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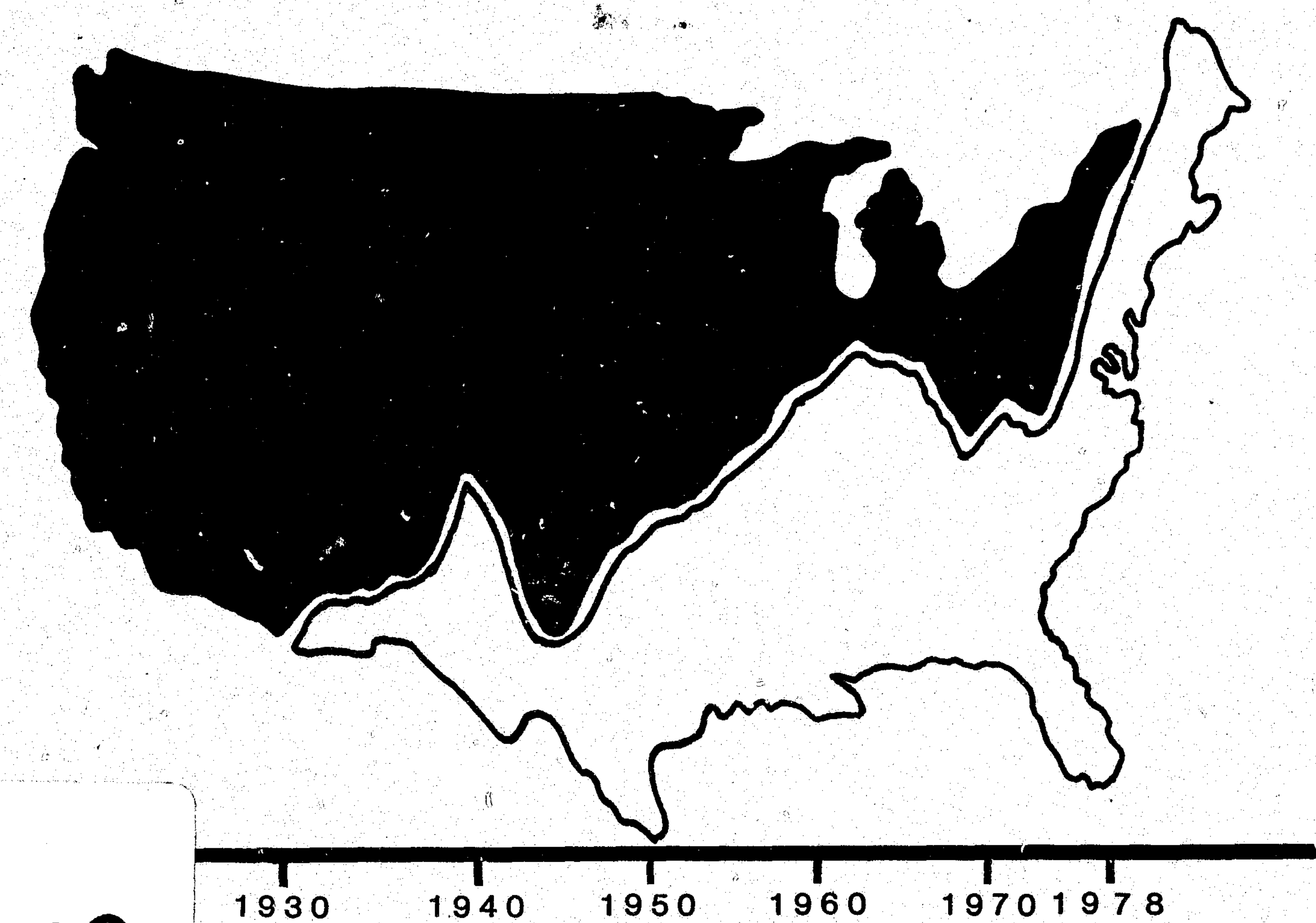
PRISON POPULATION PROJECTION METHODS



STATE PRISON POPULATION GROWTH

82373

ILLINOIS DEPARTMENT OF CORRECTIONS

VOLUME I October, 1981

ILLINOIS DEPARTMENT OF CORRECTIONS

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PRISON POPULATION PROJECTIONS

A Review of Methods Used by State Correctional Agencies

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PREFACE

This report is based on a survey conducted of all State Departments of Corrections on their prison population projection methods. It represents information gathered early in 1981. Funding for this report by the Illinois Department of Corrections, Bureau of Policy Development/Research, was provided by the Illinois Law Enforcement Commission. Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position or policies of I.L.E.C.

ACKNOWLEDGEMENTS

This report would not have been possible without the exceptional cooperation of the Departments of Corrections all over the United States and Canada. In several cases, these Departments took extensive time and effort to provide us with written documentation of their projection methods although no documentation had existed before.

Data for experimentation with some of the methods was provided by several sources and we wish to thank them all:

Mr. George Erhart, of the Bureau of Labor Statistics, U.S. Department of Labor, provided us with data on unemployment in Illinois and provided with it invaluable information about its limitations.

Mr. Anthony E. Valaika, of the Administrative Office of the Illinois Courts, supplied court data and discussed with us some of the issues involved in relying on them.

Mr. Lynn Thorkildson, also from the Administrative Office of the Illinois Courts, gave us data on probation populations in Illinois.

Mr. William V. Kauffman, Jr., from the Prisoner Review Board, helped us get and understand parole statistics.

Past and projected information on Illinois population was provided by Dr. Cheng H. Ciang of the Illinois Bureau of the Budget.

Mr. David Dunning, of the Illinois Department of Law Enforcement, helped us understand Illinois arrest data.

Mr. Don Lowder, of the Illinois Department of Public Aid, provided several tables of persons receiving public aid.

Possible use of social indicators for projecting prison populations was discussed with several members of the National Opinion Research Center of the University of Chicago.

Our special thanks are given to the Illinois Law Enforcement Commission (I.L.E.C.) for the help in several important areas. Mr. J. David Coldren, Director of the Criminal Justice Information System, gave us access to Illinois arrest data and to the computer facilities of the Commission. Dr. Carolyn Rebecca Block gave valuable advice on projection methodologies and helped us in checking for seasonality of correctional data in Illinois. Mr. Larry Dykstra helped us run several programs on the I.L.E.C. computer and helped extract information from Illinois arrest data. Mr. Douglas Hudson provided valuable advice in running the two segment line linear regression on Illinois data.

Dr. Lorraine T. Fowler, of the Department of Sociology, Oklahoma State University, served as a technical consultant and attended the various project meetings. She reviewed several drafts of the report and her valuable comments have improved the final product.

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Several individuals within the Department of Corrections helped in the collection of data. J. William Gilbert supervised the collection of historical data of the Illinois Prison System. Beverly Adler helped in the collection of data, coded most of the information, and computerized it. Without their enthusiastic help, data collection would not have been possible within our time limitations.

The Information Services Unit did most of the programming for the simulation effort mentioned in this report. Staff who were involved in the programming included: Terry Powell, Willard Wietfeldt, Linda Brown, Roger Mollett, and Rich Keefner.

A special thanks to the following individuals: the cover design by Ann Kozeliski of the Corrections Training Academy; support staff from the Department's Word Processing Center for the various figures and tables done by Marcha Smith, and special thanks to Betty Rotherham for the many, many typings and revisions of this document; printing of this document was performed by George Curry of the Corrections Training Academy; proofreading by Lorraine Reynolds; and proofreading and coordinating the production of this report by Regina Cain.

PRISON POPULATION PROJECTIONS

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I. INTRODUCTION

Early in 1981, the Illinois Department of Corrections, Bureau of Policy Development, received a Management Systems, Research and Procedures Assistance Grant from the Illinois Law Enforcement Commission*. The focus of this grant was twofold: design and validation of prison classification instruments and improvement in the Department's prison population projection methods.

This report, one of two being prepared on prison population projections, is aimed at improving IDOC's knowledge of current projection techniques used by various state correctional agencies. It is primarily based on responses to requests from other states regarding population projection methods currently used, with additional input based on our own experience. Material from the growing literature on prison population projection methods is also included in the discussion.

As part of this information gathering effort, the project research staff requested Directors of Corrections in states throughout the nation to supply information on the projection techniques used by their departments. The response has been magnificent. To date, we have received replies from 45 states, Washington, D.C., Puerto Rico, the Federal Bureau of Prisons, Guam, and Canada.

The requests included the following questions:

1. What method(s) have you used? (It would be most helpful if the details were sufficient to allow us to replicate your method on our population.)

2. What are the projections for your prison population in the near and distant future? (Even if you do not have formal projection methods, your estimates of prison population changes are useful.)

3. How accurate have past projections been? (Both the difference between the actual and projected population and the lag between projection being made and projected to date are of interest.)

4. Who used your projections? (Did the projections help the state legislature decide on your appropriation? Were the projections used internally to plan staff and resource allocation?)

The responses to the first question were generally quite specific. However, this was not always universal since several states do not have detailed written accounts of their methods. With the increasing sophistication of techniques, short descriptions leave many unanswered questions. Some of the more detailed accounts are written for internal consumption and assume that the reader has considerable knowledge of the workings of the particular system.

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*ILEC Grant No. 3890: Management Systems, Research and Procedures Assistance, February 1, 1981 - September 30, 1981.

Appendix I provides a summary description of the methods used by each responding jurisdiction.*

This survey of projection techniques is not the first one conducted in the United States. At least two surveys have been previously conducted by other states. The Florida Department of Offender Rehabilitation conducted a similar survey in 1977, and the Kentucky Department of Justice completed another one in 1980. A comparison between these two surveys indicates several changes between 1977 and 1980. Our survey shows that still more changes have occurred since the 1980 Kentucky survey. These will be discussed in Appendix II.

Responses to the second question were very specific. Almost all jurisdictions supplied us with their most recent projections of anticipated prison population, for the near and distant future. Not all jurisdictions, however, make projections on an annual basis.

The responses to the last two questions were less specific. Determining accuracy on the basis of published reports is not an easy task. Prison projections are based on certain assumptions concerning future developments. As the system moves toward the target date of the projection, one is able to judge the accuracy of these assumptions and adjust projections accordingly, narrowing the degree of uncertainty.

Subsequent reports do not always distinguish between the original projection and later adjustments. This fact renders any efforts at error measurement highly suspect. In addition, while a department may use one particular method today, it may also have accurate data on other methods utilized in previous years also. Several jurisdictions, however, have no data at all, due to a lack of long term experience with projections. Judging accuracy is also very subjective. While some departments seem to be satisfied with approximate projections, others require a much higher degree of accuracy. Appendix III looks at the accuracy of the method used where the data are provided by a state.

With respect to the last question, the majority of respondents indicated that projections have been used by departments and legislatures. However, most were not sure about the specific impact of the projections, especially with regard to appropriations by the legislature.

*If the present report indicates that we have misunderstood the techniques in some of the states, we would very much appreciate their comments so corrections could be made in any future publication.

II. THE OBJECTIVES OF PRISON PROJECTIONS

Forecasting future trends is one of the more difficult tasks confronted by analysts and administrators. Difficulties may arise due to a lack of sufficient data, a lack of long term experience with projection techniques, or the need to rely on forecasts from other fields (see Chapter III, The Logic Behind Projections). Despite these difficulties, almost all states are engaged in making some form of prison population projections. Of the 45 jurisdictions responding thus far, only two (West Virginia and New Hampshire) do not try to project their prison population. Two other jurisdictions not currently making projections are in the process of instituting procedures to make them. In all other states, projections are made on a more or less regular basis. Many jurisdictions have recently intensified projection efforts by utilizing more sophisticated techniques and by investing additional monies and effort in this activity.

The movement toward use of more sophisticated projection techniques stems, in part, from recent court decisions against crowding conditions in prisons. This issue will be discussed later. Another reason for the willingness to invest time and money in making prison population projections is the fact that jurisdictions view these projections as a very important management and budgetary tool.

A. How Projections Are Used In The States

What are the objectives of this projection tool? The answer to this question has more than a mere theoretical significance. Different objectives require different levels of accuracy, different techniques, and different time lags (how far in advance the information is needed).

Most states share similar goals for their projections. Nevertheless, differences do exist among the states in the actual use and applications of their projections. Differences also exist in circumstances surrounding the projections. These differences are likely to influence the actual uses of forecasts. Table 2-1 presents some of the similarities and some of the differences. Since the table includes items which were not specifically requested, there is insufficient information for inclusion of jurisdictions under each heading. The percentages of "yes" responses represent, therefore, the minimum number of states for which a particular situation applies.

It is evident that legislative budget requests are a major concern of departments of corrections. They try to use projections in support of these requests. Only three jurisdictions do not do so. The significance of this issue puts many departments under pressure to produce quick projections. Several states indicated that these projections are then modified by the legislatures, mostly by reducing the projected population. Some of the legislatures also attempt to get projections from outside sources. It is unclear whether this apparent mistrust has been caused by unreliable past projections or simply by a belief that the staff of a department of corrections would want to see its budget grow and would, therefore, tend to overproject.

TABLE 2-1. PERCENTAGE USES OF PROJECTIONS BY STATES AND OTHER JURISDICTIONS

	ARE SEPARATE METHODS USED FOR LONG & SHORT TERM PROJECTIONS?	ARE PROJECTIONS SUBMITTED TO LEGISLATURE, EXECUTIVE?	IF PROJECTIONS ARE SUBMITTED TO LEGISLATURE, EXECUTIVE, ARE THEY EFFECTIVE, "INFLUENTIAL"?	ARE PROJECTION TECHNIQUES USED IN IMPACT STUDIES?	ARE ALTERNATIVE SCENARIOS PROVIDED FOR PROJECTIONS?
YES	14.0	72.1	22.6	44.2	37.2
NO	76.7	7.0	9.7	46.5	51.2
INSUFFICIENT INFORMATION	9.3	20.9	67.7	9.3	11.6
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0
TOTAL N	43	43	31	43	42

B. Long Term vs. Short Term Projections

It is advisable to distinguish between short and long term projections, as at least six states do.* While short term projections are used for personnel and budgetary planning, long term projections are required for long range planning of capital outlays, such as adding new prisons and renovating existing ones.

The required lead time for personnel and budgetary purposes is between one and two years. This lead time is needed to plan the budget request and is used in support of the request in legislative hearings. Long range projections are needed because of the lead time required for the construction of new prisons or the renovation of existing ones. Prison construction is expensive and time consuming and does not allow for many shortcuts. It may take up to 5 years, or even longer, to complete a maximum security prison. If we add to that the time needed to submit and approve a request for appropriation and the time needed to purchase land and settle potential law suits, the necessary lead time may reach 10 years.

During the 1970's, prison authorities around the country were often able to adjust to rising prison populations within relatively short periods of time by double celling and by acquiring mental health facilities. The deinstitutionalization policy in the mental health field, which had started in the late 1950's (in some states) and continued in the 1960's, had considerably reduced populations of many state hospitals (and in some cases causing a shift of a portion of that population into the criminal justice system). Departments of corrections were able to convert several closed mental institutions to prisons. In Illinois, this method led to the reopening of Logan and East Moline Mental Health facilities as prisons. It should be obvious that this approach cannot last forever. Even when closed mental institutions are available, it may take years to convert them to prisons, or overcome public resistance to having a prison in the community.

Unfortunately, whether because of budgetary constraints or because of lack of faith in prisons projections, legislatures have tended in the past to approve new prison constructions when there were already strong pressures on the system. When new prisons were finally completed, they were quickly filled, leading many to conclude that prison populations will always strive to reach capacity. Since very few prisons have been built under no pressures of crowding, it is very difficult to disprove this point. Nevertheless, there have been periods when prisons remained empty, or half empty, for several years. For example, Illinois prison population declined from 1961 to 1973 without any major decline in capacity. In 1972, felony admissions started to rise again. A year later the size of the inmate population started to increase. Yet,

*The major concern in these states is the time needed for projections. For short term projections, a short-cut technique may be used, even when its accuracy is suspect, simply because projections are needed often and quickly.

in 1974, the department decided to reduce the rated capacity by adopting the individual cell concept.

Fortunately, long term projections require less accuracy than do short term projections. As we shall see, errors in projections tend to accumulate through the years. Usually, the longer the range, the larger the error. (Sometimes, there are lucky errors. These occur when one error compensates for another.)

It is important to understand that the definition of "long" and "short" are very subjective. What may be considered short by one jurisdiction may be considered long by another. For example, Oregon regards projections of up to two years as short and projections of up to 20 years as long. The District of Columbia, on the other hand, views projections of up to one year as short and projections of up to three years as long. For Alaska, projections of up to five years are still regarded as short. The different distinctions are probably caused by different circumstances. Whatever their definition, very few states project beyond 20 years, and few states project beyond five years with any degree of confidence. It is possible that the length of the projection period will increase if and when forecasters have more experience with their projection techniques.

It is also important to note that long, as well as short, term projections are not necessarily used for increasing the capacity of the prison system. Efforts to counteract possible increases in prison populations may lead to the introduction of alternatives to incarceration, early release programs and legal and administrative changes (such as reducing the number of parole revocations, increasing support to county facilities, and probation subsidies).

The possible use of prison projections for counteracting potential future trends may lead to viewing these projections as inaccurate. <u>It is a paradox that good projections may be regarded as highly inaccurate by policy makers only because these same policy makers use these projections to counteract expected trends</u>. As long as prison projections are used by authorities to determine policy changes, these authorities should realize that their action may alter the conditions which led to the particular projections. This fact must be considered in evaluating existing projection techniques. Good forecasters are always careful to spell out the assumptions under which they make their prediction.

C. <u>Other Important Distinctions</u>

Besides the distinction between long and short range projections, the literature reveals another important goal for projections. Projections are used to help departments in studying the impact of new legislation or recent court decisions.

Some states use their projection techniques for straight impact studies. Others merely provide different "scenarios" of future trends because of shifts in policy.

We feel that the difficult task of impact projection will eventually be better served through a clearer understanding of processes in other jurisdictions. After all, new legislation in one state may be old legislation in another.

The pressures under which projections are made deserve special attention. Since the early 70s, prison populations in most jurisdictions have increased dramatically. The sudden, and mostly unexpected, rise has led to a stronger felt need for projections. This need has been intensified lately by extreme conditions of crowding and by several court orders limiting the number of persons that can be housed in many of the existing institutions. In at least seven respondent jurisdictions, there has been a recent court order limiting populations at some or all of the institutions. (Sometimes the court order is directed at the conditions which are caused by crowding; sometimes it directly limits the size of the population.) Besides these seven, three other states have also indicated to us that they operate under extreme crowding conditions. This information had been unsolicited by us and the actual numbers may be higher. For example, Illinois, which is not one of the seven states, is currently involved in a court battle over the crowding issue. As temporary measures, states have resorted to early release programs, use of county facilities to hold new admissions, sentencing guidelines, and expansions of "alternatives to incarceration". Since new prisons are expensive and require relatively long lead times, policy makers want to know whether the increases are temporary or not. While state governments may be willing to tolerate crowded prisons for short periods of times, they recognize that if there is no relief in sight, it is better to begin to prepare for it.

III. THE LOGIC BEHIND PROJECTIONS

Forecasters of prison populations have been using several techniques in their attempts to accurately project future prison populations. Although these techniques differ substantially from one another in important respects, they do share common logical presuppositions. A better understanding of this logic will help the discussion of indicators and projection techniques contained in Chapters V and VI.

It is best to start with a fundamental caveat: all projection techniques involve assumptions.

While intuition may play a major role in making projections, they should, nevertheless, be based on measurable information regarding the past and present. Forecasters study various past and present relationships between "indicators" and the "to be projected" variable. They then generally assume that these relationships will continue into the future.

Since more people are familiar with horse racing than with projections, it is possible to explain the logic of projections by equating it with handicapping horses. The handicapper studies previous performances and present conditions of the horse and uses that information to determine the likelihood of success in the future. The forecaster uses similar logic. However, unlike the handicapper, the forecaster often does not have distinct criteria of past success and present health. He/she has to explore many possible past relationships and determine which of these relationships "explain" changes in prison population in the past and whether they are likely to continue into the future in some predictable fashion. Projection techniques differ in outcome depending on the types of past relationships being explored and on the assumptions about the nature of these relationships in the past and in the future.

All techniques have to assume that some present relationships will, or will not, continue into the future. Other assumptions also have to be made (for example, the assumption that a relationship is linear). That is why the same technique may be accurate under some circumstances and inaccurate under others. Good forecasters try to collect as much information as possible in support of their assumptions.

The sensitivity of projections to incorrect assumptions may not be the same for all assumptions. While some projections may remain fairly accurate despite certain assumptions being incorrect, others may be vital to the accuracy of the projections. A small error in such assumptions, may lead to substantial projection inaccuracies.

The previous discussion leads to an inevitable conclusion: much depends on the kind of information available. When very little information is available, the simpler techniques may be far superior to the more sophisticated ones, since they require fewer assumptions. When more data are available, this may change.

There are also times when it is clear that certain assumptions cannot be justified. For example, when new legislation supplementing probation services is passed, it cannot be assumed that past patterns of commitments to prison will continue into the future. It would also be a mistake to assume that they will not continue.

Impact studies are frequently used in such cases to estimate the impact of change on the current situation. Since new legislation is involved, lack of previous experience hampers the attempt to estimate impact. In some circumstances, experience in other jurisdictions may be helpful to a degree. However, since jurisdictions are different in many respects, similar legislation may produce different results because it interacts with different sets of variables. While impact studies may be sufficient to point toward the general direction the system is going, it is unlikely that they can produce, or even pretend to produce, an accurate picture of the future.

Our questionnaire did not measure this problem directly, but several states have indicated that their criminal justice systems have undergone important legislative and policy changes. The major types of changes are listed in Table 3-1. Commentary by several respondents suggested that these changes made their efforts at projections more controversial.

It must be emphasized that Table 3-1 represents unsolicited information. The actual number of states experiencing major legislative and policy changes is much higher, reflecting the current feeling that existing "old" methods have failed. That so many jurisdictions discuss the issue in reporting their projections is an indication of the awareness that legislation and policy changes affect projections. Several states, in fact, have had to change their projection techniques in recent years because their methods no longer were satisfactory after such a major change.

Among the more problematic are changes affecting length of stay. It takes years to assess the impact of these changes. Fortunately, most of the recent changes in this area have established determinate sentencing. Under some of the determinate sentence laws, length of stay can be estimated without waiting for the actual release of inmates. For the long run, determinate sentencing will probably improve projections, provided states can establish adequate recording of Good Time Credits and better offender tracking information systems.

TABLE 3-1. MAJOR LEGISLATIVE AND POLICY CHANGES DISCUSSED BY STATES REPORTING ON THEIR PROJECTION TECHNIQUES

TYPE OF CHANGE	NUMBER OF STATES REPORTING
1. Legislation Affecting Sentencing	3
2. Legislation Affecting Length of Stay	6
3. Parole Board Policy and Reorganization	7
4. Other Changes	2
Total	18

IV. CRITERIA FOR METHODS ASSESSMENT

Our review of the literature has revealed several methodological approaches to projecting prison populations. In Chapter VI the major "techniques" will be reviewed. However, in reality, almost every jurisdiction has its own unique method. Differences between jurisdictions in terms of the structure of the correctional and criminal justice system and the nature of available data are responsible for much of the variety. Furthermore, lack of communication/information transfer between jurisdictions has also led to the use of different methods by "similar" jurisdictions. We hope that the present publication will encourage greater information exchange between states. When a state is considering improving its projection capabilities, it will need some criteria which will be helpful in its decision-making process. The present chapter discusses some essential criteria for making that needed assessment.

The purpose of this chapter is not to provide an agency with a tool to determine the best method. Such a method does not exist. Each jurisdiction should analyze its own situation and adopt or devise the method best fitted to its unique circumstances. In Chapter VI, the most commonly used methods are assessed on the basis of the criteria presented below.

As part of our criteria development efforts in Illinois, twelve assessment criteria have been identified. Here they are divided into four groups: the first group includes criteria dealing with external validity; the second group deals with the tasks faced by projection methods; the third group includes criteria of internal validity; and the fourth group includes a long list of practical considerations which should be taken into account.

A. Criteria of External Validity

All projection techniques strive to be as accurate as possible. The accuracy of a method or the likelihood that it will be accurate will always be considered in assessing projection techniques.

1. Accuracy

Projections are designed to help policy makers in their decision-making processes. A better understanding of what the future holds, it is assumed, will lead to more rational decisions. Money will not be spent on unneeded prisons or services but will be appropriated when the need for them is projected. Accurate projections are, therefore, extremely important.

While accuracy should always be strived for, it should nevertheless be put in the proper perspective.

First, the definition of what is "accurate" is very subjective. While some systems are satisfied with a 10% error rate, others are dissatisfied with anything above 1%. Obviously, the need for accuracy rises with increasing crowding conditions and the need to plan new prison construction or renovation. If the system can easily handle errors in projections, the importance of accuracy is diminished.

Second, present methods have not been around long enough for accurate data to be available. Thus, when new projection techniques are considered, their accuracy and applicability assessment may not yet be available. One way to solve this problem is to use historical data to predict the recent past. This solution and its limitations will be discussed under criterion validation.

Third, there is the problem of self-fulfilling and self-defeating prophecies. When projections are taken into account in the decision-making process, some decisions may act to conteract the projections. For example, when forecasts suggest a large increase in prison population, the Parole Board may be encouraged to release an increasing number of inmates. In this instance, the projection will lead to its own defeat. Under other circumstances, a similar projection may lead to a decision to build additional prisons and the reduction in overcrowding may then convince some judges to sentence offenders to prison even though they would not have done so under previous conditions. In this instance, the projections would be self-fulfilling.

Even if it is determined that one method is more accurate than others, it is not necessarily the best method for a particular jurisdiction if it scores low on some of the other criteria. Furthermore, similar methods may produce different results in different jurisdictions. Even within the same jurisdiction, a method may be accurate during some periods and inaccurate during others.

2. Validation

Validation is a process of testing the accuracy of one or more methods. In this process, projections on what is already known can be used to test for accuracy.

Validation is an important step in choosing the appropriate projection technique. It is very likely that a correctional agency considering a new projection technique will not have sufficient data on its accuracy in other jurisdictions. Even if it did, there would be no guarantee that this accuracy would be duplicated. Validation is a partial solution to this problem.

In assessing the feasibility of a projection method, it is important to determine first if it lends itself to validation. Theoretically, validation is possible for all methods; in practice this is not always so. Sometimes enough data are available for a particular projection technique, but not for the validation process.

Since validation requires more historical data, the problem is serious in states who have only recently begun to collect systematic and reliable information on the criminal justice process. For example, a state may consider a technique which seems to require certain data on at least three years. For projections done in 1981, 1978 through 1980 will be

chosen. Reliable data exist only since 1978. Under these conditions, projections can be done, but a validation of the method is impossible.

Ideally the time span used for validation should be equal to the time span needed for projections. If five year projections are needed, validation for a five year span is desirable, for a total of 10 years. This requirement increases the likelihood that major legal or policy changes will affect current and future validation efforts.

B. Versatility of Tasks Required of the Method

Some jurisdictions may need more from their projection techniques than others, and additional tasks may require new approaches.

1. Measurement of Change

Sometimes a method will produce overall accurate results but will still be rejected because it lacks adaptability to an environment with changing circumstances. Some jurisdictions place prime importance on measuring the impact of new legal and/or policy changes. These impact studies involve much more than population projections. The projection part provides two projections - one without the change and one with it. The projection of the population with the change, minus the projection without it, provides policy makers with the expected net gain or loss in population due to the change. As we shall see, some techniques are more readily adapted than others to impact studies.

It should also be noted that even inaccurate methods may still be adequate for impact studies. Since only the difference between two projections is measured, a bias in the projections may be accepted provided it is consistent.

2. Ability to Project Turning Points

While some correctional systems proceed for years with no dramatic changes in their incarceration trends, others undergo severe fluctuations in the size of their prison populations. Not enough is known about the causal factors related to these fluctuations. Some explanations blame economic changes while others emphasize demographic changes (such as migration patterns and the size of "risk" groups). Shifts in social values, level of criminal activity and/or law enforcement practices are also suggested as possible causes for the ups and downs in the size of prison populations. (Incarceration rates decline during wars but, even then, not enough is known about the process.)

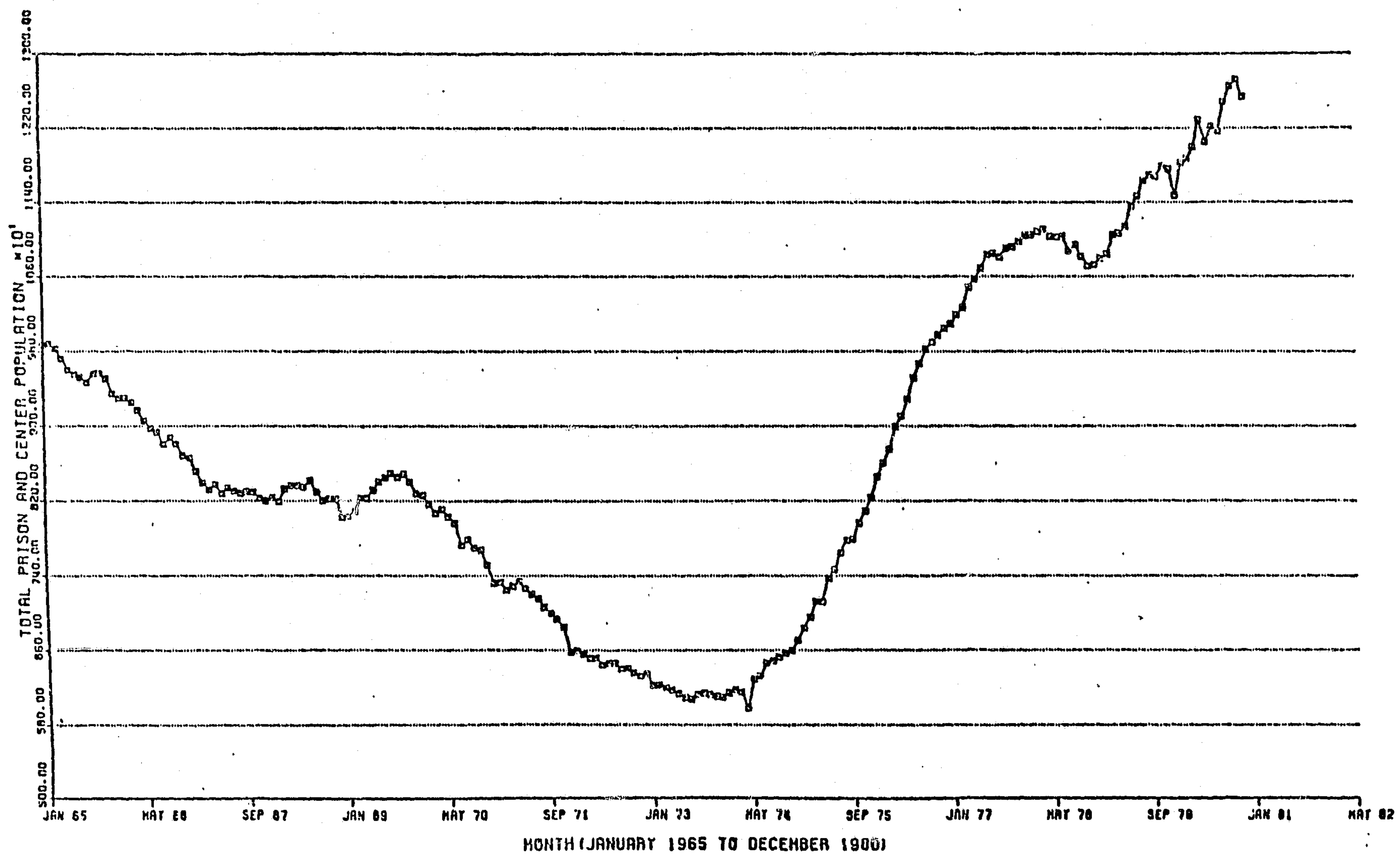
The Illinois institutional population may serve as a good example for sudden reversals of incarceration trends. Figure 4-1 shows a definite turning point for Illinois in 1973. Several other states (but not all of them) underwent similar changes in the 1970's.

Some methods are not equipped to project <u>any</u> turning point. Others, are likely to project some. None are sensitive enough to project all of them. If it is suspected that a turning point in the near future is likely, it has to be determined what the likely causes will be. Analysis

FIGURE 4-1.

ILL. PRISON AND CENTER POPULATIONS: 1965-1980

RAW DATA SERIES = ▢



ILLINOIS LAW ENFORCEMENT COMMISSION (CJIS)
STATISTICAL ANALYSIS CENTER GRAPH

of previous trends, plus common sense and understanding of the system, are important to such a determination. When the likely causes are selected, the technique best suited to project the turning point may then be tested. Both accuracy and validation assessment may be an important step in determining the ability of a method to project certain turning points.

3. Level of Specificity Required

Some jurisdictions are satisifed with end of year or average population projections. Others require more specific projections. For example, it may be necessary to distinguish between males and females or felonies and misdemeanors (in states where some misdemeanors are housed in state institutions). In some jurisdictions, the need may arise to project even in greater detail the composition of the prison population.

Two such possibilities are: projecting future needed capacity for maximum, medium, and minimum security prisoners and separate projections for admissions and length of stay. For example:

- The cost of housing a maximum security prisoner is higher than the cost of keeping a minimum security one.

- A system with high turnover (short length of stay, high admissions) will be more expensive to maintain than a system with low turnover even if end year populations are equal because of mounting processing expenses (classification, admissions, and release procedures).

C. Criteria of Internal Validity

These criteria are important under all circumstances but they assume special importance when external validity cannot be determined.

1. Theory

There is a certain attitude in the field of projections that if it works, it is good, whether or not it makes sense. This attitude eventually spells disaster. All projection techniques rely on time series measurements. The use of conventional statistical techniques in measuring relationships between different time series variables is a risky business. Two separate time series may co-vary during certain periods due to the impact of outside variables or even due to pure chance. Consequently, measured relationships in the past may not continue into the future. This problem cannot be eliminated, but confidence in relationships will increase if they are supported by some theoretical or at least logical explanations. Obviously, theory is instrumental in choosing indicators once a method is selected.

2. Reliance on Outside Projections

Most prison projections cannot completely avoid a reliance in their projections of some outside indicators which are themselves projections, e.g., state population, unemployment. The need to rely on these outside projections creates a major problem. In order to project prison populations, prison experts have to project changes in indicators about which they know very little. This problem arises when unemployment is used as an indicator of changes in the levels of incarceration. Economists widely disagree in their projections of unemployment and several of their projections miss the target by wide margins. Criminologists or statisticians are even less equipped to project unemployment, yet several of them reluctantly rely on projected unemployment as an indicator for making their projections.

A rule of thumb in this regard is that a forecaster should rely on projected outside indicators only if he/she feels more confidence in using them than in projecting prison populations directly.

3. Reliance on Assumptions

Every forecaster has to rely on some assumptions. The most common assumption in projections is that past trends will continue in the future. Another common assumption that external indicators will behave in a certain way, has already been discussed earlier. While making assumptions in forecasting is unavoidable, some important steps should be taken to reduce risk:

- o Assumptions should be spelled out.
- o Assumptions should be rationally supported by available information and, at the very least, should be theoretically sound.
- o The number of needed assumptions per projection method should be weighed against the degree of confidence in these assumptions.

Sometimes, reliance on several assumptions in a sophisticated technique will produce projections which are less accurate than a simpler technique with fewer assumptions. This may occur especially when several similar assumptions are made with similar biases (creating a cumulative effect).

D. Practical Considerations

While it is always nice to have "the best", practical considerations are of prime importance in choosing a projection technique. Most states are well aware of it. Some of the more important considerations we have identified include:

1. Money

Some techniques are very cheap to handle. While they may produce less accurate projections (but not necessarily so), the price to pay for increased accuracy is not worth the effort. This will be particularly true for some small jurisdictions which have undergone very little change in recent years and do not have crowded institutions.

2. Personnel for Instituting Projections

More sophisticated techniques require personnel with specializations not always available "in house". An agency may choose to hire someone to do their projections or rely on outside consultants. Either way, the result is extra cost.

3. Personnel for Maintenance

Once a technique is established, there is constant need to maintain it by updating the data base or by adapting ("tuning the model") to changing circumstances, e.g., new legislation, changes in indicators.

More sophisticated techniques require a larger data base, more computer programming and more testing, and research staff with strong experience in statistical techniques. It would be a mistake to get into a new technique without calculating the maintenance requirements in staff time and money. (This error has been made in the past by some of the reporting states.) Equally problematic is the hiring of outside consultants, to institute projections who then leave without a built-in maintenance capability. The availability of an ongoing maintenance capability is an important criterion in choosing a technique and in choosing consultants.

4. Time

Many jurisdictions operate under time pressures. Projections are required often and quickly. This frequently precludes the use of more sophisticated methods. For this reason, several states have instituted two projection techniques - one for quick projections and one for more deliberate projections.

5. Nature of Data

Any technique is only as good as its data base, and data cannot be forced or "created". If the data needed for a sophisticated method do not exist, or are highly inaccurate, a simple method may produce equally reliable results.

A sophisticated technique with an inferior data base should be used only if other criteria indicate a need for it and plans are underway to improve the data base. When this is done, the technique should not be used for actual projections until the data base matches the sophistication of the technique.

V. THE INDICATORS

Indicators are the backbone of every type of forecasting. At the very least, past behavior is used as an indicator for projecting into the future. Indicators come in all shapes and forms and display different characteristics. Each indicator is unique and may be best suited for a specific type of forecasting. The selection and use of an indicator depends on several factors.

Certainly, the relationship between an indicator and the projected phenomenon should be strong. In statistical terms, the indicator(s) should explain a large part of the variation in the dependent variable. If one indicator does not do an adequate job, it can be combined with several others. For reasons of efficiency, however, it is not good to include an endless number of indicators.

Besides the strength of the relationship, other criteria play important roles in deciding which indicators are more suited than others. Since projections deal with time series relationships, lagging the indicators is of utmost importance. Lagging a time series means its transformation to another time series which is made up of its previous observations. A strong relationship between a lagged indicator and the dependent variable (admissions, prison population) is more beneficial than a strong relationship between unlagged variables. If changes in the indicators precede changes in the dependent variables, the forecaster can rely on solid indicators for projecting prison populations. Otherwise, separate projections of the indicators themselves will have to be made (necessitating another "tier" of indicators). This lagging of indicators actually transforms them into "leading indicators".

It is highly unlikely that projections of prison populations will ever be based solely on leading indicators. The required lead time is simply too long. Under these circumstances, indicators which are easier to project are preferable over others, even if the relationships between them and the dependent variables are not as strong.

A. Types of Indicators

Numerous indicators have been presented in the literature for use in projecting prison populations. One of the efforts of this project was to identify and review the applicability of various indicators to prison population projections. This discussion concentrates on five groups of indicators:

- Demographic Indicators
- Economic Indicators
- Social Indicators
- Criminal Justice Indicators
- Correctional System Indicators

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Table 5-1 provides by group indicators currently reported in use by states in their prison population projection efforts.

A brief look at the Table reveals that social indicators are not currently in use, even though they are much talked about. Social Indicators have emerged as an area of special scientific interest only recently and the historical data base is very limited. This may account for their lack of use in prison projections. When data on fear of crime and punitive attitudes toward criminals are consistently collected for longer periods of time, they may be important additions to the list of variables currently in use.

B. Discussion of Current and Potential Future Indicators

A review of the current types of indicators (Table 5-1) also raises serious questions and suggests that additional indicators not currently in use may be potentially beneficial (Table 5-2).

1. Demographic Indicators

The use of demographic data as indicators of incarceration is based on the assumption that when the population at risk increases, the number of persons committed to institutions increases as well. This would make sense if "all things being equal" is added. Unfortunately, many times things are not equal. Other variables such as crime rates, arrest rates, and conviction rates may have to be added to the equation. In the 1970's, many states experienced increases in general population and admissions to prisons. This relationship had not always existed and may not exist in the future.

Since there is strong evidence that certain groups are more likely to be incarcerated than others, several states measure the changes in the size of these particular risk groups only. Others use the entire general population but disaggregate it into risk groups with different risk levels. This approach may indicate increases in incarceration even when there is no increase in general population, as long as the composition of the general population changes (larger high risk groups). This issue will be discussed in more details in Chapter VI.

The most common risk factors used are sex, age, and race. Sometimes, location is added (city - non-city; urban - rural). In general terms, young, non-white males from urban areas form the highest risk group.

Demographic indicators enjoy a definite advantage over other types of indicators: due to the vast experience in population projections, they are more reliable than projections of most other indicators.

2. Economic Indicators

Only unemployment data are currently in use. There are two prevailing approaches to the relationship between unemployment and incarceration. According to one approach, unemployment creates financial distress, idle time, and frustrations which lead to crimes and admissions to prison.

TABLE 5-1. INDICATORS USED IN PROJECTING PRISON POPULATIONS IN 44 U.S. JURISDICTIONS AND CANADA

TYPE	INDICATORS	# OF STATES USING THE INDICATOR	
Demographic Indicators	General Population	5	
	Risk Group(s) (2)	17	
	Total # of Jurisdictions Using Demographic Indicators (1)		21
Economic Indicators	Unemployment Rates (Lagged or Unlagged)	6	
	Unemployment Numbers	1	
	Total # of Jurisdictions Using Economic Indicators (1)		6
Criminal Justice Indicators	# of Crimes	2	
	# of Arrest	3	
	# of Convictions	4	
	# of Prison Sentences (3)	3	
	Sentence Length	5	
	Other Court Information (4)	5	
	Commitments to Detention,		
	Jail Population	2	
	Legislation	2	
	Total # of Jurisdictions Using Criminal Justice Indicators (1)		15
Correctional System Indicators	# of Admissions	15	
	Length of Stay	15	
	Prison Population (Primary Only)	17	
	Prison Behavior and Movement	3	
	# of Releases	2	
	Parole Data (5)	4	
	Total # of Jurisdictions Using Correctional System Indicators (1)		34

(1) Totals are not summations of individual indicators because jurisdictions may use more than one indicator in a given type.
(2) Includes disaggregated general population (entire population is divided into groups with different risk probabilities).
(3) Including probabilities for all major alternative dispositions (Minnesota).
(4) Court intake, indictments, unspecified.
(5) # of parole hearings, # of parole grants, "parole actions", parole population, participation in parole programs.

The other approach stresses unemployment. Decision-makers (policemen, prosecutors, probation officers, judges, parole officers, and parole boards) treat the employed and unemployed person differently. An employed person facing the judge is more likely to receive probation than an unemployed one. Similarly, a person with a job to come back to is more likely to be paroled than a person with no employment prospects. Even for two unemployed persons, a court disposition may reflect the potential for employment which is low in periods of unemployment and higher during periods of low unemployment.

The first approach leads to lagging unemployment because of the time gap between the commission of crime and admission to prison. The second approach requires no lag. It should be noted that the two approaches are not necessarily mutually exclusive. Current evidence is not conclusive as to their relative merits. (Our own initial analysis for Illinois shows the highest correlations at time lag=0, giving added support to the second approach.)

Both approaches suggest that unemployment numbers may be better indicators than unemployment rates. Unemployment rates reflect not only unemployment but also the size of the work force. Unemployment numbers reflect only the size of the unemployed group.

Since it is still unclear whether unemployment should be lagged or not, and whether numbers should be used instead of rates, some forecasters have opted to use lagged unemployment together with unlagged unemployment and the number of unemployed together with the rate of unemployment. This may make sense as long as it is supported by the data. It should also be remembered that when independent variables are highly correlated, the multiple regression analysis between them and the dependent variable may be distorted (problem of "multiculinearity").

Another distinction between types of unemployment data is almost completely ignored in the literature of prison projections. Unemployment information is available adjusted (through X-11) and unadjusted. Unadjusted figures reflect the real numbers and rates of the unemployed. Adjusted numbers and rates smooth the differences between seasons. While both may be used, it would be useful if forecasters would specify which of the two they are using. If only annual data are used, the question of seasonality is obviously irrelevant.

It is reasonable to expect relationships between unemployment and incarceration. However, some of the states rely on regression analyses based on very few observations. The increases in unemployment and admissions to prison during the 1970's may still be coincidental and may not reflect true relationships. Some states produce correlations well over .9 for very few annual observations. It is very unlikely that these correlations will remain that high for longer periods.

Since evidence suggests that the likelihood of incarceration is high for certain "risk" groups, it would seem likely that unemployment in these particular groups would be a better indicator of imprisonment than general unemployment. Nevertheless, none of the states which use unemployment as an indicator, relies on risk group unemployment. This

may be caused by a lack of accurate historical data or confidence in projecting it.

This problem exists for general unemployment as well. Projecting unemployment is a task economists find difficult to accomplish and there is no reason to believe that criminologists will do a better job. Previous government projections of unemployment have been proven wrong. With that track record, it makes little sense to use unemployment as an indicator for long term projections. For short term projections, unemployment may be a useful indicator, especially when lagging it is possible.

While unemployment is the only economic indicator currently in use, other economic indicators are available for use. Among them are gross national product (per capita); index of leading economic indicators; number of business and corporate failures; rate or number of persons below proverty line (family, individual; white, non-white); stock market indexes (Dow Jones, Standard & Poor); number or rate of persons on welfare or other state or federal support. Some of these indicators may be easier to project. The index of leading economic indicators may be particularly useful, because it precedes economic changes and, therefore, has a "built in" lag.

3. Criminal Justice Indicators

The relationship between criminal justice data and prison population is obvious. Changes in the number of crimes, arrests, and convictions can easily be tied to changes in the number of prison admissions and prison populations. Other criminal justice trends may also affect imprisonment.

In view of this apparent relationship, the number of states relying on criminal justice information is surprisingly small. The reason for this neglect is the difficulty in using these criminal justice indicators to directly project admissions to prison and prison populations. Further, some of these indicators "lead" prison admissions by a year and, sometimes, even more. This is the time it takes from the initial crime to the final sentence to prison. Since a large portion of crimes are commited by juveniles, the lead time may be even longer. A juvenile crime wave in 1980 may precede an adult crime wave in 1983, and an adult incarceration wave in 1985. (Here we must consider the time needed for a juvenile criminal group to move into the ranks of the adult criminal group, the time needed for apprehension and conviction and some time under probation supervision for first offenses as adults.)

Other points of consideration suggest that using criminal justice data has definite benefits. When the early stages of the criminal justice system are projected and are then used to project later criminal justice and system indicators, a system of "assumption checks" is produced. If projections turn out to be inaccurate, it would then be possible to pinpoint the error to a particular assumption or a particular "internal" projection. The error could then be analyzed and corrected, when necessary. (Some of these "errors" may be due to temporary conditions and may not require corrections.)

Furthermore, since not all crimes carry the same risk of incarceration, it would be feasible to use data on early criminal justice stages for only certain serious crimes and to give different weights to different crime groups. (This would be done automatically in a stepwise multiple regression analysis.)

Other types of criminal justice indicators listed in Table 5-1 need special attention. "Legislation" is unique because it cannot be incorporated formally into a mathematical or statistical model. It is used informally by two jurisdictions. We suspect that other jurisdictions also use legislative changes informally to adjust their formal models. Legislation is not mentioned because its use is informal. The high emphasis placed by several jurisdictions on impact studies suggests that the impact of recent or proposed legislation is not taken lightly.

The other indicator in need of special attention is "sentence length". It is used as an indirect indicator of "length of stay" or as an intermediate process in determining length of stay. Sentence length is used in states with new determinate sentencing legislation, where "length of stay" cannot be determined. It is also used by some states to help determine release on parole since parole eligibility depends on sentence length.

Criminal justice indicators which are not currently used, but may be considered for the future as leading indicators, are admissions to juvenile institutions, court backlogs (as an indicator of the lag between arrest and conviction), and estimated size of the criminal population (persons on probation, and parole are the highest risk group).

Further exploration is needed of the lag between future crime rates and of prison populations.

4. Correctional System Indicators

The number of inmates in a correctional system is a function of the number of offenders admitted and their length of stay. All the system indicators listed in Table 5-1 except one are direct or indirect measures of these two variables.

The indicator "prison population" deserves special attention. Prison population is the independent variable of prison projections. Populations of prior years are always part of the projection process. If some indicator "projects" prison populations in the past, it is assumed that it will be able to project it in the future. "Prison populations" in Table 5-1 refers to those cases where it is used only as a "primary" indicator, i.e., that future population is projected solely on the basis of past trends in prison populations.

System indicators are used more than others because forecasters of prison populations know them better and have more confidence in them. Many of them, however, are used only as secondary indicators; namely, they are projected by some outside indicator and are then used to project the population.

The three most used system indicators ("admissions", "length of stay", and "prison population") are frequently disaggregated into major groups (felony-misdemeanor, first admissions-readmissions, etc.) and are also used in conjunction with other types of indicators (for example, number of admissions of young, non-whites from certain counties). Disaggregation will be discussed in more detail in Chapter VI.

A system indicator which has come into prominence with a recent report on prison projections done for the National Institute of Justice is not currently in use. That report raised the possibility that prison populations are a function of prison capactiy and developed a methodology which incorporates capacity as an indicator. (U.S. Department of Justice, American Prisons and Jails, Vol. II: Population Trends and Projections, 1980.)

Although Table 5-1 lists only six system indicators, it should be realized that these are very general in nature. "Length of Stay", for example, incorporates several operational definitions and several different procedures of measuring it. For some states, parole eligibility date may be a necessary ingredient. For others, it may be insignificant. Some of the major procedures for determining admissions and length of stay will be discussed in Chapter VI.

C. Summary

Our discussion has revealed a wide open field of indicators. Many indicators are currently in use but others deserve consideration in the future. Table 5-2 provides a partial list of promising indicators. More research, extended data bases, experimentation and theory will lead to the identification of other promising indicators.

TABLE 5-2. POSSIBLE INDICATORS OF PRISON POPULATIONS (INDICATORS NOT CURRENTLY IN USE)

Type	Indicators	Comments
Economic Indicators	o Gross National Product Per Capita o Index of Leading Economic Indicators o Number of Business and Corporate Failures o Rate and Number of Person Below Poverty Line o Stock Market Indexes o Number and Rate of Person on Welfare	When any economic indicator is used in a time series, it is important that it will be standardized. For example, all money indicators should be with constant dollars.
Social Indicators	o Fear of Crime o Attitudes Towards Criminals	What is needed is more consistent observations for longer periods and more studies on the relationships between social indicators and the criminal justice system.
Criminal Justice Indicators	o Juvenile Arrests o Admissions to Juvenile Institutions o Estimate of Criminal Population o Court Backlogs	Police and court data, while usually available in some form, do not always correspond to correctional data. Some problems in this area will be discussed in Chapter VI.
System Indicators	o Capacity	1. The problem with system indicators is not that they are not used but that sometimes they are used when they should not be. The quality of data in many jurisdictions is still lacking, despite tremendous improvements in recent years. What is needed most of all is time to develop good and consistent data bases. 2. Capacity is very subjective and its definition changes constantly. This should always be taken into consideration.

VI. THE METHODS

Forecasters of prison populations have followed a path similar to the one taken by forecasters in other fields. The similarities between the history of prison projections and projections of the general population are of particular interest. Early projections of the U.S. population extrapolated past trends in general population into the future. In the 1930's, attempts were made to project the general population by projecting separately birth rates, death rates, and migration. In the 1950's, these three components were further disaggregated. For example, projections of birth rates were no longer based on the general birth rate of previous years. Instead, birth rates were calculated separately for young women and older ones. The disaggregation did not result in immediate improvements in projections, but it made sense, because it allowed forecasters to trace specific trends and adjust projections more easily when necessary. Prison projections have generally followed this same path, with one exception: there is a recent trend for using time series analysis. The time series models currently in use are merely more sophisticated models of extrapolating past trends.

Current projections of the U.S. population have a good reputation for accuracy. It remains to be seen whether the newer methods in projecting prison populations will enjoy a similar reputation. It seems that prison projections have to rely on more unpredictable variables. While birth rates, death rates, and migration patterns do not usually undergo sudden and dramatic changes, factors such as crime rates, arrest rates, length of stay, and several others are more susceptible to such changes.

Previous surveys by the states of Kentucky and Florida, as well as by others, have identified five distinct types of projection methods.

1. Linear regression.
2. Multiple regression.
3. Ratio. (Not included in the Florida survey.)
4. Simulation.
5. Time series analysis and non-linear approaches. (Not included in the Florida and Kentucky surveys.)

Table 6-1 reviews the use of these five methods by the jurisdictions reporting to our survey. Note that several jurisdictions use more than one method. Only projection techniques currently in use are included in the table.

The most popular method right now is simulation, but, as we shall see, several simulation models are used. Simulation users also apparently have enough confidence in the method to rely on it exclusively. In addition to the 18 jurisdictions which use simulation, at least four others are in the process of implementing a simulation model. One state is implementing multiple regression, another is working on a combination of multiple regression and time series, and another is implementing a ratio model. While linear regression is still popular, several jurisdictions are in the process of replacing it. Of the five states which use "other" methods, four rely on informal analysis of information and intuition. One state (Vermont) uses rate of growth which may be regarded as a linear model or a non-linear one, depending on how it is used.

The following discussion of methods is an effort to simply explain what they do and what are the limitations of each. Every effort has been made to use non-technical descriptive language. However, some mathematical symbols have been used.

For the purpose of continuity, the present discussion will rely on the distinctions used by others. However, with the exception of linear regression, each of the methods has several variations and differences between variants may be significant. Even linear regression has undergone some recent innovations which have introduced some variety.

In the following pages, the five types and the major subtypes will be reviewed. This review is not designed to present the mathematical and statistical methodologies. Reviews of these methodologies can be found in several books and articles, some of which are included in the bibliography. What will be provided here are the logical steps involved. Mathematical and statistical equations will be included only when they contribute to the general understanding of these logical steps.

A. Linear Regression

Fifteen jurisdictions use linear regression for projections, six of them exclusively.

In linear regression, a relationship between two variables is expressed as a straight line. An equation for a straight line is $y=ax+b$, where a is the slope of the line and b is the y intercept. In order to identify the line which best describes the relationship, it is customary to choose a line for which the sum of the squares of the differences between y's on the line and their corresponding real y is a minimum. The attempt is to minimize the expression $\Sigma\ (y-y')^2$ or $\Sigma\ [y-(ax+b)]^2$. (The two equations are equal because in a straight line $y' = ax+b$.)

The values of a & b can be determined through matrix algebra techniques.

The way in which linear regression can be used to make projections is obvious: in a solved equation, if we determine the value of x, we can project the value of the corresponding y.

Linear regression can be used with any independent variable (x), but in projections of prison populations it is customary to take "time" as the independent variable. In a time series, "time" only goes up. (After 1980 there will always be 1981, never 1979.) Consequently, linear regression projects a continuation of the straight line established for prior observations. "Time", in a sense, is used here as a "dummy variable". In reality, past trends of y determine its future values.

When linear regression is discussed as a projection method, the dependent variable is always the projected prison population. However, linear regression as a statistical technique may also be employed as a part of other projection methods.

TABLE 6-1. USE OF FIVE PROJECTION MODELS AMONG U.S. JURISDICTIONS AND CANADA

	Number of Jurisdictions Relying on the Method	Number of Jurisdictions Relying on the Method Exclusively
Linear Regression*	15	7
Multiple Regression	6	1
Ratio**	5	1
Simulation	18	14
Time Series	4	1
Other	5	5
None	7	7
Total	60	36

*This includes non regression linear models.
**Includes combination of ratio and exponential function (Guam).

While the role of the slope and the intercept in projecting future trends is clear, equally important are two additional quantities associated with regression analysis -- the coefficient of correlation and the distribution of the residuals. Regression analysis chooses the "best" fitting line. The coefficient of correlation (r) tells us how good is this "best" fit. Many times even the best fitting line for a particular relationship does not inspire confidence in predicting accurately the value of y from the value of x. This would occur whenever the actual values of y differ significantly from the corresponding y's. Only very high coefficients are usually accepted for linear regression (as a projection technique).

The distribution of the residuals usually receives less attention than the correlation. This may be a mistake. The residuals are actually the deviations of the actual y's, from their corresponding y's on the "best fit" line. If these residuals are not distributed randomly (or equally) around the regression line, the relationship between the variables is not linear and projecting the linear line into the future would produce grave errors. The importance of a careful examination of the residuals is commonly demonstrated in the following example: Suppose we are studying the relationships between the first ten integers and their squares. These numbers and their corresponding squares are:

1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100

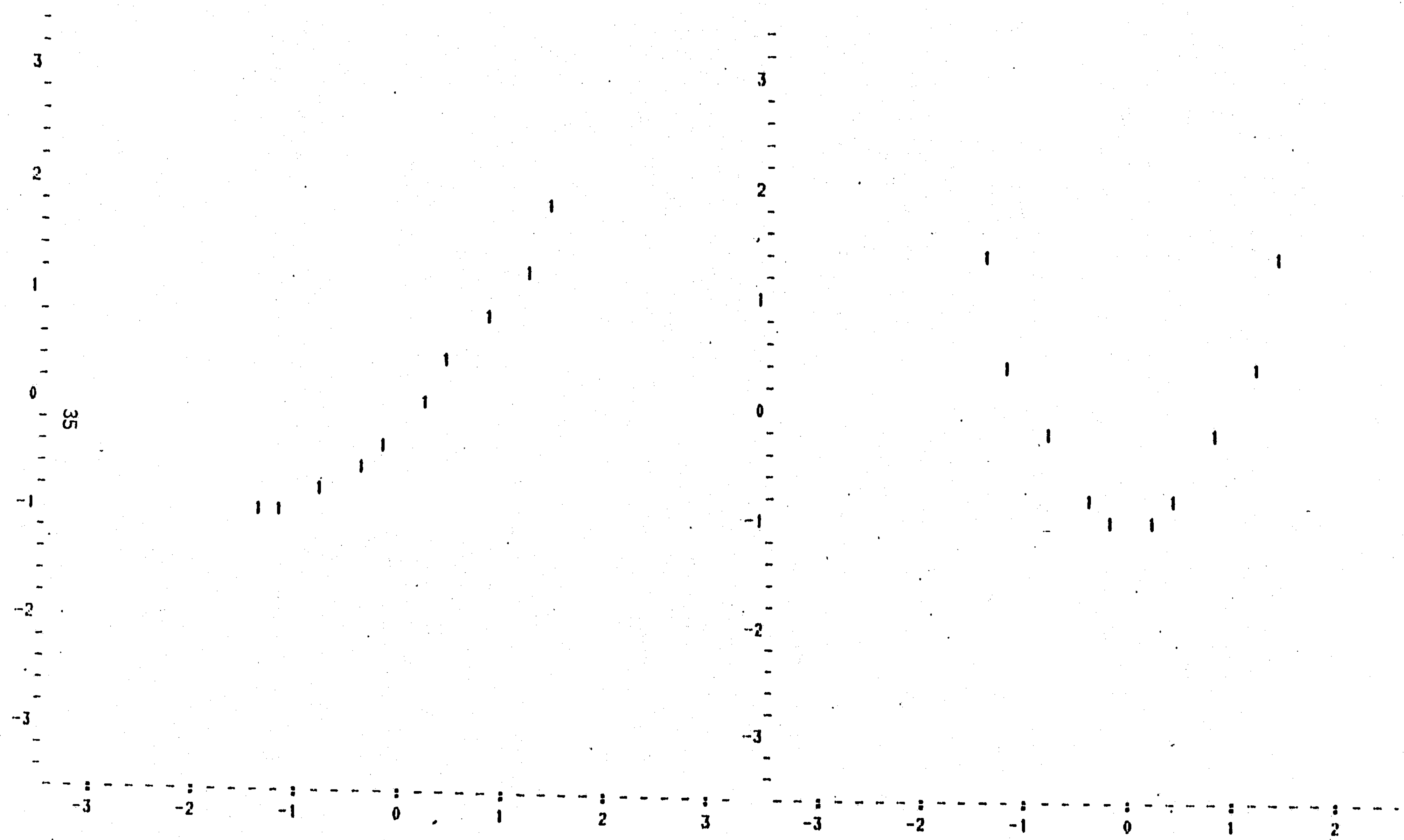
The correlation coefficient (r) of the regression is very high (.97). We would normally be happy with much smaller correlation coefficients. Despite the high correlation, the regression analysis fails to predict observation No. 11 accurately (99 instead of 121) and the discrepancy between the expected value of y (y') and the observed y keeps widening with each additional observation. Even when 11 and its square are added to the regression equation, the correlation coefficient is still a high .93. The non-linearity of the relationship between the numbers and their squares is evident in viewing a scattergram of the values of the two variables, and even more evident in viewing a scattergram of the residuals and the fitted line, as demonstrated in Figure No. 6-1.

The linearity of the relationships between two variables can be tested in several ways. A standard program such as IDA analyzes linearity through scattergrams of the residuals, "runs" of the residuals, normal cumulative probability plots of the residuals, Skewness and Kurtosis, coefficients, and a plot of the residuals. IDA also provides warnings whenever the residuals are excessively auto-correlated, an indication that they are not randomly distributed around the regression line.

FIGURE 6-1.

SCATTER PLOT OF 10 STANDARDIZED VALUES OF SQ VS. NUM

SCATTER PLOT OF 10 STANDARDIZED VALUES OF RESIDU VS. FITTED



	MEAN	STD.DEV.
VERT. VAR.	3.8500E+01	3.4174E+01
HORIZ. VAR.	5.5000E+00	3.0277E+00

SAMPLE SIZE = 10

	MEAN	STD.DEV.
VERT. VAR.	0.0000E+00	8.1240E+00
HORIZ. VAR.	3.8500E+01	3.3304E+01

The issue of linearity raises a related problem. Choosing the base period for the regression may affect the projections. Figure 6-2 presents again Illinois Prison Population between 1965 and 1980. Included in this figure are the regression line for the entire period and a two segment regression line. It is clear that the base period 1965-1980 would provide a different projection than the period 1974-1980. Even when the differences between base periods are not so obvious, the decision about the proper base period does make a difference. Table 6-2 provides three sets of projections for the Illinois Prison System. The first set is based on the period 1965-1980, the second on 1974-1980 and the third on 1977-1980.

It is clear that using the entire period as the basis of projections will lead to grave errors. In fact, the 1981 projection is 2000 inmates under the 1980 actual population. Less obvious is the difference between the two other base periods. Without any clear turning point between 1974 and 1980, the two base periods still produce widely divergent projections. Choosing the right base period requires better understanding of the system. In Illinois, the difference between the two base periods probably has something to do with: 1) The practice of early releases of prison inmates which started in December 1980, first as a result of a court order and then as part of departmental policy of reducing crowding conditions in the system; 2) Temporary effects of the new 1978 determinate sentencing legislation.

A regression analysis may provide a standard error for the predicted population. This error appears in parentheses in Table 6-2 (IDA would do it automatically for projections of future values of y). This error is a function of the deviation of the residuals from the line, the length of the base period and the length of the projected period (the longer the projection -- the higher the error). Forecasters should not ignore this standard error. If it is not within their acceptance of error range, they should not rely on the projections produced by the regression.

In assessing the feasibility of using linear regression, some definite advantages of the method emerge. It is very easy to validate, does not rely on any outside projections, and employs few assumptions (actually only one assumption, although it is a big one: that the past trend will continue into the future). In addition, it scores high on all the practical considerations: It is cheap to maintain, requires no specialized personnel and very little maintenance efforts, can be produced fast and often and requires a set of data (end year or average population) which is visually more reliable than most.

If linear projections in the past have proved to be accurate, linear regression may be a good tool. However, it will fail to measure the impact of changing circumstances, will not project turning points, and will provide very little specificity for the projections (at most, separate linear regressions can be used for separate sub-populations).

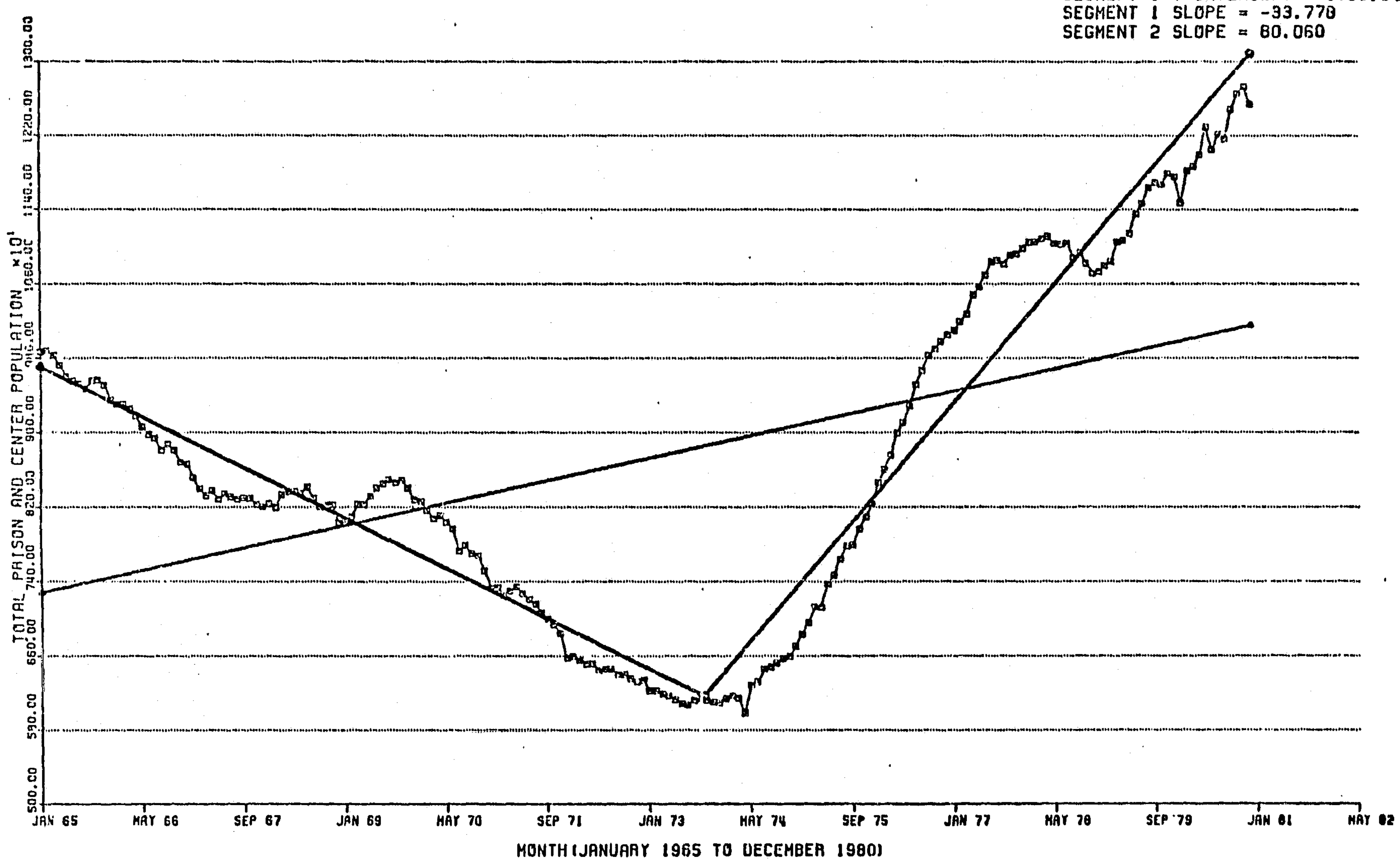
FIGURE 6-2.

ILL. PRISON AND CENTER POPULATIONS: 1965-1980

RAW DATA SERIES = ⊡
SIMPLE REGRESSION LINE = △
TWO-SEGMENT LINE = ⊙

SIMPLE REGRESSION LINE: SLOPE = 15.051
INTERCEPT =7264.429

TWO-SEGMENT LINE: TURNING POINT = 105.6
SEGMENT 1 Y-INTERCEPT = 9739.941
SEGMENT 1 SLOPE = -33.770
SEGMENT 2 SLOPE = 80.060



ILLINOIS LAW ENFORCEMENT COMMISSION (CJIS)
STATISTICAL ANALYSIS CENTER GRAPH

TABLE 6-2. PROJECTED ILLINOIS PRISON AND CENTER POPULATION FOR THE YEARS 1981-1983 (END YEAR) THROUGH LINEAR REGRESSION WITH THREE BASE PERIODS (S.E. OF PREDICTED POPULATION)

Base Period	1980 Population	1981 Projected Population	1982 Projected Population	1983 Projected Population
1965-1980	12,539	10,335 (1,640)	10,515 (1,644)	10,696 (6,648)
1974-1980	12,539	14,029 (572)	14,985 (580)	15,940 (589)
1977-1980	12,539	12,823 (282)	13,343 (295)	13,863 (311)

It is also hard to find any theoretical justification for it.

A recent improvement to linear regression -- the two segment line -- does provide a better analysis of past turning points, but cannot project these turning points into the future.

As is true for all projection methods, linear regression should always be supplemented by a careful analysis of past trends. If past turning points are better understood, their likelihood in the future can then be estimated and linear regression can then be used only when no turning point is expected.

We have emphasized the importance of analyzing the residuals to determine linearity. Sometimes, non-linearity can still be corrected by manipulating the dependent or the independent variables. A common practice is to log the independent variable. Technically, this procedure actually transforms the function to a non-linear one, although it is not treated as such here. When data transformations such as these are needed in order to transform a non-linear function into a linear one, specialized personnel may be needed.

Finally, while linear regression is at best a crude method of projection, with very little effort, it could be used as a supplemental method for fast, short term projections, even when other, more sophisticated, methods are available.

B. Multiple Regression

Linear regression is actually a special case of multiple regression, but when multiple regression is referred to, it is implied that there are two or more independent variables. An additive function which describes this relationship may get the form:

$$y=a + b_1x_1, + b_2x_2+\ldots\ldots. b_kx_k$$

Again, the values of a and b can be estimated and a best fit line established. The preceeding discussion on linear regression applies to multiple regression as well. The relationship itself cannot be graphically illustrated the way linear regression can because it is multi-dimensional. The residuals, however, can be graphically illustrated and should be vigorously analyzed for signs of non-linearity or non-randomness of any other kind - (seasonally, for example).

While it is conventional wisdom that "multiple regression" implies at least two independent variables, for our purposes, every regression analysis in which the independent variable is not "time" is regarded as multiple regression (only one state uses one non-time independent variable).

Unlike time, other independent variables in a regression may go up and down in a time series. Therefore, while the regression line will always be straight, the projection line will not. For example, if it is determined that prison population would go up and down with unemployment, if unemployment is projected to go down, so will prison population.

The two major indicator groups used in multiple regression have been unemployment and risk group population. Criminal justice data have also been used.

Presently, risk group population has two advantages over other indicators. There is a considerably longer data base and future populations can be projected with some confidence.

Unemployment data, on the other hand, have been consistently collected only in the recent past and are very hard to project. In Illinois, consistent disaggregated and non-disaggregated data on unemployment are available only since 1970. Total unemployment data have been collected and published since 1948, but the methodology of calculating unemployment was changed in the 1970's. Data for the period after 1970 were adjusted to the new methodology (differences between the two methodologies are substantial).

For lack of lengthy series of data bases, forecasters have relied on multiple regressions with very small n's (frequently less than 10). Some states have tried to combat the problem by moving to monthly observations. Doing so may only introduce "noise" (random error) into a time series which is still very short.

With very short time series, high correlations may be coincidental. In the 1970's, unemployment and prison populations soared. This has produced very high correlations between the two variables. Table 6-3 presents a list of disaggregated unemployment data which have produced correlations of .85 or better with male felon prison population for Illinois (based on the period 1970-1980, no lag).

The breakdown to disaggregated groups is very helpful here. Of the 11 coefficients, none is for male unemployment. Of twenty-seven coefficients over .80, only three are for male groups. Fourteen are for female groups.

The high correlations between unemployment of women and male prison populations, at the very least, raises the possibility that unrelated time series just happened to co-vary during a short span of time. We suppose that some hypothetical explanation for this phenomenon can be found. Nevertheless, this example should serve as a warning against taking things for granted. More specifically, those using total unemployment in multiple regressions should consider disaggregating it to see if their theoretical reasons for including unemployment are supported.

The problem of short time series for the independent variables may be improved in time if federal and state agencies stop changing their definitions and methodologies. Potentially more serious is the difficulty in projecting the independent variables, a problem which was discussed in Chapter V.

TABLE 6-3: HIGHEST CORRELATION COEFFICIENTS AMONG 198 DISAGGREGATED UNEMPLOYMENT DATA AND FELON PRISON POPULATION IN ILLINOIS (N=11)

Age Group (1)	Location (2)	Sex (3)	Race (4)	Type (5)	Correlation with Felon Population
25-44	T	F	NW	N	.89
25-44	T	T	NW	N	.87
16+	T	F	T	N	.87
25-44	SMSA	T	NW	N	.86
20-24	CCC	T	T	R	.86
16+	CCC	F	T	R	.86
25-44	CCC	T	NW	N	.85
25-44	T	F	T	N	.85
16+	SMSA	F	T	N	.85
20-24	SMSA	F	T	N	.85
20-24	CCC	F	T	R	.85

Note: 198 unemployment variables were used overall, the disaggregations were:

(1) Age group = 4 (16-17; 18-19; 20-24; 25-44) except for Chicago SMSA where 16-19 replaced 16-17 and 17-18.
(2) Location = 3 (Total, Chicago Center City, Chicago Standard Metropolitan Statistical Area SMSA).
(3) Sex = 3 (Male, Female, Total).
(4) Race = 3 (White, Non-White, Total).
(5) Type = 2 (Numbers, Rates).

Since forecasters have difficulties in projecting economic and criminal justice data, they tend to assume that continued levels of the independent variables will remain unchanged, will go down, or will go up. Under these circumstances it may be wise to make similar assumptions directly for prison populations. After all, these forecasters know the prison system at least as well as they know the ups and downs of the economy. Even with criminal justice data as independent variables, we feel that forecasters may be better off projecting prison populations directly, because here they are aware of some definite constraints, such as prison capacity.

This discussion does not mean that multiple regression should not be used with economic and criminal justice data as the independent variables. Such an analysis does provide much insight into the changes in prison population and may provide reasonable estimates for comparing the impact of two or more economic or criminal justice scenarios.

Unlike most other indicators, population data have been available for several years. Census data are considered reasonably accurate and data for in-between periods can be extrapolated by the forecaster or may already be available in federal or state agencies (state agenices interested in this kind of information are budget bureaus, departments of education and commerce and planning agencies). Our own experience with projections of Illinois disaggregated populations has shown reasonable accuracy, although some migration patterns have not been fully anticipated.

Any time multiple regression is used for projecting prison populations or as part of any other projection technique (see discussion on simulation), the impact of <u>multiculinearity</u> on the regression analysis should be considered. Some degree of multiculinearity exists whenever independent variables have a correlation other than zero. It creates problems when this correlation is very high. Multiculinearity may lead to high standard errors, among other things. A way to avoid the problem is to modify one of the variables in a way that will negate its relationship with other(s) independent variable(s) but not with the dependent one. This difficult task may be done on a trial and error basis or on the basis of more solid theoretical and logical foundations.

Multiple regression will be able to project certain turning points, may have some theoretical support and scores high on all practical considerations (but not as high as linear regression). It cannot measure the anticipated impact of most changes and provides no specificity. It is easy to validate, but this may mean reducing a number of observations which may already be too small. It relies on outside projections and will fail whenever these projections are proved to be incorrect. A reliance on few past observations may put too much emphasis on shakey assumptions.

C. <u>Ratio</u>

The relationship between two variables can always be expressed in ratios. If the ratio and one of the variables can be projected, the other variable can be projected as well.

If $r = \frac{y}{x}$

then

$y = r\,x$,

where r is the ratio and x and y are the two variables.

In this equation y can be projected when the future values of x and the ratio can be reliably estimated. Several states do feel that this can be done, in particular with demographic indicators such as the general population or any risk group.

The first step is to establish past ratios which can easily be done and can be graphically illustrated. Figures 6-3 and 6-4 provide graphic illustrations of the ratio of Illinois male prison population per males between the ages of 17-39. Figure 6-3 charts changes in the rates of all male prisoners and Figure 6-4 is confined to felons only. For convenience, the ratios have been multiplied by 100,000 to provide rates of persons in institutions per 100,000 members of the risk group.

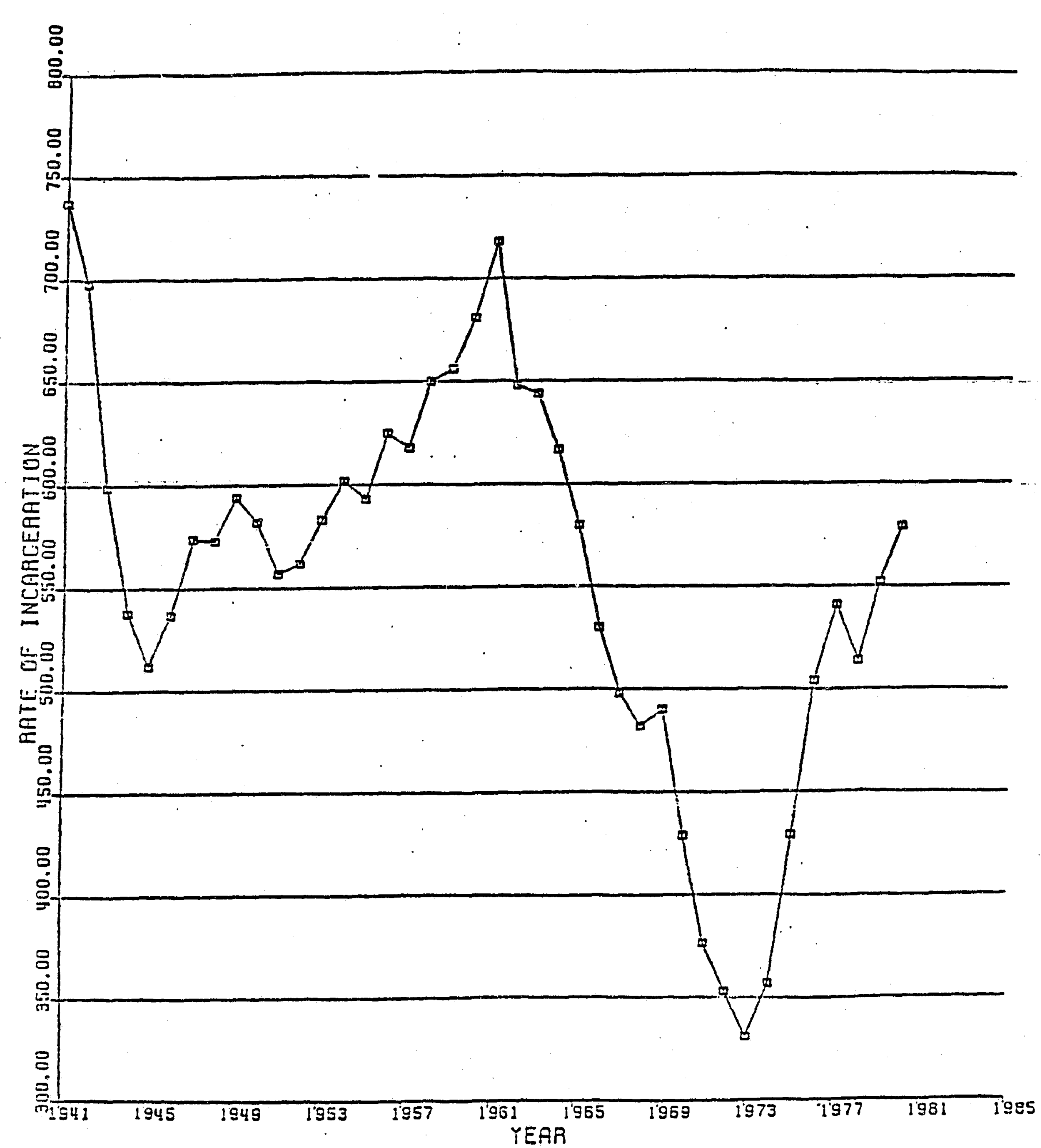
Some social scientists claim that incarceration rates in a society tend to stay at an equilibrium. We suppose that it could be argued in a very general sense that Figures 6-3 and 6-4 support the claim. However, at least for prison populations, the fluctuations should not be ignored.

Whenever these rates fluctuate, forecasters have to determine what rates to rely upon.

FIGURE 6-3.

RATES OF INCARCERATION IN ILLINOIS: 1941-1980

(MALE PRISON POPULATION PER 100,000 MALES 17 TO 39 YEARS OF AGE)

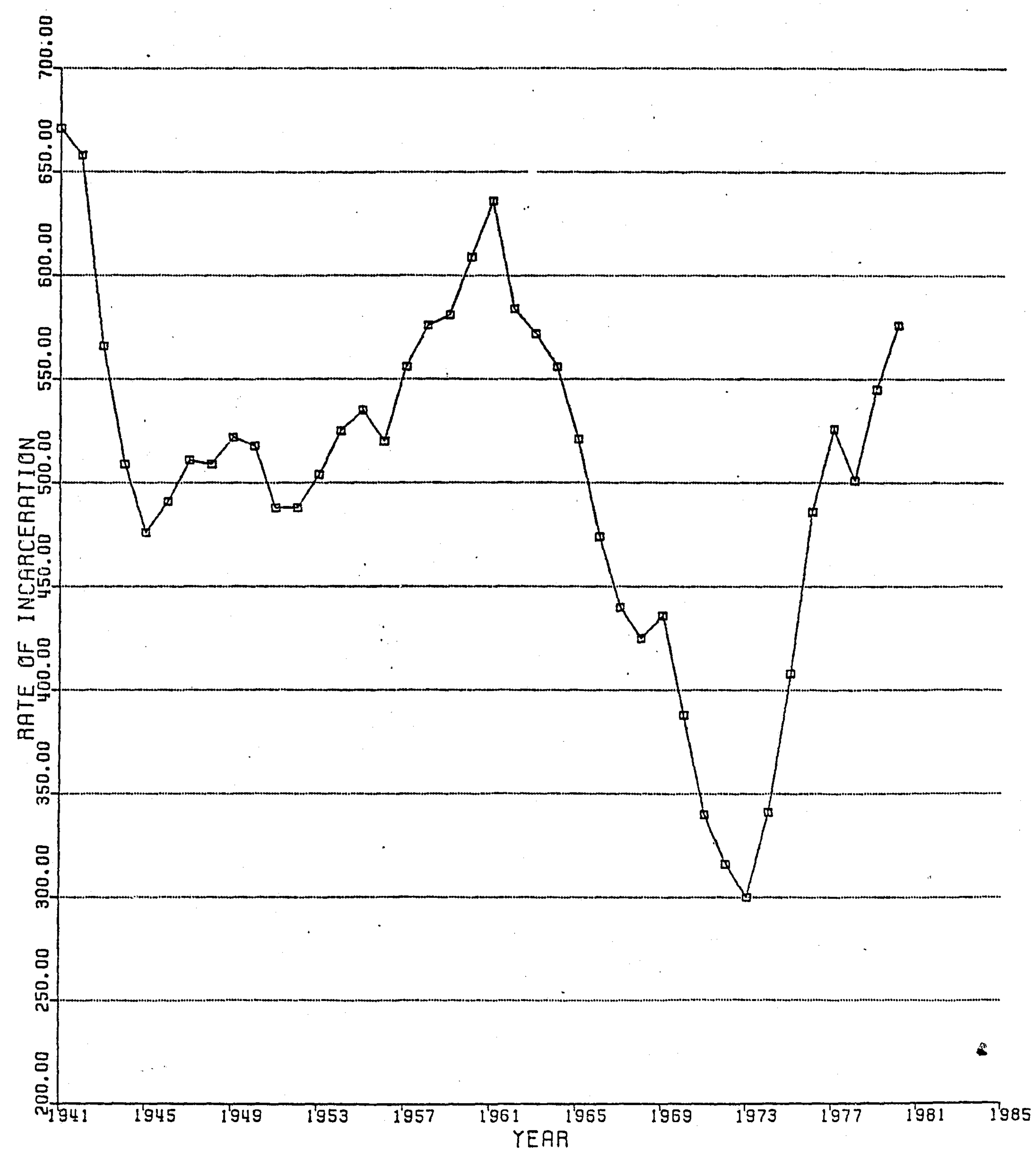


ILLINOIS LAW ENFORCEMENT COMMISSION (CJIS) STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 6-4.

RATES OF INCARCERATION IN ILLINOIS: 1941-1980

(MALE FELONS ONLY PER 100,000 MALES 17 TO 39 YEARS OF AGE)



ILLINOIS LAW ENFORCEMENT COMMISSION (CJIS) STATISTICAL ANALYSIS CENTER GRAPH

The conventional wisdom is that recent ratios are probably more indicative of future trends than old ones. If even recent periods show considerable variations in ratios, researchers can either average the ratios in the significant period or establish a trend and continue it into the future. Averaging makes sense only if ratio differences are assumed to be random error. If this assumption cannot be made, any suitable statistical method can be used to establish the nature of the trend, including linear regression (with or without modifications), non-linear smoothing, moving averages, and any other time series approach.

Some states use the ratio model in steps. Instead of calculating the ratios of prisoners per population, they calculate ratios for several intermediate criminal justice steps. For example, 1) crimes per population; 2) arrests per crimes; 3) convictions per arrests; 4) admissions to prisons per convictions; and 5) prison population per admissions. Seemingly, this procedure will not improve the initial projections. After all 8 x ¼ will always equal 8 x ½ x ½. However, the advantage of the procedure is that whenever an error in the projections occurs, it can be traced to a particular step, leading to a better understanding of the mechanisms involved. This better understanding will eventually lead to better projections. Even for initial projections, future ratios for each step may be fine tuned to produce better projections.

If the age composition of the prison population is known, ratios can be used separately for different age groups. Doing so in combination with the inclusion of some intermediary steps brings the ratio approach closer to some of the simulation models.

Although we discussed here ratios per population, the same approach can be used with any other conceivable indicator as long as it makes sense, can be supported by some theoretical arguments and produces good results. The advantage of demographic indicators is merely that their projections are more reliable than most.

The method receives high marks for ease of validation, reliance on minimum outside projections, and on all practical considerations.

The level of specificity it provides is low, its versatility is limited and it can project only turning points produced by projected drastic changes in the indicator. Consequently, the method is not very sensitive in measuring the impact of proposed sentencing legislation. This legislation affects sentencing directly and prison population only indirectly. There is always a time lag between the full impact on the two and the ratio method cannot produce estimates on this time lag. Assuming that enhanced or reduced numbers of releases will simply compensate for sentencing changes will lead to grave results, as indicated by the vast increases of prison populations in the 1970's.

The method will therefore produce better results in states with proven stability of rates of incarceration and no plans for major changes in the criminal justice system.

D. Simulation

Simulation seems to be the most popular approach in recent years. More and more states are trying to adopt it. The sketchy data on accuracy of projection methods do not provide evidence yet that this approach leads to more accurate projections. Even so, many states are still interested in it. It is primarily due to some potential benefits which will be discussed later.

Despite these potential benefits, states should not rush into any simulation technique without careful preparations and a long test period in which the procedure is tested and is supplemented by other methods.

Although the method generally requires more special programming than any other, we believe that the most difficult steps involve preparing the files for the simulation procedure and not using the procedure itself.

Previous surveys discussed simulation as a single technique. In reality, simulation is only a general category of several techniques which have some things in common but are different in some important details.

All simulation techniques can usually be expressed in one or the other of the following two general equations:

1. Population = admissions x length of stay, or

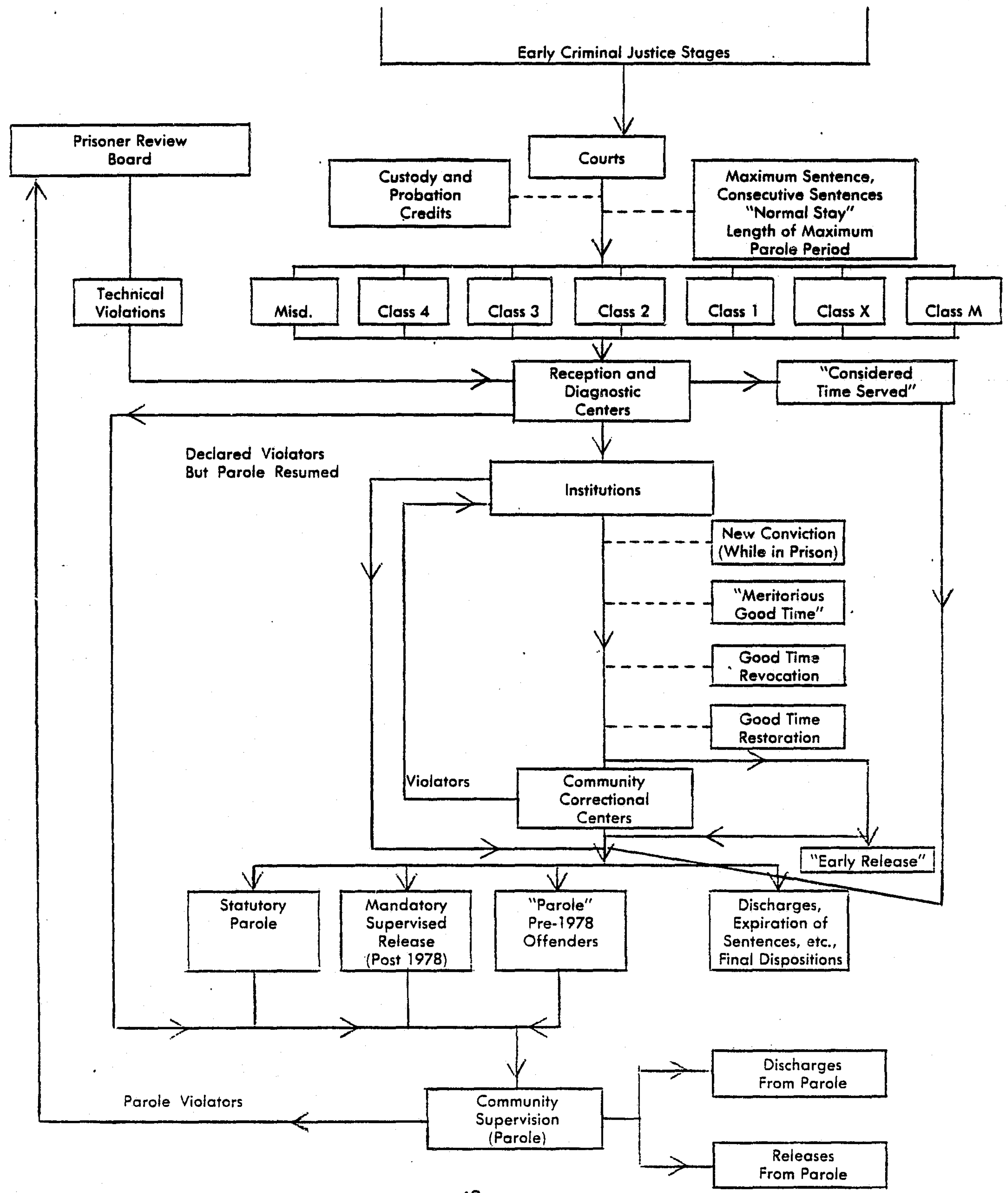
2. $P = P^1 + A - R$, where P is the projected end year population for the year in question, P^1 is the population in the previous year, A is the number of admissions during the year in question and R is the number of releases during this year.

In order to simulate the process which leads to projecting P, two parameters have to be estimated--admissions up to the date(s) for which the projections are made and releases up to that point. That is why simulation techniques are sometimes referred to as inflow-outflow models. Actually some crude simulation approaches project population without really projecting releases, because they are based on equation No. 1 without getting into the specificity of equation No. 2.

Simulation models will generally (but not always) involve separate procedures for "aging" the population already in prison and for "aging" the offenders yet to be admitted (the term "aging" will refer to the release patterns from institutions). Since more is known about inmates already in institutions, projecting their release can be done with more confidence.

One of the first steps in developing a projection technique is to chart the criminal justice and correctional systems. The charts should include all stages of dispositional decisions which affect admissions or length of stay. Figure 6-5 provides a flow chart of inmates admitted to the state correctional system in Illinois. The solid lines represent the physical flow of inmates through major stages. The dotted lines represent behavior or dispositional decisions which affect the length of stay in

FIGURE 6-5. FLOW CHART OF INMATES ADMITTED TO THE ILLINOIS DEPARTMENT OF CORRECTIONS



institutions. Not included in the chart are external variables such as age, sex, and race of the offenders These variables should be considered in building the simulation files because they may affect both admissions to, and releases from, the system.

When the entire system is charted, decisions can be made whether simulation would be a reasonable approach and if it is--what particular technique should be used. In making these decisions, the nature of the available data base should receive the utmost consideration. Some of the questions to be asked are:

- o "Are good data available for all or most of the stages and the disposition decisions?"
- o "Are the data available for individuals or only in aggregates?"
- o "If some data are not available, can their impact be estimated?"
- o "Is the information computerized?"
- o "Is it available in a form which can be utilized by a simulation program, and if not--what transformations are necessary?"

The simulation methods currently in use differ in their approaches to projecting admissions and projecting releases.

1. <u>Projecting Admissions</u>

Technically, projection of admission is not part of the simulation itself, but it is, nevertheless, an important part of any simulation model. There are three major approaches:

a. Projecting admissions through linear regression. The earlier discussion on linear regression applies here almost in its entirety.

b. Projecting admissions through multiple regression. The earlier discussion on multiple regression applies here almost in its entirety.

c. Projecting admissions through ratios. The earlier discussion on ratios applies here almost in its entirety. Establishing ratios for intermediate steps is the goal several states are striving for.

The only issues in the previous discussions on the three methods which do not apply here are those related to the attempts to directly project end year populations. For example, all three approaches suffered from lack of specificity. This problem is reduced in simulation models because admissions and releases are projected separately.

Although currently only these three general approaches are in use, admissions in the future can be projected through exponential smoothing, moving averages or more sophisticated univariate or multivariate time series techniques.

Within the three general approaches to projecting admissions, there is room for additional sophistication. The most prominent improvement is disaggregation. At the moment, it is done mainly with ratios, but can easily be adapted to linear regression. The goal of disaggregation is to isolate divergent impacts on the system so they could be identified and measured. The most common disaggregations are by age, race, sex, and type of crime, but other disaggregations are possible (urban-rural, for example).

Disaggregation leads to the creation of several cells. For example, disaggregation by sex (2 categories), race (2) and age (5) would produce 20 cells (2 x 2 x 5). If five types of crimes are added to the disaggregation, 100 cells would be produced. The problem with too much disaggregation is that it will produce too many cells, several of them empty. Because the rate of women admitted to state prisons is low, full disaggregation of females is, therefore, not recommended.

The merits of disaggregation can be demonstrated by a few examples.

a. In a certain jurisdiction, most offenders committed to the state system are of certain age groups. If the size of this "risk" group is expected to decline in the future, admissions to prison will be expected to decline accordingly. While rates of admissions for each disaggregated group remains the same, the general rate of prison commitments may still decline.

b. New legislation affects admissions of a certain class of offenders. Since past sentencing patterns for this group are known, the impact of the legislation on the group can be estimated and through it -- the impact on overall admission rates.

The preceding discussion introduces not only some possible merits for disaggregation but also introduces its major prerequisite: the need for a good data base on sentencing patterns of disaggregated groups. This condition cannot be always fulfilled. Even when good data are available, they are usually available only for the most recent years, not enough to establish trends.

When data on disaggregated groups are not available, states estimate their parameters using several sets of assumptions, hoping that several likely errors will cancel each other.

2. Projecting Releases

True simulation means an attempt to recreate the movement of an inmate through the system until he/she leaves.

Ideally, probabilities are assigned to each stage in the criminal justice and correctional flow charts. This invites the use of a model such as a Markov chain in which a matrix of probability vectors is assigned to movements between states in the chain. Note that we are not only interested in the probability of movement from one state to another but in the probability that this will happen during the year in question.

Our own definition of simulation is less strict and includes every method in which admissions and releases are projected separately. In many states, the data base will not support anything more than the most basic simulation approach.

The simplest methods for projecting releases involve linear regression and ratios. In linear regression, past trends of release determine future ones, regardless of admission trends. This approach was suggested by the ABT report, but we have not found it in use in any of the jurisdictions we have surveyed. The ratio approach projects releases on the basis of their past ratios to admissions.

Another technique ignores the projection of releases altogether. Projected admissions are multipled by projected length of stay as a way to estimate resident population. This requires producing estimates of the length of stay. The traditional method of averaging the length of stay of persons released from institutions over-represents short termers. Disaggregation may reduce this problem but not solve it. A system of weights may also be used to correct the imbalance, but setting the weights may require information which is hard to obtain.

The best solution in our opinion, is to estimate length of stay by dividing population (P) by admissions (A).

$\frac{P}{A}$ = estimated average length of stay.

The advantage of this approach is that the same relationships are actually projected into the future.

P = A x estimated average length of stay. The most accurate approach to estimating length of stay requires following a cohort of admissions until all members are released. This is an impractical approach for states using the simple approach of multiplying admissions by length of stay. These states probably use the simple approach because others are too expensive, time-consuming, and cumbersome. Following cohorts for many years <u>is</u> very expensive, time-consuming, and cumbersome. In addition, this procedure is not sensitive to recent changes. If the maximum sentence for a particular offense is five years, following the cohort for five years to establish an average stay may reflect a five year old sentencing policy and not a more recent one.

The more sophisticated techniques of estimating releases involve some type of "probability functions". (The term is used here in a very broad sense.)

Releases are projected by applying these release probabilities on offenders projected to be admitted into the system. These probability functions are estimated from prior experience. When 30% of an inmate group are released within a year, the probability of staying at least one year is estimated as .70.

These probability functions are determined sometimes by following cohorts until their release and other times through other means.

Whatever the process, several assumptions have to be made before the probabilities are estimated.

One of the techniques used to estimate release probabilities is by incorporating the average sentence length in an exponential function which describes the start of release probabilities around the average. This procedure relies on the ability of the forecaster to determine a reliable average and on the "fit" between the exponential function and real data.

The problem of estimating release probabilities is reduced in states with determinate sentences when the length of stay is more predictable.

Disaggregation of offenders can be used for simulating releases the same way it can be used to estimate admissions. By doing so, it is possible to measure the impact of changes in the composition of the prison population on the expected number of releases. It also makes it possible to assess the impact of legislation affecting the length of sentence of particular offender groups (such as increasing penalties for certain offenses).

Since "simulation" refers to a variety of techniques, it is not easy to discuss the merits and demerits of the model. Nevertheless, some general comments can be made.

The major advantage of a <u>good</u> simulation technique is the diversity of tasks it can perform. It can measure change, project <u>some</u> turning points and provide a level of specificity which is higher than other methods. Despite these definite advantages, its drawbacks should not be overlooked.

A simulation program is an expensive proposition. It requires computer time, programmers, and other personnel to develop the technique.

The job does not end with the program in place. Data files have to be continually updated, assumptions employed have to be continuously checked and the entire program should be continuously under inspection. While the program may be designed, instituted, and maintained with the help of outside consultants, personnel inside the department should also be trained for updating and running it. In short, simulation is a long term investment and not a one shot deal.

When the program is set in motion, it will not always be able to produce immediate projections at all times upon request because of the time and expense involved. A backup technique for fast short term projections may be necessary.

Simulation programs do have to rely on several assumptions about commitment rates and length of stay of several groups of defenders passing through several stages in the correctional system.

If these assumptions are tested and readjusted, they may be used to the advantage of the forecaster. If subsequent tests of the model cannot test the accuracy of these assumptions, this problem is likely to generate

serious difficulties. For example, some states may not have good computerized data bases on the practice of good time or jail time credits. If assumptions are made and the projections are inaccurate, newer assumptions will be based on no more than educated guesses.

<u>It is not sufficient to readjust assumptions so their overall impact will produce good post-dictive projections. Two bad assumptions which cancel each others error in a validation study may not do so for future projections.</u> For example, it may be assumed that all classes of offenders gain or lose equal amount of good time per unit time. This general assumption generates a set of assumptions about prison behavior of different classes of offenders. Good time can then be adjusted to produce good results. These adjustments will not improve projections if some classes lose or gain credit more than others. Error in projections will occur whenever the distribution of offenders admitted to prison changes.

The validation of simulation programs is another potential problem. Since some states have had reliable computerized data bases only for a few recent years, the tendency is to validate the simulation of the period which served as the basis for estimating the parameters of the model (numbers of persons admitted, length of stay). This usually leads to successful validations, but will not guarantee accurate projections in the future.

Despite the pitfalls discussed here, the price may not be too high to pay for systems interested in specificity, measuring the impact of legal, administrative, and even demographic changes or long term improvements in projecting turning points. If the decision is to proceed with developing the technique, it should be done with great care as a long-term project which may take years to perfect.

E. <u>Time Series or Non-Linear Methods</u>

Non-linear or semi-linear techniques have not been used extensively in projecting prison populations. The field is still wide open for exploration and it seems that in recent years attempts to use such models have increased. The same techniques used for projecting prison populations directly may be used for projecting admissions in simulation models. The benefit of time series techniques may indeed be greater in that capacity.

Some jurisdictions use curve smoothing in their projections more as an art than as a science (simply following the general line of the curve). At the other extreme, some jurisdictions rely on sophisticated ARIMA models (autoregressive integrated moving averages) which identify type of the time series (autoregressive, moving averages, or mixed), identify its characteristics (stationarily, seasonality) and estimate the parameters of the equation which describes it. Rarely used--if at all--are several other possible techniques such as exponential smoothing and others.

All of these methods require some expertise in mathematical models.

Even though ARIMA models are available in several packaged computer programs with easy to follow steps, using them for projections requires more than following some prescribed formula.

Models may indeed provide a definite improvement over linear regression. In a way, ARIMA models start as multiple regression models in which prior values of y are the independent variables in the equation:

$$y = a + b_1 y_1 + b_2 y_2 + \ldots . b_k y_k + u:$$

Where Y^k represents the value k years prior to the year in question to which x is being projected.

These models rely heavily on autocorrelations and partial autocorrelations in determining characteristics such as seasonality and stationarity (a system is stationary when no trend is detected).

For ARIMA models to be effective, the series has to be stationary - a rare occurrence in social sciences in general and prison populations in particular. Consequently, differencing the time series at least once is almost always a must (differencing transforms a time series x_1, x_2, $x_3 \ldots\ldots. x_n$ to a series of x_2-x_1, x_3-x_2, x_n-x_{n-1}).

Differencing a series reduces the number of observations by one. Autocorrelations reduce the number of observations by the number of lags used in the autocorrelation. That is why ARIMA models require at least 40 to 50 observations. It is unlikely to see definite population patterns for the last 40 to 50 years, a period which included three wars. That is why ARIMA models would be more beneficial with monthly data for short term projections. In this capacity, ARIMA models are superior to linear regression because of their capacity to give more weight to recent observations. (Since observations at time t usually are correlated more with observations in time t-1 than they are with observations at t-2, t-3, etc.) These models can also be used successfully in determining the impact of any type of intervention in the process (new legislation, for instance). However, they cannot anticipate the impact of future observations.

ARIMA or any other non-linear approach should be considered whenever the residuals of the linear regression are not distributed randomly around the regression line.

The general literature on projections discusses many linear and non-linear techniques which have not been used at all in projecting prison populations. Some, such as multi-variate time series analysis, may hold some promise. Others are more available for economic analysis. In fact, time series techniques and non-linear models are merely borrowed by prison forecasters from other fields. Many have to be adjusted to the special problems involved in projecting prison populations.

F. Reviewing the Method

In this chapter, we have reviewed the major projection methods currently in use. We have intentionally avoided technical analyses of the methods. There is vast literature on several of the methods discussed and on several others which are not currently being used for prison projections. A short selected bibliography is included at the end of this report for those interested in the mathematical and statistical steps involved.

The five major types of projection techniques discussed in this chapter are compared in Table 6-3. The comparison is done on the basis of the 13 criteria for assessment discussed in Chapter IV. Much of the assessment is based on our subjective judgment.

Accuracy is a question mark for all methods. Only time and experience will tell which method provides better projections for a particular jurisdiction. A method receives a "+" whenever it rates favorably on a particular criterion and "-" whenever it is judged unfavorably. "+ -" means that much depends on circumstances or that there are some good points and some bad ones. The table includes two comments whenever our crude scoring system needs to be supplemented, or whenever it is considered inappropriate.

TABLE 6-3 COMPARING MAJOR PROJECTION TECHNIQUES

	Linear Regression	Multiple Regression	Ratio	Simulation	Time Series, Non-Linear Models
Accuracy	?	?	?	?	?
Validation	+	+	+	-	+
Measurement of Change	-	-	-	+	+ Measure Impact of past intervention
Ability to Project Turning Points	- None	+- Some, when turning points in the indicators can be projected.	+- Some, when turning points in indicator can be projected.	+ Can be adjusted to project turning points more likely to occur.	+- Some, short term fluctuations more experience necessary.
Level of Specificity	- Minimal	- Minimal	+- Minimal to Moderate	+ Best	+- Minimal to to Moderate
Theory	- Very little theoretical contribution	+- Some possibilities	+- Some possibilities	+ Several Possibilities	+- Some possibilities
Reliance on Outside Projections	+	- (except for demographic indicators)	+-	+-	+
Reliance on Assumptions	"Past trend will continue"	"Past trend will continue"	"Past trend will continue"	Several assumptions or on the continuation of several trends and on parameters of simulation model.	Past trend patterns will continue
Money	+	+	+-	-	+-
Personnel for Instituting	+	+	+	-	+-
Personnel for Maintenance	+	+	+	-	+-
Time	+	+	+	-	+-
Nature of Data	Minimal data needed.	Good only for recent years.	Minimal data needed but may be expanded.	Requires several data bases. May be a serious problem.	Minimal data needed.

VII. SUMMARY AND CONCLUSIONS

This report was not intended to teach the art of projecting prison populations or to develop new methodologies. It should be viewed merely as an attempt to review what is being done in the field by U.S. and Canadian jurisdictions and what issues are of major concerns to these jurisdictions.

It is clear that the field is still in its infancy. The study of potential indicators has not yet produced anything more than adequate guesses about the future relationships between indicators and prison populations. Great strides have been made in improving methodologies. Nevertheless, much has yet to be done. Much of the current methodology is borrowed from other fields, particularly from economic and demographic forecasting. Forecasters of prison populations have yet to develop their own methodologies, suitable for solving problems which are unique to the criminal justice system.

We feel that improved lines of communications among forecasters, policy makers, and other interested parties are a necessary condition for improving methodologies in the future.

In developing these new methodologies, policy makers, as well as forecasters, should not ignore some very important considerations.

The first and foremost of these considerations is the definition of the goal(s) of the projection model: What does it have to accomplish? Are short term projections sufficient or are long term projections also necessary? Should the model be strictly limited to projections or also used as an instrument for effecting policy decisions? Is it going to be used extensively for studying the impact of new conditions or only for presenting a few alternative scenarios?

Once the goals are set, the available data bases should receive prime consideration. It can not be overstated that any projection technique is only as good as the data which support it. Therefore, while striving toward more sophisticated approaches is commendable, a simultaneous attempt must be made to improve data bases. Currently, most data bases are designed to inform administrative problems but are not easily adaptable to prison projections.

An important third consideration is that any method can only supplement the use of common sense and the reliance on an overall understanding of criminal justice processes. Several jurisdictions have indicated reliance on the environmental approach to forecasting but now there is a tendency to get away from that. We feel that it is absolutely essential to incorporate the informal approaches into more formal models. It is surprising that only one jurisdiction attempts to incorporate the "Delphi" technique into its projection methodology. This technique formalizes the informal opinions of a diversified group of experts.

Finally, while jurisdictions may feel an apparent need for projections, patient practice should be exercised when introducing new methodologies. Any new method requires testing of assumptions and experimentations with the data before it can be used reliably. As this survey was going on, we also developed a new simulation model for the State of Illinois. While we feel confident in the model, we also understand that several of the underlying assumptions need more testing. And the quality of the data base requires further improvement. Further testing will probably leave the general structure of the simulation model intact, although it may change its projections. Hard as it may be, thoroughness in implementing new approaches, even in the face of strong pressures to produce quick results, is recommended. In the field of forecasting, there are no simple solutions.

APPENDIX I

METHODS USED BY EACH JURISDICTION

A. SUMMARY TABLE

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Alabama	No response	-	-
Alaska	1. Linear Regression 2. Ratio	"Time" General Population	Short Term (Two segment line) Long Term
Arizona	1. Simulation 2. Simulation 3. Time Series	General Population Unemployment Rates "Time", Length of Stay Past Prison Populations	Admissions - M - R Releases - Unknown Admissions - L - R Releases - Probabilities (?) ARIMA (?)
Arkansas	Ratio	General Population	Last Projections: 1975
California	1. Simulation 2. Unclear	Risk Group (18-49), Offense distributions, Other factors affecting Length of Stay -	Admissions - Unknown (M - R; Ratio (?)) Releases - probabilities Trace Vectors. -
Colorado	Simulation	Risk Group (M, 18-49), Unemployment	Admissions - M-R Releases - Propagation Table

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Connecticut	Time Series	Past Prison Populations	"Autoreg" in SAS
Delaware	Linear	"Time"	-
Federal System	1. Ratio	Risk Group (20-36)	-
	2. Ratio	General Population	-
	3. Ratio	General Population, Convictions, Prison Sentences	-
	4. Linear Extrapolation	Past Prison Populations	Averaging the percentage of growth in last ten years.
Florida	Simulation	Risk Group (M, 18-29), Unemployment, Length of Stay	Admissions M-R Releases - Probabilities
Georgia	Simulation	Disaggregated General Population (County, Race, Age, Sex), Length of Stay.	Admissions - Ratios (?) Releases - Length of Stay (?)
Guam	Ratio	General Population, Arrests, Guilty Adults, Prison Admissions.	-

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Hawaii	Linear Regression	"Time"	Weights are used to fit exponential function to linear model
Idaho	Simulation	Male and Female State Populations, Admissions, Releases	Admissions - Ratio Releases - Ratio of Releases to Admissions
Illinois	Linear Regression	"Time"	Two Line Segmented Linear Regression. Simulation Model is in progress.
Indiana	No response.	-	-
Iowa	No response.	-	-
Kansas	Linear Regression	"Time"	-

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Kentucky	Simulation	Lagged Unemployment Length of Stay Several Adjustments	In progress Admissions - M - R Releases - Length of Stay
Louisiana	Ratio	No Information	In progress
Maine	Multiple Regression	"Risk Groups (18-34)	Independent variable was logged, and different weights were used for different age groups.
Maryland	1. Linear Regression 2. Simulation	"Time" Disaggregated General Population (Age, Sex, Race), Admissions by Type of Crime, Average Stay.	Three different base periods Admissions - Ratios, Possibly combined with M-R Releases - Length of Stay (?)
Massachusetts	Informal	Intuition, Population at Risk, Court Reform, Sentencing Patterns	-
Michigan	1. Simulation 2. Simulation	Intuition, Sentence Distribution Intuition, Average Length of Stay	Short Term (2 Yrs) Admissions - Intuition Releases - Estimated Sentence-Distribution Long Term Admissions - Intuition Releases - None

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Minnesota	Simulation	Sentencing, Revocation Probabilities, Several Individual Characteristics of Offenders, Length of Stay	Admissions - "Growth Parameter" (?), Sentencing Probabilities (Ratios ?) Releases - Probabilities
Mississippi	Multiple Regression	General Population, Number of Indictments, Unemployment	There is probably a move toward the adoption of a Simulation Model
Missouri	1. Multiple Regression 2. Linear Regression (?)	General Population Economic and Labor Indicators "Time"	It is being replaced by an unspecified method Temporary until new method is operational
Montana	1. Simulation 2. Simulation	Risk Group (M, 18-60), Release Matrix Disaggregated Population (Age)	Admissions - Ratio Releases - Probabilities based on Length of Stay Distribution Admissions - Ratio (?) Releases - Unknown
Nebraska	1. Multiple Regression 2. S Curve	Unemployment Rates of Incarceration Per Risk Group (M, 20-29)	Three Unemployment Indicators - Current and Two Lags -
Nevada	No Response	–	–

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
New Hampshire	None, except for intuition	-	-
New Jersey	Simulation	Disaggregated Population (Age, Race), Length of Stay by Type of Offense	Admissions - Unclear Releases - Estimate Probabilities or Average Length of Stay
New Mexico	Combination of Multiple Regression and Time Series	Economic Indicators (?) Disaggregated Offender Information (Age, Sex, Race, Education)	In progress. Previously - L - R and M - R
New York	Simulation	Population at Risk (15-34) Rates of Parole Readmissions	Admissions - M - R Releases - Unclear
North Carolina	Simulation	"Time" Sentence Length, Length of Stay	Admissions - L - R (For some scenarios) Releases - Probabilities
North Dakota	Intuition	Economic, Demographic Legislation	-
Ohio	Linear Regression	"Time"	-

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Oklahoma	Linear Regression	"Time"	Two Base Periods
Oregon	1. Ratio	Risk Group (15-29 ?)	-
	2. Curve Fitting	Past Prison Populations	Smoothing the curve and continuing it into the future.
	3. Multiple Regression	Several Unclear	Was not adopted
Pennsylvania	Simulation	Disaggregated Population (Age, Sex, Race), Offense Distribution, Crime, Arrests, Adjudications, Prison Sentences, Average Length of Stay	Admissions - Ratios Releases - Probabilities (Estimated from average length of stay)
Puerto Rico	Linear Regression	"Time"	-
Rhode Island	None	-	Nevertheless, has analyzed impact of legislation on future prison population
South Carolina	Multiple Regression	Population at Risk, Past Prison Populations	Several Sets of Projections

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
South Dakota	Informal Analysis of Trends	Length of Sentences, Parole Actions	-
Tennessee	Multiple Regression	Risk Group (15-39 or 20-39), Unemployment Rate, Unemployment Number	Admissions - In Progress
Texas	Simulation	General Population, Length of Stay	In Progress Admissions - L - R Releases - Propagation Table of Probabilities
Utah	No Response	-	-
Vermont	"Rate of Growth"	Past Prison Populations	-
Virginia	Simulation	"Time", Sentence Distribution, Parole and Release Data	Admissions - L - R Releases - Probabilities (?)

JURISDICTION	METHOD	MAJOR INDICATORS	COMMENTS
Washington	Simulation	Disaggregated Risk Group (18-39; by Sex and Age), Parole Revocations	Admissions - Ratios Releases - Probabilities
Washington, D.C.	1. Linear Regression 2. Multiple Regression	"Time" Parole Population, Jail Population, Number of Parole Grants, Arrests for Part I Offenses, Number of New Commitments to Detention	Short Term (Up to one year) Long Term (Up to Three Years)
West Virginia	None		
Wisconsin	1. Linear Regression 2. Ratio	"Time" Risk Group (18-44)	Details are Vague
Wyoming	No Response	-	-
Canada	Simulation	Several Rates and Time Delays, involving all stages of the Criminal Justice System	Admissions - Ratios (Exact Procedure is unclear) Releases - Probabilities for Different Types

B. More Detailed Descriptions of State Projections Methods

ALABAMA

No response.

ALASKA

Alaska is one of the states with separate methods for short and long terms. For short term it relies primarily on a least squares line of best fit. Although the Department of Health and Social Services has used curvilinear as well as straight lines, it has published only reports which are based on straight lines. Another interesting feature is the use of the segmented line in a way similar to the way it has been used in Illinois.

For long term projections, the state has used the ratio method. The state, with the help of outside consultants, established the current ratio of prison population per general population. This ratio was then projected to the future. In doing that, Alaska was faced with two major problems which are unique to that state: first, there is an imbalance in the composition of the state. As a "frontier" state, it has higher than average males and a relatively younger population. It is hard to project whether this imbalance will continue into the future. The forecasters made the assumption that the Alaska population composition will drift toward the national average. Consequently, they adjusted their projections downwards. Second, Alaska is a fast growing state and is affected by unpredictable migration patterns. This makes the projections of the general population very speculative. Several highly divergent projections of the general population were available to the state forecasters and they found it difficult to choose among them. As a result of these two problems, the state has at least two different sets of long term projections and they differ both in the projected future ratio and in the projected population base. As far as accuracy is concerned, short term projections do "surprisingly well", but the "long range estimations seem to have moved progressively further from reality".

ARIZONA

Several recent developments have led this state to intensify its effort to improve its projection capabilities. A successful suit against the Department of Corrections on behalf of inmates seeking relief from overcrowding conditions has resulted in a court order forcing the department to improve conditions. While litigation on the law suit was going on, a new criminal code was enacted into law and became effective in 1978. The new code mandated prison sentences for several types of offenders, increasing the pressure on the system even more. Finally, the department was advised in 1979 by the attorney general that it should change its method of computing eligibility for certain types of releases. The change resulted in longer sentences for some inmates, increasing the pressures on the system even more. The department realized that previous projection efforts were inaccurate and commissioned three outside experts to come up with three competing models.

CONTINUED

1 OF 2

Not enough information is available to us about the particular techniques used by the experts. It seems that two of them used simulation models. In one model (Kososki), admissions were projected through multiple regression analysis, using general population and unemployment rates as indicators. Release patterns were "inferred from DOC's actual release experiences", possibly (but not necessarily) through a linear regression.

In the other simulation model (Galbraith), admissions were projected either through linear or non-linear regression. It seems that this model uses some form of probability of release date for those entering the system to project their length of stay. The third expert (McCleary) used time series analysis for his projections. Using probably an ARIMA model, he tried to find patterns in past observations and project them into the future.

The three models have produced different projections. For the first two years of projections, the differences are rather small, but one of the models (Galbraith) projects a much higher population growth for the period after that.

ARKANSAS

Attempts to develop reliable projection methods last year were unsuccessful. In the past, the department used both linear regression and ratios to project prison population. The last projection was made in 1975 and was based on the ratio of prison population to the general state population. Recent legal changes (new parole law, new sentencing law) make any projection effort unreliable.

CALIFORNIA

California has been using a progressively sophisticated simulation model since the mid-seventies. Recently, however, many of the assumptions of the model could no longer be used, because of the move toward determinate sentencing in the state. Consequently, the state no longer uses the simulation model exclusively. The modelers use sophisticated mathematical and probability manipulations and an attempt to simplify them in a limited space will do the model great injustice. Interested readers should read "Population Projection Methodology with Emphasis on Simulation Techniques" by W.C. Pannel. While the paper elaborates on the mathematical foundations of the California model, it is rather brief in describing indicators of admissions to prisons. It seems that admissions are projected from rates of projected California residents between the ages of 18 and 49. The model relies heavily on charting the movement of California prisoners in flow charts. For inmates in any particular stage, the program applies some criteria which will determine what their next stage will be and how soon they are likely to get there. Criteria used for newly received from court, for example, are offense, aggravation, jail credits, and others. Since these projected criteria are unknown (for persons not yet admitted, at least), the selection is made randomly within the range of possible values the criterion may take (based on prior experience). This involves probability mass functions (for discrete variables) and probability density functions (for continuous variables). Although particular values are assigned randomly, every

value has its own probability. Thus, not all values within a range have equal chance. In practice, each inmate, and anticipated inmate, is assigned trace vectors which follow his movement through the system (0 when he is not there and 1 when he is). These vectors cumulatively represent the projected population. Initially, the model starts from two different starting points: prisoners received from court and parole violators (projected as lagging one year behind releases on parole). It then follows each inmate until he reaches one of several exit points. California has not yet evaluated the accuracy of its model but is planning to do so in the near future. It should be noted that this model requires, among other things, an excellent record keeping system which many states do not have.

COLORADO

Colorado is one of several states which have enacted determinate sentence legislation in recent years. The new legislation resulted in significant changes in the length of sentences. Unlike many other states, the initial analysis showed a decline in length of sentences. Since the number of parole revocations has also dropped recently, the Department of Corrections expects the prison population to stabilize after steady increases in recent years. In the past, new court commitments were projected through multiple linear regression with unemployment and risk group (males, ages 18-49) as indicators. Also mentioned in past reports is the distribution of court commitments among quarters. It seems likely that this distribution has been used only as a guide for assigning anticipated commitments to more exact dates. The most recent report refers only to unemployment, but since it is referred to as multiple regression, one or two of the other indicators are probably included also. After projecting admissions, the department uses a "propagation matrix" based on anticipated proportion of consecutive sentences, the anticipated average sentence and the anticipated length of stay for classes of offenses. The propagation table produces expected release dates and the final product shows how many from each particular cohort of admissions are expected to remain in institutions in future dates. A summary of members of all cohorts expected to stay at a given point provides an estimate of prison population at that point. The department is satisfied with its short range projections (less than 1% error for one year). The error rate increases for longer term projections.

CONNECTICUT

The Department of Corrections uses the "autoreg" procedure of SAS. The procedure estimates the parameters of a linear model whose residuals are assumed to be autoregressive. The procedure essentially looks for patterns of relationships among the residuals and projects these patterns into the future. The determination of the best fit line is basically similar to ordinary linear regression. The projection, however, takes into account the relationships among the residuals and the order of the autoregressive process.

We have no data on the uses of the projections and no subjective evaluation of its accuracy. Accuracy ranges between close to zero error to over 3% but we do not have information on the length of the projection period used in validating projections.

DELAWARE

Projections based on linear regression have had "varying degrees of successes and failures". The Statistical Analysis Center of the Governor's Commission on Criminal Justice has been trying to come up with a better method but has not yet done so. During the late 1970's, sharp increases in prison population led to a court order limiting overcrowding. Based on the 1978-79 increases, the Department of Corrections projected sharp increases for 1980. However, the population actually declined during that year.

FEDERAL SYSTEM

The Federal Bureau of Prisons reports that its experience with projections has been "less than satisfactory". The bureau makes an annual composite projection based on four different models. The average projection of the four models is the composite projection. Three of the models are ratio models and one is linear (but not linear regression). The three ratio models are:

A. Last year's ratio of incarceration per U.S. population between the ages 20 to 30, multiplied by projected U.S. population for the same age group (Flanagan).

B. The same approach but for entire U.S. population (Blumstein).

C. Ratio of convictions per population, multiplied by the ratio of incarcerations per convictions, multiplied by the ratio of institution population per convictions (University of Illinois). The basic ratios are arrived at by averaging each ratio category over a selected time span.

The linear model averages the percentage of growth or decline in the last ten years and projects it into the future.

The bureau also sent us data of a linear regression analysis which projects an increase far exceeding any of the increases projected by the above methods.

All the models projected slight increases for 1979, but the prison population actually dropped by more than 3000 inmates.

The bureau also studies legal and constitutional trends to subjectively estimate future prison populations.

FLORIDA

The current projection method in Florida is a product of extensive research in the field, including a 1977 survey of projections in other states. The method is called SLAM II (Simulated Losses and Admissions Model Phase II). Phase II was developed after SLAM I was off in its

projections of releases from institutions. Both phases have used a multiple regression analysis to project future admissions. The independent variables used have been the population of young (18-29) male adults and unemployment rates. SLAM II calculates incarceration probability functions for each sentence group separately. To do so, Florida attempts to rely on the most recent data available. The length of time served for those released from prison is a poor indicator of the length of stay probabilities, because it does not take into account those still in prison from any particular cohort. Solving the problem by waiting for an entire cohort of admissions to be released makes the release probabilities obsolete, especially for longer sentences. Therefore, in calculating probabilities of release, SLAM II includes in the equation of all those released during a year plus all those still in prison with a system of weights that attempts to neutralize increasing numbers of admissions in recent years.

The incarceration probabilities have been applied separately for current population and anticipated admissions. The Department of Corrections was very happy with the results of its projections until the Florida Parole Commission established new criteria for setting presumptive parole release dates. This increased the average monthly error rate from .36 to over 5%. Subsequent adjustments have reduced the rate of error to .64% for the next 10 months.

GEORGIA

The institution population in Georgia has grown by approximately 70% since 1973. This rise has led the Department of Offender Rehabilitation to the realization that old projection methods were inadequate. With the help of other state agencies, scientists from Emory University, and the California Department of Corrections, a new computerized simulation model has been developed recently. We only have sketchy information on the model. It seems that it relies on disaggregations of the state population by county, race, sex, and age. These disaggregations determine the size of the admitted population (probably by using rates). It is unclear how length of stay is determined. The department relies on introducing different scenarios for admissions and for length of stay into the simulation model to fit changing circumstances. The model looks interesting and we hope that more information on it will be available soon. For the first 10 months of the model, the cumulative error rate was 2.6% The undercount was attributed to a policy of early release by the Parole Board. The department is satisfied with the model not only because it is more accurate than earlier ones but because it can also be adjusted to changing policies.

GUAM

In 1975, the Guam Department of Corrections projected the 1980 prison population, using a ratio model. Instead of using a direct ratio of prison population/island population, the Department calculated a series of intermediate ratio steps: the ratio of arrests per population; the ratio of guilty adults per arrests; the ratio of prison admissions per guilty adults; and the ratio of average daily population per admissions. Three scenarios were used. In one, the 1966 to 1969 ratios were assumed to be valid for 1980; in another, a 15% increase in efficiency capabilities by police, prosecutions, courts and corrections was assumed; in the last -- it was simply assumed that a 10% annual increase in admissions to the system would occur. Since the increase was assumed to compound, this implied an exponential function for the increase.

Under all three scenarios, it was assumed that the average daily population would be 70% of the number of admissions. The rationale for this ratio is unclear because historically the ratio was much lower than that.

The first scenario projected a population of 84 for 1980, the second - 105 and the third - 140 (actually, a mistake was made in the third option and our calculations indicate that the projection should have been 134). The actual average daily population in 1980 was 112.

Forecasts made in 1980 project an inmate population of 240 for 1984. For this projection, a 58.33% increase above the 140 projection for 1980 was assumed. (Again, 14.58 compounded annually.)

HAWAII

The Hawaii Department of Social Services and Housing has eight formulas at its disposal but generally uses one - linear regression - to determine the future trend of several types of institutional populations. Since some of the populations seem to rise exponentially, in order to give more weight to recent measurements, a weighting factor is introduced into the formula. The resulting projection is still linear in nature.

We do not have specific details on the exact procedure. The department has considered other methods such as ratios, multiple regression, and simulation, but all were rejected because of the insufficiency of the institutional data base. Some of the projections seem to have a cumulative error rate of 25% for a two year period. It seems that the system has been expanding in recent years and this makes projections very difficult.

IDAHO

Due to shortage of money and personnel, the Idaho Department of Correction has not made new projections since 1977. The 1977 projections used a simplified simulation approach. Admissions were projected based on the past trend in the ratio of admissions to total male and female state populations. Since the rates of commitments for both had been increasing up to the projection study, the increase was projected to continue into the future.

Releases were then projected on the basis of the average past ratio of releases to admissions (.841 for males and .690 for females).

The projections were "fairly accurate" for the first two years but not for 1980-81.

ILLINOIS

Several projections of the Illinois prison population were made during the 1970's. Most of them were conducted by groups outside the Illinois Department of Corrections. The department itself entered the field only in 1978. Projections made that year relied on subjective assesments and have been proven to be highly inaccurate. All the projections by the outside groups have also been unsuccessful. In 1979, the department issued its first formal projections. These projections relied on multiple regression with the size of the Illinois young adult population and the unemployment rate as the independent variables. In 1980, the department used linear regression. Monthly data for the period between 1965 and 1980 were used. Prior to 1973, the prison population declined considerably. The trend was reversed during that year and from then on it has consistently increased. The department chose two line segmented linear regression. The regression equation of the second line was used to project the future prison population. The projections have proven to be fairly accurate (less than 1% error for the last two years). Nevertheless, the department is attempting to improve its projection capabilities. Several major concerns have led to the current attempt to come up with a new projection technique:

- In 1978, the Illinois legislature enacted new legislation which incorporated determinate sentences and severe prison sentences for several offense groups. (Specifically, a new class of offenses - Class X - was created with a minimum sentence of six years. Existing classes also underwent many changes and life imprisonment was prescribed for "habitual criminals".) The full impact of the new legislation has not yet been felt, but if changes do occur, linear regression will not be sensitive enough in measuring their impact (initial analysis indicates longer time served).

- In the last year, the prison population came very close to exceeding its rated capacity. This was avoided through early releases of thousands of offenders. The early release program reduced the 1980 year end prison population by close to 700 offenders. In addition, the Prisoner Review Board (formerly the Parole Board) responded to the pressures on the system by reducing the number of parole violations. Linear regression, which is based on data from earlier periods, cannot be sensitive enough to these recent changes. (It should be noted that some early releases resulted from a court decision which led to the use of a different formula in calculating Good Time.)

- There is a very strong feeling in the department that its chosen projection method should be able to predict a "turning point". If linear regression had been used in 1972, it would have missed its mark by a mile. If the upward trend is reversed again in the future, linear regression would again be highly inaccurate.

INDIANA

No response.

IOWA

No response.

KANSAS

The Kansas Department of Correction started projecting the future prison population only recently. The method which was used in projecting 1981 and 1982 average daily population (ADP) was linear regression. Since projections were not made in the past, information on the degree of accuracy is not yet available, but the department feels that, based on current trends, "the projection for fiscal year 1981 will be vindicated."

KENTUCKY

Here is another state which is under a court order to reduce prison overcrowding. In the past, the Bureau of Corrections relied mostly on linear regression in projecting prison population. The results were "relatively worthless". In addition, the department relied in the past on a semi-simulation technique to determine the impact of policy changes. The method used did not provide accurate projections in terms of numbers. It was merely used to assess the degree of change due to new policies (assuming continuation of past trends under an assumption of equilibrium and then changing one component, such as length of stay). Currently, the bureau is in the midst of an effort to develop a new technique, using the simulation approach. The new technique will provide estimates for the length of stay of inmates already in institutions, will use linear regression with unemployment lagged three months as the independent variable to project future court commitments, and will use prior experience to determine the number of other admissions and length of stay. It will also use standard rates as adjustments for escapes, deaths, and similar occurrences.

LOUISIANA

The Office of Management and Finance has used linear regression in the past. Recognizing the limitations of the technique for long range projections, the office is in the process of adopting a ratio technique. The ratio model has not been fully implemented.

MAINE

In the past, the Maine Department of Mental Health & Corrections relied exclusively on straight linear projections and viewed the results as satisfactory (less than 2% error, apparently with quarterly adjustments). However, the department felt that using "year" as the base for the regression implies an increase "infinitum" of the prison population. Therefore, they decided to move toward an approach which leaves the door open for a possible decline in the size of its resident population.

The Maine Criminal Justice Data Center has recently come up with an alternative method. Linear regression is still used for projecting the size of the average daily population, but risk group (ages 18-34) has replaced year as the independent variable. Some other adjustments have also been made. First, since the ADP showed a slight curve rather than a straight line, the independent variable was logged, a common practice or "curing" certain non-linear relationships. Second, a careful examination revealed that there was no uniformity of admissions within the risk group. For every person between the ages 25-34 who was admitted to the system, 2.4078 persons between the ages 18-24 were admitted. In order to take it into account, the younger group received a weight of 2.4078.

The independent variable was, therefore, taken to be the logarithm of the sum of persons 25-34 years old and the weighted number of persons 18-24 in the state population. It is too early to tell how accurate this method is, but the Department of Mental Health and Corrections seems confident.

MARYLAND

The Maryland Department of Public Safety and Correctional Services has used in the past projections developed mostly by the Governor's Commission on Law Enforcement and Justice. The methods used have been linear regression and a simulation model. The simulation technique analyzed arrest rates for specific types of crimes as a function of age, sex, and race of the state population. (It is unclear whether multiple regression or ratios were used.) It then relied on current probabilities for being convicted and sentenced to state correctional institutions and the average duration of incarceration (for specific types of offenses) to determine admissions and length of stay. We do not have data on the exact procedure, but it seems to be similar to the one used by Blumstein in Pennsylvania.

The simulation model and three linear regressions (using different base periods) seem to have missed their mark by a considerable margin. All the projections have usually overestimated prison population, sometimes by as much as 20% or more. Present plans call for new construction of additional 1028 beds, but some legislators feel that even more beds are needed. An outside consulting agency was hired, and in January, 1981, it submitted its report to the legislature. The consultants - Correctional Services Group - recommended increasing the capacity by close to 1000 beds above and beyond present construction plans.

The method used by the CSG is not spelled out in detail. It seems that they followed the flow (simulation) model of the 1977 ABT report to the U.S. Department of Justice. Whatever the method used, it relies on past trends of crimes, arrests, court intakes, releases, and other criminal justice dispositions to determine future admissions and releases (possibly all are projected through a linear regression). What is clear is that CSG provides three different scenarios for future developments (one assumes an implementation of a proposed program, another assumes a continuation of recent developments, and a third assumes a return to historical trends).

MASSACHUSETTS

Projections are made by the Massachusetts Department of Correction but the "approach has not been particularly scientific". Indicators such as population at risk, court reform, sentencing patterns, and others are used informally. The current prison population is well over the rated capacity or even the bed capacity. It is projected to increase in the next five years.

MICHIGAN

Like so many other states, Michigan has been under court order not to exceed capacity. Consequently, the recent practice in the Department of Correction is to project that the population of the prison system will reach capacity. For more normal times, the department relies considerably on intuition to supplement its projection techniques. For projections up to two years, a quasi-simulation model is applied: admissions for the next 24 months are projected intuitively. To these numbers, the computer applies sentence distributions based on the most recent past experience. The program provides the department with the estimated number of releases during the next twelve months. For longer term projections, the current annual intake number is multiplied by the average length of time expected to be served.

The department feels that the accuracy of its previous projections has been better than anticipated for short terms. For longer periods, the errors have been larger (usually underprojecting). Still, "with few exceptions, the errors have been on the order of hundreds rather than thousands in a two year period". (In October 1979, the population projection for January 1, 1981 was 15,047. The actual number was 15,121.)

MINNESOTA

Minnesota uses one of the most complicated simulation models we have seen, a model which requires a good and extensive data base. No summary will do justice to the model. The interested reader should refer to a publication by the Minnesota Sentencing Guidelines Commission titled Population Projection Program User's Manual, (Feb. 1981). The Department of Correction has modified the model.

The program relies on several data files, some of which are:

- A probability file provides grids of probabilities for being sentenced to prison, receiving a misdemeanor sentence and being revoked from probation. The probabilities may be real or perceived (if the purpose is to estimate the impact of policy changes).

- A base file contains information on the existing prison population, including their scheduled release months.

- A Micro Data file contains information on individual offenders (felonies).

- An adjustment file contains adjustment factors for the duration component in the Micro Data file.

In addition to those files, other parameters are also built into the projection model. Since the model is limited to the probability of sentencing disposition and to duration of stay, a growth parameter is used to try to anticipate the growth of the convicted felon population (this will affect future admissions). It should also be noted that information in the subfiles is disaggregated. The probability file, for example, provides separate probabilities of imprisonment and non-imprisonment dispositions for 10 different categories of offenses. The base file is disaggregated by three demographic and three criminal justice categories.

A special program is applied on all the files to project likelihood of commitment and length of stay, leading to the projection of future prison populations. According to the Minnesota Department of Corrections, the accuracy of projection up to now has been "within the ballpark". The designers of the model view its major benefit as assessing impact of policy changes rather than straight projections based on the continuation of past experience.

MISSISSIPPI

A 1972 court decision by a federal judge was issued against the state of Mississippi for "unconstitutional conditions ......[in] the state penitentiary". A 1975 court order closed several inmate camps and limited severely the capacity of the system. These developments have led to a backlog of inmates in the county jails. In 1978, the Department of Corrections used multiple regression in projecting the prison population up to 1981. The indicators used were state population and the number of indictments. The department was not satisfied with the accuracy of the projections (the error rate is unclear but the projection was close to 10% under the actual population for mid 1980). Attempts to improve the model in 1980 by adding indicators to the equation (unemployment, prime interest rate) did not improve its prediction. It seems that the department is currently moving toward an adoption of a simulation model. In the meantime, a 1980 report projected the population up to 1982 using an unspecified method (possibly linear regression).

MISSOURI

Multiple regression has been used in the past by the Missouri Division of Corrections, but the results have been disappointing. As independent variables, the regression equation has included Missouri population, economic and labor indicators, previous population levels and recidivism rates. Currently, the Department is developing a new projection technique of an unspecified nature. In the meantime, it seems that linear regression (or another linear approach) is used until the new projections become operational.

MONTANA

The prison population in Montana more than doubled between 1974 and 1979. In 1979, the state replaced the old prison with a new one but in 1981 its population already exceeded its capacity. Three efforts to project the population of the state prison were done in 1979. One was made for the corrections master plan by outside consultants. We do not have any information on the method used, but it is clear that it over-projected the population by a significant number.

The Department of Institutions itself developed later in the same year a simulation model which is called SARM (Simulated Admissions and Releases Model).

The model projects future admissions from past ratios of admissions per risk group (males between the age 18-60). Releases are projected by applying a release matrix on the admitted (and current) population. The release matrix is based on the length of stay distribution for the last 18 months (through August 1979). It is unclear if and how the overrepresentation of lighter sentences in the released population was taken care of.

A 1979 consultant's report to the Governor's Office of Budget and Program Planning provided more refined projections of admissions. In that report, the risk group was disaggregated by age to provide projections of admissions which are more sensitive to changes in the age composition of the risk group.

The Department of Institutions is generally satisfied with its projections. Error rate has ranged between close to zero and 10%.

NEBRASKA

Nebraska has only recently developed a projection methodology. It utilizes two different methods - multiple regression and S-curve fitting. The multiple regression relies on the relationship between unemployment and incarceration, but it has a slight twist to it. Since it is unclear what the exact nature of the relationship is, the Department of Correctional Services has chosen to use three different measures of unemployment as independent variables in the regression equation. The first is the rate of unemployment, the second is the rate of unemployment lagged one year, and the third is unemployment lagged two years. Four different scenarios of future unemployment rates are used. Since the methodology is new, the department does not have data yet on the level of its accuracy.

S-curve fitting is based on historical data. Rates of incarceration per risk group (males aged 20-29) are determined. The trend in rates is then projected into the future. Specifics of the methods are unavailable to us.

NEVADA

No response.

NEW HAMPSHIRE

Past attempts to project the population of the state prison through a variety of statistical techniques were "so inaccurate as to be useless". Consequently, the state has dropped its effort to project the prison population statistically and relies currently only on intuitive projections "which seem to be as accurate and considerably less expensive".

NEW JERSEY

We have very few details on the projection method used in this state. It is a simulation technique similar to the one used in Pennsylvania and some of the other states. Admissions are projected from past rates within age/sex/ethnic groups. Past length of stay serves as the basis for future projections and this is computed for each of several general types of offenses (person, property, and other).

Projected admissions are for totals only; the distribution among offense types is estimated from past trends combined with judgment and future expectations. It is unclear whether probabilities of release are estimated or average length of stay is used. The New Jersey Department of Correction tries to project the distribution of its population among different security levels (using basically current distribution as a criterion). In earlier years, the error rate for the method was high, but it has improved in recent years.

NEW MEXICO

In the past, the New Mexico Corrections Department used both linear and multiple regressions to project its prison population. The indicators used were arrest, conviction, and admission rates. These methods were unreliable. Currently, the department is in the midst of developing a new methodology which will combine multiple regression and time series analysis. It will use economic indices as well as disaggregated offender information (age, race, sex, education).

NEW YORK

The population of the New York prison system increased by 72% between 1972 and 1980 and the increase is expected to continue in the next five years. The Department of Correctional Services uses simulation for projecting the future size of its population. Admissions are projected through an initial use of multiple regression which is then adjusted and modified to reflect recent and anticipated legal and policy changes. It seems that "population at risk" (i.e., youth between the ages 15-34) is the major indicator. Adjustments reflect added commitments caused by the violent felony offender laws (effective since September, 1981). Parole readmissions are projected on the basis of past experience (rates of return over time). It is unclear how releases are projected. Past projections have been "reasonably accurate". Data for the last four years show error rates from .3% to 1.3% for the projections of end year populations. Projections are adjusted annually.

NORTH CAROLINA

Presumptive sentences were due to go into effect this year, but impact studies conducted by the Department of Correction convinced the legislature to scale down these sentences in view of the anticipated pressures on a system which is already crowded. The model used by the department involves simulation of admissions and releases. Felony admissions increased steadily from FY 68-69 through FY 76-77. In the next two years, felony admissions declined slightly. The projection method used tries to project future admissions for separate sentence length categories. The method uses three possible scenarios for admissions:

A. Steady state admissions and their distribution among sentence lengths will remain at the 1978-1979 level.

B. Steady admissions/increasing sentence lengths, admissions will remain at the 1978-1979 level but the average length will continue rising at the same level it has increased in the last eleven years ("best estimate").

C. Maintaining the eleven year trend, both overall admissions and distribution among sentence levels will continue to rise at the rate experienced in the last eleven years. (This assumes that the recent declines have been temporary.) Assumptions B and C lead to linear regressions of admission trend (C only) and distribution of admissions among different sentence lengths (both).

Release probabilities are calculated for each sentence group. Since each group includes a range of sentences, the probabilities are applied to the average sentence in each sentence group (there are seventeen such groups). Admissions during a year are assumed to be distributed equally throughout the year and the expected length of stay is calculated from the hypothetical date of admission. Release probabilities are based on 1977-1978 releases. Release probabilities are calculated separately for four different groups of sentence length (each of them includes several of the categories used for calculating distributions of admissions). The method calculates how many of any particular sentence length will serve a certain fraction of their sentence. It then calculates the average stay of this group and projects release dates accordingly.

The department provides separate projections for felons and committed youthful offenders.

Two more significant points: First, the releases of persons admitted prior to 1968-1969 are projected to follow a pattern of exponential decay (a constant percentage of the remaining population is projected to drop every year). Second, the department assumes no change in parole policies in the future, although it realizes that parole policies are subject to unpredictable changes.

In fact, only recently, parole legislation and parole policies changed in a number of points leading, probably, to a decline in length of stay. It is

unclear how these changes affected the probabilities of release. When prison populations are projected on the basis of 1977-1978 releases for the period 1970-1979, the error rate ranges from 0.9% to 5%. (The error rate for 1978-1979 is 3.6%.)

NORTH DAKOTA

This is a small state with a small prison population. It has a biennial budget; which means that about 3½ years elapse between the initial stages of the budget and the final expenditures. In the past, the state penitentiary relied on national and state rates of change to project its future population, but the current preference is to rely on intuition and take into account such intangibles as inflation, demographic changes, and pending legislation.

A New York firm was recently commissioned to do a twenty year development plan which, apparently, included some form of population projection. We do not have a copy of its report.

OHIO

Since 1974, the Ohio prison population has continued to expand. In slightly more than six years, the prison population almost doubled. Throughout this period, the Department of Rehabilitation and Correction have relied on simple linear regression for its projections and views the results as "very accurate". Error rate has ranged from 0 to 5%, but it is not clear what base periods were used for computing the errors.

In addition to projecting the prison population, the department also invests considerable effort in projecting admissions only.

OKLAHOMA

This is another state with severe crowding problems. Like many of the others, it is currently under court order to restrict the total bedspace in its existing facilities. In addition to crowded prisons, there is a backup of inmates in county jails awaiting to be admitted to the state system. The Oklahoma Department of Corrections is trying to combat the problem by advocating several programs which will serve as "alternatives to incarceration". As part of this effort, the department has projected future increases of its population by using two linear regression analyses. In one of them, the base period included the last six years (yearly average daily population). In the other, only the last two years were included in the regression (monthly ADP).

In addition, the department has tried to assess the possible impact of alternative programs on the projected population. Some pending bills in the Oklahoma legislature are expected, if passed, to provide some relief from crowding.

OREGON

Recent changes in the criteria used in parole, legislative approval for extending work release programs, and a court order to reduce population in some institutions, have made prison projections in Oregon difficult. The Oregon Law Enforcement Council (OLEC) developed in 1980 a projection methodology which relies on multiple regression to project prison commitments and average daily populations.

It seems that for ADP, several risk groups were used as independent variables. Initially, the multiple regression used for projecting short term admissions relied on 45 variables. It is unclear how many of them proved beneficial enough to be included in the final regression equation. The Correction Division of the Department of Human Resources had several other projection methods at its disposal and did not choose the OLEC projections because these projections did not take into account the recent changes in parole. Instead, the division relied on a ratio and a curve fitting method. In the ratio method, the size of a risk group (probably 15-29) was projected into the future. Based on past ratios of prison populations, future ratios were projected. The curve fitting technique took note of the apparent slowing of the long term population growth and extended the smooth curve into the future.

Since all the techniques covered here have been used in Oregon only recently, no data on accuracy levels are available.

PENNSYLVANIA

The Pennsylvania Bureau of Corrections relies on projections done by the Urban Systems Institute at Carnegie Melon University. Their projections were published in 1980 in the Journal of Criminal Justice (A. Blumstein et al, "Demographically Disaggregated Projections of Prison Populations").

The article should be useful to anybody interested in projections. The method projects admissions to prison by using past rates of admissions per risk groups. Risk groups are the general population disaggregated by age, sex, race, and offense. Unlike many others, Blumstein, et al, do not arrive at admission rates directly. Instead, they follow the entire process of the criminal justice system.

In simplified form, population (or risk group), multiplied by probability of committing crimes, multiplied by probability of being arrested, multiplied by probability of being adjudicated, multiplied by probability of being sentenced to prison would result in the estimate of admissions to prison. Probabilities are based on the average of past ratios wnen no definite trends are detected, and on linear regression when a definite trend does exist. Some of the probabilities may be unknown. For example, it is unlikely that anybody knows the probability of committing crimes per risk group. Until a criminal is apprehended, his/her age, sex and race are unknown. In this case, it is possible to jump over a stage (using probability of arrest per risk group). The advantage of the method is that it will detect changes in admissions due to demographic changes only, even when the general policy toward crime remains unchanged. An added advantage is that if projections are incorrect, it is possible to pinpoint what stage in the criminal justice process produced the error. The disadvantage is that a large data base is required including many cells (336 for Pennsylvania). Not all the

necessary data are available for all states. In fact, several of the cells in Pennsylvania were estimated from the marginals. The same disaggregation categories were also used to project length of stay probabilities. These probabilities were estimated from the average length of stay under the assumption that time served in prison is exponential. Separate probabilities were assigned to persons in institutions at the beginning of the year and persons admitted during the year. When the model was used on the data from the data base period it proved to be fairly accurate (correlation of .888 for 1970-1977 and .994 for 1971-1977). We have no data on the accuracy of the actual projections.

PUERTO RICO

Puerto Rico uses the least squares method. Projections done in 1975 overestimated 1976 population by about 35%. The population has been rising in recent years but recent revised projections estimate that the projected 1976 level will not be reached within the next four years.

RHODE ISLAND

The Rhode Island Department of Corrections has no formal projection technique beyond projecting a continuation of past trends in rate of growth. Nevertheless, the department was recently successful in lobbying against mandatory sentencing bills. In a report to the legislature, the department was able to show how definite mandatory prison sentences may increase the numbers of persons admitted to prison for certain offenses. The department claimed that passage of the bills would require enormous expenses for prison construction. The legislature was apparently convinced enough to defeat the proposed legislation.

SOUTH CAROLINA

The simulation technique used by the South Carolina Department of Corrections projects admissions of three separate cohorts through multiple regressions.

The initial regression analysis included several possible indicators, but only few of them were chosen as predictors. The cohorts (and the indicators) are: regular offenders admitted from court (population at risk), youthful offender admissions (population at risk and unemployment rate), and other admissions. (None showed promise and, therefore, the average of past observations is added to the admission figures.) The department uses a separate but similar formula to estimate releases of those already in the system and those expected to enter it in the future. For the existing population it is assumed, based on past experience, that 65% of parole hearings will result in parole. Another factor included in the formula is the "earned work credit release". The number of releases projected to be released in a year includes all those serving full sentence (excluding work credits) who have not been paroled before, plus 65% of those eligible to have a parole hearing. Projecting length of stay for future admissions uses actually the same formula but it does require making additional assumptions on future work credit distribution and the anticipated sentence lengths. The 1978 projections were "within 2% of forecasted level".

SOUTH DAKOTA

No formal statistical projections are made in this state. Instead, the state penitentiary analyzes several trends, such as length of sentences, seasonal influxes, and parole actions. It also surveys courts to determine the number of potential admissions. The legislature has tended in the past to reduce projections and to fund at lower levels.

A new Parole Board has increased recently the number of persons paroled each year and, consequently, earlier projections turned out to be on the high side.

TENNESSEE

In the past, the Tennessee Department of Corrections relied on least square estimates but was not satisfied with it. Currently, the department is in the midst of an attempt to improve projection capabilities. The method being explored is multiple regression with risk population (ages 15-39 or 20-39), unemployment rate and unemployment number as independent variables. Correlations between these variables and ADP range between .65 and .85. No projections have been made yet using this approach.

TEXAS

It seems that no formal projections have been utilized in Texas up to this year. Currently, a team from Sam Houston University is in the process of developing a projection model suitable for the state. Since the project is in progress, the method may still undergo several changes. In general terms, however, admissions to the system will be projected through a linear regression with the total state population as the independent variable (R^2=.97). Length of stay probabilities will most likely be estimated in a way similar to the one used in Colorado.

UTAH

No response.

VERMONT

The Vermont Department of Corrections has relied up to now on the rate of growth of prison population as an indicator for future trends. However, in the last six months, the population increased at a rate of 22% while the expected rate of increase, based on previous observations, was only 6.3%. This rendered the projections "inadequate". The Department hopes to develop a more sophisticated technique in the near future. The feeling is that the current rate of growth cannot last forever.

VIRGINIA

The simulation model developed by the Virginia Department of Corrections seems complicated because of the nature of the data and because of the nature of the system. The state cannot accommodate all convicted felons. Some felons are in local jails awaiting transfer to the state system and the model attempts to accommodate this group in the projection. Admissions are projected on the basis of historical trends, probably through linear regression. However, the department also monitors arrest data "to make sure there are no surprises". (The historical rate of commitments per arrests is used as a guideline.)

The model then projects the distribution of sentences among future admissions on the basis of historical trends. Then, for each separate sentence length, the department projects the likelihood of parole and the likely date of release (through parole or expiration of sentence). Separate projections are done for persons already in prisons. These projections, done in a similar way, require fewer assumptions.

It seems that previously the department used total population and economic indicators in projecting admissions. The discrepancy between projected population and actual population between 1977 and 1979 has ranged from a high of -8.0% in 1978 to a low of -.6% in 1979. (It is unclear whether adjustments were incorporated into the comparisons.) At least part of the problem is that the DOC population has exceeded bed capacity for several years. This leads to extended use of local facilities, sometimes through emergency legislation.

WASHINGTON

This is yet another state with a simulation approach to projections of prison populations. The state population between the ages 18-39, further disaggregated by sex and age is used as the basis for projecting prison commitments. Conviction rates per 1000 population at risk are then forecasted on the basis of historical trends. Projected convictions are disaggregated by sex, offense, and age (the latter, for males only).

This creates 56 cells for males and 10 for females. For each of these cells, a probability of prison sentence is estimated again, based on past experience. To account for persons outside the risk group population, admissions are adjusted by multiplying them by 1.05. Parole revocations are estimated separately through an unspecified process. Recent changes in parole policies and recording of information make the projection of revocation difficult. The changes are attributed to a 1978 Supreme Court decision (Akridge) which held that parolees convicted for the commission of new felonies are entitled to on-site hearings before their paroles are revoked. The Department of Social and Health Services has had more difficulties in projecting the number of releases; this is because releases depend on policy decisions of the Parole Board and these are hard to predict. In 1978, the Parole Board introduced objective guidelines for setting the minimum sentence. This necessitated the use of four different approaches for four different subgroups (those admitted prior to guidelines, those admitted after but to whom guidelines do not apply, and two groups with different sets of guidelines).

Probabilities of release for persons admitted prior to the guidelines are based on historical data. Probabilities for post guidelines, inmates are based on good time release dates (1/3 off) and additional reductions of time allowed under the new guidelines. Estimated length of stay for future admissions is derived from past experience. Washington is one of the few states which subject their assumption to sensitivity tests. This allows the department to estimate the error rate if one or more of its assumptions are incorrect.

WASHINGTON D.C.

The Department of Corrections uses both linear and multiple regression. Linear regression is used for short term projections (up to one year) while multiple regression is used for longer periods of time (up to three years). Accuracy studies indicate that the multiple regression is better for short periods also. The initial attempt to develop a multiple regression equation involved several possible indicators. Among them were arrest data (with and without lags), felony and misdemeanor filings, guilty dispositions, delays between arrests and dispositions, number of sentences imposed (with and without a lag), probation population, commitments to detention (with and without a lag), sentence length information, and parole data. The initial process has led to the current reliance on five indicators: the parole population, the jail population, the number of parole grants, arrests for Part I offenses lagged one year, and the number of new commitments to detention. The parole data are negatively correlated with the prison population, while the other indicators show a positive correlation.

The department projects that these five indicators will continue past trends into the future. It seems that at least some of them are projected through linear regression.

The error level for a period of one year is over 7% for the linear regression and between 3% and 4% for the multiple regression. The average error level for one year or over is between 3.1% and 3.9% (only up to 21 months).

The department feels that the multiple regression technique has "provided accurate population estimates" but is reserving judgment on its accuracy for periods over 21 months.

WEST VIRGINIA

This state is one of very few fortunate states. The population of adult institutions has remained virtually unchanged for the last twelve years. No projection techniques are used, but the Department of Corrections had relied on studies done in other states to assess the possible impact of determinate sentencing on the prison population.

WISCONSIN

The Wisconsin Department of Health and Social Services uses two projection techniques. One is simple linear regression where the last

sixteen quarterly averages of the average daily populations are used to project the population in the next sixteen quarters.

The other technique is less clear. The statewide population for adults (ages 18-44) is used to estimate ratio of prison population per risk group. It seems that the ratios for the last 16 quarters are then used to project the ratios for the next 10 quarters. This is done either through linear regression or through some other technique. (This part is not clear, but since a slope is involved, linear regression seems a likely possibility.)

There is no information about the accuracy of the methods. The linear projection leads to a projected increase in population and the ratio method leads to a projected decrease.

WYOMING

No response.

CANADA

Since 1976, Canada has developed its Offender Projection System (OPS). After many trials and tribulations, the Correctional Service of Canada now feels that it has a working simulation model which will not only project future populations under current conditions, but will also be able to estimate the impact of legislative and policy changes. In developing the model, special emphasis was placed on "conditional simulation" - simulating input and output into the system under different sets of conditions, as they are specified by the users of the model. The model recognizes the interrelationship between the correctional system and other systems, such as the courts, police, the parole board, and other agencies. One of the difficulties in implementing the model is that while Canada has a federal system, each province has its own unique police, courts, legislatures, and policies.

In order to project prison populations, the model stimulates the flow of offenders in the entire criminal justice system. Several indicators were considered for inclusions in the model. They were finally reduced to 9 key rates and 10 time delays. It would be far beyond our scope here to describe the entire simulation process. In essence, it simulates rates of admissions (disaggregated by type) and factors affecting length of stay (sentence, participation in prison programs).

The model also takes into account factors affecting the likelihood of parole revocation and factors affecting recidivism in general. It is important to note that delay factors are incorporated into the model so that not only probabilities of incarceration but release are considered. For example, certain parole programs may not change the probability of revocation but will delay it, thereby affecting the size of the prison population. The Correctional Service of Canada has several publications describing the model.

Assumptions incorporated into the model are arrived at through the use of a variant of the Delphi method. In this method, several experts in the field project future trends and their estimates are relied upon for the projections (through averaging or other manipulations).

Accuracy tests performed on the period which served as the basis for the assumptions employed by the model show an error rate ranging from 5% to -3.3% (averaging out to zero for an eleven year period). The Service feels that the ability of the model to "predict" the past should give planners confidence in its ability to serve them in planning the future.

APPENDIX II

SURVEY COMPARISONS

SURVEY COMPARISONS

At least two other surveys of projection methods in the U.S. have been done in recent years.

One of these surveys was published in 1977 by the Florida Department of Offender Rehabilitation. ("A Survey of Population Projection Methodologies in the States and the District of Columbia", Document #77-R-065, September 23, 1977.)

The other survey was published in 1980 by the Kentucky Department of Justice. ("Survey of Projection Techniques", November 3, 1980.)

A comparison between these two surveys and our own may serve as a general indicator of recent trends in projections of prison populations.

Many of the differences among the three surveys may be due to different interpretations of incomplete information supplied by some of the states. Nevertheless, a trend can easily be detected: projections rely more and more on more sophisticated techniques and among the more sophisticated techniques the one which has gained the most is simulation.

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A general comparison between the three surveys is provided in the following table:

NUMBER OF JURISDICTIONS USING VARIOUS PROJECTION TECHNIQUES IN THREE SEPARATE SURVEYS (CATEGORIES ARE NOT MUTUALLY EXCLUSIVE)

	Florida (1977)	Kentucky (1980)	Current Survey (1981)
Linear Regression	23	17	13
Multiple Regression	7	12	9
Ratio	Not Included	10	7
Simulation	8	14	19
Time Series, Non-Linear	0	3	4
No Projections	3	8	3
Other	-	-	3
No Response, No Data, Not Included in Survey	25	5	6

Following is a more detailed state by state comparison. There is no attempt to reconcile differences even when it is obvious that interpretation and misinformation cause discrepancies.

STATE BY STATE COMPARISON

Code for abbreviations:
- L.R. = Linear Regression
- M.R. = Multiple Regression
- R = Ratio
- SIM = Simulation
- T.S. = Time Series

	Florida	Kentucky	Current Survey
Alabama	L.R.	M.R., T.S.	No Response
Alaska	No Information	L.R., R, SIM	L.R., R
Arizona	L.R.	M.R., SIM	SIM, T.S.
Arkansas	L.R.	R	R
California	SIM	SIM	SIM
Colorado	L.R., M.R.	SIM	SIM
Connecticut	None	L.R.	T.S.
Delaware	None	L.R.	L.R.
Federal	Not Included	Not Included	L.R., R
Florida	L.R., M.R., SIM	SIM	SIM
Georgia	SIM	SIM	SIM
Guam	Not Included	Not Included	R
Hawaii	L.R.	L.R., M.R.	L.R.
Idaho	L.R., SIM	None	SIM
Illinois	L.R., M.R.	M.R.	L.R.
Indiana	No Information	L.R.	No Response
Iowa	No Information	None	No Response
Kansas	Insufficient Data	None	L.R.
Kentucky	L.R.	L.R.	SIM

	Florida	Kentucky	Current Survey
Louisiana	No Response	L.R.	R
Maine	No Response	L.R.	M.R.
Maryland	L.R., SIM	SIM	L.R., SIM
Massachusetts	L.R.	L.R.	Informal
Michigan	No Information	SIM	SIM
Minnesota	SIM	SIM	SIM
Mississippi	None	M.R.	M.R.
Missouri	No Response	M.R.	M.R., L.R.
Montana	No Information	SIM	SIM
Nebraska	L.R.	No Response	M.R., S Curve
Nevada	L.R.	M.R.	No Response
New Hampshire	No Information	None	None
New Jersey	No Information	L.R.	SIM
New Mexico	L.R., M.R.	L.R., R	M.R., T.S.
New York	No Information	SIM	SIM
North Carolina	No Information	M.R.	SIM
North Dakota	No Information	None	Intuition
Ohio	L.R.	R	L.R.
Oklahoma	L.R.	None	L.R.
Oregon	No Information	R, M.R.	M.R., R, Curve Fitting
Pennsylvania	L.R.	L.R.	SIM
Puerto Rico	Not Included	Not Included	L.R.
Rhode Island	No Information	None	None
South Carolina	No Information	SIM	M.R.
South Dakota	No Response	R, M.R.	Informal
Tennessee	No Information	R	M.R.

	Florida	Kentucky	Current Survey
Texas	L.R., M.R.	Composite Curve(?)	SIM
Utah	L.R.	L.R.	No Response
Vermont	No Response	L.R., R	"Rate of Growth"
Virginia	L.R.	L.R., SIM	SIM
Washington	L.R.	R, SIM	SIM
Washington, D.C.		L.R., SIM	L.R., M.R. L.R., M.R.
West Virginia	No Information	None	None
Wisconsin	L.R., M.R.	L.R.	L.R., R
Wyoming	No Response	R	No Response
Canada	Not Included	Not Included	SIM

APPENDIX III

CURRENT AND PROJECTED PRISON POPULATION

OF THE STATES

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CURRENT AND PROJECTED PRISON POPULATION OF THE STATES

Unless otherwise noted, data on "current prison populations" are taken from the U.S. Bureau of Justice Statistics, "Prisoners in 1980", as of December 31st. There are some minor discrepancies between these data and data submitted to us by several states. Unless otherwise noted projected populations are also for end year.

Jurisdiction	1980 Actual Population	1981 Projections	1985 Projections
Alabama	5,961	-	-
Alaska(1)	832	-	1,077(2) 900
Arizona	4,607	4,193 4,094 4,291	6,433 4,394 4,743
Arkansas	2,909	-	-
California	24,579	25,810	31,195
Colorado	2,784	2,819	2,773(3)
Connecticut(1)	4,308	4,613	-
Delaware(1)	1,339	1,582	2,379
Federal	24,363	29,252	32,624
Florida	20,742	21,218(4)	25,373
Georgia	11,932(5)	13,668	14,080
Guam(1)	112	-	240(6)
Hawaii(1)	990	1,005	1,346
Idaho	817	1,304	-
Illinois	13,104	13,595	15,788
Iowa	2,512	-	-

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Jurisdiction	1980 Actual Population	1981 Projections	1985 Projections
Kansas	2,494	2,463(7)	-
Kentucky	3,608	-	-
Louisiana	8,661	-	-
Maine	829	846(8)	833(8)
Maryland	8,424	8,524	8,675
Massachusetts	3,251	3,480	3,850
Michigan	15,158	15,380	15,810
Minnesota	2,001	1,757	1,651
Mississippi	3,374	3,480	3,850
Missouri	5,524	6,000	-
Montana	746	826	884
Nebraska	1,239	1,308	1,337
Nevada	1,839	-	-
New Hampshire	325	-	-
New Jersey	6,087	-	-
New Mexico	1,478	-	-
New York	21,819	22,262(9)	24,212
North Carolina	15,382	15,931(8)	-
North Dakota	302	249	249
Ohio	13,256	15,044	-
Oklahoma	4,648	-	-
Oregon	3,125	3,436	3,781-4,552
Pennsylvania	8,153	8,600	9,500
Puerto Rico	3,907(11)	3,913	4,131(6)
Rhode Island(1)	823	825(7)	1,021(7)

Jurisdiction	1980 Actual Population	1981 Projections	1985 Projections
South Carolina	7,862	8,092(8)	8,922
South Dakota	635	656(12)	-
Tennessee	7,023	-	-
Texas	29,866	-	-
Utah	932	-	-
Vermont(1)	476	-	-
Virginia	8,920	9,493	12,141
Washington	4,333	4,509(8)	5,578
Washington, D.C.(1)	3,145	2,647(13)	-
West Virginia	1,248	-	-
Wisconsin	3,857	3,592(4) 3,464(4)	3,730(4) 3,506(4)
Wyoming	490	-	-
Canada (14)	9,270(15)	9,470(16)	10,020(16)

(1) Jail and prisons combined (one system)
(2) 1/1985
(3) 1986
(4) June 1981
(5) Considerably less than our data indicate
(6) 1984
(7) Fiscal Year ADP
(8) ADP
(9) End fiscal year
(10) Estimated from a graph
(11) 1979
(12) Midway point between 1980 actual population and projections for 1982
(13) Third quarter; sentenced adults only
(14) Males only, end fiscal year
(15) April 1st
(16) A median scenario with assumptions based on the focus Delphi method

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SELECTED BIBLIOGRAPHY

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