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THE ART AND METHODS OF CRIMINAL JUSTICE FORECASTING

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THE ART AND METHODS OF CRIMINAL JUSTICE FORECASTING

A Dissertation

Presented to

the Faculty of the Institute of Contemporary Corrections
and the Behavioral Sciences

Sam Houston State University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

Allen R. Beck

May, 1978

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DISSERTATION

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ABSTRACT

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The purpose of this study is to examine forecasting methods from social and technological fields that could be applied to the forecasting of prison population and other criminal justice concerns. The study is designed to meet informational needs for an audience of varying levels of statistical sophistication, such as researchers, planners, and administrators. General forecasting concepts and theory, as well as techniques, are discussed.

Sixteen forecasting methods have been selected from a larger list of techniques that could be considered for use in the field of criminal justice planning. These sixteen methods are presented in ten modules that are grouped into three general categories: subjective methods, naive methods, and causal methods. Each forecasting method is presented and evaluated according to a uniform format which facilitates comparison among the techniques. The steps of technique application are illustrated using either data obtained and analyzed for the study, or by examples drawn from correctional research literature and relevant social science research. Many of the illustrations concern the forecasting of prison populations in order to present a common basis for discussion.

The study of prison population forecasting methods indicates the need to avoid equating quality of the forecast to complexity of calculation and to standards borrowed from cross-sectional analysis in

behavioral research. A method synthesized within this study, Subjective Extrapolation, presents the basic considerations that the analyst should address in forecasting prison population by naive and causal methods.

Forecasts of prison population are shown to include many utility concerns other than accuracy. The consideration of accuracy represents only the single-future exploratory forecast. Other considerations of forecasting, such as multi-alternative possibilities and normative forecasting, are examined.

The role of prison population forecasting is shown not to be simply that of determining a prison population at a given point in the future. Forecasts are constructed for a variety of purposes in planning and, as such, may reflect differences in the nature and type of information presented.

The study also examines the pitfalls in forecasting. Problems are shown to arise both from the manner of using forecasting techniques and from within the correctional environment in which the forecaster works.

Charles M. Friel, Ph.D.,
Supervising Professor

ACKNOWLEDGEMENTS

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The writer is also indebted to the Florida Department of Offender Rehabilitation, particularly to Messers Robert Roesch, Lonnie Fouty, and Robert Morgen for sharing their work "A Survey of Population Projection Methodologies in the States and the District of Columbia" (1977). Their survey, elsewhere unpublished, appears in Appendix B. This research by Florida will help the reader appreciate the state of the art of prison population forecasting. In addition, to this survey, Mr. Fouty was often a helpful source for other information during this study.

In the course of the study many correctional researchers were contacted. Those analysts involved in forecasting were open and interested in sharing information about their efforts. The reader will find that several of the collected reports and studies are used to illustrate forecasting concepts later in the text.

An important aid in conducting this study was the generation of ideas and development of alternative ways of viewing the topic. In this effort, this writer would like to acknowledge that he appreciated and enjoyed the support offered by Dr. Charles Friel. Thanks are also extended to Drs. Beto, Pilcher, and Sweeney for their comments and suggestions during preparation of the manuscript.

A core of this study is that of information--information from well-known and little known sources. The hours of digging for little known sources were made easier by Messers Dong Ko and Paul Culp and their staffs who not only processed many interlibrary loan requests but became alert for publications that might be of value to this study. As a result the research was more pleasant because the library staff "joined in."

Many hours of reading and rereading the various sections and chapters helped to clarify the translation of statistical concepts into non-statistical terms. In this task my wife, Mary, and assistant, Jan Blomerth, proved to be extremely patient and helpful. Mary's support was invaluable in helping to bring this long project to a successful conclusion. Jan Blomerth has the distinction of truly having had the last word "warranted," which appears as the last word of the last chapter. Her suggestion for choice of words gives her this unusual distinction in this study.

Thanks to Kay Billingsley for her close attention to the set-up and typing of the manuscript. Many of her suggestions helped to structure the format of presentation.

Not to be overlooked is the patience and silent support of my eleven-year-old son, Robert. Many times his phone calls at night to talk to Dad helped me to keep in mind that I was working on the future for the sake of the reader and for my family.

A.R.B.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE		PAGE

CHAPTER I

STATEMENT OF THE PROBLEM

The Need for Forecasting in Corrections

Corrections, in 1977, faces the problem of overcrowding. At the start of 1976, there were 250,000 inmates in state and federal institutions. In comparison to 1973, this is nearly 55,000 more inmates, roughly a 35 percent increase in prison population. Never before have so many persons been incarcerated in U.S. prisons (Gettinger, 1976). Prison space does not exist to humanely house all of these persons, nor has a solution to the problem been formulated. In 1976, Richard Velde, speaking before the convention of the American Correctional Association, urged administrators to begin planning on "the hard decision of how to best cope with the population increase."

In the last ten years, national emphasis on prison population planning cannot be wholly characterized as the reactive approach to planning which is indicated in Velde's statement. In 1973, before the rise of the present prison population problem, the National Advisory Commission on Criminal Justice Standards and Goals sought to establish a policy on construction of prison facilities. However, the effective life-span of that recommendation, which would limit construction, was but one year; in 1974, the dramatic increase in prison population began. This suggests that the influential committee members were insensitive to crucial characteristics of the Criminal Justice System and to the need for exploring alternate futures. It is doubtful that the mechanisms of prison population growth are so erratic that planning must become a discontinuous, yearly event. Such short-sighted planning falls within Dror's (1968) characterization of government planning as a process of "muddling through" and incremental innovation.

Certain features of politics and government may always produce a degree of "muddling through" and incremental innovation. Ideally, the administrator should possess the capability to question and limit that process. However, in regard to forecasting, he is hampered from the start by conditions beyond his control.

Tugwell's (1973) investigation of planning and policy-making brings to light an aspect of planning not possessed by administrators in the Criminal Justice System, because that area, futuristic thinking, is poorly developed. In Tugwell's assessment, policy-making or any other rational, action-oriented choice can be broken into components or tasks:

1. Normative Thinking. The clarification and specification of values and goals. (What is good?)

2. Scientific Thinking. The explanation of behavior, both static and dynamic with predictive intent. (How do things work?)

3. Futurist Thinking. The elaboration of possibilities and alternatives. (What is possible and what is probable?)

4. Strategic Thinking. The specification of action paths or sets designed to attain desired outcomes at estimated cost. (How can I get what I want?) [p. ix]

These four components exist in any rational, action-oriented choice even though they may be unconsciously executed. Most planning in the Criminal Justice System draws upon tasks 1 and 4, normative and strategic thinking, and sometimes task 2, scientific thinking. However, futuristic thinking, task 3, is not often called upon because of its primitive state.

To this point Dror (1968), directs his argument: "If current problems are to be successfully managed and not allowed to develop into crises, futures research must be incorporated into public policy making" [p. 40].

Objectives of the Study

Research into the area of futuristic thinking, particularly forecasting, is the basis of this study. The general framework of the study is built upon four aspects: (1) methods employed in forecasting, (2) assumptions underlying these methods, (3) guidelines for using these techniques, and (4) problems in using the techniques.

The above four aspects could be applied to any field of forecasting whether in business, science, or meteorology. Within these fields, the kinds of methods vary, as shown in Figure 1. For example, there are qualitative (subjective) methods which differ from time-series methods for business forecasting. The methods also vary according to the period of time being forecasted; causal methods of forecasting the immediate business future may not be the same as those employed in causal long-range business forecasting.

Although Figure 1 may not be exact in depicting the number of forecasting methods, the point to be made is that the range of methods is so broad that coherent investigation calls for narrowing the focus of study. In this instance, it has been the decision of this investigator to select the form of forecasting most familiar to the correctional

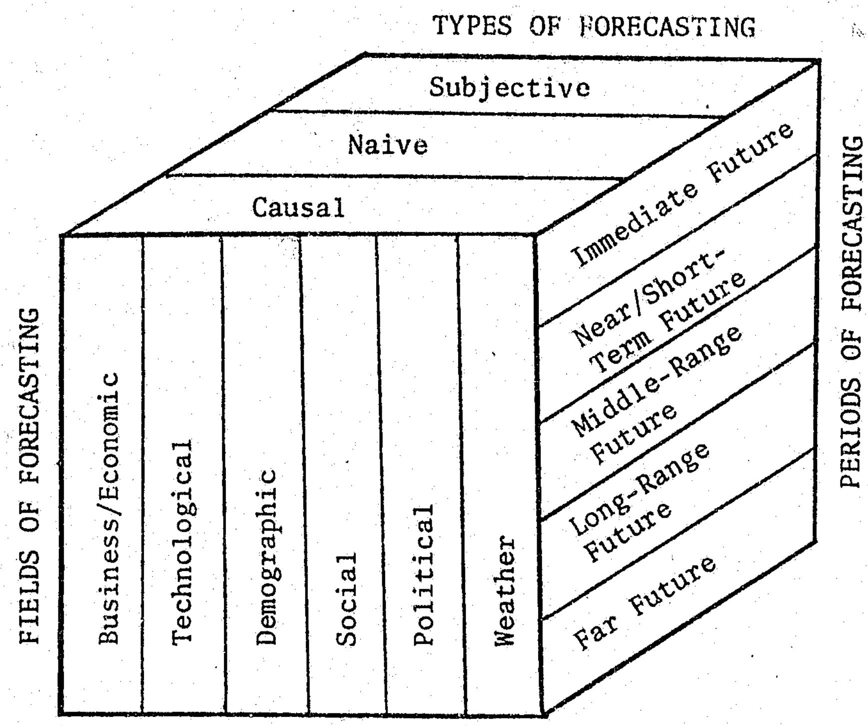

Figure 1. Methods of Forecasting

administrator (prison population forecasting[1]) within the framework of the four general aspects indicated above. In this manner, the study will provide the correctional administrator with a familiar starting point upon which to expand working knowledge. This groundwork of knowledge can then be used as a basis for generalizing to other kinds of situations in which forecasting may be employed.

In this study, the general research objectives are:

- Develop a classification which the administrator and forecast analyst can use to select forecasting techniques according to such considerations as cost, time requirements

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[1]Prisons and corrections will be treated as similar terms to refer to all of the programs under the auspices of the various state departments of corrections. For example, this includes community-based programs, as well as medium and maximum security facilities.

for constructing the forecast, data requirements, expertise required, strengths and weaknesses of technique, and time perspective of forecast.

- Identify techniques used for prison population forecasting and evaluate their strengths and weaknesses.
- Identify techniques used in allied social science fields which can be applied to prison population forecasting.
- Identify the role of forecasting in the criminal justice planning process.

The objectives of this study intend to examine the art of criminal justice forecasting. This study does not purport to open the future to scientific determination of what will happen in the Criminal Justice System. Social forecasting is an art and, as such, it must not mislead the analyst or forecast user into perceiving that the future can be determined with an air of certainty.

Explanation is forthcoming as to the reasons for mistaken perception of forecasting as a borrowed form of scientific prediction. Many other considerations will be discussed, such as the pitfalls and sources of forecast error the analyst may encounter in using forecasting techniques, calculating forecasts, and from problems arising within the environment in which he works.

Defining the future of the Criminal Justice System is a difficult process. Had this process been easy, this study would not have been necessary. An essential point to be held in mind when exploring this study is that defining the future is an art not to be taken lightly and one in which some will find their work more readily accepted than others. In addition, the reader should hold in abeyance the desire to find the best predictor of the future until all of the roles of forecasting have been examined.

State of the Art of Social Forecasting

In 1969, Duncan described the state of the art of social forecasting which seems not very different from today's state:

> A 'state of the art' report on social forecasting should, in all honesty, be quite brief. Such an art, in the sense of a coherent body of precepts and practices, has not yet been developed. It would be misleading to claim that social forecasting is carried on in a continuous and concerted fashion as one could claim in regard to, say, economic or business forecasting [p. 40].

There is one exception, demographic forecasting, which has developed a pattern of practice and precepts because of the length of its existence. In that area, more forecasting information exists than for any other social area (Duncan, p. 41).

Wilkins, in 1970, assessed that the only form of forecasting applied to the Criminal Justice System was projection of prison populations and similar types of estimation. There seemed to be a "surprising paucity" of forecasting methods in the field of jurisprudence, law, and criminology.

During the period of 1970 to 1976, the major emphasis on forecasting in the Criminal Justice System arose in the area of modeling. Models were constructed that ranged from such concerns as simulation of the overall Criminal Justice System to individual court simulation. Chaiken et al in Criminal Justice Models: An Overview (1976), reviewed forty-six applications of modeling.

In 1976, Project Star produced what it considered to be "an initial exploratory effort at applying forecasting methods to problems in the Criminal Justice System" [p. 347]. In scope, the study involved only a few forecasting methods. This work, however, did not identify the previous efforts in prison population projection or modeling as part of this "initial exploratory effort." This disparity of viewpoints about what comprises forecasting is related to Duncan's comment about the state of the art. There appears to have been no systematic or concerted effort to build a body of knowledge about forecasting in the Criminal Justice System.

Outside of the Criminal Justice System, several theorists in economics such as Becker and Harris, have constructed economic models of deterrence. Although these models are general in nature and have limited forecasting content, they represent the possibility of applying techniques from other fields to forecasting problems in the Criminal Justice System.

CHAPTER II

THE DEFINITION AND NATURE OF FORECASTING

This chapter calls attention to the definition of forecasting as a misused and poorly understood concept. To clarify what will be presented as forecasting, a definition of forecasting will be formulated which narrows the focus of study. Forecasting will be viewed, also, as an undertaking influenced by expectations of the user.

Definition of Forecasting

There is no consensus of the definition of forecasting. Kendall and Buckland's A Dictionary of Statistical Terms (1971) states that "'Forecasting' and 'prediction' are often used synonymously ..." [p. 58]. Various outcomes of intuitive processes may also be termed predictions, forecasts, or even fall into the classification of prophecy. This flexibility of terminology frequently results in difficulty of communication. The social researcher with training in psychology is likely to interpret forecasting as prediction because of his experimental orientation in applying statistics to social settings.[1] In order to clearly understand forecasting and its uses, forecasting must be distinctly differentiated from prediction, intuition, and prophecy. To this end, four forms of dealing with the future will be compared across five utility characteristics.

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[1]Psychological research was chosen for this example because much of the research in corrections is conducted by persons with background in psychological statistics as opposed to business statistics.

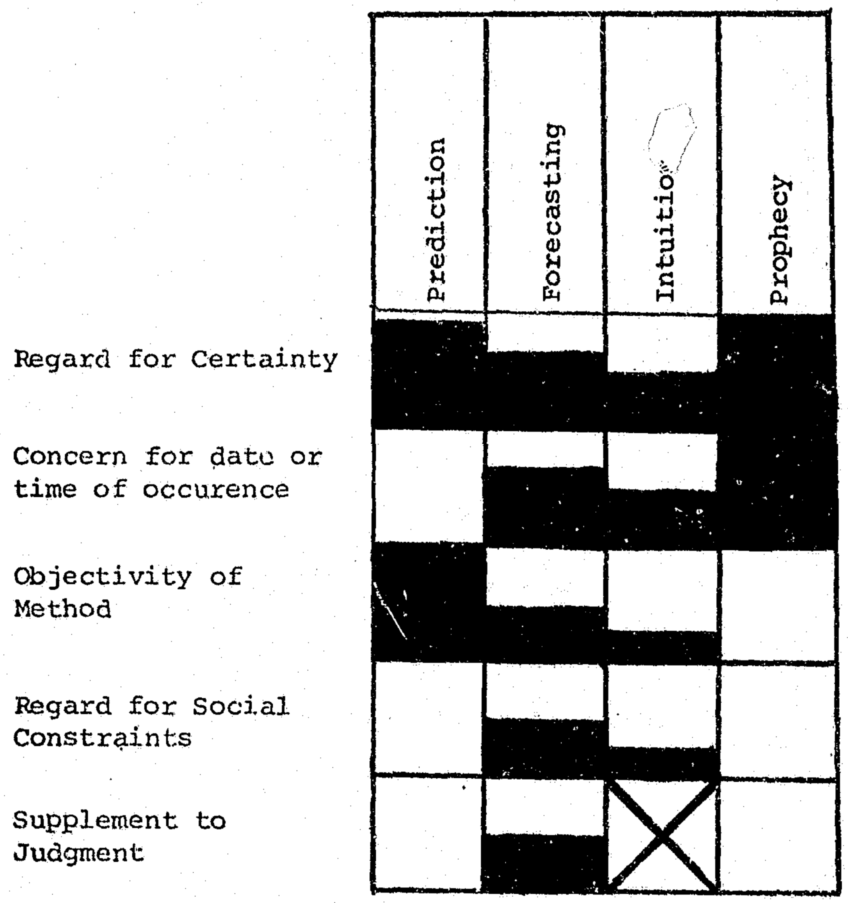

Figure 2. The Relative Utility Characteristics of Four Approaches for Dealing with the Future

In Figure 2, the relative utility of each approach is depicted in block shading. A totally shaded block indicates an absolute regard for the utility characteristics. Partially filled blocks indicate a partial concern and, as such, represent a relative comparison of methods. The "X" in the block for intuition in the last row indicates that the relative value is not established because of the synonymous meaning of judgement and intuition.

Regard for Certainty and Time

Our first consideration of Figure 2 involves two utility characteristics, certainty and time. These two characteristics are frequently encountered in the literature as intertwined. For the purpose of developing clarity in definition, certainty and time are graphically distinguished. This will be the only instance in which two utility characteristics will be discussed together.

Seemingly, at first glance, the chart betrays common conviction about certainty and time. The question may be asked, are not all methods of dealing with the future concerned with certainty? Yet the chart seems to show that only prediction and prophecy make statements of total certainty. And, how is it that prophecy can make exact statements about the date of occurrence and that prediction appears not to do that? These apparent incongruities are really not as confusing as common definition suggests. To go beyond this nebulous mixture of meaning and to clarify definition is the goal of the following section.

It should be noted that when we speak of "prediction" we are borrowing a term from the physical sciences. Therefore, in the quest for clarity, prediction and forecasting will not be used as interchangeable terms in this dissertation to refer to man's social future.

Prediction, in the scientific sense, "seeks a statement of outcome if certain conditions are met" [McGrath, 1974, p. 71]. Prediction, then, involves two elements: conditions (or a situation) and an event (or outcome). In prediction, the relationship between the situation and outcome, if properly established, must hold not only for the past, but for all future observations of the same phenomena (Cox, 1931).

Time enters into the concept of prediction in sort of a roundabout way, as Nisbet illustrates:

> When the astronomer 'predicts' an eclipse he is merely vouchsafing that part of a well known astronomical regularity that happens to be capable of statement in public-pleasing terms of a certain day, hour or even minute [1971, p. 21].

Essentially, a prediction is timeless. The outcome of a prediction need not be announced for any given time, but may be regarded as the consequence of a particular situation whenever the situation occurs (De Jouvenel, 1967). Jantsch, who is well known as a contemporary researcher of forecasting techniques, goes so far as to define prediction as "an apodictic" (non-probabilistic) statement on an absolute confidence level about events which can occur in the future" [1967, p. 15]. This definition, which denotes strict determinism is not, however, wholly acceptable in the physical sciences, particularly physics.[2] Jantsch's definition is presented

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[2]The notion of strict determinism which arises from Newton's principles has been challenged by contemporary science. The forefront of this challenge has been advanced in the argument of uncertainty presented in quantum mechanics. This branch of physics deals with energy and small particule (atomic) phenomena. Brillouin in Scientific Uncertainty and Information (1964) asserts:

> Determinism assumes a 'must;' the cause must produce such and such effect ... but such strict determinism cannot be accepted ... Causality accepts a statement with a 'may': a certain cause may produce such and such effects with certain probabilities and certain delays ... This distinction is very important. A law of strict determinism may be based on (or contradicted by) one single experiment: the effect is present or it is not ... A probabilistic causality requires a very large number of experiments, before the

here to the reader to emphasize that prediction can approach, within certain limits, a point of high confidence in describing the relationship of causal events to outcome.

When a person speaks of prediction from a regression equation, what is being predicted is merely the points on which the regression was based or other points drawn at random from the same population (Keyfitz, 1972). What this means is that the data comes from the past, such as from observations over a period of time or from an experiment. The future is not involved; data do not come from the future (an impossibility, of course) nor do they come from estimated future conditions (which are quite possible to construct)

Prophecy, like prediction, deals with certainties of the future, but for different reasons. Prophecy regards the future as pre-existent in the mind of the supernatural. Therefore, the prophet can claim to make statements about the future with complete confidence

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law of probability, can be approximately stated [pp. 69-70]. This argument does not mean that the deterministic approach to physical science should be abandoned. The Encyclopedia Britannica (1971) interprets the impact of the uncertainty principle and quantum mechanics:

> ... ordinary physical processes appear to be so fully in accord with the law of Newton. Planck's element of action (an equation denoting a movement of particules) is, for example, far too fine-tuned to have any bearing on the driving of an automobile ... In other words, Newtonian dynamics must represent a special case of quantum dynamics appropriate to cases where the action is very large compared to elementary quantum... As a result, one of the most important philosophical implications of quantum mechanics concerns the apparent breakdown of the causality principle in atomic phenomena [Vol. 18, p. 919].

The interested reader may refer to Heisenberg's work, Physics and Philosophy (1958) and Capek's The Philosophical Impact of Contemporary Physics (1961) Chapters XV and XVI.

as to the likelihood of even occurrence and the time it will happen. Often, though, prophecies are offered in timeless statements.

The prophecies of Nostradamus illustrate what we are talking about in regard to certainty and time reference. Nostradamus, a figure of sixteenth century France, is described by Robb (1961). Nostradamus was

> an involuntary prophet, though he wisely cultivated his God-given faculty by prayer and meditation ... [He] won extraordinary fame and repute as a doctor curing thousands in the plague years by unorthodox remedies.

Nostradamus published his first book in 1555, Les Vrayes Centuries, (The True Certainties) and became so famous that he was summoned to court by Henry the Second and his wife, Catherine de Medici (p. 9). In 1566, just before his death, Nostradamus wrote:

> In the year seventeen hundred and nine heavens will be witness
> That one will hardly be able to exchange gold for wheat

Robb, who by now you recognize as seeking "to prove that prophecy is a scientific fact" [p. 7] declares that this prophecy of Nostradamus was a "hit" and not a miss. For, in 1708-09, France suffered a terrible winter and spring in which the year's new crop was spoiled by unexpected cold weather and the period was a "year of despair ... [in which King] Louis was in such need of money that he sold a service of gold plate to raise a few hundred thousand francs" [p. 49].

This example of Nostradamus' prophecies reflects both the concern for certainty and precise time of happening. Nostradamus did not say that the event could have been avoided by human intervention or that other futures were possible; in addition, the date is specifically designated. Nostradamus also offers another form of prophecy:

> In the year when a one-eyed man reigns in France
> The Court will be in a very grievous trouble:
> The Great One of Blois will kill his friend;
> The Kingdom put in evil and double doubt [Robb, p. 47].

This form of prediction leaves the time element open for the believer to decipher. This is the most common practice.

Forecasting is unlike prophecy and prediction. It does not make statements with absolute[3] certainty about the future. Forecasting seeks to move in the direction of certainty, although certainty is not seen as achievable. Forecasting assumes that the future is unknowable because forecasted events which involve human input are subject to influence from a variety of sources. The construction of alternative futures in forecasting is one of the means of developing a greater sensitivity to possible future changes. This assumption of uncertainty is unlike that of prophecy, which asserts that the events which are foretold are beyond the creative will of man and cannot be changed by intervention (Lompe, 1968). Furthermore, prophecy, like prediction, has no need to seek greater sensitivity to possible future changes through construction of alternative human futures.

Forecasting also constructs probabilistic statements about the various future possibilities (Bestuzhev, 1969). Frequently, a forecast is abbreviated and the probabilistic statements are implicit,

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[3]In this context, "absolute" is used to connote the ability to achieve the maximum attainable certainty within the limits of scientific prediction.

giving the appearance that only one future alternative is explored. Although a forecast may take this form, it does not mean that the forecast is offered on an absolute level, as in prediction and prophecy.

Forecasting is similar to prediction in that it involves the collection of historical data. But to that data is added information about anticipated future conditions and changes (Johannsen and Page, 1975). This expanded scope of data collection to incorporate hypothetical data generation lowers the similarity between prediction and forecast. For this reason, forecasts are not subject to the same positive proofs required of prediction because, in actuality, the data for forecasts have not yet occurred (Meinert, 1973).

Forecasts usually do state a general or specific timeframe for the occurrence of events. One of the objectives of forecasting is to relate time to outcome. This causes the forecast to be more global in nature than prediction. For example, the forecast must consider both a wider range of subevents and the likelihood of those subevents occurring in a timely pattern to facilitate development of anticipated trends. Unlike prediction, forecasting often considers the effect of intervention on outcome and time. This consideration encompasses both what could happen if intervention did not occur and what could be changed if intervention could be planned. Such consideration is far removed from the timeless quality of prediction in which the situation is followed by a specific event.

Intuition, as shown in Figure 2, is similar to forecasting in regard to certainty and time. As in forecasting, a decision-maker may make a single intuitive statement about the future which he professes to be certain. However, examination of the intuitive process will disclose that he formulated several future alternatives and chose the one he preferred.

There appears in Figure 2, also, to be some inherent difference in the relative concern for certainty and time between the approaches of intuition and forecasting. As will be seen, intuition, being less formalized, does not as thoroughly investigate alternative futures nor the time element in occurrence of subevents.

Objectivity of Method

Returning to Figure 2, objectivity of method can be seen as an outstanding feature of prediction. The use of the scientific method in prediction establishes a rigorous procedure by which data can be examined and evaluated by other investigators.

Forecasting may incorporate many of the mathematical tools of prediction; however, forecasting is not an exact science because of the role of subjective input. Subjective input is a part of both forecasting and intuition, although in Helmer and Rescher's view, forecasting can be more of an exact science than intuition. They see an exact science as "a formalized reasoning process" and an inexact science as an "informal process" [p. 25]. In formalized reasoning, the objective is to replace implicit methods with explicit methods, based on a combination of data and theory (Martino, 1972). As will be shown later, the Delphi method is an example of an explicit reasoning process.

Martino's reference (above) to "theory" as an element of explicit methodology concerns the forecaster's assessment of future relationships of conditions and outcomes. De Jouvenel (1962) points out that it is important to explicitly construct this "intellectual scaffolding" to support the forecast. Emphasis, he adds, should also be placed on using all causal relationships that can be found to build this intellectual scaffolding (p. 117). To illustrate this idea, an excerpt is drawn from Project Star's Impact of Social Trends on Crime and Criminal Justice (1976):

> Negroes can be expected to seek equality of treatment in prisons just as they are seeking it in other areas of society. Prison riots involving black inmates and white guards, therefore, can be expected to increase in frequency and intensity during the 1970-1980 decade [p. 137].

This excerpt displays a theory of causal relationships within a time frame. Thus, as forecasting strives for greater objectivity, the subjective becomes formalized and implicit reasoning is explicitly stated. Because of this, Zarnowitz (1968) feels that, in principle, a forecast should be verifiable with regard to method and development of constructs. This is not the same proof required of prediction, although these criteria are more rigorous than those for intuition.

Regard for Social Constraints

Figure 2 depicts prediction as involving little or no concern for social constraints. The timeless predictive relationship between the situation and outcome exists outside of the influence of human intervention. For example, an eclipse will occur regardless of man's opinion that it might not be desirable to experience the darkness, and man's intervention cannot influence the relationship of earth and moon.

Forecasting, on the other hand, must develop an awareness of social constraints. A forecasted future state of affairs must be both a plausible and imaginable product of the present state. Social desirability and resources are examples of constraints that influence the course of man's behavior, e.g., public health in the future will be affected by governmental plans, funding capabilities, and response of the public. Of course, the effort to attain accountability of social constraints will be less than perfect. No forecast can possibly be so comprehensive as to account for all eventualities and accidents.

Intuition, being less formalized than forecasting, may not as extensively investigate social constraints. Both intuition and forecasting are affected by personal bias; furthermore, the same person can be involved in both processes. It becomes apparent, then, that the difference reflected in Figure 2 is one of mechanics, which in forecasting lessens bias and directs a wider evaluation of constraints.

The last approach to consider in this utility category, prophecy, is similar to prediction in that it is not concerned with social constraints. The prophet asserts that unquestionable divine inspiration or magical influences have guided him to foretell man's actual future. His prophecy exists as truth regardless of questions about feasibility or social desirability.

The Use of Techniques and the Place of Judgement

The final utility consideration of Figure 2 reflects the manner in which the technique is used in regard to the decision-making process. Prediction and prophecy seek to replace human judgement. The goal of prediction is to establish scientific laws about situation and outcome, and prophecy seeks the "truth" about the future. In contrast, Cooper-Jones (1974) points out that the place of forecasting is not to replace judgement, but to enhance it. Forecasting accepts that the future is unknowable and that human intervention influences the course of events. Forecasting is a tool of planning.

Reevaluating the Popular Definition

This definition of forecasting is the piecing together of various ideas. As such, it may differ from definitions in common usage. For example, weather forecasting, according to this definition, would be classified as prediction. You will recall that prediction has been defined as projection into the future of data from the past. The nebulous status of weather prediction exists because many of the environmental relationships between situation and outcome have not been discovered. Weather is a science in the poor state of development, much similar to man's early attempts to explain and predict the movement of the planets.

Weather prediction differs from forecasting in much the same way that astronomy differs from forecasting. The astronomer, in seeking to predict the paths of the planets, does not seek to evaluate the influence of society's wants and capabilities. The heavenly bodies operate independently of man. Forecasting, on the other hand, seeks much subjective information.

Probability is expressed in weather prediction because the scientist is uncertain that he is dealing with the appropriate underlying scientific principles. A weather prediction expresses a hope that it is actually identifying the relationships. The state of the art of weather prediction has yet to develop sufficiently sophisticated instruments to obtain and interpret the information required.

In forecasting, no instrument can be built that can detect data that have not yet occurred. Furthermore, we cannot assume that today's data and inference about man's behavior apply exactly to the same population of data in the future (Keyfitz, 1972).

Images of the Future

The images of the future that we create are intimately related to the time concepts that we hold. Today, we entertain a great number of time concepts unrecognized by ancient and primitive man. Today, when thinking about the future, we apply various concepts according to personal criteria. Our image of the future may also influence the choice of forecasting technique. In evaluating the use of forecasting, applied time concepts may be as important as element of choice as is the forecaster's fondness for a particular tool, such as regression analysis.

Basically, man has five perspectives through which he views the future: circle, straight line, balance, zig-zag line, and spiral.[4]

The Circle

The circle represents man's most primitive thinking about the future. The origins of this perception go back to antiguity and are still reflected in religious literature. The circle has been, perhaps, the longest surviving notion of the future.

Early agricultural man's view of the future was restricted. Progress was not a common part of future thought until nearly the nineteenth century. For ancient man, seasonality was probably the basis of his time concept. During primitive ages, seasonal tasks developed into traditions sanctified by usage and surrounded by ritual. This repetitive life-style required neither planning nor foresight and included no notion of time other than the seasons. Eliade (1954) identifies this setting as the foundation of man's early concept of religion. This early concept of religion established that life was an eternal repetition of archetypal patterns constructed by the gods. Because of this viewpoint, the ancient intellectual may have been

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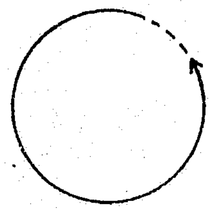
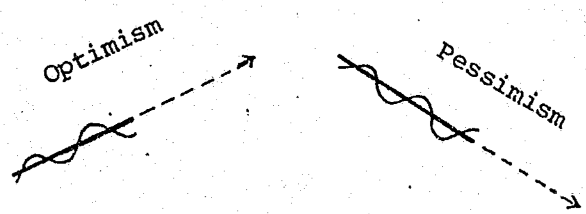
[4]Lewinsohn's work stimulated the development of these five perspectives. It should be noted that his presentation in Science, Prophecy and Prediction (1961) mentions only four time perspectives. Only in the graphic presentation of the circle, straight line, and balance is there agreement of his illustration with the illustration of the five perspectives. The discussion of the five perspectives is only vaguely similar to Lewinsohn's explanation. Although, credit must be given to him for the stimulating start he provided for the development of this writer's five time perspectives.

1. CIRCLE



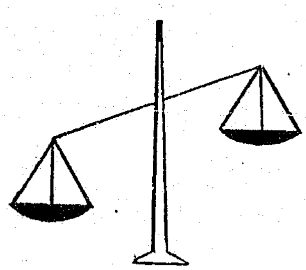
Theme: Nature repeats itself.
- Historical events are believed to occur in a periodic schedule. Once that schedule is known, future events can be determined.

2. STRAIGHT LINE



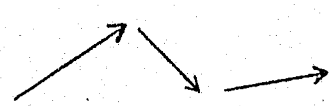
Theme: Continuance of a trend.
- Events are perceived as part of a continuing rise or fall. The eventual trend has a basic direction in which fluctuations may occur without affecting the general direction.

3. BALANCE



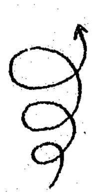
Theme: Nature displays a tendency towards equilibrium.
- Fluctuations from equilibrium are counterbalanced by other events. If the upsetting event can be identified, then the nature and magnitude of the offsetting events can be determined.

4. ZIG-ZAG LINE



Theme: Actions and reactions/ causes and effects over time.
- Social occurrences are viewed as a discontinuous series of situations, each involving an action and reaction. Man's assignment of cause and effect is related to his level of sophistication.

5. SPIRAL



Theme: Progress occurs at an increasing rate.
- The future is becoming increasingly complex. One innovation may stimulate several other innovations which brings about a mushrooming effect.

Figure 3. Time Perspectives for Viewing the Future

inclined to interpret all of the events of the day, be they famine, war, or wretchedness, as part of the yearly repetition of archtypal patterns. In this light, change was irrelevant and differences in one's yearly life were meaningless and without impact on man's future.

The circle also exists in the greatest writings of the Classical Period. Plato's Republic, which was to become a model for the numerous later versions of utopia, was based on the circle concept. His utopia did not deal with the emergence of a perfect world, but rather the return to the perfect state which had existed before. His period of time, he evaluated, was an inevitable period of degeneration prescribed by the cyclical nature of time (McHale, 1969).

Early Judaism and Christianity sought to repudiate this circular notion, the doctrine of regeneration. The early Judeo-Christian philosophy interpreted events as disclosing the will of God, rather than reflecting a repetitive pattern. Thus, a sense of history developed and events were viewed as individually meaningful. For Christianity, the coming of Christ established a benchmark in the evolution of religions. Once and for all times, the redeemer of mankind came; he did not return every year as had been the tradition portrayed by the doctrine of regeneration (Eliade, 1954). History began to develop a meaning of its own and man's future was no longer circular. Man could now control his destiny and modify his future.

Judaism and Christianity did not, however, totally develop a time perspective which excluded and prohibited notions of cycles and repetition of patterns. Religious thought in the middle ages embraced cyclical astral theories. Many prominent religious philosophers believed that cycles and periodicities of history were governed by the stars which reflect a cosmic or divine regularity (Eliade, 1954).

The liturgical structure of contemporary Judaism and Christianity impart a theme of repetitive and cyclical existence. Judaism reflects a preoccupation with the seasonal rituals developed in earlier agricultural life. The Christian liturgical year contains a circular theme based on the repetition of the Nativity, Passion, Death, and Resurrection of Jesus. In the sense of its deep mystical drama, the Christian experiences regeneration and expectation of the events of the coming year and years.

Religion is not the only conveyor of the circular theme. For example, man's study of science involves theories in which phenomena are represented as following circular motion. Also, man's observations during everyday experiences sensitizes him to those notions of seasonal regularity which ancient man perceived. However, religion has been the focus of this discussion of the circle because it is one of man's most influential forms of socialization which is active in developing the circular perspective from childhood.

The Straight Line

The second time perspective through which contemporary man views the future is symbolized by the straight line. As mentioned earlier, the element missing from the ancient's view of the future was that of material progress. Not until the late 1700's did progress play an active role in futuristic thinking. In 1763, in what might be considered the first serious attempt to represent the future, an unknown writer in England described the English world as he foresaw it in the twentieth century (Clarke, 1969). His work, Reign of King George VI, 1900-1975, merely extends his experience of an unchanging, non-technical life. If anything were to be different at all, he contended it would be in the quantity, not quality, of materials. There would be more ships of the existing design, more carriages and bigger armies. Even America would remain as a happy British Colony.

Two events in the latter part of the eighteenth century brought about a revision in extrapolations which had been based on "more of the same." In 1783, the Montgolfier brothers accomplished the first manned balloon flight. Also, in this period, the steam engine was invented. Quickly, man's hopes of the future changed. This was reflected by a spurt in the growth of literature and artwork depicting the application of new inventions to future life.

The straight line perspective is commonly found in today's futuristic thinking. However, extrapolation has not developed to the point that it reflects the procedural rigor of deduction (De Jouvenel, 1967). Rather, it is a general process in which present knowledge is carried forward. Usually, this is an unconscious process in which the mind transfers ideas gained from the individual's limited contact with the total world, e.g., ideas gained from newspapers become pseudo-knowledge about the future.

The average man may purposefully shape future thought to conform to the straight line perspective. Lewinsohn (1962) contends that the average man prefers tangible forecasts that are extensions of what he knows. This extension of knowledge need not be totally optimistic; pessimistic forewarnings have also been popular. The preference for this perspective is apparently satisfied if the individual can recognize that the future is an extension of his established logic of the way life is and should be.

This process of carrying an idea "straight" into the future does not seem to be a trait restricted to the average man. Jantsch (1967) observed experts working on scientific and technical parameters. The results of supposedly sophisticated intuitive processes were found, also, to be linear projections. Thus the straight line perspective appears to be a favored way of viewing the future.

The Balance

The third time perspective for viewing the future is represented by the balance. This perspective is the embodiment of the concepts of equilibrium and homeostasis.

Religion, again, appears to have been an early source for this notion of time. In Judeo-Christian writings, God is portrayed as maintaining a spiritual balance. Man's sacrifices are rewarded and his misdeeds are offset by compensation for the human victim, and punishment follows to even the record. The offsetting punishment is not limited to the individual in his lifetime nor to the individual; his descendants or affiliated group could suffer his atonement; in the end, right counter-balances wrong.

The idea of equilibrium was established in mechanical analogies in early science; however, before the eighteenth century, it had not been applied to social behavior (Clark, 1931). In 1776, Adam Smith introduced equilibrium as part of a formal theory into the emerging social sciences field. Smith's notion of the "invisible hand" in Wealth of Nations described how an equilibrium price could be established in relation to supply and demand. Leon Walras expanded and groomed the concept of market equilibrium and today equilibrium theory is an essential part of the framework of mathematical economics.

In the biological sciences, equilibrium arose as the principle of homeostasis. According to this principle, the organism or the interaction of organisms maintains and restores steady states and conditions. Cannon, a physiologist at Harvard, described the principle and coined the term "homeostasis" in 1932. He also became one of the first to postulate the relevancy of homeostasis to group social processes.

This perspective, the balance, implies that the mechanisms of balance can be described and man may be able to detect the events which interrupt equilibrium. In evaluating these events, man seeks to estimate the weight of the disturbing influences so that he can assess the extent of the opposite swing of events which will restore future balance. It is man's goal in this perspective to identify disturbing events and foretell the coming of offsetting events.

The Zig-Zag Line

The fourth perspective, the zig-zag line, appears at first to be composed of small segments of the straight line. Such composition would imply that the future is a series of short trends arising from one another but proceeding in different directions. This, however, is not the nature of the idea. The difference lies in the assignment of cause and effect. The zig-zag perspective assigns cause and effect to events, but the straight line assumes continuance of a trend without a specific search for underlying causes and search for outcomes. The future in the zig-zag perspective is a series of cause-effect situations occurring as discontinuous segments; the last outcome does not necessarily give rise to the next situation. The idea of discontinuity between segments accounts for the historical irregularity of accident and the unpredictable. By stretching the time frame of a segment, as in global assignment of cause-effect, this perspective can be made to resemble the straight line.

This zig-zag perspective develops out of man's earliest contact with the world around him. Both primitive and contemporary man share these early life experiences.

> As soon as the child can hold anything, that is when after three months, the play with objects begins. In a thousand ways the child gives himself a little lesson in physics and geometry [Stern, 1928].

Whitehead (1929) says also that the human organism develops a "causal feeling." For example, sudden exposure to bright light and the following reflexive eye blink will be formulated into a cause-effect explanation.[5]

Man's experience of reasoning is different from his physiological experience. An adult's assignment of causality to events outside of physiological experience does not exhibit the uniformity of explanation found in the "causal feeling." Other factors seem to be at work in man's logical rationality. Hume (1911) postulated that rational assignment of cause and effect to two events is a function of the relationship between the objects and of man's experience. Basically, he says, three conditions must be satisfied: (1) the two events must be spatially contiguous, (2) one event precedes the other, and (3) the two events have been observed in this spatial and temporal relationship many times before. For example, if a person says that poverty causes crime, it is implied that poverty and crime are spatially contiguous, that poverty precedes crime, and that many cases of crime are associated with poverty. Hume denies that there is any necessary connection between two such events and that the experience of the observer supplies the link. When applying Hume's concept to the zig-zag line, we will find that one man's interpretation is not identical to another's, even when the same situations are observed. Each man's zig-zag line proceeds in different directions.

Sophistication is, of course, a guiding element

[5]Piaget and other child psychologists have conducted extensive research on the progressive stages of growth of causal thinking in the child. Although such work is interesting, such concepts are not central to the zig-zag perspective.

in the production of ideas of causality. Lower levels of sophistication tend to limit selection of causal factors to one or two of the most obvious conditions. Imitation and mystical thinking often assist in satisfying the need to explain the question of "Why did it happen?" On the higher level, the observer attempts to identify the less obvious but essential contributing conditions of causality. For example, the sophisticated viewer is less likely to accept the notion that thunder causes lightening, or that poverty causes crime.

The higher plane of causal thinking is characterized by at least two additional features. First, the assessment of cause and effect in social situations will consider that the magnitude of an action and reaction are not necessarily the same. For example, cruel repression of people by an uncaring government may not result in an equally cruel or violent revolution. Change in government can occur in small steps or as a peaceful revolution in which one leadership is replaced by another without terrible turmoil (Lewinsohn, 1961). The second feature of greater sophistication is identified by Bell (1967):

> ... most models of [social] change assume the introduction of a new element and some determinate consequence, which can be charted. But change actually proceeds on the basis of action and reaction, and consequences often 'react back' and change the original variable itself. Social change should be regarded, therefore, as a series of stages that exemplifies such a process [pp. 66-67].

Sophistication is not a uniform state of rationality which, when reached, will prevail throughout all thought. Abel (1932) points out that whenever adults are presented with unfamiliar, complex problems, they may make the same errors in judgement as children. Both adults and children rely on two "prelogical structures": the lack of synthesis and an excessive degree of synthesis. Thus, we might expect the adult's thought about the future to reflect some regression to prelogical patterns of analysis. Certainly, few efforts could be more complex and unfamiliar than attempting to "explain" the future.

In illustration of the zig-zag perspective, it may be seen that man's history reflects an evolution of the notion of causality from lower to higher levels of sophistication. Laurendeau (1962) conjectures that primitive man may have attributed life-like qualities to inanimate objects, e.g., since man's body gave off heat and the sun also was warm, the sun was alive. The Etruscans held that all phenomena were sent by the gods to acquaint men with their demands (Beajeu, 1963). Classical Greek thought reflected the remnants of animism. Thales, the "inventor of physics and philosophy" expressed "All things are full of soul" and Aristotle alluded to "vital forces" and the "prime mover" as influences in causation (Brumbaugh, 1964). In the seventeenth century, Zilsel (1970) notes, man had outgrown primitive animism and begun to see the world with the eyes of an engineer. Engineers were able to produce the effect they desired if they know the cause. The causal mode of explanation attributed to the engineer gave rise to a basic, and previously unknown, conception:

> In a well-governed state there are laws which are prescribed by the government and, for the most part observed by the

> citizens. Lawbreaking is rare and is punished when detected. Let us now suppose the government to be omnipotent and the police to be omniscient. In this case laws would always be observed. The seventeenth century began to compare nature with such a perfect state, ruled by an almighty and omniscient king. Thus the recurrent associations of natural processes were named natural 'laws' by scientists who investigated them--especially if they had succeeded in expressing the regularities by mathematical formulas. The term 'law' became so common that people soon began to forget that it originated in a metaphor; the idea arose that all events, without exception, were subject to natural laws [p. 810].

In the nineteenth century, this mechanical determinism of the seventeenth century was tempered by the development of the social sciences.

Today, man seeks to maintain a philosophical balance between determinism, religion, and the urge to regress to prelogical patterns of assigning causality. The educated man, hopefully, more often accepts the discontinuity reflected by the zig-zag perspective than the poorly educated man. However, we can expect that the complexity of attempting to view the future will often evoke less than the most logical response.

The Spiral

The fifth time perspective is represented by the spiral. This category contains those assessments of the future activity for which the rate of change is greater than that signified by the straight line.

In 1737, Giovanni Battista Vico suggested that progress does not occur in a straight line, but in a spiral, whose every turn is higher and more advanced than the last. His theory expressed in

"New Science," though popular today, did not catch on and was largely forgotten (McHale, 1969).

Today, the two fields in which non-linear growth is most discussed are those of demography and technology. In demography, one of the early theorists to apply this time perspective was Velhulst. In 1838, he constructed a mathematical equation which would avoid the irrational features of the straight line in describing population growth. His formulation, an exponential curve, when graphed proceeds in a symmetrical S-shape. His explanation accounts for the rapid growth of population in early stages and the decline in growth in later stages. Unfortunately, his work was based on too few observations to yield reliability of results (Reed, 1936).

Alvin Toffler's Future Shock (1970) is representative of contemporary concern for the ever-increasing rate of social and technological change. The base of this change, technological advancement, is perceived as providing a catalytic stimulus for growth. Toffler points out that "ninety percent of all scientists who ever lived are now alive, and that new discoveries are being made every day" [p. 27]. The evidence shows, he contends, that the time between the steps of technological ideas and generation of new ideas is being reduced. There are more scientists working on an explosion of ideas; as a result, change in technical and social spheres is occurring at unprecedented speeds.

The time perspective of the spiral may engender the viewer with an uneasy anticipation of the future, an anticipation in which society will encounter difficulty in keeping pace with technological innovation. This viewer senses that the expectations of his parents and grandparents may be radically different from those he and his children may have to develop.

These five time perspectives may be clues to man's anticipations about the future. In highly structured situations involving a low level of subjective input, individual differences in application of time concepts may not be detectable. However, in situations calling for the application of judgement, it is likely that different individuals will describe different futures given the same set of data. The future one constructs may be a reflection of basic cognitive systems which arise as part of the interaction of personality, education, and experience.

CHAPTER III

THE RISE OF FORECASTING

In working toward an understanding of the nature of contemporary forecasting, the influences in the evolution of forecasting will be reviewed. The rise of forecasting will be separated into stages of development. The general nature of each stage will be indicated, the important contributors to thought in each stage will be identified, and events highlighting the spirit of the period will be briefly presented.

Forecasting's General Pattern of Growth

Except for the experiences in economic and demographic forecasting, there has been little attention paid to forecasting of social and political trends. Population forecasting emerged first, stimulated by an interest of rulers to determine the size of their countries. Economic forecasting evolved more slowly. The early economic theorists, such as Adam Smith and Leon Walras, did not apply economic theory to specific situations. Morganstern (1954) suggests that they perceived their abstract concepts as too complicated to be portrayed in working models which would be capable of numerically manipulating essential variables.

Although population forecasting developed before economic forecasting, economic forecasting has been the underlying force in the growth of present-day forecasting. Cox (1931) asserts that this is a result of the interest in gathering and summarizing general business conditions. Impetus for the interest in business derives from four areas:

1. The recent rapid accumulation of economic statistics,
2. The development of statistical techniques,
3. The study of business cycles, and
4. The urgent need of men of affairs to make prompt and appropriate adjustments to the increasingly frequent changes in business conditions [pp. 348-9].

After World War II, forecasting was spirited forward by two other developments. The electronic computer was built and marketed in mass quantities. Today, computers can be found in nearly any organization of substantial size. The second development was decision theory. When operations research and information technology fostered interest in decision theory, the mechanics of planning and decision-making also fell into the spotlight of interest.

The Stages of Forecasting Development

The history of forecasting can be depicted in four general stages. The earliest stage does not reach beyond the sixteenth century. Before that, the elements of forecasting basically did not exist. Prophecy and other forms of divination, although they dealt with the future, did not directly influence the growth of forecasting.

The Formative Period of Forecasting

The sixteenth and seventeenth centuries introduced the conditions and elements essential for the rise of forecasting. The

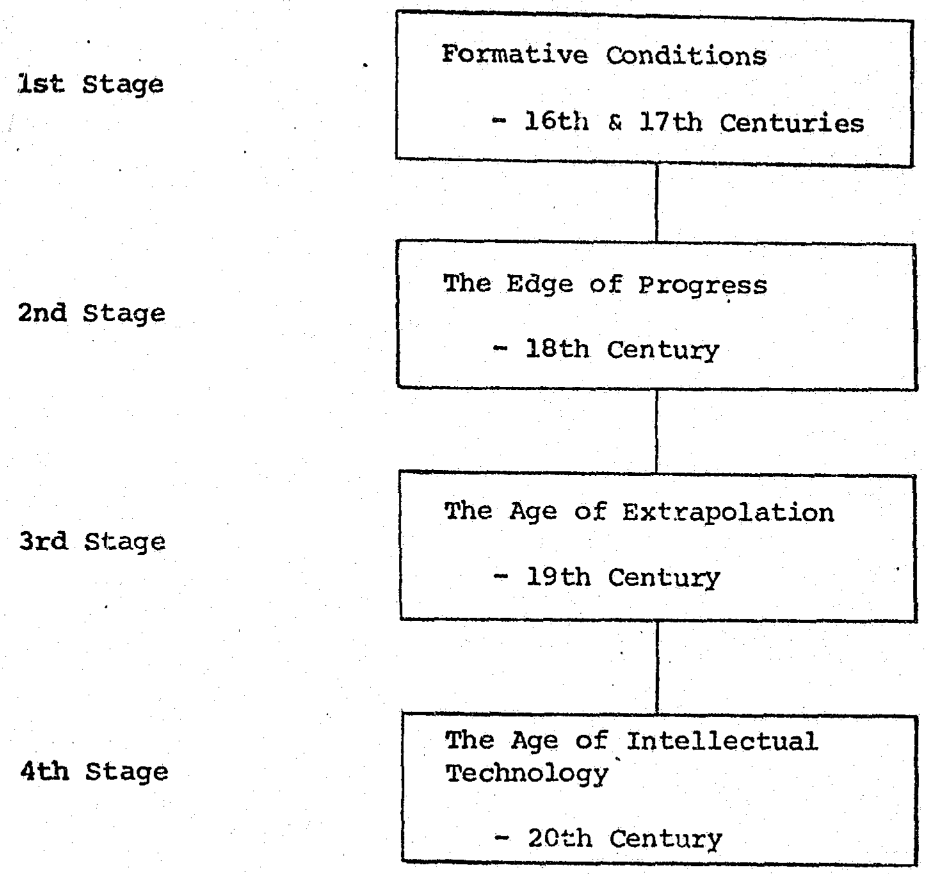


Figure 4. The Four Historical Stages of Forecasting

sixteenth century marks the development of an awareness of data collection. Information gathering services for merchants in Venice and the private organization of the Juggers of Ausberg flourished. They demonstrated that a trade advantage could be gained through the timely collection of information on national and international market conditions. In Germany, during this same period, "Staatenkunde" was formulated. Staatenkunde was a collection of general information and numerical observations about the German states. This information of political interest became a popular topic in the training of the many statesmen for the various German states (Westergaard, 1968).[1]

During the early seventeenth century, the idea that social topics could be subjected to quantitative analysis gained prominence. Lazerfeld (1961) identifies some of the influences behind this idea as part of the intellectual climate of the Baconian era, the desire to imitate the success of the physical sciences, the rational spirit of capitalism, and the development of a more impersonal and abstract basis of administration necessitated by the increasing size of countries. It was also during this century that insurance systems arose, and that the mercantile belief postulated that the size of population was a crucial factor in the power and wealth of a country. These influential factors added an impetus to the social sciences which never before had been experienced.

During this formative period, four men stand out as important contributors to the foundations of forecasting. The probabilistic basis of forecasting owes its beginning to a mathematician, who by the age of sixteen had already become famous. Pascal, in 1654, applied mathematical axioms in a manner which gave rise the theory of probability. Later in the 1600's, the brilliant work of Jacques Bernoulli contributed greatly to probability theory. From his sensitivity to the application of mathematical concepts, he was also able

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[1]Westergaard comprehensively presents the evolution of statistics from the time of Staatenkunde up to the twentieth century. This work, Contributions to the History of Statistics (1968) was also the major source for information on Graunt and Petty.

to formulate a distinction between "knowing" and "opining" which remains applicable to the distinction between knowledge and forecast. In Ars Conjectandi (1713), which was published after his death, he expressed:

> ... with regard to things which are certain and indubitable, we speak of knowing or understanding; with regard to other things, of conjecturing, that is to say, opining.[2]

The other two men who stand out during this period were the Englishmen, John Graunt and William Petty. Graunt was a haberdasher by trade and Petty was an Oxford professor and physician to the English Army in Ireland. These two men were friends, collaborators in statistical work, and founding members of the Royal Society (of statisticians). Graunt was interested in counting the population of England. This effort brought fame to him because England had been concerned about the effects of the plagues on the country's population. He wrote only one book, Natural and Political Observations upon the Bills of Mortality (1661).

Petty's work was related, in part, to Graunt's. Petty labeled his endeavors "Political Arithmetick," which was also the title of his book, published in the late 1660's. By definition, Political Arithmetick was "the art of reasoning by figures upon things relating to government"[Davenant, 1968].[3] In 1687, Petty appears to have made one of the earliest population projections based on collected

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[2]This quote from Bernoulli (1713) appears in De Jouvenel, The Art of Conjecture, 1967, p. 49.

[3]Davenaut's seventeenth century statement is quoted in Westergaard, 1968, p. 41.

data. In his Five Essays in Political Arithmetick, he estimated the population of England by drawing upon Graunt's work for birth and death rates and by such other means as estimating the population of London by determining the number of houses. With this information, he projected that England's population would double in 120 years, a figure much larger than the actual eighty-three years. The ambitiousness of this projection and other efforts in his essay are characteristic of the early enthusiasm of statisticians to overstep the limitations of their data. For example, Petty also attempted to determine the increase of the world's population since the Great Flood of Noah.

The spirit of this early formative period of forecasting may also be reflected in two occurrences related to forecasting. Francis Bacon, one of the seventeenth century's intellectual leaders, criticized prophecy in The Essays or Counsels: "Of Prophecies" (1625). So grave did he perceive the social harm caused by prophecies that he suggested "severe laws to suppress them." Prophecies, he claimed, gained their falsely received credit in three ways. First, "men mark when they hit, and never when they miss." Second, prophecies are the mere statement of tradition. The prophet is not foretelling the future, rather he is collecting information. Third, the prophets "have been imposters, and by idle and crafty brains merely contrived and feigned after the event past" [p. 142]. This criticism of prophecy by Bacon is likely to reflect the feelings of the early social science pioneers who had to struggle to sort mysticism from fact and to establish reliable methods of data analysis.

In 1644, the first non-religious fiction of the future appeared. Francis Cheynell wrote Aulicus: His Dream of the King's Sudden Coming to London. According to Franklin (1970), this was a political tract resembling "a plodding exercise in progressivist dreaming" [p. 26]. At least, it signifies a break from the domination of religious influence on futuristic thinking.

The Edge of Progress

In the second stage of forecasting occur the beginnings of the development of man's idea of progress. The eighteenth century opened with only a fair degree of agreement on progress which was envisioned in only one field, that of science. This opinion of progress changed during the eighteenth century. The great philosophical surge of the French Enlightment helped to modify man's expectations of social change. Adam Smith's work ushered in a new era of thought, which would apply mathematical concepts to economics. Later in the century, the public became excited about new technological developments, such as the manned balloon flights and the invention of the steam engine. So, by the end of the eighteenth century, man began to perceive progress as a concept applicable to his social, economic, and physical well being. He was now speculating what life could be if it could be different than envisioned by his ancestors.[4]

Four men should be identified as adding to the growth of

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[4]Sidney Pollard presents similar ideas on man's notion of progress in The Idea of Progress, 1968.

thought on forecasting in the eighteenth century. Turgot and Condorcet are names to be linked with the philosophy of progress.[5] Turgot became one of France's most brilliant administrators. In 1750, at the age of twenty-three, he delivered a Latin discourse which included the first philosophy of progress. This work, On the Successive Advances of the Human Mind, included a logical analysis of how progress could be predicted, even though the advent of invention is chancy. Turgot concluded that innovation depends on the general state of society. When conditions are right, those geniuses who are mixed with the rest of mankind will be stimulated into action (Pollard, 1968).

Condorcet was a French nobleman, philosopher, mathematician, and one of the leaders of the French Revolution. His famous work, Sketch for a Historical Picture of the Progress of the Human Mind, was written while in hiding in an interval between his public disgrace after being president of the French Legislative Assembly and his miserable death in a police cell. This work formally introduced to the world an important concept in forecasting, the concept of extrapolation (Gilfillan, 1968). Condorcet saw history as a sequence of types of society, each arising logically and necessarily from the preceding one. Carried within each type are the seeds of the next type to [illegible] (Pollard, p. 81). In these thoughts of Condorcet and

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[5]For the reader interested in the works of Turgot and Condorcet and in examining the impact of their efforts, two sources may be recommended: Pollard's The Idea of Progress, 1968 and Gilfillan's "A Sociologist Looks at Technical Prediction" in Bright, James R. (ed.) Technological Forecasting for Industry and Government (Englewood Cliffs, N.J.: Prentice-Hall, 1968, pp. 3-34).

Turgot, progress was established as having a role in thinking about the future. This had been an element missing from man's earlier fascination for prophecy and divination.

The third person of interest, during the eighteenth century was the first writer to formulate a word which carries today's connotation of forecasting. Maupertuis adopted the term "prevision" which in French has come to mean forecast or foresight, rather than foreknowledge. While president of the Academy of Berlin in 1752, he published his Letters which contain the idea of prevision.

> Our mind--that being whose chief property is to perceive itself and what is presented to it--has, in addition, two other faculties, memory and prevision. The one is a retracing of the past, the other an anticipation of the future. The greatest difference between the mind of man and that of an animal lies in these two faculties.[6]

He emphasized that both man's memory and prevision are imperfect. However, as man's memory or history of the past improved, so would his prevision. This usage of "prevision" differed from the old usage which implied a possession of complete knowledge about the future.

Near the close of the eighteenth century, an interest in demography was stimulated by the concern over the great increase in population in England and Europe. Into this spotlight of interest came a writer from an outside social discipline, with a theory developed from ideas of his contemporaries. Thomas Malthus, during his career, was an English clergyman associated with Jesus College

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[6]De Jouvenel translates and describes Maupertuis' ideas in The Art of Conjecture, 1967.

at Cambridge, and the first professor of political economy at the East India Company's Haileybury College. Malthus' concerns in Essay on Population (1798) lie primarily with economic growth, of which population growth was an element.

> I think that I may fairly make two postulata. First, that food is necessary to the existence of man. Secondly, that the passion between the sexes is necessary, and will remain nearly in its present state.
>
> These two laws ever since we have had any knowledge of mankind, appear to have been fixed laws of our nature; and as we have not hitherto seen any alteration to them, we have no right to conclude that they will ever cease to be what they are now, without an immediate act of power in that Being who first arranged the system of the universe; and for the advantage of his creatures, still executes, according to fixed laws, all its various operations.
>
> ... Assuming then, my postulates as granted, I say that the power of population is indefinitely greater than the power in the earth to provide subsistence for men.
>
> Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio [pp. 11-14].

Because of this theorizing in his works, some have attributed to him the role of forecaster of population. However, he made no quantitative projections, although he subjectively estimated that without checks, population would tend to double every twenty-five years. According to Page (1973), Malthus' basic model is more sophisticated than some of the numerical projections which followed. For example, the assumptions and reasonings of the model were made explicit, thus permitting evaluation of his ideas by others. Also, he identified the possible determinants of birth and death rates and established other relationships which avail themselves to analysis.

If Malthus' model is used for quantitative projection, an aspect for which it is not strictly suited, the population forecast for England for 1801 to 1901 would have been overstated by 350 percent.

The eighteenth and nineteenth century popularity of Malthus' model seems to stem, not from its mathematical reliability but, partially for its political use to justify retention of Poor Laws and the policy not to intervene in the Irish famine.

The eighteenth century also experienced the beginning of an important governmental practice, of which forecasting is an inherent element. The first budget of the coming year's revenue and expenditure was instituted in France. In the late 1700's, Baron Joseph-Dominique Louis proposed that the state had a right to tax according to future needs. However, what those future needs would be could not be clearly established. In answer to the question of goals, the French president, Villele, decreed that, since he knew the figures from the year before, that would be the basis for the next year's budget. Fortunately for the French, they had underestimated past expenditure and also kept on-going expenditure low (Lewinsohn, 1961). Thus, the success of the first budget derives, not from skillful forecast or planning, but from error.

The Age of Extrapolation

The nineteenth century ushered in the age of extrapolation. From the last decade of the previous century, the number of imaginative predictions and forecasts increased until, by the end of the century, extrapolation had become a favorite means of studying progress (Clarke, 1969). Man's progress in industrialization and scientific innovation excited the imagination. For the first time in the history of literature a writer, Jules Verne, was able to make a fortune using science as material for stories. Interest in the future was also reflected in the growth of population and economic forecasting.

In the 1800's in America, territorial expansion and immigration sparked government interest in population forecasting. For the American forecaster, the naive method of simple extrapolation produced rather accurate population estimates; however, this was not the case with the British. The difference in accuracy cannot be attributed to skill or exceptional tools, rather the British did not experience the consistent rate of growth found in America (Page, 1973).[7]

The economic crises of 1825, especially, lead an interest in the development of a theory of crisis. By the end of the nineteenth century, a considerable body of observations had been formulated. These efforts established a framework for the theory of business cycles in the twentieth century (Mitchell, 1913). The analysis of business cycles is one of the most important and original economic developments of the period. Also during the nineteenth century, the blossoming of statistics supported the development of

[7]A consistent rate of growth would be represented by a straight line. If the rate were to fluctuate, simple extrapolation would not be a satisfactory forecasting tool.

forecasting methodologies.[8] However, not all of the events of the nineteenth century followed the path away from mysticism. Among the incongruities of the period was the recrudescence of Tarot cards and prophecy which had been popular during the eighteenth century (Rakoczi, 1970). Progress and scientific thought had arisen in the minds of the learned researcher, but the attitudes of the general public had not become as sophisticated.

Among the contributors to forecasting in the nineteenth century, five men appear in the vanguard of the new art. J. B. Say, first academic teacher of economics and practical businessman, became known for "Say's Law." His work of 1803 may be said to "stand at the fountain-head of the scientific analysis of cycles" and to mark the point at which economic thought broke away from pre-analytic thought on business cycles (Schumpeter, 1954, p. 739).

In 1862, Clement Juglar, a Frenchman, became the first to extensively apply statistics to buttress the analysis of historical information of business cycles. For example, he used time-series materials, that is, the periodic measure of prices, interest rates,

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[8]One of the century's most important contributions to the rise of mathematical forecasting was the advance of statistics. Francis Galton in 1877 conducted his famous studies on sweet peas in which he observed a "regression" of seed sized toward the average. Karl Pearson picked up the idea and developed the equation for correlation. There followed a period of concentrated work by Pearson in which he groomed or developed other statistical ideas, such as fitting frequency curves, Chi Square, and probable error. Strictly speaking, the theory of correlation was not a unique discovery, rather it was a synthesis of ideas from the earlier theories of probability (Westergaard, 1968). However, Pearson's contribution was so impressive that by some he may be called the "Founder of the Science of Statistics" (Walker, 1969).

and central bank balances to detect a ten-year business phase. This analysis involved the sophisticated intertwining of facts and theory, a remarkable achievement for a physician who had no formal economic training. According to Schumpeter (1954), Juglar ranks as one of the greatest economists of all times and is the ancestor of business cycle analysis.[9]

There appeared in 1815 one of the earliest references on long-term forecasting by quantitative projection. Elkanah Watson, an American, applied the idea of a constant rate of population growth to the three existing census counts to construct decennial estimates to the year 1900. Several of the estimates were reasonably close, but by 1900 his method produced a 33 percent overstatement. Watson's assumption of a straight line as a rate of growth is representative of the bulk of the mathematical projections made during that century. Although Verhulst, in 1838, suggested using an S-shaped (logistic) curve (Reed, 1936).

Later in the century, Bonynge, an American, introduced what was to be the predecessor of modern population forecasting. His "method of components" divided the population into homogeneous groupings, e.g., whites, slaves, and free Negroes. For each group, a separate projection was constructed and by summing all of the group estimates, the total population estimate was formed. This approach permitted a more detailed analysis of growth rates for each

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[9]Garfield Cox in "Business Forecasting" (1931) also describes in a concise manner the nature and role of Juglar's work in economic forecasting.

group, and could make more apparent the consequences of different growth rates for the various components than would be recognized in a simple aggregated projection. Theoretically, it would have been possible to analyze the effect on population growth of abolishing slavery by assuming that the growth rate of now-freed slaves would approach that of the Free Negro. Although such an estimate would have been wrong, the principle of being able to investigate the impact of policy planning had been introduced (Page, 1973).

Quetelet and Durkheim are names that appear linked to forecasting in the Criminal Justice System in a round-about manner. They did not actually formulate a numerical estimate of the future size of the criminal population, but their theories suggest a future constancy in the rate of crime. Adolphe Quetelet, a Belgian, was known as a nineteenth century leader of statisticians and successful organizer of statistical projects. He is distinguished as the first on a systematic basis to call attention to the kinds of behavior which could be observed and identified through statistical analysis. In 1827, he began analysis on a pool of data which included data on criminals. From that effort, not only did he derive what he called the "average man," but he found what he believed to be certain social regularities. Among these regularities were three distinctive groups of behavior ("moral" characteristics) which involved human choice of action: suicides, rates of marriage, and crime. About crime, he contended, there was a constancy in rates from year to year within age groups (Landau and Lasarsfeld, 1968).

Emile Durkheim, professor of education and sociology at the Sorbonne, was interested in applying philosophy to political and social problems. His efforts were a major contribution to the development of modern sociology. In one of his shorter books, The Rules of Sociological Method (1895), he hypothesizes that punishment is meted out at a constant rate:

> In a society in which criminal acts are no longer committed, the sentiments they offend would have to be found without exception in all individual consciousness, and they must be found to exist with the same degree as sentiments contrary to them. Assuming that this condition could actually be realized, crime would not thereby disappear; it would only change its form, for the very cause which would thus dry up the sources of criminality would immediately open up new ones ... There is no occasion for self-congratulation when the crime rate drops noticeably below the average level, for we may be certain that this apparent progress is associated with some social disorder. Thus, the number of assault cases never falls so low as in times of want, with the drop in crime rate, and as a reaction to it, comes a revision in the theory of punishment, or the need of a revision in the theory of punishment [pp. 66-72].

This quotation is presented here for a particular purpose. Later, when considering various forecasting techniques, Durkheim's concept will need to be entertained as one of several possible underlying assumptions. In this quotation, Durkheim implies that there is a socially expected average number of crimes which will be punished. He is not referring to a consistency in the number of criminal acts committed, but to a stability in the percentage of people punished by a society. It is not too great of a logical leap to say that Durkheim also speaks about a trend in prison populations; as the size of the general population grows, so proportionately will grow the number of persons incarcerated.[10]

The Age of Intellectual Technology

The twentieth century is called the "Age of Intellectual Technology" by Bell (1973). The distinctive feature of this century is the "effort to define rational action and to identify the means of achieving it" [p. 30].

> We know more of economics than the Political Arithmetick of Sir William Petty who started us out with 'number, weight, and measure'. We have clearer conceptual distinctions than Herbert Spencer and his primitive efforts at establishing social differentiation. We have more complex statistical tools than Pearson or Galton. What is more important, perhaps, is that we have a better appreciation of method. For what method allows us to do is to reformulate insight into consistent explanation [Bell, 1964, p. 846].[11]

Forecasting in the twentieth century has grown to the point that distinctive fields of specialization can be identified. In their order of evolution, the oldest field of forecasting is population forecasting, next arose business forecasting, then technological forecasting, and lastly sociological (and political) forecasting. These fields did not evolve as entities characterized by unique techniques. The fields are primarily differentiated by the fact that their experts do not cross disciplinary lines. Techniques, though, have been borrowed from each other. For example, sociological forecasting has drawn upon techniques developed for

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[10] Blumstein and Cohen present this thesis in "A Theory of the Stability of Punishment," Journal of Criminal Law and Criminology, 1973, pp. 198-207.

[11] Daniel Bell speaks to great length on the change in twentieth century America from that of the past. See particularly The Coming of Post-Industrial Society (1973), Toward the Year 2000: Work in Progress (1968), and "Twelve Modes of Prediction--A Preliminary Sorting of Approaches in Social Sciences" (1964).

technological and population forecasting--the Delphi technique from technological forecasting and component projection from population forecasting. Although some borrowing has occurred, Jantsch (1969) points out that "cross-fertilization" between fields has not been as great as one might expect or as would appear feasible.

The 1900's arrived with a ready interest in the study of economic crises and a concern for scientific management. Industry, by this time, had increased in complexity of organization and production. Business leaders began to seek increased profitability through innovations to reduce costs of fluctuating operations. Experiments to stabilize business conditions were conducted by prominent manufacturers. In 1908, after the depression, Dennison Manufacturing Company introduced a comprehensive program to "regularize" business operations. These efforts were based upon reorganizing sales to secure orders during slack periods and to systematically produce inventory during those low periods to offset times of high demand (Metcalf, 1975).

America was the first country to establish organizations specializing in forecasting business conditions. This, to a great extent, was attributable to the fact that Europe did not experience such great fluctuation in business conditions. In 1904, R. W. Babson established the first commercial service to provide information to private clients. In 1910, he published the "Babsonchart" which became widely known. This chart provided a single index or barometer of business conditions.[12] At about the same time, the first chart based on business cycles was published by Brookmire. This was composed of three indices: credit supply, stock prices, and volume of business (Cox, 1931).[13, 14]

After World War I, a movement was afoot by engineers to maintain their social involvement which they had experienced during the war. On November 19, 1920, representatives of nearly 100 national and local engineering societies met to form the Federated American Engineering Society. They elected Herbert Hoover, who at the time was outgoing president of the American Institute of Mining and Metallurgical Engineers, as their first president. The next day Hoover called for "an investigation of industrial wastes." The ensuing report, "Waste in Industry," was to become the "thin point of the wedge" of Hoover's campaign to rationalize America's

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[12]The Babsonchart "combined into a single weighted index of general business a large number of time-series representing agricultural and industrial production, interest rates, and comodity prices ... In so far as Babson's forecasts were based upon this chart, they were said to be inferred primarily from the relation of the composite index to the line representing normal" which has been determined by adjustments for seasonal variation (Cox, 1931, p. 349).

[13]See Victor Zarnowitz, "Economic Prediction and Forecasting," International Encyclopedia of the Social Sciences, Vol. 12, Edited by David L. Sills (New York: Crowell, Collier and MacMillan, 1968), pp. 425-438, for greater detail of the development of business forecasting.

[14]Economic cycles as commonly defined incorporate two characteristics: (1) the sequences of actual economic quantities do not display a uniform (monotonic) increase or decrease, but reflect an irregular time pattern for the various economic values, (2) these fluctuations do not occur independently, but display an association to one another, such as a lagged, leading, or instantaneous relationship (Schumpeter, 1935).

economic policy (Metcalf, 1975).[15]

As Secretary of Commerce in 1921, Hoover stated that the role of government was "to mobilize the intelligence of the country, [so] that the entire community may be instructed as to the part they may play ..." "Prevention rather than cure" was Hoover's philosophy. The provision of better data on production and business cycles, etc. would overcome the "indifference of management." The idea was to take scientific management out of the privacy of industrial shops and apply it as a market/economic principle. This ideology went beyond Adam Smith's Invisible Hand concept without imposing governmental control; an informed business sector would promote self-regulation. The strength of this position may have been reinforced, at least in Hoover's mind, by the popularity of the 1921 Unemployment Conference and Committee on Unemployment and Business Cycles.

The role of forecasting, but not necessarily the quality, changed in the 1920's. Before that time, forecasting had been the domain of private interest. In 1929, the possibility of social forecasting gained governmental attention when Hoover appointed the Research Committee on Social Trends, which was to be headed by the most prominent of all business cycle researchers, Wesley C.

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[15]Forecasting literature makes numerous references to Hoover's influence. One of the most comprehensive analyses is Metcalf's article, "Secretary Hoover and the Emergence of Macroeconomic Management" (1975). Much of the information about Hoover presented in Chapter 2 is drawn from Metcalf.

Mitchell.[16] Out of this committee's efforts came a report in the form of a collection of descriptive articles concerning recent historical trends.[17] With the exception of the first chapter, population forecasting, the future was left to the interpretation of the reader; the past and present were presented in a passive manner, with only a superficial concern for tomorrow; possible future conditions (alternatives) were not explored. What the reader found was a myriad of disconnected ideas which Hoover hoped would "help all of us to see where social stresses are occurring and where major efforts should be undertaken to deal with them constructively."

Although the governmental report, Recent Social Trends, straddled the edge of forecasting, the work of the Natural Resources Committee may be seen as entering the realm of forecasting. In 1932, Hoover appointed a National Resources Committee to investigate technological trends. The committee's major public report, which appeared five years later, Technological Trends and National Policy, attempted not only to envision a trend, but to estimate future

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[16] Harold F. Dorn in "Pitfalls in Population Forecasts and Projection" Journal of the American Statistical Association, Vol. 45, No. 251 (September, 1950), pp. 311-334, expresses that for demographers this was the first time that they were recognized as a particular group and given endorsement because of their special abilities to forecast population changes.

[17] Two of the articles, Chapter 12 and Chapter 28, dealt with trends in the Criminal Justice System. The first is "Crime and Punishment" by Sutherland and Gehlke, which is sort of a "what has happened and what is happening now" kind of article. The other article is "Law and Legal Institutions" by Charles E. Clark and William O. Douglas.

impact and raise questions relative to policy choices. Governmental interest in forecasting finally emerged as part of Hoover's initiative to stimulate economic self-regulation by business.

In 1936, Keynes' work added substance to the body of economic forecasting. His General Theory of Employment provides a theoretical framework for construction of macroeconomic forecasting models. Not only was this theory of interest to private researchers, but government could not justify intervention into the public economic machinery. The level of economic activity could be measured and inspected to determine how intervention in various economic sectors would affect possible future outcomes. Clarke (1970) indicates that Keynes' work "became a sacred text with forecasters and planners" [p. 379]. However, full realization of Keynesian theory in forecasting had to await the computer's capacity for manipulating complex macroeconomic models.

In 1939, the beginnings of an explicit methodology for subjective forecasting arose from the work of Pendray of Westinghouse. Pendray "asked fifty outstanding scientists and engineers what new developments in their workshops were most likely to affect the life of the average man in the next twenty-five years" [p. 344]. He then wove a description of future progress by fusing their ideas together and by infusing his own judgement as well. A year later Bliven, editor for the New Republic, went one step further by taking a "pledge they [the scientists] would not be quoted by name"

[1941].[18] In these efforts of Pendray and Blivan, the apparent simplicity of approach should not obscure an important shift in methodology in subjective forecasting. The shift was from reliance upon a single expert's description of his expectations to a method which seeks to elicit from a group of experts a core or consensus of ideas around which possible futures can be constructed. In addition, Bliven counteracted potential distortion of individual opinion by establishing anonymity; a practice now employed to avoid peer pressure and exposure to criticism. These characteristics are essential elements in the more sophisticated Delphi process later developed by the Rand Corporation.

In 1944, Von Karman, an eminent U.S. scientist in the field of gas dynamics and propulsion systems, instituted what may be considered as the first comprehensive forecast.[19]

- He put much emphasis on the evaluation of alternative combinations of future basic technologies, i.e., on the assessment of alternative options.

- He considered basic potentialities and limitations, functional capabilities and key parameters, rather than trying to describe in precise terms future functional systems.

- He replaced intuitive thinking by thorough and comprehensive analysis in a well defined time-frame [Jantsch,

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[18]Gilfillan (1968) offers nearly the same analysis of the work of Pendray and Bliven. However, Gilfillan does not identify that a major difference in Pendray's and Bliven's work is to be found in the pledge of anonymity.

[19]Jantsch (1967) describes this as the "first technological forecast in a modern sense" [p. 273]. It should be noted that Jantsch is only dealing with the field of technological forecasting. Van Karman's work as interpreted in Chapter 2 by this writer is also identified as the first comprehensive forecast of any field.

1967, p. 273].

The forecasts derived from Von Karman's efforts recognized the possibility of supersonic aircraft and ICBM's. His classic work was the forerunner and guideline of later periodic U.S. Air Force forecasting efforts and has found application in contemporary social forecasting.

World War II fostered the growth of the "establishment prophets." Beginning with the work in operations research in predictive systems control, such as the application of refined mathematical probability techniques to problems of weaponry aiming, the role of the expert gained in prominence. During the cold war era, the military was a large consumer of the services of the think-tank philosophers (McHale, 1969). In 1948, the best known of the think-tanks, the Rand Corporation, had its beginning. Out of that organization came such innovations as the technique of systems analysis, the military cost/effectiveness system, the Planning-Programming-Budgeting System (PPBS), the descriptive scenario technique and the Delphi technique. The scenario technique, which is often associated with forecasting, was pioneered at the time by Kahn. It was devised as a manner of describing hypothetical sequences of events in political-military contexts, for instance in the analysis of international relations as affected by various uses of sophisticated weapons systems. Helmer, also at Rand, developed the Delphi technique of forecasting as a method for systematically collecting opinion from a panel of experts.

This technique is one of the most important developments in subjective forecasting.[20] Later, in another chapter, the Delphi technique will be reviewed in greater depth.

In the 1960's, study of the future became an industry not necessarily limited to military work. Besides Rand, other organizations such as the Hudson Institute, founded by Kahn who left Rand, and the Institute for the Future undertook future oriented research. Government agencies during the 60's let innumerable contracts to these organizations. The scope of the forecasting field should not be over-emphasized, however. The actual number of persons identified as forecasters (in non-business and non-demographic fields) was restricted to a small number, probably near 20-30 in the United States (McHale & McHale, 1976). The first World Congress of forecasters in Oslo in 1967 was composed of approximately thirty participants. The surging interest in forecasting was reflected in the attendance of the Second World Congress in 1970, which was attended by over 250 persons.

A trademark of the 1960's in economic forecasting was the development and testing of multi-equation econometric models and the refinement of time-series methods (Fogler, 1974). However, some of the glitter of business cycle forecasting faded. Cycle theories did not appear to perform well after World War II. But Lewinsohn (1961) points out that some of the disappointment may

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[20] The Delphi technique was developed during the 1950's, but was classified and therefore not released to the public until 1966.

have been "a little too rash" because cycle theories should have been accepted as tentative; furthermore, he notes, there seems to be no good reason why theorists should give up looking for economic rhythms. If the assumptions and premises of economic models are held as tentative, it is possible that changing economic relationships can be accepted without abandoning the practice of forecasting. For example, the expansion to a world market will, as Drucker (1976) expresses, "cause marketing men to rewrite their rules" [p. 20]. The question challenging business cycle forecasting now is: Can the new relationships between economic factors be identified, or must other theories be developed?

In the non-economic field, one of the catalysts of forecasting interest of the 60's came out of the work of Ralph Lenz, a member of the Aeronautical Systems Division of the Air Force Systems Command. Lenz, in 1962, published a small monograph, Technological Forecasting, which was based on his master's thesis ten years before at M.I.T. This work established a system for classifying and ordering technological forecasting techniques. Included was a framework for identifying application requirements for each type and combination of types (Bell, 1973). The logical perspective he developed facilitated communication between researchers and the research on methodology.

In the 1970's, the practice of forecasting has been drawn closer to government planning, according to Starling (1974). For example, Congress has moved both to establish the Office of Technological Assessment and to require that environmental impact statements accompany federal development grant applications. The trend in government appears to be toward increasing interest in forecasting as a part of planning.

Recent history portrays technological and business forecasting as developmentally preceding sociological forecasting. Jantsch (1967), although, asserts that "forecasting in the political and social areas is more or less developing parallel to technological forecasting" [p. 110]. And Bestuzhev-Lada (1969) comments that the slow development of sociological forecasting has been the partial result of misplaced emphasis:

> Sociological forecasting is still far behind economic forecasting, largely because it is frequently treated as a subsidiary of the latter. The forecasting of demographic processes and of the development of public health services, education, and so on, is undoubtedly of great economic importance at present, and, in forecasting, sociology and economics are as closely linked as are science and technology, military affairs and politics, geography and outer space. But to study human personality and society on a purely economic level and only as related to productive forces [although this is of prime importance] would be to over-simplify historical materialism. Man and society are relatively independent entities, and therefore sociological forecasting is an independent entity, as is sociology--which we know, is not merely a branch of economics [p. 531].

Looking back at sociological forecasting, we can see "what it isn't" perhaps with greater clarity than "what it is." Duncan (1969) has pointed out that it isn't well structured as a field of knowledge. Dror (1968) has indicated that it isn't used effectively in governmental planning. And, McHale and

McHale (1976) determined that it isn't the domain of many specialists in government. Yet, as will be indicated in the next chapter, forecasting isn't necessarily a concept foreign to administrative thought.

CHAPTER IV

SELECTION AND COMPARISON OF PRISON POPULATION FORECASTING TECHNIQUES

The student of criminal justice forecasting stands on top of the proverbial iceberg. The techniques popularly used are only part of a number of methods that could be used. A compilation of all methods most likely would appear as a large dictionary of brief descriptions. The dictionary format, although complete, would not provide the reader with a coherent discussion of forecasting principles and concepts. An alternative approach to the dictionary format is that of selecting a few techniques applicable to prison population forecasting and discussing them in a relatively non-technical manner. Such a discussion could attempt to present concepts and technique requirements that would generalize to similar methods.

The audience for a handbook of selected criminal justice forecasting techniques ranges in sophistication from the expert statistician to those in planning and administration who emphasize skills other than statistics. The presentation of information about forecasting may not be as difficult as the diversity of audience needs might imply. General information about forecasting has not been widely taught. Some forecasting concepts are part of education in economics; however, that information tends to be specialized and does not span the majority of techniques relevant for criminal justice forecasting. Those persons experienced in behavioral science research are familiar with predictive techniques but are most likely not steeped in forecasting concepts. Thus, the audience for a handbook of forecasting methods share a common need for introduction to elemental concepts and techniques of forecasting. Such an introduction would not be all things to all people, yet most users would find some part of the study to be of interest.

In this study of techniques for forecasting prison population, the emphasis will be placed on selecting a few techniques rather than cataloging all techniques. This study, also, will downplay technical knowledge to focus on an intuitive inspection of concepts and methods. For example, the later discussion of multiple regression is highlighted with illustrations, analogies, and examples, but does not delve deeply into the mathematics of calculation. Such discussion assumes that a forecaster who would consider using a technique can obtain a formula for calculation or use a computer program but is less likely to find information about the problems and requirements of forecasting with the technique. The planner and decision-maker who are users of forecast information also do not need to explore mathematical mechanics of multiple regression. Their concern is usually directed toward pragmatic considerations of finding out what the technique does, how well it forecasts, and how much it costs. Although addressing these considerations is decidedly a pragmatic orientation, the reader seeking mathematical information is not forgotten. Numerous references and an annotated bibliography are provided for the techniques and concepts. For those readers interested in exploring a wide range of forecasting techniques, a listing of forecasting techniques with references has been included as an appendix to this study.

The selection of techniques applicable to prison population forecasting was no easy task. An objective survey of criminal justice forecasters as to what should be included, of course, was impracticable because there is no group specifically identifiable as criminal justice forecasters. This meant that the process of selecting forecasting techniques could, at best, be an arbitrary undertaking supported by a screening process. This screening process occurred in three steps. The first step was to identify the techniques which could be used in forecasting in the behavioral science field. This list is presented in Appendix B.

The second step was to review prison population forecasting methods being used in the various states. Rather than replicating a recent study, agreement was reached with the Florida Department of Offender Rehabilitation to share the results of their 1977 survey. That unpublished survey is presented in Appendix C. The results of the survey disclosed that three classes of methods are most often used in the various states:

- Least squares (Simple regression)
- Multiple regression
- Flow models (Simulation models)

Because these three methods are popular, they were selected for inclusion in this discussion of prison population forecasting techniques.

The third step was to select from the list of techniques twenty other techniques which appeared to be relevant to prison population forecasting. By reviewing forecasting literature and presenting the list to other researchers in forecasting, additional techniques were selected for inclusion in this study.

The Techniques Selected for this Study

The final list of methods contains sixteen techniques which will be discussed in ten modules:

Subjective Forecasting Methods

1. Delphi Technique

2. Matrix Forecasting

   - Cross-Impact Matrices (CIM)
   - Matrix Ranking
   - Matrix Volume Forecasting

3. Scenarios

   - Single Forecast Scenarios
   - Multi-alternative Scenarios
   - Planning Scenarios

Naive Forecasting Techniques

4. Subjective Extrapolation

5. Simple Least Squares

6. Smoothing Techniques

   - Moving Averages
   - Exponential Smoothing

7. Indicator Forecasting

Causal Forecasting

8. Multiple Regression

   - Multiple Regression with Alternative Data Sets
   - Impacted Forecast with Surprises

9. Flow Models

10. Simultaneous Equation Forecasting

This list of techniques reflects four considerations of selection. First, as mentioned above, some of the techniques such as

Least Squares, Multiple Regression, and Flow methods are included because of current use in prison population forecasting. Second, the methods of Delphi, Matrix techniques, and smoothing were included because of strong recommendation of other forecasters. Third, the emerging application of Indicator forecasting and Simultaneous Equation models seem to be areas of developing interest. And fourth, the concepts of Scenarios and Subjective Extrapolation are included because of general misunderstanding of concepts in practice of criminal justice forecasting.

This selection of techniques attempts to present a well-rounded starting place for an evaluation of the state of the art and in a sense is a forecast of techniques that may find application in future efforts of forecasting prison population. A theme woven throughout these ten modules is that of developing an awareness of forecasting's potential as a tool available to the correctional decision-maker. This theme not only looks at the possible benefits of the tools, but of the weaknesses and caveats surrounding their use.

The Format for Presenting the Modules

Each of the ten modules is arranged in a similar manner. The format shown in Table 1 is designed to facilitate comparison of techniques.

The format category which may provoke the greatest problem for the reader is that of "accuracy." Throughout these ten modules, the problem of accuracy will be investigated from various perspectives. The message fundamentally being presented is that accuracy is relative.

TABLE 1

Utility Characteristics

	Subjective Methods			Time Series and Projections				Models and Simulations		
	Scenarios	Delphi	Matrices	Subjective Extra-polation	Simple Least Squares	Indicator Forecasting	Smoothing	Multiple Regression	Flow Models	Simultaneous Equations
Forecast Span (Immediate, Short, Medium, Long)	Long	Medium Long	Medium Long	Immediate Short	Immed. Short	Immed. Short	Immed. Short	Short-Med.	Immed. Short	Medium
Ease of Under-standing technique (Easy, Medium, Difficult)	Easy	Medium	Medium	Easy	Medium	Medium	Medium	Difficult	Medium	Difficult
Assistance Need-ed to make fore-cast (None, Routine, Sophis-cated)	None-Sophis.	Sophis.	None-Sophis.	None	None-Routine	Sophis.	Routine	Routine	None-Sophis.	Sophis.
Cost of making forecast (Low, Medium, Costly)	Low-Med.	Medium	Med.-Costly	Low	Low-	Low Med.	Low	Low-Medium	Low-High	Medium-High
Time to make forecast (Days, Weeks, Months)	Days-Weeks	Months	Weeks-Months	Days	Days	Days	Days	Days	Weeks-Months	Weeks-Months
Number of variables being analyzed (1, Several, Many)	Many	Many	Many	One	One	Many	One	Several	Several-Many	Several Many
Data Require-ments (None, Low, Medium, Extensive	None	None	None	Low	Low	Exten.	Low	Med-Ext.	Low-Ext.	Exten.

Relative, though, not in the sense of refusing to take a stand, but relative in terms of the user's data, his needs, and his actions after receiving the forecast. If indeed the future is, in part, man-made, the notion of accuracy becomes moot when the decision-maker finds what paths into the future are open to him. In the consideration of a man-made future, the concern for usefulness of the information appears more important than "accuracy." No forecast can promise a sneak-preview of the future, therefore, an evaluation of accuracy may also consider utility of the information.

The notion of accuracy is downplayed in this study. The concept of accuracy borrowed from the behavioral sciences (cross-sectional analysis) is avoided because it may lead the reader to expect a simple, straight-forward comparison of techniques which would disclose the best predictor. No doubt, the search for a most accurate method for all times is an appealing thought. Such an effort, though, conjures in the mind the image of Don Quixote riding forth in a chimerical quest.

Format for Presenting the Selected Methods

Definition of the Forecasting Method

- What it does
- Basic structure

Brief History of the Method

Case Illustration(s)

- Selected examples from criminal justice literature, hypothetical illustrations, analysis of actual data, and relevant examples borrowed from other fields
- Objective of the illustration is to demonstrate the steps of constructing forecasts.

Assessment of Assets and Limitations

Assumptions: Asks what the method or manner of data usage assumes.

Span of forecast: Considers the forecast span in relation to five time periods:

- Now to next year
- Short-term future (1 to 2 years)
- Middle-range future (2 to 5 years)
- Long-range future (5 years to 15 years)
- Far future (15 years +)

Accuracy/Usefulness

Unique Limitations/Considerations

Communicability of Results

Time Required to Produce Forecast

Resources and Cost Requirements

- Staff or consultant requirements
- Equipment
- Data
- Estimated total cost

Transferability

- Assessment of applicability to prison population forecasting and other correctional use
- Ease of application

Comparison of Techniques

As mentioned briefly in the discussion of accuracy, the comparison of forecasting techniques may more appropriately be made in regard to relative qualities rather than to absolute standards. The construction of a table for comparing techniques provides an overview of the general comparisons and can serve as a reference for tentative matching of forecasting problem to tool.

The utility of a particular technique depends in a large part upon the constraints with the planning and research environment. Application of a technique to conditions other than those reflected in Table 1 would weaken the basis of the tabular comparison.

Table 2 compares the utility considerations of the techniques. These considerations relate to those sections of the module format which assess assets and limitations of the methods.

Table 2 presents a breakdown of resource requirements which are also reflected in the format for module discussion.[1]

Presentation of Modules

The ten modules will be presented in chapters which logically correspond to their assigned categories: subjective methods, naive methods, and causal methods. These three categories are general and may differ from other categorizations of techniques. For example, several of the techniques could be seen as straddling several categories. This assignment of techniques to categories, although arbitrary, is designed to provide a logical framework for discussion of forecasting concepts.

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[1]Tables 1 and 2 draw upon ideas for tabular comparison of forecasting techniques developed by Arnold Mitchell in Handbook of Forecasting Techniques. Menlo Park, Calif.: Standford Research Institute, 1975.

TABLE 2

Resources Needed to Forecast

Type of Resource	Subjective Methods			Time Series and Projections				Models and Simulations		
	Scenarios	Delphi	Matrices	Subjective Extrapo- lation	Simple Least Squares	Indicator Forecasting	Smoothing	Multiple Regression	Flow Models	Simultaneous Equations
Data										
Historical				X	X	X	X	X	X	X
Expert Opinion	X	X	X							
Personnel										
Gereralists	X	X	X							
Methodologists	X	X	X			X			X	X
Statisticians		X			X	X	X	X	X	X
Computer Programmes	?		X			X	X	X	X	X
Questionnaire & survey experts		X	X							
Physical										
Computers	?		X		?	X	?	X	X	X
Programmable Hand Calculators					X		X	?		
Existing Computer Programs			X		X		X	X	X	
Statistical packages					X		X	X		
Data Banks					X	X	X	X	X	X

CHAPTER V

FORECASTING PRISON POPULATION BY SUBJECTIVE METHODS

Introduction

Three forms of subjective forecasting are discussed in this chapter: the Delphi technique, matrix forecasting, and scenarios forecasting. Each form of forecasting is presented in a separate section of this chapter.

Subjective forecasting methods draw upon the opinion of experts instead of analyzing data about previous prison populations. Delphi is a technique specifically designed to obtain subjective estimates of future states and events. Matrix forecasting and scenarios construction are not as concerned as Delphi for informational gathering, rather focus more upon the process of analyzing obtained subjective information.

Not all subjective forecasting techniques approach the future in the same manner. For example, the Delphi technique and matrix forecasting are exploratory methods, that is, they seek to determine what the future may grow into. On the other hand, scenarios construction adds a normative concern to the exploratory information. In the normative outlook, the future is viewed as man-made and composed of decisions open to the correctional administrator. The normative future is similar to a decision tree that evaluates the variations on the general theme of present and future trends.

Delphi Technique

Not surprising is the fact that expert opinion is the most called upon means to seek cues about the future. Neither would it be surprising to forecast that expert opinion will persist in popularity during our lifetime. In practice, expert opinion is offered as a service. Purchase of this service contains both elements of appraised past performance and hope--hope that the problems disturbing the decision-maker are not outside of the expert's appraised competence. The place of expert opinion in corrections seems to be that of compensating for a lack of theory and proven practices. Unlike business, corrections has no general theory of economics to guide market behavior. The value of expert opinion is enhanced by the consideration that in times of difficult decisions, man is responsible for the final say, and that machines and equations are secondary tools.

The informed reader, no doubt, recognizes that there are problems in using expert opinion. Perhaps the most well-known problem is bias of opinion. Other problems include the reluctance of the expert to give advice which runs counter to his publicly announced position; also, the expert may hesitate to make recommendations disfavored by superiors or his clientele.

Expert panels[1] seem to be the favored manner of using expert opinion in forecasting (McHale & McHale, 1976). However, when experts

[1]The term "expert panel" as used in this paper includes both the forum in which opinion papers are read and discussed and groups assembled in any manner to share ideas about a topic.

are placed in groups, additional problems are brought into play. In groups, experts behave like people in general; they are concerned with social dynamics. Groups of experts will establish status and power structure. Innovative ideas from low status persons are not accepted as readily as ideas from those of high status. The powerful seek to validate their opinions by coercing group acceptance. Other members act to protect the integrity of their expertise by reluctance to offer ideas. Frequently, the group attends to criticism of opinion rather than the process of exploration and synthesis of concepts. Discussions of complex questions tend to become oriented toward seeking solutions rather than defining the problem and investigating alternatives. In general, conduct of the group resembles an ebb and flow of attention in which short periods of intense concern for the topic seem to drift.

Given these additional problems, what accounts for the fact that expert panels are a favored way of forecasting? Basically, this preference stems from several issues. First, inference would suggest that if one expert is valuable, a group of experts is more prized. Second, groups of experts are sought to validate policy. In practice, a group of experts may offer real input into problem solution or exist as a tool to validate an already formed position.

Improving Performance of Expert Groups

The usual procedure for improving group performance is to overlay formal structure for directing interaction. Such overlaying onto expert groups overlooks the possibility that experts may resist structure. We must consider that the expert achieved his status of publicly acknowledged expertise in a free market place. A closed structure of interaction represents a process of establishing expertise. Of course, there are a variety of structural overlays characterized by different interaction patterns. For example, the imposition of Robert's Rules of Order on the meeting of correctional experts would offer little stimulus for increasing production of innovative ideas.

We may be guilty of expecting too much from techniques that promise to resolve problems of face-to-face communication. Some group methods perform well with a homogeneous group selected on the basis of specific personal characteristics.[2] However, a meeting of correctional experts cannot be envisioned which would not include opposing mixtures such as outgoing and reserved personalities.

If the problem of group dynamics cannot be resolved at this time, perhaps the problem should be attacked from a different perspective. That is, if group interaction among experts is not amenable to direction which would facilitate free communication, then the emphasis on face-to-face communication should be downplayed during the phases of problem identification and generation of alternatives. Such phases could be conducted before the occurrence of a face-to-face gathering. Taking this line of thought one step further, it might be reasoned that if the

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[2]Group methods such as the Nominal Group Technique (NGT) described by Delbecq, et al (1976) and brainstorming may best work with middle managers and researchers. Such correctional experts as directors of state agencies and deans of law schools may not be responsive to the polling of their opinion because of inherent political considerations and time requirements.

sole purpose of assembling experts is to develop a forecast, then a face-to-face meeting may not be necessary. However, given the inclination of governments to prefer assemblage of experts to validate later action, the advent of communication without a later meeting hardly seems plausible.

Let us pause for a moment and envision a hypothetical situation in which correctional experts collectively forecast prison population trends and alternative futures before meeting to recommend action. In our vision, the process begins when the national project leader contacts thirty arbitrarily selected correctional experts. In his call he explains his desire for their assistance and that they will be paid for offering their opinions, which will be presented at a meeting six months hence. Instead of preparing papers on their opinions, they will be paid to participate in a polling process of several rounds of questions. Their responses are to remain anonymous, known only to the project pollers. As the hypothetical scene progresses, we see the experts assembling at the meeting six months later. The project leader describes what the majority saw as the trends affecting prison populations in the next twenty years and the variety of alternative ways of coping with those trends. After this briefing, the members begin their discussions to develop policy recommendations. In this example, we have seen the beginning of a meeting in which the membership has been informed of the majority's opinion without the interference of disruptions of face-to-face communication. The meeting that follows may experience the problems of face-to-face communication. However, the critical first phase of policy development has not been sidestepped. The adoption of recommendations by a forceful few is made more difficult when trends and alternatives perceived by the majority challenge their assumptions. In this brief example, the Delphi technique was employed in a novel fashion, as the precursor to a meeting of experts.

History

In the early 1950's the Rand Corporation was hired by the Air Force to forecast Russian military air strategy. Researchers assigned to the project devised a series of questionnaires interspersed with controlled feedback which would elicit the opinion of experts. Their objective was to forecast the most likely use of Russian bombers for a long-range strike, likely U.S. industrial targets, and the number of atomic bombs required to reduce American industrial output by a prescribed amount. Partially, because this technique for polling experts was linked to military applications, not until 1963 was the technique described to civilian forecasters. The name assigned to the technique was drawn from ancient Greek history; Delphi was the most famous oracle, consulted by kings and philosophers for nearly 500 years.

As practiced, Delphi applications seem confusing to many observers. Confusing because variants of the original method also carry the name Delphi. Argument abounds as to Delphi's applicability, its theoretical structure, and credibility. The potential user of Delphi forecasts should keep in mind that no set or rigid framework characterizes this general method. Although Delphi is described as a

CONTINUED

1 OF 4

"technique," only through inspection of the actual procedures can the user appreciate the usefulness of forecasted information.

The 1976 McHale and McHale survey indicates that Delphi had been employed in about 5 percent of forecasting efforts conducted by industry and government. A majority of effort has been in the technical and economic areas. An up-to-date scanning of Delphi literature indicates that health care and education have been the major focus of Delphi application in the social welfare field.

Description

The majority of Delphi applications share five general characteristics:

- Concern for topics which are not suitable for statistical analysis
- Anonymity of respondents
- A succession (iteration) of opinion polls involving the same respondents
- Use of Likert-type rating scales during at least one round of opinion polling
- Simplicity of data analysis

The generality of these characteristics attest to the possibility that Delphi forecasts may be similar in a few major respects and markedly different in others.

Delphi's greatest promise is in the treatment of topics which are not suitable for statistical analysis. For example, a forecast of society's value trends and their impact on prison populations lies beyond quantification. Usually, Delphi is applied to topics for which the critical variables cannot be counted or readily observed, for which data may be incomplete or not available, for which the laws of causality may not be well understood, and for time periods extending beyond the short-range applicability of most statistical methods.

Anonymity of respondents reduces inhibitions associated with group processes. Although in many Delphi forecasts the respondents recognize they are members of an identifiable group of persons, their opinions are not individually identified. In the instance of particularly sensitive topics, an increase in group size may provide safety in numbers.

Delphi is not a one-shot questionnaire, although its question format is the equivalent of a questionnaire. The Delphi process involves the polling of the participant's opinion at least twice. The usual form of Delphi begins with several open-ended questions (3-5 questions). Out of the responses of this first round, the researcher constructs statements or propositions representing identifiable trends and ideas about the future. These statements become the material of the questionnaire for the second round. The third round uses the same statements with the addition of feedback to the respondent about the group's opinion for each statement. The objective of the repeated polling is the achievement of consensus which denotes the trends and situations perceived most likely by the experts. A mechanism central to this procedure for eliciting consensus is the expert's intuitive analysis of complex and ambiguous information.

Likert-type scales are the medium for recording opinion on each questionnaire statement. Likert scaling assigns numbers to a judgmental dimension. For example, the frequently used numbers "1" through "4" (and "1" through "6") divide the concept of important/ non-important into four grades: 1 - Very Important, 2 - Somewhat Important, 3 - Somewhat Unimportant, 4 - Not Important. The use of an even-numbered scale avoids the fence-setting response of a middle or neutral choice, e.g. "3" on a five-point scale represents neither an important or unimportant opinion.

Data analysis is relatively simple. Analysis usually begins with tabulation for each statement of the number of times each number 1-4 (or 1-6) was chosen by the group. The group's opinion for the statement may be represented by either the median (the point in the middle of the group), the mode (the most popular choice), or the raw mean score (the average rating of the group). To describe the range of disagreement on the item, the interquartile range is frequently given. This measure roughly indicates the most concentrated area of opinion by chopping off the infrequent, very divergent responses on the extremes of the range.[3] The median, mode, raw mean score, and interquartile range are very easy to calculate. As will be noted later, simplicity of analysis has its drawbacks.

Delphi applications inspired by Gordon and Helmer's original work in 1963 emphasize the attainment of consensus to determine the one best estimate of a future situation. Feedback was an essential feature of this process. When the expert indicated an opinion which varied from the group, he was informed in the next round about his extreme

[3]The interquartile range indicates the value below the median that encompasses one-quarter of all responses, and the value above includes the upper-most quarter of responses.

position and asked to provide the basis of his rationality. His reasoning was shared in an anonymous fashion with the group during the next round. In this manner the entire group shared the same information on which to base opinion. The polling continued until consensus was reached. Of course, this process involved more than three rounds.

Variants of the general Delphi method usually share the five characteristics discussed earlier. The most frequently encountered versions are identified below.

- Closed Form--This, the most popular variation, omits the open-ended questions. All statements are constructed by the researcher. The objective is to identify the most popular statements in two rounds of polling.

- Form for Idea Generation--This form uses only rounds one and two. It is concerned with generating ideas by experts and only the general identification of the most favored statements.

- Standard Format with Added Rating Scale--Added to the Likert scale is another assessment, such as "N"-"F" for Feasible/Nonfeasible.

- Standard Format with Different Rating System--This form asks for estimation of dates, weights, and other numerical measures. It usually omits Likert scales. This rating method may restrict intuitive analysis, thus is not as favored.

- Polling of Groups of Experts--This procedure differs only in selection of experts and analysis. Experts are compared according to speciality, i.e., lawyers, police chiefs, law enforcement educators.

- Polling of Experts and Non-experts--This version is similar to the preceding variant except that non-experts, such as policemen, may be compared to experts.

- Non-forecasting Applications--The Delphi format may also be applied for the identification of ideas, goals, values, etc.

The wide variation of Delphi format reflected above suggests that the format varies according to research objectives. Generally speaking, when the Delphi process contains more than two rounds, the assumption can be drawn that consensus is the objective.

An example of the Delphi method is presented below. This example illustrates the general Delphi technique using open-ended questions in the first round and separate polling of two groups, experts and non-experts.

Example

A Delphi poll on the trend of police values was conducted in 1972-73 by Cooper (1974) as a research project at the Center for Urban Affairs, University of Southern California. This Delphi forecast is discussed in the sequence which typifies the general Delphi method. These seven steps are:

1. Identify the basic Delphi question and target group
2. Develop first round questions
3. Select and contact experts
4. Prepare and mail first round questions
5. Analyze round two returns and prepare and mail round two
6. Analyze round two returns and prepare and mail round three
7. Analyze round three returns and prepare final report

In describing Cooper's Delphi forecast, actual findings are referred to only when necessary to clarify procedures followed. The results of his study are presented in "Professionalization and Unionization of Police: A Delphi Forecast on Police Values," (1974).

Step 1. Identify the basic Delphi question and general target group. If the topic to be forecasted is not clearly defined, the application of Delphi may turn out to be both a frustrating experience for the respondents and an expensive exercise producing non-sensical results. Cooper, though, has developed his general topic before choosing Delphi. Several contacts with other researchers helped to determine the applicability of Delphi to the topic. At the same time, he elicited the assistance for the development of the questions and questionnaire construction.

His target group was generally identifiable as educators in law enforcement, a group to which he belonged. A second group for comparison could be drawn from a special program at the university.

Step 2. Develop first round questions. In order to lessen personal bias and oversight, Cooper sought assistance in developing the open-ended questions of round one. An experienced Delphi forecaster and an expert in aesthetics joined him in constructing and evaluating open-ended questions. They strove to avoid both narrow questions which would focus on only a few police values and broad, vague questions which might confuse and frustrate respondents. Their efforts produced three questions. Each question directed attention to a logical segment of future time: continuing trends, changing trends, and new trends. Specifically, these three questions were:

1. What have been the significant trends in the changing attitudes and values of police officers concerning their professional role and the institutions within which they function during the last ten years?

2. During the next thirty years, do you expect these trends

to continue in the same direction at the same rates, or do you anticipate significant changes? Please explain.

3. Do you expect any new trends in values and attitudes to emerge during the next thirty years? Please explain.

Step 3. Select and contact experts. The selection of experts was not a random or value-free procedure. Rather, as Cooper states

> Since the Delphi process involves a designed sample of persons who are presumed to have particular knowledge and/or experience in the field under investigation, rather than a random sample, it is assumed that a relatively small number of individuals will represent the considered knowledge of a very wide range of inputs from other individuals [p. 24].

Directories of several organizations for criminal justice professionals were scanned by the researcher and an associate also familiar with the organizations' membership to identify candidates for the Delphi panel. The initial list of candidates contained 122 persons, a majority of whom were educators in law enforcement. These persons were not contacted prior to the mailing of the first round questions.

Within a week to ten days of the mailing every person on the list who could be found had been called about the project. Sixty experts were found who would participate.

A second panel of fifty-two non-experts was also selected but did not participate in round one. These panelists were seasoned police officers of various ranks sent to the university by their agencies for an in-service training program.[4]

Step 4. Prepare and mail first round questions. The first round appeared in the form of a letter which invited participation, explained the purpose of the study, described the Delphi process and general amount of participation, presented the three open-ended questions, and indicated that a call would be forthcoming to answer questions about the study.

The three open-ended questions appeared near the center of the letter. The panelist was instructed to respond in his own written manner. A stamped return envelope was enclosed for the response.

Step 5. Analyze round two returns and prepare and mail round two. The response to the open-ended questions was "extraordinarily full." The response ranged from one-half page to seven pages in length. The typical response was two to three pages of typed copy.

Out of these responses, 164 statements were selected and cross-checked by research associates to assure that all ideas and themes had been identified and were not duplicated. The original wording was retained as much as possible. Not only would this wording indicate to the respondent that his opinions had indeed been used, but

[4]Although Cooper's panel was not randomly selected, he did not consider inclusion of members as self-selection. The students were not voluntarily enrolled in the university but sent as part of an eleven week in-service program for police personnel. Out of these students, only those with at least two year's experience and a majority of their service remaining were chosen. By rank, there were five patrolmen, eleven sergeants, thirteen detectives, six lieutenants, one captain, and sixteen from other areas related to law enforcement, such as probation.

the questionnaire would exhibit the richness of a variety of writers.

The 164 statements were grouped into sixteen identifiable themes and presented under three general headings: Trends of the Last Ten Years, Continuing Trends During the Next Thirty Years, and New Trends During the Next Thirty Years. Likert scales were the response media for each statement.

An example of the round two questionnaire is shown below.

	(Circle <u>one</u> number which designates your assessment of the statement.)			
	HIGHLY AGREE	SOMEWHAT AGREE	SOMEWHAT DISAGREE	HIGHLY DISAGREE
<u>Trends of the Last Ten Years</u>				
V. Past Trends in Attitudes Toward Roles as Perceived				
1. Younger officers have tended to expect more organizational changes and greater participation in decision making.	1	2	3	4

The round two questionnaire was mailed to Panel A and delivered to members of Panel B. The instructions for round 2 included a requested date for return of response. Follow-up by the researcher after that date helped to increase the return rate.

Step 6. <u>Analyze round two returns and prepare and mail round three</u>. The responses of the two groups were not combined in analysis but kept separate. The items on which consensus had been attained were identified. Cooper's rule of thumb determined consensus to be the matching of the median and interquartile range. For example, if the median response for an item was a "3" and the interquartile range also fell entirely with responses indicating "3", then no further polling of the statement was necessary. This analysis was sufficiently simple to be calculated with desk top calculators and with the assistance of several persons. The main feature of the task was the great number of times the same calculations had to be performed; the calculations had to be performed on each group's 164 items.

The format for round three was nearly identical to that of round two except that in the left margin a letter "C" was placed by the items on which consensus had been reached by that particular panel. In the margin beside the other items, the median score and interquartile range were listed one under the other, i.e., median = 2, range = 2-3. In round three, the panelist was asked to reconsider his response given this new information about his group's perception of the statement.

Step 7. Analyze round three and prepare final report. The analysis of consensus used in prior steps did not permit suspection of the percentage of agreement. Cooper arbitrarily specified that 65 percent agreement about a statement was significant. For example, if 65 percent or more of Panel A selected "4", this indicated a general consensus. With this information he was able to compare percentages of agreement between Panel A and Panel B. For example, he found that 88 percent of Panel A (experts) and 98 percent of Panel B (in-service policemen) felt that "younger officers have tended to expect more organizational changes and greater participation in decision-making."

This identification of items receiving significant levels of response facilitated three additional evaluations:

- Identification and inferential interpretation of relationships among those items receiving significant responses.
- Identification and interpretation of areas of convergence or divergence between the two panels.
- Assumption that the strongest consensus judgments are those concurred by both panels.

Part of the statements displaying significant agreement could be grouped into two major trends: movements among police officers toward professionalization and unionization. This represents an agreement of both panels on 39 items. Fifty-four other items were grouped into secondary trends: education, attitudes toward society, police hierarchy, and police roles.

This illustration of Delphi demonstrates the technique's ability to draw ideas from experts and determine which ideas are intuitively most likely.

Assumptions

Delphi shares the assumption upon which brainstorming is based. This is the assumption that structured group interaction is capable of producing more ideas of value than the sum of ideas produced by the members alone or in an unstructured group. In the Delphi method, this premise is generalized to assume that directed interaction is also the best means of identifying which of the group's ideas are most important.

A second assumption contends that feedback is a positive influence. This assumption has been subject to debate. Efforts to confirm the exact role of feedback have not been conclusive. For example, the original form of Delphi required that a response deviant from the majority's response be justified in writing and shared with the group in the next round. In this way, consensus could be reached through consideration of all information. However, experience suggests that the process of intellectualizing during justification and later group consideration interferes with the intuitive reasoning of expert opinion. The question is, how much feedback and what kind is required for group consensus? The evolution of Delphi seems to be in the direction of presenting only the median and range without justification of deviance.

The third assumption is partially related to the second assumption. This assumption holds that the iterative process improves the group's judgment. However, observation of various Delphi applications suggests that repeated rounds may only narrow the range of opinion without influencing the median. Thus, the user must decide whether it is important merely to identify the opinion that may be agreed upon or to continue until the majority agrees. On the one hand, this consideration pertains to the problem of credibility and, on the other, to the limitations of added time and expense required by further polling.

The fourth assumption asserts that random selection of experts is not required. Regardless of the validity of this assumption, the reader, no doubt, realizes that trust is an element of using a forecast as an input to decision-making. Not all experts are equally respected, thus it is important to explicitly describe the selection of Delphi participants. As is now the practice, adequate justification is rarely given nor are the names of panelists disclosed. Of course, if the decision-maker selects the experts, selection ceases to be a problem unless he seeks to validate his position publicly or shares his forecast with others.

Span of Forecast

Delphi has been applied to a variety of time spans. A range of twenty to thirty years is very frequently associated with Delphi forecasts. Periods shorter than two years may be more appropriately undertaken by methods requiring less time to complete.

Accuracy

The accuracy of Delphi has also been a topic of debate. To a great extent, assessment of accuracy depends upon the decision-maker's opinion of the experts' qualifications. Almanac studies, that is, the forecasting of little known past events given relevant data, have often been cited as indicative of successful Delphi forecasting. However, disagreement among critics suggests that not all almanac studies are supportive. Generally speaking, there is no clear-cut formula for evaluating accuracy when using experts to forecast complex events.

Since the Delphi process lacks a rigid methodological structure, this writer suggests that particular attention be paid to five aspects which could distort results:

1. Structuring of questions--poorly written questions will fail to elicit response and assess opinion.

2. Drop-out of experts--if many drop out and some stay, one must ask how the absent opinions would have influenced the results.

3. Number of items--too many items may result in fatigue and "agreeing to get it over with."

4. Pitfalls of simple analysis--one of the most obvious pitfalls is the fact that the median, mode, and raw mean score cannot represent polarized opinions (bi-model distribution). These measures seek to identify a single region of agreement.

5. Bias of selection--one man's expert may be another's narrow-minded advocate.

Accuracy also involves the question of how many experts is enough. Delbecq et al (1975) suggest that thirty well-chosen experts in a single speciality area are sufficient. No doubt, panel size would increase in a multi-specialty forecast of prison populations.

The application of Delphi may encounter different interpretative patterns in prison population forecasting than in technological forecasting. The experts polled in technological forecasting may be those involved in making the questioned developments occur. In the social sciences there are no such experts. "The use of Delphi in social forecasting is likely merely to distill journalistic impressions about social change in the elites consulted" [Encel, 1976, p. 142]. Accuracy as viewed in this perspective of actual involvement in change, becomes more general in meaning for prison population forecasting than for technological forecasting.

Delphi views the world in rather simplistic terms. There are no mechanics for determining which social trends might interact or the results of such interaction. The format of Delphi would also permit experts to assign high probabilities to mutually exclusive events. This mechanical weakness confuses the meaning of probability of occurrence.

Unique Limitations/Considerations

In order to enlist the participation of experts, the Delphi project must be openly supported by a high status administrator. By themselves, persons of lower status, such as junior researchers, will not elicit adequate expert participation.

Delphi forecasts should be conducted by researchers trusted by the decision-maker. The absence of universally accepted guidelines for Delphi thrusts the researcher into the position of making crucial judgments at critical points in the process.

The Delphi process could be used to mold, as well as sample opinion. For this reason, many respondents may be suspect of successive rounds that do not reflect the content or wording of their earlier responses to the open-ended questions of round one. Delphi variants, having no open-ended questions and being composed only of statements constructed by the researcher, could also arouse suspicion.

Communicability of Results

The communicability of Delphi results is high. Written or spoken communication does not of necessity require complex charts, special jargon, or mathematical symbols.

Time

The minimum time to conduct a three round Delphi by experienced

Delphi researchers is estimated by Delbecq et al (1975) as 44-1/2 days. This, of course, assumes no hitches or problems. The majority of Delphis take much longer. Probably a time range of five months to a year is more realistic for a full three round Delphi. Shorter versions would, of course, require less time (and expense).

Resources and Cost

Since the Delphi format is essentially a questionnaire, the statements and polling forms should be developed by someone competent in questionnaire construction. Such persons are not normally found in the research departments of state correctional agencies. Although, inexperienced researchers may provide the legwork of collecting and tabulating results.

A large study involving many experts may necessitate computerized data handling. Smaller projects may require only desk calculators and several clerks for assistance.

Project cost depends upon the design. If experts are to be paid to offer their opinion, cost rises rapidly. In a small project, for example, Cooper's research, the cost was estimated at $2,500. His major expenses were postage, telephone, and assistants for data analysis. His salary was not included in this estimate.

Considering everything except paying experts, a low estimate for a mailed three round questionnaire would be $5-10,000. Other estimates have been found in the range of $10-50,000 (Mitchell, 1975).

Transferability

Delphi is not the instrument of choice for forecasting short-term prison population changes. The greatest potential of Delphi appears to be in determining trends 5-30 years away. Such applications have merit for the developing of policies and standards for prison construction.

Delphi's time and cost requirements indicate that this is more than a casual tool employed by a research staff. Efficient application dictates that the total responsibility for forecasting cannot be delegated to staff researchers by the high level decision-maker. If he is unable or unwilling to offer minimal support and participation, it is doubtful that he will accept or apply the results.

As envisioned earlier, Delphi forecasting could be employed as the precursor to a meeting of experts working to formulate government policy on prisons. As such a part of a larger program, Delphi could serve as a much needed communication tool.

Matrix Forecasting

Matrix forecasting is a family of techniques which attempts to fill the methodological gap between subjective and objective methods. Subjective methods tend to identify future events and trends, but do not consider how these occurrences would affect one another. Objective methods, on the other hand, may be able to deal with interaction of events but suffer from lack of data. Thus, a gap exists because subjective methods generally fail to assess interaction, and objective methods could assess interaction but cannot perform without data.

Matrix forecasting attempts to supply data by subjective means and provide an objective method of calculating interaction.

The basic characteristic which distinguishes this family is, of course, the matrix. A matrix is a box-like affair having rows and columns in which data are placed.

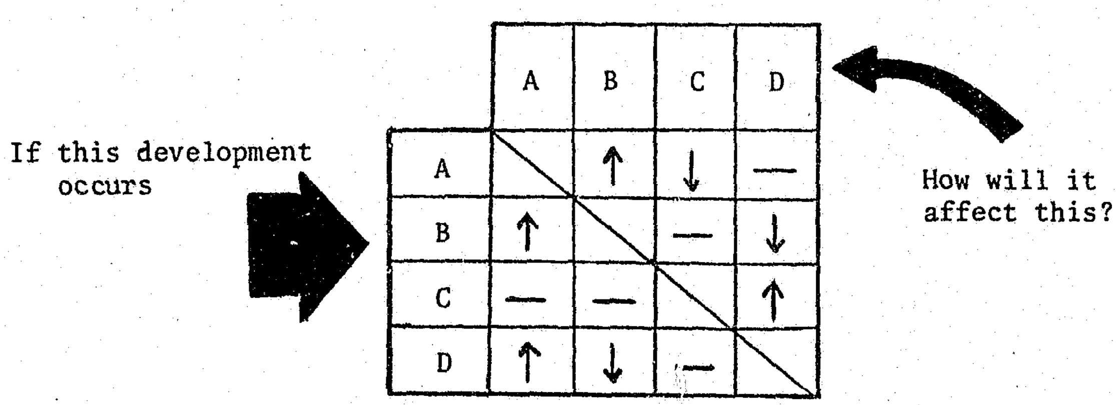

Figure 5. Basic Form of the Matrix

The construction of a matrix facilitates evaluation of the question, "How does one factor 'impact' or affect the likelihood of occurrence of another?" For example, in the figure above, the matrix illustrates that Factor B has been judged to increase the likelihood of the occurrence of A, not to affect C, and lessen the possibility of D's occurrence. Instead of arrows and dashes, the matrix boxes can be filled with the numerical estimate of the impacted likelihoods of occurrence.

The roots of matrix forecasting are imbedded in two kinds of probability theory: conditional probability and subjective probability. Conditional probability was essentially described in the paragraph above when it was shown that the development of Factor B affected the occurrence of A in a positive manner, C not at all, and D negatively. In terms of probability theory, the occurrence of A, C, and D is said to be "conditional" upon the occurrence of B.

Conditional probability theory works for events whose probability of development are known. This is the quandry of social forecasting--the probability of development of social events is unknown. Therefore, to apply conditional probability theory to social forecasting, the probability of development has to be established by intuitive methods. This process of intuitive estimation is part of the role of subjective probability theory. The other part of the role is that of assigning numerical estimates instead of arrows or dashes in the matrix.

An example of conditional and subjective probability theories applied in the social forecasting matrix may be reflected in the possibility of outlawing handguns and reinstating the death penalty by 1985. In this example, outlawing handguns may be represented in the matrix as development B with the subjective estimated likelihood as .65 of developing by 1985. The reinstating of the death penalty may be represented as Factor C and estimated subjectively to have the likelihood of development as .50. The question raised by the matrix is "What is the likelihood of reinstating the death penalty if handguns are outlawed?" The experts assembled in this hypothetical situation to conduct matrix forecasting agree that the development of B (handgun control) would affect the likelihood of C's occurrence. They assess that the likelihood of reinstating the death penalty would be lowered from .50 to .30 if handguns were outlawed. Represented in the matrix, the impact of B on C would appear as the value .30 in the box formed at the intersection of row B and column C.

History

The Cross-Impact Matrix (CIM) is the conceptual centerpiece around which other matrix techniques have evolved. CIM proposes an optimal approach for blending subjective and objective methods into matrix forecasting. The other members of the matrix family of techniques attempt to compensate for the weaknesses of CIM and to propose methodology for problems not suited to CIM.

CIM arose out of the research by Gordon and Helmer on Delphi. The Delphi technique seemed appropriate as an instrument to elicit expert opinion; however, the structure for evaluating future events yielded incongruous results. The technique did not guide experts to avoid assigning high probabilities of outcome to mutually exclusive events. This problem of assessing event probabilities was partially resolved by Gordon and Helmer in the design of a futures game created for the Kaiser Aluminum Company. Concepts from the game were then incorporated in an analytic procedure for the matrix.

The CIM analysis revises the initial probability estimates assigned to future events by the polling of experts, e.g., in the

Delphi survey. The data analyzed by the CIM analysis are not the initial probabilities but the second set of estimates established by the experts--the conditional probabilities of impacts. The "Cross" aspect of Cross-Impact Matrix analysis derives from the manner of analyzing the matrix data. In Figure 5 above, as was pointed out, Factor B was found to positively affect or impact the likelihood of occurrence of Factor C. If, however, the development of Factor B was preceded by Factor A, then probability of Factor B would be raised. Indirectly, Factor A would affect Factor C through B. For example, if a portable, small-scale metal detector (Factor A) was developed, then as hypothetically shown, the likelihood of outlawing handguns (Factor B) would be positively impacted and raised. The probability of reinstating the death penalty, Factor C, is thereby indirectly impacted by the development of portable metal detectors. Within the matrix there are other permutations or patterns in which the sequence of the events may occur. For instance, in the matrix having four factors (4 X 4) twenty-four different chains of events could be determined. As more factors are added to a matrix, the number of chains increases and the matrix analysis becomes more complex to follow. The analysis simulates the occurrence of events in a complex social environment. The outcome of this analysis is to revise the initial probabilities of events established by the experts.

CIM was first applied in 1968 in a retrospective study of event probabilities behind the deployment of the minuteman missle. The first forecast of the future with CIM was also conducted in 1968 and dealt with American transportation. Since that time a variety of mathematical procedures for analyzing CIM have been proposed, yet little actual application of CIM to social problems appears in forecasting literature. The writings on CIM seem restricted to a very few sources. Theodore Gordon, at the Futures Group, has created a CIM computer analysis program which he markets. Despite the lack of CIM application, the method is frequently mentioned among the major forecasting techniques.

CIM is only one of several ways of evaluating matrix information. Simpler mathematical procedures have been proposed that would avoid CIM problems and broaden the subject matter of matrix analysis. Examples of CIM and alternative techniques will be presented below.

Example

A hypothetical example of CIM has been constructed because no example of criminal justice application has been found. Before inspecting the example, the reader needs to assume that a Delphi survey or other means of polling experts has identified and estimated the initial probabilities of events which would influence the growth of prison population. Listed below in Figure 6 are four events selected from the hypothetical pool of events:

Event or State	Probability of Occurrence before 1990
1. 90% of the nation's major police departments will keep records on computer.	.70
2. Formal pretrial diversion programs will increase by 30% nationally.	.70
3. Two-thirds of the major cities will have habitual offender prosecution programs.	.50
4. Two-thirds of the states will have enacted determinate sentencing legislation.	.60

Figure 6. Hypothetical future events and the initially established probabilities

These four events/states are placed into the rows and columns of a matrix as illustrated in Figure 7. The initial probabilities for the events have been placed in parenthesis.

	More computers	More diversion	More prosecution	Determinate sentencing
More computers (.70)		.75	.60	.65
More diversion (.70)	.85		.55	.60
More prosecution (.50)	.85	.65		.60
Determinate Sentencing (.50)	.60	.80	.50	

Figure 7. Matrix of Conditional Probabilities of the Events in Columns Given that Each Row Event Occurs

Source: Hypothetical data

The matrix above also reflects the conditional probabilities estimated by the experts. For example, the development of computerization of police records will raise the likelihood from .50 to .60 that habitual offender prosecution programs will arise in the major cities of our country by 1990.

The analysis of cross-impacts in this hypothetical example will be conducted by a simulated computer program. The program selected for this analysis involves six steps (Rochberg, et al., 1970):

1. An event is selected at random from the list. For example, event number 2 could be selected (more diversion).

2. A Monte Carlo routine "decides" the event. This routine generates a random number between 0 and 1. The generated number is compared to the initial probability of the event. A decision rule specifies that if the random number is less than the event's initial probability, then the event is considered as having occurred.

3. The probabilities of the remaining events are "adjusted" or modified by a formula which assesses interactions (the cross-impacts).

4. Steps 1-3 are repated with those events which have not been decided.

5. The computer repeats steps 1-4, beginning with the original or initial probabilities. In the instance of a large matrix, this process is "played" up to a 1000 times. The results of play establish the "final" or revised probability of each event.

The number of times the event "occurred" in the program determines the event probability; e.g., if event 2 (more diversion) occurred 750 times out of a 1000, its revised probability would be .75. The revised probabilities for the four events in an interactive environment appear as illustrated in Figure 8.

In Figure 8, the initial and revised probabilities do not coincide. The analysis suggests that in a complex and interactive social environment the probabilities of the four events may be higher than originally estimated. An increase in probabilities need not

Event	Initial Probability	Revised Probability
1. 90% of the nation's major police departments will keep records on computer.	.70	.84
2. Formal pretrial diversion programs will increase by 30% nationally.	.70	.75
3. Two-thirds of the major cities will have habitual offender prosecution programs	.50	.66
4. Two-thirds of the states will have enacted determinate sentencing legislation.	.60	.61

Figure 8. Results of hypothetical Cross-Impact Matrix Analysis of events affecting prison population growth.

always be the case. A larger matrix with more factors or a matrix of different factors may just as readily reflect decreases in revised probabilities. The question of how many events should be considered in a matrix is, of course, subjective. The selection of events and assignment of probabilities has an important bearing upon the outcome of analysis.

Example of Simplified Matrix Analysis

Methods other than CIM have been suggested for matrix analysis. Some alternative methods attempt to overcome problems of CIM--others present novel ways of assessing impacts.

The following example addresses the problem of calculating a version of cross-impact analysis without computer simulation. The events that will be assessed are those appearing in Figure 8 above. The major difference in calculation is that numerical probability and impacts are assessed in a simpler form.

How will it effect this?

If this develops

	More computers	More diversion	More prosecution	Determinate sentencing	Relative Ranking
More computers		+8	+6	+7	=21
More diversion	+8		+5	+6	=19
More prosecution	+8	+6		+6	=20
Determinate Sentencing	+6	+7	+5		=18

Figure 9. Matrix analysis to determine the relative ranking of developments by relative strength of influence on other events (Source: Hypothetical Data)

The matrix was constructed by asking experts to identify positive and negative impacts with pluses and minuses. The strength of impact is judged on a 0 to 10 scale indicating negligable to every strong impact. For example, the development of habitual offender prosecution programs would have a strong positive influence on the conversion to computerized police record keeping. This impact is relatively easy to understand; the implementation of prosecution programs could call for better habitual offender identification and follow-up capability, etc.

The objective of this form of matrix analysis is to determine the relative ranking of the events according to their importance in a complex interactive social environment. To obtain this ranking one merely sums the rows. The event or development having the largest sum is the most influential.

This method of ranking does not reveal forecasted impact in probabilistic or numerical figures of prison population. This tool is helpful in identifying which future trends may strongly influence the growth of prison population.

Example of Matrix Assessment of Numerical Effect

The resulting effect of the occurrence of an event on prison population cannot be estimated by the Cross-Impact Matrix or by the simplified matrix above. Increases or decreases attributed to a particular event can be estimated by asking the experts to evaluate the event's numerical impact on the flow of offenders. An example of such a procedure is drawn from the 1974 study of the federal court caseload volumes conducted by the Battelle Institute. In that study, a panel of criminal justice experts generated a list of thirty-two possible events which might impact thirty-three selected case filing categories. The impact of the events were estimated as shown in Figure 9.

The assessment of impact on volume can be estimated by the experts. This assessment evaluates the change per 100 cases filed that will be brought about by the event. The numbers in the matrix represent the case volume after the estimated increase or decrease per 100 cases is accounted for. For example, in Figure 10 decriminalization of drug use is estimated to reduce by seventy cases per 100 the number of Marijuana

Case Categories

If this occurs → How will it affect this?

Possible Future Events	Prisoner Petitions	Civil Rights	Marijuana Tax Act	Weapons & Firearms
Increased decriminalization of drug use	88		30	
Increased legal assistance to welfare and low income groups	115	131		
Increases in non-judicial handlings of prisoner complaints	88			
Increased regulations on firearms				125

Figure 10. Impact of events on the volume of Federal court case-filing categories

Source: Hooper, R.C. Forecasts of Case Filing Volumes in the Federal District Courts, Richland, Washington: Battelle, Vol. 1, pp. 55-60.

Tax Act filings. By adding the impacts per 100 cases filed, the case categories forecasted from historical data can be modified to show how the future trends could be impacted by surprise events. This method of matrix analysis could be applied to prison growth as well as court case-filing volumes.

Assumptions

In this and the following section on matrix forecasting, CIM will be the primary focus of evaluation, although some of the information will apply to the family of matrix techniques. Seven assumptions are identified for discussion below:

1. The assumption of expert awareness: The basic inputs, the events and conditional probabilities are generated by a group of experts. The polling of expert opinion assumes that complex intuitive models of the future can be verbalized and that as such, these models resemble the future reality.

2. The assumption of meaningful probability: Even though statements of subjective probability are personal in meaning, CIM assumes that experts commonly understand the metric or basis of assessment being used. In addition, it is assumed that a meaningful and accurate correspondence exists between subjective probability estimates of one-time occurring events and statistical probability of events that occur repeatedly over time. A weakness of this assumption is that at best a loose relationship exists between subjective and objective probability.

3. The assumption of an atheoretical environment: Probability statements are reflections of the behavior of a system and as such cannot depict the system's structure. Very different system models could produce the same behaviors. Matrix analysis is, in this sense, atheoretical because it assesses behavior rather than structure.

4. The assumption of value-free forecasts: Matrix analysis is restricted to events and does not consider political values and processes. This avoidance of open consideration, although it may be implicit in event estimation, gives rise to the forecaster's claim of value-free forecasting.

5. The assumption of a binary world: Matrix analysis accommodates only binary combinations (pairs) of events. The matrix concept of conditional probability does not recognize that more than two events may interact.

6. The assumption of randomness: In CIM Monte Carlo simulation decides the sequence of events in a chain by a process of random selection. This process may introduce logical

inconsistencies into event chains. Some events are more likely to precede other events in development. This introduction or randomness distorts the play of matrix analysis and thereby affects the meaningfulness of the revised probabilities.

7. Assumption of finality: CIM assumes that the final (revised) probabilities more accurately represent the real event probabilities than do the initial probabilities established by the polling of experts. Yet, if the entire CIM analysis were to be played again using the revised probabilities as initial probabilities, the outcome would be a new set of different probabilities. CIM may assume finality but the process is unable to converge on a stable set of revised probabilities.

Span of Forecast

Events within matrices are usually estimated in logical blocks of time, such as 5-10-20 years into the future. A forecast span less than five years is unlikely to be encountered.

Accuracy

The Cross-Impact Matrix technique should be considered a crude device. A matrix forecast is highly speculative and at best provides a "ball-park" estimate.

Accuracy of CIM forecasts is difficult to interpret. The CIM is constructed in terms of probabilities rather than numbers of inmates. A specific meaning of probabilities evaluated at the end of the forecast period must interpret how occurrence or non-occurrence of equally likely events relates to accuracy. That is, does non-occurrence of a high probability event represent a missed prediction, and the occurrence of another equally high probability event represent an accurate prediction?

Considerations/Limitations of CIM

A CIM forecast of prison population would necessarily be an inter-disciplinary undertaking. This effort would require input by experts in a variety of social fields. However, no specific methodology has been developed which would limit expert opinion only to those events within the area of the individual's expertise. Gordon, et al (1970) suggest that matrix cells be classified as to requisite skill and then solicit input accordingly.

Communicability of Results

The basic method of estimating impacts is not difficult to explain. However, the presence of seemingly rigorous mathematical calculations tends to imply precision not possessed by the matrix forecasting technique. The essential message to be conveyed is that CIM is a process of investigating the future via expert judgment.

Time Considerations

Six to eight months would probably be required to accomplish a CIM forecast of prison population. Most of that time would be spent in selecting and polling experts. Actual computer analysis requires a few hours at the most, using the available prepared CIM analysis program.

Resources

The primary CIM resource is that of experts from a variety of social fields. Representation should not be limited only to criminal justice personnel. Experts from other areas such as economics and demography are needed.

The person conducting the CIM research would expectedly be very sophisticated in statistics. For this reason, a consultant may need to be employed to construct the forecast.

A computerized CIM analysis program is available from The Futures Group, Inc., in Glastonbury, Connecticut. The rental fee for first year use is $3000 and approximate cost per run is $20.

Overall, a CIM forecast appears to be rather expensive. Perhaps the expense and resource requirements place CIM beyond consideration of casual research projects typically found in state correctional agencies.

Transferability

Although matrix forecasting may occasionally be offered as a method for forecasting prison population, its forte appears to be that of explorative research. This recommendation does not necessarily relegate CIM or other types of matrix forecasting to a lesser standing than such techniques as naive projection of risk population. Rather, CIM takes a place beside other speculative forecasting techniques.

An important quality of matrix forecasting is the potential of exploring to determine which possible future events could most dramatically affect prison population growth. This heuristic capability may be of some aid in evaluating policy preferences for the planning of corrections. Perhaps this is more than can be said for most of the naive and some of the causal forecasting techniques.

Scenarios Forecasting

A tool which offers promise, but not a rigid form for prison population forecasting, is scenarios construction. This tool holds the potential of reducing the bias in expert opinion and of revealing hidden reasoning in forecasts. Scenarios construction, though, lacks a strong methodological tradition to guide interested but unacquainted researchers. In practice, scenarios writing ranges from an intuitive art exemplified by Herman Kahn's work to a structured and computer-assisted process found in some of Clark Abt's forecasts. Before the potential of this method can be realized, general guidelines must be defined. The proposal of such guidelines is the intent of this examination of scenarios construction.

In its simplest form, a scenario is merely the written description of a forecast. It is communication in words rather than graphs, charts, and numbers. In contrast to the simple form, the vigorous form involves the development, explanation, and justification of a forecast containing alternative futures. The simple and vigorous practices differ significantly. The former establishes only the vehicle for relating a single opinion, while the latter seeks to portray a somewhat pliant future of alternative paths.

Expert opinion is enhanced in several ways through vigorous application of scenarios construction. Multi-path scenarios call attention to a wide range of alternatives and establish a basis for assessing choice between strategies. In such scenarios, the expert illustrates the functioning of various principle and issues underlying the envisioned outcomes. Details often implied, such as evaluation of possible future cause-effect relationships and identification of decision/branching points of alternative futures, are made explicit. This process not only conveys more information to the reader, but stimulates the expert to examine his opinion and develop a "feel" for the forecasted conditions.

Essentially, there appear to be three types of scenarios:

- Single-future scenarios
- Multi-alternative scenarios
- Planning scenarios

The single-future scenario presents the future with no alternative paths. This scenario is fundamentally an argument supporting the expert's interpretation of "what's in store." Such forecasts offer little advice as to how various decisions might affect the course of events. The decision-maker, if he accepts the forecast, must either fatalistically await the foretold condition or reactively plan to avoid an undesirable future. Characteristically, the single-future scenario involves the analysis of a few easily identifiable social trends. This analysis assumes that global trends evolve slowly and that change is signaled by disruption in cultural behavior. An example of the single-future scenario is Alvin Toffler's Future Shock (1970). Toffler's work reflects the characteristic "if-then" development of theme. The "if" is derived from identification of trends and their signals, and "then" assumes non-interruption of the evolution of results. The rigidity of the "if-then" forecast precludes reevaluation of variation in outcome. Because of this rigidity, the single-future scenario should be respected as only one of many possible interpretations about "what's in store."

The multi-alternative scenario and planning scenario both present more than one possible future. The difference between these two lies in the attention to decision points available to the administrator. Multi-alternative scenarios tend to describe forecasted possibilities in a cursory fashion. The forecast is often described as general waves which propose to sweep the reader into various alternative conditions. Even though the analyst may address several futures and elicits reader interest, specific attention is not directed toward decision-making alternatives. Rather, the alternatives tend to be evaluated in terms of probable combinations of trends evoking anticipated outcomes. Herman Kahn's well-known work, The Next 200 Years (1976) is an example of the general format of multi-alternative scenarios.

Planning scenarios also present alternative futures but differ from multi-alternative scenarios in the focus on identification of decision points and paths sensitive to actions of the decision-maker. Rather than viewing the future as a wave, the reader is supplied with several major themes and tentative branching points which might be considered in planning. Such scenarios tend to be the product of a structured search for alternatives. An example of such a structure process is found in Abt's Scenario Generation Methodology:

- Scenario variables are derived in an explicit manner using content analysis of expert forecasts.

- Scenarios are generated in sufficient detail for planners to identify the threats to the [social] environment and derive the missions, tasks, and systems needed to counter them.

- The establishment of a range of possible relationships between variables promotes examination of alternative futures. Examination is not limited by bias about classes of possible relationships. A random number generator rather than bias determines the paired relationships.

- By having an envelope, or range of possible scenarios, one can examine more than one possible future. In addition, the range can be divided into classes of strategies formulated for each class and current plans designed to meet the set of probable futures rather than a single event [pp. 194-214].

As described above in Abt's methodology, the search for alternatives is an important aspect of scenario construction. The specific technique suggested by Abt is just one of several manners of exploration. The analyst could select from a menu of methods which includes:

- Delphi technique
- Decision Trees
- Factor Listing
- Cross-Impact Matrices
- Morphological Analysis
- Counterplanning

The major features of planning scenarios appear in the intent to communicate policy considerations and in the effort to objectively identify alternatives. These features distinguish planning scenarios from single-forecast and multi-alternative scenarios.

History

The term "scenario" was first used as a synonym for movie script. In forecasting, the term was initially applied to descriptions of political-military projections. In those early scenarios, the analyst set out to describe hypothetical sequences of the cold war. This articulation seemingly helped the analyst to develop a "feel" for critical decision points and branching paths emanating from these points. Cold war scenarios were constructed on a wide variety of possible world crises and stored for immediate reference by the President, Department of State, and selected military advisors.

Herman Kahn, then a researcher at Rand and Hudson Institute, popularized the concept of scenarios construction. His early scenarios for public readership, On Thermonuclear War (1963) and On Escalation: Metaphors and Scenarios (1965) introduced such catchwords as "overkill" and "megadeaths." His two works were descriptions of first and second nuclear "strike" strategies.

The role of scenario writing in forecasting often seems to be in dispute because it appears not far removed from older forms of conjecture such as science fiction and utopian literature. Scenario writing, though, is a step beyond opinion constructed without benefit of a definite data set or methodology. Scenario writing stands for more than persuasive reasoning.

In criminal justice forecasting, scenarios construction has not been enthusiastically embraced. Greater emphasis has been placed on opinion statement. The solitary effort of Project Star's The Impact of Social Trends on Crime and Criminal Justice (1976), differs from many statements of expert opinion in its depth and data base, although its format is that of a single-forecast scanario.

Example

Since multi-alternative and planning scenarios offer greater forecast information, the discussion of methodology will focus on those methods: the single-future forecast scenario will be omitted. Although not specifically defined elsewhere, the construction of scenarios involves five steps:

1. Selection of objective
2. Specification of time horizon
3. Determination of basic elements (variables) composing scenarios
4. Identification of alternatives within basic elements
5. Formulation of scenarios and integration of elements and alternatives into written units

These basic steps are succinctly illustrated in Elboim-Dror's "Some Alternative Futures of Educational Administration," (1971). This work discusses alternative paths of educational development and in a general manner attends to decision points. Because of the general treatment of decision points, this work would fall under the classification of the multi-alternative scenario.

For ease of referral, the title of Elboim-Dror's work will be referenced as "Educational Alternatives."

Step 1. Select objective. In "Educational Alternatives," the forecaster specifically states that his purpose of analysis is to "be suggestive and only to provide some distinctive prototypes of alternative future developments ..." From this statement of purpose, the reader is able to quickly deduce the orientation that the forecaster adopted in constructing the scenario. The topic is seen as addressing a broad audience rather than a select group of educational decision-makers who desire to focus on studying particular issues.

Step 2. Specify time horizon of forecast. In "Educational Alternatives," the time horizon was specified as "about 30 to 50 years from today." By restricting the horizon to the not too distant future, the forecaster pointed out that his forecast did not need to include forecasts of technological innovation which might impact education.

Step 3. Determine basic elements composing scenarios. In this step, the forecaster selected twenty-five elements (variables) which would be considered in each scenario. By selecting these elements, the forecaster is establishing a basis for constructing and comparing the alternative futures. Arbitrarily, the forecaster divided the elements into two homogeneous categories. One category, "Assumed Conditions," contained nine elements about the conditions of the country and world in general. This category contained, for example, "Demography," "Domestic Politics," and "Culture." The other category, "Characteristics of Educational Administration," contained sixteen elements about education, such as "Organizational Structure," "Pattern of Work," and "Curriculum."

The process of selecting elements and classifying them will assist in the later step of identifying and sorting ideas about the future for inclusion in scenarios. Rather than constructing scenarios in a hit-or-miss fashion, the forecaster is building a comparative basis for examining administrative action under various conditions.

Step 4. Identify alternatives within basic elements. The goal of step 4 is to identify the possible alternatives that might occur for each element. In "Educational Alternatives," the major source through which alternatives for the elements were identified was forecasting literature of all fields. For example, for the element Culture, it was found that three basic groups of alternatives existed which could be defined as distinctive outlooks on the future: an evolution to a Hedonistic Culture, an Empirical Utilitarian Culture, and a Self-development Oriented Culture.

Not all of the alternatives identified for the twenty-five elements were found in the literature. Those alternatives which were found in literature helped to establish the general theme of the prospective scenarios. But within the themes, gaps in some of the elements were not filled by ideas from literature. The identification of alternatives for blank elements was a matter of postulating alternatives that would fit the theme.

The development of alternatives was similar to the construction of a table of information. The rows of the table were the twenty-five comparative elements. The columns of the table represented the different scenario themes that were developing. The identification of alternatives was then a matter of filling in or arranging information within the boxes formed at the functions of the rows and columns.

Step 5. Formulate scenarios and integrate elements and alternatives into written units. In the final form of the table, four scenario themes were evident. Each scenario theme represented a different path into the future. These scenarios were labeled by number for the purpose of identification, i.e., "Prototype 1 of Alternative Futures of Educational Administration," "Prototype 2 of ....," etc.

In the description of the twenty-five elements in each scenario, the forecaster set out specific conditions which would promote a particular administrative orientation. Some of the conditions such as presence or absence of war, were not controllable in an educational environment; other conditions such as approaches to teaching methods, were amenable to control.

The finished product of "Educational Alternatives" is a narrative describing the four themes:

Prototype 1: Educational policy-making characterized by wide citizens' participation

Prototype 2: Direction of all educational policy issues by a central political body

Prototype 3: Policy-making determined by major interest and pressure groups

Prototype 4: Policy-making by a merit elite of which highly trained professionals constitute an important part.

Within each scenario theme the twenty-five comparative elements are described as they might exist in the future. The description of Prototype 3 is most like today's trend in education. Prototype 2 is one of the future themes dissimilar to today's and as such offers an interesting example to examine. In this prototype, highly trained professionals play a key role in establishing educational policy.

> The educational complex is geographically concentrated but rich with a variety of different organizational structures, learning programmes, methods and procedures. The formal structure is very flexible and open to experimentation and constant improvement and change processes ... The educational system of the elite resembles 'development clinics,' where highly intelligent and motivated students each pursue their own self-development with help of individualized learning programmes. ... The educational system for the masses is more guided and adapted to their limited capacities. ... Teams of administrators and teachers work closely together with other educational personnel in professional peer groups, where the main authority is professional knowledge and creativity [p. 72].

The four scenarios, or as Elboim-Dror calls them, descriptions of prototypes, can be visualized as branches growing out of the present. The substance of each branch are the different combinations of controllable and uncontrollable trends. Although, aesthetically pleasing, these four paths may not represent the entire range of the most likely futures. The process of identifying alternatives and categorization reflects the basic view of the future held by the forecaster. The forecaster, as in the example of "Educational Alternatives," often does not state what alternative did not fit into the four basic themes that were developed into scenarios.

Pausing once more to inspect the example "Educational Alternatives," Elboim-Dror describes an interesting concept that was realized in step 5. This concept could also be realized in correctional forecasting. Elboim-Dror points out that

> Our description of alternative future of educational administration illustrates that specific conditions imply specific future development of educational administration. ... Our analysis of developments and of alternative futures points to an existing dualism in perceiving future developments in organizations and in educational administration. According to this perception, organizations and management develop as rational, efficient, quantitative organizations, or as qualitative, humanistic and moral ones; bureaucratic or

> democratic ones; egalitarian or hierarchial ones, centralised or decentralised ones, and so on. It seems that this tendency to think in dichotomies is very misleading and harmful for future planning [p. 74].

In retrospect, the multi-alternative scenario as illustrated in "Educational Alternatives" is broad-based and without specific detail or attention to crucial decision points leading toward a particular future. In some aspects, the educational scenario examined above is similar to the present state of conjectural activities about prison growth found in criminal justice literature. However, the activities of conjecture about future prison development lack the scenario's clarity in the specification of elements of growth and possible alternatives. Such broadened consideration found in multi-future scenarios could find fertile soil in the forecasting efforts of the criminal justice academic community.

Assumptions

In multi-future scenarios (multi-alternative and planning scenarios) construction, it is assumed that simple trend extrapolation constitutes an inadequate forecast. Drawing from the thoughts of Popper (1957), we can say that trends exist but their persistence depends upon continuity of specific initial conditions in a particular environment. To overlook this dependence on a set of unvarying initial conditions is, in Popper's words, "a central mistake." If trends are treated as unconditional, they may indeed carry us irresistably in a specific direction into the future.

Multi-future scenarios construction assumes that a single-view forecast is misleading because the future is unknowable. The distortion of perception of single-view forecasts arises from the inference that the identified causal relationships are necessary conditions rather than sufficient conditions. The single-view forecast ignores the possibility that several paths may lead to the same outcome or that "sufficient" conditions interacting in a multi-faceted world can yield different outcomes.

Single-future scenarios also tend to assume that the future is surprise-free. That is, the future is described as logically arising from readily identifiable trends. "Wild-card" or unexpected events and trend changes are not considered explicitly in the single-future scenario.

Span of Forecast

Scenarios construction is a long-range forecasting method. Periods greater than five years and within 10-50 years seem most suitable for planning scenarios. Longer time periods tend to enter into the realm of entertainment and speculative fiction.

Accuracy

Accuracy is difficult to assess for several reasons. First, if a scenario is employed as a normative device, that is for exploration of alternative paths to an objective, the forecast may become self-fulfilling. Secondly, the question is raised about what is acceptable partial accuracy. Since scenarios involve a number of alternative futures, how is a "hit" or "miss" for one of the alternatives to be scored? Then, too, are the missed alternatives really missed or should they be evaluated on some scale of supporting creditibility?

The perception of scenario accuracy rests, in part, on the creditibility of the writer(s). This creditibility is enhanced when the writer specifies the sources of information and spells out his assumptions. By doing so, the reader is permitted to evaluate the objectivity and basis of the forecast.

Communicability

Scenarios are the most easily communicated form of forecast. A scenario appears as an understandable and familiar form of discussion.

Special Limitations/Considerations

Well-built scenarios convey sufficient detail for consideration in planning, yet limit the precision of analysis. The objective is to identify paths and decision points. Further detail would create the problem of proliferation of expla tions which would obscure the general course of events.

Several of the greatest drawbacks of scenario methods arise from the reader's weaknesses. Readers are prone to positively evaluate well-written stories and ignore poorly written ones. A well-written single-future scenario may impart a lasting impression which interferes with the appraisal of alternatives. In addition, readers tend to assess alternatives for the purpose of selecting which is the "true" future. The presentation of a range of alternatives tends to imply that all possible alternatives have been identified. Such interpretation inhibits further search for other possibilities.

Check-lists are commonly employed in developing alternatives.

Listing helps to identify important elements and their variants; however, the listing approach by itself does not identify possible effects of interaction between the elements. More sophisticated methods such as Cross-Impact Analysis (CIM) must be employed to study interaction.

Scenarios are often written by one person. In some instances this presents no problem, yet frequently individual interpretation results in self-centered views. Scenarios, then, become a fancy way of selling the expert's opinion. For example, the situation can arise in which alternatives may be developed that are so removed from reality that only the expert's view seems plausible. This problem can be partially avoided by using structured exploratory forecasting techniques for identifying alternatives and by circulating drafts of proposed scenarios to cooperative critics.

Resources/Cost/Time

The basic resource is, of course, a skilled analyst. The process of scenarios construction is such that it can be learned by criminal justice experts. Scenarios construction is not necessarily the domain of any one person or field of study. The selection of a scenarios forecaster should consider the person's familarity with decision points and mechanics of the Criminal Justice System.

The time and cost of scenario construction hinges upon the purpose, depth and length of the analysis and description. At the least, a well-constructed scenario would require a few weeks.

Transferability

Scenarios construction seems best suited to forecasting prison population on a national rather than state level. Such application should draw considerable attention. The high level of communicability should stimulate wide readership in this topic which is already one of national interest.

One benefit not to be overlooked is that of applying scenarios to the normative forecasting of criminal justice objectives. This application could assist policy makers in evaluating alternative paths to correctional objectives. They would be able to assess correctional objectives in light of current trends, decision points, and resource trade-offs. Thus, in prison population forecasting, scenarios construction could serve as a double-edged tool, functioning both in an exploratory and normative capacity.

CHAPTER VI

FORECASTING PRISON POPULATION BY NAIVE METHODS

Introduction

Four forecasting methods are presented in this chapter on naive forecasting: subjective extrapolation, least squares, smoothing techniques, and indicator forecasting.

"Naive forecasting" is not a name describing the skill or character of the forecaster. The name connotes that the forecast has not sought to inspect why prison growth has developed in its particular pattern or why the analyst might expect that pattern to continue. As will be pointed out in the chapter, tools for analyzing data are not as restricted in time-series application as in the behavioral sciences' cross-sectional analysis. This lowering of restrictiveness adds a quality of flexibility to these naive methods which enables the forecaster to begin to look behind his data for the why's and wherefores of prison growth. Although, naive methods cannot be turned into causal forecasting methods, this chapter steps beyond the general thought of technique application to investigate naive forecasting from the standpoint of an informed rather than totally naive view of the past and future.

Generally speaking, naive forecasting is an exploratory rather than normative outlook. Again, because of the flexibility of technique application in time-series analysis, concepts about a normative perspective arise in this discussion of naive forecasting.

Subjective Extrapolation

Subjective extrapolation, as such, is not specifically described in forecasting literature. The process incorporates the practices of subjective projection and extrapolation, yet is not as narrow as are the incorporated methods. The purpose of constructing the concept is to identify an implicit process practiced by experienced forecasters. The content of the process is drawn from scattered hints that appear in various forecasting literature.

Trend extrapolation is the projection of a pattern of the past into the future; it is essentially the estimation of mathematical relationships from known relationships. This process of estimation involves both trend identification within data, such as within yearly counts of prison population, and the projection of that trend. Characteristically, a trend displays a history of continuous change with little fluctuation in magnitude. Very often trends appear to be unidirectional, although non-linear trends may be encountered.

Extrapolation may be performed with or without use of mathematical tools. The type of extrapolation referenced in this section does not involve statistical tools. The reader will find that subjective extrapolation is unlike the common form of extrapolation sometimes mentioned in literature. The basic difference lies in the process of subjective analysis, which occurs not only in the identification of the trend, but in the phase of projection as well.

Subjective extrapolation is an important tool taken for granted by the experienced forecaster, and too often ignored by the novice.

Unfortunately, there is a tendency for the novice to equate sophistication of forecast with complexity of mathematical tools, rather than to sophistication of the forecaster. The practices which emanate from this misconception are marked by unrealistic claims, misapplied methods, and shallowness of reason. By analogy, we might compare the forecaster to a mechanic. The mechanic starts with a set of tools and a problem. He does not apply complicated, gleaming new instruments when simpler and perhaps well-worn devices serve the purpose. He also depends upon his knowledge of basic tools to make adjustments in the application of elaborate instruments. It is difficult to imagine a good mechanic who does not skillfully use a screwdriver or set of wrenches. In the case of the forecaster, subjective extrapolation is one of the basic tools. Without awareness of basic tool concepts, the output of his effort may resemble the automobile stalled because a screwdriver could not be found to adjust the carburetor.

Five steps seem to characterize the general process of subjective extrapolation:

1. Adjusting data
2. Plotting data
3. Examining data for consistent patterns
4. Identifying assumptions
5. Estimating possible future variability of patterns

These five steps suggest that this is not the naive procedure of drawing a line through data points and extending it into the future.

History

Since the five steps identified above may not be found, per se, in forecasting literature, there cannot be a specific date ascribed to the birth of the technique. Essentially, subjective extrapolation evolved from naive forecasting methods such as simple projection. Naive forecasting dates back to the early efforts to record the population of European countries. As a spin-off of counting the population, a trend would be projected into the future. Because such simple projections are concerned with only two variables, time and population, without concern for causes or disturbances, such methods are defined as "naive." Later, statistical formulas were used to project these two variables. Although these formulas are more complex than early projections, their lack of regard for other variables places them in the category of naive techniques.

The five-step process of subjective extrapolation rests somewhere near the dividing line between naive and causal methods of forecasting. The emphasis on assessment of assumptions and identifying future changes in pattern seems, however, to establish this version of extrapolation as a causal method.

Step 1. Adjusting data. The first task is to examine the data for error or bias. Many flaws exist in the National Prisoner Statistics (NPS). Over the years, the NPS data collection effort has varied in format for collecting data and in the number of states reporting. Even recent data may not be suitable for comparing state to state. For example, in Idaho, female inmates are transferred to Nevada's women's prison at Carson City. Some, if not most, of these women are released directly from the Nevada institution. However, on paper they are readmitted to Idaho corrections and shown a second time as released. This practice inflates the true picture of women inmates in Idaho (U.S. Dept. of Justice, 1977). Such a problem is reminiscent of Herbert Stein's comment to newsmen when he was president of Nixon's Council of Economic Advisors. The problem then was the use by the news media of raw, unadjusted figures to report a rise in the cost of living. He said, "To look at these figures in an unadjusted way is like looking out of the window at night and saying there is an eclipse."[1]

Few, if any, experienced forecasters would venture an affirmative statement about the future that is based on data for which they have little familiarity. Forecast credibility quickly dissipates when the decision-maker discovers erroneous or misleading data were used to construct forecasts.

Step 2. Plotting data. There is more to plotting data than the marking of values of a time-series, i.e., yearly counts of prison population, on graph paper. First to be considered is the number of years to be plotted. Analysis of data by subjective or mathematical means is very shaky for a few data points. The analyst should keep in mind that if mathematical methods, such as regression analysis, cannot deal with less than 15-20 data points (years of information), then

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[1]This quote is referenced in Chambers, et al, An Executive's Guide to Forecasting. N.Y.: John Wiley & Sons, 1974.

subjective analysis may also have similar limitations. This hypothesis can be examined visually. Figure 11 shows a plot of Texas prison population from 1930 to 1976.

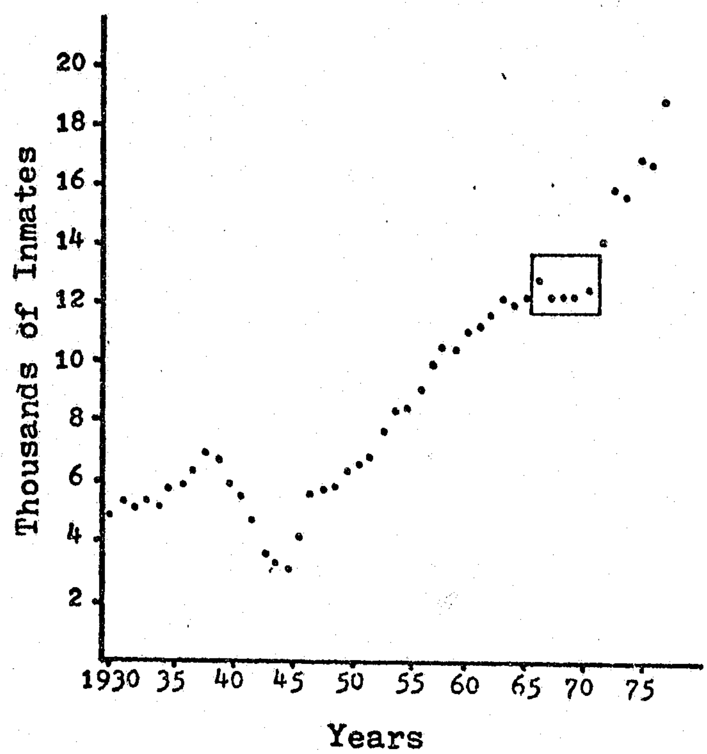

Figure 11. Texas Prison Population, 1930-1976
Source: Texas Department of Corrections

The years 1965 to 1970 have been enclosed in a rectangle.[2] Given only the data points in the rectangle, an extrapolation of the trend would suggest that 1971 and the following years would be characterized by slightly declining growth. As the reader can readily see, this is insufficient data upon which to construct an intuitive estimate

[2]Five years of data were selected for this example because this writer has encountered CJ forecasts based on this number of data points. Unfortunately, the forecasts were not accompanied by warnings about the problem of few data points.

of the next year. You will notice that the eye has the tendency to want to inspect what happened before the period 1965 so that the nature of the pattern can be evaluated.

A longer period of data would be of benefit to the analysis if it included a variety of disruptions representative of those expected to be found in the years of the forecast. Such information might suggest clues about the effects of possible similar future disturbances. Of course, not all possible future disturbances can be identified; however, many changes in laws and revision of social service programs are discussed one to two years before the changes are enacted. Other changes, such as war or power failures in cities, may not be foreseeable. However, the forecaster may be alert to the possible long-term effects occurring after various types of unforeseeable events. An extrapolation based upon a period of calm, though, should be examined to determine if it is representative of the more distant past and of the possible future. The analyst must begin to peer behind his data to become familiar with the phenomena being forecast.

This writer wishes to digress for a moment to point out that adjustment of the data must meet the test of rationality. In a particular Southern state, which will not be identified here, researchers faced the problem of having too few yearly data points to feed into their forecasting technique. They needed over fifteen and had only three years of data. So, they transformed the data into monthly figures and conducted the analysis. Then they projected future yearly prison populations. No doubt, the astute analyst would have forewarned them that such manipulation of data is not a reasonable solution to insufficient data. Similarly, we would find in

Figure 11 above, that if the few data points in the rectangle are transformed into monthly figures, the outcome is the same.

The actual plotting of data should involve at least two graphs and perhaps more. The most common form of plot is accomplished on common (arithmetic) graph paper. This form of plot facilitates the inspection for trends in absolute change. That is, if prison population were to grow by 500 inmates each year, those years would appear to lie in a straight line. The second manner most frequently recommended is to plot the data in logarithms. This is an easier process than might be expected. Semi-logarithmetic graph paper (a common item) permits direct plotting of the data; the scale of the graph paper automatically sets data into log form. An advantage of this plot is that a constant rate of growth, for instance 15 percent per year, would appear as a straight line. This transformation also smooths the data so that regularities are easier to identify.[3]

There are several reasons which would justify the extra effort of plotting data on semi-logarithmetic paper. First of all, the comparison of several prison populations of greatly different sizes would be difficult to accommodate on arithmetic paper because of the range of the scale. Figure 12, below, illustrates the use of semi-log paper to compare three prison populations of different sizes.

Secondly, the comparison of the absolute change does not impart as much information as the comparison of differences in rate of growth.

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[3]The reader interested in finding more information on plotting may refer to Robert Parsons, Statistical Analysis: A Decision Making Approach, N.Y.: Harper & Row, 1974.

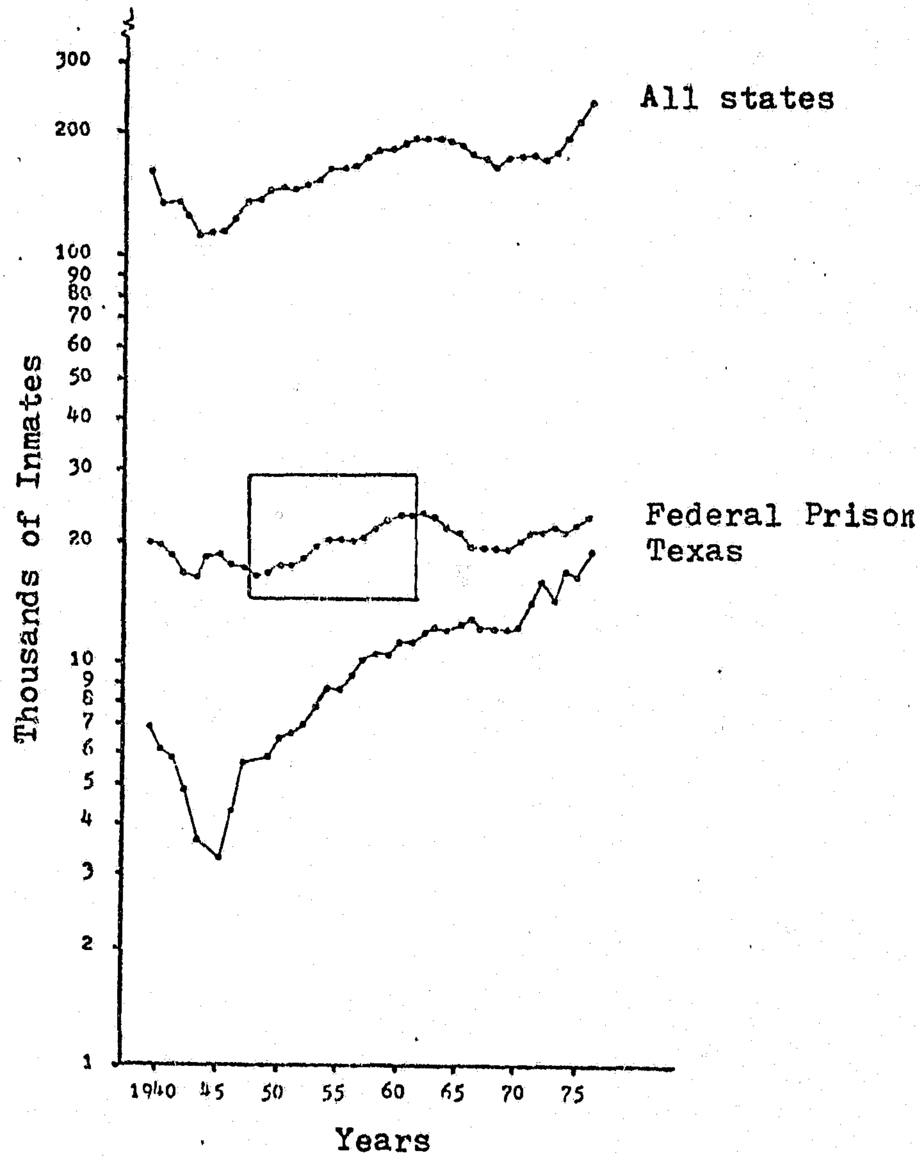

Figure 12. Yearly Prison Population of the states combined, the Federal Prison System & Texas
Source: National Criminal Justice Information and Statistics Service

For instance, a change of 100 inmates may be relatively unimportant to a state like Texas (prison population of 20,717 in 1976), but to South Dakota that represents a growth of 30 percent (from 1975-76).

A third justification is suggested in the evidence that some human and biological populations and economic time-series display periods of a constant rate of change.[4] If prison populations have any similar underlying characteristics, and at this point theory does not deny the possibility, then the semi-log plot may be relevant.

Step 3. Examining for consistent patterns. Extrapolation is often thought to be the drawing of a straight line through data and projecting the future. However, this is not a wholly satisfactory manner of forecasting prison populations and other criminal justice time-series. In Figure 12,[5] a rectangle encloses the period 1948-61, a period of fourteen years of apparently steady growth in the federal prison population.

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[4]Pittenger discusses the concept of constant growth rate of population in various projection models. See Donald B. Pittenger, Projecting State and Local Populations. Cambridge, Mass.: J.B. Lippincott, 1976.

[5]The data for Figure 12 specifically were compiled from: U.S. Law Enforcement Administration. National Criminal Justice Information and Statistics Service. (1) "Prisoners in State and Federal Institutions on December 31, 1976." March, 1977. (2) "Prisoners in State and Federal Institutions on December 31, 1975." National Prisoner Statistics Bulletin No. SD-NPS-PSF-3, Feb., 1977. (3) Sourcebook of Criminal Justice Statistics--1976, Report No. SD-SB-4, 1977. (4) Sourcebook of Criminal Justice Statistics--1975, Report No. SD-SB-3, 1976. (5) Sourcebook of Criminal Justice Statistics--1974, Report No. SD-SB-2, 1975. Washington, D.C.: Government Printing Office. The reader should note that successive reports of NPS frequently modify previous reported data. For this reason, all of the above references were used to compile the data in this figure.

These data from 1970-76 represent only those inmates having a sentence greater than one year and one day. Before 1970, the reporting basis varied from state to state. Over time, the reported procedures were changed during the times various different agencies were in charge of collecting the data. Precise manipulation of prior 1970 data is not recommended because of important reporting incongruencies. For example, a real change (growth) in a state's prison population could be hidden by changes in reporting procedures. The problems of reporting are well-documented in the above references.

An extrapolation of the data in the rectangle would portray a straight line of continual growth which would grossly overestimate the years to come.

A straight line is the easiest of the various shaped lines to subjectively draw through data when portraying the basic pattern of a trend. Although many extrapolations of criminal justice data use only the straight line, there are other patterns such as the simple parobola and growth curves, which may be tentatively identified by visual inspection.[6] The procedure for fitting a straight line through data is relatively straightforward, if you will excuse the expression. You need only to lay the edge of a clear ruler through the data so that an approximately equal number of data points fall above and below the edge line. The ruler should be adjusted until the distances of the various points above the edge are roughly equal to the distances below the line. A trend line has been fitted to data in Figure 13, below.

For some naive forecasters, the fitting of a straight line through prison data is an enlightening experience. However, the process is deceiving because it reduces reality to an artistic exercise. The simplicity of the process is fraught with problems. Specifically, three of these problems should be brought to the reader's attention: randomness, number of data points, and closeness of fit.

The conditions of line-fitting are best met in data which reflect a constant trend and in which the fluctuations of the data points

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[6] The subjective inspection of data can only tentatively identify if data fit a non-linear curve. Substantiation of that identification should be left to mathematical methods.

occur randomly around the trend line. The requirement of randomness is a problem because time-series data are frequently non-random. In Figure 13, the data points occur in sequential "swings" around the trend line.

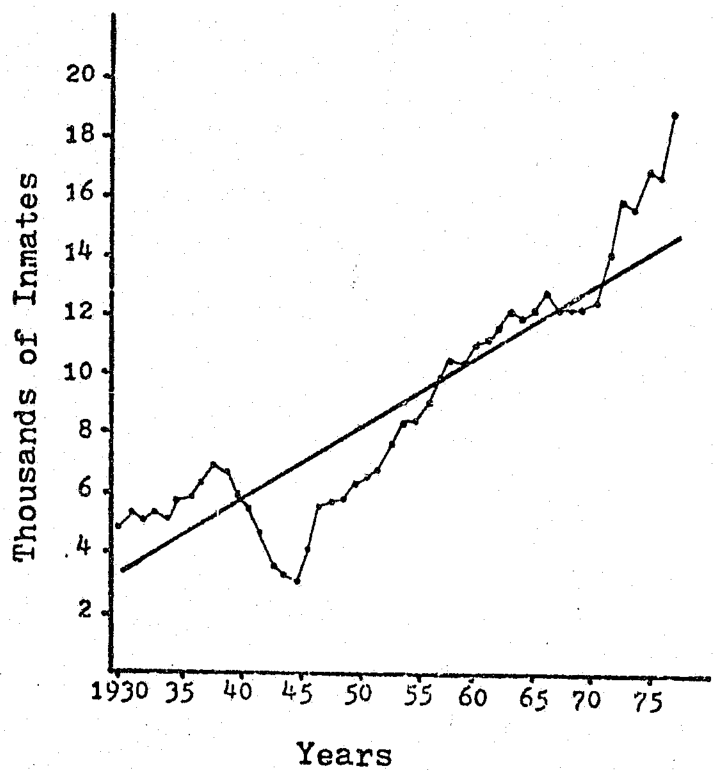

Figure 13. Texas Prison Population, 1930-76

In other words, the data move in more or less uniform directions around the trend line. This means that the departure from the trend line is not happening by chance. In this instance, the trend line is not the best estimate of the expected value of the year to be forecasted, 1977. We would expect the 1977 data point to be nearer the sequential path of dots than near the trend line. Either a different method of forecasting or data transformation to remove the non-random influence is required.[7]

Fitting lines to a few data points has been mentioned before in this discussion of subjective extrapolation. Further discussion of this consideration does not seem out of place because the forecaster will be faced many times by limited data on prison populations and other criminal justice topics. There is no easy way of projecting a line from a few data points. This writer has found various suggestions in the literature about the number of data points. Among these are two suggestions which must be cautiously evaluated. First is the recommendation that the number of data points should be roughly equal to the number of years being forecasted. The logical leap in this assertion would lead the forecaster to assume that if only a few data points are available, then only a few years can be forecast. Looking back at the rectangle in Figure 11, it is shown that a few data points will not reliably estimate the next year to come. A second suggestion, mentioned in the literature, is that in fitting a straight line to a few data points, the fit must be very close. This idea is also misleading and would appear to be related to the problem of few data points in Figure 11. A short trend may be

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[7]For further information on this problem, the interested reader may refer to W. Sullivan & W. Claycombe, Fundamentals of Forecasting. Reston, Va.: Prentice-Hall, 1977. Also see: Morris Hamburg, Statistical Analysis for Decision Making. 2nd edition, N.Y.: Harcourt Brace Jovanovich, 1977.

identified by a close fit,[8] but projecting that trend is another issue.

Step 4. Identifying assumptions behind trends. Drawing a trend line through prison population data points should involve more than a pencil, ruler, graph paper, and a list of numbers. Unfortunately, examples of criminal justice forecasting can be found which seem to go no further than the mechanical exercise with these tools. It stands to reason that the more acquainted the forecaster becomes to the social forces behind the data, the greater the likelihood that a sensible projection can be constructed. For example, the correctional administrator is in contact with various sectors which affect corrections, such as lawmakers, criminal justice agencies, and the public. Because of this awareness, he may be able to more accurately use subjective extrapolation than are some researchers who have little awareness of the environmental factors which generated the data.[9]

In order to avoid forecasting gibberish, the analyst should identify the assumptions underlying the data. This means questioning the use of a single straight line. An informed critic will quickly recognize that the causes of prison population growth may change over

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[8] Sartorius & Mohn illustrate various considerations in curve fitting in Sales Forecasting: A Diagnostic Approach. Atlanta, Ga.: Georgia State University School of Business Administration, 1976.

[9] This assertion must be evaluated cautiously. The statement does not imply that intuition is necessarily better than intuition assisted by tools. Intuition by itself may over-react to perceived influences. The role of tool use is to challenge capricious estimation of trends.

time. However, a single straight line assigns equal weight to all data without regard for changes in causation. Rather than selecting a single trend to characterize his data, the analyst may choose to represent the various trends by broken lines with different slopes. Figure 14 illustrates the beginning of such an interpretative process.

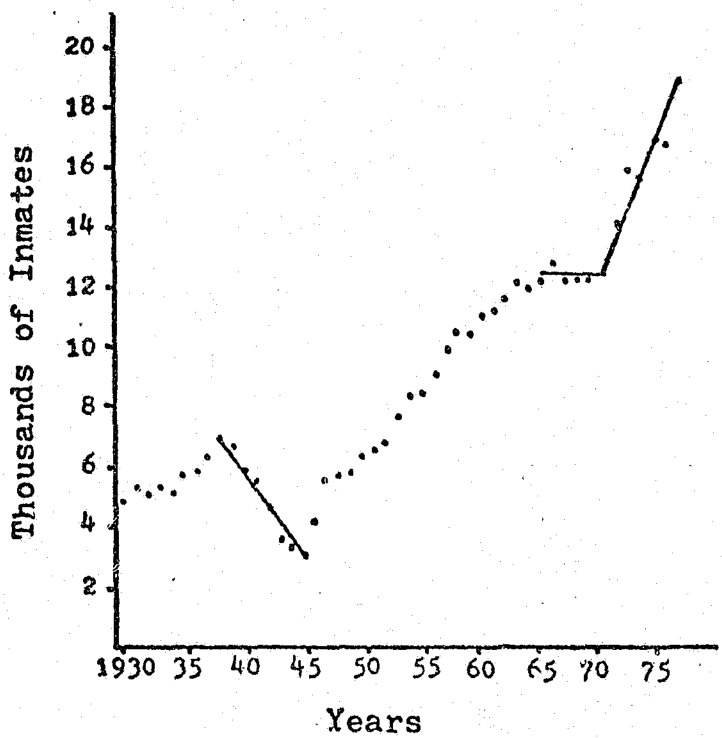

Figure 14. Texas Prison Population, 1930-76
(partially trended)

Without a great deal of knowledge about the prison data, the observer may begin to assess the most likely trends. For example, it would seem reasonable to fit the war years, 1939-45, with a straight line sloping downward. The short period thereafter, 1946-47, may be part of the following years, 1948-64, or independent of that period. From appearances, the years 1948-64 seem to be related; however, in light of the many social disturbances during that length of time, it is possible that these data are generated by several different forces acting at different times.[10] The remaining two periods appear to be distinctly characterized, although the final period reflects inconsistent growth, which means that the uniformity of a trend may not be anticipated in the future. A single straight line drawn through all the data would identify only the general direction of population growth. For planning purposes, the analyst is usually requested to present a forecast that is not so broad.

The unrelenting chartist--the person devoted to hand drawing lines--may reach for his French curve when a single straight line cannot be drawn. However, the results of this practice are not likely to improve on the information gained from a series of discontinuous trend lines. To draw curves, the data must support the assumption of a systematic and continuous influence acting on society and the Criminal Justice System to produce fluctuation in prison growth.

In the process of identifying the assumptions behind the trend(s), the forecaster is able to begin to compare behavior of the influences behind the present trend with those which might exist tomorrow. In 1961, the Federal Bureau of Prisons constructed a forecast in which the analysts evaluated the historical influences on prison growth, but

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[10] The forecaster may begin to check for continuity of underlying causes, such as growth of the young offender risk group and its relation to prison growth. These relationships may be plotted and subjectively investigated or examined by statistical means. Before assuming linearity in a lengthy period of population growth, the relationship between population size and the proposed independent variables should be graphed.

did not evaluate future possibilities.[11] The reader should once more refer to the rectangle in Figure 12 to gain an idea of the nature of prison growth at the time of the 1961 forecast. The researchers took efforts to identify various laws and to relate them to various past surges in prison growth. However, close scrutiny by this writer of the projection of the trend line (not shown here) disclosed that the forecast was made by drawing a line through the last four years, 1958-61, and projecting the trend to 1966. No mention in the forecast is made of changes that were then occurring or that were being contemplated for legislation. The resulting forecast over-estimated the actual population in 1966 by approximately 5,000 prisoners. The year after the forecast, the federal prison population began to decline to the twelve year low in 1968.

In contrast to the federal prison forecast, the 1977 State of Colorado Master Plan takes the plunge and explores the impact of changes in assumptions upon future prison populations.[12] The forecast (not shown here) presents a future trend line which branches into three possible paths. Each path represents the best estimate of the effect of three variations of assumptions on the trend of prison growth. Also, the forecast includes an evaluation of the possible impact of changes in

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[11]The forecast being referenced in this discussion appears in "Thirty Years of Prison Progress" published by the Bureau of Prisons in 1961. This pamphlet seems to have been intended for general distribution and not used in specific planning. However, the circulation of this forecast to agencies and legislators may, in fact, influence the expectations of the reading audience. In this sense, information used to influence the public may be considered as an important forecast.

[12]Colorado employed statistical methods in part of the forecast. However, their manner of dealing with assumptions is relevant to this discussion of subjective extrapolation.

criminal laws upon prison population. The Colorado forecast demonstrates that the investigation of assumptions may impel the analyst to alter the simple straight line trend to establish a basis for evaluating several likely courses of action.

Once identified, the assumptions should become part of the text of the forecast. The inclusion of this information permits the decision-maker to readily examine the premises of the forecast. The analyst should state within the forecast the basic underlying factors behind the trend and the possible disruptions which might deflect it.

Step 5. Estimating variability of the extrapolation. In behavioral science statistics (cross-sectional analysis), the estimation of confidence intervals or estimate bands[13] specifies the expected variability of prediction. Subjectively, this estimate band is placed

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[13] Since the calculation of confidence intervals is accomplished by statistical means, the term "estimate band" is used to connote a similar concept derived in extrapolation by subjective means. Strictly speaking, a probability statement would be difficult to determine for confidence intervals by subjective means. To avoid confusion of processes, the term confidence interval will not be used in reference to subjective extrapolation. In subjective extrapolation, we are dealing with dispersion of forecast estimate--from this is drawn the notion of estimate bands.

In behavioral science statistics (cross-sectional analysis), confidence intervals deal with sampling and the probability of constructing an interval which will most likely include the value being sought. Because time-series data of yearly prison population are not sample values nor is this form of forecasting a sampling procedure, the term "estimate band" seems more appropriate than confidence interval.

The concept of forecast errors and confidence intervals may be further investigated by the interested reader in Sullivan & Claycombe, Fundamentals of Forecasting. Many other texts, such as Runyon-Haber's Fundamentals of Behavioral Statistics discuss confidence intervals.

around both sides of the trend line so that the data points fall within this range or band as shown in Figure 15.

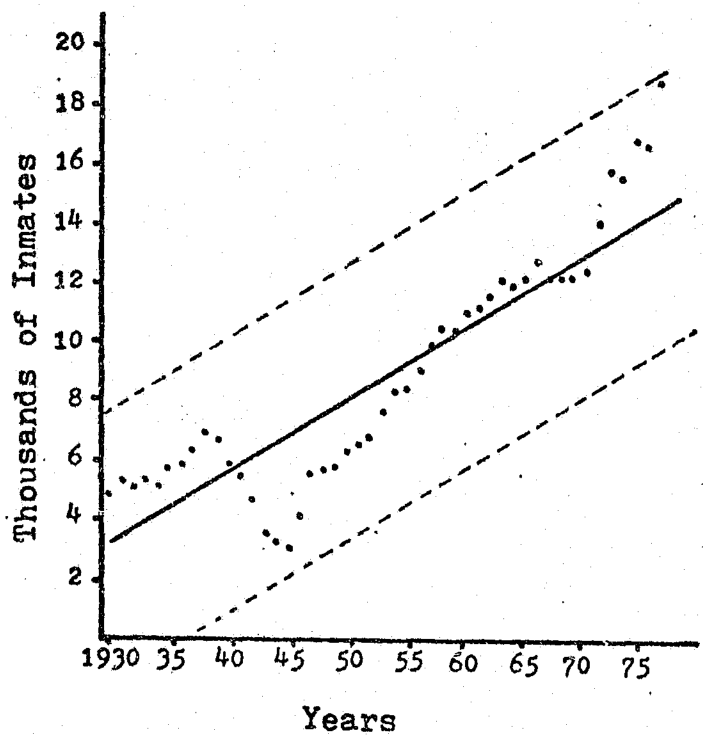

Figure 15. Texas Prison Population, 1930-76
(Estimate bands depicted by broken lines)

In subjectively determining the distance of the estimate line above and below the trend line, the analyst should first identify which side of the trend line exhibits the most widely removed data points. A line should be drawn on that side so that it is parallel to the trend line and encloses all of that side's data points. The distance from the trend line to the estimate band is also the distance to be used to establish the estimate band on the other side of the trend line. In the case of a very removed data point, which occurs one time only, the analyst may decide not to include the point within the estimate band. When doing this, he should be aware of the possible cause of the unusual data point and should have judged that it will not occur again. Such an exception did not occur in Figure 15.

The estimate band establishes an interval which encompasses the data points. The wider the estimate band, the more distant the actual population value may lie from the trend line. On the other hand, the narrower the band, the greater the potential of the trend line to represent the future population value (given that the trend does not change).

This information provides the decision-maker a clue of how well the trend line can predict. Since the trend line does not really exist but is an abstraction, we must consider that the value to be forecast may vary. The wider the variance, the less information the forecast can impart. For example, if the trend line above indicates that the best estimate of 1977's prison population is 15,000 inmates, plus or minus 2,000 (width of the estimate band), the decision-maker has little useable information. It will be difficult to allocate prison resources based on a forecast of 13-17,000 inmates for next year. The decision-maker can do just as well without the forecast. Thus, the width of the estimate band helps the decision-maker determine the usefulness of the forecast for his particular planning need.

The concept of estimate bands and confidence intervals is not germane to forecasting and time-series analysis. Rather, the basic idea has been borrowed from behavioral science statistics (cross-sectional analysis) without fully reconciling the underlying theoretical differences. In mathematical methods of forecasting, when time-series data are serially correlated (sequentially occurring around the trend line), the formula for confidence intervals seriously underestimates the interval. Furthermore, unlike cross-sectional data, the unknowable nature of the future makes it difficult to assume that variation in the past will hold in the future. The key to construction of estimate bands resides in the skill of the forecaster; if the forecaster is familiar with the social forces influencing the trend, then his informed judgment would seem to support the specification of a subjectively established estimate band. The forecaster can modify confidence intervals established by mathematical forecasting techniques, as well as the estimate bands which are established in subjective extrapolation. If he assesses that the shape of the confidence interval will not hold for future assumptions, there is no violation of theoretical doctrine when the interval is subjectively modified.

In these five steps of subjective extrapolation presented above, the reader may have found several new concepts. One of the fundamental notions being conveyed is that informed judgment may be of greater value than strict reliance on statistical principles which are not wholly applicable to the task of forecasting. A well-prepared forecast presents the logical basis for the forecast and an estimate as to how useful the information may be.[14] These methodological suggestions

[14]In 1976, the office of the Comptroller General recommended in a report to Congress that the Federal Prison construction plans should be better developed and supported. In the text of the report are found these major recommendations to the Bureau of Prisons:

--Maintain a range of estimates of expected population with specification of the possible variations (both higher and lower). The construction program should satisfy the minimum estimate of projected population.

--Explain in more detail the indicator used to forecast population and the importance, interrelationships, and consistency of their use. [Comptroller General, "Report to the Congress: Federal Prison Construction Plans Should be Better Developed and Supported," Washington, D.C.: U.S. General Accounting Office, No. GGD-76-10, April 27, 1976.

can be applied to a forecast with several alternative futures, as well as to a single trend.

Assumptions

Simple linear extrapolation, unlike subjective extrapolation, is more likely to assume that:

- present trends will continue at the same rate
- population is a function of time, rather than underlying factors
- other trends in other fields will not arise to influence prison population growth.

Subjective extrapolation shares the assumption with other subjective and mathematical methods that there is order in the course of events. Unknown influences are not unknowable, rather they are hidden from the forecaster's efforts to collect data that describe them. Of course, accidental influences, such as power failure, may never be foreseeable.

Span of Forecast/Accuracy

Since subjective extrapolation is basically concerned with data, the span of the forecast shares data restrictions. Implicitly, a long-term forecast deals with that time period which extends beyond continuity of present structural relationships. Thus, the extrapolation of relationships from present data would not apply to long-term forecasting.

Subjective extrapolation seems to be of greatest potential value for the short term of one to five years. The further removed the forecast target, the greater the likelihood of change from the present trend. Some writers suggest that confidence intervals tend to fan out with the passage of time.[15] In the medium range, six to fifteen years, mathematical trends should be regarded as general indicators of growth of prison population. Of course, this reference to range of forecast is very general. Some criminal justice time-series may be volatile, that is, characterized by rapid changes. In some instances, the structural relationships between causes and effect may be rapidly changing. Thus, the span of the forecast should relate to the characteristics of the phenomena being forecast rather than to a hard and fast classification of time periods.

Simple linear extrapolation performs best during periods of relatively constant growth and not so well during erratic periods. In some instances, extrapolation has been found to provide as good or better forecasts than methodologically complex procedures. Subjective forecast accuracy is, of course, largely a function of the analyst's knowledge of the Criminal Justice System and of the underlying socio-political influences.

Replication of subjective extrapolation by another forecaster may be expected to reflect disparity of results. This may be a desirable condition during periods of high uncertainty of trend. The decision-maker may gain greater insight from several forecasts describing possible outcomes of various alternative courses of action than would be gained from a single forecast of high consensus.

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[15] See for example L.R. Klein "Forecast Errors: Predictable But Unavoidable." The Wharton Magazine Economic Newsletter, Fall, 1976, pp. 47-48 and Morris Hamburg, Statistical Analysis for Decision Making.

Considerations/Limitations

Extrapolation is frequently employed as the starting point for other forms of forecasting. The extrapolation is used as a reference or guide against which to compare results.

Straight-forward projection, without modification, often yields embarrassing forecasts. Only a naive forecaster would prefer a trend line without explanation. An unmodified projection can be expected to miss turning points when the trend changes direction. Prison population does not exist independently of housing space restrictions and program capabilities, even in times of serious over-crowding. A straight line projection does not evaluate such constraints.

The decision-maker reviewing a forecast should assess the bias of the forecaster. The choice of the shape and slope of a subjectively constructed trend and shape of the estimate band should be free of bias resulting from the forecaster's desire to please an audience or to mold facts to fit a theory.

Communicability of Results

Extrapolation is one of the most frequently employed methods of forecasting and is therefore very familiar to the decision-maker. Unfortunately, many extrapolations are misleading because the trend projection is either not accompanied by an estimate of the variability of the forecast or by an indication of possible future changes impacting the trend.

The addition of this information must be in a form easily understood, otherwise the decision-maker may turn to more familiar but less informative forecasts.

Time/Resources Required

Subjective extrapolation may be among the quickest and least costly of all forecasting techniques. Few tools and complex computations are necessary. Depending upon data availability, purpose of the forecast, and analysis to be performed, the forecast construction period may require only a few hours to a few days.

The person selected to prepare the forecast should not only be well informed, but should be knowledgeable of these basics of time-series analysis. A great majority of behavioral science researchers do not have experience in time-series analysis. Predictably, their forecasts will reflect this deficit.

Transferability

Subjective extrapolation, as defined in the five steps above, is not being practiced in the Criminal Justice System. Many of the basic concepts are applicable to other forms of forecasting, even if subjective extrapolation is not used per se. However, there is much to be said for a well-thought-out subjective forecast when compared to naively constructed maehematical projections.

Adoption of the concepts of subjective extrapolation may be brought about through criticism in correctional literature of the shortcomings of presently used methods. Sophistication in forecasting may be a state of skill, rather than the ability to copy formulas from pages in a statistical manual.

Least Squares

In the previous section on subjective extrapolation, the essential elements of extrapolation were discussed within the framework of a non-mathematical approach. Not mentioned in that section was the fact that extrapolation can be accomplished by a family of methods. This family of extrapolative methods can be subdivided into subjective and mathematical groups as suggested below.

Extrapolation

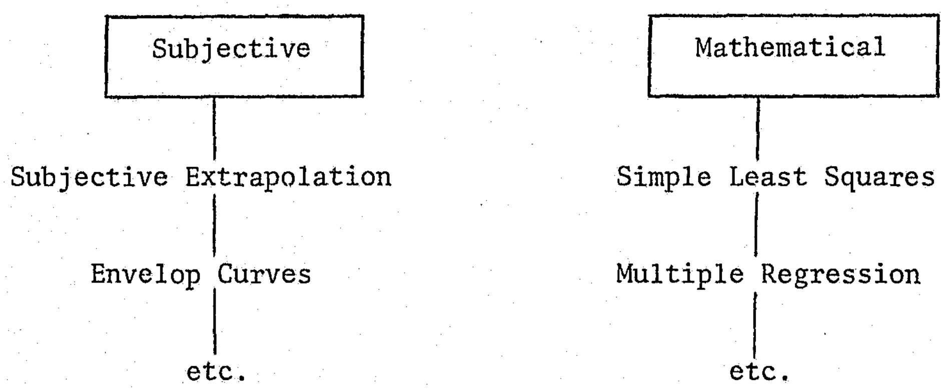

Figure 16. The Family of Extrapolative Methods

The reader familiar with behavioral science statistics (cross-sectional analysis) will notice that simple least squares is not described as regression forecasting. Explanation is forthcoming in this section as to the reason for this definition.

In the classification of Figure 16, simple least squares and those subjective methods shown are generally considered to be naive forecasting methods. Multiple regression is considered as a causal forecasting method. This reclassification into naive and causal methods is not meant to confuse the reader but to point out that the object of this section's discussion, least squares, can be classified in several different manners.

Many of the concepts in this section are the developmental offspring of the ideas of subjective extrapolation. Rather than treating the various forecasting methods as unique and separate tools, the family of extrapolative forecasting should appear as additive and complementary concepts. Just as subjective extrapolation laid a foundation for the exploration of least squares, least squares will, in turn, provide information useful in the exploration of multiple regression.

History of Naive Mathematical Forecasting

The identification of a pattern in data and the drawing of a line through that pattern is referred to as curve fitting. The line drawn through the pattern may be either straight or curved; the notion behind the practice is to represent the trend or relationship of elements by a uniformly shaped line.

In the 1930's, curve fitting was a popular practice in business and economics. The assumption behind this practice was that the past and future are part of a continuum. Finding the pattern of the past, therefore, would disclose the future. The econometrician has since recognized that economic activity does not behave in such a predictable pattern.

In other areas of the behavioral sciences, the development of data analysis did not parallel that of economics. In the behavioral sciences upon which correctional research draws heavily, the primary thrust was in cross-sectional analysis. Cross-sectional analysis deals with samples; that is, the researcher has only a fraction or sample of data about a phenomena being investigated. If he acts according to certain concepts of probability, he can draw inferences about the data he does not possess. This type of statistics is "cross-sectional" in the fact that what the researcher has is a representative section of all the data. For example, a correctional researcher could take a sample (under certain probabilistic conditions) of the number of years served and post-prison adjustment so that he could study the effects of incarceration. Then, with mathematical tools, he could draw a trend line through his data which would indicate, for example, that the longer the time spent in prison, the more likely the person would be to return to prison. Given a particular number of years spent in prison, the researcher could identify via his trend line, the chance of post-prison success. Thus, he predicts success from number of years served. There is no time limitation to this prediction; the prediction should hold for 1970, 1981, or any other date during which the present form of incarceration exists. Cross-sectional analysis is essentially timeless.

For the researcher in corrections, forecasting calls for methods of time-series analysis. Unfortunately, time-series analysis and cross-section analysis are not generally taught together. For example, an inspection of sixty behavioral science statistics textbooks, including both advanced and introductory work, disclosed that only three mentioned time in data analysis and only one devoted more than one page to study of time-series analysis.[16] This finding suggests that those correctional researchers schooled in the behavioral sciences, such as sociology and psychology, may lack familiarity with the basics of forecasting via time-series analysis.

If confusion about forecasting techniques were to exist, the most likely areas would involve those in which cross-sectional analysis resembles time-series analysis in formula but not in theory. For example, both types of data analysis share the formula for curve fitting. However, time-series analysis often uses the formula without the probability theory which characterizes application in cross-sectional analysis. Forecasting does not assume that social phenomena, such as law-making or crime, behave according to probability theory.[17]

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[16]The researcher examined sixty-three behavior statistics books on the shelves of the university (Sam Houston State University) library and those being used in on-going coursework in psychology and sociology as indicated by university bookstore sales. The identification of popular statistical texts included such works as Kerlinger's Foundations of Behavioral Research and the manual for SPSS (Statistical Package for the Social Sciences). In all, sixty books were reviewed. The key words used in the examination were: time, time-series, cycle, and forecasting. Although this review of literature on behavioral statistics is not a random sample, this researcher feels that the results are representative of the literature.

[17]Robert Brown in Smoothing, Forecasting, and Prediction (1962) identifies three essential elements of probability models:

(1) Probability distribution that is relatively stable; changes that occur over time are very gradual.

(2) Successive observations should have no important serial correlation. The observations may reflect a seasonal influence but the knowledge of arrival yesterday is of no particular help in forecasting today's time or arrival.

(3) The essential description of the phenomena should be contained in a probability distribution.

These criteria are not met by many social phenomena. The exception includes a class of events such as the dispatching of police cars.

Karl Popper has written:

> Long-term prophecies can be derived from scientific conditional predictions only if they apply to systems which can be described as well-isolated, stationary and recurrent. These systems are very rare in nature; and modern society is surely not one of them [1963, p. 339].

The forecaster cannot say, as does the behavioral researcher, that a probability interval can be constructed that can specify the likelihood of spanning the actual size of a future prison population.[18] As Popper points out, this aspect of man's social future may not behave according to probability theory.

In time-series analysis, the formula for curve fitting is called least squares. In cross-section analysis, the same formula accompanied by probability theory, is known as regression analysis. "Regression," in a sense, is a misnomer. Francis Galton, cousin of Charles Darwin, gave the name to the formula as a result of an application rather than for its mathematical structure. In a study of heredity, Galton found that fathers whose height was significantly different from the height of all fathers, had sons whose heights tended to be average. This tendency in inheritence to revert to the average, Galton identified as a "regression" to "mediocrity." So as a result of designing a method of investigating the heights of fathers and sons, the name regression became affixed to the formula of least squares in cross-section analysis.

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[18] Morris Hamburg, in Statistical Analysis for Decision Making (1977), states for instance, that in time-series of most social phenomena that (a) the dependent variable is not random, (b) deviations from the regression line are not random, and (c) the observations are not independent.

Simple Regression and Least Squares Defined

The formula for simple regression and least squares is no more than a mathematical method of drawing lines through data. The researcher has the choice of either judgmentally drawing the lines as described in the section on subjective extrapolation or using a mathematical tool. The major advantage of the mathematical tool is that several persons possessing the same data will draw identical trend lines.

The computation of formula for least squares and simple regression is a mathematical version of subjective extrapolation. In the mathematical formula, the slope of the trend line, that is, its direction, is identified and the starting point from which it originates is established.

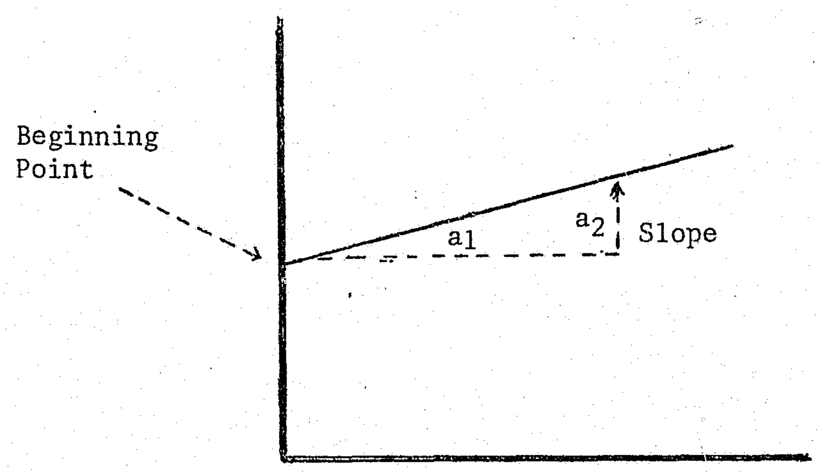

Figure 17. Basic considerations in calculating trend line

The slope of the trend line (ratio of a_1 to a_2) is fixed by the pattern of the data (not shown above) and the beginning point is the place or reference at which the trend line crosses the verticle boundary (axis) of the graph.

Prediction is the mathematical way of reading the graph. Rather than visually inspecting the graph for the values of interest, the observer inserts a value, such as a particular height, say 5'9", into the formula and receives the predicted value, such as 165 pounds. By slightly varying the formula for simple regression, curved lines may be fit through data.

If the reader will recall that subjectively, a trend line is drawn through data points by laying the edge of a clear ruler so that an approximately equal number of data points fall above and below the edge. The ruler is adjusted until the distances of the various points above the edge are roughly equal to the distances below the line. Similarly, in the formula for least squares, the distances are considered. Except in least squares, the formula seeks to adjust the trend line so that the sum of distances from the line (distances above added to distances below) is smaller than the sum resulting from any other path the line could take. The values of the distances are squared so that a problem of dealing with plus and minus values is avoided. Thus, the formula became known as least squares because the best fitting line has the smallest sum of squared values.

A trend line is a naive forecasting method, therefore, stands as a neutral device for describing past data. The manner in which the future is forecast is left to the analyst. For example, he may assume that the past and future will be alike and therein extend the trend line. On the other hand, he may consider that the trends of the past are likely to change and thus modify the path of the projected trend. However, he cannot assume that the future can be discovered by a simple mathematical formula. Any trend line which surpasses existent data is drawn at the whim of the forecaster, not open mathematical theory.

Just to keep in perspective what it is that a mathematical calculation of trend line is achieving, the definition of trend line should be reviewed. By definition, a time-series trend line is that underlying general pattern of growth (or decline) which is consistent in direction, marked only by a slowly changing rate or direction. Prison population growth does not specifically fit the concept of trend. Growth has been marked by sudden spurts, rapid declines, and other irregularities. Thus, when trend lines are drawn in data on prison population, the lines do not precisely fit and must be recognized as general and broad indicators of prison growth. This means that a naively-based trend line cannot precisely predict to the man future prison populations. All forecasts will, to some degree, be inaccurate; only by luck will a forecast demonstrate pinpoint accuracy.

Example

One of the very few published examples of the fitting of lines through prison population data in the spirit of the atheoretical approach of least squares is found in the work of Tim Carr of the Georgia Department of Corrections (1974). His work appears as more of an exploration investigating "what if" propositions than an effort to forecast an inevitable future. These "what if" propositions are derived by varying the length of the base period of the forecast. For example, prison admissions are displayed in Figure 18 below.

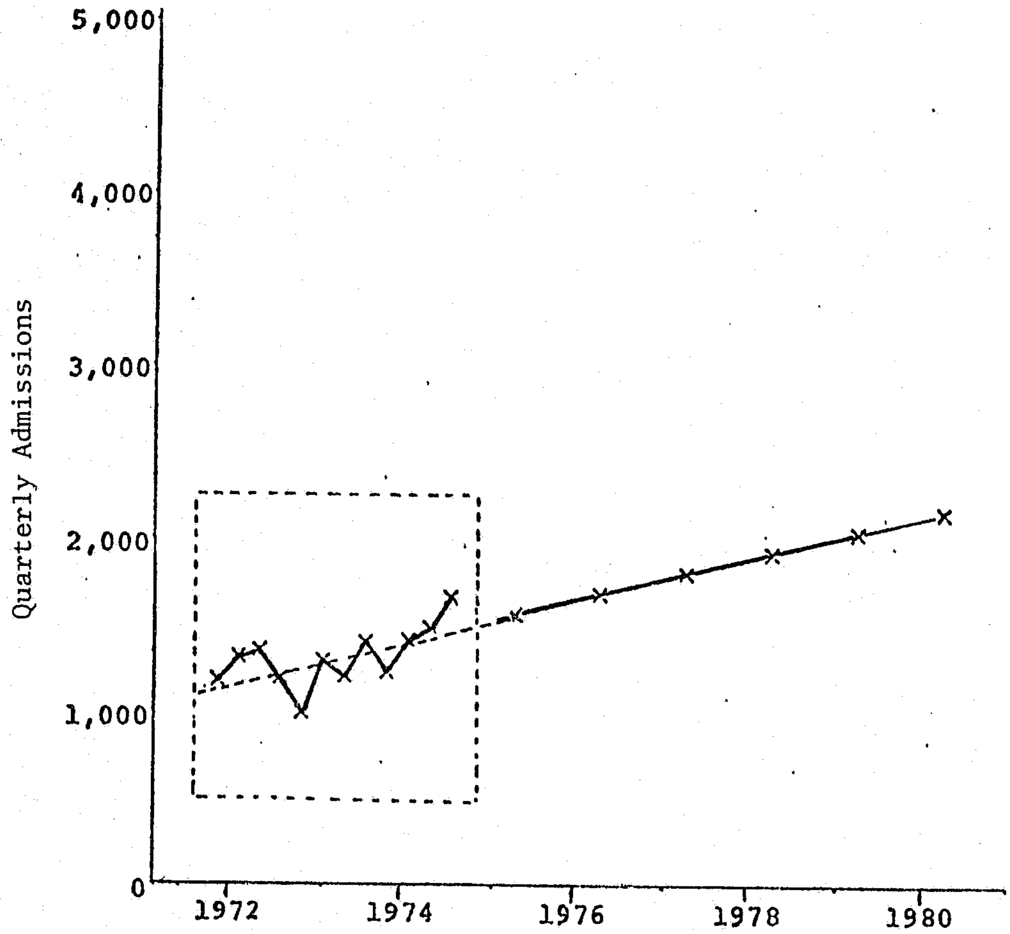

Figure 18. Projection of Quarterly Admissions from Courts Based on Last 12 Quarters, Fall 1971 - Fall 1974.
Source: Tim Carr, "The Georgia Population: The Outlook Until 1980," Research Publication for Georgia Department of Offender Rehabilitation, July 1, 1974, p. 11.

In this extrapolation, the question is implied, "what if" the admissions of inmates from the courts continues at the same rate as in the last twelve quarters? In a second extrapolation,

Figure 19 below, the question is asked, "what if" admissions from courts continued at the rate evidenced in the last four quarters?

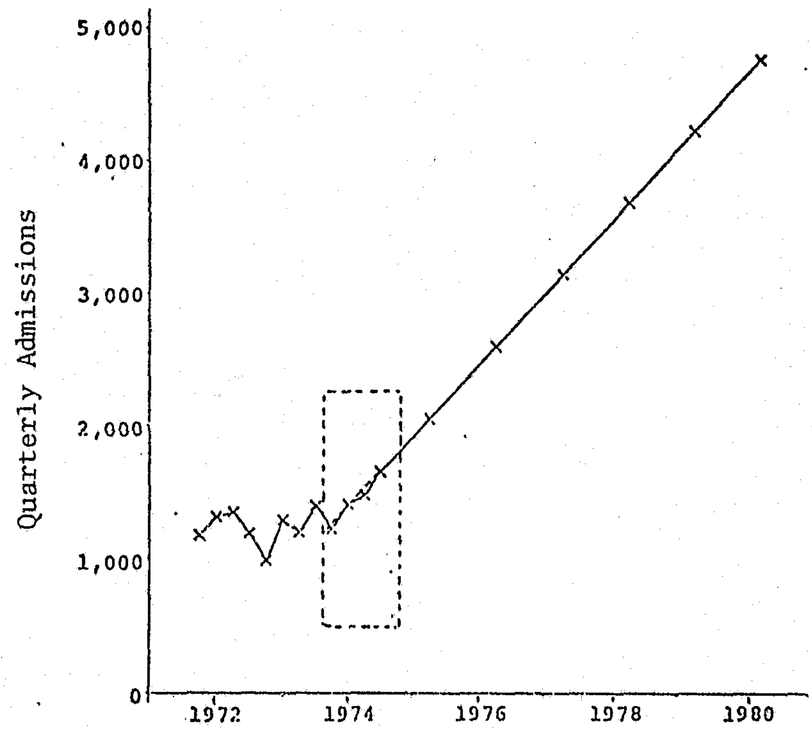

Figure 19. Projection of Quarterly Admissions from Courts Based on Last Four Quarters, Fall 1973 - Fall 1974.
Source: Tim Carr, "The Georgia Population: The Outlook Until 1980," Research Publication for Georgia Department of Offender Rehabilitation, July 1, 1974, p. 13.

These two extrapolations reflect the effects of changing assumptions. The base period, that is, the assumption about future rate of prison growth, establishes a different sloped trend in each case.

An example of fitting curved lines to data and projecting that curvelinear pattern is also found in Carr's work. Only a modification of the basic least squares formula is required to fit curved lines. In Figure 20, below, the last four quarters of total prison population are used as the base period for the extrapolation.

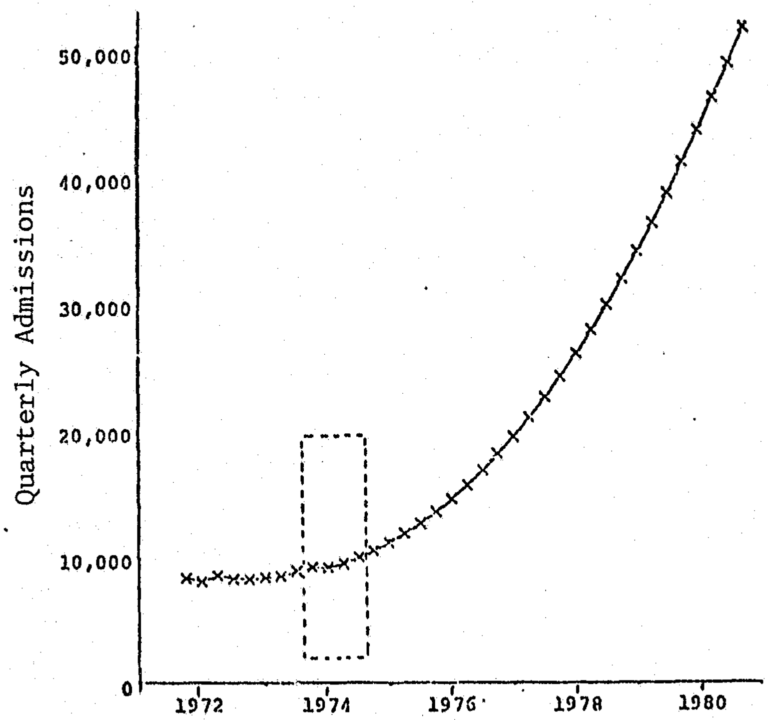

Figure 20. Curvilinear Projection of Prison Population Based on Last Four Quarters, Fall 1973 - Fall 1974

Source: Tim Carr, "The Georgia Prison Population," Georgia Department of Offender Rehabilitation, 1974, p. 27.

As mentioned earlier, these examples of line fitting and projection should be considered as an exercise. For instance, Carr states, "no reasonable person can truely believe that the population of the Georgia prisons is going to be between forty and sixty thousand by 1980 ...". This disclaimer for the extrapolation in Figure 20 above, does not make his effort valueless. Perhaps Carr is stating what many other criminal justice forecasters have not--that curve fitting is an aid to evaluating assumptions, and as such, is the beginning rather than the objective of the forecasting process.

The Range of Estimate

In the discussion of probability and least squares above, it was pointed out that a forecaster could not assert that a future event would fall within a specific interval. For example, the forecaster cannot specify that 99 out of a 100 times of resampling, the future Texas prison population would lie between 19,500 and 20,000. This inability to use probability statements does not totally hamper the forecaster's efforts to present some picture of future prison population variability. A reasonable man might justifiably assert that prison population growth is bounded by certain system constraints, such as court caseload capacity and the arrest capability of the police. Thus, an evaluation of past ups and downs (variability) of prison population may establish clues to a range of variability that could be drawn around the trend line.

In subjective extrapolation, past variability is described by a subjectively established range which encompasses all past data points. A mathematical counterpart of this subjective process is found in cross-sectional analysis. This mathematical counterpart, confidence interval, looses descriptive power when applied to serially correlated time-series. Serial correlation, in effect, causes the range to be underestimated. This means that the confidence interval no longer conveys meaningful information to the user.

If the forecaster uses a mathematical calculation to establish the first approximation of the range of estimate and then modifies that approximation to compensate for underestimation, he is essentially following the subjective procedure for constructing a range of estimate. This writer sees no justification in charading precision for a process that is subjective. It would be more appropriate to use the subjective process throughout.[19] This is a sensitive point and is, perhaps, one of the qualities that separates the art of forecasting from the science of prediction. The forecaster must, at times, be an informed analyst not bound by lines and formulas. Pictorially, he may desire to describe his naive forecast by trend lines and a range of estimate. However, he should not expect to foretell the future by crystal ball, formulas or computers.

Assumptions

The assumptions surrounding least squares seem to fall into seven general categories that are somewhat interrelated:

1. Assumption of the closed system.

   Basically, this assumption implies that influences of the past will continue in an undisturbed manner. The

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[19] Erich Streissler, in "Pitfalls in Econometric Forecasting" (1970), asserts

> ... the best statistician is he who remember that even the confidence limits of a forecast, calculated by common estimation procedures, can be next to pointless: this procedure mistakenly assumes that we have to reckon only with the same variation as that registered in the past. It records random variations of a basically constant system, not the systematic variation of the drift of social systems. The great problem of economic forecasts is not what they are subject to error, but that we must always remain ignorant--more or less ignorant, it is true, nevertheless basically ignorant--about the size of the error we commit [p. 55].

environment which contains prison population growth is closed and beyond outside influence. This assumption overlooks the possibility of the collision of prison population growth with other major social trends which could drastically alter the path of the trend. New trends which do not now exist and therefore are not represented by the trend line may arise as the result of war, scientific discovery, social disturbances, or failures with man's physical environment. This assumption is also known as the surprise-free future.

2. Assumption of simplicity as the best representation.

   A single trend line appeals to the need to reduce uncertainty in the realm of decision-making. The single trend line assumes that a complex process can be adequately represented by a simple construct. The least squares calculation to closely fit a line to data merely says that the net effect of many social forces could be summarized for a period of several years. Summation, in itself, does not attest of the ability of the technique to forecast.

3. Assumption that mathematics substitutes for informed expertise.

   The fitting of a line through data via mathematical calculation implies that a scientific choice has been made which will result in better forecasts. The process of calculation seems to mask the simplicity of the underlying assumptions which must be considered by the decision-maker.

4. Assumption of futility.

   A single line implies that the future is inevitable. The future is represented as an on-rushing great wave. Regardless of the actions of the decision-maker, the trend established by the past will continue. This assumption ignores the possibility that identification of the pattern [feedback] of the past may spark the decision-maker to action to overcome historical inertia. Acceptance of this assumption is dangerous to decision-making and planning. New programs and modification of procedures may be downplayed because of perceived inability to affect the trend in corrections.

5. Assumption of man's independent actions.

   The addition of probability theory to projection of social trends would suggest that past actions do not influence future behavior. Man is depicted as waking up in the morning with a blank mind and clear slate. His actions of today are made independently of previous behavior. This view of man overlooks his goal-oriented social philosophy. Under this assumption, prison population growth is portrayed as the collective result of criminal happenings which occur randomly but in relation to a general collection of causes, such as number of youth in the population--man's pursuit for social control does not affect the supposed random character of prison population growth. This assumption disregards the possibility that political decisions, such as legislation against drugs impetus to swell and lessen prison population as the decisions of politicians evolve.

6. Assumption that trends are laws.

The attempt to represent a time-series, such as prison population growth, by a single straight line infers that a trend is a homogeneous unit with a quality of permanence. The single straight line ignores the possibility of a series of social trends, each characterized by different slopes. The single trend blends into a nebulous whole a great number of dissimilar periods of social behavior, thus implying a general social law when none can be espoused.

Accuracy

The ability to forecast with least squares rests upon the stability of the social trend. If the time-series remains stable during times of sudden shocks and varying events, then naive methods of extrapolation may perform as well as more complex methods. The stability of trend implies that the social institutions involved react in habitual manners, tending to continue chains of reactions already initiated. Corrections and the Criminal Justice System, however, do not appear to be stable systems in this sense, rather their behavior would be classified as volatile. A volatile series displays erratic and changing behavior. For example, societal response to crime is not uniform but is marked by reactions of varying type and intensity. For the volatile time-series, one of the greatest failings of least squares and other naive methods is the inability to detect turning points, that is, when the trend is going to change direction. In practice, forecasts of volatile series tend to be evaluated on the basis of infrequency of failure rather than on frequency of success. An analogy of this practical evaluation is that of a blind man crossing the street. The worth of his white cane is appreciated not in the number of times he crosses successfully, but in the number of times he is hit by cars. Likewise, the practical evaluation of least squares may cause the person concerned with non-stable (volatile) patterns of prison growth to be wary of this technique of forecasting.

For the volatile series, the ability to forecast may rest in the understanding of the driving influences. This requirement of understanding would suggest that a single naive trend should be accompanied by a full description of the underlying assumptions. Such documentation may not affect the forecast, but it would convey to the decision-maker the basis by which to evaluate the utility of the forecast. Another implication of this need for understanding is the call for the construction of causal models which incorporate the driving factors into the forecast method. A third implication, perhaps the overriding one, is that a forecast of a volatile process should not be accepted on face value. The least squares forecast should be considered in light of the decision-maker's experience and social awareness. When the forecast differs from the decision-maker's estimate, he may desire to check both the assumptions underlying his estimate and those of the forecast.

Accuracy of least squares, in part, is dependent upon its application. The forecaster should be aware of both the nature of the time-series and of the best transformations to use, such as the logarithmetic transformation. Pittenger (1976), for example, in a study of methods for forecasting general population, was unable to demonstrate least squares with arithmetic data because of "finding no examples of populations that had experienced constant numerical growth for several decades. Such population growth [he assesses] is very rare ..." [p. 47] This evaluation of least squares application seems appropriate for many series of prison population. Few records of prison growth reflect a steady rate of arithmetic growth for several decades.

Accuracy of a single trend forecast may be a moot point. If the decision-maker acts upon the basis of the forecast to change the direction of prison population growth, he is, in effect, nullifying the forecast. Thus, the single trend forecast may be beyond assessment of accuracy because of the inability to determine what would have happened if no action had been taken.

Time Span

Time span and accuracy of least squares would seem to be intertwined. However, the issue is not nearly this clear-cut. Literature on the topic is filled with contradictory statements. For this reason, the following discussion avoids matter-of-fact statements and, instead, will review several general considerations of time span.

As briefly noted above in the section on accuracy, a volatile time-series, such as prison population, may be difficult to forecast for any length of time. Stable patterns, on the other hand, raise the confidence of the forecaster to extend the trend into the future.

An obvious problem of the extension of the trend is that absurd or impossible forecasts may ensue. For example, the reader will recall that Tim Carr warned that the Georgia prison population was not likely to reach the level indicated by his least squares projection.

The further into the future the forecast, the more removed we become from experience and the more difficult forecasting becomes. To use Brown's analogy (1963), forecasting is similar to the military problem of tracking manned aircraft. We can only forecast the volume of space in which the target will be found in the next few minutes. The boundaries of this forecast are established by the aircraft's physical capability to maneuver. The size (width) of the forecast boundaries grow with the passage of time. Likewise, the further into the future we extend a least squares forecast of prison population, the wider the range of estimation (confidence interval) becomes.

Not only is time span of the prison population forecast beseiged by the problem of volatility, but the least squares application, also, faces a data problem. Accuracy of the short-term forecast is obviously related to accuracy of the data. However, the forecaster cannot assume that recency of data necessarily implies accuracy. For example, the NPS (National Prisoner Statistics) reflect that recent data may be modified or changed in later reports.[20] A person using 1976 data this year may find that the next NPS report reflects a different magnitude for 1976 data. On the state and local level, this data collection problem may not be as critical, although the decision-maker should not discount the possibility that even recent data is an approximation. Thus, the forecaster seeks refuge from time span problems by restricting the application of least squares to short-range forecasts.

Uses of Least Squares/Transferability

Least squares as the sole method for decision-making offers little solace for the correctional administrator. However, the role of least squares is not defined by such restricted use. Five other uses of least squares in forecasting can be identified. First, least squares may be used as the basis of input of expert opinion by identifying various signals in the criminal justice environment. For example, Project Star, which presents a general forecast of the criminal justice future, employs numerous projections to buttress discussion of trends. Secondly, straight lines and curves may be fitted to various time-series for the purpose of comparison. In this way, trends among various state prison populations could be studied. You will recall, Tim Carr evaluated prison population growth with reference to intake

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[20] An example of such discrepancies is readily detected in the NPS (National Prisoner Statistics) Advance Report for Dec. 31, 1976 and the NPS Bulletin for Dec. 31, 1975. The 1975 Bulletin indicates that the 1975 population of all state institutions is 218,619, but the Advance Report shows that the 1975 population now is calculated as 229,685. Between these two reports, a difference of 11,000 is evidenced for the prison population of 1975.

from the courts. Thirdly, complex forecasting methods may employ least squares projection as a guide against which to assess model performance. The simplicity of least squares does not tend to hide the main sources of error. In more complex models, the source of error is easily compounded and difficult to assess.

Fourth, a comprehensive forecasting program which is not restricted to a single method, usually begins with least squares analysis and projection. Fifth, least squares is of use in studying factors (variables) that are being considered for inclusion in more elaborate forecasting models.

Communicability of Results

The projection of trends with a single line is one of the most widely known forecasting methods. As a minimum, the decision-maker should be given the trend and the range of estimate (confidence interval) by which to gauge the projection.

Time Consideration

The calculation of least squares is fairly rapid. Computer programs commonly contain curve-fitting routines. Simple straight line projections can be calculated by hand in a few hours. The time required for data collection will probably be the crucial factor in the application of least squares.

Resources

Anyone with a graduate course in behavioral science statistics (cross-section analysis) can compute least squares, although he may not be aware of the caveats of time-series application.

Simple straight line projection could be accomplished with an inexpensive $15 pocket calculator. The fitting of curved lines, probably, for time's sake, requires access to a computer.

Curve fitting with least squares is among the least expensive of all mathematical forecasting methods. However, if data are unavailable and extensive efforts are necessary for collection, the efficacy of using least squares as a sole forecasting method may be questioned.

Smoothing Techniques

Moving Averages

Moving averages are part of the family of naive forecasting methods. By their nature, moving averages (M.A.) have two roles. The first role involves the class of data displaying serial correlation. The problem of serial correlation is common in criminal justice data. Because of this problem, least squares does not appropriately describe time-series of prison population. Serial correlation calls for a forecasting method which places greater weight on recent events, rather than equally treating all historical information. In decision-making, the presence of serial correlation is commonplace. An example of serial correlation familiar to all readers can be readily drawn from everyday life. The almost habitual task of taking a shower involves adjusting the water temperature according to the most recent information rather than on equal consideration of all past water temperatures.

The equal evaluation of all temperatures is analogous to the method of least squares and the weighing of information about the last few moments is analogous to moving averages. In its forecasting role, moving averages selects only the most recent of data and dismisses the distant past.

The second role moving averages plays is that of a descriptive tool. As indicated by its name, the general characteristic of the method is the process of averaging. When several numbers are averaged together, the result is a moderate value. When applied to time-series data, the technique describes the general path of the time-series. As seen in Figure 21 , below, the extreme fluctuation of the original data are reduced. This reduction of fluctuation is known as smoothing.

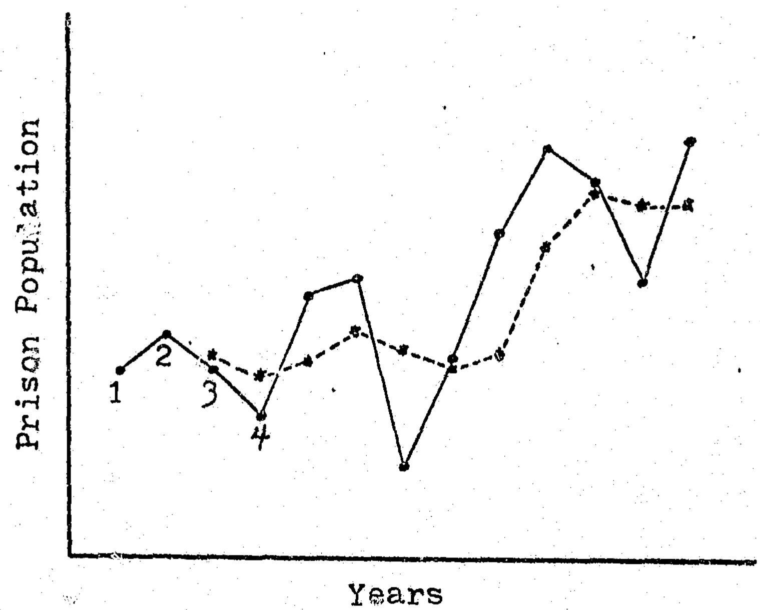

Figure 21. Hypothetical Prison Data with Moving Average Shown in Broken Lines
Source: Hypothetical Data

The illustration depicts a moving average of three year's span, that is, three data points are being averaged. Since this moving average is composed of three numbers, the first averaged value would be placed at the end of the third data point. The second averaged value derives from the data at points 4, 3, and 2. The average has in essence "moved" to include the next new data point and has left off the oldest. The calculation of averages continues throughout the time-series picking up a new data point and leaving off the oldest until all the data have been averaged. The moving average lags behind general magnitude changes in the time-series. For example, in Figure above, the second half of the time-series reflects an overall increase. Since the average downplays the occurrence of a far removed data point, an overall change in the magnitude of the time-series is not detected early in the shift to a new level. The wider the span of the average, that is, the more data points included, the slower the response to an overall magnitude shift. Thus, a moving average of four numbers would lag behind a moving average of three. This tendency to respond slowly is both an asset and liability. Unusual disruptions which produce extreme fluctuations will be partially absorbed, thereby, clarifying the general path of the time-series. However, the technique will be slow in signalling new trends in prison growth.

Figure 21, above, illustrates the single moving average (SMA). This type of moving average finds greatest application in data containing no upward or downward trend. In other words, the data would appear as a random progression of values around a horizontal line or axis. Since no specific trend exists, the best predictor of a future value would be the last data point of the moving average. This means that the average has identified the general horizontal path and that any other direction is basically unpredictable. Therefore, a forecast via a single moving average is merely the horizontal extension of the last calculated value. For example, if the last smoothed value of prison data had been 1,500, then the best prediction of prison population a year away or ten years away is 1,500.

Prison population data that contains a linear, that is, straight line, trend upward or downward should be smoothed by a double moving average (DMA). As shown in Figure 22, below, a double moving average is the moving average of the values calculated by the single moving average. In other words, a double moving average is the average of an average.

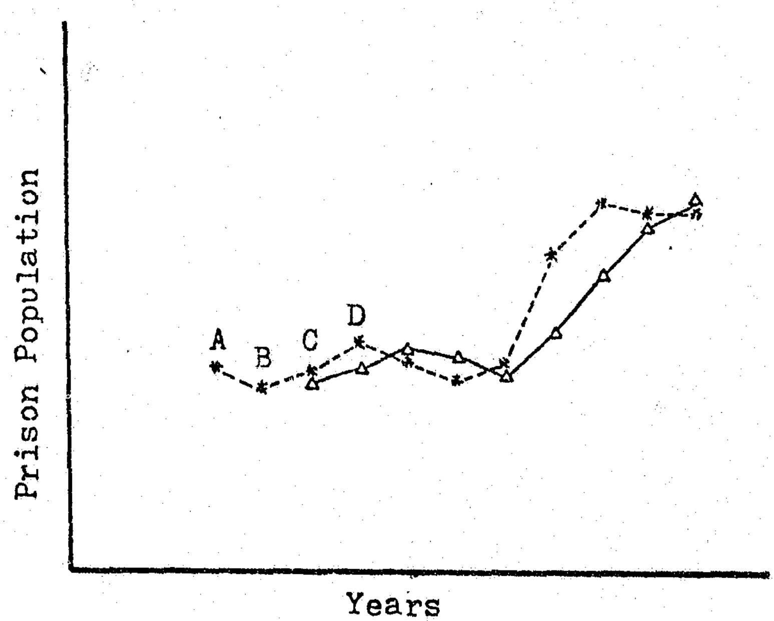

Figure 22. Single Moving Average from Figure 21 represented by Asterisks and a Double Moving Average Represented by Triangles.
Source: Hypothetical Data

CONTINUED

2 OF 4

The double moving average would begin by selecting the first three values of the single moving average: A, B, and C. The first triangle in Figure 22 represents the first calculated value of the double moving average. The second double moving average value includes single moving average values B, C, and D and drops out the oldest, A. In this fashion, the double moving average "moves" through the data as did the single moving average.

The reader will notice that the double moving average lags the single moving average, and therefore, would be expected to respond more slowly to a general shift in the magnitude of a time-series than the single moving average.

Forecasting with double moving averages cannot be as was the case in single moving averages, a horizontal extension of the last value smoothed. Since D.M.A. is applied to data displaying a non-linear trend, the projection must key onto the direction of the trend. Essentially, the forecast is based on the slope of the trend line that is evident in the last smoothed values of the time-series. Both least squares and smoothing techniques are similar in their concern for projection of a trend line.

Data which reflect a curvilinear (quadratic) trend are not suited to single or double moving averages. In this situation, triple moving averages (T.M.S.) could be used. This method is merely an extension of double moving averages in which the smoothed values are smoothed again. Although T.M.A. could be used, another technique, triple exponential smoothing, is preferred. That technique will be discussed below.

Exponential Smoothing

Exponential smoothing is basically a weighted moving average. There are three versions of exponential smoothing: Single (S.E.S.), Double (D.E.S.), and Triple (T.E.S.) which correspond just as did the three forms of moving averages to the type of trend reflected by the data. The name of the version signifies how many times the data have been smoothed. Generally speaking, exponential smoothing is more attractive to the analyst than moving averages. Foremost in its attractiveness is the efficiency of calculation. A double moving average of prison population which averages six numbers at a time would span eleven years of data before producing the first D.M.A. value.[21] Such data requirements quickly eat into the pool of data on yearly prison population. Double exponential smoothing, on the other hand, uses only two data points to calculate a smoothed value.

A second attractive quality of exponential smoothing is the process of weighting. Rather than equally weighting data points in the average, as in moving averages, exponential smoothing assigns greatest weight to the most recent datum and progressively decreases the impact of the weight over time.

The general calculation of this weighted process can be described without mathematics. According to the formula for exponential smoothing, the forecast for the next (future) period is the value of

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[21]A double moving average of six consecutive data points would be used in calculation of the Single Moving Average (the first calculation) and six data points in the Double Moving Average (the second calculation). An overlap of one data point accounts for the total of eleven rather than twelve points averaged.

the current period plus a part of the error made in the last forecast.[22] The error is nothing more than the difference between what had been forecasted for the last period and what actually happened. For example, the prison population forecasted for 1978 is represented in Figure 23 below.

1978	=	Prison population in 1977	+	Part of the error in forecasting 1977

Figure 23. Process of Forecasting with Exponential Smoothing

Only a part or fraction of the error is used. This fraction is called the weight. Usually, the weight is .3 or less. This means that in Figure 23, perhaps only three-tenths of the error made in forecasting 1977 would be added to the prison population figure for 1977.

Now, it can be reasoned that if this weight had also been used in constructing the previous forecast and the previous forecast is represented in the error term, then the multiplication of the error term involves multiplying the weight by itself. Furthermore, this means

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[22]The application of exponential smoothing must necessarily begin at the most removed (oldest) time period. Obviously, that first time period will not have had a forecast made about it and cannot facilitate calculation of error between actual and forecasted value. In this instance, the analyst must subjectively estimate the value of the second period based on the first period. He may choose to use the first period's value as the forecast of the second period. This process enables the analyst to begin the calculations. The fact that he started out with an artificial value will be quickly downplayed as the exponential smoothing calculation progresses through the data series.

that the cumulation impact of a weight extends over a series of periods as suggested in the illustration below.

Next Period	=	Value of Current Period	+	weight	+	weight	+...

Figure 24. Illustration of Cumulative Impact of Weights

Figure 24 shows that the successive multiplication of weights causes the successive impacts of the weights to become smaller and smaller. Within several time periods from the current forecast, the impact of previous error is insignificant. How far back this consideration extends is dependent upon the magnitude of the weight. The size of the weight is roughly analogous to the span or number of periods averaged in the moving average.[23] From this illustration, we can see how the technique came to its name, by the exponentially decreasing impact of the error.

History

Smoothing techniques are among the oldest statistical procedures in economic forecasting. The popularity of business cycle analysis in the 1920's and 30's gave rise to methods which would downplay the effect of "spiked" up and down fluctuation (noise) in time-series data. Moving averages provided a method of identifying the trend within data

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[23]The size of the weight is loosely analogous to the number of periods in a moving average. A large weight (Alpha value) corresponds to a moving average spanning only a few periods. The relationship appears to be that the smaller the weight, the further the impact over time.

that appeared to have a dispersed pattern.

Over the years, smoothing techniques fell from the spotlight to become one of many tools for studying the behavior of time-series. No longer are cyclic methods treated as the only or preferred means of forecasting economic behavior. Interest in smoothing techniques has recently been brought to front in the criminal justice field in the training of criminal justice planners.

Example

The following discussion of smoothing forecasting techniques will walk the reader through both moving averages and exponential smoothing. Before examining these two techniques, the data set will be identified and a basis for comparing techniques will be established.

Figure 25 represents Texas prison population from 1930-66. The years 1966-77 are not included but will be used to compare against forecasts constructed from the 1930-66 data. A second basis of comparison has been constructed in the straight line fit by simple least squares through the data in Figure 25 . The straight line is shown for the reader's comparison of methods because it is the most frequently used form of forecasting.

The reader should take particular note of the general rather than close fit of the trend line in these data. As it will be later shown, the forecasts constructed by moving averages and exponential smoothing will fit data more closely than that established by simple least squares.

Data analysis for moving averages and exponential smoothing

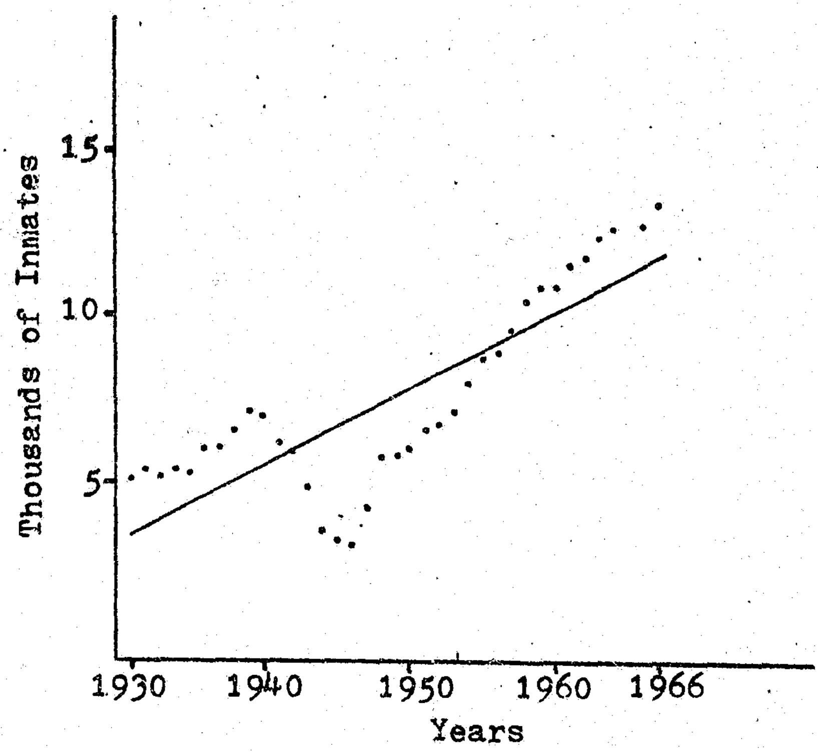

Figure 25. Straight line fit by simple least squares to Texas prison population data, 1930-66. Source: Texas Department of Corrections

was accomplished by computer program.[24] The method which best fit the data was selected according to the criteria of lowest error of forecast. The lowest error is merely the lowest sum of differences between the forecast and the actual values; in other words, sums of how much the forecasts constructed by the various techniques were "off" of being right.

The data in Figure 25 above, show that the war years, 1939-45

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[24]This researcher used the computer program given in Sullivan and Claycombe's Fundamentals of Forecasting. During the inspection of the results of data analysis, a major program flaw was detected for the calculation of moving averages. The problem was corrected and the data reanalyzed. For this reason, the reader is advised against using computer program in the cited reference.

reflect a dip in prison population. Probably, the dip stems from a particular set of conditions brought on by the war; such as reduction in the size of the offender risk population. The presence of this pronounced fluctuation in data offers the opportunity to test the effectiveness of different smoothing techniques.

In the first analysis of data, the years earlier than 1946 were not included. The analysis was accomplished by three methods: the three forms of moving averages, three of exponential smoothing, and simple least squares. This analysis by different methods disclosed that double moving averages calculated on a six year span produced the best fit (lowest error) of forecast to data.

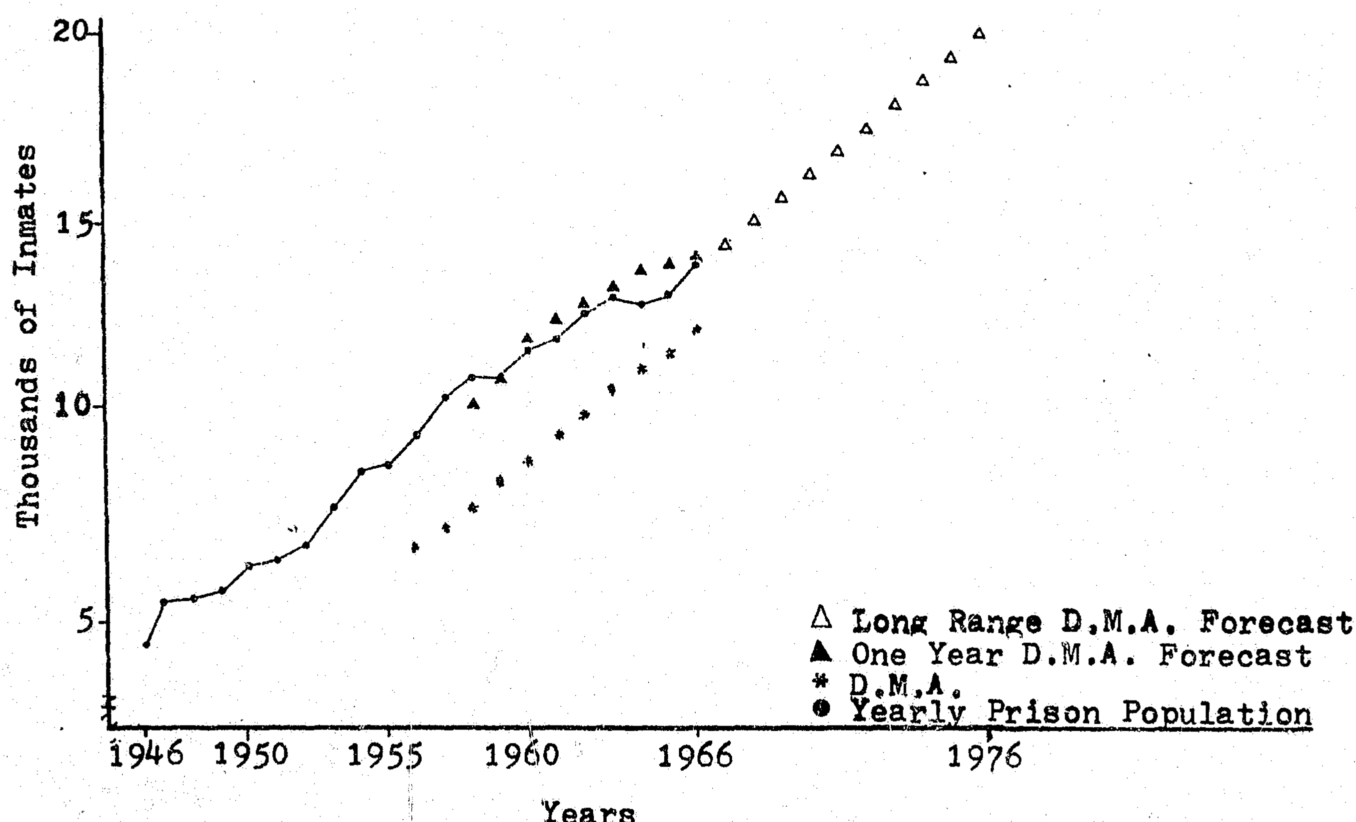

Figure 26. Double Moving Average forecast with 1946-66 data

As shown in Figure 26, the D.M.A. values expectedly lag behind the upward trend of prison growth. The one year forecast for the D.M.A. compensates for the lag and is closer to the actual value. Within the years 1946-66, the D.M.A. are forecast at intervals of only a year at a time. For example, 1959 would be forecast from data 1958 and back. The forecast from 1967-77 is a linear extrapolation of the trend calculated by the D.M.A. in the last years smoothed. Unlike yearly forecasts in existing data, the forecast into the future must extrapolate more than one period.

Figure 27, below, illustrates how well the D.M.A. forecast fared against the actual values of prison population, 1966-77.

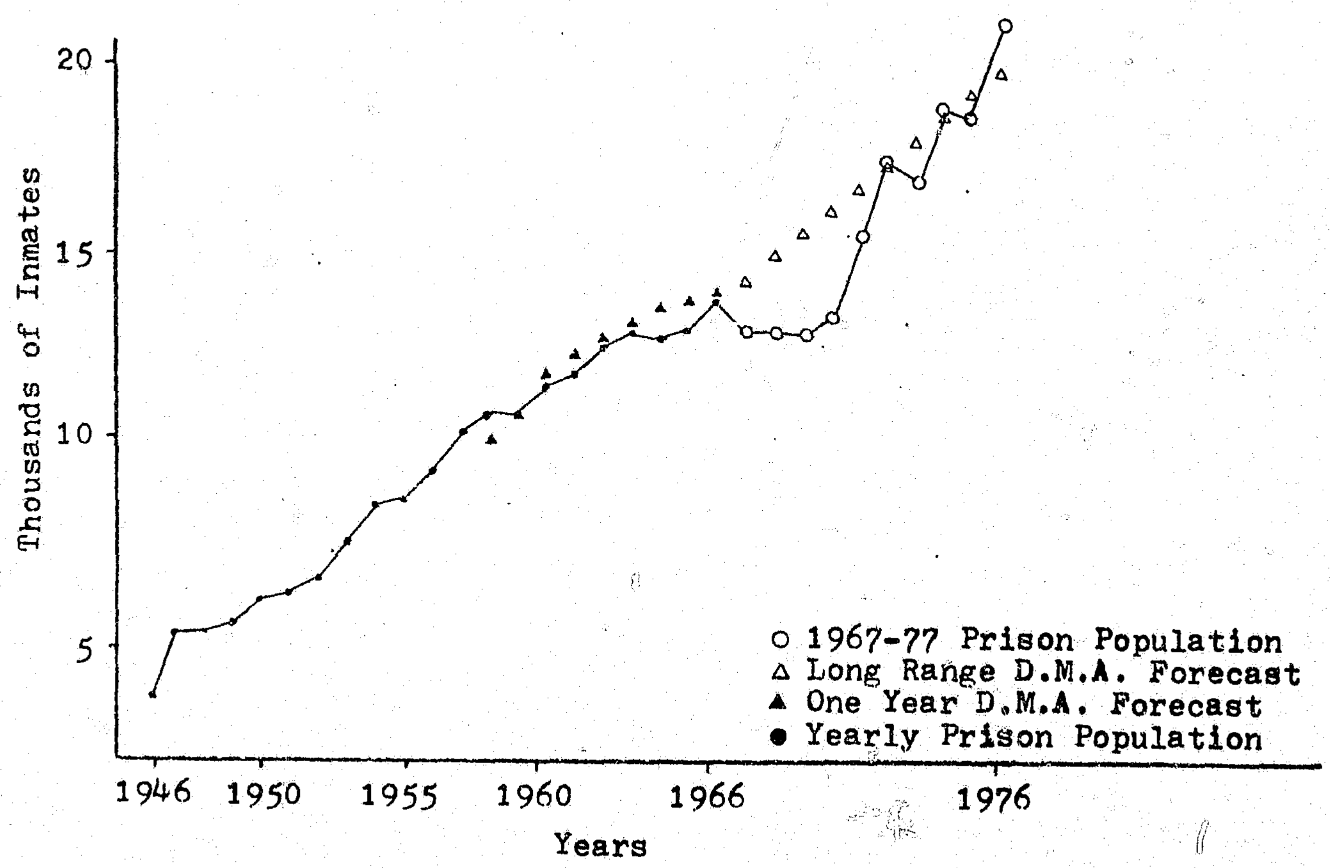

Figure 27. Double Moving Average forecast compared to actual prison population from 1966-77.

Immediately evident in Figure 27, above, is the shortcoming of smoothing techniques: a line may be closely fit through data in the form of one-year forecasts, but a linear projection of trend will be as awkward and imprecise as that calculated by simple least squares. The naive projection of trend fails to identify the turning point of prison growth in 1967 and only by accident appears to come close to the last five years.

In a second analysis of data (1930-66), the war years were included. The analysis disclosed that of the seven methods, the best fit of forecasts was calculated by triple exponential smoothing (T.E.S.). The two lines formed by the single year forecasts and the ten year projection from 1967-77 are shown in Figure 28, below.

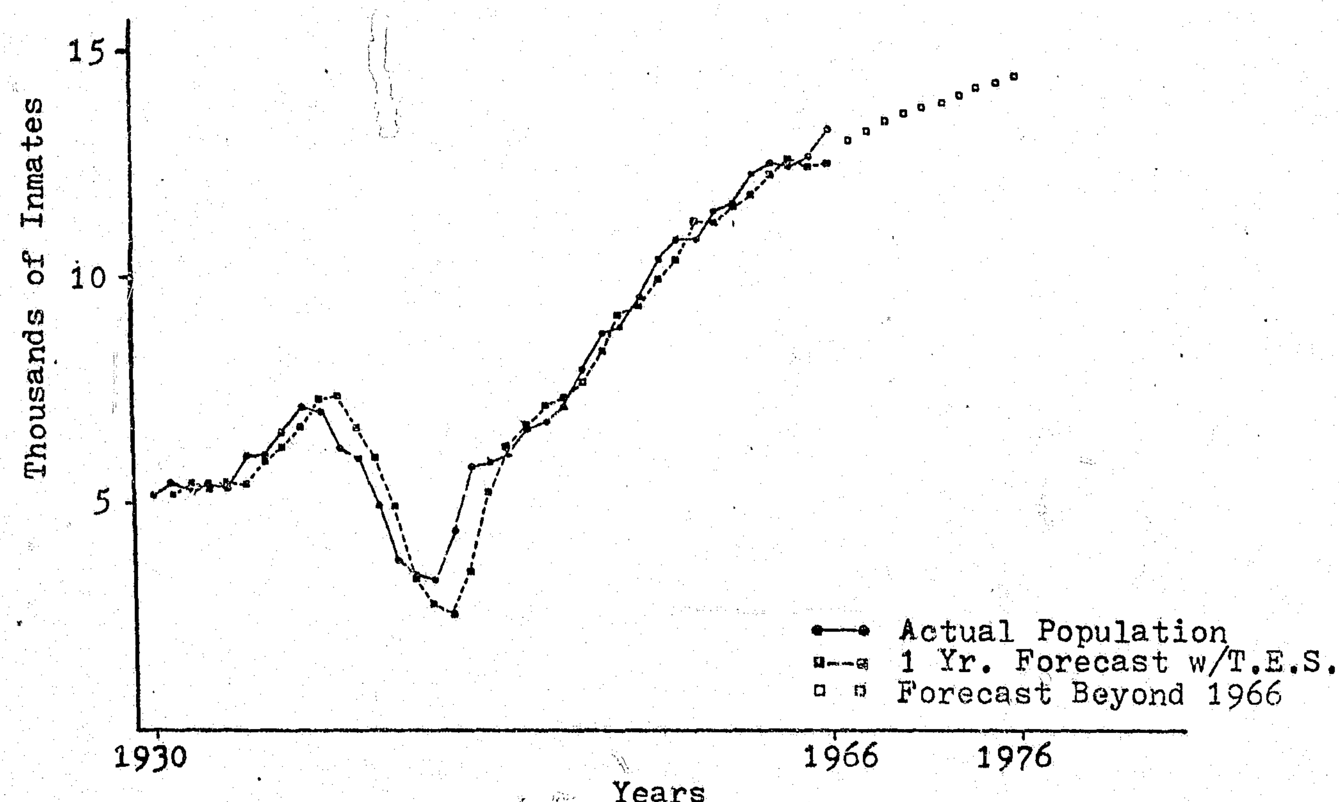

Figure 28. Triple Exponential Smoothing Forecasts of Prison Population

In Figure 28 , the T.E.S. one-year forecasts appear to closely follow the pattern of actual data. However, the ten-year forecast as it appears is little more than a linear extrapolation of trend identified in the last few data points.

The selection of the T.E.S. weighting value for the 1930-66 data was necessarily arbitrary. The fluctuation in the war years data produced in the T.E.S. calculations was an unstable condition. This unstable condition was characterized by the lack of an optimal weighting value.[25] Such a problem did not arise when the war year's fluctuation was dropped from analysis.

Figure 29 displays the performance of the T.E.S. ten-year forecast. The gap between actual and forecasted values in Figure 29 is discomfortingly wide. In comparison to the ten-year D.M.A. forecast in Figure 27 , triple exponential smoothing performed no better, it not worse.

If the only problem facing the analyst is that of choosing between the two methods, D.M.A. and T.E.S., the logical course of action would be to apply D.M.A. to the shorter time-series. The analyst could, also, hedge his forecast by constructing a Range of Estimate around the projection.[26]

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[25]The nature of the 1930-66 data was such that no optimal value within the range of possible weights could be identified. The problem of selection boils down to what would be analogous in a double moving average of improving accuracy by reducing the number of data points smoothed. The best exponential weighting value would smooth only one data point. In other words, the higher the weight, the lower the error. The weighting value selected in Figure is .3.

[26]The construction of the Range of Estimate is described in the section on Subjective Extrapolation.

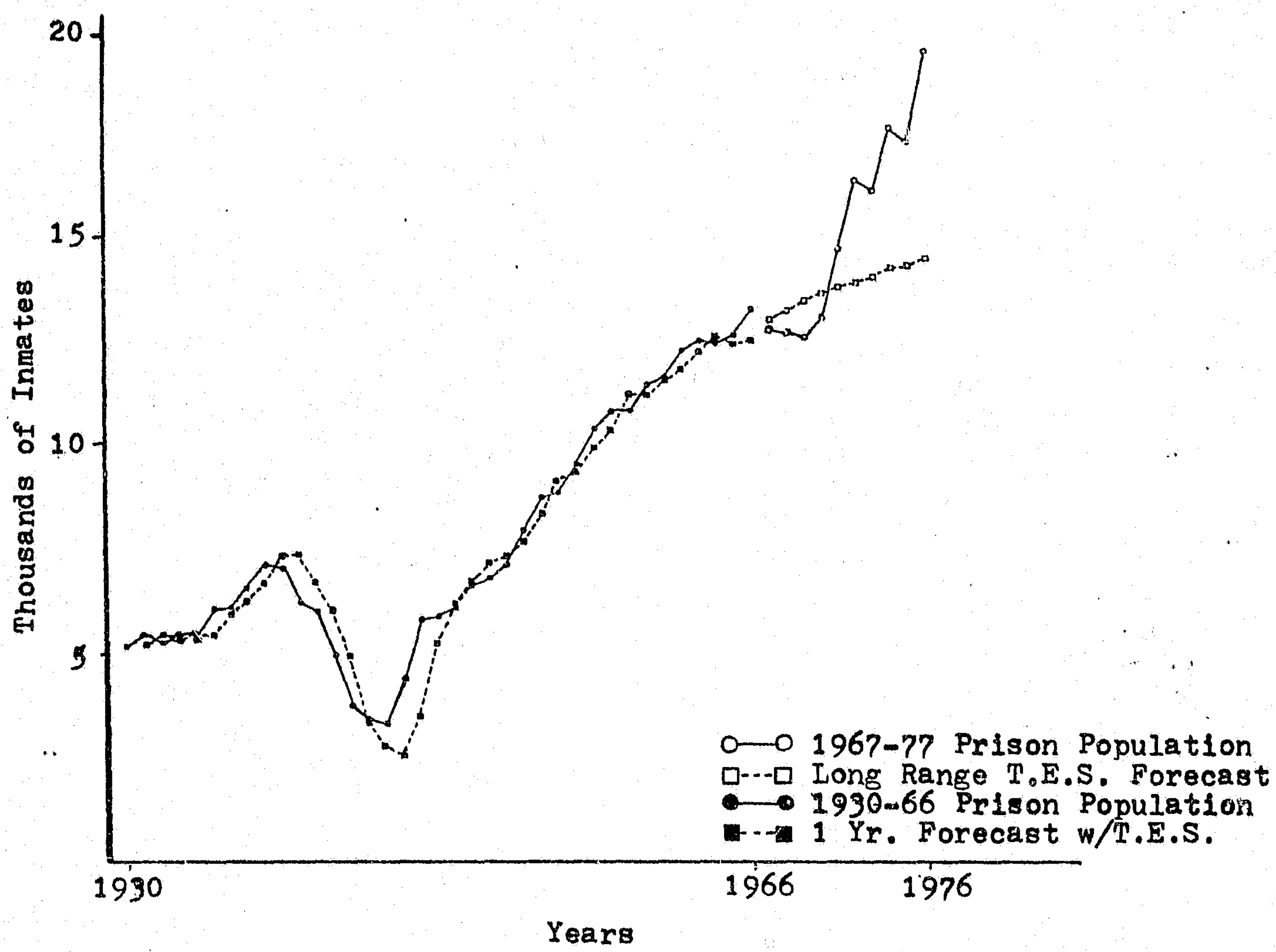

Figure 29. Triple Exponential Smoothing forecast and actual prison growth.

Assumptions

Smoothing methods share many of the assumptions of simple least squares. Smoothing methods differ basically in the assumption that there is a need to place greater emphasis on the most recent data. But as seen in the cases of both least squares and smoothing forecasts, the linear extrapolation of a trend assumes there will be no change in the environment as it exists now in producing prison population growth.

The focus by smoothing methods on the section of the data that sets the direction of the trend overlooks the inadequacy of the no change assumption. The assumption of no change may be appropriate to data having a history of little fluctuation; however, criminal justice data tends to be far less predictable.

Span and Accuracy

Accuracy of smoothing forecasts may best be considered for two time horizons: one-year forecasts and longer-than-one-year forecasts. All of the figures above illustrating smoothing forecasts indicated that one-year forecasts provided slightly better forecasts than would be obtained by estimating that next year and this year would be the same. In the instance of erratic fluctuation (not represented in the figures above), smoothing methods would have been preferred over simple estimates of no change in next year's prison population.

Long-range use of smoothing forecasts fared no better than other naive methods in estimating future prison population. Long-range forecasting requires the ability to identify turning points. This ability is not a characteristic of smoothing techniques.

Considerations/Limitations

A major weakness of smoothing methods lies in the absence of theoretical principles for choosing the best forecasting technique. The most used selection process is merely that of applying each technique to the data and assessing which method has the smallest error of prediction.

Smoothing techniques can introduce into the data an oscillatory movement that does not exist. Several random (chance fluctuations) data points lying sequentially in the same direction and having similar magnitudes may cause the smoothing technique to portray a pattern that could be interpreted as a cycle. For this reason, the analyst must examine cyclic fluctuation and justify his interpretation in terms of social forces and dynamic conditions of the Criminal Justice System.

The length of the moving average determines its smoothing properties. For example, a twelve month moving average will remove any seasonal fluctuation. A moving average equal to the length of a cycle will also completely dampen or eliminate the wavelike movement.

Communicability of Results

The mechanics of smoothing are easier to explain than those of complex forecasting models. Smoothing also may be easier to explain to a person with a background in business rather than behavioral science. Behavioral science research does not consider, as a rule, ideas similar to the concepts of smoothing or the need to smooth cross-sectional data. The problem of explanation is not the same as that for techniques, i.e. least squares, shared by both behavioral science and economic research. In the instance of shared techniques, the mechanics and conceptual approach to analysis may be similar, albeit the assumptions and explanations vary. The explanation of smoothing forecasting to behavior science researchers begins without a familiar frame of reference and therefore may not be readily grasped.

Perhaps the best mode of presenting smoothing forecasts, is by graphic illustration. Additional explanation about assumptions and limitations of the forecast would aid in the use of smoothing forecast information.

Time Considerations

Constructing a smoothing forecast is not a lengthy process. In most cases, little outside data collection has to be obtained besides the on-hand yearly prison count. Depending upon the depth of smoothing analysis, e.g., whether cycles will be examined, the required time may be that of a day to a few weeks.

Resources Required

The calculations of moving averages are tedious when performed by hand. A computer or programmed hand calculator is almost a necessity for the process of calculating all of the six smoothing techniques in order to select the method with the lowest error.

Since smoothing methods are germain to economic forecasting, their application in an extensive analysis of prison population may require assistance of an economic forecaster familiar with the nuances of the techniques. For example, familiarity would be required in using smoothing methods to bisect cycles and describe seasonal patterns.

Other expenses involved are those of computer expenses which would be nominal for most simple applications of smoothing forecasting methods.

Transferability

Smoothing techniques may never become the mainstay of correctional forecasting. The techniques may be helpful in establishing a simple and inexpensive ballpark forecast. They also can be used to compare the performance of complex forecasting models. Importantly, these techniques have a high descriptive value in the examination of trends and seasonal movements. Such information can be useful in adjusting data, i.e., to remove seasonal movements and in exploratory studies of the limits of growth of the prison system.[27]

Indicator Forecasting

The study of indicator forecasting of prison population addresses this basic question: What if the cause and effect of prison growth cannot be specifically identified at this time? There exist many theories of crime and criminal behavior, yet no clear-cut advantage is gained by using a particular theory to forecast. In support of the theories, this may not lie in the fault of the theory, but in a lack of data to support the interpretation of the theory into a model. On the other hand, one may take the position that such a complicated phenomena as prison growth, and for that matter criminal justice activity, is beyond the present ability of research to measure or quantify cause and effect.

Popular forecasts abound of crime and prison population which assert the basis of prediction from one or two factors. Perhaps,

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[27] An example of the application of smoothing techniques can be found in Alfred Blumstein and Jacquelin Cohen's "Theory of the Stability of Punishment," (Journal of Criminal Law and Criminology, Vol. 64, No. 2, pp. 198-227).

the most commonly selected causes of prison growth are attributed to the size of the critical risk group (usually the youth) and unemployment. Although these two concepts are popular, their sole use as a basis for forecasting prison population may be questioned. For example, unemployment was found in one state to be a leading indicator, in another to be a coincidental indicator, and for an aggregation of states to be a lagging indicator.[28] In the field of economics, the users of indicators forewarn against the reliance on one or two indicators because what is found to lead on one occasion may lag on another. Economic forecasting is rich in such information and is often a source of exploration in the following discussion of indicators in prison population growth.

History

The creation of a system of social indicators appears to have begun in the 1920's. The prominent sources of indicator information during that period were the U.S. Department of Labor which published labor statistics, and the National Bureau of Economic Research

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[28] The studies which specifically deal with the differing findings on the timing of unemployment and prison population growth are:

a. Cox, G.H. and Carr, T.S. Unemployment and Prison Population Trends in Georgia: 1967-1975. Atlanta, Ga.: Georgia Department of Corrections, Mar. 5, 1975.

b. Hromas, C.S. and Crago, T.G. Colorado Unemployment and Commitment Rates. Denver, Colorado: Colorado Div. of Correctional Services, Office of Research and Planning, May 1976.

c. Robinson, W.H., Smith, P. and Wolf, J. Prison Population and Costs--Illustrated Projections to 1980. Washington, D.C.: Congressional Research Service, Library of Congress (HV 8442; 74-95ED), April, 1974.

which studied economic indicators. A major push for other forms of social indicators did not occur until the mid-1960's. During the mid-60's, social unrest sparked a call for social indicator development from behavioral scientists, government administrators, and legislators. The variety of proposals that ensued addressed the need for establishing additional social indicators, but little other agreement was reached about what should constitute their content. Missing was a specific definition of concept and role of social indicators which would solidify attention and effort. Little (1975), for example, identified at least six major, distinct approaches for the definition and construction of social indicators.

In the field of criminal justice, attention did not turn to the development of specific indicators until the 1970's. In 1974, Battelle Laboratories reviewed 158 indicators that might be used for forecasting caseloads of federal district courts. This research was not widely distributed and thus is not well known. In 1977, LEAA began to sponsor further research into indicators with the award of a contract to the Social Science Research Institute at the University of Southern California. That contract calls for the development of a broad selection of crime indicators.

Definition of Indicator Forecasting

In a general sense, a prison population indicator is similar to a barometer. That is, an indicator is a phenomena sensitive to change in the growth of prison population. Of course, some indicators could reflect activity in both prison growth and other facets of the

Criminal Justice System. The barometer analogy implies that an indicator plays a passive role, but in at least one respect, this analogy is inadequate. The analogy overlooks the possibility that an indicator may act as a causal factor in affecting crime and changing activity within the Criminal Justice System. As a definition, the analogy of a barometer is of limited usefulness.

The concept of indicators seems to imply that any measure related to prison growth would be covered by the definition. However, drawing from Lewis' definition (1962) of "foreshadowing data," the definition of indicator may be narrowed. Lewis classifies as foreshadowing data such measures as surveys of opinion, budget proposals, and hints of institutional program changes. This narrowed perspective facilitated the construction of the following definition which will be adopted for this discussion forthwith. Indicators are considered to be those phenomena which can be measured at given periods of time (as a time-series), are sensitive to changes in the Criminal Justice System, and need not firmly establish a causal relationship to criminal justice activity, although such a relationship should be plausible.

Indicators can be classified into three categories: leading, coincident and lagging. For the leading indicator, all that is claimed is that a change in direction of growth (of prison population) is preceded by a change in direction of the indicator. A coincident indicator would change direction at the same time as a change in prison population growth, and a lagging indicator changes afterwards. Obviously, the need for leading indicators is clear but not so obvious is the need for coincident and lagging indicators. As in economic/business forecasting, the role of coincident and lagging indicators in correctional forecasting would be to assist in determining if a rise or dip in prison population represents a temporary change or reversal of trend.

Indicators, to be useful in forecasting prison growth, must display: (1) regularity in conforming to the fluctuation in prison population growth, and (2) consistency in leading, coinciding, or lagging the turning points. Other criteria that should be considered are statistical adequacy of the data, smoothness of the data, and promptness of publication of the data (Moore, 1975).

Since a single indicator, as suggested above, could not be ideal and therefore predictably dependable, groups of indicators must be employed. A single indicator in concept would be related directly to changes in prison growth; however, a group of indicators is not so simply applied. For example, a group of leading indicators would contain a variety of individual lead times. Such problems of grouping led to the creation of a "diffusion index" which summarizes general indicator activity. The process of constructing a diffusion index for the three groups of indicators consists essentially of smoothing the individual indicators (time-series) by a moving average, then counting the number in the group that are rising (not stable or falling) at a given time, and converting that number into a percentage of the group. If the number of risers is above 50 percent, then the indicators are interpreted as expanding. An expanding group of leading indicators would suggest, for example, that an upturn in the growth of prison population could be forthcoming. A contracting group (more than 50 percent falling) forecasts a decrease in prison growth.

These examples of grouping convey the basic concept of indicator interpretation. Many of the other methods of indicator interpretation being used in economic forecasting are similar to the diffusion index.

Example

Historically, the state of the art of indicator forecasting in the Criminal Justice System has sparsely developed. Because of this slow development, an example of prison population indicator forecasting must be contrived. The steps of building a system of indicators will draw upon several studies to illustrate a methodology.

The four basic steps of indicator forecasting of prison population proposed in this research are:

1. Indicator identification
2. Data collection
3. Indicator evaluation
4. Selective grouping

Step 1. Indicator identification. The first task to face the forecaster would be to generate a list of potential indicators. Rather than a random approach to the task, the adoption of a planned attack on the problem will facilitate exploration of a broad range of indicator areas. This process of search can be envisioned in three phases.

The first phase of search will appear obvious to most readers; however, instances of enthusiasm have spurred some forecasters to leap ahead to the second phase. The first phase involves the thorough search of literature in a variety of fields, such as economics and demography. Many of the ideas that could be found are not reported in criminal justice literature. For example, Predicasts, Inc. of Cleveland, Ohio, in 1973, conducted research which developed indicators of increasing law enforcement spending.

The 1974 Battelle study of federal district court caseload indicators partially illustrates the process of indicator identification. In phase one, Battelle cites a study of indicators performed by Forecasting International, Ltd. of Arlington, Va. In phase two, a questionnaire and panel of experts generated ideas. The questionnaire asked about possible indicators of caseload volume, and was distributed to the chief counsels of all U.S. government departments and one randomly selected lawyer in each state. The panel of experts were chosen for their knowledge of federal courts. Brainstorming generated a list of indicators which were evaluated in a matrix by the panelists.

Step 2. <u>Data collection</u>. The forecaster's next effort after indicator generation would be to collect data on the proposed indicators. During this collection, the number of indicators would be expected to shrink due to finding some unreliably reported or otherwise unusable.

The Battelle research conducted a pilot study of this step in several states to determine feasibility. After the pilot, the collection was expanded to the remaining states. The problem of shrinkage was avoided in some cases by methods which estimated missing data within time-series.

Step 3. Indicator evaluation. The use of a time-series as an indicator does not require a close association (high correlation) with the phenomena being forecast. Correlational statistics and leading, coincident, and lagging indicators are different concepts. Correlational statistics, for example, would measure how well the entire predictive time-series conforms to the shape of prison growth--equal weight would be placed on the comparison of every data point. Indicators, on the other hand, are concerned only with signaling changes, not in correlation. A leading indicator, for example, would contribute to the identification of a forthcoming turning point in prison growth but would not disclose magnitude and duration of change.

An illustration of a general approach to indicator evaluation is found in the practices of the National Bureau of Economic Research (NBER, 1971). The Bureau's method of reference cycle analysis would lend itself to the evaluation of time-series consistency to lead, coincide, or lag with turns in prison population growth. Essentially, reference cycle analysis would involve matching the peaks of the indicator series to peaks in the prison population. Such matching could not be accomplished on just one turn in prison population. Therefore, an extensive data record on both the indicator and prison population would be needed. The mechanics of matching are highly subjective, although NBER has quantified the matching criteria for computer-assisted application.

An additional possibility of analysis would permit the comparison of indicators between states. Factors other than unemployment probably would be found to vary with location. Also, state prison indicators could be compared to indicators of aggregate prison growth. Since aggregate growth may be easier to forecast, local evaluation would gain an interpretative benefit through such comparison.

Step 4. Selective grouping. Selective grouping is an interpretative process of arranging indicators according to criteria. The criteria are not set as hard and fast rules, but are treated as tools for interpretation. NBER employs at least three methods of grouping applicable to interpretation of criminal justice indicators.

The first manner of grouping has been briefly mentioned in step 3, above. That grouping was, according to the criteria of function: leading, coincident, lagging, and unclassified. The last category, unclassified, was not mentioned in step 3 for purpose of clarity of explanation. Unclassified indicators are those not specifically falling into the other categories but which seem of consequence in interpretation of time-series fluctuation.

A second method of selective grouping scores the indicators according to utility criteria. For example, indicators might be scored on their significance or impact on prison growth, statistical adequacy, historical conformity to prison growth, timing record of consistency relating to turning points of prison growth, smoothness of the time-series, and promptness of publication.[29] The numerical scoring of

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[29] A more detailed discussion of these grouping concepts may be found in Moore, Geoffrey H. and Shiskin, Julius, Indicators of Business Expansions and Contractions. Occasional Paper 103, National Bureau of Economic Research, New York: Columbia Univ. Press, 1967.

indicators establishes a means of assigning importance or weighting for forecast construction.

A third grouping employed by NBER is that of classification by sector or economic activity. In economics, for example, a sector grouping of indicators would be that of housing. In criminal justice forecasting, a similar classification would be that of police, courts, corrections, etc. The purpose of such classification is to enable a large research organization conducting criminal justice research to separate the general indicators from specific activity indicators. The strength of such classification, of course, would depend upon the number and variety of indicators generated.

Considerations

Obviously, comprehensive research into indicators of prison growth would require resources of time, funds, and expertise not found in state correctional agencies. Such research, therefore, must begin in a federal organization or through federal funding.

The scope of such research should include the entire field of criminal justice. Emphasis solely on prison population indicators would overlook and discard useful criminal justice forecasting information. Of course, the interrelationships of criminal justice activities suggests that activity indicators other than those for prison population would indirectly impact the corrections' population. For example, specific judicial caseload indicators would aid in identifying possible changes in composition of prison population.

Indicator research, although conducted at a higher level, need not focus solely on aggregate data. The Battelle study demonstrated the feasibility of constructing both state and national indicators.

Indicator interpretation can be accomplished by a variety of means. The problem of grouping dissimilar indicators does not lend impetus for the development of a cut-and-dried interpretative formula. Interpretative formulas tend to be highly subjective and open to differences of theoretical agreement. Loosely-connected assemblages of indicators selected without preformulated schemes have been tried, although forecast accuracy rests wholly in the wisdom of the analyst.

Assumptions

Underlying the application of indicator forecasting to the Criminal Justice System are three major assumptions:

- The forerunner assumption: This assumption sees the state of the art of criminal justice model forecasting as primitive and poorly developed. Existing models lack the needed variable to forecast prison population changes. A general lack of model information stems from inadequate data and errors in model specification. Indicator forecasting, in part, is a forerunner of modeling. Indicators act to summarize processes which have not been modeled. The identification of indicators may facilitate model development.

- The non-random assumption: This assumption asserts that other than non-random influences have greatly contributed to prison growth. This state of non-random regularity portends the possibility of indicator forecasting. Indicators summarize processes or ongoing phenomena rather than single events. These processes may be related to prison growth in economic, social, and demographic manners. The notion of processes implies that prison growth may be represented as a wavelike fluctuation of unequal cycle length.[30]

- The need-to-know assumption: This assumption states that given the unavailability of models to forecast magnitude (size) of prison population, it would still be desirable to forecast the turning points at which time prison size would begin to increase or decrease. Under this assumption, the correctional administrator operates with the knowledge that prison population growth is limited to certain maximum size. Limitations to growth are set by available prison capacity, correctional standards, and the courts stand on overcrowding and civil rights. The correctional administrator may also perceive that the behavior of judges is such that at times their actions alone can determine the exact magnitude of prison population. Therefore, forecasts of specific magnitude may not be as important as would be the forewarning of a reversal of trend.

Accuracy

Indicator forecasting will not estimate future magnitude of prison population or how long growth will continue. The indicator is essentially used as a warning device so that problems can be avoided. Sensitivity to turning points is a quality that sets indicator forecasting apart from extrapolation. Extrapolation does not identify turning points.

Indicator forecasting, in economics, has the history of problems with garbled signals. The unscrambling of information is frequently time consuming, thus cutting down valuable lead time.

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[30] The concept of the wavelike fluctuation of prison population growth is discussed in:

a. Blumstein, Alfred and Cohen, Jacqueline, "A Theory of the Stability of Punishment," Journal of Criminal Law and Criminology, Vol. 64, No. 2, 1973, pp. 198-207.
b. Blumstein, Alfred and Nagin, Daniel, "The Dynamics of a Homeostatic Punishment Process," Journal of Criminal Law and Criminology, Vol. 67, No. 3, 1977, pp. 317-34.

Used by themselves, leading indicators have given misleading signals. The incorporation of coincident, lagging, and unclassified indicators in a form of ratio has been one of several approaches to clarify signals.

Economists have found that indicators have been an indispensable, although imperfect, tool for forecasting. Some difference, perhaps in greater or less degrees of reliability, may be found for criminal justice indicators. However, the prospects of accuracy greater than that enjoyed in economics is not anticipated.

Communicability of Results

Indicator forecasts are commonplace in the field of economics. It can be reasonably assumed that the well-read correctional administrator is familiar with indicator forecasts. Furthermore, the indicator method is similar to the general process of scanning the criminal justice environment. Through scanning the administrator, in many instances, it has intuitively selected and watched indicators of prison population growth. Given this perspective, indicator forecasts may not be difficult to explain.

The approximate level of difficulty for communicating forecast results may be gauged from easy to medium difficulty. Indicator forecasts are not likely to contain complex statistical analysis which increase the difficulty of understanding.

Transferability

If the reader will entertain a side-note on forecasting, a point about indicator forecasts may be made. The side-note comes from the U.S. News and World Report of November 28, 1977. The article is entitled: "If You Think the U.S. Has Trouble Finding Jobs for Young People," and the content addresses the problems of young people in England:

> ... concern mounts about the social effects of so many jobless youths in urban areas ... So far, predictions of rising crime, drug addition, and the like have not been borne out [p. 102].

The quote alludes to the difficulty of limiting the view of the future to just popular indicators of crime. The writer of the article seems to be without useful clues which might account for the condition of the low crime-rate. Some other force or set of forces seem to be at work which are not accounted by the popular view. A wide variety of indicators are more likely to provide signals of criminal justice activity than are a limited few.

The indicator approach to forecasting is not a panacea. Indicator forecasts must be accompanied by other information, such as foreshadowing knowledge of forthcoming policy changes. The indicator forecast does offer the possibility of assessing conditions not amenable to other data-based forecasting methods. The indicator approach may gain support of the administrator seeking information for his intuitive model of prison growth.

CHAPTER VII

FORECASTING PRISON POPULATION BY CAUSAL METHODS

Introduction

Three methods of causal forecasting are presented in this chapter: multiple regression, flow forecasting, and simultaneous equation forecasting.

As might be expected by the name of this chapter, these methods are concerned with the causes of prison population growth. These methods explore the social forces and internal pressures contributing to prison growth. Mechanically these methods are described in simple terms, although, very complex versions could be used in forecasting.

The concept of modeling is often used to describe causal forecasting techniques. This description is more of a convention of usage than a true differentiation between subjective, naive, and causal methods. Models can be any representation of reality from a physical model to a complex mathematical model. We can, for example, speak of models that would be portrayed by simple equations less rigorous than simple least squares. The concept of modeling in this discussion of causal forecasting methods focuses on distinguishing between simple representations of reality from those more complex structures which investigate the relationship of a number of factors in their contribution to prison population growth. In this sense, complexity of structure is being equated to modeling.

Multiple Regression

The characteristics of multiple regression tend to shroud the technique in an aura of complexity and mystery to the unfamiliar onlooker. Multiple regression is a technique usually restricted to computer application and is taught as part of advanced coursework in research. Yet, these characteristics should not stop the potential forecast user from exploring on an intuitive level the mechanical structure, strengths, and caveats of the technique.

The mechanical underpinnings of multiple regression is that of simple least squares--fitting of a line through data. As discussed earlier, the least squares equation permitted the plotting of a line which indicated the relationship of time to prison population. In this relationship, prison population could be said to have but one explanatory variable,[1] time. The nature of the plot of time and prison population occupies two dimensional space and the forecast is represented by a straight line projected into the future.

Multiple regression is an extension of simple least squares to incorporate more explanatory variables.[2] For example, prison population could be "explained" by the two variables: unemployment and size of state population. Changing the least squares equation by adding more

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[1]The term explanatory variable will be preferred in this discussion of forecasting. Later, it will be pointed out that the explanatory variable in time series analysis may not be independent. Since many of the assumptions of probabilistic research are not supported in forecasting, a modification of some terminology will be introduced.

[2]This writer recognizes that this analogy of multiple regression and simple least squares is a simplification. A multiple regression equation is a more powerful tool than least squares. However, for this discussion the simplification does not contradict the basic concepts of either method.

variables also changes the manner of plotting the data. Additional variables require additional dimensions. By adding one variable to the simple least squares, the plot is no longer illustrated by a two dimensional straight line but by a three dimensional form or plane. Figure 30, below, illustrates a plane fit through two explanatory variables by means of a multiple regression equation.

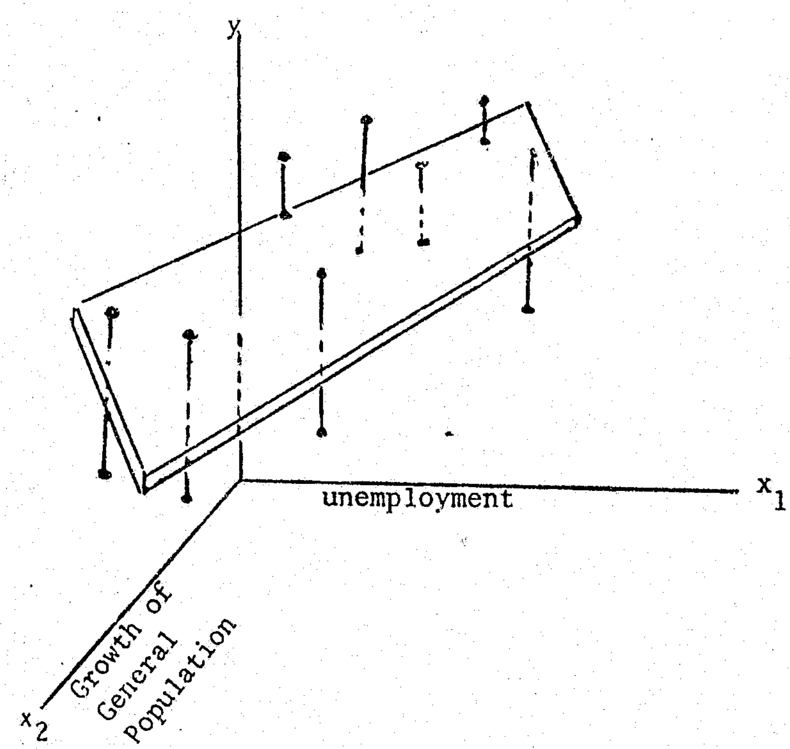

Figure 30. Visual Representation in Three Dimensions of the Fitting of a Plane by Multiple Regression Through Two Explanatory Variables, x_1 and x_2.

In the figure above, an "x_1" variable and an "x_2" variable constitute a set which are linked together by a straight line for the purpose of illustration. The segmented line portions represent that section of the line which is hidden by the plane passing between a set of data points. This illustration shows the plane passing between sets of data to indicate the relationship of unemployment and state population to the growth of prison population (y).

The addition of explanatory variables to a multiple regression equation adds dimensions to the form which is fit between the sets of variables. Thus, the addition of a third explanatory variable would result in the fitting of a form having four dimensions. Such representation of more than three dimensions is difficult to visualize, although it theoretically exists in mathematical space.

Forecasting with least squares did not involve a problem of selecting explanatory variables. The analyst merely measured prison population over a number of years and prepared the data for analysis. The selection of variables for analysis was simple--there were only two variables: prison population (the forecast variable) and time (the explanatory variable). The selection of explanatory variables is not so easy in multiple regression unless the analyst decides ahead of time that he wants to relate particular variables, such as unemployment and state population to prison growth. The question arises: "How does the forecaster decide which variables among the many possible variables are more important to the forecast?" The most common approach to this problem is to use step-wise regression. This form of multiple regression determines in descending order of contribution the variables which are most important to the forecast. The process is "step-wise" because the first round of analysis determines the most influential explanatory variable, the next round or step selects the next most influential, and so on. Resulting from this step-wise analysis is an equation which lists the variables in order of importance and indicates the proportion of each variable that should be used in making the forecast. This is roughly analogous to a baking recipe in which the cook does not just add flour, but a specific amount, such as 3/4th of a cup. In a similar vein, the forecaster does not add just the value of unemployment, but a specific proportion of unemployment. Hypothetically, the results of step-wise regression might disclose that one unit of change in prison population, i.e., 100 inmates, is associated with specific proportions of change in state population, unemployment, and inflation.

At least four advantages can be identified for using multiple regression in forecasting:

1. Factors associated with prison growth can be measured in objective terms. Opinion does not dominate the variable selection process. Also, interrelationships among the factors can be explored.

2. Multiple regression furnishes a method for uncovering factors associated with prison population growth that may not be discovered intuitively.
   - Factors that are divergent and often conflicting can be evaluated to identify the most influential.

3. Factors can be assigned weights proportioned on the basis of association with growth of prison population.

4. Factors can be so represented that the impact of effects can be spread over time.
   - For example, the effects of increased spending for police manpower may not be immediately reflected in an increased prison population. Several years may be required before paperwork processing, hiring, and training of new officers places significantly more personnel on the street. Such a variable as funding can be moved out of step in sequence (lagged) for analysis of delayed impact.

Background and Premises

The interpretation of multiple regression changes in accordance with its analytic application. In the fields of sociology and psychology, the major thrust of research is cross-sectional analysis. In forecasting, the mode of research is time-series analysis. Each class of analysis carries unique assumptions and requirements for the interpretation of multiple regression.

An objective of cross-sectional analysis is to control the environment of the explanatory variables and manipulate their occurrence in order to identify the effects on outcome. The scope of study in cross-sectional analysis represents the effort to measure a very narrow range of phenomena. Assumptions underlying this mode of analysis establish two major conditions which affect the interpretation of multiple regression. The first assumption states that the expected values of the explanatory and outcome (dependent) variables occur in a predictable manner, that is, according to probabilistic concepts. The second assumption asserts that the explanatory (independent) variables are free of influence from the object of prediction, the dependent variable. In other words, the independent variables may affect the dependent variable but the converse of the relationship is not anticipated. Under these conditions of cross-sectional analysis, multiple regression is a very powerful tool. Indeed, so much so that multiple regression ranks among the most popular of tools for that class of analysis.

The power and popularity of multiple regression changes when the conditions of application change. The conditions of time-series analysis in forecasting usually do not support either of the assumptions described for cross-sectional analysis. Because of this difference, the interpretation of multiple regression must be grossly modified. Furthermore, since the difference in interpretation of multiple regression in forecasting does not arise from formula difference, the analyst must look to the data for clues to interpretation.

Prison population growth occurs within a complex social system. Causes and effects tend to become blurred so that variables cannot be clearly identified. A measure of a variable in a complex social system is called an indicator. The concept of an indicator may be expressed as a proposition: Measures of complex social systems are distorted approximations of reality. To this proposition ten corollaries can be defined:

1. An indicator is a summary measure which cannot effectively represent all of the forces of a complex social system.
   - Prison population growth cannot be adequately represented by any single indicator even though high correlation (degree of association) seems to exist.
   - High correlation of a single indicator with prison population growth would be a spurious phenomena resulting from incomplete analysis.
2. Indicators are general in meaning because of error introduced in the process of definition and measurement.
   - An indicator may be defined by administrative fiat, legislative action, or by a consensus of researchers. Even the measurement of prison population must be considered an indicator because measures have been frequently revised from state to state to accommodate changes in definition. A change in an indicator changes the relative meaning of the relationship between explanatory indicators and prison population.
   - Error in measurement arises from many sources, for example: indicator measures are usually collected by agencies and subject to selection on the basis of convenience rather than validity; transmittal from agency to agency often involves summarization of data; interpretation of transmitted data by the forecaster often requires injection of the forecaster's judgment about collapsed data and the intent of the collector; the calculations of data analysis not infrequently introduce error; error may also arise from the impact of unexpected events upon the phenomena being measured.
3. Social phenomena which grow in similar directions (either upward or downward) from whatever influences will reflect a statistical association because of similarity of direction.

- Correlational techniques, such as multiple regression, analyze only numbers without regard for cause.[3] If prison population shows a history of increase, then any time-series that increases will display statistical correlation. For example, prison population growth could be associated with the growth of salaries of college professors. --It would not be academically justified to attempt to reduce prison population by decreasing the pay of professors.

4. Indicators represent only the active influences of a complex social system.

   - Dormant elements in prison growth that later emerge will introduce error into forecasting models. In such instances, a new indicator(s) must be constructed and the model respecified.

5. At times, an indicator may represent both cause and effect.

   - For example, the growth of prison population may be the response to an increase in crime but on some occasions the concern for a growing prison population may elicit greater public awareness of crime in the community. Very possibly both conditions exist at the same time.

6. The exact contribution of an indicator to a specific outcome or event cannot be determined.

   - The observation required to confirm the relationship of complex social phenomena to prison growth cannot be accomplished in an uncontrolled, nonreplicable environment.
   - Causes of prison population growth will remain as theory rather than verified conclusions.

7. Controlled measurement of complex social variables, in general, is not an achievable state.

   - The impetus for collection of indicators does not derive from conditions conducive to the development of experimental control. Indicators are the results of opportunity, funds, agency or organizational interest, and individual opinion. Measurement of social phenomena tends to be a political rather than experimental effort.

8. Adequacy of data as an indicator of a complex social phenomena is relative to the general purpose of forecasting.

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[3]Causal relationships cannot be verified by mathematical equations. A relationship between variables can only be suggested by data analysis. Theory and judgment of the analyst enter into the formulation of a hypothesis of causation.

- Improvement of measurement will always be possible in a system of social indicators. There is an optimal level of precision in data collection beyond which greater efforts at improvement yield diminishing returns in precision.
- Selection of prison growth indicators may depend upon data adequacy in general and the forecasting model's sensitivity to error.

9. No one procedure of indicator forecasting may be optimal.
   - Any forecasting scheme can be improved. As the refinements in indicators and methods and user sophistication continues, satisfaction for a particular forecast of prison population becomes a subjective evaluation.

10. Time is a naive indicator unlike other indicators which summarize complex social phenomena.
    - Time is neither specific in its identification of the social process being summarized nor is it existant. Time is an abstraction when used in a regression equation as a specific variable to represent the contribution of unknown or unmeasurable variables. The inclusion of time as a specific variable is a naive forecasting device signifying only that prison population changed. Such inclusion is void of insight into the nature of that change.

There are no rules for the application of these corollaries, although they should be held in mind when reviewing any technique involving indicators. For example, these corollaries are relevant to the review of the 1974 Battelle study which used multiple regression to construct forecasting models of forty-two case filing categories of the federal district courts. Identified within the study are a number of regression equations having very high correlation (above .95) and a few with perfect correlation to the time-series of various case categories. One of the perfect matches involved a single indicator: direct per capita expenditures by the state for education matched to the volume of prisoner petitions. In this example, educational expenditure might very well be related to social awareness which, in turn, would facilitate interest in civil rights of inmates. But to infer that the single indicator can summarize and reliably forecast the forces underlying inmate activities is questionable. The high degree of correlation of educational expenditure and volume of inmate petitions could arise from several sources, such as an accidental similarity in the direction of growth of the two time-series.

Not only should a forecaster examine high correlations, he should examine any correlation, large or small. There would seem to be little justification in assuming that multiple regression models of only moderate correlation could be free of spurious correlation and other problems. The degree of correlation and existence of indicator problems should be separate considerations in prison population forecasting.

Example

The essential steps in multiple regression forecasting are:

1. Indicator identification
2. Data collection
3. Construction of the multiple regression equation
4. Construction of the forecast

The first two steps are the same first two steps of the technique of indicator forecasting as discussed in another chapter. In the following example, only steps three and four will be presented. The example is drawn from the 1977 State of Colorado Corrections Master Plan.

Step 3. Construction of the multiple regression equation. Construction of the multiple regression equation is nearly always accomplished by a computer program. Step-wise regression is usually the program of choice. In preparation for the input of data, the forecaster should sort the indicators so only those which seem to possess a plausible link to prison growth are used. The data may be input in several forms, again upon the judgment of the forecaster, for example in some form of transformation, such as logarithmic form or manipulated by lagging.

The results of multiple regression analysis for Colorado data produced a model having four explanatory variables: Colorado's unemployment rate, rate of parole revocation, rate of diversion to community programs, and size of risk group (males, 18-49 years of age).

Step 4. Construction of the forecast. A forecast derived from a multiple regression model is not merely an extrapolation of a pattern; that is, a geometric plane is not projected into the future. A geometric figure of more than two dimensions could not be graphed. A forecast via multiple regression is made by inputting data about the future into the model. Data about the future are contrived by forecasting or lagging the indicators. Lagged data are suited for very short-term forecasts because data are not usually lagged more than several years. An exception to this is a class of demographic data. Children born during the last few years can be lagged into the future to represent the size of later groups of young adults. In the majority of cases, indicators must be forecast by such means as simple least squares. Thus, variables may be forecast before being used by the multiple regression model.

The Colorado forecasters used a multiple regression equation to construct alternative forecasts of prison population. By altering the assumptions underlying the four explanatory variables of the model, three projections of prison population were obtained as illustrated in Figure 31 below.

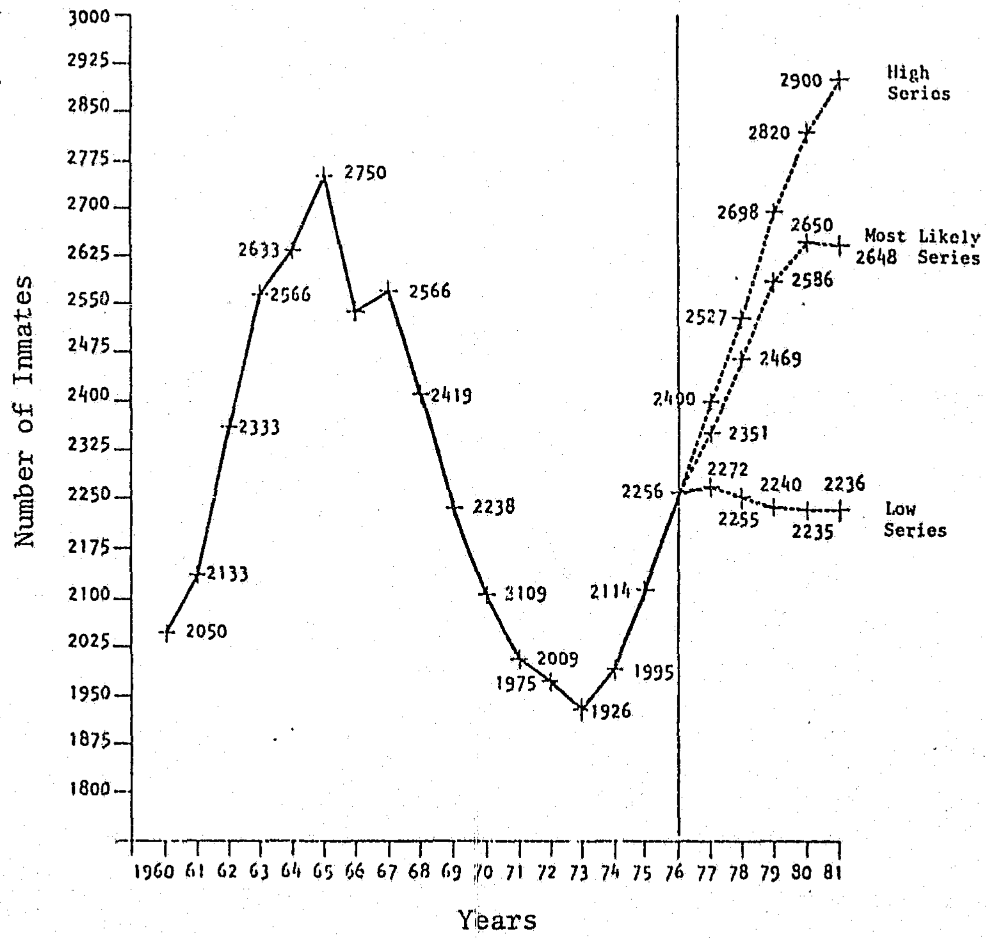

Figure 31. Colorado Prison Population Forecast with Three Alternative Futures Constructed by Means of Multiple Regression
Source: State of Colorado. 1977 Corrections Master Plan, p. 3.40

The alternative futures forecast above depicts a high forecast, most likely forecast, and low forecast. The construction of alternatives means that the regression model was run three times using three different data sets. Each computer run analyzed a different set of forecasted indicator data. For example, unemployment was projected as continuing at 5 percent of the employable population for the low series, 6 percent in the most likely or middle series, and 7 percent in the high series. Of course, the crucial element of constructing the data sets was to appropriately group the assumptions and the data derived therefrom into homogeneous units.

The Battelle study, mentioned earlier, uses multiple regression in a slightly different manner. That difference of approach is note-worthy here. A separate indicator forecasting model was constructed for each of forty-two case filing categories in much the same way Colorado constructed its model for prison population--instead of one model Battelle constructed forty-two. The Battelle forecasters then constructed a "surprise free" forecast for each case category. The surprise free forecast is somewhat analogous to the "most likely" forecast constructed by Colorado. A surprise free forecast implies that the indicators will follow a course of logical development in accordance with their history. Put in a familiar frame of reference, a surprise free forecast is merely a forecast of the kind well-known to most readers--a forecast without alternative futures. Each surprise free forecast contained estimates for five, ten, and twenty years into the future.

The major difference in the Battelle and Colorado studies was that instead of changing data sets and reanalyzing the data, Battelle modified the projected values of the surprise free forecast. The modification involved adding or subtracting the impacts (change in number of cases) brought about by events not included in the surprise free forecast. These impacts were assessed by a panel of experts which had agreed that certain surprises or changes could occur in the federal district courts. For example, increased decriminalization of drug use could bring about a decrease of twelve cases per 100 in the volume of prisoner petitions filed. Using this estimate, the projected figures for prisoner petitions would be adjusted downward at a rate of twelve cases for every 100 originally forecast. Increases in volume rather than decreases could also occur for other surprise events affecting prisoner petitions. Together, the increases and decreases in filing volume constituted the modification of a surprise free forecast. Modifications were made for each of the forty-two filing categories at five, ten, and twenty years into the future. Through this process of including surprise events, the output of regression analysis was altered to reflect the future as it might appear if the most likely changes occurred.

Mentioned earlier in the section on "Background and Premises", a concept was established that multiple regression differed in interpretation because of the differences in data. In cross-sectional analysis probablistic data assumptions can be made, but in time-series analysis probabilistic data assumptions are not supported. The data input into multiple regression for a forecast is arbitrarily selected by the forecaster. The Colorado and Battelle studies demonstrate several ways to approach the selection of data. The power of multiple regression becomes somewhat irrelevant in forecasting if agreement is not reached between forecaster and user/decision-maker on assumptions about the manner of selecting and modeling data.

Assumptions

The general application of multiple regression to forecasting seems to imply, at least, these five assumptions:

1. Assumption that accuracy on the parts is greater than for the aggregate: This assumption is the justification for using models which choose not to naively forecast prison population as a single variable over time. The forecaster assumes he can forecast the variables within the multiple regression equation with greater accuracy than if he naively forecasted prison population.

2. Assumption of a non-cyclical future: Regression analysis treats data in such a manner that magnitudes and sequences in timing are irrelevant. The analysis focuses on relations among forces that become operative in specific circumstances. General movements of prison population develop in the direction that interaction of forces dictate.

3. Assumption of no feedback: The multiple regression equation is not designed to consider the impact (feedback) of prison growth on the explanatory variables. For example, the number of inmates sent to prison would not be influenced by the size of the prison population. The regression model attempts to separate cause and effect into independent (explanatory) and dependent (outcome) variables. The independent variables predict the dependent variable. Because of feedback, outcome of a forecast may not be the result of just the independent variables but of itself also. For this reason, the term "dependent" variable will be sometimes replaced by "outcome" or "forecast" variable.

4. Assumption of independence between explanatory variables: Multiple regression is applied in cross-sectional analysis upon the assumption that the explanatory variables do not derive from the same causes, that is, they are independent. However, the indicators of time-series analysis are not as clean and neat as the variables of cross-sectional analysis. Indicators may at times be related because of the influence of causal factors which are unmeasured or unmeasurable. This condition of non-independence is known as collinearity for two related variables and multi-collinearity for more than two. The use of highly correlated indicators would defeat the purpose of constructing an explanatory model in cross-sectional analysis but is more acceptable in forecasting. There are instances in which a multiple regression forecast can be improved through the inclusion of correlated variables. The use of indicators precludes the requirement of independence. In the sense of the word, the independent variables in forecasting are not independent. Thus, in this study the term "explanatory" variable is sometimes substituted for "independent" variable.

5. Assumption of continuing relationships: The regression equation produces forecasts of prison population and is unaffected by the data fed into it or by the outcome. The regression model assumes that the relationship of forces (indicators) that exists today will continue into the future. In other words, a model of prison growth established in 1948, given the necessary data, should accurately forecast 1978's prison population. This assumption is also referred to as the steady state assumption.

Accuracy/Span of Forecast

The use of more than one explanatory variable in a forecast does not assure greater accuracy than found in naive forecasting. The inclusion of a greater number of explanatory variables would, hopefully signify that the forecaster is able to replicate the past wi greater accuracy than possible by naive methods.

A surprise-free forecast which correlates highly with records of past prison growth would seem to offer, on face value, a reasonable chance to forecast the short-range future (1-2 years). The further removed the forecast target, the more likely an accumulation of man-made changes will alter the growth of prison population from the predicted path.

The forecaster is dealing with a second kind of accuracy, turning point accuracy, which is not characteristic of naive forecasts. Rather than estimating population figures, turning point forecasting signals the approximate time a change in direction of prison growth could occur. Again, accuracy would be expectedly better for the short-range forecast.

Multiple regression in time-series analysis carries a lower potential for accuracy than in its application in cross-sectional analysis.

The general nature of time-series data can support only vague statements about general trends in the intermediate and far future. The esteemed Bertrand de Jouvenel (1967) observes that

> It is utterly implausible that a mathematical formula should make the future known to us, and those who think it can would have believed in witchcraft. The chief merit of mathematicization is that it compels us to become conscious of what we are assuming [p. 173].

Multiple regression differs from naive methods in opening the forecast to evaluation of its components. By varying the data input into these components, alternative futures present an array of assumptions that can be evaluated by the decision-maker. A greater opportunity to evaluate assumptions may not affect accuracy as much as it may improve credibility.

Considerations

Forecasting credibility can be further improved by examining indicators that are correlated. Highly correlated indicators may be substituted for explanatory variables that are not as intuitively appealing to the modeling of prison population growth. For example, police expenditures may be highly correlated to GNP which was selected as the better explanatory variable in the regression analysis. Although the accuracy of the model might be slightly lower by substituting police expenditures, the meaning of the model is reconciled with theory of prison population growth.

The forecaster may, also, consider substituting an instrumental variable (those variables subject to administrative control) at the expense of a more efficient explanatory variable. This substitution may result in a decrease in accuracy but an increase in value to the decision-maker. A model with one or several instrumental variables could be used to evaluate the impact of administrative decisions on prison population. For example, parole revocation in the Colorado forecast is an instrumental variable. By varying the data sets, that is, by raising or lowering the number of paroles, the administrator can preview possible impact of parole alternatives on prison population growth. This modification of a model addresses the administrator's raison d'etre--the management of the organization and control of prison population.

Communicability of Results

The mechanical/statistical structure of multiple regression is more difficult to convey than the mechanics of linear extrapolation, yet not so difficult that it would be considered esoteric. Other elements of the forecast, e.g., indicators and assumptions can be easily described. If the forecaster avoids the implication that statistical complexity is accuracy, a multiple regression forecast should be within the grasp of understanding of most decision-makers.

Time Considerations

Multiple regression exists in most statistical analysis packages available for computers. Run time for such a program is brief. Calculation without a computer is virtually impossible. The preparatory time of data collection may require more time than the analysis of data. This, of course, depends upon whether data will be collected on a large number of variables or restricted to a limited few on hand.

Resources and Cost

Three major resources are required to forecast prison population by multiple regression. The first is a computer. The second is an analyst/forecaster familiar with time-series analysis and criminological theory. The third is data. A rough rule of thumb about data is that a minimum of fifteen data sets for each explanatory variable and for the prison population are needed.[4]

Given the hypothetical (and perhaps far-fetched) situation that in-house expertise, computer facilities, and a rich expansive data base exist, the cost of a multiple regression forecast could be as low as several hundred dollars.

Transferability

Multiple regression is now being used in various states at various levels of sophistication. As computers become widely available, increasing use is anticipated.

Multiple regression as a tool for forecasting prison population falls into three areas of application. The first form of application has been the focus of the discussion above--the modeling of several indicators to forecast prison population. The second application would be that of preparation for forecasting. Multiple regression may be used to evaluate indicators for later inclusion in a more sophisticated forecasting model. In the third application, multiple regression is a tool in multiple-equation model building such as in simultaneous equation fore-

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[4]Less than ten observations per variable is not usually recommended. A precise estimate of the number of observations depends upon the desired precision of the coefficients.

casting. In this role multiple regression would be employed to estimate the values of various components of a model of prison population.

Flow Model Forecasting

Flow model forecasting is composed of a family of methods, some of which presently are being used in corrections. This family contains, for example, simple flow models, dynamic flow models, systems dynamics models, queueing models, and Markov models. The ease of understanding of these models varies from the very easy for the simple flow model to very difficult for the Markov models.

The majority of the flow forecasting methods share three characteristics:

- Systems approach to forecasting:
  The basic data are derived by research which identifies the number of persons moving in and out of the prison system
- Flow-chart representation:
  The representation of prison population would be depicted in the familiar chart of input and outgoing flows.
- Closed view of the Criminal Justice System:
  The slow process of forecasting does not incorporate outside (exogenous) variables into the model. The forecaster focuses on activity within the Criminal Justice System to the exclusion of examining social causes of arrest.[5]
  This closed view means that flow models must be combined with other forecasting techniques; i.e., trend extrapolation, in order to estimate future system inputs and other flow characteristics affected by external factors.

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[5]An exception to this practice of excluding external information can be found in a dynamic flow model constructed by William Shaffer (Court Management and the Massachusetts Criminal Justice System. Ph.D. dissertation at the Alfred P. Sloan School of Management, M.I.T., Cambridge, Mass.: 1796). Shaffer established a simple cause-effect relationship between feed-back on the rate of incarceration of offenders and deterrence.

In addition to the three characteristics above, there is another quality that permeates the study of flow forecasting. That is the quality of having a confusing terminology. Each method tends to rename the elements of flow analysis. For example, the terms branching ratios, decision rates, and decision point percentages are interchangeable. For the neophyte forecaster, the learning of relatively uncomplicated basic concepts is impeded by terminology problems.

History

The history of interest in flows dates back to mankind's earliest plumber. Social application of flow concepts appears formally in the early 20th century. Early social application dealt with industrial production and monetary flows.

The direct ancestors of contemporary social flow forecasting are not found in one but five areas of research. This mixture of ancestry accounts, in part, for the diversity of terminology. Operations Research (OR) gained status in World War II. After the war OR fostered interest in queueing theory, which is an approach for improving system performance through reallocation of existing resources. A second ancestor, systems engineering, grew out of the struggle to understand complex technical systems that came as part of the machine/computer age. Systems research, a third form of flow analysis, does not reflect the complexity of OR or systems engineering. The goal of systems research is simply that of identifying the relationships among parts of a system and its operation. The fourth ancestor, systems analysis, is the progeny of military weapons systems research during the 1950's. In the early 1960's, McNamara enthusiastically endorsed systems analysis as a means of improving governmental functioning. Systems analysis attempts to evaluate cost and effectiveness of flow structures (programs) and to propose alternative designs.[6] The fifth approach to flow research, input/output analysis, is a recent development in economics during the 1960's. Input/output analysis identifies and quantifies cash flows between industries.

Flow forecasting is gaining popularity for prison population planning. LEAA is funding research in information systems and had done so since the early 1970's. Out of this research on information systems for the Criminal Justice System has come the concept of OBTS (Offender Based Transaction Statistics) and other data bases which are capable of providing much of the essential data for flow forecasting. As the implementation of these information systems grows, the use of flow forecasting models will increase.

Example

The simplest flow model of prison population would be that of subtracting prison outflow from prison intake. A five year forecast of prison population using the simple flow model would sum up the yearly projected intake, add that to the number now in prison and subtract the sum of the projected releases.

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[6] Alfred Blumstein defines these four areas of systems research in "Systems Analysis and the Criminal Justice System," The Annals. No. 374, Nov., 1967, p. 93.

The flow forecast example that will be described in this section is more detailed than the simple flow model above, although the concept is the same. The model selected as the example is SPACE (Simulation of Populations from Arrest to Corrections Exit) developed under the auspices of the Council of State Governments in 1977. This model is not presently in use, although it was constructed and tested on the offender population flows of several states.

The basic flow forecasting procedure contains four steps:

1. Identification of system flows
2. Collecting flow data
3. Constructing the model
4. Estimating future inputs and rates
5. Constructing the forecast

Some variation of these steps can be expected within the broad family of flow models. SPACE represents the general configuration of the flow forecasting process.

Step 1. Identification of system flows. The flows of the prison population may be viewed as either general (aggregate) flows or in detail according to specific kinds of offender categories. For example, SPACE divides prison inputs into three aggregate flows: incarceration, probation revocation, and parole revocation. A flow forecasting model developed by Florida corrections considers fourteen sub-streams within the incarceration flow. These sub-streams represent classes of admissions, such as type of crime and sentence length. The justification for disaggregation would be to gain greater sensitivity to possible changes in flow and to quickly estimate later impact on the nature and number of the prison population.

The system of flows as represented by SPACE is illustrated in Figure 32 below.

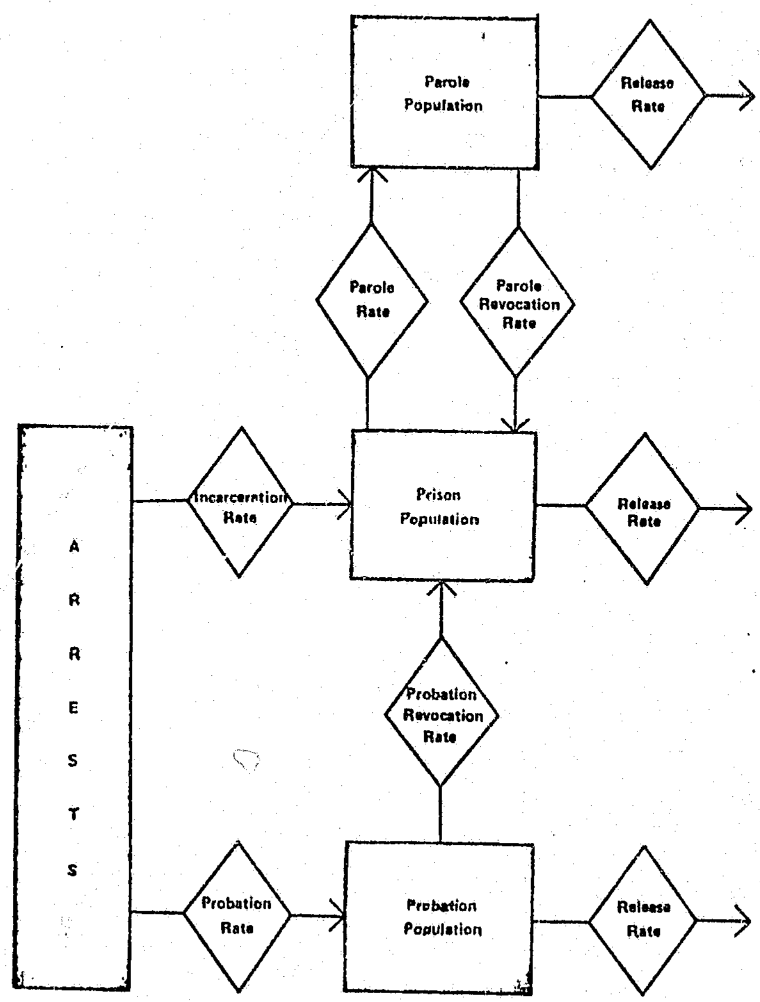

Figure 32. The SPACE Flowchart Which Simply Describes the Flows Into and Out of Prison
Source: Council of State Governments, "Planning for Changes in Populations," Lexington, Ky.: Council of State Governments, p. 3.

The flowchart does not describe flow through the courts. Flow is represented as coming directly from the stage of arrest. This representation is an expedient because court data are often difficult to obtain and then difficult to interpret. The increasing availability of court information systems, such as PROMIS (Prosecutor's Management Information System), may help to plug the data gap between arrest and incarceration.

Step 2. Collecting flow data. The flow analysis within SPACE calls for the counting of the number of persons in the ten stages of the flow model:

- Arrests
- Probationers
- New probationers
- Released from probation
- Probation revocations
- Parolees
- Parole revocations
- Prisoners
- New prisoners
- Unconditional releases from prison

If SPACE is to be an ongoing forecasting program on the data above, variables would be collected on a monthly basis for computerized analysis.

Step 3. Constructing the model. As described earlier, pool size of prison population is that number remaining after adding inputs and subtracting releases from the previous population count. Flow models that do not incorporate probabilistic concepts, e.g., Markov chains, are relatively easy to calculate.[7] For example, JUSSIM II is

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[7]Flow forecasting becomes difficult to understand for the non-expert when the analyst decides to represent flows in probabilistic terms. The analyst is essentially saying that he is uncertain about the exact number of the arrivals and prefers to couch his estimate in terms of likelihood. Monte Carlo simulation, Markov chains, and queueing concepts are the most common methods of probabilistic flow estimation.

much more elaborate than SPACE, yet the calculations for future pool sizes are not much different.

An important consideration of modeling flow is that an arrival at one stage of the system does not immediately affect pool size at another stage of the system. For example, those offenders arrested today do not immediately enter prison; there is a delay of several months before prison population would gain that person. The determination of these delays is a major aspect of flow modeling.

In the SPACE model, prison population is calculated by six operations:

Count:	(1) Number of persons in prison
Subtract this:	(2) Proportion of arrestees incarcerated X (times) Number of arrests 4 months previously
Add:	(3) Proportion of probation revocations X Number on probation 2 months previously
Add	(4) Proportion of parole revocations X Number on parole 6 months previously
Subtract:	(5) Proportion of prisoners released on parole X Number of persons in prison 8 months previously
Add:	(6) Proportion of prisoners unconditionally released X Number of persons in prison 6 months previously

Written in the form of a mathematical eqution for the SPACE computer program, the six operations appear:

$$N_{t+1} = N_t = (LAMBDA_t A_{t-d4}) + (V_t L_{t-d2}) + (R_t P_{t-d6}) - (C_t N_{t-d8}) - (MU_t N_{t-d6})$$

This equation merely establishes that next month's (t+1) prison population is the result of the six operations described above.

Step 4. <u>Estimating future inputs and rates</u>. Immediate-term, that is next month's prison population can be calculated from the lagged data in SPACE. To forecast beyond the lagged data, such as three months into the future, requires contrived data. The analyst has to individually forecast the ten model variables which will then be analyzed by the model in making the SPACE forecast. The SPACE computer program contains a sub-routine that extrapolates a trend for each variable. For example, the computer program would use past data on arrests to fit a straight or curved line and project the number of possible future arrests. Opinion of the forecaster is required if the curve fitting routine is to be modified to match a particular view of the future; i.e., to stress the most recent data rather than all data equally. If the analyst elects not to use the sub-routine for variable estimation, a "best guess" can be substituted.

The rates of parole and probation are often assumed to remain relatively constant, and therefore, are easy to forecast. The number of new arrests, on the other hand, is an unstable variable and not so easy to estimate.[8] Guesswork plays a greater role in forecasting arrests than in most of the other variables of the SPACE model.

Step 4. Constructing the forecast. The obvious manner of forecasting with SPACE is to substitute the lagged and forecasted data into the forecasting equations and solve. This calculation provides a single forecast of the months ahead.

Alternative forecasts can be made in order to assess the effects of changes in assumptions. For example, SPACE can evaluate changes in the rate of prison release, a concern also investigated by the Colorado multiple regression model. The Florida model with its disaggregated intake flows could construct alternative forecasts to test the effects of changes in sentencing. Both concerns for sentencing and release are now of interest for prison planning in those states adopting determinate sentencing laws.

Assumptions

Underlying SPACE are five assumptions. These assumptions tend to typify flow forecasting models.

1. Assumption of specification: Flow models assume that a complete mathematical formulation of prison population growth does not exist or has not yet been developed. The alternative to such development is to simulate the actual movement of persons within the Criminal Justice System.

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[8] Belkin, et al (1973) assert that "In a multi-year run [of a Criminal Justice flow model], such parameters as branching ratios and probabilities of rearrest may be reasonably constant, but the number of virgin [new] arrests will almost certainly vary. ..." [The forecaster may] "include a table of virgin arrests for a several year period ... As the program calculates the results for different years, the values for virgin arrests for that particular year will be automatically taken from the table." [Belkin, Jacob; Blumstein, Alfred; & Glass, William JUSSIM II, An Interactive Feedback Model for Criminal Justice Planning. Pittsburg: Carnegie-Mellon University, June, 1973, p. 15].

2. Assumption of simplicity: SPACE and other simply constructed flow models assume that a trade-off exists between model complexity and longevity of model application. The less complicated the flow model, the greater the forecaster's awareness to what's happening to the data at all points in the flow. This awareness seems related to the user's interest and ability to maintain the program. Complex models that are difficult to comprehend tend to fall into disuse after direct support of the model builder, who is often an outside consultant, is withdrawn. This consideration of simplicity came into play in the development of SPACE.[9]

3. Assumption of reality: This assumption does not underly the flow model as much as it characterizes the perception of the onlooker. Flow models in their appearance of dealing with recognizable numbers in a non-abstract manner seem to represent reality. Yet, in actuality the specification, that is, choosing the elements to include in the model was guided by the opinions and theories held by the forecaster.

4. Assumption of adequacy: Flow models assume that those elements essential to the derivation of the forecast are included--those not successful are excluded. SPACE, for example, excludes feedback information on pool sizes. Only the flows into and out of the pools are modeled. SPACE does not consider that feedback about prison capacity will influence the rate of incarceration flowing from arrest through the courts. The SPACE model, as it stands, could forecast more inmates than capacity would permit. This unbounded tendency to forecast results from the simple calculation of the pool size as the sum of flows. The mechanism for extrapolating values for future flow variables is not governed by feedback on pool loads (vacancies). The decision-maker cannot assume that policy actions excluded from the model are adequately considered in the forecast. For example, SPACE cannot assist the decision-maker in assessing the need to build prisons. The act of increasing capacity could result in a counter-intuitive increase and the rate of diversion decrease in response to perception of the judiciary of improved housing and treatment of offenders.

5. Assumption of arrival: Estimating arrival or input into the flow model is, perhaps, the most difficult and important aspect of flow forecasting. SPACE does not specifically

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[9] The assumption of the trade-off of complexity and model use in the design of SPACE was discussed in personal communication with Tom Henderson of the project staff for SPACE.

resolve the problem of determining future arrests. The Florida model represents inputs via multiple regression. Other flow models such as Markov Chain models, assume that flow between various stages of the model cannot be described precisely. Therefore, probabilistic simulation depicts the uncertain arrivals at each stage in terms of likelihood. The manner of representing arrivals is a major characteristic by which the types of flow models can be distinguished.

Span of Forecast

The forecast span for flow models should be considered in terms of lead-time. That is, corrections officials would be made aware of a soon-to-come increased incarceration flow when an increase of arrests occurs. In the SPACE model that lead-time was four months. Lead-time forecasts cover periods of just a few months, although the range can be extended if the forecaster judges he can accurately forecast the variables of arrivals and departures for a longer period of time. During periods of fluctuating conditions, such as in the early 1970's, the forecast span was relatively short--perhaps, no more than one or two years.

Accuracy

The accuracy of flow models as referenced above depends on two conditions: ability of the analyst to forecast rates and inputs and upon the stability of prison growth. During relatively stable prison growth in Oregon in 1976, SPACE forecasted six months ahead with only 1 to 2 percent error. In the same year, SPACE forecasted prison population in Florida for nine months with a monthly error that ranged from 1 to 5 percent and a 3 percent overall error.

Precise flow forecasts should not be expected. When close forecasts are encountered, as in the above instances, this may be more accidental than planned precision. Accidental precision in the beginning stages may mislead the user to expect similar accuracy in longer range forecasts or during periods of unstable conditions.

Flow models are particularly sensitive to record keeping problems in the Criminal Justice System. SPACE, for example, does not trace flow through the courts. Besides the general inaccessibility of court records, the files are maintained according to cases instead of offenders. Translating cases into definable individuals within a flow becomes a problem to cost and accuracy. For the disaggregated model which depends on FBI data, the accuracy of count in crime categories is less than desirable. As one forecaster expressed, "holes" in the data thwart efforts to improve flow accuracy at the police processing stage.

Communicability of Results

The ease of describing flow forecasts is, of course, related to model complexity. SPACE is not as difficult to describe as are models containing probabilistic flows or feedback loops. Graphic representation of flow facilitates communication. Overall, flow forecasting is relatively easy to explain and understand.

Time Considerations

The most time consuming facet of flow forecasting is, often, that of data collection. The advent of OBTS (Offender Based Transaction Statistics) will no doubt alleviate part of the problem of data collection.

Once data are on hand, a simple model could be developed and programmed in a few weeks. The time to debug and test revisions, that is, to correct programming and specification errors, increases as model design becomes more complex.

Resources Required

The construction of flow models requires collecting a data base to accommodate calculation and rates of flow. This means that each of the ten SPACE variables may need to be supported by one to two years of monthly data.

SPACE is a rather simple model which does not require an in-depth knowledge of systems analysis or simulation programming. The analytic program for SPACE is pre-packaged, as is JUSSIM II in form of a computer program. SPACE is available at no charge upon request, whereas JUSSIM II carries a price tag of $50,000.

Although SPACE appears to be a bargain, the user would still encounter start-up costs and computer run expenses. Run expense amounts to several dollars for SPACE and up to ten dollars for JUSSIM II.

Flow forecasting not only involves the explicit costs above but, also, implicit costs. Implicit costs stem from the decision to implement flow forecasting. Building a flow model from scratch can be costly and time consuming. Such an outlay assumes continued use. SPACE requires monthly input of data. JUSSIM, at $50,000 assumes that application in either the line agencies or academic institutions. The demand for use will be rather frequent.

Transferability

The development of OBTS concepts and implementation of criminal justice information systems is a positive indication that the interest in flow forecasting will increase. The area of promise for flow forecasting is that of evaluating possible effects on prison population of tentative policy/administrative flow changes, such as changes in good time, probation, and parole.

Simultaneous Equation Forecasting

Forecasting via simultaneous equations is popular in the field of economics. So greatly has been the association of simultaneous equations with economic forecasting that the method has gained the identity of being the "econometric method."[10] Simultaneous equations is an algebraic concept which can be applied to other fields and types of data, thus the name "econometric method" belies the latitude of potential application.

Simultaneous equation forecasting is somewhat similar to least squares. In one regard a simultaneous equation can be viewed as a revision of least squares which seeks to compensate for the assumptions of independence. Least squares assumes weakly in time-series data that a change in an explanatory variable must temporally occur before the event being forecast. For example, a change in police and judicial activity must necessarily occur before a change in prison population. This assumption about the order of temporal occurrence denies the possibility that feedback about prison population size, such as overcrowding, could influence the courts to divert a greater percentage of offenders from

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[10]"Econometric" refers to a group of analytic techniques which combine the disciplines of economics, mathematics, statistics and accounting. Some interpretations portray econometrics as the mathematical application of economic concepts.

prison or influence the police to shift priority from less serious offenses which might backlog local jails. Least squares also assumes weakly in time-series data that explanatory variables explain the variable being forecast (dependent variable) but do not explain each other. Under this assumption a change in one explanatory variable should not affect another explanatory variable. For example, if prison population were forecast from variables representing police activity and court activity, then a change in police activity should not affect output of the judicial system. Simultaneous equations can be used in instances such as these when the assumptions of independence are questioned.

In another regard, a simultaneous equation can be considered an extension of multiple regression. A multiple regression equation is comprised of several explanatory variables which are usually estimated by naive means, such as simple projection. Rather than naively estimating explanatory variables, a simultaneous equation develops models of the explanatory variables. These models disaggregate the explanatory variables into their components. For example, police activity may be estimated by its components of planned budgets and projected population growth. This extension of analysis builds submodels within an overall model. The simultaneous equation, then is known as a multiple equation rather than a single equation forecasting method.

A single equation forecasting method, such as multiple regression may not effectively represent a complex social system. Usually, a multiple regression equation does not contain more than four or five variables. On the other hand, a simultaneous equation can portray the effects of many variables. For example, econometric forecasting models have been constructed with over 100 variables. This does not mean that it is presently possible to build such a model of prison population growth, but it does open the door to more effective modeling.

The basic structure of the simultaneous equation derives from elementary algebra. This structure is not so complicated that the fundamental concept cannot be grasped even by someone discomforted by topics of a mathematical nature. The essence of the structure of simultaneous equations can be represented in two equations, (1) and (2) below:

(1) $X - Y = 1$

(2) $X + Y = 5$

The structure of these two equations implies that the two unknown values, X and Y have known outcomes when added or subtracted to each other. The values of X and Y can be found in this example without great difficulty. By expressing equation (1) in terms of X:

(3) $X = Y + 1$

a new equation has been constructed. Although this new equation shows that the value of X is still unknown, the representation of X's value $(Y + 1)$ is such that it can be substituted for X in equation (2). Equation (2) now becomes

(4) $Y + 1 + Y = 5$

By adding the Ys together in equation (4) and moving the value "1" across the equal sign, the equation reduces to

(5) $2Y = 4$
or $Y = 2$

Now that the value of Y is known, the value of X can be found merely by substituting Y's value into one of the two original equations, either (1) or (2). For example, equation (1) will appear as

$$\text{(6)} \qquad X - 2 = 1$$
$$\text{or} \quad X = 3$$

This process of solution has permitted the expression of X and Y in terms of each other in order to solve for their values.

This simplified solution of the simultaneous equations above suggests that a simultaneous equation is more than a set of separate equations listed and solved sequentially in an independent manner. The solution of large simultaneous equation models is solved in a similar manner as portrayed above, although several subequations may be considered (reduced) at the same time.

In the following discussion of simultaneous equation forecasting, further elaboration on the mechanics of solution will not be required. The discussion will focus on the intuitive elements of the method and important aspects of application.

History

The 1960's was a period of resurgence of experimental interest in simultaneous equation forecasting in economics. The concept of large econometric forecasting models had been around for 20-30 years but the problem of massive data analysis had to await the development of electronic computers. After the electronic computer became an economically viable tool, acceptance of econometric models did not automatically evolve. One of the many resistances to acceptance lie in the abstract and mathematical nature of econometric models. These unfamiliar quantities placed econometric models beyond the understanding of the would-be user, the business executive. Those econometric models which were designed so that the business executive could understand them seemed so simplified that other methods appeared as good.[11]

As the 1960's progressed into the early 70's, an interest developed in crime as an economic phenomena. Research on economic factors of crime was spearheaded by Gary Becker in 1968.[12] Following his lead, a number of other economists, i.e., Stigler, Harris, and Erlich contributed to the microeconomics of crime behavior.[13] In the area of corrections, an increasing interest in economic models of prison growth may be drawing impetus from:

- The accumulation of economic data: Economic research has accumulated data resources and files that are massive in comparison to most forms of criminal justice information. Data collection in economics has been a major effort for decades. How much of that data is applicable to prison population forecasting and crime analysis is a concern yet to be fully explored.

- Economic policy is one of the few tools under some control of administrators and policy makers. The control of prison growth and crime may of necessity focus on economic factors. Econometric modeling offers a way of testing hypotheses about the effects of economic manipulation on criminal justice activity and prison growth.

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[11]Edward Bennion in "Econometrics for Management" (HBR, Vol. 39, No. 2, Mar.-Apr., 1961, pp. 100-112) offers several other factors which may have retarded the acceptance of econometric models.

[12]Becker may be seen as reviving the notion of the "rational" or "economic man" concept which had been proposed by Jeremy Bentham in the early 19th century.

[13]The early articles on crime and economics are: Becker, G. "Crime and Punishment: An Economic Approach," 1968. Stigler, G.L. "The Optimum Enforcement of Laws," 1960. Harris, J.R. "On the Economics of Law and Order," 1970. Ireland, T.R. "Optimal Enforcement of Laws: A Comment," 1970. Ehrlich, I. "Participation in Illegitimate Acts: A Theory and Empirical Investigation," 1973 & "Deterrent Effect of Capital Punishment," 1975.

- The Uniform Crime Report is dominated by crimes in the categories of robbery, burglary, larceny and auto theft. All of these categories suggest that economic factors may be involved in crime. The economic link of crime may be open to further analysis and study through simultaneous equation models.

- Given the interest of economists in crime, the move toward econometric models in forecasting may be part of the natural trend toward more sophisticated economic research.

- General public concern often focuses on the monetary return of governmental spending. Recently, correctional treatment programs have received critical scrutiny from the standpoint of economic evaluation of impact. As public attention for governmental spending increases, the concern for the economics of crime control is not likely to diminish.

- The contemporary correctional administrator as contrasted to the administrator of 20-30 years ago is more business oriented and economically informed. Through contact with general business publications and newspapers, the correctional administrator may be introduced to concepts of econometric forecasting.

Although large scale application of simultaneous equation forecasting may not occur in corrections, the considerations above suggest that this form of forecasting could become a topic of growing interest.

Example

The process of forecasting with simultaneous equations can be summarized in seven steps:

1. Specification of the hypothesis or theory underlying the forecasting model

2. Translation of the hypothesis/theory into a mathematical equation

3. Determination of data and other resource requirements--pilot study if necessary

4. Construction of the forecasting model

5. Evaluation of the forecasting model

6. Forecasting with the model

7. Verification of the forecast

The illustration of these seven steps will draw upon James Fox's study, "Econometric Analysis of Crime Data" (1977).[14] In this study, Fox forecasts the general growth of crime to the year 2000. His model deals with the front-end of the Criminal Justice System, crime and the police. Fox's forecasting model is a closed system in which feedback from down-stream elements, such as corrections, is not considered: the police-crime model exist independently of the other elements of the Criminal Justice System. The response of the courts and corrections to an ever-increasing arrest rate is not represented as capable of influencing police behavior.

Step 1. Clearly specify the hypothesis or theory underlying the model. The specification of a simultaneous equation forecasting model is far from being an objective exercise. Variables for the model are judgmentally selected according to the forecaster's preference. The completed model is the expression of his opinion of the future.

Failure to specify the theory implies an objectivity not possessed by the model. In some instances, a highly complex simultaneous equation forecast would be difficult to theoretically interpret without guidance of the forecaster's explicit statement of his theory about the future.

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[14]Fox's work generally follows the seven steps, although some difference exists. Those differences have been downplayed because the objective of the study is not to critique his work, but to illustrate a subjective process of model building. In several instances, Fox's work does not specifically report a step that has been illustrated. In these instances, the discussion presents an interpretation of what might have occurred in the construction of his model.

The econometric forecast constructed by Fox was based on the following hypotheses about the growth of crime:

1. Crime is not a homogeneous unit. Aggregate growth is the result of changes in violent crimes and property crimes.

2. The violent crime rate is negatively related to the clearance rate for violent crime and positively related to both the critical risk group and the price of consumer goods.

3. The property crime rate is negatively related to the clearance rate for property crime and positively related to the critical risk group and the price of consumer goods.

4. Clearance rate is negatively related to the crime rate and positively related to the size of the police force and arrest rate.

5. "The size of the police force is a positive function of police expenditure."

6. "The expenditure for police is a function of the total crime rate of previous years" [pp. 38-41].[15]

Step 2. Translate hypotheses/theory into mathematical equations. Step 2 is a step often hidden during the construction of a simultaneous forecasting model. Although hidden, its importance should not be brushed casually aside. Translation of the hypotheses into mathematical terms is a process which glues together the theory and the forecasting model.

The inspection of Fox's translation of theory into mathematical equations will first identify the symbols which represent elements of the hypotheses:

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[15]The first four statements are modifications of Fox's stated hypotheses on pp. 38-41.

Y_1 = Violent Crime Rate

Y_2 = Property Crime Rate

Y_3 = Clearance Rate for Violent Crime

Y_4 = Clearance Rate for Property Crime

Y_5 = Size of Police Force

Y_6 = Police Expenditure

Y_7 = Arrest Rate for Violent Crime

Y_8 = Arrest Rate for Property Crime

Y_9 = Total Crime Rate

x_1 = Critical Risk Group for Violent Crime

x_2 = Price of Consumer Goods

x_3 = Critical Risk Group for Property Crime

μ = Error Resulting from Random Shocks and Unaccounted Influences

Using these symbols the approximate mathematical equations of Fox's model can be illustrated:

$$y_1 = y_3 + x_1 + x_2 + \mu_1$$

$$y_2 = y_4 + x_3 + x_2 + \mu_2$$

$$y_3 = y_k + y_5 + y_6 + y_7 + \mu_3$$

$$y_4 = y_2 + y_5 + y_6 + y_7 + \mu_3$$

$$y_5 = y_6 + \mu_5$$

$$y_6 = y_{9-\text{ lag } a} + y_{9-\text{ lag } b} + \cdots + \mu_6$$

$$y_7 = y_1 + y_5 + y_6 + \mu_7$$

$$y_8 = y_2 + y_5 + y_6 + \mu_8$$

$$y_9 = y_1 + y_3$$

The equations above have been simplified for the purpose of illustration, therefore do not follow exact notational form. For example, the y_6 equation in a simplified manner illustrates that police expenditure is a function of the crime rate of previous years.

The condition of interdependency can also be seen in the equations above. Interdependency is indicated when variables are involved in the explanation of each other. For example, the rate of violent crime is partially explained by the clearance rate (for violent crime). In a reciprocal fashion, the clearance rate is partially explained by the violent crime rate. Both violent crime rate and clearance rate partially explain each other.

Inspection of the model above also discloses that variables may indirectly affect one another. For example, in the y_1 equation, the variable y_3 appears as an explanatory variable. Inspection of the equation for y_3 discloses that y_5, y_6, and y_7 explain y_3. Indirectly, then, these three variables explain part of the initial equation for y_1. In the process of reducting the simultaneous equation, as demonstrated in the example in the introduction to this chapter, the values of y_5, y_6, and y_7 can be substituted into the equation for y_1, when calculating a solution.

The maze-like complexity of relationships and interrelationships tends to repulse many persons. Yet, this representation of reality may be no more complex than is the sensitivity of the astute correctional administrator who has mapped in his mind the intricacies of the environment in which he works.

Step 3. Determine data and other resource requirements. In step

3, the forecaster meets one of his many challenges to maintain the theoretical integrity of his model. The variables identified in the translation of the model may not have the resource of collected data which can exactly represent them. Rather than settling for precision, the analyst must accept indicator data which generally resemble the variables in his model. Obviously, the problem of step 3 is to select measures which will not compromise the theoretical underpinnings of the model. With each selection of data the analyst must judge the impact of his choice upon the model.

Fox, for example, selected the Consumer Price Index (CPI) as the measure of x_2, price of consumer goods. The CPI measures changes in prices of goods and services purchased by urban wage earners and clerical workers. As such, it does not directly evaluate the impact of price changes on lower class consumers. The risk population for most UCR Part I offenses is not the middle class but the lower class. Thus, the CPI is an approximate measure. The relevancy of the indicators could be evaluated further if it were possible to examine Fox's unwritten intentions. For example, if he had intended to measure the concept of comparative welfare of the general risk group, the CPI becomes even further removed from similarity to an ideal measure.

The analyst must consider in the selection of measures, the feasibility of data collection. The size of the research budget and access to resources can shape decisions about the choice of measures.

Such considerations as discussed above suggest that selection of measures of the variables in a simultaneous equation model is not wholly an objective practice with hard and fast rules. It would not be unreasonable to expect that two forecasters holding identical theories could construct dissimilar models.

Step 4. Construct model and test. Two steps ago in step 2, Fox's simplified mathematical equations were presented. Those equations, however, are not the version appearing in the mathematical model. The mathematical model version of the equation for variable y_1 (violent crime rate) appears as:

$$y_1 = B_1 + B_2 y_{3t-1} + B_3 x_{1t} + B_4 x_{2t} + \mu_{1t}$$

The process of going from step 2 to this equation above involves the analysis of the measures selected to represent the variable for violent crime. If the reader checks the similarity of the y_{1t} above and the equation for y_1 in step 2, the notational differences are those of B (Beta weights) and the subscripts for time lag. The Beta weights which are often estimated by modified least square methods play the role of determining how much or how little of the value of each variable will be added in the equation. B is expressed in the form of a fraction (coefficient), such as .5. The subscript notation for time lag can be seen in the section of the y_1 equation: $B_2 y_{3t-1}$. This particular subscript for lag indicates that the variable y_3 is lagged one period. This one period lag means that instead of using the present clearance rate (y_3), the rate for one year ago is used.

The process of model construction also checks to determine if all of the equations can be reduced or solved. Fox, for example, found that for two of his equations, the Beta weights could not be estimated. As a result he chose to drop the variables of violent crime arrest rate

(y_7) and property crime arrest rate (y_8). Such a decision to eliminate variables could radically change the theoretical basis of the forecast model and therefore must be cautiously accomplished. Fox, for example, sought to justify the design and evaluate the impact on the model in this rationale.

> It seems reasonable to exclude the arrest rates on substantive grounds as well. Crime and clearance rates deal with offenses, whereas arrest rates deal with offenders. Discarding y_7 and y_8 avoids this inconsistency [p. 35].

Not always can the problem of inability to reduce equations be so easily resolved. Reformulation of the model in step 2 could be called for.

As a result of step 4, Fox's mathematical model abbreviates his hypothetical model; fewer equations are contained than initially envisioned. This step may not always involve abbreviating the model, other cases could call for expanding the number of equations.

Step 5. Evaluate the model. In this step, the analyst determines how well the model operates and if that functioning is logical. Operation is assessed by feeding historical data into the model and comparing similarity of forecasted outcome to actual outcome. Fox generated forecasts for the years 1952-74 and found that his model tended to produce what he judged to be a reasonable match between the forecasted and actual crime rate. Similarity, though, of past and forecast does not prove that the future can be forecast accurately. A number of possible interferences or influences could be operating to produce a spurious match.

The model may also be inspected or evaluated to assess sensitivity to changes in variables. A large change in forecast resulting from a slight change in a less important variable signals to the forecaster that a revision should be made in the model structure. On the other hand, a large change in a lesser variable that has no impact on the forecast could indicate that the variable could be dropped from the model.

The final form of the model should be no more than a fine tuning of the original model. Revision should seek to maintain the integrity of the model's theory.

Step 6. Forecast with the model. This step is similar to step 5's testing with historical data. The basic difference is that future data, of course, does not exist and must be contrived in order to create a forecast.

Not all variables of the model require contrived data because some can be calculated within the model. The variables not requiring outside data are known as "endogenous" variables. Those variables which are not calculated within the model but require supplied or contrived data are called "exogenous" variables. A forecast, then via simultaneous equations requires only data on exogenous variables. For example, in Fox's model some of the exogenous variables were:

x_1 = Proportion of population, non-white, 18-21 years old

x_2 = Natural logarith of the CPI

x_3 = Proportion of population, non-white, 14-17 years old

The future measures or estimates of these exogenous variables can either be forecast by the analyst or obtained from other sources.

In the case of the variables x_1 and x_2, the data were obtained from a publication of the Bureau of the Census, "Projections of the Population of the United States: 1975-2050." Through such contrived or forecasted data, Fox was able to produce a forecast about the rate of crime to the year 2000.

Step 7. Verifying the forecast. The forecasting process is often not considered to be complete when the forecast in step 6 is produced. The evaluation of the model in step 4 assessed forecast quality with historical data but does not support or lend credence to the model's view of the future. Actually in operational terms, a forecast cannot be verified but it can be compared to other opinions and forecasts from other sources and inspected for credibility.

Econometric forecasts often are adjusted according to the opinion of experts who have inspected the mechanics of the model. Such adjustment, of course, affects the objectivity and theoretical structure of the model. The point to recognize about such processes of verification is that a forecast cannot be accepted on face value without some form of consensual validation that the forecasted future is possible.

Assumptions

A system of simultaneous equations (forecasting model) rests on a number of assumptions. Although many of these assumptions are not unique to simultaneous equation forecasting, some of them deserve to be reviewed in this discussion. Five particular assumptions are identified below:

- Assumption of Stability: Stability of the relationships among variables is one of the major assumptions underlying simultaneous equation forecasting. During the process of model building the structure of variable relationships is established as if they are permanent conditions. Change, if it is envisioned, is assumed to occur slowly. For example, Fox's forecasting model holds that social relationships fostering crime will not significantly change before the year 2000.

- Assumption of Random Error: The symbol or term "μ" in the system of simultaneous equations is an estimate of error. This term represents the analyst's hopes that those variables not included in the model will not be important omissions. If a particular and pronounced pattern of error between forecast of the variables and actual values is detected, then the analyst will need to reformulate his model. Of course, the error term cannot accommodate large shocks to the Criminal Justice System which might be caused by unexpected disturbances as major civil disorder or war.

- Assumption of Disaggregation: The major justification for breaking a variable into a model of its components (disaggregation) is that greater forecasting accuracy is achieved. The measures selected to represent the variables could, through their added errors of dissimilarity with the original variable, offset the gain of disaggregation.

- Assumption of Specificity: Construction of a system of simultaneous equations assumes that the analyst is able to exactly describe how variables with the system interact. The model structure logically converts input data into a forecast. If the structure of variable interaction cannot be specified, probabilistic models may be called on. The probabilistic model establishes probability relationships of input and outcome without exactly describing the mechanics of variable interaction.

- Assumption that Dynamic is Better than Static: Most simultaneous equation forecasting models are dynamic rather than static. A static model does not consider the effects of time in forecast calculation. The changes within the static model are depicted as occurring at the same time. In the dynamic model time passage is considered in the interaction of variables.[16] For example, Fox's model lagged the clearance rate by one year. This lag asserts that last year's clearance

[16] A very readable treatment of dynamic modeling concepts can be found in Hubert Blabock Theory Construction (Englewood Cliffs, N.J.: Prentice-Hall, 1969).

> rate rather than this year's is the information known to the police, reported to the public, and acted upon by policy makers for next year's program.

Span of Forecast

The time horizon of econometric models is but a few months and rarely beyond two years. The forecast span for economic data is affected by volitility (evenness of trend) of the data and desired accuracy. Correctional data, perhaps, offers the possibility of stepping from short-range to medium range (2-5 years) forecasts. Long range forecasts (beyond 5 years) via any forecasting method must be considered only as an interesting guess about far-away things to come.

Accuracy

Accuracy in simultaneous equation forecasting has three forms. The first form is that of accuracy in detecting turning points of prison population growth. This form of accuracy is an aspect not shared by naive forecasting methods. Such accuracy would most likely decrease as the time horizon is extended.

A second consideration of accuracy is the presence of error arising from faulty specification and measurement. Both of these concerns of specification and measurement have been defined above. The handling of these errors is different in simultaneous equation models than in simpler methods.[17] Specification error can sometimes be improved upon through the maintenance of a forecast record which can later be

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[17] Erich Streissler cogently points out that "simultaneous equation models do not only require precision statistics--those are already required for single-equation regression models--they require precision theories as well" [p. 72]. [Pitfalls in Econometric Forecasting, Tonbridge Printers, Ltd., 1970].

analyzed. The objective of such analysis of forecast record is to trace the error in the disaggregated model to specific structural elements which may need to be respecified. This process of identifying sources of specification error and improving thereupon is, of course, not possible in naive forecasting methods. The problem of both specification and measurement error becomes very complex as model size increases. The intricacies of structural error becomes hazy and difficult to examine in the presence of numerous inaccurate measures of exogenous variables. The forecaster must find the optimal trade-off between increasing accuracy through further disaggregation and decreasing ability to identify sources of error.

Accuracy of the simultaneous equation model is also related to its application. For example, forecasts of prison population would tend to be more accurate when applied to a comprehensive or nationwide forecast than to single states. The individuality of state politics would be evened out in a comprehensive model of the nation's prison population.

In retrospect, an evaluation of accuracy suggests that simultaneous equation forecasting has the potential to surpass the accuracy of many other methods. Whether that accuracy can be achieved or not may require years of experimentation and research. At the present, simultaneous equation forecasting models are expectedly clumsy and inaccurate.

Considerations

The purpose of forecasting is an essential consideration in building a simultaneous equation forecasting model. A forecast model which includes variables under the control of the decision-maker (instrument variables) may be of greater use than a strictly exploratory forecast not having instrument variables. The forecaster can vary the instrumental variables to disclose for the decision-maker's inspection the effect that certain decisions might have on the growth of prison population. For example, an instrumental variable in Fox's model was that of police budget.

Often overlooked in modeling is the need to plan the construction of complex models. In an interesting study of this overlooked problem Garry Brewer (1973) in Politicians, Bureaucrats, and the Consultant points out that many modeling projects end-up as a disorganized and very costly product that cannot be used.

Among the many suggestions for the planning of model construction, three seem especially relevant in this discussion of simultaneous equation forecasting. First, the simultaneous equation model should be simply formulated rather than starting out in complexity. Expansion to greater complexity can be undertaken after the essential structure is designed. Secondly, model development should be related to available time. The guidepost for the planning of model complexity is the degree of accuracy that can be attained within the time period set for construction. Thirdly, the forecaster must approach expensive models as programs to be developed for ongoing use in the user organization. Requirements which would make a simultaneous forecast model an ongoing program should be agreed upon by the forecaster and decision-maker before an expensive model development program is funded.

A major pitfall of simultaneous equation forecasting and other complex models is that of computer halo. The aura of computer program intricacies tends to obscure from the user the theory upon which the model is based. The fact tends to become hidden that amount of computer programming and development expense can compensate for forecast error stemming from weakness of theory.

Communicability

The mechanics of simultaneous equation forecasting can be very difficult to communicate. The best focal point for communication may be that of beginning the explanation with a clear and simple statement of the model's theory. The results (output or forecast) of the model can be displayed simply in a graph.

Communicability of this form of forecasting cannot be considered easy. A rating of communicability would lie within the medium to difficult to understand range.

Resources/Cost

Building a simultaneous equation forecasting model of prison growth would require unique resources. In a state correctional agency the decision-maker who will use the forecast should be considered as a resource. His involvement will not only preclude the problem of selling the finished product, but may assist in the identification of instrument variables as well.

The construction of a large simultaneous equation model usually requires the interaction of several persons, e.g., a team of researchers. Such a team may include persons with talents in simulation programming, econometric modeling, systems analysis, and criminal justice theory.

The cost of simultaneous forecasting could easily become exorbitant unless agreement is established at the beginning about the limits of program cost. In general, this method of forecasting is considered as expensive. For example, a large and complex econometric model for industrial use may cost between $50-100,000.

Transferability

Simultaneous forecasting models of prison population are more likely to be constructed at the national level than at the state level because of the availability of expertise, funds, and data. The introduction and spread of this form of forecasting may be analogous to the growth of econometric forecasting in economics/industry. Experimental application occurred first, followed by application to large systems, and later spreading downward to major industries.

A simultaneous equation forecast model of collective (national) prison growth could function as a benchmark by which to check and compare other forecasts of prison growth. For example, in a large state several years ago, prison population was forecast to continue decreasing over a ten year period. Prison population in other states, however, was on an increase at the time of the forecast. Because of that collective increase the question should have been raised about the impact of nationwide influences on the development of local attitudes about imprisonment. Several years later the state's prison growth came into line with the national trend. The existence of a general simultaneous equation forecasting model of national prison growth could have served as a basis for comparing the rationale and structure of the state-made forecast.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

The Place of Forecasting

When the topic of prison population forecasting is broached in conversation, the common response is to seek a specific figure or number of inmates. The idea of a future number, though interesting, does not convey the total notion of roles played by prison population forecasting techniques. Although there may be more, at least five roles can be identified. In the first role, forecasting techniques appear as a manner of clarifying a problem. Not always are the planners, decision-makers and policy-makers lacking information about conditions affecting prison growth; they may have too much information. Forecasting offers a method of reducing a mass of data and opinions into coherent packages of information. This process of analyzing and packaging may compel the various persons to consider a broad range of factors and at the same time elicit a homogeneity of results.

In the second role, prison population forecasting is seen as a political tool. This role considers planning as a subjective process. In the political context, forecasting provides a way of addressing data about prison population so that the discussion of planning can move on to topics about goals and values which may be concern for debate.

The mere recognition that forecasting occupies a place in the political process of planning does not insure effective use of forecasting techniques. There must be more to the consideration of this role than just that awareness. For example, a multi-alternative forecast that offers several interpretations of the same data base,[1] also offers to opponents of a plan, ammunition for their positions. In the open arena of legislative discussion about the future of prisons, such attempts to be objective by the forecaster would, at the same time, detract from the position of the correctional administrator.[2] In the closed environment of the administrator's offices, such multi-alternative forecasting may stimulate planners to look further into their assumptions and suppositions of outcome. Thus, in one situation a forecasting technique may detract from planning and in another it can help stave off the tendency for planning to become routinized.

Readily seen in the political consideration of forecasting is the need to fit the tool to both purpose and audience. It is commonly held that the application of scientific method to the estimation of future prison population should facilitate reduction of prejudice and bias. Reduction of bias in a process which involves subjective selection of assumptions and data does not necessarily concurrently affect the process of having plans adopted. In the process of proposing plans in a political environment, the administrator may

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[1]Forecasts which reinterpret the data from several perspectives are known as argumentative or counter-forecasts.

[2]The possibility of offering the opposition ammunition has also been pointed out to the author as a problem of using a range of estimate around a single exploratory forecast of prison population.

prefer to use that tool from among a set of equally adequate forecasting techniques which supports his presentation. This political consideration reflects a Machiavellian attitude in its implication that forecasting should not be wholly objective. If, however, the future is viewed as being influenced by decisions of the correctional administrator and policy-makers, the notion of a true future awaiting to be discovered by objective exploratory forecasting techniques does not stand the test of reason. The search for wholly scientific objectivity in the forecasting of events and conditions affected by political and social decisions may need to be replaced by the pursuit of a rational social planning. This pursuit would recognize that correctional planning is not premised on passive reaction to the environment, but tends to focus on shaping the future with an awareness of what is possible and what is in line with the values of decision-makers. In this light, more than one future is open to a responsive organization with appropriate leadership. Prison population forecasting may then be a part of the political process which affects the size of future prison population.

A third role that prison population forecasting plays is that of providing an estimate by which to evaluate performance of correctional programs. For example, a correctional administrator has various options open through which prison population can be reduced. Planning for that reduction, though, would mislead the decision-maker if future goals of reduction were based on present levels of prison population. General goals, such as "to reduce population by 10 percent," become meaningful when related to the forecasted increase, decrease, or stabilization of prison population. A goal of 10 percent reduction might be reevaluated if the forecast suggested that a 15 percent decline in population might occur if only present operational conditions were maintained. In such instances, a forecast contradicting the implication of program goals does not, of necessity, call for discarding the favored program. The recognition of possible incongrous plans and outcomes may stimulate the decision-maker to justify programs on other bases.

A fourth role of prison population forecasting addresses the requirement of providing expected information for budget requests and grant approvals. This role is almost ritualistic and often unrelated to budget approval. Nevertheless, the forecaster and administrator must select the appropriate forecasting technique to meet information expectations of those reviewing the budget proposals.

The fifth role of prison population forecasting is heuristic in nature. The forecasting process of investigating assumptions underlying prison growth can add to the administrator's understanding of the Criminal Justice System's behavior. This role is related to the type of forecasting tool used. Simple extrapolative forecasts of prison population would not contribute as much to the administrator's understanding as would causal forecasting models.

Planning to Forecast

Much has been said in the previous section and chapters about the considerations of selecting a forecasting technique. The most concise presentation of selection considerations appeared in Tables 1 and 2 of Chapter IV.

Not much has been said about planning to forecast and reporting the results. Although these aspects have been by-passed in previous discussions, they are important elements of forecasting.

The first concern in planning to forecast is the determination by the decision-maker of the need for a forecast. Sometimes the decision-maker is not the originator of the forecast request; the forecast originates in the activities of a research department. In either case the question of what kind of decision will be based on the forecast should be ascertained. Different decisions call for different kinds of information to be gathered by normative or exploratory techniques.

As seen in previous chapters, there are intuitive techniques, exploratory techniques, and normative techniques. Each class of technique can address a different kind of information problem. The forecaster, though, is not limited to any one technique, as he can employ a combination of techniques. Since the informational need in forecasting prison population is not the same in every situation, the analyst or decision-maker cannot rely on a single technique for all applications.

Also relevant in the plan to forecast, is the attitude of the decision-maker toward forecast error. For instance, given the problem of deciding to construct additional housing for inmates, the decision-maker is faced with several concerns. Having fewer inmates in prison than expected is not as damaging logistically as is having too many. Overbuilding, on the other hand, may be politically damaging, particularly if the administrator were to again seek money for expansion projects. Overbuilding, with its political implications, may not be all that serious a problem to the administrator. The history of job holding and longevity indicate that few top correctional administrators hold their position for more than five-ten years. Thus, a five-year building program which overestimates prison population may not adversely affect the administrator. The error of short-term prison population decrease, though, might affect the administrator's credibility even though his long-range estimate calls for an aggressive building program.[3]

Given a simple trend line enclosed by a range of estimate (range of possible error) as a forecast of prison population to be considered in planning prison construction, the administrator may choose to report either of two interpretations of the forecast in substantiation of his plans. The very moderate administrator may choose the trend line as his forecast. The cautious decision-maker would choose the top range (largest estimate) as his basis of planning. The top estimate carries the assumption that variation in prison

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[3]This statement about credibility is cautiously expressed. The author's experience in corrections suggests that at least on some local levels (county prison camps), that the warden establishes "accordion" capacity. That is, he reports capacity at different levels during different times of the year. During the winter months when inmates cannot work as much outside, the capacity of his facility is reported to be less than during the summer months when popular country work projects call for a large inmate work force. The astute state correctional administrator may similarly adjust to situations of short-term population fluctuation.

growth would not surpass this point because of growth limitations imposed by constraints within the Criminal Justice System, i.e., by capacity of the police to arrest and the courts to prosecute. The cautious administrator has chosen to err in favor of over-estimation and therefore avoid the possibility of overcrowding and its complications of inmate unrest and judicial intervention.

The wise administrator, in contrast to the moderate and cautious decision-makers, may use one of the approaches above; however, he will not completely rely on a statistical forecast. His approach is sensitive to the fact that prison population is not as stable a phenomena to forecast as is the general national birthrate and is affected by political decisions and social conditions. The wise administrator may take the trend forecast into consideration but that is not the only future information he digests. He may include his own information gained in scanning the environment and ideas gleaned from other forecasts. Planning to forecast for the wise administrator is an active commitment to seek information.

Another concern of planning to forecast is that of deciding to track the forecast. The concern for tracking is relevant in exploratory forecasting and less so in intuitive and normative methods. Tracking helps to give early warning of change of prison growth from the forecasted path. Early warning of change is particulalry important in cases of planning which use forecasts developed at earlier times. Tracking also establishes a forecast record so that causal forecast models can be evaluated as to the source of error; e.g., as suggested in the discussion of simultaneous equation forecasting.

A fourth concern of planning to forecast is that of selecting the format for reporting the results. The format, of course, is structured to suit the purpose and audience. Elements included in an exploratory forecast are not set, but variable, according to the complexity of the forecast. In the list of format elements below, the first four elements should occur in all exploratory forecast reports whether they report simple or complex methods. The fifth element should appear in in-house reports but may not appear in some published reports. The sixth element should be reported for multi-alternative forecasts.

Format Elements for Reporting Exploratory Forecasts

1. Assumptions of the technique
2. Assumptions of the data and correctional system
3. Graphic or tabular presentation of the prison population forecast
4. Statement explaining methodology
5. Identification of the range of estimate
6. Identification of events and trends which might affect the projected trend

These six format suggestions are more appropriate for exploratory forecasts, although, most of the elements could be adopted in some form for the reporting of normative and intuitive forecasts.

Assessing the Forecast

In evaluating a prison population forecast, the decision-maker cannot be guided by the same principles used in assessing prediction in cross-sectional analysis. Since forecasting is, in part, an art and not wholly objective or quantifiable, the assessment of prison population forecasting may need to turn attention to questions of utility. A primary consideration of utility is that of determining how well the technique meets its purpose. Obviously, an expensive and time-consuming forecasting method would not be suitable for estimating the general growth of a local jail or county work camp.

Choosing between several forecasts offered by different forecasters could require that the administrator assess the skill of the analysts in using the available information and techniques. Expertise of the correctional forecaster, in a large part, depends upon his familiarity with the Criminal Justice System. Just as the correctional forecaster would not be expected to forecast in the field of missile technology, the technological forecaster may not, without familiarity, enter the field of correctional forecasting. Time and study would be required for the technological forecaster to effectively pursue forecasting prison population. In this assessment of different forecasts, the administrator is also challenged to draw upon his knowledge of the system in order to raise questions about the assumptions underlying the forecasts.

The many and varied kinds of forecasting techniques make the task of establishing uniform evaluation guidelines difficult. There are, however, several criteria that are of uniform concern. Objectivity of the forecast is a relevant criteria. Objectivity, obviously, is the goal of applying techniques to a speculative endeavor. Explicitness is another criteria. Explicitness of reasoning and of assumptions is the only means by which to open the art of forecasting to inspection by a decision-maker. Without this explicitness, the most expensive forecast should be as suspect to question and doubt as is the cheapest estimate. Among the most frequently overlooked criterion is the ability of the forecast to incorporate the decision-maker's questions and concerns into the forecast. For example, a multi-alternative forecast that overlooks the decision-maker's interests may be regarded as unuseful as the simple naive forecast which offers few insights.

Pitfalls of Forecasting

In the study of prison population forecasting, certain problems and errors seem recurrent. Twelve pitfalls seem to characterize these problems. For ease of discussion, these twelve pitfalls have been classified according to the source of the problem.

Pitfalls Relating to the Forecaster

The misperception of sophistication is an error found to be among the most prevalent of prison population forecasting errors. The misperception arises as the result of equating sophistication of the forecast with complexity of mathematical tools rather than to the sophistication of the forecaster. The art of correctional forecasting draws heavily upon the sensitivity and awareness of the analyst to operation of the Criminal Justice System within the social environment. Naive forecasts cannot be assumed to enjoy higher status than other forecasts just because of complexity.

The pitfall of misplaced objectivity is related to the error of misperception. In a claim of objectivity, the forecaster denies that he is making value judgements in selecting data and performing analysis. He claims that he is using scientific tools and that his analysis seeks only to impartially identify the major trends of prison growth. Although seeking to present "this is how it is," the analyst had to make assumptions about the future. Failure to state those assumptions or ignorance of the assumptions does not make his forecast an objective statement.

The error of dependence on a single method is analogous to the problem of construction of a house without a hammer--everything requires banging. In a similar vein, there is a tendency in prison population forecasting to run all data through curve fitting equations without regard for data restrictions, the assumptions of the future, the purpose of the forecast, and other concerns. In some instances, the researcher is unaware of other tools or has settled on a favorite way of forecasting.

The misapplication of method is an error that sometimes arises because of the researcher's misunderstanding of the difference between time-series analysis and cross-sectional analysis. A signal of such misunderstanding is found in the statement of the future magnitude of prison population in terms of confidence intervals.

In the social fad pitfall the researcher is influenced to select a forecasting method on the basis of its popularity rather than its utility. For example, this writer has found the Delphi technique recommended as a cure-all for a variety of criminal justice forecasting problems. Those persons making the recommendations often lacked an awareness of the method, its requirements, and problems.

The Edsel Error is so named because it represents one of the all-time blunders in forecasting. One of the major errors made in that forecast was the failure to consider the attitudes and buying preferences of the intended consumer. The Edsel error can also occur in prison population forecasting. For example, experience has shown that plans to reduce prison population based on forecasted flows to community-based projects have sometimes failed to consider the community. In some instances, the intended locations of community-based half-way houses have been rejected by the community and, subsequently, have not been built.

The pitfall of wishful thinking, in some respects, may be considered as a sub-class of the Edsel error, but is sufficiently important to deserve individual attention. In this form of error, wishful thinking is disguised as a forecast of prison population. The implication of the disguise is to assure the audience that the assumptions of growth have been assessed and that a program proposal resting on the forecast can encounter no problems. This disguise differs from the normative process of forecasting which evaluates the likelihood of encountering other difficulties. An example of wishful thinking may have been the forecast, in the early 1970's, that sufficient prison capacity existed and that other programs could be instituted instead of construction.

Pitfalls Related to the Forecast User

The "Give Me One Forecast" pitfall characterizes the situation in which the decision-maker seeks what he perceives as the real future of prison population growth without questioning the assumptions and basis of the forecast. Use of an unchallenged forecast was an embarrassment to at least one correctional administrator known to this researcher. The administrator found that he could not defend his forecast when confronted with a contradictory forecast.

Forecasting can be used as an excuse for not planning. Although this problem was not specifically encountered in this study of prison population forecasting, its possibility of occurrence deserves mention. The call for more information is a common ploy for delaying or avoiding making a decision. To ask for a time-consuming study and forecast of prison population would be a scientific way of obfuscating the issue.

The pitfall of the search for the perfect tool may characterize the thinking of both the decision-maker and forecaster. In this realm of thought, more funds must be spent and research conducted in the hopeful search for a better exploratory forecasting tool. This focus of attention ignores the possibility that the problem is suited to normative forecasting. This search also tends to overlook the data restrictions which limit exploratory prison population forecasting.

Pitfalls in Using Forecasts

The self-fulfilling prophecy pitfall is an obvious problem of forecasting. By making known a forecast, the condition being forecast may be affected. This self-fulfilling effect is cautiously approached in business. This effect may hold in certain instances in prison population forecasting. The possibility of a self-fulfilling prophecy is evident in the release of the FBI's forecast of rising crime in the early 1970's. The effect may have been to influence policy-makers to allocate more money to law enforcement with the resulting impact of increasing crime reporting and arrest.

The inflationary pitfall is subtle and may not be noticed by the forecaster or decision-maker. The basis of this pitfall is identified by Bauer (1966):

> Virtually every trend series pertaining to social problems has a built-in inflationary bias that would make it look as though things were 'getting worse', unless the trend for improvement were very strong [p. 30].

This implication carries a cautionary note for assessing exploratory forecasts of prison population.

Environmental Conditions Affecting Forecasting

In addition to the general pitfalls in forecasting described above, difficulties in forecasting also arise from within the correctional environment. Some of these correctional difficulties will affect the aggregate forecast of overall prison population; others will impact efforts to forecast various prison population components, such as the number of inmates estimated to require psychological services in the future, the number of inmates in each custodial class in the future (for estimating housing needs), etc. These problems of environment are germane to correctional forecasting, although similarities may be recognized in other fields.

The first environmental problem to be discussed is a major concern for causal forecasting. That concern is for the lack of a theory of prison population growth upon which models can be built. The relationship of such factors as crime rate, demographic characteristics of offender risk groups, and economic conditions have not been fully integrated into a theoretical model which explains prison growth. By comparison, economic research has progressed to the state at which general theories provide a focal point for study and model building. Durkheim's concept of stability of punishment is one of the few theories which attempts to explain prison population growth. The specification of the mechanics of Durkheim's concept into a working theory, however, is still in the beginning stages of development.[4]

A second environmental problem is that of defining what is meant by a trend. A trend is more than affixing a line through data points; it involves the identification of what is generating the forecasted growth. For example, in a particular state correctional agency, an analyst obtained data about psychological treatment

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[4]The reader interested in current research on Durkheim's concept may refer to:

Blumstein, Alfred and Cohen, Jacqueline. "A Theory of the Stability of Punishment," The Journal of Criminal Law and Criminology, Vol. 64, No. 2, 1973, pp. 198-207.

Blumstein, Alfred; Cohen, Jacqueline; and Nagin, Daniel. "The Dynamics of a Homeostatic Punishment Process," The Journal of Criminal Law and Criminology, Vol. 67, No. 3, 1977, pp. 317-334.

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3 OF 4

programs in order to forecast future housing needs. In the process of inspecting the data, the analyst found that a change of program administrators had brought about a change in the policy of what constitutes treatment. As a result of the change, the data showed that during a period of increasing overall prison population, the number of inmates housed for psychological treatment increased under the old administrator and decreased under the new administrator. Given such data, the analyst faced the problem of defining and mathematically justifying his forecast of future growth of inmates housed for psychological treatment. This problem faced by the analyst is not an isolated example of the difficulties in defining correctional trends; rather it reflects the fluidity of programs brought about, in part, by the debate over the role of corrections in the service of criminal justice.

A third problem which affects correctional forecasting is the sensitivity of prison population flows to political decisions and other subjective processes. In contrast to the practice of forecasting the general population of the United States, laws and actions of persons at decision points in the Criminal Justice System affect prison population growth. In one state, for example, the rate of incoming inmates seemed to change after judges were given a tour of overcrowded prisons. In another state, a drug treatment program had been designed to serve a particular number of inmates that was forecast to be eligible for treatment. Soon after opening, however, the drug problem was found to be too small. From the inspection of the problem, the correctional analyst surmised that some judges increased the percentage of drug using offenders they committed to prison so that more persons could receive drug treatment. Such examples of the subjective nature of controlling the prison population flow indicate that the analyst must function in an environment in which hard data does not forecast subjective actions and counterintuitive processes.

Adequacy of data is another concern of the correctional forecaster. Data inconsistency is not an unfamiliar problem. For example, in 1976 the GAO inspected the records of the headquarters of the Bureau of Prisons and found that only the initial custody classifications of inmates were recorded; later custody classifications assigned at the institutions were missing. Such incomplete information could not be used in forecasting housing needs based on estimated custody assignments.

Data adequacy is also reduced by changes in definitions of collected measures. For example, the National Prisoner Statistics (NPS) contain several changes of definition of prison population. Not too long ago the reported prison population of the various states became a planned undercount. This change in definition required the counting of only those inmates sentenced with terms of at least a year and a day; inmates with less than a year and a day were excluded from the NPS definition of prison population. Because of such changes in definition, the study of the history of prison population growth becomes a jumble of dissimilar measures. In some instances the numerical increase of prison population is an artifact of measurement and is not suited for trend analysis.

The calculation of forecasting may also be affected by changes in definition of the explanatory (independent) variables. For example, the National Advisory Commission on Criminal Justice Standards and Goals in 1973 recommended that the definition of "recidivist" exclude anyone returning to prison after three years. The result of this change would grossly distort a prison population forecasting model that used a raw, unadjusted time-series of the flow of recidivists. There are only a few instances in correctional forecasting that raw data can be used without careful scrutiny of the reliability of measurement.

A forecasting problem similar to changing definitions is that of using incompatible data sets. Incompatibility of data files became a problem in the attempt to forecast the flow of inmates into Florida's prisons. Several court systems had computerized their record keeping; however, one of the systems was constructed on the basis of case flow and another was based on the flow of individual defendants. These two data sets were unusable because they could not be translated into a common form. Another instance of incompatible files was found within corrections itself. In that instance, a state had stored correctional information in three different computers which used different computer programs, data identifiers and coding, and languages.

Inaccessability of collected information is a familiar dilemma for the correctional forecaster. Varying interpretations of privacy and security regulations prohibit researchers in some states from viewing juvenile justice data. Such data on young offenders would be helpful in assessing trends in future prison inputs. CCH, the Computerized Criminal History information system which could provide adult offender flow information between criminal justice agencies, has met similar difficulties. The various criminal justice agencies are uncertain about what they can safely provide to a centralized information system. Within corrections, accessibility of stored data may also be challenged by local institutional security precautions which question the "need to know." Such security questioning is sometimes accompanied by a reluctance to provide unusual information. In addition, practices and departmental rules set to avoid disruption of work routines may hinder the forecaster who seeks an unusual, one-time data retrival from files. One state correctional agency, encountered in this study, hampered researchers with a rule that only twenty-five inmate files could be inspected per day.

Interpretation of the forecast can also be a problem in the correctional environment. Some forecasting models are complex and lengthy. The correctional administrator, not unlike the business executive who first encountered simultaneous equation forecasts, can be expected to be wary of calculations not readily understood. The problem of explaining a forecast is made more difficult, as one correctional forecaster pointed out, when the administrator expects a hard data forecast on possible candidates for proposed treatment programs that have no precedent for assessment. In that instance, the forecaster must cautiously explain his problem of using contrived data and modified methods of calculating the forecast.

The problem of interpretation takes a difficult turn when the forecast must be related to projected prison capacity. Standards for determining housing capacity are fluid and open to debate. Prison systems also may have optional housing resources. For example, the Bureau of Prisons and some states contract for housing inmates with other agencies. At times, county prison facilities will accept varying numbers of state prisoners. Then too, state facilities which have been closed because of outdated conditions sometimes have been reopened when overcrowding becomes problematic. Thus, the interpretation of prison population in relation to capacity forecasts becomes a vague undertaking.

The last of the correctional environment problems to be considered is that of the unfamilarity of the analyst with forecasting methods. Some states, such as Florida, have researchers who are knowledgeable in time-series analysis; but in many other states the analyst's background includes familarity with only methods of cross-sectional analysis. The lack of knowledge is not only reflected in the forecasting results, but causes discomfort in the analyst when he is asked to defend his work before an administrator or political body.

Improving the State of the Art

During this study of prison population forecasting, several recommendations for improving the state of the art have been developed. There is first a need to refocus attention from single exploratory forecasts of prison population to multi-alternative forecasts. The refocus of attention carries philosophical implications for the forecasting of prison population. The new perspective clearly identifies prison growth as subject to correctional decisions, as well as to discretionary behavior of other elements in the Criminal Justice System. Although this has been accepted in the study of the Criminal Justice System, the practice of exploratory forecasting has not fully joined that stance of reasoning. Given this viewpoint, the study of the future of prison population growth may focus on identifying variations on a basic theme or trend, instead of exploring for an immutable chain of events.

In academic research, greater attention to subjective forecasting methods may yield rewarding insights into prison and crime growth. The collective efforts of several researchers through subjective forecasting methods may provide more insights of value than the sum of those individually accomplished in individual research and publication.

A third recommendation, also academic in nature, is that of emphasizing the study of the mechanical functioning of the Criminal Justice System. Textbook approaches can be supplemented with computer-based simulation programs (flow models) such as JUSSIM II or Georgia Institute of Technology's Criminal Justice Training models. These programs provide an interactive learning environment in which the student can evaluate the impact of data and assumptions on the operation of criminal justice functioning and prison growth. This recommendation addresses the notion that prison population forecasting is an art which, in part, grows out of the individual's sensitivity to the functioning of the Criminal Justice System.

The Future Executive and Forecasting

Planning for prison growth essentially exists in the far-sightedness of the correctional leader (the chief executive). The non-leader will fail to envision goals, see his job as short-lived, and respond at the mercy of prison population pressures.

The farsighted executive attempts to cushion his organization from fluctuations in prison population. Part of the task of building a cushion of program depth and flexibility is related to awareness of the political environment and scanning for changes in the social environment. The farsighted executive is well-informed and, as such, respects forecasting as an incomplete aid for decision-making. This incomplete aid may not need to be discarded, but used astutely at times when additional information is warranted.

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APPENDIXES

APPENDIX A

Annotated Bibliography

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Annotated Bibliography

This annotated bibliography is divided into four sections: (1) Bibliography on forecasting, (2) Publications which deal with forecasting concepts and methods, (3) Publications of general interest to the correctional forecaster, (4) References for each of the prison population forecasting methods that were presented in Chapters IV, V, and VI. The books and articles referenced in this annotated bibliography were selected because of their quality, relevancy, and reader interest. Numerous other references have been acquired and examined during this study, but only a few are presented in this bibliography.

In order not to duplicate the listing of sources, a full citation is only presented once. Publications may be identified a second time in instances of applicability to several forecasting concepts and techniques; however, subsequent citations appear only in abbreviated form.

A. Annotated bibliography of bibliographies on forecasting.

Balachandran, M. "Basic Economic Statistics." Exchange Bibliography No. 971, Monticello, Ill.: Council of Planning of Librarians, Feb., 1976.

This volume is a bibliography of data sources for three categories of economic statistics: (1) historical statistics, (2) current economic indicators, and (3) economic forecasts and projections.

Cornish, Edward. The Study of the Future. Washington, D.C.: World Future Society, 1977.

This book is not as much a bibliography as it is a review of the futurists and their ideas and views of the future. An annotated bibliography is part of the text.

Grant, Donald P. "A Partially Annotated Bibliography on the Morphological Approach to Plan Generation." Exchange Bibliography No. 1125, Monticello, Ill.: Council of Planning Libraries, Sept., 1976.

This is a bibliography on normative planning (forecasting). The morphological approach includes those techniques such as decision trees.

Johnson, Maggie. "Economic Forecasting--An Annotated Bibliography of U.S. Government Documents." Exchange Bibliography No. 1265, Monticello, Ill.: Council of Planning Libraries, April, 1977.

Johnson has compiled this bibliography of sources for economic forecast information from three sectors of government publications: (1) regular reports of all government agencies, (2) hearings, reports, and research done by Congress, and (3) publications of all executive agencies, the President, and independent agencies.

Marien, Michael. Societal Directions and Alternatives. Lafayette, N.Y.: Information for Policy Design, 1976.

Marien's work is a comprehensive annotated bibliography of 1,015 items, primarily books, concerned with the future. Included are a recommended reading list for a curriculum and a brief analysis of the trend in future oriented publications.

Martin, R. H. "The Future of Consensus--Formation Technology Utilization in a Normative Governmental Planning Support System Environment: Social and Political Protocol Aspects of Large Scale Media-Conferencing Planning Systems, and Consensus--Formation Technology Utilization." Exchange Bibliography No. 1061, Monticello, Ill.: Council of Planning Libraries, June, 1976.

This book is a two-part bibliography about the impact of information systems on social planning.

Merwin, Donna J. "The Quality of Life: A Bibliography of Objective and Perceptual Social Indicators." Exchange Bibliography No. 1079, Monticello, Ill.: Council of Planning Libraries, July, 1976.

This bibliography reports books, reports, documents, papers, and journal articles.

World Future Society. The Future: A Guide to Information Sources. Washington, D.C.: World Future Society, 1977.

This volume is a book length directory of research projects, books, educational films, individuals, organizations, and other resources concerned with the study of the future.

See also the extensive bibliographies in sections below on

- Jantsch, Erich. Technological Forecasting in Perspective.
- Linstone, Harold A. and Turoff, Murray. The Delphi Method.

B. Annotated bibliography of publications which review and explain forecasting techniques and concepts.

Bright, James R. and Schoeman, Milton E.F., editors. A Guide to Practical Technological Forecasting. Englewood Cliffs, N.J.: Prentice-Hall, 1973.

This volume is a reader on technological forecasting methods, considerations and applications. It is similar to the volume by Bright, above, but inclusive of more methods of forecasting.

Bright, James R., editor. Technological Forecasting for Industry and Government. Englewood Cliffs, N.J.: 1968.

This book is a collection of articles on a few techniques of technological forecasting and some of the issues and problems in the practice of technological forecasting. Bibliographies on forecasting and research and planning are also contained in this volume. No particular statistical expertise is required by the reader.

Butler, William F.; Kavesh, Robert A.; and Platt, Robert B., editors. Methods and Techniques of Business Forecasting. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

This volume is a general reader containing a brief review of methods of business forecasting with examples of application and considerations for use. No particular statistical expertise is required by the reader.

Chambers, John C; Mullick, Satinder K.; and Smith, Donald K. An Executive's Guide to Forecasting. New York: John Wiley & Sons, 1974.

This work reviews business forecasting techniques, makes suggestions for application, and discusses the roles of the manager and forecaster. One highlight of the work is the appendix summarizing the characteristics of costs of various techniques.

Dorn, Harold F. "Pitfalls in Population Forecasts and Projections." Journal of the American Statistical Association, Vol. 45, No. 251, pp. 311-334.

This article is an excellent historical review of demographic forecasters and their methods. Dorn identifies nine of the most common errors in forecasting population.

Draper, N. R. and Smith, H. Applied Regression Analysis. New York: John Wiley, 1966.

This book is one of the popular texts for intermediate statistical education. The reader will find this work often cited as a reference for the application of multiple regression to cross-sectional analysis in the behavioral sciences.

Emery, Frederick E. "Methodological Premises of Social Forecasting," The Annals of the American Academy of Political and Social Science, Vol. 412, Mar., 1974, pp. 97-115.

This paper is most interesting because of the concepts about the problems of detecting emerging social processes.

Encel, S.; Marstrand, P.K.; and Page, William, editors. The Art of Anticipation: Values and Methods in Forecasting.

This is an easy to understand book which reviews both problems in forecasting and a variety of methods. Because it is brief and insightful, this book is highly recommended.

Fowles, Jib. "An Overview of Social Forecasting Procedures." Journal of the American Institute of Planners. Vol. 42, No. 3, July, 1976, pp. 253-63.

This article is a brief critique of Delphi, Scenarios, and dynamic Modeling, and a general discussion of the future as developed by intellectual leaders.

Heneley, Stephen P. and Yates, James R. Futurism in Education. Berkeley, Calif.: McCutchan Publishing Co., 1974.

This volume is a collection of brief articles on forecasting techniques. The reader will find the materials clearly and concisely presented. The articles tend, however, to portray the techniques only in optimistic terms. The work includes very understandable explanations of Markov Chain theory and Monte Carlo techniques.

Hetman, Francis. The Language of Forecasting. Paris: Futuribles, 1969.

This book is a comprehensive dictionary of forecasting terms and methods.

Jantsch, Erich. Technological Forecasting in Perspective. Paris: Organisation for Economic Co-operation and Development, 1967.

This is one of the most extensive cataloging of forecasting techniques of its kind. A large annotated bibliography is also included.

Johnston, J. Econometric Methods. 2nd edition. New York: McGraw-Hill, 1972.

This book is a well-known intermediate text for naive statistical forecasting techniques and simultaneous equations. It is one of the key works in the field.

Jouvenel, Bertrand de. The Art of Conjecture. New York: Basic Books, 1967.

This well-known book should not be overlooked by anyone interested in social forecasting. de Jouvenel establishes a philosophical basis for forecasting which places the desire to forecast within the perspective of what is possible.

Keyfitz, Nathan. "On Future Population." Journal of the American Statistical Association, Vol. 67, No. 338, pp. 347-363.

A brief survey of methods of demographic forecasting is presented in this article.

Leser, C.E.V. Econometric Techniques and Problems. New York: Hafner Press, 1974.

This work is a most useful reference for simple regression, multiple regression, and simultaneous equations. Although the discussion is statistically oriented, the reader with only a brief background in statistics will appreciate the clarity, depth of explanation, and exploration of problems of forecasting with the three techniques.

Lewis, John P. "Short-term General Business Conditions Forecasting: Some Comments on Method." Journal of Business, Vol. 35, No. 4, Oct., 1962, pp. 343-56.

This article is a brief introduction to techniques and philosophy of economic forecasting. Some of the methods examined are NBER leading indicators and foreshadowing data.

Martino, Joseph P. Technological Forecasting for Decision Making. New York: American Elsevier, 1972.

This book is one of the often cited references which reviews technological applications of subjective, naive and normative forecasting methods. The depth of explanation / more detailed than other handbooks of this kind. No particular statistical expertise is required by the reader.

McHale, John and McHale, Magda C. "Futures Studies: An International Survey." New York: United Nations Institute for Training and Research, 1976.

This is a world-wide survey of forecasting methods. The analysis identifies characteristics of organizations involved in forecasting, methods used, and characteristics of personnel constructing the forecasts.

Mendenhall, William and Reinmuth, James E. Statistics for Management and Economics. 2nd edition, North Scituate, Mass.: Duxbury Press, 1974.

This book is a standard statistics text in economics that should be noted for its clarity of explanation. The reader having slight sophistication in statistics will appreciate the chapters on time-series analysis and forecasting models.

Miles, Ian. The Poverty of Prediction. Lexington, Mass: Lexington Books, 1975.

This book is a probing discussion of the problems of quantative forecasting. Highlighted are concepts of validity, reliability and social indicators. It is an insightful work that avoids statistical presentation.

Mitchell, Arnold; Dodge, Burnham H.; Kruzie, Pamela G.; Miller, David C.; and Schwartz, Peter. Handbook of Forecasting Techniques. Standford Research Institute Report #10, Washington, D.C.: National Technical Information Service, December, 1975.

This work is a handbook of forecasting methods oriented toward use by the Corps of Engineers. The explanation of techniques is concisely presented as to considerations of application, problems of application, and resources required.

Valvanis, Stefan. Econometrics. New York: McGraw-Hill, 1959.

Valvanis' book is a very readable introduction to econometrics and time-series analysis. Unfortunately, this book is out of print,--one of the best in this category of texts.

Wheelwright, Stephen C. and Makridakis. Forecasting Methods for Management. New York: John Wiley, 1973.

This book is a survey of forecasting techniques written for the business manager, although a basic familiarity with statistics is required. Problems of technique selection and interpretation are also discussed.

C. Annotated bibliography of books and articles that may be of interest to the correctional forecaster. This section includes social trend analysis and forecasts, organizational considerations in forecasting, and research guides.

Barnes, William F. and Jones, Ethel B. "Women's Increasing Unemployment: A Cyclical Interpretation," The Quarterly Review of Economics and Business. Vol. 15, No. 2, Summer, 1975, pp. 61-69.

This is an article of possible interest to the correctional forecaster in considering the impact of economic events on prison population.

Bregger, John E. "Unemployment Statistics and What They Mean," Monthly Labor Review. Vol. 94, No. 11, Nov., 1971, pp. 22-29.

This article is of particular interest in the identification of assumptions for prison population forecasts which incorporate unemployment as a factor.

Council of State Governments. "Improving the 1980 Census." Lexington, Ky.: Council of State Governments, 1974.

Since much of prison population forecasting has been based on population estimates, this pamphlet presents insights into the problems of using census information.

Gilroy, Curtis L. and McIntire, Curtis L. "Job Losers, Leavers, and Entrants: A Cyclical Analysis," Monthly Labor Review, Vol. 97, No. 11, Nov., 1974, pp. 35-39.

Rather than lumping the unemployed into one vague category, the authors identify three groups and describe their general behavior.

Hammond, John S. "Do's & Don'ts of Computer Models for Planning," Harvard Business Review, Vol. 52, No. 2., March-April, 1974, pp. 110-123.

This article contains practical advice for the forecaster and manager in considering modeling. Ten stages of modeling are reviewed and the roles of the analyst and manager are inspected.

Mohr, Lawrence B. "The Concept of Organizational Goal." The American Political Science Review. Vol. 67, No. 2, June, 1973.

This article presents an analysis of the central views that leave set definitional trends in the concepts of organizational goals. These views are identified and a concrete conceptualization of the themes are presented. This topic is especially relevant to the inspection of the place of forecasting in criminal justice planning.

Project Star. The Impact of Social Trends on Crime and Criminal Justice. Cincinnati, Ohio: Anderson-Davis, 1976.

This work is a subjective analysis of trends in the Criminal Justice System. It is an insightful work that falls into the category of a single-future scenario.

Simpson, Anthony E. Guide to Library Research in Public Administration, New York: John Jay College of Criminal Justice, 1976.

Although the title addresses public administration, the information specifically addresses research in the criminal justice field. This will be a useful reference for the forecaster in his search for data and supportive information.

"Theory Deserts the Forecasters." Business Week, No. 2337, June 29, 1974, pp. 50-59.

This is general comment of the problem of forecasting in economics. The article raises the possibility that forecast assumptions can change.

Vancil, Richard F. "--- So You're Going to Have a Planning Department!" Harvard Business Review, Vol. 45, No. 3, May-June, 1967, pp. 88-96.

Although this article does not address forecasting directly, the implications for supporting the forecasting effort are evident. It is an insightful and interestingly written article.

Woods, Donald H. "Improving Estimates that Involve Uncertainty," Harward Business Review, Vol. 44, No. 4, July-August., 1966, pp. 91-98.

This is a brief article discussing forecasting in the business organization. One highlight of the article is the exploration of how companies reward conservatism in performance.

Zaltman, Gerald; Duncan, Robert; and Holbek, Jonny. Innovations and Organizations. New York: John Wiley 1973.

This is a particularly interesting book for the reader who is trying to place forecasting within the appropriate perspective in criminal justice organizations. The work studies the environment for organizational change and the characteristics of the process of innovation.

D. Annotated bibliography of forecasting methods presented in Chapters IV, V, and VI.

Delphi

Cooper, J. Phillip and Curtis, Gary A. Econometric Software Package--User's Manual. Chicago, Ill.: Univ. of Chicago, Graduate School of Business, Jan. 1, 1976.

This book is a reference manual to one of the more extensive computer programs for naive forecasting. Of particular value is the brief description of techniques and suggested references to the concepts.

Correctional Service of Minnesota. "Delphi Study on Minnesota Correctional Institutions," Minneapolis, 1975 (Mimeographed).

This study is an example of a Delphi variation which presented first round closed statements. The subjects were asked to identify the likelihood of the occurrence of various scenarios about future correctional and facility needs in Minnesota. It was unpublished and is partially forgotten in Minnesota corrections.

Delbecq, Andre L.; Van de Ven, Andrew H.; and Gustafson, David H. Group Techniques for Program Planning. Glenview, Ill.: Scott, Foresman & Co., 1975.

This small book is one of the best works on the mechanics of conducting Delphi. Cost and time considerations are given. Also, included with as much detail is the Nominal Group Process (NGT).

Doane, David P. "Court Case Weights Using the Delphi Method: Report on an Experiment in Michigan Circuit Courts." Paper presented at the Joint National Meetings of the Operations Research Society of America and the Institute of Management Sciences, Miami Beach, Florida, Nov. 3, 1976.

This is an illustration of Delphi's application as a survey tool to study court workload measures.

Fusfeld, Alan R. and Foster, Richard N. "The Delphi Technique: Survey and Comment." Business Horizons, Vol. 14, No. 3, June 1971, pp. 63-74.

This article evaluates Delphi's functioning in such terms of group size, group response characteristics and interpretation of scored information.

Goldschmidt, Peter G. "Scientific Inquiry or Political Critique? Remarks on 'Delphi Assessment, Expert Opinion, Forecasting, and Group Process' by H. Sackman." Technological Forecasting and Social Change, Vol. 7, No. 2, 1975, pp. 195-213.

This is an inspection of Sackman's strategy of evaluating Delphi and his conclusions.

Hill, Kim Quaile and Fowles, Jib. "The Methodological Worth of the Delphi Forecasting Technique," Technological Forecasting and Social Change, Vol. 7, No. 2, 1975, pp. 179-192.

This article inspects the problems of reliability and validity in Delphi. Reasons for continued use of Delphi are also considered.

Jillson, Irene A. "Developing Guidelines for the Delphi Method." Technological Forecasting and Social Change, Vol. 17, No. 2, 1975, pp. 221-222.

This is a brief article which points out that the controversy surrounding the Sackman report may indicate a need to develop specific guidelines for application. Five guidelines are suggested.

Linstone, Harold A. and Turoff, Murray, editors. The Delphi Method. Reading, Mass.: Addison-Wesley, 1975.

This book is an in-depth reader on Delphi with a chapter devoted to an extensive bibliography.

McLaughlin, Curtis R.; Sheldon, Alan; Hansen, R.C.; and McIver, Brian A. "Management Uses of the Delphi," Health Care Management Review, Vol. 1, No. 2, Spring, 1976, pp. 51-62.

In this article, a step illustration of Delphi is applied to a large urban mental health center for the purpose of obtaining staff member opinion on major administrative problems. The article tends to skip lightly over Delphi's limitations.

Sackman, H. "Delphi Assessment: Expert Opinion Forecasting and Group Process," Rand Report R-1283-PR, Santa Monica, California, April, 1974.

This report is one of the major critical works that brought the debate of Delphi's usefulness into the open.

Sandow, Stuart A. "The Pedagogical Structure of Methods for Thinking about the Future: The Citizen's Function in Planning," Syracruse, N.Y.: Educational Policy Research Center, Sept. 1970 (Mimeographed).

This interesting, but hard to find, report inspects the strengths and weaknesses of Delphi, Cross-Impact, Scenarios, PERT and a few similar concepts. (Can be found at University of Illinois, Urbana-Champaign.)

Sartorius, Lester C. and Mohn, N. Carroll. Sales Forecasting Models: A Diagnostic Approach. Research Monograph No. 69, Atlanta, Ga.: Publishing Services Division, School of Business Administration, Georgia State Univ., 1976.

This text is designed for the businessman and student having only an elementary background in statistics. The depth of explanation of forecasting formulas is more extensive than most texts of this kind. Topics covered include selecting forecast methods, time-series analysis, exponential smoothing, and adaptive filtering, and causal forecasting.

Skutsch, Margaret. "Goals and Goal Setting: A Delphi Approach," Unpublished Master's Thesis, Northwestern University, Evanston, Ill., Aug., 1972.

This study probes Delphi's capabilities with an illustrative application.

Ventura Regional Criminal Justice Planning Board. "Delphi: A Manning Tool," Ventura, California, 1978 (Mimeographed).

This is one of the few examples of Delphi actually used in criminal justice planning. The 16-page in-house document very briefly describes the method and illustrates the forms used. Analysis of results is not provided.

Welty, Gordon. "Plato and Delphi," Futures, Vol. 3, No. 3, June 1973, pp. 281-286.

This article explores the possibility that Delphi is susceptible to manipulation to mold opinion.

Matrix

Folk, Michael. A Critical Look at the Cross Impact Matrix Method. Research Report RR-5, Syracruse, N.Y.: Educational Policy Research Center, August, 1971.

This research inspects the processes of CIM computation and raises questions about computational feasibility. A simplified alternative to CIM computation is offered.

Gordon, T.J. and Hayward, H. "Initial Experiments with the Cross-Impact Matrix Method of Forecasting," Futures, Vol. 1, No. 2, Dec., 1968, pp. 100-116.

This article presents a description of the early experiments with CIM and the basic concepts of analysis.

Kelly, P. "Further Comments on Cross-Impact Analysis," Futures, Vol. 8, No. 4, Aug., 1976, pp. 341-5.

In this article, CIM is assessed as to the justification for applying rigorous matmematical analysis to subjective data.

McLean, Mick. "Does Cross-Impact Analysis Have A Future?" Futures, Vol. 8, No. 4, pp. 345-349.

In this article, two "wrong turnings" of the CIM approach are discussed. The role of CIM is seen as a heuristic device.

Rochberg, Richard; Gordon, Theodore J; and Helmer, Olaf. The Use of Cross-Impact Matrices for Forecasting and Planning. IFF Report R-10. Middletown, Conn.: The Institute for the Future, April, 1970.

This is a discussion of CIM's mechanics and procedures from the viewpoint of CIM's major advocates. An alternative approach to CIM is also presented.

Scenarios

Abt, Clark C. "Forecasting Future Social Needs," The Futurist, Feb., 1971, pp. 20-21.

This article gives a brief description of recommended procedures for constructing scenarios for social futures. Is presented in two pages.

Abt, Clark C.; Foster, Richard N.; and Rea, Robert H. "A Scenario Generating Methodology" in A Guide to Practical Technological Forecasting, Edited by James R. Bright and Milton E. F. Schoeman. Englewood Cliffs, N.J.: Prentice-Hall, 1973, pp. 191-214.

Clark Abt's guide provides an explanation of a mechanical (computer-based) approach to generating alternatives for scenarios.

Gerardin, Lucian. "Study of Alternative Futures: A Scenario Writing Method," in A Guide to Practical Technological Forecasting, Edited by James R. Bright and Milton E. F. Schoeman. Englewood Cliffs, N.J.: Prentice-Hall, 1973, pp. 276-288.

This study presents a discussion of scenario writing in relation to the development of a social philosophy (attitude) about the unpredictability of future events.

Kahn, Herman. "The Alternative World Futures," in Search for Alternatives: Public Policy and the Study of the Future. Edited by Franklin Tugwell.

An intuitive rather than structural or rational approach to the creation of multi-alternative scenarios is presented in Herman Kahn's work.

Subjective Extrapolation

Parsons, Robert. Statistical Analysis: A Decision Making Approach. New York: Harper & Row, 1974.

Information on semi-log charting can be found in detail in this text.

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger Pub. Co., 1976.

This source discusses a variety of population forecasting techniques and provides examples. Concepts about subjective estimation of confidence intervals (error bands) are presented.

Sartorius, Lester C. and Mohn, N.C. Sales Forecasting Models: A Diagnostic Approach. Research Monograph No. 69, Atlanta, Ga.: Publishing Services Division, School of Business Administration, Georgia State University, 1976.

The use of discontinuous trend lines and other ideas on fitting lines to data are presented in this work.

Sullivan, Wm. G. and Claycombe, W. W. Fundamentals of Forecasting. Reston, Va.: Reston Pub. Co., 1977.

This book serves as an information source for problems of serial correlation and application of regression to social forecasting. It presents an easy to understand review of selected forecasting methods in the business field.

Least Squares

Cochrane, D. and Orcutt, G. H. "Application of Least Squares Regression to Relationships Containing Autocorrelated Error Terms." Journal of the American Statistical Association, Vol. 44, No. 245, Mar., 1949, pp. 32-61.

This is one of the benchmark studies of the problems of using least squares in time-series analysis.

Hamburg, Neonis. Statistical Analysis for Decision Making. 2nd Edition. New York: Harcourt, Brace, Jovanovich, 1977.

This text explores the statistical problems of predicting outside the range of the data set. The difficulties of meeting the assumptions of regression in social time-series are strongly pointed out. Hamburg introduces the name least squares as an alternative name for simple regression when the objective is forecasting. The text is recommended for the student examining differences in cross-sectional and time-series analysis.

Tintner, Gerhard. The Variate Difference Method. Bloomington, Ind.: Principia Press, Inc., 1940.

The earnest student of forecasting will find this work very easy to read and an invaluable source of history and insight into the problem of serial correlation. Tintner presents the concept of transforming time-series data through methods of finding differences. Unfortunately, this book is out-of-print.

Smoothing

Blumstein, Alfred; Cohen, Jacqueline; and Nagin, Daniel. "The Dynamics of a Homeostatic Punishment Process," The Journal of Criminal Law and Criminology, Vol. 67, No. 3, 1977, pp. 317-334.

This article presents an example of time-series analysis through an autoregressive moving average process. The analysis evaluates Durkheim's concept that society establishes expectations of levels of punishment.

Box, George E. P. and Jenkins, Gwilym M. Time Series Analysis. San Francisco: Holden Day, 1970.

This is a well-known work on naive analysis of time-series. A strong background in statistics is needed by the reader.

Brown, Robert G. Smoothing, Forecasting, and Prediction. Englewood Cliffs, N.J.: Prentice-Hall, 1962.

This is one of the key texts in forecasting which presents an in-depth study of the mechanics of smoothing. A moderate understanding of statistics will be needed by the reader.

Fuller, Wayne A. Introduction to Statistical Time Series. N.Y.: John Wiley & Sons, 1976.

Although this work is called an "introduction," the reader must be versed in statistics. Topics covered by this text include the Fourier transform, spectral densities of moving averages, and Gauss-Newton estimation.

Nelson, Charles R. Applied Time Series Analysis. San Francisco: Holden-Day, 1973.

Smoothing and autoregressive analysis are presented for the student with a moderate background in statistics. Included are the concepts of stationarity, autocorrelation, differences, and ARIMA (Integrated Autoregressive Moving-Average) models.

Also see the references above

- Sullivan and Claycombe. Fundamentals of Forecasting.
- Sartorius and Mohn. Sales Forecasting Models: A Diagnostic Approach.
- Wheelwright and Makridakis. Forecasting Methods for Management.

These texts provide an easy to understand explanation of smoothing techniques.

Indicator

Bry, Gerhard and Boschan. Cyclical Analysis of Time Series: Selected Procedures and Computer Programs, National Bureau of Economic Research Technical Paper 20, N.Y.: Columbia Univ. Press, 1971.

This book gives an explanation of the general mechanics of analyzing business cycle indicators. It is easy to read, with a minimum of statistical explanation. This work points out that much of indicator analysis is subjective in nature.

Etzioni, Amita and Lehman, Edward W. "Some Dangers in 'Valid' Social Measurement," Annals of the American Academy of Political and Social Science, Vol. 373, Sept. 1967, pp. 1-15.

This article presents discussion of the problems of indicator construction. Various approaches to indicator modeling, such as single vs. system models are presented. The article warns against ritualistic adherence to scientific analysis.

Little, Dennis L. "Social Indicators and Public Policy," Futures, Vol. 7, No. 1, Feb., 1975, pp. 41-51.

Little identifies six major approaches to construction of social indicators. He asks the probing question of what is wanted from social indicators?

Liu, Ben-Chieh. Quality of Life Indicators in U.S. Metropolitan Areas.

Liu's book is a stimulating attempt to identify a number of social indicators by which to rate quality of life in cities. It is a valuable source of information on available statistical series about the social environment.

Neufville, Judith Innes, de. Social Indicators and Public Policy. N.Y.: Elsevier Scientific Pub. Co., 1975.

This book is a comprehensive study of social indicators. It is one of the best studies found on this topic. It includes a section on the evaluation of crime rate as an indicator. It is also valuable for the bibliographies accompanying each chapter.

Nordhaus, William D. "The Political Business Cycle," The Review of Economic Studies, Vol. 42, No. 130, Apr., 1975, pp. 169-190.

This article presents an interesting exploration of the politics of public policy and staying in office as they might impact the economic cycle.

Shiskin, Julius. "Business Cycle Indicators," in The Management of Forecasting. Edited by John J. Clark, N.Y.: St. John's Univ. Press, 1969, pp. 47-88.

Shiskin presents an excellent discussion of business indicator forecasting. It includes definitions of the types of cyclical indicators, construction of indices, and problems of use.

Steckler, H.O. "An Analysis of Turning Point Forecasts," The American Economic Review, Vol. 62, No. 4, Sept., 1972, pp. 724-9.

This analysis presents an argument for the use of leading indicators in combination with quantative economic forecasting models.

U.S. Department of Labor. BLS Handbook of Methods. Bulletin 1711, Stock No. 2901-0659, Washington, D.C.: U.S. Government Printing Office, 1971.

This document describes the methods of gathering forecast information, methods of analysis, and history of these Labor Department indicators. A good starting point in the development of an awareness of presently reported social indicators.

Ward, Ritchie. "If You Look Hard Cycles Are All Over," Smithsonian, March, 1977, pp. 104-1

This general article presents the possibility that cycles are more prevasive than popularly thought.

Zapf, Wolfgang. "Systems of Social Indicators: Current Approaches and Problems," International Social Science Journal, Vol. 27, No. 3, 1975, pp. 476-498.

One highlight of this article is the concise presentation, in tables and text, of the social indicator systems. These social indicator systems are broad indicators, such as those for general quality of life and net national welfare.

Multiple Regression

Berman, Robert A. "An Econometrician's Reaction to 'A Non-econometrician's Guide to Econometrics," Business Economics, Vol. 9, No. 1, Jan., 1974, pp. 81-82.

Berman clarifies several problems in McLagan's work listed below.

Box, George E. P. "Use and Abuse of Regression," Technometrics, Vol. 8, No. 4, Nov., 1966, pp. 625-9.

Box points out that regression analysis encounters difficulty when applied to systems which are not positively observed.

Levin, Martin A. "Policy Evaluation and Recidivism," Law and Society Review, Vol. 6, No. 1, Aug., 1971, pp. 17-46.

Of particular interest to the study of forecasting, the first section of the article discusses the problem of multicollinearity in regression analysis of factors affecting social policy. It is easy to understand and interestingly written.

McLagan, Donald L. "A Non-econometrician's Guide to Econometrics," Business Economics, Vol. 8, No. 3, May 1973, pp. 38-45.

In combination with Berman's article above, this brief article succinctly explores the interpretation and problems of multiple regression as a forecasting tool.

Palmer, Jan and Carlson, Paul. "Problems with the Use of Regression Analysis in Prediction Studies," Journal of Research in Crime and Delinquency, Vol. 13, No. 1, Jan., 1976, pp. 64-81.

This well written article presents problems of regression analysis in criminal justice research. The focus of this article is upon cross-sectional analysis and, for that reason, may serve as a contrast to time-series applications.

Also see the references above:

- Hamburg, Statistical Analysis for Decision Making.
- Leser, Econometric Techniques and Problems.
- Pittenger, Projecting State and Local Populations.

Flow

Bohigian, Haig Edward. The Foundations and Mathematical Models of Operations Research with Extensions to the Criminal Justice System, Yonkers, NY: The Gazette Press, 1971.

Systems concepts, fundamentals of operations research, and illustrations of queuing theory applications to criminal justice problems are features of this book. The reader with a moderate background in statistics may find this work to be an interesting introduction to the study of operations research.

Brewer, Garry D. and Hall, Owen P. "Policy Analysis by Computer Simulation: The Need for Appraisal," Public Policy, Vol. 21, No. 3, 1973, pp. 343-65.

This article critiques Forrester's Systems Dynamics. The general conclusion holds that the promise to forecast exceeds the capability.

Chaiken, J. et al. *Criminal Justice Models: An Overview.* Washington, D.C.: U.S. Government Printing Office, April, 1976.

Chaiken presents a review of criminal justice models which describes models in terms of general design, capabilities, and requirements. Included in the study are dynamic simulation and queuing models. Some of the models presented are more suited to an ongoing analysis of system functioning than for forecasting, although the formulation of that distinction was not a major objective of the review of models.

Elmaghraby, Salah E.; Llewellyn, Robert W.; Stidham, Shaler; and Muth, Mary B. "A Dynamic Population Model for the North Carolina Department of Correction," Raleigh, N.C.: North Carolina Department of Correction, 1976 (Mimeographed).

This is a research project conducted by North Carolina State University. The project report contains explanations and illustrations of Markov Models, Systems Dynamics Models, and Q-Gerts Simulation.

Forrester, Jay W. "Counterintuitive Behavior of Social Systems," *Technology Review*, Jan., 1971, pp. 53-68.

Forrester's article points out that simple flow models, although intuitively appealing, can be deceptive in operation.

Forrester, Jay W. *Industrial Dynamics.* Cambridge, Mass.: M.I.T. Press, 1961.

This is Forrester's early work on dynamic modeling. The section on classification of models ranks among the best of explanations found in the literature.

Hoos, Ida R. "Can Systems Analysis Solve Social Problems?" *Datamation*, Vol. 20, No. 6, June, 1974, pp. 82-92.

Hoos argues that systems techniques born in the military and technological environments are often inappropriately applied to social problems. This is an interesting article which stimulates thinking about flow forecasting.

Jantsch, Erich. "Forecasting and Systems Approach: A Frame of Reference," *Management Science*, Vol. 19, No. 12, Aug., 1973, pp. 1355-1367.

Jantsch examines the tasks of forecasting with the systems approach and the reasonable use of systems forecasting techniques.

Reich, Robert B. "Operations Research and Criminal Justice," Journal of Public Law, Vol. 22, 1973, pp. 357-387.

This article inspects the assumptions underlying the application of operations research concepts, such as flow modeling, in criminal justice planning. It is a most unusual and provocative article written from the viewpoint of the lawyer.

Simultaneous Equations

Blalock, Hubert M. Theory Construction. Englewood Cliffs, N.J.: Prentice-Hall, 1969.

Blalock's book is a key text in the field. It is exceptional in the clarity of explanation of concepts. A core of the text covers static and dynamic models and simultaneous equations.

Christ, Carl F. Econometric Models and Methods, N.Y.: John Wiley, 1966.

This work is recommended for the reader who is versed in statistics. This is a key work in the field of econometric modeling.

Doherty, Noel. "Econometric Models," The Management of Forecasting, Edited by John J. Clark. N.Y.: St. John's Univ. Press, 1969, pp. 89-115.

Doherty's work is a short non-statistical explanation of econometric modeling. Included are considerations of estimators, autocorrelation, and the identification problem.

Streissler, Erich W. Pitfalls in Econometric Forecasting. London: Institute of Economic Affairs (Publisher); Tonbridge, Kent: Tonbridge Printers Ltd. (Printer), 1970.

Streissler gives an excellent critique of forecasting with simultaneous equations. A great number of ideas are presented within the 74 pages of this booklet. The reader having little statistical background will find this work to be very readable.

See also the reference above:

- Leser, Econometric Techniques and Problems.

APPENDIX B

Seventy Techniques Associated with Social Forecasting

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Seventy Techniques Associated with Social Forecasting

Listed below are seventy techniques for social forecasting. Several sources identified in the Annotated Bibliography, above, list more than seventy techniques. However, this list does not contain forecasting methods which would be restricted to technological forecasting. The emphasis in selecting these seventy techniques was to focus on those methods which might be viewed with interest in the field of social forecasting.

This listing of forecasting techniques does not pretend to be an exhaustive identification of methods. In some cases those techniques not identified here may exist in the literature under alternative titles or as modifications of another method.

Most of the forecasting techniques mentioned below include a reference which describes the method. Those techniques without references are well-known methods, such as Opinion Polling, which need no specific citation of reference.

Bibliography for Subjective Forecasting Techniques

Brainstorming

Osborn, Alexander F. Applied Imagination. N.Y.: Charles Scribner's Sons, 1957.

Counterforecasting

Moreland, Frank L. "Dialectic Methods in Forecasting." The Futurist, Aug., 1971, pp. 169-171.

Cross-Impact Matrix

Decision Trees

Hamburg, Morris. Statistical Analysis for Decision Making, Second edition. New York: Harcourt Brace Jovanovich, 1977.

Delphi

Divergence Mapping

Expert Opinion

Expert Panel

Field Anomaly Relaxation (FAR)

Gappert, Gary. "The Development of a Pattern Model for Social Forecasting." Futures, Aug., 1973, pp. 367-382.

Force Analysis

Haskew, L.D. "Force Analysis," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan, Pub., 1974, pp. 55-70.

Functional Capability Trend

Future History Analysis and Review (FHAR)

Ziegler, W. L. An Approach to the Futures--Perspective in American Education. Syracruse, New York: Educational Policy Research Center, May, 1970.

Historical Analogy

Martino, Joseph P. Technological Forecasting for Decision Making. New York: American Elsevier, 1972.

Lateral Thinking

Bono, Edward de. "Zigzag Thinking," The Futurist, Vol. 4, Feb., 1970, pp. 29-31.

Life Styles Analysis

Linguistic Usuage Analysis

Emery, Fred E. "Concepts, Methods, and Anticipations." Forecasting and the Social Sciences. Edited by Michael Young. London: Heinemann, 1968.

Mapping

Pyke, Donald L. "Mapping--A System Concept for Displaying Alternatives," in A Guide to Practical Technological Forecasting. Edited by James R. Bright and Milton E. F. Schoeman. Englewood Cliffs, N.J.: Prentice-Hall, pp. 81-91.

Morphological Analysis

Ignatovich, Frederick. "Morphological Analysis," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan Pub., 1974, 211-234.

Nominal Group Technique

Delbecq, Andre L.; Van de Ven, Andrew H.; Gustafson, David H. Group Techniques for Program Planning. Glenview, Ill.: Scott, Foresman and Co., 1975.

Operational Gaming

Shubik, Martin. The Uses and Methods of Gaming. New York: Elsevier, 1975.

Opinion Poll

Organizational Unit Trajectory Method (OUT)

Gappert, Gary. "The Development of a Pattern Model for Social Forecasting." Futures, Aug., 1973, pp. 367-382.

Policy Capture

Mitchell, Arnold, et al. Handbook of Forecasting Techniques. Standford Research Institute Report No. 10. Springfield, Va.: National Technical Information Service, Dec., 1975.

Precursive Event Analysis

Martino, Joseph P. Technological Forecasting for Decision Making. New York: Elsevier, 1972.

Relevance Trees

McGrath, J.H. "Relevance Trees," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan Pub., 1974, pp. 71-96.

Scenario

Sensitivity Analysis

Social Trend Analysis

Bell, Daniel. The Coming of Post-Industrial Society. New York: Basic Books, 1973.

Study of Unanticipated Events

Subjective Probability Determination

Ackoff, Russell L. and Sasieni, Maurice W. Fundamentals of Operations Research. New York: John Wiley, 1968.

Survey of Intentions

Cohen, Morris. "Surveys and Forecasting," in Methods and Techniques of Business Forecasting. Edited by William F. Butler, Robert A. Kavesh and Robert B. Platt. Englewood Cliffs, N.J.: Prentice-Hall, 1974, pp. 76-95.

Symbol Analysis

Emery, Frederick E. "Methodological Premises of Social Forecasting." Annals of the American Academy of Political and Social Science, Vol. 412, Mar., 1974, pp. 97-115.

Synectics

Gordon, Wm. J.J. Synectics, the Development of Creative Capacity. New York: Harper, 1961.

Teleogistics

Woodfield, Andrew. Teleology. Cambridge, Mass.: Cambridge Univ. Press, 1976.

Value Change Analysis

Taviss, Irene. "Futurology and the Problem of Values." International Social Science Journal, Vol. 21, No. 4, 1969, pp. 574-584.

Bibliography for Naive Techniques

Adaptive Filtering

Wheelwright, Steven C. and Makridakis, Spyros. Forecasting Methods for Management. N.Y.: John Wiley, 1973.

Autoregression

Nelson, Charles R. Applied Time Series Analysis. San Francisco: Holden-Day, 1973.

Bayesian Statistics

Tanner, C. Kenneth. "Planning the Future with Bayesian Statistics," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan Pub., 1974, pp. 283-299.

Box-Jenkins Technique

Box, George E. and Jenkins, Gwilym M. Time Series Analysis: Forecasting and Control. San Francisco: Holden-Day, 1970.

Cohort-Compound Projection

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Component Trend Projection

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Counterprojection

Cycle Analysis

Denton, Carl A. and Valentine, Lloyd M. Business Cycles and Forecasting. Cincinnati, Ohio: South-Western Pub., 1974.

Density Analysis

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass: Ballinger, 1976.

Diffusion Indicators

Direction of Change Tables

Envelope Curve

Ayres, Robert V. "Envelope Curve Forecasting," Technological Forecasting for Industry and Government. Edited by James R. Bright. Englewood Cliffs, N.J.: Prentice-Hall, 1968, pp. 77-94

Exponential Smoothing

Gompertz Curve

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Interval Prediction

Leading Indicator

Logistic Curve

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Moving Average

Parametric Sensitivity Analysis

Jantsch, Erich. Technological Forecasting in Perspective. Paris, France: Organisation for Economic Co-operation and Development, 1967.

Pattern Recognition

Fogler, H. Russell. "A Pattern Recognition Approach for Forecasting," Management Science, Vol. 20, No. 8, April, 1974, pp. 1178-89.

Propagation of Variance

Jantsch, Erich. Technological Forecasting in Perspective. Paris, France: Organisation for Economic Co-operation and Development, 1967.

Quantitative Contextual Mapping

Ratio-Trend Method

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Regression Analysis

Shares Analysis

Pittenger, Donald B. Projecting State and Local Populations. Cambridge, Mass.: Ballinger, 1976.

Social Indicators

Surprise-Free Projection

Kahn, Herman and Wiener, Anthony J. The Year 2000. New York: McMillan, 1967.

X-11 Routine

Chambers, John C.; Mullick, Satinder K.; and Smith, Donald D. An Executive's Guide to Forecasting. New York: John Wiley, 1974.

Bibliography for Causal Methods

Econometric Models

Input-Output Models

Platt, Robert B. "Input-Output Forecasting," in Methods and Techniques of Business Forecasting. Edited by William F. Butler, Robert A. Kavesh, and Robert B. Platt. Englewood Cliffs, N.J.: Prentice-Hall, 1974, pp. 190-206.

Monte Carlo Simulation

Bruno, James E. "Monte Carlo Techniques in Educational Forecasting," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan Pub., 1974, pp. 347-374.

Markov Chain Simulation

McNamara, James F. "Markov Chain Theory and Technological Forecasting," in Futurism in Education. Edited by Stephen P. Heneley and James R. Yates. Berkeley, Calif.: McCutchan Pub., 1974, pp. 301-346.

Queueing Models

Bohigian, Haig E. The Foundations and Mathematical Models of Operations Research with Extensions to the Criminal Justice System. Yonkers, N.Y.: Gazette Press, 1971.

Synoptic Model

Brech, Ronald. Planning Prosperity. London: Darton, Longman and Todd, 1964.

System Dynamics

Forrester, Jay W. Industrial Dynamics. Cambridge, Mass.: M.I.T. Press, 1961.

APPENDIX C

A Survey of Population Projection Methods in the States
and the District of Columbia
(Florida Department of Offender Rehabilitation)

APPENDIX C

A Survey of Population Projection Methods in the States
and the District of Columbia
(Florida Department of Offender Rehabilitation)*

EXECUTIVE SUMMARY

This document is a review of the work that has been done to date by the states in the field of inmate population projections. The results reported here are in response to a survey on projection methodology conducted by the Florida Department of Offender Rehabilitation. All of the other states and the District of Columbia received the Department's questionnaire. Responses were received from 44 of these jurisdictions. Below is a summary of the results:

STATES SURVEYED	50
STATES RESPONDING TO THE SURVEY:	44 88%
RESPONDING STATES FURNISHING DOCUMENTS:	20 46%
RESPONDING STATES THAT PUBLISH PROJECTIONS:	32 73%
RESPONDING STATES THAT HAVE USED LINEAR REGRESSION:	21 48%
RESPONDING STATES THAT HAVE USED MULTIPLE REGRESSION:	7 16%
RESPONDING STATES THAT HAVE USED A SIMULATION MODEL:	6 14%

*Research Study, Bureau of Planning, Research and Statistics, Document #77-R-065, Tallahassee, Florida, Sept. 23, 1977.

In its efforts to develop more satisfactory projections of the inmate population, the Florida Department of Offender Rehabilitation has conducted a survey of population projection methodologies and approaches in all of the other states and the District of Columbia. The response to the survey has been excellent, and the Department wishes to thank the states that have responded for their assistance.

This survey reveals a picture of tremendous diversity. Some states do not make any population projections, while others employ complex methodologies. In the first group are states of various size and character. One state responded laconically that "We provide custody for whomever the courts send us," another, in stating that it did not make projections, remarked that "We are [sic] decreased our population from over 2500 to 1700 in the past year."

By contrast several states have employed either multiple regression or a simulation model (only Florida at this writing has employed both).* There is a similar diversity in the time periods covered by those states that produce population projections. In several states, long-range projections cover a period of five years or less, whereas in some other states periods of up to twenty-five years are covered (see Table 1).

*Florida previously employed a simulation model to predict the total incarcerated population. The model currently employed utilizes the simulation technique to predict the release date for each offender. Admissions are predicted by a multiple regression equation, with population at risk and unemployment rate as factors. A detailed description of the techniques used by Florida can be found in "Inmate Population Projections--Short and Long Range Estimates," available from the Department upon request.

TABLE 1

Population Projections Performed by the States

STATE	Projections Published	Linear Regression	Multiple Regression	Simulation Model	Short-term Projections-years	Long-term Projections-years
Alabama	x	x			3	
Alaska					2	
Arizona	x	x	x		4	
Arkansas		x				
California	x			x	2	10
Colorado	x	x	x		-	5
Connecticut		Projections not performed				
Delaware		Projections not performed				
D.C.	x	x		x	6 mos.	1
FLORIDA	x	x	x	x	3	25
Georgia	x			x	6	6
Hawaii	x	x			6 mos.	3
Idaho	x	x		x	5	15
Illinois	x	x	x		1-2	10
Indiana	x					4
Iowa	x					10
Kansas		Insufficient Data				
Kentucky		x			2	5
Louisiana		No Response				
Maine		No Response				
Maryland	x	x		x	1	5
Massachusetts	x	x			2	4
Michigan	x				2	
Minnesota				x		
Mississippi		Projections not performed				
Missouri		No Response				
Montana	x					24
Nebraska	x	x			1	20
Nevada	x	x			2	4
New Hampshire	x					25
New Jersey	x				4	9
New Mexico	x	x	x		2	5-8
New York					2	5
North Carolina	x				3	
North Dakota					3	10
Ohio	x	x				
Oklahoma	x	x			2	5
Oregon	x				5	24
Pennsylvania	x	x			1	2
Rhode Island	x				7	18
South Carolina	x					10
South Dakota		No Response				
Tennessee					5	
Texas	x	x	x		3	10
Utah	x	x			3	13
Vermont		No Response				
Virginia	x	x		x	5	5
Washington	x	x			2	6
West Virginia	x				3	3
Wisconsin		x	x		2	5
Wyoming		No Response				

Of the states that have responded to the Department's survey, it does not appear that there is any particular pattern as to the degree of sophistication found. Major states, or states with large incarcerated populations, do not necessarily make population projections in more depth than do small states, or states with few persons behind bars. For example, Ohio, Pennsylvania, and Michigan, all populous states with large prison rolls, have used neither multiple regression nor simulation models, and have not projected for more than two years ahead. On the other hand, Idaho, a sparsely populated state with a low number of prisoners, has utilized a simulation model and has projected prison population over a fifteen year period.

Attempting to cull the significant findings from a survey of this sort is a difficult task for several reasons. First of all, the extent and quality of data varies widely among the states. This makes comparison difficult, even when two or more states are using similar methodologies. Secondly, conditions in the different jurisdictions vary a great deal. Some states are rural in nature while others are heavily urban; some are growing very rapidly while others are not; some have high rates of incarceration and some have low rates; several have misdemeanants in their correctional facilities while many systems are limited to felons. With this sort of situation it is once again difficult to compare the approach of one state with that of another. The unemployment rate, for example, may be highly predictive in a state with an industrial economy, but far less useful in a primarily agricultural state. Thirdly, the more sophisticated methods for population projection have only been developed in the past few years. Thus, there has not been sufficient time to gauge their effectiveness or degree of accuracy.

It should be pointed out, however, that the objective of this survey was not to offer judgements or rankings of the efforts taking place in the different states. The purpose was rather to learn more fully what the states were doing in the area of population projections, and to describe and summarize our findings in a single document.

A noteworthy finding of the survey is that there is widespread displeasure with the linear regression technique when the data base used is the previous inmate population. Although a couple of states report this method to be reliable, more have serious doubt about it. The D.C. Department of Corrections, for example, stated that "the accuracy of these projections is less than ideal." In its Population Report, a descriptive analytical report issued every quarter, it was said of these linear projections that "some are labeled as not acceptable in the report each quarter." Nevada, to cite another example, remarked that "current intake exceeds predictions by 350%."

The displeasure with the variety of linear regression that uses past inmate population is related to the efforts in many of the states to develop improved methodologies, for it is widely recognized that the past growth in inmate population does not <u>determine</u> the rate of future growth. Although there may be a relationship between past and future growth, <u>both</u> are determined by other factors.

Recognition of this in several states is reflected by the use of a multiple regression methodology. This methodology has the potential for offering more accurate predictions than a linear method that utilizes past inmate population as the sole data base. The goal in multiple regression is to determine which combination of factors has the greatest predictive ability. Different states use a different set of factors.

Illinois uses the same factors that Florida uses in its short-range projections for admissions: unemployment and population at risk. Colorado predicts both new court commitments and the total incarcerated population by means of multiple regression equations. The factors used for the prediction of new court commitments are: (1) the unemployment rate for the preceding quarter, (2) the average percentage of yearly commitments received each quarter, and (3) the population at risk. The factors used to predict the total incarcerated population are: (1) the percentage of all commitments received three quarters earlier with an indeterminate minimum sentence, (2) the parole revocation level during the quarter, and (3) the number of commitments projected for the quarter.

Wisconsin likewise employs multiple regression, but uses a different set of factors. Wisconsin utilizes a set of three very diverse factors, which include: (1) age specific census data, (2) economic factors such as employment and income, and (3) arrest rates and conviction data. Texas is another state that uses three factors in its multiple regression equation: (1) new receives per annum (indicating all transactions, not just actual persons received), (2) paroles per annum, and (3) discharges per annum. New Mexico uses yet another combination of factors: (1) intake statistics over the past decade, (2) state population change, and (3) critical age groups in the work force. The factors used by Arizona in its equation are: (1) number of admissions, (2) typical length of sentences, and (3) the pattern of parole decisions. South Carolina includes: (1) the number of parolees, (2) economic variables, and (3) the population at risk. Table 2 lists the factors employed by those states utilizing multiple regression.

The degree of success reported by the states that have used the multiple regression technique is not all that encouraging. New Mexico, for instance, reports less reliability for this method than for linear regression. Wisconsin states that the technique has produced "no involvement over linear admissions model," while the comment from Texas is that the reliability of multiple regression has been "inadequate due to change (legislative) in parole assumptions." Colorado remarked that their projections utilizing multiple regression have turned out to be conservative, and attributed the discrepancy between the projected and actual population to the passage of mandatory sentencing legislation.

A few states have approached population projections through use of a simulation model. The purpose of such a model is to reproduce the workings of the criminal justice system, or of a part of that system. For example, the model employed by Georgia attempts to simulate the movement of offenders through the prison system.

TABLE 2

Factors Used in Multiple Regression by States Employing This Technique

Florida	1. Population at Risk	2. Unemployment Rate	
Illinois	1. Population at Risk	2. Unemployment Rate	
Colorado	(admissions) 1. Unemployment rate for preceding quarter	2. Average percentage of yearly commitments received each quarter	3. Population at Risk
	(total population) 1. Percentage of all commitments received three quarters earlier with an indeterminate minimum sentence	2. Parole revocation level during this quarter	3. Number of commitments projected for the quarter
Wisconsin	1. Age specific census data	2. Economic factors such as employment and income	3. Arrest rates and conviction data
Texas	1. New receives per annum	2. Paroles per annum	3. Discharges per annum
New Mexico	1. Intake statistics over the past decade	2. State population change	3. Critical age group in the work force
Arizona	1. Number of admissions	2. Typical length of sentences	3. Pattern of parole decisions
South Carolina	1. Number of paroles	2. Economic variables	3. Population at Risk

In order to do this, actual release policy was studied. Since sentence length and the amount of time actually served differ considerably, the distribution of time actually served for each different sentence length was examined for 18,000 inmates that had been released over a three year period. It then became possible to estimate how many inmates currently incarcerated would still be in prison for each successive quarter. The same process was followed for the expected future admissions. The method used for predicting admissions was an extremely simple one. A "low track" of admissions was based on the assumption that admissions would only grow at the same rate as the state population, while the "high track" assumed that the recent rate of very high growth in admissions would continue. A point midway between the two tracks was chosen as the best estimate.

Virginia also uses a simulation model. In this state, the inmate population is divided into four groups. These four groups are: (1) misdemeants, (2) felons currently confined in the State institutions, (3) convicted felons in local jails, awaiting admission to the State system, and (4) felons expected to be committed during the projection time frame.

Since the number of misdemeanants is very small, and has remained stable for some time, it is assumed that this population will continue to show little change. For felons currently confined, an expected release data is projected, based on trends in time served for the given sentence. Distinctions are made among expected release data, minimum discharge date, and the full sentence term.

The expected date of release is likewise projected for each felon awaiting admission to the prison system. The number of felons expected to be committed--the admission figure--is determined by the projected state population, felony arrests, and commitment rates. This group is divided into seventeen categories that reflect expected sentence upon commitment. Each group is further split into one consisting of inmates expected to be paroled, and another of inmates expected to be directly discharged. After all four groups of inmates have been analyzed, the total population can be determined by adding expected new commitments to the current population, and subtracting the number of expected releases.

North Carolina has perhaps developed the most complicated series of models that attempts to simulate the workings of the correctional system. Four different models of varying degrees of complexity have been developed.

The first is a simple flow model. In this model the prison population is partitioned into a small number of categories, represented by the nodes of a network, with each category corresponding to a custody class or group of classes. The flows between the categories are determined on the basis of flow-conservation equations.

The second is a general Markov deterministic population model. In this model, a subdivision of the population into various categories (such as custody levels) is combined with a detailed representation of transfers between these categories by means of a matrix of transition probabilities.

The third model developed, a systems-dynamics model, is one in which the system is modeled in continuous time. Population levels are represented as continuous variables, with flows governed by functional relations that can show time-delay and feedback effects.

The fourth model in question is the most complex: a discrete event digital simulation of the system, in which the progress of inmates through the system is tracked. Statistics are gathered on inmate characteristics such as age, sex, custody classification, crime category, sentence length, history of infractions, and so on.

The models were developed so that the effect of alternative policies on the correctional system could be assessed. The policies in question involved: (1) parole policy and the effect of an elimination of paroles, (2) sentence length, and (3) the transfer of inmates between custody levels.

Although some of the models developed by North Carolina become very complicated in the effort to trace an inmate's progress through the system, these models do not address themselves to another important input into the correctional system, the number and rate of admissions.

If the North Carolina methodologies emphasize what happens to an inmate once he enters the correctional system, the Maryland technique is primarily directed towards predicting the probability of an offender entering the system in the first place. Maryland planners have recognized the well-known weaknesses of the linear regression technique that relies on past inmate populations as the data base. As a result, they have developed the "arrest/ demographic" technique to help provide more accurate projections.

Although this method does make use of length of sentence data in making projections, the technique applied here appears to be rather unsophisticated. The main thrust of the Maryland technique involves the prediction of admissions through an examination of arrest and population trends.

In this technique an analysis is made of current arrest rates for specific crime types as a function of the age, sex and race of the state's population. An assumption is made that current arrest rates for specific crime types and demographic groupings of the population will remain more or less constant for several years. Thus, any change in the number of arrests would be the result of changes in the total population of the state and/or its demographic composition over time. For example, if the arrest rate for non-whites is several times higher than for whites in particular crime categories, it is assumed that this differential will continue. If the population projections show that the non-white segment is expected to increase, the number of arrests can be adjusted accordingly.

An analysis is also made of the current probabilities of being convicted and sentenced to a correctional institution for a specific crime type. Once again it is assumed that this probability will remain reasonably constant (until 1985). The objective of this simulation model is to trace the progress of an offender through the criminal justice system.

Since crime rates do not necessarily translate into potential prisoners, the starting point is arrests. Inmate intake is seen as equivalent to "the number of adult apprehensions times the product of several intermediate 'offender' flow probabilities or percentages (e.g., the probability given arrest of going to trial, the probability given trial of being convicted, the probability given conviction of being sentenced to a State correctional facility)."

One noteworthy feature of Maryland's technique is that the analysis of arrest rates and the probability of incarceration is broken down into specific crime types. This should allow the criminal justice planner the opportunity to gauge the impact on prison populations of a sharp rise in arrests and convictions for one particular crime, even when the trend elsewhere is downward.

So far, we have briefly covered those states reporting use of either multiple regression, or a simulation model. A different approach has been taken in Indiana. The correctional planners in that state have remarked:

> In the analysis of potential projection methodologies it quickly became apparent that traditional mathematical models, such as trend analysis, classical forecasting, and time series would not incorporate the effects of many of the factors which are presently causing major increases in the correctional population. Many of these factors cannot be quantified in a statistical manner, but instead must be viewed from a qualitative perspective.

The factors included in the analysis are: societal attitudes and conditions, population and economic conditions, crime and arrest rates, implications of the new State Criminal Code, past and present utilization of probation and other community alternatives, and parole policies.

It should not be assumed that the largely qualitative multi-factor approach used by Indiana necessarily represents a less advanced stage of population projection methodology. In some respects precisely the opposite may be the case. An excellent example is furnished by the discussion on population and economic factors. The correctional planners in Indiana believe, as do other planners elsewhere, that the depressed economic conditions will give way to a more favorable situation. They point out, however, that "the unemployment rate for the 20-29 age group will not significantly improve over the next five years. This situation will be especially true of minority groups." Thus a very considerable improvement in the aggregate economic indicators may have little effect since the improvement would not be filtering down to the most crime prone segments of the general population.

One possible weakness of Indiana's approach is that there is a tremendous range between the low and high projections (low: 5,014; high: 10,028). These projections are for 1981 and there is no comment as to which projection, the low or high, is more plausible.

New York also uses a multi-factor approach, although the factors involved are somewhat different than those used by Indiana. Oregon likewise employs a variant of the multi-factor approach. In that state, the size of the population at risk (males 15-29) is studied, and cycles of "public sentiment" are analyzed. Let us quote the Oregon report, since the approach is somewhat unorthodox:

> We believe we see a pattern: without regard to details of law or events, public sentiment appears to control the percentage of the risk group which must at any given moment be under state felony control, and the percentage of those under control who will be confined. Every 20 years, public sentiment shifts and a new and higher percentage is established. It takes from five to seven years for the new level to be reached, and it thereafter remains fairly constant for the remainder of the twenty year cycle. At all times, however, the level actually noted is modified in direct relation to two factors: Oregon rates of unemployment, and U.S. Military strength as a percentage of the national risk group.

Most of the other states that carry out population projections employ some variant of demographic analysis. New Jersey, for instance, breaks down the state into "catchment" areas and determines the expected prison population for each area. The projected population for the entire state is studied, as well as the confinement rate for certain subgroups of the population. In particular, the confinement rate for males aged 20-44, and for non-white males in the same age bracket, is examined.

Rhode Island offers projections based upon: (1) the highest incarceration rate per 100,000 for 1970-77, (2) the average of the highest and the lowest rate for 1970-77, and (3) the average rate of increase from 1970-77.

New Hampshire analyzes these factors: (1) projected population for each county in the state along with an age breakdown, (2) the anticipated conviction rate, based on historical data, (3) the relative distribution of offenses, and (4) detailed information relating personal factors to criminal record.

Utah studied the ratio of the average prison population to the population of the state, going back as far as 1900. War years were excluded, and fifty people were added to the projections for 1985 and 1990 on the assumption that Utah's low incarceration rate would move closer to the national average.

Nebraska analyzed the S-shaped growth curves of the prison population and compared the incarceration rates at different points with the expected growth of the population at risk (defined as the age group from 20-29). This state also analyzed the lag between admission and release (found to be two years), and projected total population by assuming that this pattern would continue.

Iowa analyzed the growth in the population at risk group (males aged 15-29), and also the expected growth in the crime rate. Several projections were offered, reflecting varying degrees of optimism.

Minnesota analyzed the commitment rate to state institutions along with the growth in the population at risk. Total population was projected using these factors along with that of sentence length.

Most of the states reported that there were constraints involved in the process of making population projections. Although lack of money, political interference, and the lack of inter-agency cooperation were reported occasionally, several other constraints were cited much more frequently. These were the lack of sufficient data of high quality, the absence of specially trained staff, and policy changes. More states mentioned "insufficient data" as a constraint than any other difficulty.

In summary the survey has generated a picture of the diversity of methods and approaches currently employed. Several states do not perform any population projections, while others have developed methods of considerable sophistication and complexity. Certain common features are apparent in those states that do perform projections. In the area of inmate length of stay, there is an attempt to determine the actual amount of time served by inmates as opposed to the official sentence length. In trying to predict admissions, population at risk and the unemployment rate are used more frequently than other factors. It will be noted that the age group included in "population at risk" varies considerably: in one state it is males 15-29, in another, males 18-34, and so on. No particular reasons are given as to why certain ages rather than others are included. Many of the states claim that unemployment is a reliable predictor of admissions, but a few states dispute this claim. In a case like this it is difficult to tell whether a prediction is valid or invalid everywhere or whether the special conditions found in different states are decisive.

It is similarly difficult to judge the merit of a particular prediction methodology. If a high degree of accuracy is reported for a given state over a period of several years, that may or may not indicate generalized value for the methodology. The way in which to determine the comparative merit of methodologies presently available--quite apart from the issue of developing better techniques--may well be to test a specific methodology, using data for several decades, in a single state. Those that pass this test with the greatest degree of success could then be tried in other states. If nothing else, a procedure of this sort would enable correctional planners and researchers to understand more fully the extent to which conditions bearing on prison population in the states are similar or dissimilar.

TABLE 3

Summary of Survey Results

STATES SURVEYED:	50
STATES RESPONDING TO THE SURVEY:	44 88%
RESPONDING STATES FURNISHING DOCUMENTS:	20 46%
RESPONDING STATES THAT PUBLISH PROJECTIONS:	32 73%
RESPONDING STATES THAT HAVE USED LINEAR REGRESSION:	21 48%
RESPONDING STATES THAT HAVE USED MULTIPLE REGRESSION:	7 16%
RESPONDING STATES THAT HAVE USED A SIMULATION MODEL:	6 14%

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END