES	(N_{ad1})		33,970	91
NUMBER OF ADULT DISPOSITIONS	(N_f)		19,217	95
NUMBER OF ADULT SENTENCES	(N_s)		16,353	96
NUMBER OF ADULT SENTENCES TO A STATE CORRECTIONAL INSTITUTION	(N_{s4})		4,309	99

FIGURE D-1. Computed Flows at Various Stages of the California CJS (Total of Seven Major Offense Categories)

Tables C-1 and C-2)--list III for adults and list I for juveniles. Charges for adults are based on list III definitions. The remainder of the variables are defined in list II. Thus, only flows for robbery, aggravated assault, burglary, and auto theft can be meaningfully and consistently compared among processing stages. Since the crime category lists become even more inclusive with deeper CJS penetration, the flow attrition indicated in the figure is an underestimate of the attrition rates that would be observed if there were a consistent, inclusive set of crime definitions.

Figure D-1 indicates that less than 30 percent of the reported major offenses lead to an arrest (where arrest is defined on a broader classification of crimes); 9 percent of crimes lead to an adult being charged with a felony in magistrate's court; 4 percent lead to adult conviction in Superior Court; and about 1 percent lead to sentencing of an adult in a state correctional institution.

Flows deriving from reported robberies, aggravated assaults, burglaries, and auto thefts can be traced consistently through the system. These attritions are depicted in Figs. D-2 through D-5. For robbery, the attrition is much less than that observed for the aggregated seven crimes: 57 percent of reported robberies result in an arrest. Since 85 percent of the robbery arrests are adult arrests, this adult attrition diagram presents a reasonably complete picture of what happens to those arrested for robbery. There is 80 percent attrition at magistrate's court (compared to 91 percent for the aggregated crimes), 89 percent attrition at Superior Court disposition, and 91 percent at the sentencing stage. Of all reported robberies, 6 percent lead to sentencing of the offender to a state correctional institution; this is the highest percentage sentenced to prison of the four consistently defined crimes.

Aggravated assault can be compared directly to robbery, since 85 percent of the arrests for both crimes are adult arrests. Attrition is less for aggravated assault than for robbery at the arrest stage, but it is greater at the magistrate's stage. This effect probably results from the greater likelihood that assault victims and perpetrators know each other. Thus, victims are more likely to identify their assailants, leading to a relatively high arrest probability; this same relationship also leads, however, to a lower probability that the victim will press charges. Attrition of assault cases is greater than that of robbery cases throughout the remainder of the system, with only 1.2 percent of assault arrests leading to sentencing of an adult to a state correctional institution.

Burglary is a particularly difficult crime to solve.* Since about half of the burglary arrests are juvenile arrests, comparison of

*Of the seven FBI index crimes, only larceny had a lower clearance rate (19 percent) than that of burglary (22 percent) in 1966.

STAGE		GRAPHIC DECLINE	NUMBER	CUMULATIVE PERCENTAGE DROPPED
NUMBER OF REPORTED CRIMES	(N_c)		26,088	0
NUMBER OF ARRESTS	(N_a)		15,794	39.5
NUMBER OF ADULT ARRESTS	(N_{ad})		13,418	49
NUMBER OF ADULT CHARGES	(N_{ad1})		4,576	82.5
NUMBER OF ADULT DISPOSITIONS	(N_f)		2,259	91
NUMBER OF ADULT SENTENCES	(N_s)		1,821	93
NUMBER OF ADULT SENTENCES TO A STATE CORRECTIONAL INSTITUTION	(N_{s4})		338	98.8

FIGURE D-2. Computed Flows at Various Stages of the California CJS (Robbery)

STAGE		GRAPHIC DECLINE	NUMBER	CUMULATIVE PERCENTAGE DROPPED
NUMBER OF REPORTED CRIMES	(N_c)		21,055	0
NUMBER OF ARRESTS	(N_a)		12,041	43
NUMBER OF ADULT ARRESTS	(N_{ad})		10,199	52
NUMBER OF ADULT CHARGES	(N_{ad1})		4,222	80
NUMBER OF ADULT DISPOSITIONS	(N_f)		2,297	89
NUMBER OF ADULT SENTENCES	(N_s)		1,918	91
NUMBER OF ADULT SENTENCES TO A STATE CORRECTIONAL INSTITUTION	(N_{s4})		1,216	94

FIGURE D-3. Computed Flows at Various Stages of the California CJS (Aggravated Assault)

STAGE		GRAPHIC DECLINE	NUMBER	CUMULATIVE PERCENTAGE DROPPED
NUMBER OF REPORTED CRIMES	(N_c)		218,078	0
NUMBER OF ARRESTS	(N_a)		51,052	77
NUMBER OF ADULT ARRESTS	(N_{ad})		27,410	87.5
NUMBER OF ADULT CHARGES	(N_{ad1})		13,705	94
NUMBER OF ADULT DISPOSITIONS	(N_f)		6,970	97
NUMBER OF ADULT SENTENCES	(N_s)		5,874	97
NUMBER OF ADULT SENTENCES TO A STATE CORRECTIONAL INSTITUTION	(N_{s4})		1,454	99.4

FIGURE D-4. Computed Flows at Various Stages of the California CJS (Burglary)

STAGE		GRAPHIC DECLINE	NUMBER	CUMULATIVE PERCENTAGE DROPPED
NUMBER OF REPORTED CRIMES	(N_c)		81,541	0
NUMBER OF ARRESTS	(N_a)		24,479	70
NUMBER OF ADULT ARRESTS	(N_{ad})		10,560	87
NUMBER OF ADULT CHARGES	(N_{ad1})		4,404	95
NUMBER OF ADULT DISPOSITIONS	(N_f)		2,584	97
NUMBER OF ADULT SENTENCES	(N_s)		2,301	97
NUMBER OF ADULT SENTENCES TO A STATE CORRECTIONAL INSTITUTION	(N_{s4})		401	99.6

FIGURE D-5. Computed Flows at Various Stages of the California CJS (Auto Theft) burglary attrition estimates with those for robbery and aggravated assault, for instance, must be made with care. Direct comparison shows burglary attrition to be consistently higher than that of robbery, aggravated assault, or even the aggregated crimes. However, of those adults arrested for burglary, 21.5 percent reach the sentencing stage in Superior Court, whereas only 19 percent of those arrested for robbery and only 13.5 percent of those arrested for assault reach that stage.

The attrition pattern for auto theft is very similar to that for burglary. There are comparatively more arrests for auto theft, but these are arrests of juveniles; only about 13 percent of reported auto thefts and burglaries give rise to an adult arrest. From adult arrest through to sentencing, the attrition patterns are vitually identical. At final sentencing, however, relatively fewer auto theft defendants are sentenced to a state correctional institution.*

B. FLOW OF JUVENILES

In this section we trace some aspects of the flow of juveniles through the juvenile CJS. Since the data from which the branching ratios were computed were tabulated from a special report (Ref. 21) and yearly flow data are not regularly reported, the results of this section have not been validated by checking with statistics from operating agencies. The calculations reported here have all the problems of validity (for instance, the effects of failure to report re-referral) that were discussed in Appendix C.

For robbery, aggravated assault, burglary, and auto theft, several flows computed for the juvenile system are given in Table D-1. Approximately 70 percent of the juvenile arrests for these crimes are referred to juvenile probation authorities. The scale factor that we

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*This is indicated by the sentencing branching ratios: $P_{s_4}(4) = 0.25$ for burglary and $P_{s_4}(6) = 0.18$ for auto theft, where P_{s_4} is the probability of a convicted defendant being sentenced to a state correctional institution.

used to account for referrals from other agencies, rereferrals, and changes in crime definition cause the total number of juvenile referrals for aggravated assault to jump to 4501; the scale factors for the other crimes were unity. For the crimes considered, slightly more than half of the referrals are referred to juvenile court by filing of a formal petition. Relatively few of these juvenile court cases result in the juvenile being placed under Youth Authority supervision. The estimated Youth Authority input ranges from 541 for aggravated assault to 840 for burglary.

TABLE D-1. SOME COMPUTED JUVENILE FLOWS

Stage	Robbery	Assault	Burglary	Auto Theft
N_{aj}	1,842	2,375	23,642	13,918
N_{jr}	1,483	1,793	16,833	9,896
N_{je}	1,483	4,501	16,833	9,896
N_{pf}	1,096	2,829	8,876	5,361
N_{jy}	131	339	213	429
W_{ya}	621	541	840	814

N_{aj} = Number of arrested juveniles.

N_{jr} = Number of arrested juveniles referred to the juvenile probation authorities.

N_{je} = Total referrals per year.

N_{pf} = Number of referrals who have a petition filed in juvenile court.

N_{jy} = Number of juveniles referred to juvenile court who are incarcerated under the Youth Authority.

W_{ya} = Youth Authority population at any given time.

C. POPULATIONS IN CORRECTIONS

All populations in the model have been computed by independently estimating parameters applicable to individual offenders and ignoring (except as checks) any population data reported by operating agencies. With estimates of the annual input to a facility and the mean stay of individuals assigned to that facility and an assumption of a steady-state process, the total population of the facility can be estimated as the product of the annual input and the mean stay. We can investigate the reasonableness of this procedure by comparing such estimates of populations to reported populations. Unfortunately, since total populations are not reported by crime type, this comparison cannot be made precisely now.

Several of the computed results are given in Table D-2. Specifically, for robbery, aggravated assault, burglary, auto theft, and the aggregated total of the seven crime types, the estimated populations are given for adult probation, jail, prison, and parole. The computed probation population is the largest of the four groupings for all crimes except robbery.

TABLE D-2. ESTIMATED CORRECTIONS POPULATION

Population	Robbery	Assault	Burglary	Auto Theft	Total of All Seven Crime Types
Jail, W_j	205	341	1,167	430	2,930
Probation, W_b	1,157	3,073	7,908	2,820	21,981
Prison, W_r	4,777	1,292	4,967	1,159	15,708
Parole, W_f	3,700	914	3,705	737	11,623

To compare these computations with reported figures, as of December 31, 1965, there were 33,677 active adult jurisdictional probation cases that were originally received from the California

Superior Courts (Ref. 1). About half of those granted probation (straight or with jail) from the Superior Courts are associated with one of the seven crimes of interest. Since these crimes are generally the more serious of the felonies, we would expect the probation terms for these individuals to be somewhat longer than the average. Thus, we would reasonably expect the probation population of offenders charged with one of the seven major crimes to be somewhat over half the total population. The computed probation population of 22,000 is, in fact, about 65 percent of the reported total probation population of 33,677, a reasonable consistency. In the model, the probation term was set as three years for all crime types. Once the probation term can be established as a function of crime type and if the probation population is reported by crime type, then we will be able to obtain a much more meaningful test of the population estimation method.

The total California prison population as of January 1, 1965, was 22,822 (Ref. 1). This can be compared with the computed estimate, as was done above for the probation population. Of those sent to prison during 1965, about 60 percent were charged with one of the seven major crimes. The model-derived prison population of 15,700 is approximately 69 percent of the reported population of 22,822. Again, considering that felons associated with one of the seven major crimes probably receive longer sentences, this comparison also seem reasonable.

The estimated average parole population in 1965 was 12,657 (Ref. 1). The computed estimate of number of parolees charged with one of the seven major crimes is 11,623; this is about 92 percent of the actual average population for all crimes. We would expect the model-derived parole population to be roughly 70 percent of the total parole population, since parolees first had to serve a prison term and about 70 percent of the prison population were associated with the seven major crimes. This assumes no difference between the two groups in regard to parole probability and duration. One possible explanation for the overestimate could derive from the fact that the parole violation probabilities have increased by about 50 percent since 1959.

Our estimates of the time spent on parole were computed from the times spent on first parole of those discharged from first parole in 1961, 1962, and 1963, a period when the violation probability was lower. The parole duration was therefore longer in 1965. Thus, our input data on parole duration may be too large. Also, lacking other data, we assumed that the mean time spent on reparole was no different from the time spent on first parole. These assumptions should be investigated further so as to make further refinements on the model.

The estimated population in jails as a result of Superior Court disposition for one of the seven major crimes is estimated to be 2,930, only about 10 percent of the 25,000 adult jail and prison camp population reported as of September 23, 1965. This huge difference results from the fact that a large fraction of the jail population is composed of persons either awaiting trial or found guilty of less serious crimes.

D. AGGREGATED COSTS

This section reports on some of the cost distributions computed from the model. We are particularly interested in how the costs and effects are currently distributed among parts of the CJS and among the seven crime types.* Because of rounding the percentages in Figs. D-6 through D-8 may not equal 100 percent.

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*Here again, the qualifications and assumptions that were stated in structuring the model must be taken into account. The inconsistency in crime definitions at various stages of the system represents one major class of problems. Since the crime-category lists tend to become more inclusive with deeper system penetration, our cost estimates err on the low side near the system input (e.g., police costs) and on the high side for corrections.

In addition, some costs have not been allocated because of the difficulty in measuring them (e.g., costs of juvenile local detention) or assigning them to crimes (e.g., the cost of preventive patrol). For this latter case, we allotted only one hour of preventive patrol time for each hour spent servicing a crime call; this allocation of time to the seven crimes accounts for only a small fraction of total patrol effort and may thus be considered to represent a lower bound for police costs associated with these crimes.

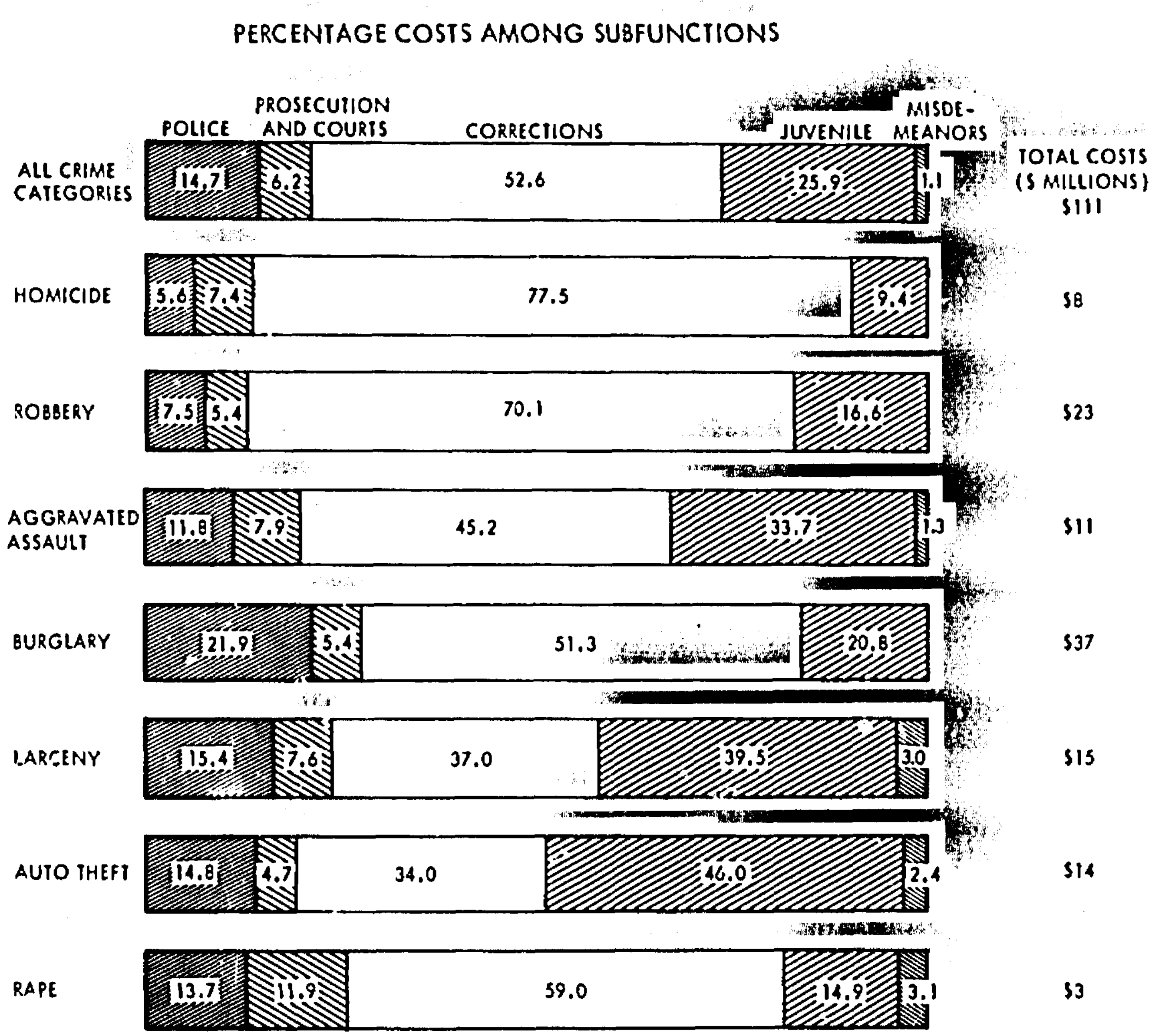

FIGURE D-6. System Costs Among Subjunctions

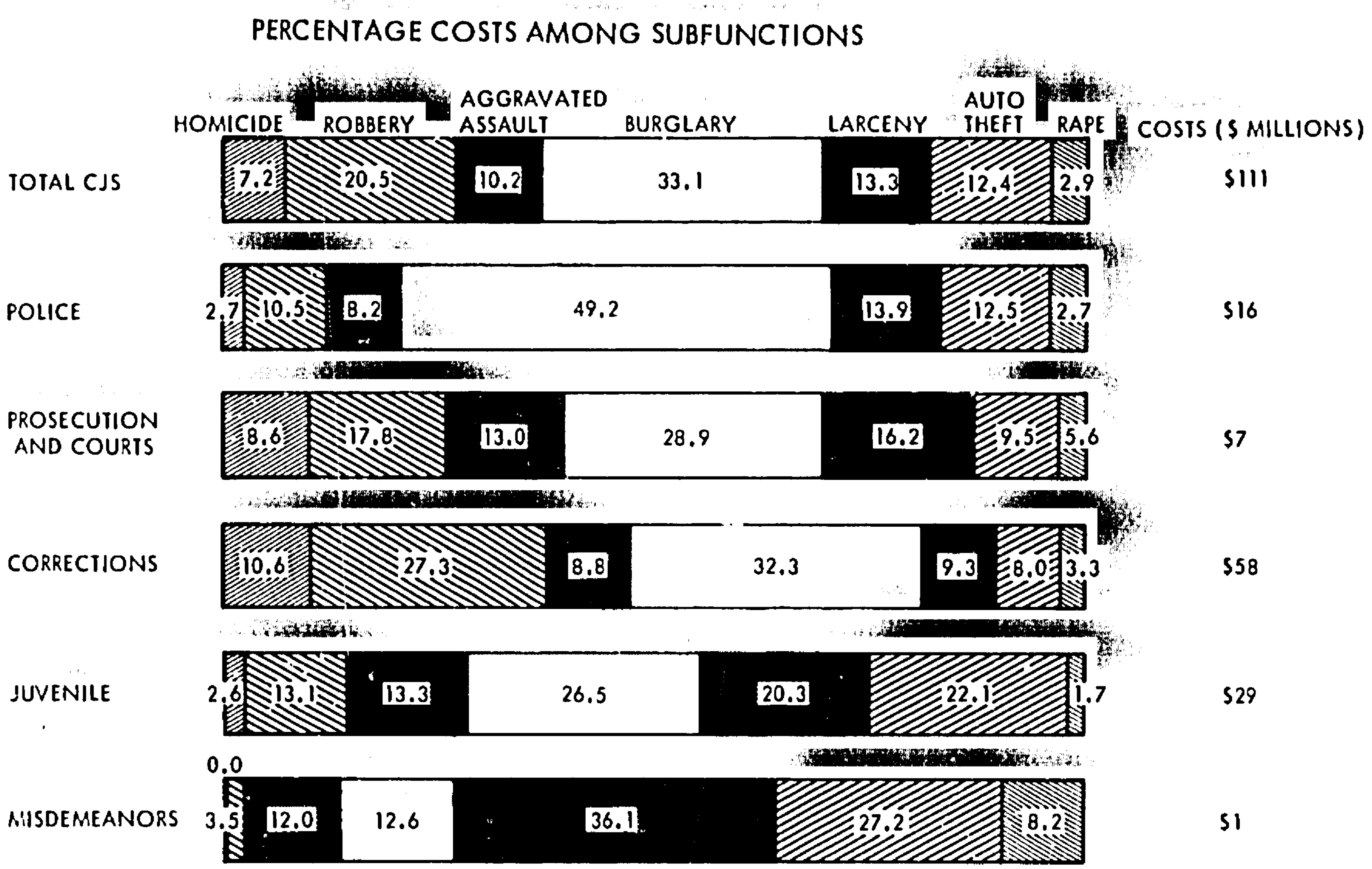

FIGURE D-7. CJS Cost Distribution Among Crime Types

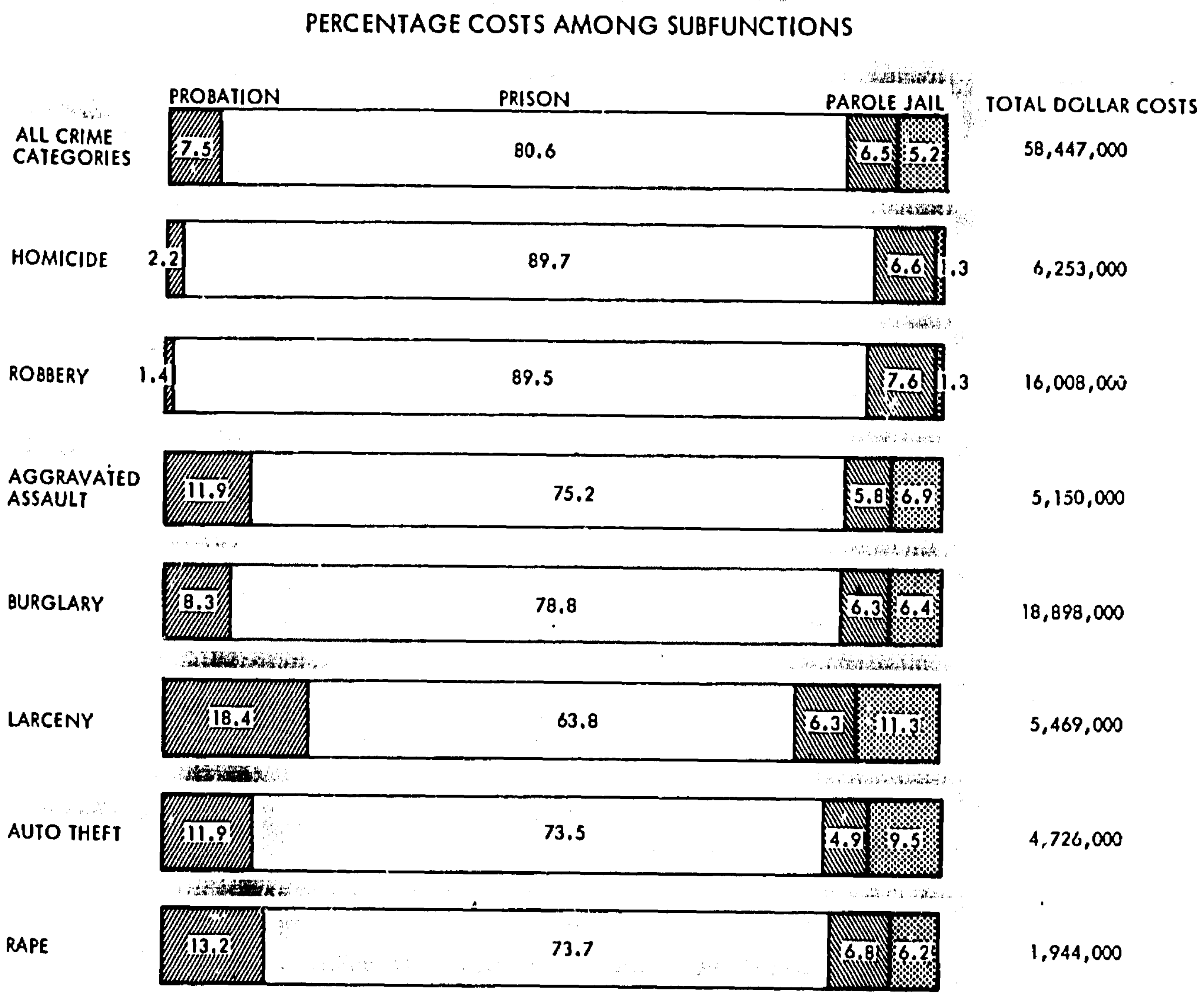

FIGURE D-8. Distribution of Corrections Costs

The percentage distribution of CJS costs to each of the subfunctions (police, prosecution and courts, corrections, juvenile processing and corrections, and misdemeanor adjudication) is given for each crime category in Fig. D-6. When averaged over all crime types, corrections involve the largest proportion (52.6 percent) of the total CJS costs. Following are juvenile (25.9 percent), police (14.7 percent), prosecution and courts (6.2 percent) and handling diversions to misdemeanors (1.1 percent).

Among the individual crime categories, corrections costs range from 77.5 percent of total CJS costs for homicides to 34 percent for auto thefts. Juvenile costs are proportionately highest (46 percent) for auto theft and lowest (9.4 percent) for homicides. Police costs are proportionately highest for burglary (21.9 percent) and lowest for homicide (5.6 percent). This reflects the high clearance rate for homicide (making police costs small compared to corrections) and the low clearance rate for burglary (many police investigations, few sentences). The most significant feature of these distributions is the relatively high cost of corrections and the relatively low cost of courts, even though most police costs are not included.

Figure D-7 shows the cost distributions among crime types for the total CJS and for each of the subfunctions (police, prosecution and courts, corrections, juvenile, and misdemeanors). For the total CJS, burglary accounts for about one-third of the direct operating costs. Following burglary are robbery (20.5 percent), and larceny (13.3 percent). The three strictly property crimes (burglary, larceny, and auto theft) account for about 59 percent of the direct CJS operating costs. Including robbery in this group increases the total to 80 percent of the CJS operating costs for these seven crimes. Burglary consumes the largest portion of the direct operating cost in each of the subfunctions and accounts for nearly half of the allocated police costs.

The distribution of corrections costs is given in Fig. D-8. For all crime categories, more than 80 percent of the corrections costs are accounted for by prison operation, followed by 7.5 percent for probation, 6.5 percent for parole, and 5.2 percent for jail. Prison costs are proportionately highest for homicide (89.7 percent) and robbery (89.5 percent) and lowest for larceny (63.8 percent).

E. SENSITIVITY ANALYSES--INCREMENTAL FLOWS AND COSTS

1. Incremental Flows per Reported Crime

It is important to investigate the incremental system flows generated by an additional reported crime; this can be done with the sensitivity analysis segment of the model.* To illustrate the possible interpretations of this particular type of system sensitivity, consider the number of adult defendants found guilty of robbery, $N_S(2)$. The associated incremental flow is $[\partial N_S(2)/\partial N_C(2)]$, the first derivative of the number of guilty robbery defendants with respect to the number of reported robberies. In the California model this is calculated to be 0.08. Two alternative interpretations could be given to this number:

1. For each additional robbery reported there would be, on the average, an additional 0.08 adult defendant found guilty of robbery. Or, equivalently, for (1/0.08) = 12.5 additional reported robberies, there would be, on the average, one additional defendant found guilty of robbery.
2. In a randomly selected reported robbery, the probability that the robber would be found guilty of that robbery is 0.08.

The probabilistic interpretation will often be ambiguous, because several crimes can be associated with one individual. (This problem is virtually eliminated when the derivatives of the flow variables are taken with respect to the number of arrests.)

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*The real system, of course, would not observe fractional flows generated by another reported robbery, but our formalism allows us to investigate such average effects.

We can also consider the sensitivity of a population variable, such as the steady-state number of inmates in a state correctional institution. For the crime of robbery, $W_r(2)$, the associated derivative, $[\partial W_r(2)/\partial N_c(2)]$, is computed to be 0.23. This quantity has two possible interpretations.

1. For every additional robbery reported on the average, an additional 0.23 man-years are spent in prison by an individual found guilty of robbery.
2. For every additional robbery reported, the steady-state prison population is increased by 0.23 inmates.

The first interpretation is given in terms of <u>time</u> spent in prison, the second in terms of the <u>population</u> in prison.

Table D-3 lists values of several incremental flows per reported crime. These are given for the four consistently defined crimes (robbery, aggravated assault, burglary, and auto theft). The incremental number of adults charged ranges from 0.20 for robbery to 0.05 for auto theft. This signifies that, on the average, one adult is charged with robbery at magistrate's court for every five robberies reported; whereas, for auto theft, one adult is charged for every 20 auto thefts reported. The incremental number of adults sentenced ranges from 0.09 per reported robbery to 0.03 per reported burglary or auto theft.

Table D-4 shows the incremental adult corrections populations per reported crime for the four consistently defined crimes. Of these crimes, a robbery has the largest effect on the corrections system: one more robbery raises the prison population by 0.23 inmates, the parole population by 0.18 parolees, the probation population by 0.05 probationers, and the jail population (on the basis of Superior Court dispositions) by 0.01. A reported auto theft has the smallest effect (only 0.01 additional inmates) on the adult prison population. The probation population is most strongly affected by a reported aggravated assault; on the average, it increases the probation population by 0.12 probationers.

TABLE D-3. INCREMENTAL FLOWS PER REPORTED CRIME

Population	Robbery	Aggravated Assault	Burglary	Auto Theft
N_{ad_1}	0.20	0.18	0.06	0.05
N_f	0.11	0.09	0.03	0.03
N_{tg}	0.07	0.05	0.02	0.02
N_s	0.09	0.07	0.03	0.03

N_{ad_1} Number of adult arrests that result in a felony charge

N_f Number of adults charged with a felony who receive a Superior Court disposition

N_{tg} Number of adult defendants who plead guilty

N_s Number of adult defendants found guilty

TABLE D-4. INCREMENTAL POPULATIONS PER REPORTED CRIME

Population	Robbery	Aggravated Assault	Burglary	Auto Theft
Probation, W_b	0.05	0.12	0.04	0.03
Jail, W_j	0.01	0.01	0.01	0.01
Prison, W_r	0.23	0.05	0.02	0.01
Parole, W_z	0.18	0.04	0.02	0.01

The time interpretation of each of these quantities could also be used. For instance, for the crime of burglary (refer to Table D-4): for each reported burglary an average of 0.02 year will be spent in prison by a defendant charged with burglary.

2. Incremental Costs per Reported Crime

The CJS operating cost implications of crimes are indicated by the incremental costs per reported crime shown in Table D-5. Within the context of the costing assumptions, each reported robbery costs the CJS an average of about $1,083, each aggravated assault $437, each burglary $169, and each auto theft $170. Table D-5 also indicates the detailed components of these total costs. Thus, of the $1,083 incremental costs associated with robbery, $760 is attributed to corrections, of which $681 is attributed directly to prison costs. For each of the cost components except probation and jail, robbery costs are the largest. Police costs range from $82 for robbery to $25 for auto theft.*

TABLE D-5. INCREMENTAL DOLLAR COSTS PER REPORTED CRIME

Cost Component	Robbery	Aggravated Assault	Burglary	Auto Theft
Total, C_t	1,083	437	169	170
Juvenile, C_y	180	147	35	78
Adult Corrections, C_{co}	760	197	87	58
Probation, C_b	11	24	7	7
Jail, C_j	10	14	6	6
Prison, C_r	681	149	68	43
Parole, C_z	58	12	5	3
Prosecution, Courts, and Detention, C_{pc_2}	59	35	9	8
Police, C_{po}	82	52	37	25

*These are so small because of the conservative allocation procedure used. An upper bound would be to consider all preventive patrol allocated to the serious crimes. Of the roughly $300 million spent on police in California, about $75 million might be attributed to preventive patrol. Allocating this entire amount among the 390,000 reported serious crimes allocates $190 of preventive patrol per crime. This would increase the estimated total system cost (as sh n in Fig. D-6) from $111 million to $184 million (a 66 percent increase) and raise the police fraction of all crime categories from 14.7 percent to 48 percent.

To illustrate the cost computation methods, we compute here the incremental police cost per reported auto theft. In general, an incremental cost is the weighted sum of costs incurred at various processing stages, with the weights being the probability that the corresponding cost will be incurred. For a reported auto theft, police patrol costs are incurred with unity probability, because the patrol force must service the call that reported the auto theft. In addition, we allocate an additional equal amount of preventive-patrol time to auto theft. The time to service an auto theft call is 0.7 hour, and the cost of patrol per hour is \$6.50. Thus, the patrol cost per reported auto theft is

$$(2)(0.7)(\$6.50) = \$9.10$$

The relevant detective times are as follows:

$$T_{d_1}(6) = 0.6 \text{ hour}$$

$$T_{d_2}(6) = 2.1 \text{ hours}$$

$$T_{d_3}(6) = 6.1 \text{ hours}$$

where the three times correspond to those associated with investigating a reported crime, with arrest, and with processing a charge. The probability of arrest is $N_{a/c}(6) \simeq 0.30$. The probability that the arrested individual is an adult is $P_{ad}(6) = 0.43$. Given that the arrested individual is an adult, the probability that he is charged with auto theft is $P_{ad_1}(6) \approx 0.42$. The hourly cost of detectives is \$10.30. Thus, the average detective cost per reported auto theft is:

$$\$10.30 \, [T_{d_1}(6) + T_{d_2}(6) \, N_{a/c}(6) + T_{d_3}(6) \, N_{a/c}(6) \, P_{ad}(6) \, P_{ad_1}(6)]$$

$$= \$10.30 \, [0.6 + 2.1 \, (0.30) + 6.1 \, (0.30) \, (0.43) \, (0.42)]$$

$$\simeq \$16$$

Adding the detective cost (\$16) to the patrol cost (\$9), we compute the police cost as \$25. The other cost components are computed similarly, using the computer program outlined in Appendix F.

3. Incremental Flows per Arrest

The derivative of flow or population variables with respect to number of arrests permits a determination of flow or population increases later in the system as the number of arrests increases.

As an example, $[\partial N_{s_1}(2)/\partial N_a(2)]$, (where $N_{s_1}(2)$ is the number of robbery defendants who receive sentence type 1 (straight probation) and $N_a(2)$ is the number of robbery arrestees), is the average incremental number of robbery defendants who receive sentence type 1 per additional robbery arrestee. Interpreted probabilistically, it is a very close approximation* to the probability that a randomly selected robbery arrestee will have a Superior Court disposition <u>and</u> receive straight probation for robbery.

Several incremental flows per arrest are given in Table D-6. The flows resulting from a robbery arrest are seen to be the largest.

TABLE D-6. INCREMENTAL FLOWS OF ADULT ARRESTEES PER ARREST

Flow Variables	Robbery	Aggravated Assault	Burglary	Auto Theft
N_{ad_1}	0.35	0.29	0.27	0.18
N_f	0.19	0.14	0.14	0.11
N_{tg}	0.12	0.07	0.09	0.08
N_s	0.15	0.11	0.11	0.09

N_{ad_1} = Number of adult arrests that result in a felony charge

N_f = Number of adults charged with a felony who receive a Superior Court disposition

N_{tg} = Number of adult defendants who plead guilty

N_s = Number of adult defendants found guilty

*The approximation arises because of crime-type switching. In general, arrest for crime type j could be changed to Superior Court disposition under crime type k. The reported statistics from which we obtained the branching ratios, or probabilities, were based on the total numbers who were arrested, received the various dispositions, and so on. Thus, the number who receive dispositions for crime k may not be composed only of individuals who were originally arrested for crime k. For the seven crimes of interest, this type of problem occurs relatively infrequently, since most charge reductions out of a given crime category would be to misdemeanors rather than to another of the seven crimes treated in the model.

Incremental populations can be calculated similarly. These can be interpreted either in terms of time (man-years) or in terms of population units. For instance, $\partial W_r(2)/\partial N_a(2)$, where $W_r(2)$ = adult prison population of sentenced robbers and $N_a(2)$ = the number of robbery arrests, could be interpreted as (1) the average number of prison adult inmate-years per additional robbery arrest, or (2) the average incremental change in prison adult population per additional robbery arrest. A robbery arrestee selected at random would have an expected prison stay (taking account of the possibility of dismissal of the charge) of $[\partial W_r(2)/\partial N_a(2)]$ years in adult prison as a result of the current arrest.

Table D-7 contains some computed incremental adult populations per arrest. In all of these felony cases, the expected incremental jail population is small. The prison effect is largest for robbery, whereas the probation increment is largest for the other offenses.

TABLE D-7. INCREMENTAL CORRECTIONS POPULATIONS PER ARREST

Population	Robbery	Aggravated Assault	Burglary	Auto Theft
Probation, W_b	0.10	0.19	0.15	0.12
Jail, W_j	0.02	0.02	0.02	0.02
Prison, W_r	0.40	0.08	0.10	0.05
Parole, W_z	0.31	0.06	0.07	0.03

4. Incremental Costs per Arrest

This section examines the cost consequences resulting from an additional arrest. Here, a typical basic quantity is $[\partial C_t(2)/\partial N_a(2)]$, the first derivative of the total CJS robbery costs with respect to the number arrested for robbery. This is the average cost incurred by the CJS for processing of a robbery arrestee for all processing resulting from arrest and after arrest. The total cost incurred by the CJS for processing a robbery arrestee is this expected or average cost, plus the prior cost incurred for processing before arrest.

Some illustrative incremental costs per arrest are given in Table D-8. The incremental total CJS costs (C_t) is largest for an additional robbery arrest ($1823); aggravated assault ($674), burglary ($611), and auto theft ($515) are grouped fairly closely. Here, the incremental costs per arrest associated with burglary and auto theft are much larger than the corresponding costs per crime, because the low arrest probabilities are no longer factors entering the cost estimate. Because of this consideration, we note that, except for incremental police costs, each of the costs per arrest in Table D-8 is larger than the corresponding costs per reported crime of Table D-5. This is true despite the fact that the incremental costs per additional arrest do not include the police costs prior to arrest. These are more than compensated by removing the probability of no arrest from consideration.*

The incremental police costs in Table D-8 are those incurred from arrest through final disposition. They do not include prior costs of servicing the call by patrol and routine detective time spent on the crime report. Thus, the $33 reported for auto theft is computed as follows:

$$\text{Patrol costs} = \$0$$

$$\begin{aligned}\text{Detective costs} &= \$10.30\ [T_{d_2} + T_{d_3} \cdot P_{ad} \cdot P_{ad_1}] \\ &= \$10.30\ [2.1 + 6.1\ (0.43)(0.42)] \\ &\approx \$33\end{aligned}$$

*This situation can be generalized by considering a simple, single-path processing system of n stages. At each stage S_i ($i = 1, 2, \ldots, n$), flow is either to stage S_{i+1} (with probability P_i) or dropout (with probability $1-P_i$). Then, if we define

$\overline{C}_i$ = expected cost incurred at $S_i, S_{i+1}, \ldots, S_n$

a_i = cost incurred at S_i

we have

$$\overline{C}_i = a_i + \overline{C}_{i+1} P_i.$$

Then, by simple substitution, we can see that $\overline{C}_i \leq \overline{C}_{i+1}$ if and only if $a_i < \overline{C}_{i+1} (1-P_i)$ or, equivalently, $P_i < 1-(a_i/\overline{C}_{i+1})$. Thus, if the probability of proceeding from one stage to the next is sufficiently small, then the average incremental cost incurred by an additional insertion at a later stage is greater than an insertion at an earlier stage.

TABLE D-8. INCREMENTAL COSTS PER ARREST

Cost Component	Robbery	Aggravated Assault	Burglary	Auto Theft
Total, C_t	1,824	674	611	515
Juvenile, C_y	315	243	150	261
Adult Corrections, C_{co}	1,329	326	370	193
Probation, C_b	19	39	31	23
Jail, C_j	18	23	24	18
Prison, C_r	1,190	245	292	142
Parole, C_z	102	19	23	10
Prosecution, Courts, and Detention, C_{pc_2}	103	57	39	27
Police, C_{po}	73	38	48	33

5. Elasticity

A variation of the concept of incremental flows (or costs) is the concept of elasticity. Here, the derivative of the incremental flow is modified to a percentage derivative. For instance, the elasticity of the police cost with respect to the number of arrestees for crime type j would give the fraction of total police effort for crime type j that is spent on arrests and further processing.

As an example, the elasticity of the number of detective man-hours for auto thefts with respect to the number of auto theft arrests is computed to be:*

$$\frac{N_a(6)}{W_d(6)} \cdot \frac{\partial W_d(6)}{\partial N_a(6)} = \frac{\partial W_d(6)/W_d(6)}{\partial N_a(6)/N_a(6)} = 0.62$$

*The derivative itself $[\partial W_d(6)/\partial N_a(6)]$ is 3.2 hours. This is the sum of the number of detective man-hours spent in making the auto (Continued next page)

This elasticity can be interpreted to mean that for a small increase of X percent in the number of auto theft arrests per year (resulting perhaps from more auto thefts or from a slightly greater arrest probability), the detective workload for auto thefts would increase by (0.62)X percent. The elasticity could also be interpreted to indicate that under present operating conditions, 62 percent of the detective effort allocated to auto thefts involve arrest and charge processing, the remaining 38 percent involving auto theft crime reporting activities.

Table D-9 presents two computed elasticities of police cost and total CJS cost (C_t) with respect to number of arrests. The latter figure represents the fraction of the total system cost that is attributable to costs incurred at the arrest stage and afterwards. We can note that the pre-arrest costs represent the highest proportion for burglary (15 percent) and the lowest for robbery (4 percent); this is because robbery has a higher clearance rate and longer sentences. Arrest and charge processing account for only 30 percent of police costs associated with burglary, and they account for 51 percent of the police costs associated with robbery, again largely because of the difference in clearance rates.

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*(Continued) theft arrest (excluding prior time spent on routine crime reporting) and the expected time spent in charging the arrestee with the felony. Dividing the annual number of auto theft arrests into the annual number of detective man-hours spent on auto thefts [$W_d(6)/N_a(6)$] yields an average of 5.2 detective man-hours per auto theft arrest. This figure is the sum of the average time spent on arrest and later processing (the 3.20 hours computed above) <u>and</u> the total time spent on auto theft crime reporting allocated to <u>each</u> auto theft arrest. Since each auto theft arrest is associated with an average of $1/N_{ac}(6) \approx 1/0.3$ auto theft reports, there is an average of $T_{d_1}(6)/N_{ac}(6) = 0.6/0.3 = 2$ hours spent on crime reporting for auto thefts for each auto theft arrest. Thus, the 2 hours spent on crime reporting and the 3.2 hours spent on arrest and charging gives 5.2 detective hours spent per auto theft arrest. Then, the ratio 3.2/5.2 gives the elasticity of 0.62.

TABLE D-9. ELASTICITIES WITH RESPECT TO THE NUMBER OF ARRESTS (N_a)

Cost Category	Robbery	Aggravated Assault	Burglary	Auto Theft
Total CJS Cost, C_t	0.96	0.93	0.85	0.91
Police Cost, C_{po}	0.51	0.45	0.30	0.39

6. Other Incremental Costs

The previous discussion has focused on the incremental costs per crime or arrest. The method is applicable to any subsequent costs from any stage, and especially to the effect on total CJS costs (C_t) of an additional person at any stage. Table D-10 lists the expected incremental total system costs (C_t) resulting from a unit increment in several selected flow variables at successive stages within the CJS. These costs reflect processing at the incremental stage and the expected value of subsequent processing; they do not include costs incurred prior to the incremental stage.

In general, these costs tend to increase with deeper system penetration, even though earlier costs are excluded. As discussed earlier, this results from both the relatively low probabilities of reaching the later stages and the relatively high costs associated with reaching them.*

*For instance, a defendant charged with robbery in magistrate's court can expect to cost the CJS an additional $4,749; but once he reaches jury trial, the CJS can expect to spend an additional $9,477 on the jury trial and any sentence that may follow from the trial. A robbery defendant sentenced to prison can incur an additional CJS cost of $12,419 from the point of sentencing.

TABLE D-10. SOME INCREMENTAL TOTAL CJS COSTS ($)

Cost Category	Robbery	Aggravated Assault	Burglary	Auto Theft
$\partial C_t/\partial N_{ad_1}$	4,749	1,484	1,878	1,809
$\partial C_t/\partial N_f$	8,560	2,933	3,544	2,976
$\partial C_t/\partial N_{t_1}$	9,477	3,675	4,254	3,451
$\partial C_t/\partial N_{t_2}$	7,309	2,986	3,308	2,851
$\partial C_t/\partial N_{tg}$	9,460	3,143	3,864	3,053
$\partial C_t/\partial N_{s_4}$	12,419	11,587	9,905	8,209

N_{ad_1} = Number of adults charged with felony at magistrate's court.

N_f = Number of filings resulting in a Superior Court disposition.

N_{t_1} = Number of jury trials.

N_{t_2} = Number of bench trials.

N_{tg} = Number of guilty pleas.

N_{s_4} = Number of defendants sentenced to prison.

7. Estimates of Expected Punishments

Previous examination of incremental flows, populations, and costs indicated that an incremental crime generated only a small number of incremental prisoners, in the order of 0.01 to 0.10. This results from the succession of opportunities of nonpenetration into the CJS. In order for an offender to be sent to prison, at least seven actions must occur after the crime is committed:

1. The crime must be detected and reported to the police.
2. The offender must be arrested.
3. He must be charged with the felony.
4. The suspect must be prosecuted (the prosecutor must ask for an indictment or bill of information or certified confession).

5. The suspect must be brought to trial.
6. The defendant must be found guilty.
7. The convicted offender must be sentenced to a state correctional institution.

Each of these seven events has a nonzero probability of failing to occur. We want to examine the probability of imprisonment--the performance of all the above events--and the expected duration of imprisonment. If we denote by p_i the conditional probability of the i^{th} action occurring, given that the (i-1) has occurred, then the probability of imprisonment, given that a crime has been committed, is simply $p_1 p_2 . . . p_7$. If the mean time served by those sent to prison is T years, then the expected incarceration time for one offense is simply $p_1 p_2 . . . p_7 T$. This is the expected punishment to be considered by a "rational" individual contemplating the risk in committing a crime. Estimates of p_1 for each of the seven crimes of interest can be obtained from survey results reported by the National Crime Commission's Assessment Task Force (Ref. 22).* The Task Force reported the following breakdown by crime type of the fraction of cases in which a crime was committed and detected, but not reported to police.

Crime	Fraction of Cases in Which Police Were Not Notified
Robbery	0.35
Aggravated Assault	0.35
Simple Assault	0.54
Burglary	0.42
Larceny ($50 and over)	0.40
Larceny (under $50)	0.63
Auto Theft	0.11
Sex Offenses (other than forcible rape)	0.49

*The estimates were obtained by the National Opinion Research Center of the University of Chicago in a survey of 10,000 households. Respondents were asked whether they or any member of their household had been a victim of crime during the past year and whether the crime had been reported to the police.

We can thus use the complement of these fractions as an estimate of p_1, the probability that a crime is reported.

We can now make some rough estimates of the expected punishment to be weighed against the gain in committing a crime. For an adult who contemplates the crime of burglary, the p_i's assume the following values

$$p_1 = 1-0.42 = 0.58$$
$$p_2 = N_{a/c} = 0.23$$
$$p_3 = P_{ad_1} = 0.50$$
$$p_4 = P_f = 0.51$$
$$p_5 = 1-p_{td} = 0.91$$
$$p_6 = (p_{tg} + P_{tg_1} \cdot P_{t_1} + P_{tg_2} \cdot P_{t_2})(1/(1-p_{td}) = 0.93$$
$$p_7 = P_{s_4} = 0.25$$

Multiplying the p_i's, we find the probability of adult incarceration for burglary, given that the burglary is committed by an adult, to be approximately 0.007. The average time served in prison (including time spent in prison because of parole violation) is about three years. Thus, the expected time that one could be incarcerated in a state correctional institution for one burglary is 3 (0.007) years, or about 7.7 days. Adding the chance of being sentenced to jail or being incarcerated due to probation violation, the total expected time incarcerated per burglary is about 11 days.

We can use this estimate of the risk associated with arrest and conviction to explore some aspects of a potential burglar's decision in considering whether or not to commit a burglary.

For most property crimes, those presumably performed for economic gain, the losses are reported in the FBI's <u>Uniform Crime Reports</u>. Robberies averaged \$269 (but the 1840 bank robberies averaged \$5,240); burglaries averaged \$298; and larcenies averaged \$100 (but the 60 percent of larcenies that involved \$50 or more averaged \$238). Thus, we might use $300 as a rough estimate of the average benefit in a property crime, recognizing that an individual criminal considering a potential crime has much finer information on the amount involved.

The general formulation of a potential offender's expected loss might be calculated as:

$$R_j = \sum_k D_{kj} \times P_{kj}$$

where

D_{kj} = disutility in advancing to the k^{th} stage of the CJS, having committed crime C_j

P_{kj} = conditional probability of advancing to the k^{th} stage, $(k = 1,2,\ldots,7)$ already having advanced to the $(k-1)^{th}$ stage after having committed crime C_j

The sequence of conditional probabilities reflects the branching probabilities at each stage. The disutilities reflect fines, lawyer's fees, value of time, earnings lost, stigma in being caught or labeled a convict, unhappiness at being imprisoned, and so on.

For simplicity, we have ignored other more complicated routings through the CJS (e.g., plea bargaining to reduce the charge to a misdemeanor). At each stage we simply imply dropout or further penetration.

If the offender's only concern is the prison sentence (i.e., in the above notation, $D_{kj} = 0$ for all $k < 7$), then the burglar's expected prison sentence is 7.7 days. Thus, if he were to derive $300 from the burglary, then he would have to value his time at more than $40 per day, and have other means of earning that much, to think that the burglary were a bad risk.

So far, we have ignored the cost of arrest, pretrial detention, bail bonds, lawyer's fees, and the intangible costs associated with stigma and other factors that must be taken into account. Any numerical analysis can treat only part of it. For instance, if we assume a cost of $500 resulting from arrest, $800 from trial, and a time value of \$30 per prison day, then the expected costs are

$$(0.13)(500) + (0.03)(800) + (7.7)(30) = \$320$$

then we calculate an expected loss of \$320, and the proceeds of the crime must exceed that to be profitable.

Let us assume that a potential burglar were to place an arbitrary disutility of \$1,000 each on avoiding an arrest and a conviction record; in addition, we might assume that he assigns a disutility of \$20 per day for each day spent in jail or prison, an expected period of about 11 days. Then, the expected disutility 11(20) + 1000 (0.13) + 1000 (0.03) = \$380, or \$80 more than the average gain from a burglary.

On the other hand, the potential burglar's utility structure and alternatives could well be different. For instance, if he already had an arrest and conviction record, there might well be little additional disutility deriving from an additional arrest or conviction. Also, he might be unemployed and not value his time highly at all. Or he might commit a burglary with a target more attractive than the average. Or he might be convinced that he knows how to avoid detection and apprehension much better than the "average" burglar. In these cases, the burglary may well appear attractive.

This analysis is certainly very crude and preliminary. It treats very complex utility structures in an extremely simple way. It ignores such aspects as multiple charging and dependence of sentence upon prior criminal record. But it provides a framework for examining the risk-benefit aspects of committing and deterring crime. And, it suggests that because of the relatively small risk in committing a crime, intangible costs associated with arrest and conviction records play an important role in deterrent considerations. Further explorations along these lines are clearly called for.

APPENDIX E

APPENDIX E

PROBLEMS IN MODELING RECIDIVISM: EXAMINATION OF A SIMPLE MARKOV MODEL

At nearly every processing stage in the CJS, one of the possible alternative decisions is to dismiss the offender from further processing and return him to society. Once back in society, the offender may later commit a crime. We are particularly interested in the probability of this event of recidivism. Making estimates of the probability of this event, however, is made difficult by the fact that we rarely know when an individual has committed a crime. We only know when he has been arrested, convicted, sentenced to prison, or has some formal, recorded contact with the CJS as a result of being accused of having committed a crime. Thus, we are limited to using such probabilities as those of rearrest or reimprisonment as measures of recidivism. Certainly, the observed values will depend on the definition used.

Some controversy about recidivism probabilities has arisen in the literature because of the different definitions used. In criminology, recidivism is often defined as "a falling back or relapse into prior criminal habits, especially after punishment."* Correctional agencies usually view recidivism as "return to prison." Police usually consider recidivism to be "rearrest." Recidivism probabilities calculated by each of these definitions will be different from each other,** and both

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*Webster's New International Dictionary, 2d ed., G&C Merriam Co., Springfield, Mass., 1960. In this dictionary, a recidivist is defined to be "...one who is recidivous or has been guilty of recidivism; an incorrigible criminal."

**The use of rearrest includes some erroneous arrests. The use of conviction or sentencing fails to include dismissals where evidence was strong but insufficient to convict ("beyond the shadow of a doubt"). In each instance we include cases in which there was no recidivism and omit cases in which there was recidivism.

grossly underestimate the probability of "repetition of crime," the true but unknown recidivism.*

To indicate the differences in these definitions, we can consider the following simplified Markov model. Each offender, after committing a crime, is apprehended with a probability P_A and, if apprehended, incarcerated with a probability P_I. Assuming that the actions of the CJS have an effect upon the offender's future behavior, the probabilities of committing at least one more crime are P_{R1}, P_{R2}, and P_{R3}, depending on whether the offender was (1) not apprehended, (2) apprehended but not incarcerated, or (3) apprehended and incarcerated, respectively. The model is diagrammatically presented in Fig. E-1.

We now define three different types of recidivism:**

$P(C/C)$ = Probability that an offender commits at least one more crime/he has just committed a crime

$P(A/A)$ = Probability that an offender is arrested at least once more/he has just been arrested

$P(I/I)$ = Probability that an offender is incarcerated at least once more/he has just been incarcerated

For our simple model, it is straightforward*** to show that

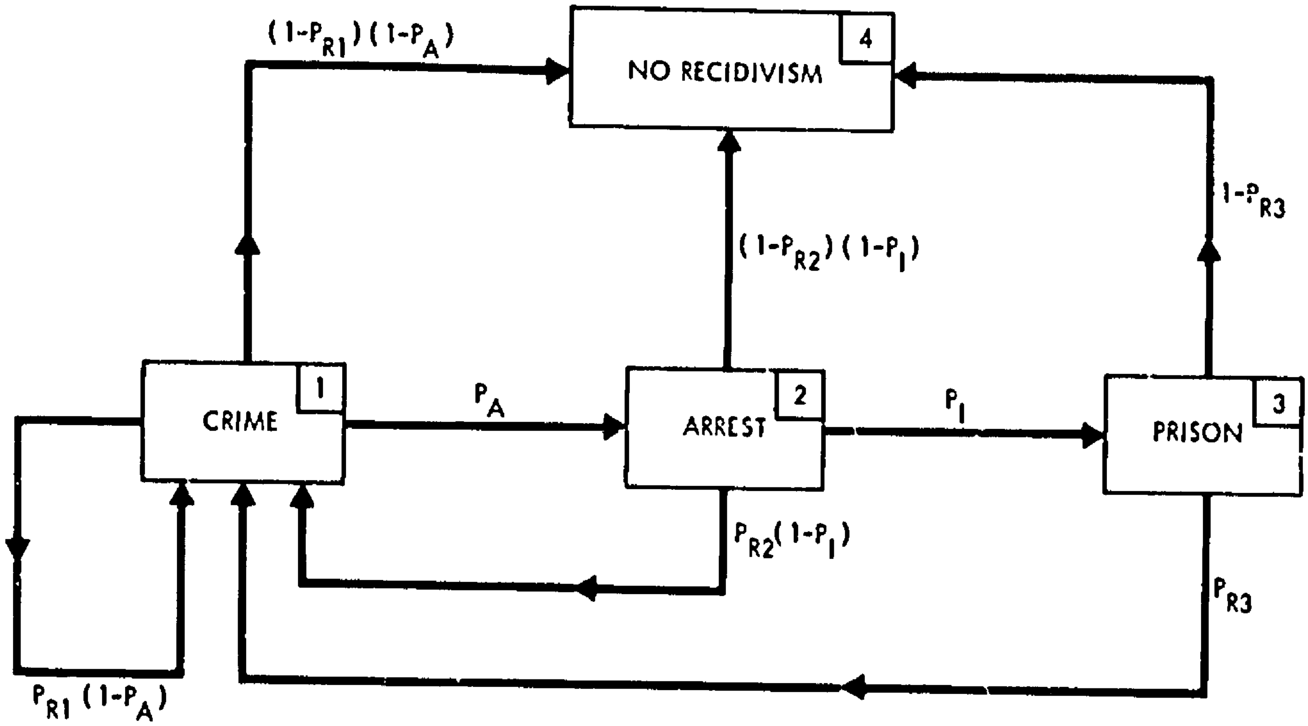
$$P(C/C) = P_{R1}\ (1-P_A) + P_A\ P_{R2}\ (1-P_I) + P_A\ P_I\ P_{R3} \qquad (1)$$

---

*Most estimates of recidivism probabilities based upon present CJS records tend to underestimate their actual values by any definition. This occurs because all records are incomplete and therefore do not record some of the recidivism that does occur. Records within a jurisdiction fail to include all arrests outside that jurisdiction. Central records kept in a large jurisdiction (say, a state or federal agency) fail to include arrests for minor offenses and for offenses perhaps not reported to the central agency.

**In fact, we could define even more types of recidivism, such as $P(C/A)$, which is the probability that an offender commits at least one more crime given that he has just been arrested, and $P(C/I)$, which is the probability that an offender commits at least one more crime, given that he has just been incarcerated.

***We use the theory of discrete Markov chains. See J.G. Kemeny, and J.L. Snell, Finite Markov Chains, Van Nostrand, New York, 1960.



STATE 1: THE OFFENDER HAS JUST COMMITTED A CRIME.
STATE 2: THE OFFENDER HAS JUST BEEN ARRESTED.
STATE 3: THE OFFENDER HAS JUST BEEN INCARCERATED.
STATE 4: THE OFFENDER COMMITS NO MORE CRIMES (A TRAPPING STATE).

[a]The directed branches are labeled with the conditional probabilities of going from each state to the immediately following state.

FIGURE E-1. Simplified Recidivism Model[a]

$$P(A/A) = \frac{P_{R2}\ P_A\ (1-P_I) + P_{R3}\ P_A\ P_I}{1 - (1-P_A)\ P_{R1}} \tag{2}$$

$$P(I/I) = \frac{P_{R3}\ P_A\ P_I}{1 - (1-P_A)\ P_{R1} - P_A\ (1-P_I)\ P_{R2}} \tag{3}$$

To indicate how greatly these quantities can differ, assume that:*

*This simplifying assumption implies that the offender's future criminal behavior is not affected by where he interacts with the CJS.

$$P = P_{R1} = P_{R2} = P_{R3}$$

and that;*

$$P_A = P_I = 1/4$$

then,

$$P(C/C) = P \tag{4}$$

$$P(A/A) = \frac{P}{4 - 3P} \tag{5}$$

$$P(I/I) = \frac{P}{16 - 15P} \tag{6}$$

Equations (4), (5), and (6) are plotted in Fig. E-2. Note, for instance, that the probability of crime repetition P can be as high as 0.90, yet the probability of rearrest is approximately 0.69 and the probability of re-incarceration is only approximately 0.36. Thus, an apparently favorable reincarceration rate of 0.36 is completely consistent with a rearrest rate of 0.69 or a crime repetition rate as high as 0.90.

Using this same model we can compute the average number of career crimes, arrests, and incarcerations.

$\bar{n}_{C/C}$ = Mean number of crimes committed in criminal career/at least one crime is committed

$\bar{n}_{A/C}$ = Mean number of arrests in criminal career/at least one crime is committed

$\bar{n}_{I/C}$ = Mean number of incarcerations in criminal career/at least one crime is committed

---

*For the crimes of burglary, larceny, and auto theft in the state of California, the approximation that $P_A = 1/4$ is very close to the actual figures ($N_{a/c}(4) = 0.23$ for burglary, $N_{a/c}(5) = 0.28$ for larceny, $N_{a/c}(6) = 0.30$ for auto theft, and the conditional incarceration probability is much less than 1/4. Thus, we are overestimating incarceration probability and understanding discrepancies between re-incarceration definitions of recidivism and other definitions.

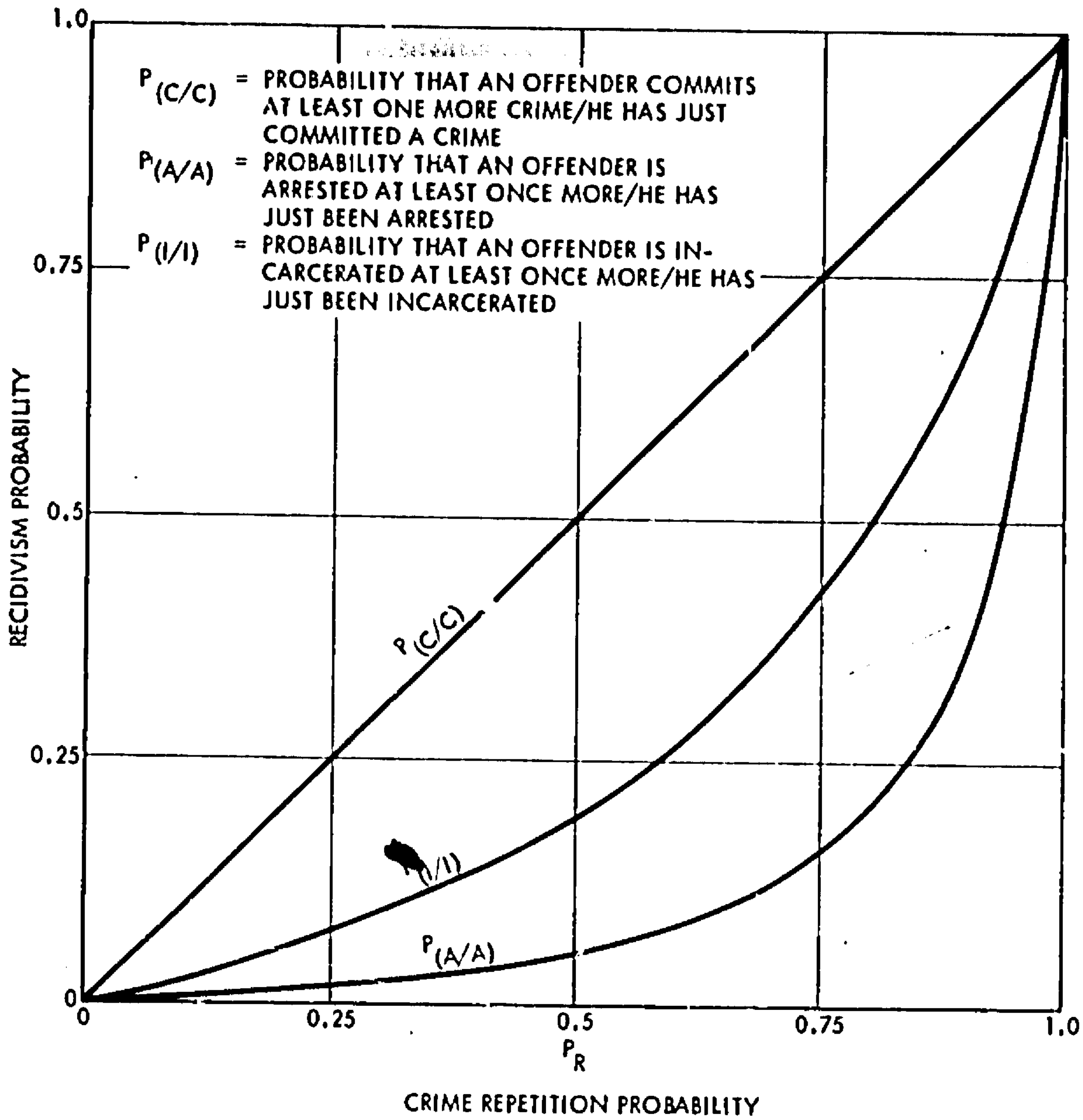


FIGURE E-2. A Plot of Three Different Recidivism Probabilities Versus the Crime Repetition Probability

It is straightforward to show, with our simplified model, and using the data values assumed above, that:

$$\bar{n}_{C/C} = \frac{1}{1 - P}$$

$$\bar{n}_{A/C} = \frac{1/4}{1 - P}$$

$$\bar{n}_{I/C} = \frac{1/16}{1 - P}$$

First, comparisons of $\bar{n}_{A/C}$ and $\bar{n}_{I/C}$ with $\bar{n}_{C/C}$ are intuitively reasonable; on the average, there is one arrest for every four crimes committed and one incarceration for every 16 crimes committed. Second, we note how sensitive $\bar{n}_{C/C}$, the mean number of career crimes committed, is to P for values of P between 0.75 and 1.0. For instance, a change of P from 0.9 to 0.8 (a reduction of 11 percent) causes $\bar{n}_{C/C}$ to drop from 10 to 5 (a reduction of 50 percent). In practice, this means that a rehabilitation program that causes only a small but measurable reduction in recidivism probability could well have a substantial effect in reducing the total number of crimes committed by those participating in the program. The more complex feedback model, which includes effects of aging and crime-type switching, demonstrates this same property.

A complete description of the recidivism mechanism requires not only the values of the crime repetition probabilities (or the other proxies for it) but also an estimate of the time until recidivism occurs. This time is especially important in determining the duration of a criminal career and in relating recidivism of an individual to the overall crime rates.

To indicate this, consider the simplified model of Fig. E-1 for the case in which all $P_{Rk} = P$ for k = 1, 2, 3. Here, we found that the average number of crimes committed during the course of a criminal career is 1/(1-P). If the average time <u>between</u> crimes is T years, then the average time between the first and last crime (or the average length of a criminal career) is [1/(1-P)-1] T years. The average number of crimes committed per year during the course of the individual's criminal career is 1/T crimes per year;* this is the "contribution" of one crime-committing individual to the crime rate during a year.

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*The value of 1/T crimes per year excluded the first committed crime.

APPENDIX F

APPENDIX F

CONTENTS

APPENDIX F

PROGRAM CRIME--A VECTOR SIMULATION LANGUAGE FOR THE ADMINISTRATION OF JUSTICE SYSTEM

A. INTRODUCTION AND HISTORY

Program Crime was motivated by the need to model the adult felon administration of justice system. The original model was suggested by A. Blumstein and was modified and restructured by S. Johnson and R. Larson.

Early in June 1966, R. Larson specified the preliminary structure of the simulation language, including the five arithmetic subroutine calls, the three vector combination subroutine calls, and the general method of the associated bookkeeping procedures. This preliminary version of Program Crime, which was written and encoded by T. Ceili and J. Heineken, was in operation by the end of July.

During August and September, while production runs were being executed with the preliminary version, C. McBride modified most of the earlier routines in order to conserve storage and lessen the number of necessary subroutine calls. He also added the very important sensitivity analysis and feedback capabilities.

B. FUNCTIONS OF PROGRAM

Program Crime is a computerized implementation of the generic overall criminal justice system (CJS) model. The heart of the program is a set of subroutines that provides the user with a block diagramming language; i.e., there is a one-to-one correspondence between a block on a flow chart and a computer instruction. This capability makes it possible to revise the model or even change it completely with a minimum of effort and without interfering with the rest of the program.

Given a reported crime rate for a jurisdiction in a particular year, a set of policy-related probabilities, and a set of certain aggregated fixed and variable costs based on data for several previous years, the program will generate costs and flows for that year at each stage of the CJS.

The effect of changing various policies, flows, or costs can be measured by using the sensitivity analysis routines. In this way the critical points in the system can be quickly isolated. Incremental flows and other quantities can be computed for each additional person inserted into the system at a particular stage and charged with a particular crime.

The cost and flow breakdown and the sensitivity analysis program both operate on an "open-loop" structure, i.e., the input is the total reported crime rate and the offenders who "drop out" of the system who are subsequently rearrested are not specifically taken into account.

The closed-loop feedback model, on the other hand, is based on offenders (those arrested), not on crimes. The input is "new offenders" and, using probabilities of rearrest, a portion of these re-enter the system, contributing to the number of total offenders. A sensitivity analysis can be made on this closed-loop model to find, for example, those factors that would be most helpful in reducing recidivism.

"Career costs" can also be found by linking the closed-loop and open-loop models. One new offender of a particular age and initial crime type is injected into the feedback model. The resultant total number of arrests is then used to compute an input to the open-loop model, which then computes the various costs resulting from the single new offender.

C. THEORY

1. Overall System Model Assumptions

There are five basic assumptions inherent in the overall system model:

1. Offender flows and costs at various points in the system can be allocated by crime type.
2. Probabilities (also by crime type) can be assigned to describe the likelihood of various outcomes at the decision points in the system. A set of these probabilities at a particular decision point forms a "policy" at that point. These probabilities are also known as branching ratios.
3. Changing a policy at a particular decision point does not affect the policies at other decision points.
4. The model is "steady state" with respect to policies and costs. Once these policies and costs have been determined for a given year, they are assumed to be constant for other years.
5. The system is linear; i.e., all costs and flows are linearly related to the input crime rate.

2. <u>Techniques Used in Sensitivity Analysis</u>

The sensitivity analysis routines compute two types of "derivatives" that measure the response of the system to incremental changes in offender flows at various points in the system. By using these derivatives, one can find both the expected cost per offender and the percentage increase in the number of offenders inserted at any stage in the CJS. These derivatives are computed numerically with the computer, and thus we use ΔX to refer to the difference $X_2 - X_1 = \Delta X$. The computed numerical derivatives closely approximate the exact algebraic derivative when ΔX is small.

A description of these derivatives follows:

a. Numerical first derivative of an output vector with respect to a flow vector

Definition: Let C = a seven-component output vector
N = a seven-component flow vector

Then $\frac{\Delta C(i)}{\Delta N(i)}$ = numerical first derivative of the i^{th} component of C with respect to the i^{th} component of N

Interpretation: The first derivative can be interpreted as the expected incremental value of C_i given a unity increment of N_i. Since the system is linear, $C(i) = A(i) + b(i)\, N(i)$

Thus:

$$\frac{\Delta C(i)}{\Delta N(i)} = \frac{b(i)(N_2(i) - N_1(i))}{N_2(i) - N_1(i)} = b(i)$$

If C is some system cost, then b(i) is the incremental system cost per additional person inserted.

b. Elasticity of an output vector with respect to a flow vector

Definition: $\dfrac{\frac{\Delta C(i)}{C(i)}}{\frac{\Delta N(i)}{N(i)}}$ = numerical elasticity of the i^{th} component of C with respect to the i^{th} component of N

Interpretation: The elasticity can be interpreted in either of two ways. First, it can be the ratio of the percentage change in C_1 caused by a percentage change in N(i). It can also be interpreted as the fraction of C(i) that is linearly dependent on N(i) since

$$\frac{\frac{\Delta C(i)}{C(i)}}{\frac{\Delta N(i)}{N(i)}} = \frac{\frac{b(i)(N_2(i) - N_1(i))}{A(i) + bN_1(i)}}{\frac{N_2(i) - N_1(i)}{N_1(i)}} = \frac{b(i)N_1(i)}{A(i)+b(i)N_1(i)}$$

= fraction of C(i) that is linearly attributable to N(i).

D. OPERATING PROCEDURE

1. Data Requirements

a. Data Cards. The data deck contains three types of information: (1) the input crime rate for the jurisdiction under consideration; (2) cost, workload, and manpower data associated with the various subsystems; and (3) probabilities of various outcomes at a particular decision point in the system.

All data are given by crime type; there is a data entry for each of the seven index crime types for each item of data. Each data item can, therefore, be thought of as a row vector with seven components. Each data vector is identified by an alphanumeric code of from one to eight characters that in some sense is an abbreviation of the data name; e.g., "VCSTARS" could be the code name for "Variable Cost of Arrest."

In some cases, a data vector may contain more than one row; each row then refers to a particular attribute associated with the offender flow at some point in the system. For example, the data vector "PJL" (probability that an adult found guilty will be sentenced to a local jail) could have three rows associated with it, corresponding to (1) those adults who were found guilty in a jury trial, (2) those who pleaded guilty, and (3) those who were found guilty at a bench trial.

b. Comment Cards. In order to add to the readability of the computer printout, a deck of "comment cards" has been added to the data deck. For each output vector (e.g., flow, cost) that the program prints out, there is an associated explanatory comment.

2. Block Diagram Implementation

The program contains five subroutines that perform arithmetic operations on the various vector flows and costs. There are also three subroutines that are used to combine or separate the vectors according to various attributes. By using these eight routines it is possible to completely specify a system and to output all necessary information.

All cards punched in this block diagram simulation language have the standard FORTRAN instruction format; to call one of the subroutines one begins in column 7 with

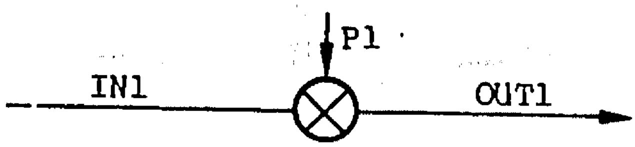
CALL (subroutine name) (ARG1, ARG2 ... ICODE)

The arguments of the subroutine are vector names, which are in the Hollerith format; i.e., the computer reads these arguments as eight or fewer characters. This requires the programmer to specify a character count before each vector name. The order of the arguments in each subroutine is normally input(s), output(s), and data. The last argument, ICODE, is an integer variable that controls the output print option.

A brief description of each of the eight block diagramming subroutines follows. Each of the first five subroutines described can be used with "vectorized" inputs, which are equivalent to matrix inputs. For simplicity, however, we have described each of these subroutines as having vector (not matrix) inputs and outputs.

a. Subroutine: GAIN

Block diagram example:



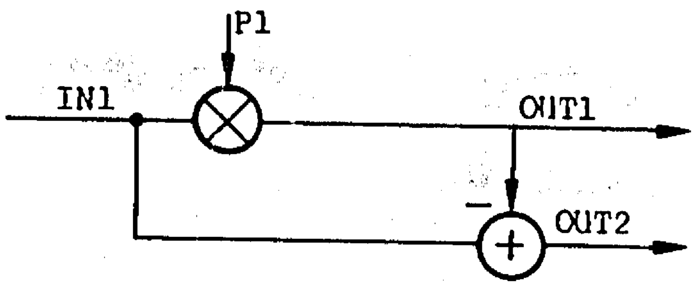
Calling instruction: CALL GAIN (3HIN1, 4HOUT1, 2HP1, ICODE)

Function: OUT1(i) = IN1(i) · P1(i)

OUT1 is a vector whose components are the products of the corresponding components of IN1 and P1. That is, GAIN takes two input vectors and performs element-by-element multiplication to obtain the output vector.

b. Subroutine: GAINDF

Block diagram example:

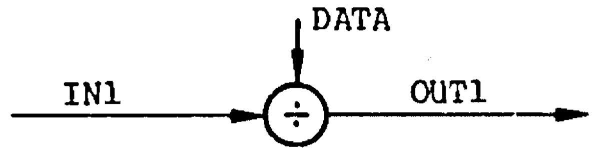


Calling instruction: CALL GAINDF (3HIN1, 4HOUT1, 4HOUT2, 2HP1, ICODE)

Function: OUT1(i) = IN1(i) · P1(i); OUT2 = IN1(i) · (1-P1(i)) In the context of the overall system model, OUT1 would be the portion of the input offenders (IN1) that continue on to the next stage of the system; OUT2 would represent those felons who were "dropped out" (released, given a suspended sentence, and so on) of the system at that point.

c. Subroutine: <u>VECDIV</u>

Block diagram example:

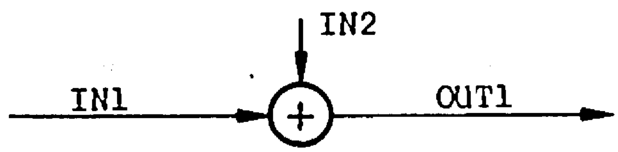


Calling instruction: CALL VECDIV (3HIN1, 4HOUT1, 4HDATA, ICODE)

Function: OUT1(i) = IN1(i)/DATA(i). OUT1 is usually a ratio, i.e., cost per offender, number of judges per jury trial, and so on.

d. Subroutine: <u>VECTAD</u>

Block diagram example:

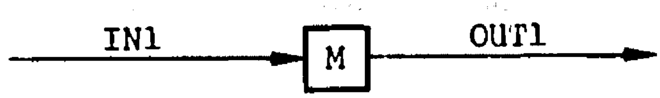


Call instructions: CALL VECTAD (3HIN1, 3HIN2, 4HOUT1, ICODE)

Function: OUT1(i) = IN1(i) + IN2(i)
Used for aggregating system costs and flows at various points.

e. Subroutine: <u>MATRIX</u>

Block diagram example:

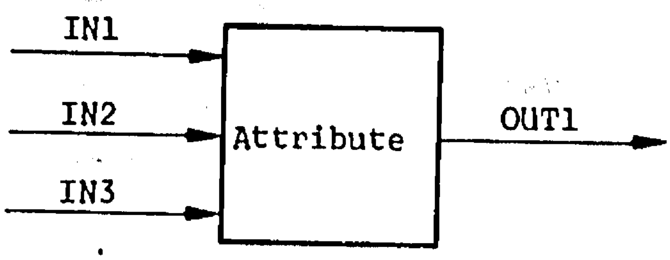


Calling instruction: CALL MATRIX (3HIN1, 4HOUT1, 1HM, ICODE)

Function: Performs matrix multiplication in the usual sense. For instance, if IN1 is a 7-component row vector, M is a 7x7 transition probability matrix, then OUT1 is the 7 component output vector resulting from the matrix multiplication IN1 · M.

f. Subroutine: VECTOR

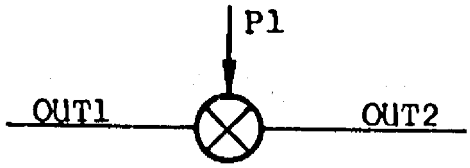
Block diagram example:



Calling sequence:

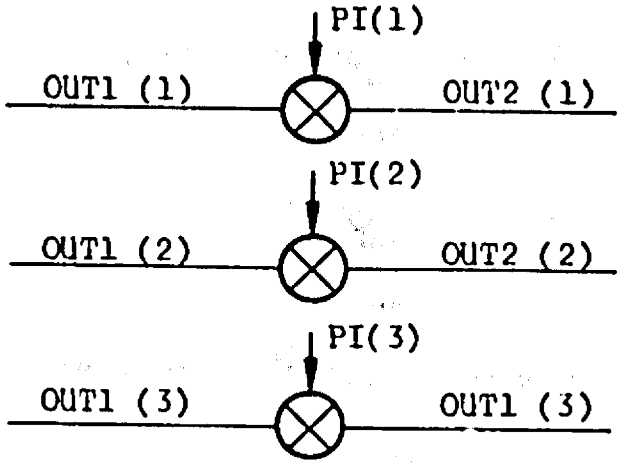
```
MANNAM (1) = 3HIN1
MANNAM (2) = 3HIN2
MANNAM (3) = 3HIN3
CALL VECTOR (3, 4HOUT1, ICODE)
```

Function: Subroutine VECTOR operates on a set of vector flows that have been partitioned according to some attribute; for example, IN1, IN2, IN3, could be, respectively, felons found guilty in a jury trial, felons who pleaded guilty, and felons who were found guilty in a bench trial. These three vectors were computed by partitioning the total number of felons found guilty at the trial stage according to trial type. By calling VECTOR, one can refer to all three components by just one name (in the case of the preceding example, this name would be OUT1). If we carry this example one step further, the advantages of using VECTOR become more apparent. Suppose OUT1 is now passed through a GAIN in the following manner:



All entries (3x7) matrices

(A)



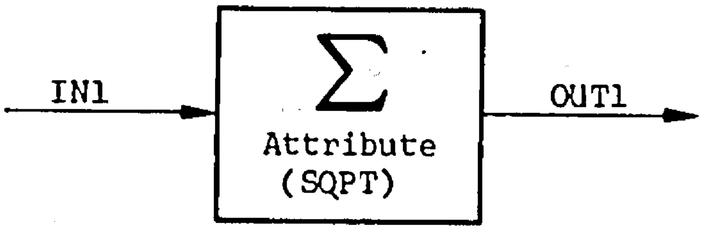
All entries (1x7) vectors

(B)

Without VECTOR, one would have to write a call to subroutine GAIN for each component of OUT1 (as in (B) above) and give separate names to each of the three rows of PI (a 3x7 matrix). VECTOR allows one to implement this particular block with only one instruction (as in (A) above).

g. Subroutine: <u>SQULCH</u>

Block diagram symbol:



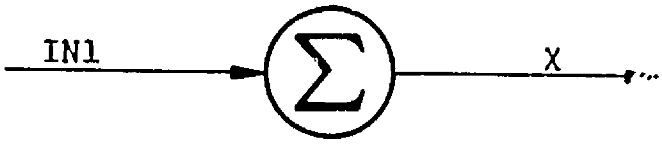
Call instruction: CALL SQULCH (3HIN1, 4HOUT1, 4HSQPT, ICODE)

SQPT is the code name for the output of the VECTOR operation that is to be nullified.

Function: SQULCH can be thought of as the inverse of VECTOR; SQULCH collects the components of a VECTOR-ized flow and sums them into a vector with a single row. In the example given above, if IN1 had three rows (each having seven components), OUT1 would have a single row whose components were the sum of the three input components.

k. Subroutine: CRIMSUM

Block diagram symbol:



Call instruction: CALL CRIMSUM (3HIN1, X, ICODE)

Function: X is a scalar equal to the sum of the components in IN1.

To illustrate the use of these eight subroutines, a section of a system model* (shown in Fig. F-1) was programmed and is given below:

(1) CALL MATRIX (4HNMAL, 6HNMJLPR, 3HMAT, ICODE)

(2) MANNAM (1) = 6HNMJLPR

(3) MANNAM (2) = 4HNMPR

(4) CALL VECTOR (2, 5HNMPRC, ICODE)

(5) CALL GAIN (5HNMPRC, 3HDUM, 4HTPRC, 0)

(6) CALL GAIN (3HDUM, 3HDUM, 6HVCSTPR, 0)

(7) CALL VECTAD (3HDUM, 6HFCSTPR, 7HTCSTPRC, ICODE)

(8) CALL VECDIV (7HTCSTPRC, 5HNMPRC, 8HTCSTPPRC, ICODE)

(9) CALL SQULCH (7HTCSTPRC, 6HTCSTPR, 5HNMPRC, ICODE)

(10) CALL VECTAD (6HTCSTPR, 8HTCSTTSJL, 7HTCSTTPR, ICODE)

(11) CALL CRIMSUM (7HTCSTTPR, X, ICODE)

(12) CALL GAINDF (5HNMPRC, 7HNMPRVIC, 7HNMSUCPC, 7HPNSUCPC, ICODE)

NOTES:

Line 1: The putput argument ICODE is used when the results of an operation should be printed. All twelve instructions would actually be part of a higher level subroutine called RUN. One of the inputs to RUN is ICODE; if ICODE is zero, nothing is printed; if ICODE is one, all calls to the eight block diagramming subroutines whose last argument is "ICODE" generate printed output.

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*This is not a portion of the overall system model and is given only to indicate how to implement the subroutine calls.

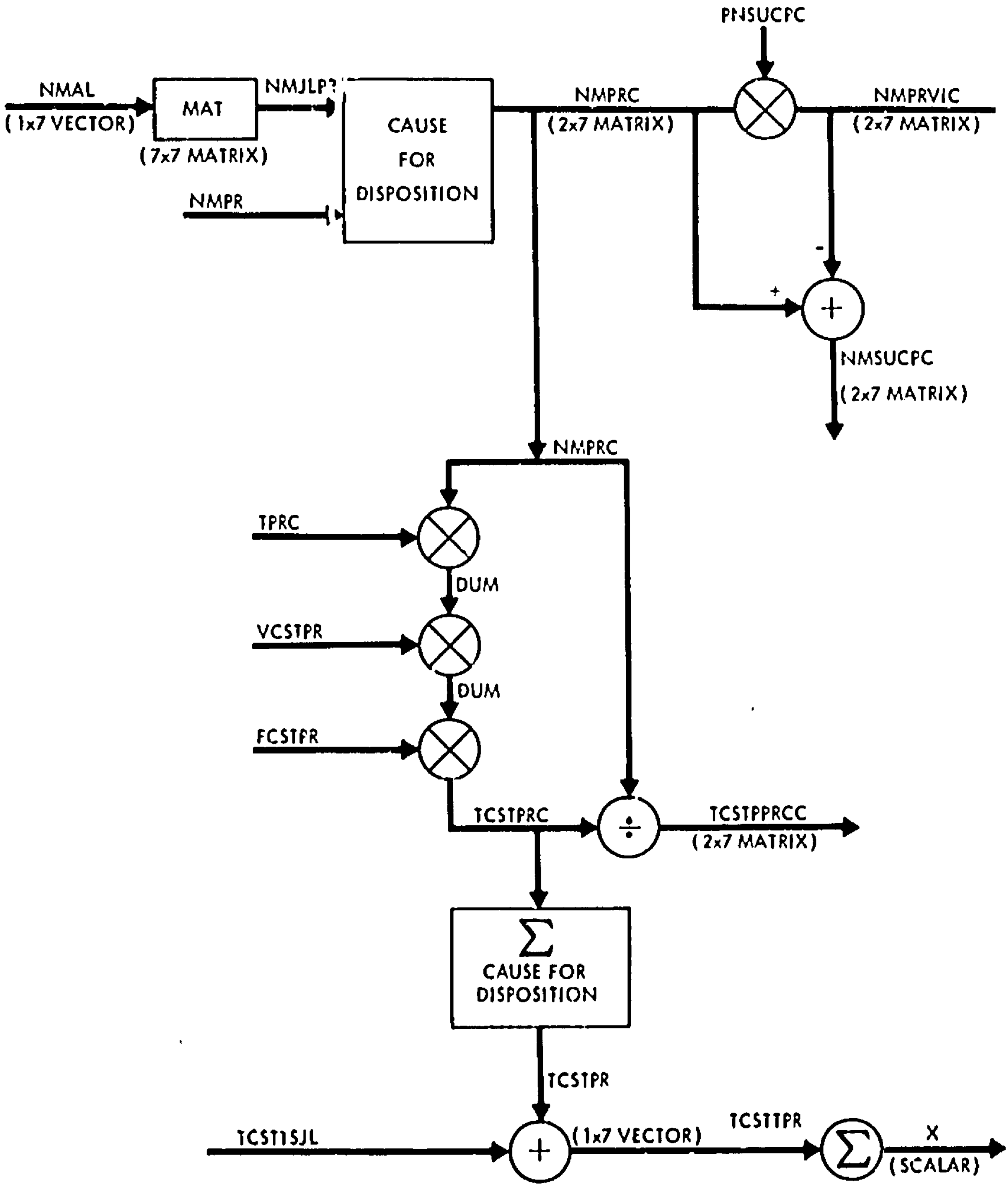

FIGURE F-1. Example of Block Diagrammed System

Line 5: Here the output argument is set equal to zero within the call; thus "DUM" cannot ever be printed.

Line 6: Here "DUM" is used as both an input and an output; the program uses the input "DUM" to calculate the output "DUM," erases the input and then stores the output in the same place. This technique conserves storage, of course, but care should be taken not to erase information that will be needed later in the program.

3. Sensitivity Program Procedures

The sensitivity analysis program uses subroutine RUN (described in the previous section), as well as six other high-order subroutines described below.

A block diagram of the sensitivity analysis system is shown in Fig. F-2. The functions of the various routines are given below.

a. Main Program:
   (1) Reads data and comment cards
   (2) Calls subroutine RUN with ICODE = 1. Thus all important flows and costs are printed.
   (3) Stores information necessary to perform each sensitivity analysis.
   (4) Calls subroutine DERIV

b. Subroutine DERIV:

This subroutine calls six other subroutines that carry out the various stages of the sensitivity analysis. The functions of each routine are listed in order to give the user an idea of the possibilities of the sensitivity analysis; it is not necessary for the programmer to use these routines directly, though DERIV calls the subroutines listed below in order given and goes through this same sequence for each data vector in PNAM.

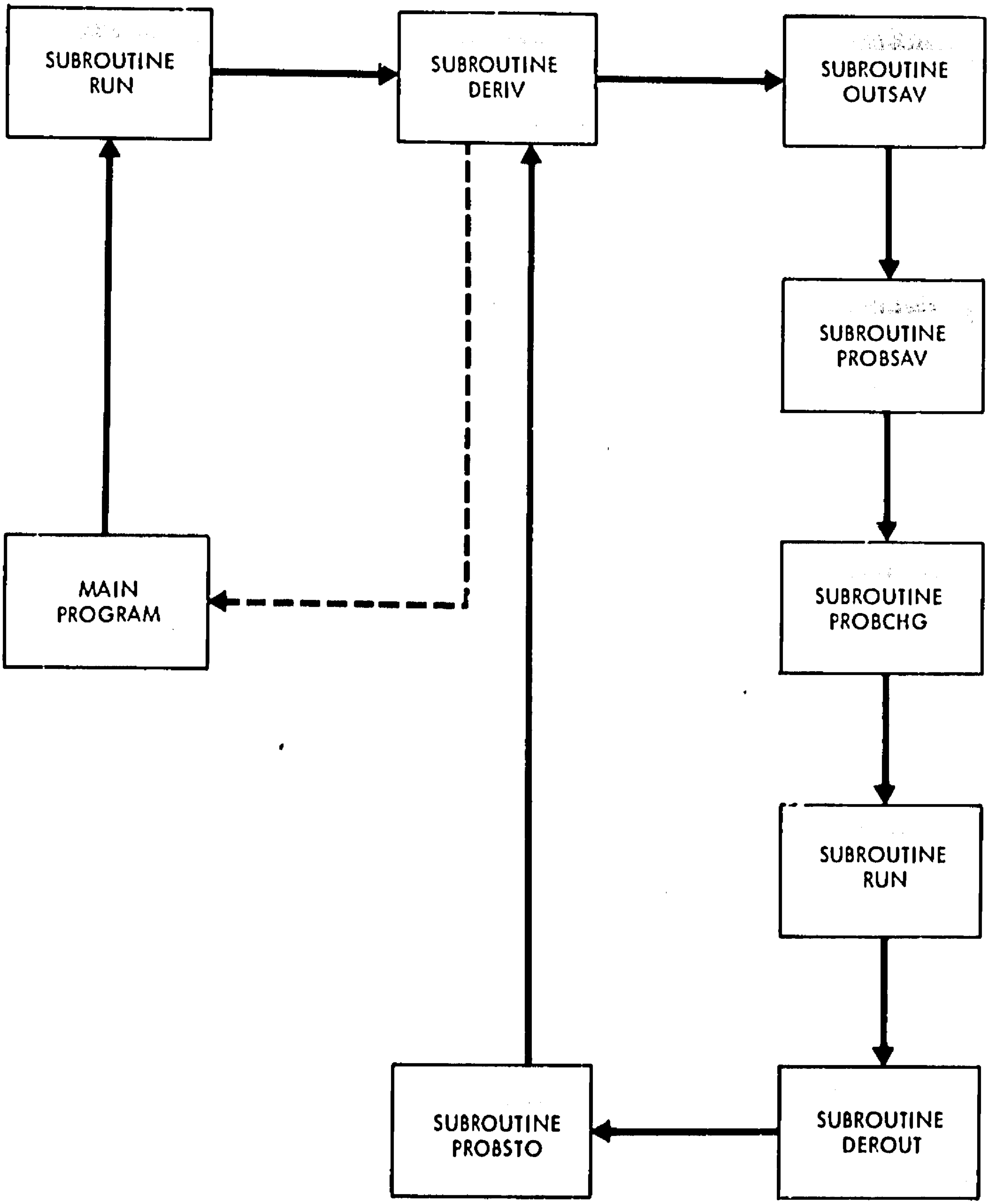

FIGURE F-2. Block Diagram of Sensitivity Analysis Routines

(1) Subroutine: OUTSAV

Function: Saves all outputs from the first execution of subroutine RUN listed in ONAM and CSTNAM

(2) Subroutine: PROBSAV

Function: Saves the data contained in one of the PNAM's

(3) Subroutine: PROBCHG

Function: Increments all components of one of the data names in PNAM and places these new data in the same location as the old data

(4) Subroutine: RUN

Function: Recalculates all outputs using new data, but does not print these outputs

(5) Subroutine: DEROUT

Function: Computes changes in all outputs in ONAM and CSTNAM, and then computes and prints derivations of these outputs with respect to the flow associated with the current PNAM

(6) Subroutine: PROBSTO

Function: Restores the original data in PNAM to its proper location

The analysis is usually performed at a "decision point" in the system. An example of such a situation is given in Fig. F-3.

It might be desirable to see how changing one of the flow vectors OUT1, OUT2, or OUT3 by a given amount influenced the vectors OUT4 and OUT5.

In writing the main program to perform this analysis, one would first load an array called ONAM with the code names of the various outputs of interest. The number of such outputs is stored in NMOUT.

The code names of the data vectors that will be changed in order to increment various flows are stored in PNAM, NMPB is the number of data vectors in PNAM. NNAM is the code name of the flow vector that is the input to the decision point.

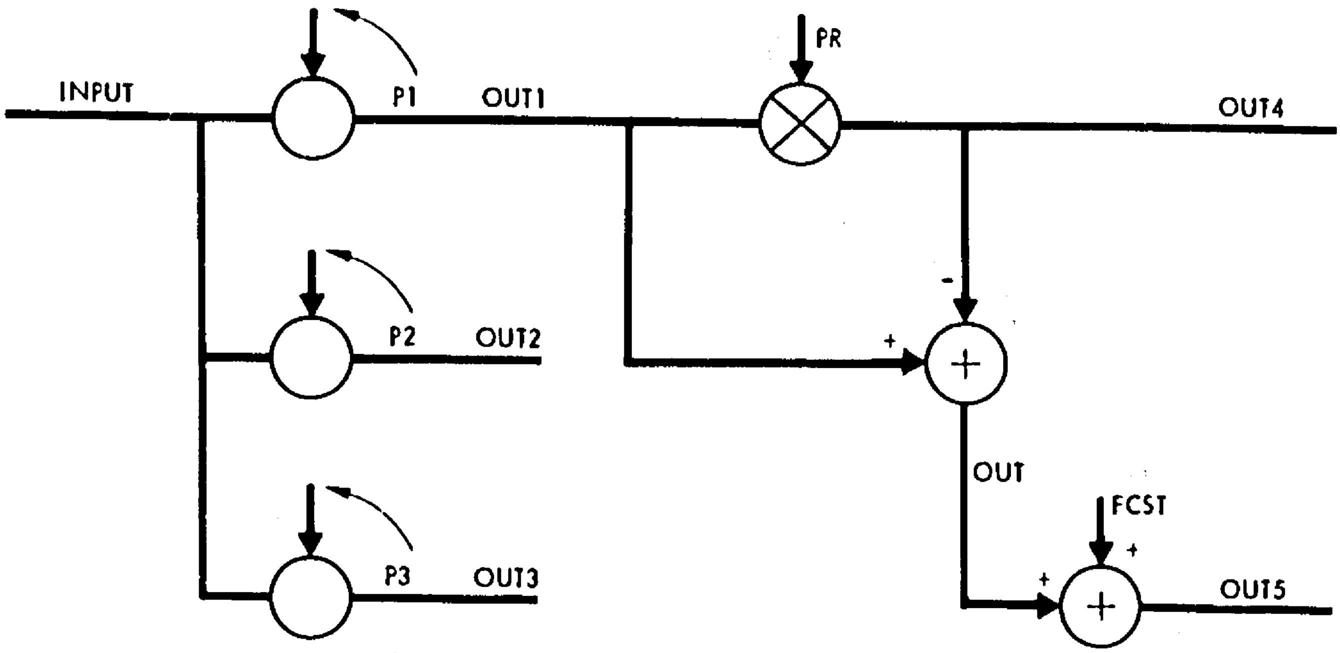

FIGURE F-3. Example of Analysis at Given Decision Point

The section of a main program necessary to perform a sensitivity analysis on the previously mentioned example is given below for illustration:

```
PNAM (1) = 2HP1
PNAM (2) = 2HP2
PNAM (3) = 2HP3
    NNAM = 5HINPUT
    NMPB = 3
ONAM (1) = 4HOUT4
ONAM (2) = 4HOUT5
   NMOUT = 2
CALL DERIV
```

E. FEEDBACK MODEL

The closed-loop feedback model was devised in order to study the effects of policy changes in the criminal justice system on recidivism. Since the probability that a felon who is released from a particular stage of the system will subsequently commit another felony is strongly age dependent, the feedback model includes age as well as crime type as an independent variable.

A highly simplified block diagram of the feedback model is shown below in Fig. F-4.

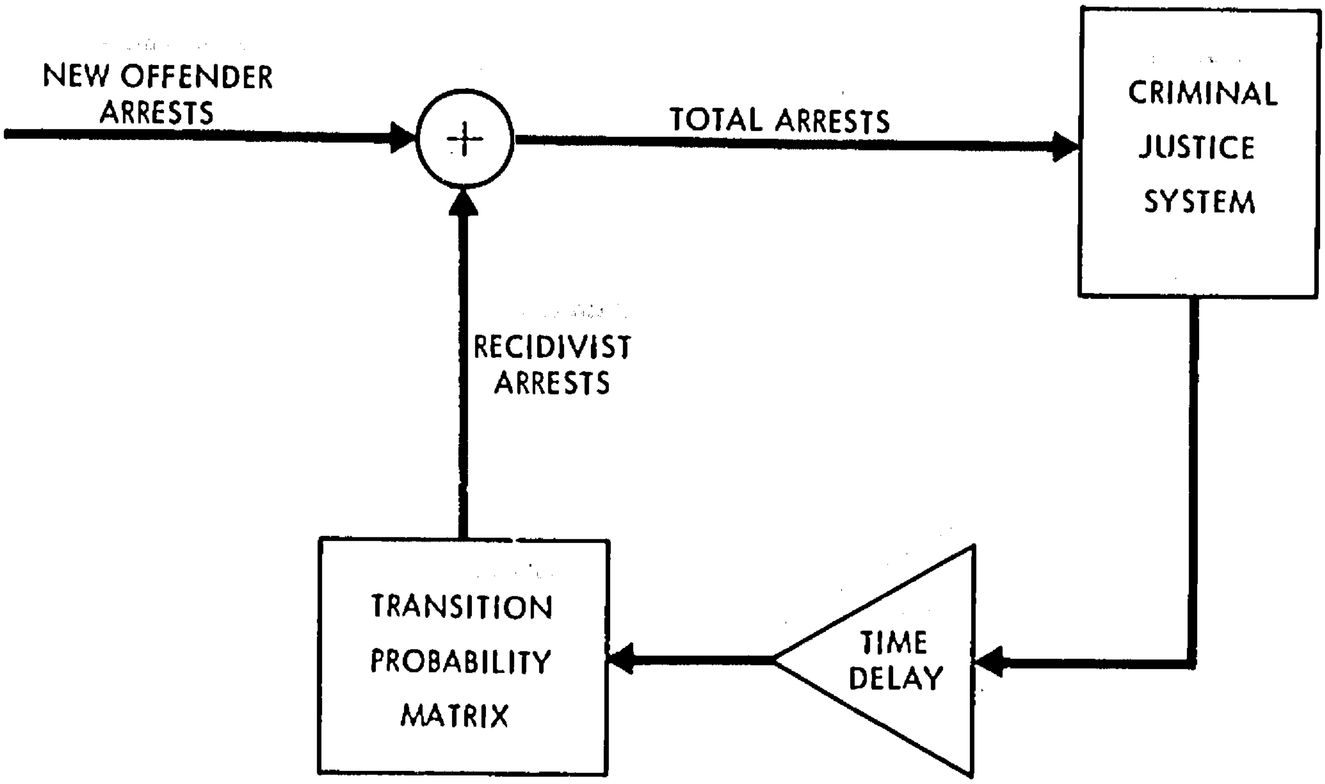

FIGURE F-4. Simplified Block Diagram of Feedback Model

The input to the feedback model is new offender arrests. After passing through the criminal justice system, an offender may later be arrested for another felony (not necessarily the same felony crime type that he committed the first time); he then becomes a recidivist. The recidivist arrests for a given year are added to the new offender arrests to give a total number of arrests for that year.

The programming of the feedback model was not general purpose, as was that of the linear model, and it will not be further developed here.

F. BRIEF DESCRIPTION OF PROGRAMMING TECHNIQUES USED IN THE VARIOUS SUBROUTINES

Program Crime uses about 35 subroutines to perform its various functions. Most of these routines have been discussed in other sections of the program, but a set of 13 subroutines have not been mentioned previously. These routines perform the vital functions of reading the data into the computer, storing intermediate calculations, locating these intermediate calculations, erasing "dead" storage, and printing useful outputs.

All of these routines take advantage of a novel bookkeeping procedure. Each information "vector" has an associated eight-character Hollerith code name (some of these characters can be blank, of course). These names are stored in a table called NAMTAB, which has room for 300 names. The actual data associated with each are assigned a location in a 7x192 array called MASTER; i.e., MASTER has room for 192 columns of 7 components each. MASTER can thus contain 192 information vectors (if the vectors contain only one row).

This relatively small amount of storage would be exceeded by even a moderately large block-diagrammed system if a method of fixed storage allocation were used. It is, therefore, necessary to use some form of dynamic storage allocation.

The program keeps track of the columns in MASTER that are currently occupied by means of a 192-bit (4 computer words) array called COLCOL. When information is stored in one of MASTER's 192 columns, the appropriate bit(s) in COLCOL is (are) set to one; when information is erased in MASTER, the bit(s) in COLCOL is (are) set to zero. Thus, the program can locate empty columns in MASTER by interrogating COLCOL until a zero bit is found.

For each line (code name) in NAMTAB, there exists an array of 192 bits called COLS which indicates where in MASTER the information associated with the particular name is to be found. For example, if "NMADAR" is stored on line 50 of NAMTAB, and the information associated with NMADAR is stored in columns 7 and 13 of MASTER, then line 50 of COLS would contain 1's in bits 7 and 13 and 0's everywhere else.

A description of the 13 "bookkeeping" subroutines follows:

1. Subroutine: DATARD

   Function: Reads the data deck in the following manner:

   a. Reads a data code name
   b. Reads a number that tells how many rows the data vector contains
   c. Reads the actual numbers to be stored in MASTER into an array called OUT1
   d. Calls subroutine STORDF (explained below)
   e. Continues steps 1-4 until a blank data code name is found. At this time, control is returned to the main program.

2. Subroutine: READCOM

   Function: Reads the comment deck as described:

   a. Reads an output code name into an array called NAMCOM
   b. Reads the rest of the card as Hollerith information, stores it in array called NAMCM
   c. Continues steps 1-2 until a blank code name is found. Control is then returned to the main program.

3. Subroutine: GETNAM

   Function: Given an input code name, GETNAM searches NAMTAB until the correct name is found; the line number in NAMTAB is returned as an output. If the name is not found, a comment is printed that indicates that the given name was not in NAMTAB.

4. Subroutine: GETDFN

   Function: Used with subroutine STORSM. If the input code name is not found, no comment is printed, but an output variable is set to record this fact.

5. Subroutine: BLANCL

Function: Examines the bits in COLCOL, from left to right, until a zero bit is found. The number of this bit is returned as an output. This bit in COLCOL is set equal to 1, as is the corresponding bit in COLS. If no zero bits are found, a comment is printed that says that COLCOL is full.

6. Subroutine: STORDF

Function: Used with DATARD. Stores a data name in NAMTAB, stores the data in OUT1 in blank columns in MASTER (located by BLANCL).

7. Subroutine: EXTRAT

Function: For a particular line (name) in NAMTAB, EXTRAT interrogates the corresponding line in COLS and returns column numbers in MASTER that contain the required data as well as the total number of columns used.

8. Subroutine: STORSM

Function: Used by all block-diagramming subroutines to store intermediate outputs. STORSM determines whether the output name has been used by calling GETDFN. If the name has been used, subroutine UNSET is called and the information loaded into OUT1 by the block-diagramming routine is stored in empty columns in MASTER. If the name is not found in NAMTAB, subroutine STORDF is called.

9. Subroutine: UNSET

Function: Used by STORSM. UNSET gives the program the capability to use a name as an output and an input without destroying any necessary information. This technique, of course, saves storage. UNSET sets the bits in COLCOL and COLS for the previous use of the output name to zero. This frees one or more columns in MASTER.

10. Subroutine INPUT

Function: Used by the block-diagramming routines to store information from MASTER in a temporary array. Subroutine INPUT loads an array called XINPUT with all information associated with a particular code name.

11. Subroutine: GETDAT

Function: Same function as subroutine INPUT. Loads data from MASTER into temporary array called D.

12. Subroutine: OUTNAM

Function: Takes an output name from a block-diagramming routine, locates the name in NAMTAB, locates the comment associated with that name by calling GETCOM, and locates the appropriate data in MASTER. Prints the code name, the comment, and the data.

13. Subroutine: GETCOM

Function: Used by OUTNAM. Looks for the given output name in NAMCOM; if the name is found, the comment information is loaded into NCOM for use by OUTNAM; if the name is not found, NCOM is located with blanks, and control is transferred to OUTNAM.

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