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ABSTRACT

The study is an evaluation of the utility of manpower forecasting in the United States as a basis for manpower, education, and health policy. It examines the methodology employed and the scope of analysis in nearly 400 forecasts made in the period 1965-73. It assesses the adequacy of the theoretical and empirical knowledge base for forecasting in three analytic areas: the forecasting of sector outputs, the estimation of human resource input requirements, and limitations of occupational classification systems in specifying the relationship between manpower requirements and supply systems. The study concludes that the major limitation on the current state of the art is conceptual and institutional, and improvements in the knowledge base are not sufficient to policy needs. It suggests an agenda of institutional and empirical research for this purpose. (Author)

MANPOWER FORECASTING IN THE UNITED STATES:

An Evaluation of the State of the Art

by

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Columbus, Ohio
1975

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FOREWORD

This evaluation of policy-related research on manpower forecasting in the United States is one of 20 in a series of projects on the Evaluation of Policy-Related Research in the Field of Human Resources, funded by the Division of Social Systems and Human Resources in the Research Applied to National Needs (RANN) Program of the National Science Foundation.

A large body of policy related research on human resources has been created over the last quarter century. However, its usefulness to decision makers has been limited because it has not been evaluated comprehensively with respect to technical quality, usefulness to policy makers, and potential for codification and wider diffusion. In addition, this research has been hard to locate and not easily accessible. Therefore, systematic and rigorous evaluations of this research are required to provide syntheses of evaluated information for use by public agencies at all levels of government and to aid in the planning and definition of research programs.

Recognizing these needs, the Division of Social Systems and Human Resources issued a Program Solicitation in January 1973 for proposals to evaluate policy-related research in 21 categories in the field of human resources. This competition resulted in 20 awards in June 1973.

Each of the projects was to: 1) Evaluate the internal validity of each study by determining whether the research used appropriate methods and data to deal with the questions asked; 2) Evaluate the external validity of the research by determining whether the results were credible in the light of other valid policy-related research; 3) Evaluate the policy utility of specific studies or sets of studies bearing on given policy instruments; 4) Provide decision makers, including research funders, with an assessed research base for alternative policy actions in a format readily interpretable and usable by decision makers.

Each report was to include an analysis of the validity and utility of research in the field selected, a synthesis of the evidence, and a discussion of what, if any, additional research is required.

The following is a list of the awards showing the research area evaluated, the organization to which the award was made, and the principal investigator.

(1) An Evaluation of Policy Related Research on New Expanded Roles of Health Workers - Yale University, School of Medicine, New Haven, Connecticut, 06520; Eva Cohen

(2) An Evaluation of Policy Related Research on the Effectiveness of Alternative Allocation of Health Care Manpower - Interstudy, 123 East Grant St., Minneapolis, Minnesota, 55403; Aaron Lowin

(3) An Evaluation of Policy Related Research on Effects of Health Care Regulation - Policy Center, Inc., Suite 500, 789 Sherman, Denver, Colorado, 80203; Patrick O'Donoghue

(4) An Evaluation of Policy Related Research on Trade-Offs Between Preventive and Primary Health Care - Boston University Medical Center, Boston University School of Medicine, Boston, MA, 02215; Paul Gertman

(5) An Evaluation of Policy Related Research on Effectiveness of Alternative Programs for the Handicapped - Rutgers University, 165 College Avenue, New Brunswick, New Jersey, 08901; Monroe Berkowitz

(6) An Evaluation of Policy Related Research on Effects of Alternative Health Care Reimbursement Systems - University of Southern California, Department of Economics, Los Angeles, Calif., 90007; Donald E. Yett

(7) An Evaluation of Policy Related Research on Alternative Public and Private Programs for Mid-Life Redirection of Careers - Rand Corporation, 1700 Main Street, Santa Monica, Calif., 90406; Anthony H. Pascal

(8) An Evaluation of Policy Related Research on Relations Between Industrial Organization, Job Satisfaction, and Productivity, Brandeis University, Florence G. Heller Graduate School for Advanced Studies in Social Welfare, Waltham, MA, 02154; Michael J. Brower

(9) An Evaluation of Policy Related Research on Relations Between Industrial Organization, Job Satisfaction and Productivity - New York University, Department of Psychology, New York, New York, 10003; Raymond A. Katzell

(10) An Evaluation of Policy Related Research on Productivity, Industrial Organization and Job Satisfaction - Case Western Reserve University, School of Management, Cleveland, Ohio, 44106; Suresh Srivastva

(11) An Evaluation of Policy Related Research on Effectiveness of Alternative Methods of Reduce Occupational Illness and Accidents - Westinghouse Behavioral Safety Center, Box 948, American City Bldg., Columbia, Md., 21044; Michael Pfeifer

(12) An Evaluation of Policy Related Research on the Impact of Unionization of Public Institutions - Contract Research Corp., 25 Flanders Road, Belmont, Massachusetts; Ralph Jones

(13) An Evaluation of Policy Related Research on Effectiveness of Alternative Pre-Trial Intervention Programs - ABT Assoc., Inc., 55 Wheeler Str., Cambridge, Massachusetts, 02138; Joan Mullen

(14) An Evaluation of Policy Related Research on Standards of Effectiveness of Pre-Trial Release Programs - National Center for State Courts, 1660 Lincoln Street, Denver, Colorado, 80203; Barry Mahoney

(15) An Evaluation of Policy Related Research on Effectiveness of Volunteer Programs in the Area of Courts and Corrections - University of Illinois, Department of Political Science, Chicago Circle, Box 4348, Chicago, Ill., 60680; Thomas J. Cook

(16) An Evaluation of Policy Related Research on Effectiveness of Juvenile Delinquency Prevention Program - George Peabody College for Teachers, Department of Psychology, Nashville, Tenn., 37203; Michael C. Dixon

(17) An Evaluation of Policy Related Research on Exercise of Discretion by Law Enforcement Officials - College of William and Mary Metropolitan Building, 147 Granby St., Norfolk, Virginia, 23510; W. Anthony Fitch

(18) An Evaluation of Policy Related Research on Exercise of Police Discretion - National Council of Crime and Delinquency Research Center, 609 2nd Street, Davis, California, 95616; M.G. Neithercutt

(19) An Evaluation of Policy Related Research on Post Secondary Education for the Disadvantaged - Mercy College of Detroit, Department of Sociology, Detroit, Michigan, 48219; Mary Janet Mulka

A complementary series of awards were made by the Division of Social Systems and Human Resources to evaluate the policy-related research in the field of Municipal Systems, Operations, and Services. For the convenience of the reader, a listing of these awards appears below:

(1) Fire Protection - Georgia Institute of Technology, Department of Industrial and Systems Engineering, Atlanta, Ga., 30332; D.E. Fyffe

(2) Fire Protection - New York Rand Institute, 545 Madison Avenue, New York, New York, 10022; Arthur J. Swersey

(3) Emergency Medical Services - University of Tennessee, Bureau of Public Administration, Knoxville, Tenn., 37916; Hyrum Plaas

(4) Municipal Housing Services - Cogen Holt and Associates, 956 Chapel St., New Haven, Connecticut, 06510; Harry Wexler

(5) Formalized Pre-Trial Diversion Programs in Municipal and Metropolitan Courts - American Bar Association, 1705 DeSales St., N.W., Washington, D.C., 20036; Roberta-Rovner-Pieczenick

(6) Parks and Recreation - National Recreation and Park Association, 1601 North Kent St., Arlington, Va., 22209; The Urban Inst., 2100 M St., N.W., Washington, D.C. 20037; Peter J. Verhoven

(7) Police Protection - Mathematica, Inc., 4905 Del Ray Avenue, Bethesda, Md., 20014; Saul I. Gass

(8) Solid Waste Management - Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, Massachusetts, 02139; David Marks

(9) Citizen Participation Strategies - The Rand Corporation, 2100 M St., N.W., Washington, D.C. 20037; Robert Yin

(10) Citizen Participation: Municipal Subsystems - The University of Michigan, Program in Health Planning, Ann Arbor, Michigan, 48104; Joseph L. Falkson

(11) Economic Development - Ernst & Ernst, 1225 Connecticut Avenue, N.W., Washington, D.C. 20036; Lawrence H. Revzan

(12) Goal of Economic Development - University of Texas-Austin, Center for Economic Development, Department of Economics, Austin, Texas, 78712; Niles M. Hansen

(13) Franchising and Regulation - University of South Dakota, Department of Economics, Vermillion, South Dakota, 57069; C.A. Kent

(14) Municipal Information Systems - University of California, Public Policy Research Organization, Irvine, California, 92664; Kenneth L. Kraemer

(15) Municipal Growth Guidance Systems - University of Minnesota, School of Public Affairs, Minneapolis, Minnesota, 55455; Michael E. Gleeson

(16) Land Use Controls - University of North Carolina, Chapel Hill, Center for Urban and Regional Studies, Chapel Hill, North Carolina, 27514; Edward M. Bergman

(17) Land Use Controls - The Potomac Institute, Inc., 1501 Eighteenth St., N.W., Washington, D.C. 20036; Herbert M. Franklin

(18) Municipal Management Methods and Budgetary Processes - The Urban Institute, 2100 M St., N.W., Washington, D.C., 20037; Wayne A. Kimmel

(19) Personnel Systems - Georgetown University, Public Service Lab., Washington, D.C. 20037; Selma Mushkin

Copies of the above cited research evaluation reports for both Municipal Systems and Human Resources may be obtained directly from the principal investigator or from the National Technical Information Service (NTIS) U.S. Dept. of Commerce, 5285 Port Royal, Springfield, Virginia, 22151 (Telephone: 703/321-8517).

This research evaluation by S.C. Kelley, Thomas N. Chirikos and Michael G. Finn of The Center for Human Resource Research, The Ohio State University on manpower forecasting in the United States was prepared with the support of the National Science Foundation. The opinions, findings, conclusions, or recommendations are solely those of the authors.

It is a policy of the Division of Social Systems and Human Resources to assess the relevance, utility, and quality of the projects it supports. Should any readers of this report have comments in these or other regards, we would be particularly grateful to receive them as they become essential tools in the planning of future programs.

Lynn P. Dolins
Program Manager
Division of Social Systems
and Human Resources

PREFACE

This study is an attempt to appraise the current state of the art of manpower forecasting in the United States through an examination of recent practice and an evaluation of the methodologies employed. Its primary objective was to assess the extent to which the current practice is constrained by limits of the knowledge base and to develop an agenda of research that could enhance the state of the art.

Toward this end, the authors reviewed approximately 376 manpower forecasts made in the period 1965-1973, which met the selection criteria detailed later in the report. We do not know with certainty whether these studies adequately represent the current practice. We believe they do, however, because our search for relevent items was a relatively extensive one. Initially, the search procedure drew heavily on three bibliographic network systems: The Educational Resources Information Center (ERIC) and particularly its Abstract of Instructional and Research Materials in Vocational and Technical Education (AIM/ARM), the National Technical Information Service (NTIS), and the Medical Literature Analysis and Retrieval System (MEDLARS). This search of formal sources produced nearly 2,000 citations, of which all but 500 were rejected on the basis of information gained from abstracts. To test the adequacy of the sample, specific computer listings of titles of forecasting studies were distributed to each regional office of the Department of Labor (Manpower Administration), the Bureau of Employment Services of each State, and to all State Manpower Planning Councils. Each respondent was asked to review the listing for his area and to provide additional references, if any were known. Although responses were received from 43 states, very few relevant citations were received. On acquisition and review, the residual set of approximately 500 studies was reduced to the 376 which met our criteria of time and scope.

These studies were divided into subsets on the basis of the size of the labor market represented, their occupational and industrial scope and the methodology employed. The description and the analysis of the current practice in the study is structured along these dimensions. The analysis of the current practice suggested that the major constraints on the current state of the art were institutional rather than substantive or methodological. Nevertheless, it also supported the initial hypothesis of the study that the major substantive limitations were those relating to the specification and projection of outputs, the forecasting of technical change, and the specification of the relationship between manpower requirements and the supply systems. Each of those areas was the subject of an extensive search of the literature and an evaluation of the current

body of theoretical and empirical knowledge as it relates to manpower forecasting and policy formation. In this literature search, the authors made extensive use of the Ohio State University Mechanized Information Center.

The report begins with a discussion of the policy objectives and institutional context of manpower forecasting in the United States, and describes briefly the human resource paradigm and the forecasting model on which the study is structured.

The three chapters that follow are concerned with the evaluation of the knowledge base for forecasting manpower requirements. Chapter II examines the theoretical and empirical basis for forecasting changes in the structure of final demand and sectoral output. Chapter III offers a similar analysis of the current basis for projecting technical change and the sectoral transformation process. Chapter IV considers the limitations of existing occupational chassification systems for specifying performance functions and qualification standards.

The next section of the study describes the current practice of manpower forecasting in the United States in the general case and in terms of two case studies. Chapter V provides an overview of forecasting practice and a general evaluation. Chapter VI is a specific analysis of the Bureau of Labor Statistics' Manpower matrix and its applications at regional levels. Chapter VII describes and evaluates manpower forecasting in the health sector.

Finally, Chapter VIII summarizes the study and its conclusions, and suggests priority areas for research to improve the state of the art. A listing of the forecasts reviewed in the study is contained in the Appendix. References cited in specific chapters appear at the end of each chapter. It should be noted that a substantial set of general reference materials was also used in preparing the manuscript, but has not been listed for reasons both of space and relevance. A complete list of bibliographic materials is available, however, from the authors on request.

The introductory chapter and Chapter II were prepared by Professor Kelley. Chapters III and VII were written by Professor Chirikos, and Chapters IV and VI by Dr. Finn. Professors Chirikos and Kelley are jointly responsible for the concluding chapter (VIII); moreover, while all three investigators contributed to the assessment of forecasting practice, they assumed principal responsibility for drafting Chapter V. Professor Chirikos also assumed general responsibility for editing the manuscript.

We are indebted to Ms. Sammy Kinard, the Librarian of the Center for Human Resource Research for her assistance in the search process, and to Ms. Jane York for typing the manuscript.

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CHAPTER I

SETTING THE STAGE

Introduction

Although manpower forecasting is a recent and still rather primative art, the use of forecasts in policy formation is a widespread practice. They are used by virtually every national government in the development of strategies for economic growth and structural change, and as a basis for employment and educational policy. They are used by public and private agencies as criteria for investment in education, training, health and labor market institutions, and for the design and evaluation of specific programs relating to the development and utilization of human resources.

The concept of human attributes as resources and the phenomenal growth of public concern with human resource endowments is a pragmatic response to a set of conditions that has long dominated public policy. The persistence of structural unemployment, of "manpower" constraints on economic growth and structural change, the simultaneous condition of employment and inflation are all partial products of structural imbalance between a system's requirements for human resources and its human resource endowments. The magnitude and the universality of this underlying condition is a result of the unique economic conditions of the past twenty years, in particular the economic recovery of the industrialized nations from the aftermath of World War II and the tremendous increase in the economic aspirations of the less developed world. In both contexts, the concern with structural imbalance created a pressing need for explicit criteria for policy formation and evaluation, while the theoretical constructs of Western economics were oriented toward the aggregate problems of the 'thirties or with incremental structural adjustments in a system in static equilibrium. This gap between real world needs and the theoretical models on which policy was based produced a proliferation of pragmatic responses to specific policy questions and a demand for relevant policy criteria.

The development of manpower forecasting was a response to this demand. Like the policy that it was intended to serve, it has developed pragmatically in specific applications, and its constructs and methodology reflect the contextual variety in which it has developed. As a broad generalization, one can say that differences in methodology in manpower forecasting, in the scope of policy analysis, and in the use of forecast information have been functionally related to the level of economic development, to the scale of the policy problem, and to the degree of social commitment to a market mechanism as a decision instrument.

This study is an analysis of current and recent experience in manpower forecasting in the United States. It attempts to evaluate this experience in terms of the adequacy of its theoretical and empirical foundations and its operational utility in policy formation. Its objetives are to enhance the diffusion of present knowledge and experience among practitioners, to identify and order the needs for expansion and improvement in the relevant knowledge base, and to delineate the potential roles and limitations of manpower forecasting as a decision instrument in this economic and political context.

The original design of the study recognized that the form and methodology of forecasting are influenced or determined by the specific policy objectives the forecast is intended to serve, and by the social and economic context in which it is made. With this in mind, the research design was focused on evaluating those elements of the knowledge base generic to manpower forecasting and impeding improvement in the state of the art, as revealed by the practice of forecasting in the United States. The a priori assumption, based on experience in manpower planning and forecasting in the developing countries, was that the major constraints were limitations of the information and knowledge base for the specification of technical relationships. It was also assumed that these deficiences were centered on the estimation of manpower requirements--in particular, the specification of social objectives and transformation processes, and the specification of the functional form of the relationship between performance roles and human attributes. Unfortunately, an extensive review of forecasting practice in the United States suggests that the state of the art is rudimentary relative to experience in other contexts, and that it would be mistaken simply to evaluate research needs or specify research priorities relating to methodological or substantive concerns.

The reason is that the practice of manpower forecasting in the United States has developed in response to a poorly specified set of policy concerns and in a variety of institutional and policy contexts. The range of experience, the variety of functional interpretations and the diversity of techniques employed seriously limits the possibility of deriving from this experience a generalized model that can serve as basis for a research agenda. Even if it were possible to do so, the best-practice technique employed in the United States and the most sophisticated conceptual models of the process extant in this country are simplistic compared with experience in the developing countries. A research agenda specified on the basis of the current practice could only reinforce the conceptual limitations that have conditioned that practice. It is this conceptual bias and its institutional consequences, rather than the knowledge base, that has determined the current state of the art.

Accordingly, this Chapter examines these conceptual and institutional factors and their effects on forecasting and its policy roles. It derives, from the generalized experience of the developing countries, a best practice model or conceptual framework to serve as a source of criteria for the analysis and evaluation of the current practice in the United States and for the evaluation of contemporary research. The latter evaluation is concentrated on those elements of analysis relating

to the forecasting of manpower requirements, rather than supplies, because it is this area that has been most seriously constrained by the conceptual and institutional context.

Given this base, the three Chapters that follow are concerned with the constraints generally imposed on manpower forecasting by limitations of the current knowledge and information base. They attempt to evaluate the current state of the art in specifying functional relationships generic to forecasting, and estimating their parameters over time. Specifically, Chapter II is concerned with forecasting the outputs or products of those systems that use human resources; in particular, it is concerned with the specification of a long-term social welfare function and the growth and structural change that it implies. Chapter III is concerned with estimating changes in the transformation process of these systems and their implications in regard to the level and structure of labor requirements. It focuses, in particular, on the concept of the production function and its utility and limitations in specifying labor inputs. Chapter IV examines the current practice of specifying human attributes and performance functions in occupational terms, and the limitations of this form of specification in linking manpower requirements to supply systems.

Chapters V-VII, then, describe the general characteristics of the recent practice of manpower forecasting in the United States, as reflected in more than 300 projection studies published since 1965. The primary task of those Chapters is to evaluate the relative importance of institutional and knowledge constraints on the current state of the art. Chapter V provides an overview of forecasting practice, while Chapters VI and VII treat, in greater detail, dominant areas of application, viz., the use of the Bureau of Labor Statistics National Manpower Matrix and its regional derivatives, and manpower forecasting in the health field. Finally, Chapter VIII summarizes the principal conclusions of the analysis, and derives our agenda for research to improve the policy utility of manpower forecasting in the United States.

The Policy Role of Manpower Forecasting: Concept and Practice

Manpower forecasting attempts to predict imbalance or inequalities between the flow of social requirements for human resources and the flow of human attributes or capacities from the social systems that develop and condition them. Imbalance between flows of attributes and requirements may constrain economic growth or contribute to unemployment or inequities in economic and social mobility. Anticipated imbalance or changes in the balance requirements are basic criteria for social intervention in these problem areas.

The need for forecasts is a function of the dynamic characteristics of labor markets in industrialized, market economies, and the inadequacies of market mechanisms in adjusting manpower requirements and supplies. Historically, the conditions of demand have been extremely sensitive to the impact of technology on the level and structure of final demand, on

the range of production possibilities, and on the cultural and institutional structure of the society. In contrast, the conditions of supply are relatively static. They are strongly influenced by the cultural determinants of labor force participation and behavior, and by the force of tradition and prior investment in the institutions that develop and allocate human resources. The employment-related attributes of persons now entering the labor force were developed in the previous two decades. They are products of institutions, including family and community, whose production characteristics were developed over an even longer period. Social investments in the more important characteristics of human resources have a very long period of gestation and, in a technologically dynamic economy, a high rate of functional obsolesence.

It is obvious that investment decisions in labor markets are made under conditions of great uncertainty. The ultimate role of manpower forecasting is to reduce uncertainty in this set of decision processes by providing future information to individual decision makers and by providing policy criteria for the development of risk-reducing social strategies. In the conceptual framework of human capital theory, the decision of an individual to invest in himself is constrained by the range of investment possibilities available to him as a result of prior collective decisions and by his expectations concerning the future conditions of demand for the product of his investment. The future condition of demand will depend, in turn, on collective expectations concerning human resource and other resource endowments as well as the set of transformation processes and the conditions of demand for their products. These individual and collective decisions are complementary in any context in which substitution possibilities for factors or products are less than perfect.

Manpower forecasting is, in this context, a partial substitute for a competitive market mechanism or a complement to an imperfect market. To provide in the long term the criteria that a market is assumed to provide in the short term, forecasting must specify the set of social goals and priorities to which economic processes will respond, the technical and social constraints on the choice of means, the human performance roles implicit in the means, the human attributes associated with those roles, and the optimal means for attribute development. Social policy may act to rationalize these process elements by various means in a variety of permutations. It may act to change social preference functions, influence time preferences, constrain the choice of means, define qualification standards or modify resource endowments. The choice of intervention possibilities and their relative weights and timing constitute a decision strategy. When conflicts exist between goals or between ends and means, a trade-off strategy is necessary. This strategic role is the primary function of forecasting. The choice of strategy and strategic instruments is constrained in the short-term by gestation lags. Consequently, short-term, crisis solutions involve social costs in the form of unemployment, income foregone and distributional inequities that could have been limited or avoided by anticipatory action.

A forecasting model is essentially an analytic instrument and its form and specification are necessarily a function of the policy objectives it is intended to serve. The diversity of forecasting models in the United States and the limited forms of their specification are reflections of the current state of manpower policy. The set of policies or programs that can be interpreted to comprise "manpower" policy have evolved pragmatically, as ad hoc responses to current crisis. They are almost exclusively curative or alleviative measures rather than preventive. They are not based in a structure of ultimate goals or priorities, and they provide limited criteria for evaluating current opportunity costs or long term implications. There is little recognition of the interdependence within the set or between this set of social concerns and other concerns that have manpower or employment implications but are not specified in these terms.

Recent intuitive evaluation of the experience of the last ten years has produced a broad concensus among experts on the need for a comprehensive manpower policy, although the manpower term is narrowly interpreted. The ability to develop a comprehensive manpower policy that is internally consistent and consistent with the total set of social goals and priorities requires a conceptual framework that views policy formation as a holistic process of decision making and that can provide organizational criteria for rationalizing the complex set of institutions that implement policy. There is little inclination in the United States to think in terms of social systems and consequently to structure decision processes in system form. It is virtually impossible to model a large system or even a major subsystem in operational terms except in the extremely abstract and aggregate terms of a market. Even those systems which have system identifications as in education and health have in reality few system characteristics. The system term is a semantic convenience rather than a descriptor.

One contributing factor that is particularly relevant to this study is the specialization and fragmentation of knowledge and its consequence for the development of a unified, consistent theory of social process; a limitation that is evident within the discipline of economics and between economics and other disciplines. The failure of economics to integrate aggregate and disaggregate analysis and consequently to move toward a dynamic process theory has separated public policy into an aggregate employment policy and a disaggregate manpower policy. It is impossible to conceive of a pattern of economic growth that does not involve structural change, or a significant change in the structure of activity that does not affect the total. Yet these changes are treated independently in conventional economic constructs and, as a result, in policy formation. The state of economic theory has also constrained the integration of economics and other social sciences. As a consequence, public policy based in economic constructs reflects their simplistic psychological, sociological and cultural assumptions. Human resources are defined in terms of functional skills in a narrow job context. Change is a simple function of profit maximizing behavior and the institutional and cultural context is static. Since the interdependence of human

resource institutions are not specified in theory, it is not reflected in practice. Policy responses to problems of unemployment or growth reflect little sensitivity to the interdependence between educational, training, health, community and labor market institutions.

These limitations of theory and concept have several implications in regard to the current state of the art of forecasting. Given the currently vague delineation of the field and of institutional responsibility, only a minute portion of an extensive if fragmentary knowledge base is brought to bear in the practice of manpower forecasting, or in the formation of manpower policy. Many practitioners in this field appear unaware of the most fundamental conclusions of the large body of empirical research that has accumulated in relevant fields, or they can not relate it to their perception of problems. A second consequence is one which stems from the first. There has not been a flow of criteria, grounded in experience, for the allocation of resources in the development of the knowledge base. This has led to an incredible waste of resources on research that is frequently redundant and at best of peripheral value. At the same time many of the most important parameters of the problems are unexplored.

A third consequence stems from the obvious fact that the dimensions of the problem set are such that they relate to the substantive concerns of several conventional disciplines. Ignoring the limitations of the theoretical foundations of any or all of these disciplines, specialists in each have a limited capacity to interact with others and to integrate or even introduce relevant perceptions or knowledge that are not of their jurisdiction. Each interested field has defined and frequently labeled the problem set in its own terms. It is hardly surprising that a set of problems that is inherently interdisciplinary or transdisciplinary, has not produced a cohesive literature; that there is no cumulative product of a consistent process of research application and evaluation; or that the difficulty of fitting a rather simple concept into the structure of a general theory of economic or social process should be so great.

A fourth consequence is that the development of the data base for manpower forecasting is also restricted by the lack of relevant criteria. Analysts are condemned to approach each new problem with data that are incomplete or structured for other purposes. The gap between average practice and optimal practice is in some degree a function of data availabilities and the high cost of data development. This effect has been particularly great in the area of manpower forecasting because of the inherent linkage between data sets that have been treated traditionally as independent. The immediate consequence is that an evaluation of current practice may present a distorted view of the current state of the art. The ultimate consequence is that without explicit needs criteria, a rational and efficient process of data development will not occur. The possibility is reflected in the fact that public agencies are currently initiating massive and expensive manpower information systems with no operational specification of the analytic purposes to be served.

Perhaps the most important consequence of all is the failure to move toward an institutional framework that recognizes the interdependence between criteria development, policy formation, and implementation. It is obvious that in any manpower forecast, the behavior of policy making and policy implementing institutions is either an important datum in the analysis or a policy conclusion. Further, there is great interdependence among the set of institutions that implement human resource policy and these institutions are primary sources of data essential to forecasting. Every forecast involves in explicit or implicit form, assumptions concerning social priorities and opportunity costs, the internal efficiency of operating systems and flows of information between subsystems with commonly perceived objectives, i.e., it assumes a rational system. That assumption is rarely consistent with reality. A few recent studies that have examined the institutional characteristics of human resource "service delivery systems" indicate that they have few, if any, system characteristics.[1] Component elements of a nominal system are usually unaware of the existence of other related components or are indifferent to their functions or capacities. The current policy of decentralization of decision processes in the public sector of the United States can only contribute to further disorganization and fragmentation as the primary independent variables of the decision process become external to the operating system. There is very little utility in further investment in methodological improvements in the absence of an appropriate institutional framework for using them.

The extreme pragmatisim that has characterized the development of human resource policy in this context stems primarily from the lack of a clearly relevant conceptual framework for the rationalization and evaluation of policy decisions. Similarly, an analysis of experience in manpower forecasting in the United States and its evaluation as a policy instrument is seriously limited by the fact that the practice of forecasting is not consistent with its institutional environment or with the dominant theoretical structure. An attempt to order that experience is inhibited by nearly total variance in objectives, concepts, technique, and institutional forms, while the literature and critique of forecasting reveals a confusion of terminology, unspecified objective functions, conflicting analytic assumptions and widely differing definitions of scope and substance.

Theoretical Foundations

The basic construct on which manpower forecasting is rationalized is the concept of investment in human capital and its corollary the concept of humans as resources. The concept suggests that the skills and knowledge embodied in people are important determinants of economic and social progress. The social welfare and the rate of social progress depend in part on the attributes of the stock of human resources and on the rate at which they are developed. Like all other resources, these human capacities are scarce and should be developed and conserved. It follows that individual and social efforts to develop or maintain them are acts of investment, conceptually comparable to investment in the machines and tools of production.

The concept of human capital is obviously an economic concept both in its origins and in its problem focus. Yet it has been ignored in economic theory since Marshall. T.W. Schultz has attributed this long lag to a repugnance to the idea of treating human beings as capital goods and to the convenience to theoretical economic models of treating labor as "a unique bundle of innate abilities wholly free of capital." He argues that "skills and knowledge are a form of capital," that their acquisition is a "product of deliberate investment" and that "its growth may well be the most distinctive feature of the economic system."[2]

This construct has been interpreted in two quite different economic and social contexts and consequently in quite different theoretical structures. One has led to the use of manpower planning and manpower forecasting as the source of policy criteria; the other to support the current reliance on market decisions. What appears to be an incredible gap between the practice of forecasting in the United States and its theoretical foundations is in fact an inconsistency between the dominant body of economic theory in the United States and the use of forecasting as a policy instrument.

The Human Capital Model

Western economists have tended to interpret the human resource construct in the framework of traditional allocation theory and to construct a theory of human capital in strict analogy to the classical treatment of physical capital.[3] While public concern with human resources is interpreted in this theoretical structure, public policy is defined and implemented through the force of the market. Much of the academic enterprise of the past decade has concentrated on aggregate empirical estimates of the relative rates of return to the society on investment in human and physical capital, and on the rate of return to the individual on investment in education or training. The criteria for investment decisions are derived from these rates of return as reflected in the (market) price of factors, and acts of investment are implemented by individuals in educational and occupational choice.

The current "theory of human capital" is a rather simple extension of wage theory in the form in which Adam Smith stated it. Wage differentials are functions of the investment cost of producing a human capacity or attribute and its value or productivity in use. In this construct, policy analysis involves the specification of the relative costs of producing an attribute by alternative processes and the relative productivity of producable attributes in use. The optimal, i.e., minimum cost, form of investment determines the supply price of the attribute in the market. The optimal, i.e., maximum productivity, use determines the demand price. The objective function of the individual is to maximize the rate of return on his investment through the useful life of the attribute. The objective of social policy is to allocate investment resources in a manner that will equate the rate of return on all alternative forms of investments at the margin.

This interpretation is particularly attractive to Western economists on both philosophic and technical grounds. It is logically consistent with conventional theoretical structures and does not depend on institutional or behavioral assumptions that are not already implicit in the conventional theory. It is symmetrical with the treatment of capital in terms of general theory and consequently investment decisions for all resources can be treated as determined simultaneously. Investment criteria are specified and decisions made by market processes without intervention by non-market institutions, except in those areas where the market is imperfect. Finally market analysis is extremely simple. The only functional specification required by theory is that of identifying alternative investment instruments and alternative resource using processes. Given the conventional assumption of a high elasticity of factor substitution, both elements can be specified in very aggregate forms.

Although this specification of the functional form of the human capital concept had dominated the literature, its several inherent limitations have restricted its acceptance as a policy instrument. One obvious limitation is in the assumption that investment decisions are private decisions and the values that enter these decisions are measured in the market. Obviously, an increasing proportion of economic activity is in the production of collective or public goods and services, and a very large proportion of the instruments for investment in human resources are public goods. They enter into the market process only in peripheral ways. They can be valued in market terms only by inference based on market proxies and then only when there are interdependencies or analagous activities in both sectors. A reflection of this condition is the recent suggestions for forcing public activities into the market or for establishing synthetic markets--as in the proposal for an educational voucher system.

A second constraint is that many of the most important acts of investment in human resources are long-term decisions. From the perspective of the individual, the returns to investment may accrue only over long periods of time. The validity of a current investment depends on the validity of the assumption that current wage criteria reflect probable long term outcomes at an acceptable level of risk. Clearly, the more specialized the investment, the greater is the risk. Similarly, public investment in human resource producer goods are usually amortized only over long periods and the gestation period of the investment process may be several years. Short term wage criteria are limited evidence on which to base long term and large scale decisions.

A third concern is that internal rates of return are inadequate criteria in any situation in which significant externalities are present. Externalities tend to be characteristic of many public sector activities, as in education, public health and highway construction. The current awareness of the limitations of the market in treating externalities and of their importance to the social welfare is reflected in the recent interest in social accounting and in the quality of life. The collective concern with the social costs of resource wastage and environmental

damage, and the social benefits of public land use are generally understood. The individual costs and intergenerational effects of discrimination, insecurity, inequities and obsolesence in the labor market are obvious concerns but are less clearly perceived as systemic in a market structure.

A fourth limitation of a market interpretation of the human resource construct is the very aggregate form of the specification. Rate of return analysis has been applied to rather general forms of investment, such as general training versus specific training, levels of formal education, education for specific professions and investment in mobility and job search. These specifications have generally neglected the fact that most acts of investment in human resources produce multiple products and the configuration of the product mix is extremely important to performance. Further, in very few applications is there an attempt to specify the functional environment in which the resource is ultimately employed. Functional or environmental differences are suppressed in a market rate of wages as an aggregate specification of the set of production functions in which a particular human attribute is utilized.

The ability of a market mechanism to respond to the problems of structural imbalance is predicated on three contextual assumptions. One is that a market economy is never in great structural disarray since market forces operate continuously to move it toward equilibrium. Further, the "exogeneous" forces that produce structural disequilibrium, changes in technique or in the structure of final demand, change only slowly and are readily anticipated by individual decision makers. Consequently, structural imbalance tends to be incremental and adjustments short term. The ease of adjustment is facilitated by a nearly infinite range of substitution possibilities and market adjustments are largely confined to the reallocation of existing resources in new combinations, rather than with changes in resource endowments. Further, the instruments for human resource development exist in forms that are relevant to needs since they are structured in response to market criteria and market stimuli.

In this theoretical structure, human resource policy is confined to facilitating rational response to market criteria in resource allocation and acts of investment, and by the reduction of constraints on the conditions of supply. There is little inclination to treat the conditions of demand as policy variables except in the aggregate form of employment policy. The few exceptions have involved great regional disparities in incomes and growth, as in Appalachia or in the treatment of family enterprise in the agricultural sector. Otherwise intervention in the determination of requirements has been through the impact of monetary and fiscal policy on aggregate demand, with an implicit assumption that tight labor markets for high level skills encourage the substitution of lower skills and reductions in qualifications standards.

Public policy has acted on the structure of final demand only through the indirect and incidential structural effects of an aggregate policy and by occasional ad hoc interventions to reduce foreign competition or to

subsidize high economic impact industries. In general, these interventions have been functions of the importance of the sector to aggregate growth (automobiles, construction), its importance to a local or regional labor market (aircraft) or its importance to specific social objectives (shipbuilding, aerospace industries). The limitations of a partial or restricted manpower policy are apparent in the current impasse concerning employment and inflation. An aggregate policy cannot respond to this conflict between competing goals except in "least worst" terms.

The Policy Model

Manpower planning and manpower forecasting evolved in the context of economic development because the policy limitations of a market model were most obvious in that context. The developing countries approached industrialization abruptly as a result of the dislocation in the world economy and power structure occasioned by World War II. The radical increase in the material aspirations of their people demanded an equally radical change in the structure of economic activity, in the techniques of production, and in economic and social institutions. These changes were constrained by a very limited supply of technical and managerial skills, by literacy constraints on the diffusion of knowledge, and by the fact that large proportions of the labor supply were unemployed and unqualified for employment in non-traditional roles. Further, the educational, health, and labor market institutions that normally develop human resources were limited in scale and adapted to the needs of the status elite and a static and traditional culture. Finally, many of these countries were only recently released from colonial roles and the political pressures for egalitarian reform demanded massive change in traditional patterns of economic and social mobility.

The gap between reality and aspirations could only be reduced by an accelerated process of industrialization, involving modes of organization and production technologies that were inconsistent with resource endowments. At the same time, any effort to change human resource endowments required a large prior investment in educational and other development systems. Further, the gestation period of that investment was very long. It was not possible, for example, to increase the flow of graduates from higher education without a prior increase in enrollments in primary education.

These real constraints on accelerated growth produced sharp conflicts in social choice between short term and long term objectives--in particular between current employment and future income, and between equality and inequality in current income distribution. In addition, the nature and magnitude of the structural change implicit in the process of industrialization required a set of social norms, individual values and institutions that were radically different from those of subsistence economies and traditional cultures. Finally, one may note that, with the possible exception of the export sector, these economies had few well-developed markets and no overriding ideological commitment to a market mechanism.

The difference between the economic and social realities of these countries and the assumptions of a market model led to nearly universal reliance on long term planning as the dominant source of criteria for policy formation, although important parts of this policy were implemented through a market. As a consequence, the set of human resource problems has been perceived as an integral part of a broader set of social concerns and the response has attempted to treat them in systemic form and in a structure of social goals and priorities. The role of planning is strategic rather than tactical. It attempts to identify alternative patterns of social response and specify their policy implications. The logical policy is to treat both the conditions of demand and the conditions of supply as policy variables and to intervene on both sides of the equation. The short or medium term objective of policy is to achieve an optimal tradeoff between growth and employment objectives while acting on resource endowments to reduce the necessity for trade-offs in the longer term. In most contexts, the growth/employment trade-off involves other trade-off conditions arising out of conflicts between income distribution, price stability and balance of payments objectives, and between economic and non-economic goals.

Where the magnitude of imbalance is great, short term policy is likely to put great emphasis on intervention in the structure of final demand, the structure of technical change and the rate of utilization of existing capacity. Growth strategies in most countries have attempted to substitute domestic consumer goods for imported goods, to limit the consumption of luxury goods and enhance the consumption of low cost substitutes. They have also tried to influence the structure of technological change, in order to maximize technical progress in investment sectors, as in utilities, commercial construction, and durable manufactures, while minimizing the introduction of labor saving technology in those sectors that currently use large proportions of semi-skilled and unskilled labor, as in the case of residential construction, agriculture, commerce and non-durable manufactures. This capital saving and skill saving strategy is designed to gain time and save the resources required for human resource development.

In this policy framework, all manpower forecasts are conditional forecasts. They are conditioned on the implementation of the policy decisions that they serve to specify and on the behavior of any variables that are exogeneous to the operating or decision system that the planning model describes. Forecasts are not simple predictions. They are statements of intended outcomes and of the process of achieving them; few of the important variables are treated as exogenous. Virtually all may be treated as policy variables subject to direct or indirect intervention through other variables, including price variables.

The general premise of forecasting is that it is both possible and necessary to specify the variables of the system and their relationships in a form that can be translated into acts of intervention or control. For example, in the human capital concept the maximization of a given objective function requires a specific process or set of processes.

These processes include and may be defined by a specific set of human performance functions. These performance functions require, in turn, a set of human attributes or capacities which are the products of a set of investment processes specialized in the development or allocation of human "resources."

Policy formation involves the ex-ante specification of the objective function, the specification of the transformation process, the specification of the attributes of labor inputs and the specification of the investment instruments and process. In each case, the specification is assumed to be optimal within some set of time constraints imposed by the round-about character of the process and, in particular, the lagged response of human resource investments to changes in requirements. The definitional scope of the system is necessarily broad. It includes the social system in which the process occurs and the human performance functions are determined by contextual characteristics or conditions as well as by the technical characteristics of the immediate process.

The basic premise implies that it is necessary to specify the characteristics of each element because they are complementary. The process of change involves the substitution of one set for another rather than substitution of the elements within a set. Social progress involves the substitution of more efficient sets for those in current use, as they become feasible. The role of planning is to guide social intervention in ways that will assure the concurrent availabilities of all complementary inputs or elements of more efficient process sets. The role of manpower analysis and forecasting is to specify the functional form of the relationship between acts of investment in human resources, the performance roles in which the resources will be used and the impact of their use on system outputs.

The premise of manpower forecasting is that changes in the structure of manpower requirements are determined primarily by changes in technology and in the commodity structure of economic activity. For any given activity, the structure of employment is defined by the current technology and the level of employment is a function of the rate of activity. That is, the process of growth is essentially a process of structural change involving shifts in the production function rather than movements along a (static) transformation curve. It assumes as a general condition that technological change is biased both between factor sets, such as differentiated labor and differentiated capital inputs, and within sets. It assumes that elasticities of substitution are ex-post very low, and changes in factor proportions are products of a bias in technical progress. These assumptions are in sharp conflict with the market theory of production which typically assumes that the elasticity of substitution is infinite or at least, "very high", that factor proportions adjust quickly to changes in supply and demand conditions and technological change is disembodied, i.e., has a neutral impact on factor proportions. They are, on the other hand, logically consistent with the observed conditions of economic development or accelerated growth.

The production possibilities available to developing countries are of two types: those indigenous to the traditional system and those developed in the industrialized countries. The latter are obviously technically more efficient and the characteristics of their factor requirements radically different. The advanced technologies are also consistent with income and growth objectives. The indigenous technologies are not. The advanced technologies are consistent with employment objectives in the long term, as a function of growth, but thus are inconsistent in the short term because of the technological gap, i.e., the absence of intermediate technologies. In brief, there exists an extensive structural imbalance between the best-practice level of technology and factor endowments, and between the current-practice level of technology and aspirations or the social utility function.

The human resource planning model that has proved most relevant to this policy and problem context is integrated into a general model for economic and social planning. It is a comprehensive, long-term, iterative planning-research model in the context of stage planning in the sense of Tinbergen.[4] In large measure, it has evolved from the OECD's Mediterranean Regional Project (MRP) in numerous applications since the early 1960's.[5] Close variants of this model are now beginning to enter the practice in the United States, but the more sophisticated versions remain methodological statements with limited experience in application.[6] These models combined a disaggregate analysis of policy instruments and an assessment of manpower requirements stemming from socio-economic strategy statements. They have been refined over time, and their specification and form has evolved with the knowledge base.[7] A description of this model, therefore, is a composite statement of the state of the art based on a set of experiences.

In this generalized form, the model estimates the flow of manpower requirements associated with a flow of sectoral outputs and a set of change processes in sectoral technology. The requirements and the supply flows are projected as conditional forecasts and the usual conditions are the policy constraints imposed on outcomes, the anticipated effects of current and scheduled programs, and intervention policies or the behavior of exogenous variables. Differences between the forecast flows over the period of the analysis are used as criteria for the specification of policy intervention in the supply process, in the specification of requirements, or on the constraints imposed on the objective function. These interventions constitute changes in the parameters of the model for further iteration until structural balance is achieved or imbalance minimized in the planning period.

The conventional form of these forecasting models expresses both qualifications (sets of attributes) and requirements (sets of functions) in occupational terms. A standard system of occupational classification defines in the same term (an occupational title) the set of functions contained in a job situation and the set of qualifications (attributes) associated with the performance of those functions. A "job cluster" implies that a given set of attributes is relevant to performance in more than one set of functions. The relative weights of the subsets in

the functions set describes, at a given moment, the occupational distribution of manpower requirements. The relative weights in the attribute set describes the occupational qualifications of the labor force.

These two distributions are functionally independent, and they are products of different sets of factors. The degree of interdependence that does exist is short-term and derives in part from real constraints on the range of production possibilities and, in part, from the extent to which attribute development occurs in the work environment. In a traditional society in which family and artisan enterprise is dominant, a large part of the learning process does occur in the work role. In industrial societies with distinct and specialized learning processes and work roles, the interdependence is slight.

Similarly, the utility or preference function of a traditional society is both simple and stable as a result of the strength of tradition in determining life styles, and by the limited range of production alternatives. In an industrial society, tradition has only limited effects on preferences, and product innovation produces radical change in the range of alternatives. The magnitude of the current structural imbalance in the developing countries is a result of the fact that current human resource endowments are products of the traditional system, while the utility function has been shifted abruptly by demonstration effects, international trade and technological diffusion.

The analytic and decision elements of the forecasting process, therefore, are:

a) The projection of the size and demographic characteristics of the population and labor force as partial determinants of consumption demand and the labor supply.

b) The estimation of the general parameters of the social welfare function as goal statements or constraints on means.

c) The specification of an aggregate rate of growth in output using a macro-economic growth model and an aggregate production function. The objective function is to maximize growth within specified constraints.

d) The specification of gross output by sectors by the use of a input/output model disaggregated to the limits of available data.

e) The specification of dynamic sectoral labor input coefficients in very disaggregate form as occupations (at the three digit level) or occupational clusters, and the projection of the level and occupational structure of sectoral manpower requirements.

f) The specification of the qualification standards (attribute sets) for each occupation or occupational group. The specification includes either explicitly or implicitly, the behavioral and other characteristics relating to labor force behavior as well as performance in the job context. They may be expressed in dynamic terms, i.e., as target standards.

g) The specification of the most efficient or effective forms of attribute development, i.e., experience, training, formal education, etc., as entry requirements into occupations.

h) The projection of the occupational distribution of employment of the base period labor supply as a function of base period employment, geographic, industrial and occupational mobility, and attrition through death, retirement and emmigration.

i) The estimation of the training requirements for the base period labor force implicit in projected occupational mobility.

j) The estimation of entry requirements into each occupation as a function of the difference between projected requirements and the supply from the base period stock.

k) The estimation of period outputs from the existing manpower supply system, using disaggregate system flow models and allocating outputs to the manpower requirements matrix on the basis of historical flows and career profiles.

l) The calculation of occupational shortages and surplus over the planning period and the specification of balancing policies and their instrumental forms and timing. Balancing policies usually emphasize quantitative and structural changes in the supply system as a means of reducing the employment constraint on output maximization. If supply adjustments are not feasible or cost effective, policy interventions will be directed toward changes in the growth strategy in terms of the level, commodity structure, and/or technical structure of production.

m) The approximation model is adjusted by changing those parameters, technical coefficients or system linkages affected by the derived policy prescriptions, and the analysis iterated until specified optimality conditions are achieved.

The literature in critique of the policy model has been summarized by Ahamad and Blaug in their recent study of the practice of forecasting, particularly in relation to its early MRP form.[8] Much of this criticism is related to the use of manpower criteria for educational planning rather than to this specific form of modeling. The overriding technical criticism relates to the use in early applications of fixed technical input coefficients, the engineering rather than economic specificaton of the model, and the specification of the sources of supply for specific

occupations. Each reflects in some degree a preoccupation with factor substitution possibilities and price elasticities, and none are generic to the model.

In early applications, research and data limitations and the state of economic theory relating to economic growth and production functions compelled the use of rather rough techniques for the specification of input coefficients. They included simple extrapolation, international comparisons of sectoral productivity and occupational structures, and the use of the production characteristics of the most efficient firms as target specifications. More recent applications are based on extensive empirical analysis of the production characteristics of establishments and specify "dynamic" input coefficients as a function of forecast or planned changes in factor supplies and efficiency goals.

Illustratively, the projections of manpower requirements in manufacturing in the Venezeulan human resource plan (1970) were based on cross-sectional analysis of complete production, accounting and employment information from several thousand establishments.[9] These data included the occupational structure of employment of each firm. Establishments were aggregated within subsectors (three digit industries) into sets representing alternative techniques, on the basis of factor proportions, scale, total factor productivity and the occupational mix. The input coefficients for each set were assumed to be constant, while those for the subsector were assumed to change as a function of changes in the relative weights of the subsets in total output. Changes in the technological mix were simulated to meet alternative specifications of the objective function and various rates of change in the technological structure. Clearly this model assumes that technical coefficients are fixed ex-post, but are variable ex-ante, and the rate of change is a function of the rate of investment in new capacity. The latter is a partial function of the rate at which existing capacity can be depreciated or "written-off" and of the rate of growth in output. Factor availabilities act as physical constraints on the choice of outcomes and changes in factor prices attributable to changes in supply costs can be incorporated in the simulation model with little difficulty. The result will be that the relative efficiency of technical sets will change with relative changes in factor prices and convergence toward the "optimal" technique will not be linear.

Similarly, the assumption that the model does not permit "substitution between different kinds of education in the performance of the operations that define a given occupation" is refuted in recent practice.[10] The model does assume complementarity between a set of attributes and a set of functions. The function set may describe a cluster of occupations, and the term "unskilled" generally implies a high degree of homogeniety in the attributes required by these functions. The model does not however assume that there is a single means for attribute development. The MRP was conditioned by the limitations of the knowledge base concerning learning processes and educational production functions and by a deliberate preoccupation with professional and technical manpower. This preoccupation

was, in turn, a partial function of the limited state of development theory.

The human resource plans of Bolivia and Ecuador (circa 1965-67) were based on extensive analysis of detailed educational profiles and labor market experience of several thousand workers in all occupations, the curricular and system characteristics of educational and training programs, follow-up studies of graduates from specific programs and other sources of empirical data.[11] These data were used to specify the relative weights of relevant learning processes in the supply function for occupations or occupational clusters. These weights were varied over time as a function of strategy decisions and investment lags. The major constraints in practice are not in the ability of the model to incorporate substitution possibilities, but in the limitations of the knowledge base for specifying alternative means and their relative efficiences. These constraints are particularly great in regard to behavioral questions.

The experience of the last decade suggests that a highly disaggregate, iterative, planning model is best suited to the needs of policy formation because it permits the specification of a variety of policy variables and consequently the consideration of a full range of strategy alternatives. Further it provides more extensive and more explicit criteria for the development of a research agenda to continuously enhance the state of the art.

The most valid criticism that has been raised in regard to the application of this planning/forecasting model in the United States is whether the considerable investment that it requires is justified in the absence of an institutional structure that links a planning or forecasting process to policy making and policy implementing institutions. We shall return to this point in subsequent chapters.

NOTES TO CHAPTER I

[1]For instance, see C. Buntz, "A Community Level Manpower Service Matrix: An Analysis," Ph.D. Dissertation, The Ohio State University, 1974.

[2]T.W. Schultz, "Investment in Human Capital," American Economic Review, LI, No. 62 (March 1961).

[3]For a concise review of recent research on human captial theory, see T.W. Schultz, "Human Capital: Policy Issues and Research Opportunities," in Human Resources, Fiftieth Anniversary Colloquium VI (New York: National Bureau of Economic Research, 1972).

[4]See, J. Tinbergen, Economic Policy: Principles and Design, (Amsterdam: North Holland, 1966).

[5]See, for example, Mediterranean Regional Project Reports for Greece, Portugal, Spain, and Turkey (Paris: OECD, 1965). Also see, S.C. Kelley, Jr. "Educational Planning in Western European Countries," in Georgianna B. March (ed.) Occupational Data Requirements for Educational Planning (Madison: The University of Wisconsin, Center for Studies in Vocational and Technical Education, 1966).

[6]C.f., H. Folk, "The Illinois Employment Model," Paper presented at American Statistical Association proceedings, St. Louis. Missouri, August 1974; and R. Bezdek, Long-Range Forecasting of Manpower Requirements, (New York: IEEE, 1974). For purposes of historical comparison, c.f., U.S. Department of Labor, Manpower Administration, Manpower Projections: An Appraisal and a Plan of Action, Report of the Working Group on Manpower Projections to the President's Commission on Manpower (Washington, D.C.: 1967).

[7]See, in particular, T.N. Chirikos, et al., Human Resources in Bolivia: Problems Policy and Planning (Columbus, Ohio: Center for Human Resource Research, The Ohio State University, 1971); and S.C. Kelley, et al., Human Resources in Ecuador: Problems, Policy and Planning, (Columbus, Ohio: Center for Human Resource Research, The Ohio State University, 1972).

[8]B. Ahamad and M. Blaug (eds), The Practice of Manpower Forecasting, (San Francisco: Jossey-Bass, 1973), especially Chapter 1.

[9]S.C. Kelley, Employment, Manpower, Requirements and Productivity in Venezuelan Manufacturing, 1970-1980 (Caracas: CORDIPLAN, 1973).

[10]Ahamad and Blaug, op.cit., p. 15.

[11]Chirikos, et al., op.cit., and Kelley, et al., op.cit.

CHAPTER II

THE ESTIMATION OF SECTOR OUTPUT

Structure of the Discussion

This Chapter and the two that follow are concerned with the current state of the knowledge base for forecasting manpower requirements. The analysis is focused on three problems of specification implicit in all manpower forecasting models: the specification of total output and its commodity structure; the specification of sectoral inputs; and the specification of the relationship between labor input requirements and sources of supply. These three specification problems are not independent and the sequential treatment accorded them in this study is a function only of expediency in treating (in rather brief form) questions based in a very extensive theoretical and empirical literature. There is as a consequence some unavoidable redundancy between Chapters and some deliberate suppression of discussion when another Chapter is more fundamentally concerned with the issue. In general we have tried to avoid purely theoretical considerations and to concentrate on those operational questions most relevant to practitioners.

This initial Chapter examines the projection of total output and its commodity structure as partial determinants of the level and occupational structure of manpower requirements. Although changes in the output structure account for approximately one half of historical change in the occupational structure of manpower requirements, the average practice of manpower forecasting, and in particular partial forecasts, frequently fail to specify the objective function of the process for which labor inputs are required. Area skill surveys and trend analysis of the occupational distribution of employment in regional or local labor markets dominate the practice, and their inability to specify the structural determinants of manpower requirements severely limit the policy utility of the forecast and its evaluation. Similarly, many partial forecasts suppress the output term in some simple functional form or in proxy terms: for example, physicians per capita or the ratio of R&D expenditures to GNP. Such limited specifications contribute very little to the precision of the forecast and often induce erroneous interpretations of their policy implications. In general this condition appears to be a result of a failure to identify and specify the process implicit in the forecast objective, rather than a constraint imposed by the knowledge base.

The best practice techniques do attempt to specify the structure of outputs in a consistent analytic framework and to derive manpower requirements from such a specification. Within this experience there are

obvious specification problems stemming from knowledge gaps or deficiencies. Nevertheless, the major limitations of these models are also in their specification of the system under analysis and in particular in the extent to which the more critical determinants of the structure of activity are treated as exogenous variables or as assumptions. To illustrate the analytic elements of an output forecasting model and to relate the evaluation of the theoretical and empirical basis for forecasting to its operational form, the Chapter begins with a brief description of the dominant model: the Inter-Agency Growth project long term forecasting model as it was employed in the BLS 1980 projections of economic growth and as modified for the 1985 projections.[1] Although national econometric forecasting models have proliferated since the early 1960's nearly all are oriented toward predicting short-term economic fluctuations as criteria for stabilization policy. They are generally too aggregate for long term manpower forecasting and most of the well known models do not generate sectoral employment estimates.

The Inter-Agency model is a growth model designed to produce output criteria for national manpower forecasts and guidelines for State and regional forecasting as described in later sections of the report. The intent of this discussion is not to evaluate the form of the model, but to use it as an agenda of analytic requirements for assessing the extent to which analytic or estimation procedures in use are constrained by the underlying knowledge base. Detailed descriptions of the model and methods of estimation are provided in various BLS publications and in the Survey of Current Business.[2]

Most long term forecasting models are supply determined. They assume that growth is a function of changes in capacity, rather than demand. They use some form of an aggregate production function to estimate potential gross output, allocate it to major income or expenditure components and estimate the commodity distribution of each component of final demand. The commodity specification of final demand is converted to producing sectors final outputs in order to estimate intermediate demand and total sector output. Sector outputs are finally converted to labor inputs and distributed to occupations. The outcome of the analysis is the occupational distribution of employment associated with a given rate of growth of potential output.

The BLS 1980 projections model estimated GNP by a relatively simple labor-output ratio. It projected the labor force as a function of changes in the size and demographic characteristics of the population, and changes in labor force participation rates. It discounted the labor force for assumed unemployment and employment in the Armed Forces to an estimate of civilian employment. It converted the employment estimates from a persons to job measure and subsequently to man-hours worked. Gross product was then estimated as the product of hours worked, and output per man-hour. Separate estimates of employment, hours, and productivity were made for farm, private nonfarm, and government employment because of the magnitude of differences in productivity growth between the farm and non farm sectors, and because of the accounting convention of assuming constant productivity in the public sector.

The 1985 BLS projection uses an econometric model to produce both supply determined and demand determined estimates of GNP.[3] The supply side estimates of private GNP are derived from a production function relating changes in the capital stock, the labor supply, and labor embodied, capital embodied and disembodied technical progress. Gross product originating in the government sector is estimated separately with the assumption of no productivity change and added to private GNP. The capital stock is estimated by a set of simultaneous equations relating the flow of internal funds, the level of private GNP, and the size of the current capital stock, adjusted for depreciation. State and local government employment is estimated on a per capita basis as a function of private GNP, school enrollments, and Federal government grants and aids. Federal employment is determined exogenously and private sector employment is estimated in the conventional modes. The technical progress functions were estimated empirically and enter the model as exogenous variables.

The demand side specification of GNP in the 1985 projections uses a set of income equations and exogenous estimates of transfers etc. to distribute the supply side GNP, treating disposable personal income as a residual. Given sector incomes, a set of demand equations estimates sector demands. These aggregate to the demand side estimate of GNP. The difference, if any, between the demand side and supply side estimates, reflect the effects of income distribution and the composition of demand on capacity growth.

In contract to the econometric model, the 1980 model allocates GNP to final demand components by a process of trend extrapolation and judgmental decisions. On the other hand it offers alternative assumptions concerning the rate of unemployment, investment variables and the rate of different scenarios for growth.

Various techniques are employed in allocating final demand to industries. Total private consumption is estimated as a residual in the previous stage and distributed by commodity using a set of consumption functions, estimated empirically by Houthakker and Taylor.[4] The industry composition of investment demand is estimated separately for construction, producers durables, and inventory change. Since new construction constitutes an industry in the input/output matrix, it is allocated directly. Producers durables are allocated by trend analysis of industry investment demand from the detailed national income and product accounts, inventory data on materials and goods in process are adjusted from a purchasing sector to a producing sector basis and projected with finished goods on the basis of historical data.

Government expenditures are distributed by estimating compensation of employees, estimating the construction component of the residual and allocating the residual government purchases to producing sectors. Federal government expenditures are estimated separately for defense and nondefense categories, while State and local government expenditures are estimated separately for eleven major categories of expenditure and a residual. In projecting trends in each category, judgmental adjustments

are made to reflect recent changes in legislation and factor substitution possibilities affecting the employment-purchasing ratio.

Exports are estimated for each balance of payments category on the basis of UN and OECD projections of gross product and industrial production of major trading partners and are allocated to producing sectors on the basis of historical distributions projected to the terminal year.[5] Imports are allocated as inputs in purchasing industries if they have no domestic substitutes. Competitive imports are treated as inputs in the industries producing these products.

Given the commodity distribution of final demand and its conversion to producers values and producing sector final outputs, intermediate demand and total output for each sector are estimated with a projected input/output model based on the 1958 matrix updated to 1966. The conversion of sector outputs to manpower inputs is made by two different methods discussed in Chapter VI.

It is obvious in this brief description that an evaluation of the current capacity for forecasting the level and structure of economic activity is complicated by the number of independent variables in the analysis and by their interaction. They include, in generalized form, three categories of variables: factor supplies, technology and individual and collective preferences, each having physical, psychological and institutional dimensions. The knowledge base and the literature they represent is formidable and often crosses several disciplinary bounds. It is not possible to examine any in great depth or to consider the full set in the confines of this Chapter. Although there are very few areas within this framework in which an extension of the knowledge base would not contribute to the accuracy of the precision of the instrument, investments in the knowledge base for many of these areas will have very marginal return to policy formation. Consequently, the following discussion places nearly total emphasis on those elements where knowledge inputs could produce significant gains in policy utility.

Elements of Analysis

Changes in technology affect the level and structure of outputs through their effects on factor proportions, factor productivity and materials substitutions. Since, however, they are also determinants of the quantity and quality of input requirements, they are discussed in Chapter III in the context of aggregate and sectoral production functions. This Chapter concentrates on the aggregate labor supply as a partial determinant of gross output; the aggregate consumption or savings function as a determinant of potential growth in the capital stock; the structure of individual and collective preferences; and the demand for intermediate goods as determined by the structure of final demand.

The discussion of individual and collective preferences is treated initially in the relatively short time frame of the current manpower forecasting model. In periods of five to ten years, changes in the structure of output are assumed to reflect alternative choices influenced by changes in supply costs and the level of income rather than shifts in

preference functions. Other variables are assumed constant and forecasting models tend to rely on empirical specification from historical data and extrapolation techniques.

In the longer time frame that manpower policy requires, these ceteris paribus assumptions include the dominant sources of change. In our opinion the most important contribution of future methodological or substantive research will be that which relates to the understanding or specification of many of the variables currently treated as outside of the forecasting model. The development of an active human resource policy depends on the development of policy criteria relevant to the "life cycle" of investment in human resources, and consequently to a time frame in which very few parameters can be treated as fixed. Forecasting in this mode cannot rely extensively on empirical analysis of historical data. It will necessarily utilize judgmental or qualitative forms of analysis. Much of the discussion in the latter portion of this Chapter explores these possibilities in examining social indicators, goals and priority analysis and futures analysis.

Labor Supply

The immediate discussion treats the estimation of the labor supply as the dominant concern in the projection of gross output for two reasons: one is the radical structural change in the labor supply in the past twenty years; the other is that the labor supply estimate in a manpower forecast is both an input term and a term in the objective function. From the perspective of employment policy, the objective is to maximize employment from a given labor supply and within a set of constraints imposed by other terms in the welfare function.

The estimation of the labor supply term in an aggregate production function obviously depends on the capacity to estimate changes in fertility, mortality, labor force participation rates and average annual hours worked. The fertility variables do not enter directly into the supply estimate since manpower forecasts rarely exceed fifteen years and the population of working age during the forecast period exists in the base year. They do, however, enter the analysis as partial determinants of the labor force participation rates of women and in the later analysis of the structure of final demand. Unfortunately, population theory offers only limited guidelines for estimating fertility trends.

As a general case, fertility rates appear to be strongly associated with social structure, the technology of birth control and cultural values. Changes in the structural and cultural environment associated with industrialization and improvement in birth control methods are assumed to account for the long term decline in fertility in Western society. The empirical basis for extrapolating this trend in population projections is currently confused by the trend reversal following World War II and by its restoration in the 1970's.

The weight of the evidence suggests that although changing attitudes toward marriage and family formation and further diffusion of birth

control information will maintain the long term decline of fertility rates in the United States, they appear to be moving toward an equilibrium position. The historical importance of income aspiration or security factors had diminished, cultural and attitudinal determinants have acquired an increasing residual weight, and fertility rates are not particularly sensitive to psychological variables in the time frame of manpower forecasting. Further, the presence of children appears to be declining in its effects on the labor force participation rates of women, although it remains a dominant variable.

Similarly, the radical decline in mortality rates in the early part of this century is attributable primarily to the control of infectious diseases. The gradual decline thereafter results primarily from changes in nutritional standards and other income-related determinants of health. The reduction of income disparities and increased access to health care should reduce the effects of changes in social structure on the rate of change in mortality. Further reductions will depend on medical breakthroughs in the prevention or treatment of coronary disease, cancer and other major chronic illnesses. Since, these factors are not likely to have significant effects on the size of demographic characteristics of the labor supply in periods of less than fifteen years, population projections are not likely to be major source of error in manpower forecasting in the United States. Errors in twenty year forecasts are not likely to exceed 2 or 3 percent in the aggregate and that error will be concentrated at the extremes of the age distribution.

The dominant determinants of change in the manpower stock are changes in age and sex specific labor force participation rates and in particular the participation rates of older and younger persons and of women. The overriding characteristic of labor force change in the post-war period has been the increase in female labor force participation rates. Between 1947 and 1973 the labor force increased by 28.4 million persons. The number of women in the labor force increased by 17.9 million and constituted 63 percent of the net increase. Further, the increase in the participation rates of single women was almost totally limited to those under 20 years of age, while the increase in participation rates for married women was highly consistent across all age cohorts under 65. Further, the participation rates for married women with children under six years of age nearly tripled in that period. In contrast, virtually all change in the aggregate labor force participation rates of men, a decline of 7 points, was attributed to men over 55 and predominantly to those over 65.

Since the participation rates of married women ranged from 21 to 29 percent among age cohorts, at the end of World War II and now vary from 51 to 53 percent, this change represents a radical change in labor supply conditions. An important question in forecasting the future participation rates of women is whether the forces that have induced

this radical change are diminishing in their effects or whether they reflect a persistent and substantial change in social parameters.

The experience of the past twenty years has generated an extensive body of empirical research on the labor supply, in particular because of the apparent inconsistency between the classical assumption of a high income elasticity of demand for leisure and actual changes in the labor force participation rates of married women. A large part of this research has occurred within the framework of the economics of the labor market and consequently focuses heavily on income and income-related determinants of participation.

The current state of the art is most readily reviewed in the definitive study by Bowen and Finegan.[6] In brief, it suggests that in the post-war period the forces acting to reduce the labor participation rates of married women, including the short-run effects of high fertility rates and the trend effects of increasing real incomes, were overwhelmed by rising income aspirations, increases in the wage rates of women, changes in employment conditions, and an increase in educational attainment. The dominant changes in the conditions of employment were changes in the structure of activity towards sectors with traditionally large proportions of female workers as in sales and education, and in increasing flexibility in working hours through part-time employment and a general reduction in hours worked. Although the reduction in average hours worked acted positively on participation rates, the total manhour effects were partially offset by the impact on full-time employees.

In contrast to the experience of married women, the persistent decline in the participation rates of men over 65 appears to be consistent with the utility assumptions of market theory. The net effects of demographic factors seem to account for about 10 percent of the total reduction in participation rates. The dominant factors appear to be an increase in assets and other income and, consequently, in the range of options concerning employment and leisure and the effects of compulsory retirement. The dominant effect, as in the case of married women, was a result of changes in the hours of work; in this case, through an increase in the relative numbers of part-time jobs.

In evaluating the utility of recent research concerning the labor supply, it is important to note that although demographic, income and job related factors appear to explain much of the change in the labor force participation rates of older men, they leave a rather large unexplained residual in regard to married women. There is very little hard evidence concerning the question of whether this residual is a function of measurement problems or unspecified attitudinal and cultural factors. Similarly there is no adequate basis for estimating the persistence of stability of some of the variables that were important contributors to the outcome in the past two decades.

The current National Longitudinal Study by Herbert Parnes and Associates and the extensive body of research generated by the data set should provide a more satisfactory base for the analysis of the determinants of labor force participation than has been possible.[7] This study has observed a national probability sample of 20,000 persons distributed in four cohorts of age and sex for five successive years, and will be continued in more limited form for an additional five years. The sample subsets include men age 45 to 59 years of age in the initial year, women 30 to 44 years old and young men and women, age 14 to 24. The data set includes consistent information for each respondent on personal and family characteristics, labor force earnings and family income, hours of work, occupation, work experience, and attitudes toward work, permitting multivariate analysis of a large set of real, institutional and psychological variables influencing labor force participation, employment, mobility and other aspects of labor market behavior.

A full analysis of longitudinal dimensions is not yet possible but the interim reports generally support the conclusions noted above--in particular the dominant effect of the presence of children under six years of age on the labor force participation rates of women. They also suggest a strong correlation between expressed attitudes toward work, attitudes of husbands, work expectation and labor force status.[8] Since the extension of the time-frame of the analysis will permit an examination of the effects of radical change in labor market conditions, and the trend strength of the attitudinal and cultural variables, the study should ultimately produce valuable insight into the discouraged worker/additional worker hypothesis.

It appears a priori that the force of some of these variables will increase significantly over the next 30 years; in particular those relating to the current change in social attitudes concerning the employment of married women and those related to occupational entry for women. Many occupations with relatively high psychic income that are dominated by women in countries that have undergone rapid social and cultural transformations including medicine and architecture are only recently open to women in the United States. Concomitantly, institutional changes including the maternal role of educational systems, day care centers, family roles, and flexibile hours may very well produce an accelerated change in participation. It seems probable that the importance of income and income aspirations will decline relative to psychological and institutional variables in the long term.

The Consumption Component of Final Demand

The Inter-Agency Growth model projects personal consumption expenditures with a discrete time, state adjustment model in the form:

$$PCE_t = Ao + A_1 DPI_{t-1} + A_2 \Delta DPI_t + A_3 PCE_{t-1} \qquad (II.1)$$

where disposable personal income is derived as an accounting identity from the supply side GNP. The same model, substituting total consumption for the income term, is then used to project consumption expenditures for 84 commodities.

The state adjustment model employed in the projections of aggregate expenditure and for purchases of most of commodities in the system specify demand as a function of total consumption expenditure and a state variable. The state variable accounts for variation in the relation of quantity demanded to total expenditure as a function of the lagged effects of past expenditures on current decisions. It represents a stock of goods remaining from past expenditures or a psychological stock of habits. The general form of the estimating equation in either case is:

$$q(t) = a + Bs(t) + \gamma x(t) \qquad (II.2a)$$

where s(t) represents the stock adjustment behavior or habit formation. Since any direct measure of durable stocks is difficult and those for psychological stocks impossible, they are eliminated by relating the change in stocks to purchases and depreciation. The resulting basic equation then relates change in expenditure to expenditure, change in income and income. Translating the model into discrete time, the estimating equation is:

$$qt = Ao + A_1 qt-1 + A_2 \Delta x_t + A_3 x_{t-1}. \qquad (II.2b)$$

The theoretical base for this specification of the consumption function is derived from an extensive body of recent theoretical and empirical research that is summarized in two recent surveys by Ferber[9] and by Brown and Deaton.[10] The immediate discussion abstracts freely from these two papers. In regard to the aggregate consumption function, theoretical and empirical research of the past twenty years has focused on two concerns with the absolute income specification of the function--the observed short-term instability of the marginal propensity to consume, and the long term stability of the aggregate average propensity to consume.

The first of these conditions suggests that current consumption is not an exclusive function of current income, and the second, that the assumption of an inverse relationship between income and the marginal propensity to consume was not valid over time. Several extensions of the basic absolute income construct have evolved which extend the time frame and the composition of the income variable. As a generalization, these extensions treat either psychological variables affecting time preference such as prior peak income or reference group incomes, or "real" variables such as the existence of stocks of consumer goods from prior purchases or the difference between actual and desired stocks.

The various roles of these variables are reflected in three dominant hypotheses; the variable income hypothesis, the permanent income hypothesis, and the stock adjustment theory. The relative income construct implies that an individual's propensity to consume or save is a function of the relationship between his current income and his standard of income. The income standard may be average income (Brady and R. Friedman[11]), the standard of a reference group he seeks to emulate, or previous peak income (F. Modigliani and Duesenbury[12]). As Ferber notes, the implication of the peak income formulation is that in the long term the savings ratio is independent of the absolute level of income and the consumption-income ratio does not vary with secular changes in income.

The permanent income hypothesis of M. Friedman[13] and the life-cycle hypothesis of Modigliani[14] treat income in two components, a permanent and a transitory component. Expenditure decisions are made in the framework of long-term or lifetime income expectations and consequently are functions of the permanent income component. The proportion of permanent income that is saved is independent of current period income and transitory income has little or no effect on current consumption. The savings ratio may rise however with a secular increase in real income because of its effect on estimated permanent income. This effect may vary with the age of the income unit because of differences in non-human net worth.

Although there has been a general acceptance and extensive empirical analysis of the implications of the personal income hypothesis, there is also extensive evidence in conflict with the assumption that the permanent income elasticity of consumption is unity (Friend and Kravis,[15] Wright,[16] Taubman[17] and others). It also suggests that there are several types of permanent income components in household incomes with quite different elasticities (Holbrook and Stafford[18]), and there is conflicting evidence on the assumptions that transitory income does not effect current consumption and that transitory and permanent incomes are not related. Friend and Taubman[19] have tested a "normal income" specification of the permanent income component and interpreted transitory income to be the difference between this trend or recent average and current income, and Mayer[20] suggests a "standard" income definition and concludes that the marginal propensity to consume from transitory income is proportionate to permanent or "standard" income.

The assumption that current consumption is a function of the rate of return on estimated wealth or assets and the assumption that it is determined by psychological factors are combined by Houthakker and Taylor (H-T) in the state adjustment model described above.[21] The empirical test of the dynamic model used in the Inter-Agency forecasts suggested that its power is greater than that of a static formulation in nearly every case. They also suggest that habit formation was the dominant factor in the stock variable in seventy percent of the expenditure categories in which the stock variable appeared and these categories accounted for 61 percent of total expenditures. Total expenditure is the dominant variable explaining consumption and appears in 79 of 81 categories. Prices are

much less important. They appear in only 44 equations and are barely significant in most of them. The Houthakker-Taylor hypothesis concerning the relative explanatory power of prices and total consumption expenditure is that at the high income levels of the United States, income is less constraining on choice, i.e., utility maximizing is less important and habit formation dominates. They suggest that this hypothesis is supported by the evidence of greater price effects observed in Swedish data.

The basic adjustment of the absolute income hypothesis has produced an impressive body of empirical research attempting to incorporate the ceteris paribus variables into the consumption function in explicit form. Ferber's inventory includes the components of non-human wealth, credit, interest rates, the price level and money illusion, social and geographic variables, the level of economic development, consumer attitudes, advertising, human capital, the allocation of time and the activity processes of households. Perhaps more importantly, he acknowledges the recent work in other social sciences concerning the process of decision-making, the search for information and the role of reference groups. In the first instance the weight of the research suggests that many families do not have conscious goals and that where they exist, goals differences can lead to very different behavioral outcomes (Honey and Smith,[22] Freeman and Due[23]). It also suggests that a significant proportion of consumer purchases are not planned or are not necessary (Ferber,[24] Katona[25]). These findings challenge the basic economic assumption of rational consumer behavior. Similarly, the research of Wells,[26] Shoemaker[27] and others suggests that the consumption decision are strongly influenced by the socio-economic characteristics of the household and by decision roles within the household, as well as by variance in the availability and uses of information.

The major conclusion of Ferber's evaluation of the current theoretical and empirical basis for explaining or forecasting consumer behavior is that the major product of this effort has been the growing realization of how little is known about consumer behavior. He suggests that, in general, an advance in the state of the art will depend upon the development of a theory of the consumption function that will unify different current theories, specify the role of socio-economic factors and other ceteris paribus variables and incorporate the knowledge and perception of consumer behavior of other social sciences. A major limitation on the capacity to react to this need is the propensity of economists to narrow the scope of inquiry into the bounds of the discipline rather than extending it in interdisciplinary form. An extension of the scope of analysis will also require data for the same consuming units.

From the perspective of long-term economic forecasting, it is obvious that the practice is limited by the current state of theory. The econometric forecasting models based in economic theory are essentially static and too aggregate across consumers to catch an apparently extensive variance in cultural and institutional variables or to anticipate or

integrate the long term dynamics of cultural technological and environmental factors. Although they are conceptually more elegant than naive models relying on trend analysis and judgmental adjustments, they are potentially less sensitive to changes in basic parameters that involve significant departures from past experience. A comparison of the logic of the H-T projection of the demand for higher education with the Carnegie Commission studies in this area should illustrate the point, as does the current state of understanding of the relationship between income, culture, the incidence of unemployment and educational participation rates at the secondary level. Similarly, the potential effects of changes in health technology and access to health care on the consumption of health services suggest that simple linear models are not adequate for long term policy formation. They are undoubtedly useful for examining potential effects of alternative policy interventions through simulation, but they should not be interpreted, as they are in the BLS projections, as predictions of a future status. The current potential for incorporating anticipatory and judgmental data into economic forecasts is discussed in a following section.

Collective Preferences and the Structure of Output

Public sector final demand.--Forecasts of public sector output or expenditure are currently limited both by problems of measurement and by the absence of any operational theory of demand for public goods. Illustratively, in the BLS 1980 forecasting model, the public sector component of the final demand bill of goods is an estimate of supply costs projected on recent trends in employment and employee compensation, associated public construction, and purchases from other sectors.

The major cost component, compensation of employees, has been projected with an assumption of constant productivity because of the absence of information on real output and a consequent inability to measure productivity change. Although projections are made independently for defense and non-defense expenditures of the Federal Government and for eleven activity components of State and local government expenditures, all except defense are estimated by the same method, with varying judgmental adjustments applied to specific sectors. With this technique, the effects of changes in the structure of outputs and technology on the occupational mix is obscured, and manpower forecasting in this sector is reduced to the extrapolation of change in historical occupational structures.

In 1972, a Federal productivity measurement task force and the BLS began to develop a data base for productivity measurement for the period 1967-71 from agencies containing about 55 percent of the Federal civilian work force.[28] The data set has been expanded in 1974 to additional agencies and to include fiscal year 1973. In order to produce the productivity index, over 850 output measures were developed from detailed output and input data obtained at the establishment level. These indicators were then combined in weighted aggregates into output indexes. They represent a diverse set of outputs or activities including mail

units delivered, square feet of buildings cleaned, weather observations etc. combined in sixteen functional groupings.

The measurement of physical output in the public sector is subject to the conventional constraints: the problem of changes in quality, the flow nature of services and the level of aggregation. Nevertheless, the attempt to specify detailed outputs in physical terms will permit analysis of the effects of changes in the structure of outputs on the structure of input requirements in an area of increasing importance to manpower forecasting, and also some indicators of the "demand" for outputs themselves.

The current state of the art in forecasting demand for public sector output is indicated by the fact that every discussion of resource allocation in this sector begins with the authors' definition of a public good. The rationale for public production has been based either in the collective nature of the good, in terms of joint consumption, externalities in production or consumption or limited exclusivity; or as a product that the private sector is unable or unwilling to provide. These distinctions imply that there are specified roles or jurisdictions for the public and private sectors and that public activity extending beyond the classical police or defense function must be rationalized. This idealogical concern has diminished in the face of reality and the most common current definition is that a public good is any good that the public sector produces.

The fundamental problem in projecting the demand for public goods is the absence of explicit criteria for resource allocation and the lack of concensus concerning the nature and determinants of demand. Further, there is little agreement concerning the way in which demand is translated or articulated into policy decisions. This condition is a result of the fact that there is no direct or necessary relationship between the distribution of costs and benefits or between the utility or preference functions of individuals and production decisions that is analagous to a private market.

The theoretical argument concerning the valuation of public goods and the interpretation of the ways in which the demand for public goods is rationalized and articulated through the political structure is conditioned by the underlying view of the source of public interest. The basic issue is wheather the public interest is exclusively a function of individual preferences, as in formal welfare theory, or whether it reflects a set of collective or social values derived from the collective character of society. In the first of these two views, efficiency in the sense of Pareto optimality is the decision criterion. In the second view, efficiency is one of a number of possible goal criteria. In the first view the decision problem involves the estimation of individual utility functions and their aggregation. Its operational value is limited by the problem of specifying individual utility functions and by the lack of absolute distributional or weighting criteria for aggregation. The second view involves an attempt to identify the underlying social values, their relative weights in the aggregate social welfare function and the policy means for serving them.

The view that interprets demand from individual preferences assumes that is expressed in individual voting behavior or in the votes of homogeneous blocs of voters. The preference functions of individuals are not directly measurable but are "revealed" in their voting behavior. The voting booth is the analogy to the market and the median preference determines the outcome.[29] The response to revealed preference is determined by the interest of public officials in retaining office[30] or by their discretionary actions controlled by ultimate accountability to the electorate. Although there are inherent limitations in this analogy as reflected in Arrow's impossibility theorem[31] and Buchanan's analysis of the effects of uncertainty, indivisibility, non-participation and the distribution of influence on the meaning of political votes, much of the empirical analysis of the demand for government services is structured in this form, although often implicitly.

A recent and representative example (Borcherding and Deacon[32]) is a test of a majority rule model applied to the demand for services of non-Federal government. The political assumptions of the model are that, "in each political unit a government is elected by majority rule. The voting franchise is general and entry into political activity is both brisk and unrestricted. Competition between political entreprenuers leads to the election of a government that chooses a platform identical to the optimal position of the median voter" and that "Citizens are assumed to be informed about the costs and benefits of government spending. The median voter--chooses the level of spending by voting for candidates who offer him the most efficient set of public services and taxes."

Within this competitive frame, the study attempts to estimate the parameters governing the demand for public services in eight categories of expenditures on the basis of cross sectional data aggregated at the State level, and using a model in which expenditure is a function of the marginal cost of the product and the quantity captured by the median voter. The marginal cost term is estimated from a Cobb-Douglas production function in which capital rents are universal and the labor coefficient varies with the wage rate. The quantity captured by the median voter is a function of income and the marginal tax price to him.

An earlier study by Birdsall[33] tests a more extensive model of the demand for public goods. He argues that public expenditures can not be interpreted as effects of preference differences in the absence of a theory explaining "how successfully citizens express their preferences" and how they are aggregated in deciding budget levels and budget allocations. He attempted to measure preferences in terms of aggregate voting behavior on finance referenda and explain them in terms of voter characteristics. Since the available data were aggregated for cities, the independent variables were characteristics of 55 cities of the state of New York and the dependent variable was the Percent Yes Vote in each city on 26 State-wide referenda.

The hypothesis tested was whether the revealed preferences of citizens, formulated as Percent Yes Vote by city, can be explained by differences between cities in property value, local public expenditures and tax levels, population and mobility rates, education levels and needs, housing values and needs and other characteristics. Fifty-two explanatory variables were tested by step-wise and normal regression. The results of the analysis suggest that the assumptions that it is possible for a citizen to make rational calculations of the benefits and costs of proposals and that in fact they make such calculations and rationally vote according to the resulting preference is not well supported by the data. Birdsall suggests that, "the difficulties the voter faces are likely to diminish the necessary rational calculations" and notes that there is evidence in related studies that indicates they do not make rational calculations (David[34]). Although several general, consistent determinants were found, he concludes that "the PYV of cities on these referenda is not a function of the specific cost and benefit of each referendum--but a function of some vague attitude" and that either the calculation is not made or it is not translated into votes.

Davis and Harris[35] have tried to test the assumption that political decisions are the outcomes of individual voters maximizing self-interest through politicians who respond to or follow the "will of the majority." They hypothesize that voters will, in their own interest, enter into coalitions to shift the incidence of taxes away from themselves. They define this set of hypothesis as a "political approach" to collective decisions and test it by examining the relationship between specific municipal expenditures and a set of "taste determining" and "interest group" variables. The former include population density, and the market value of personal and industrial property which are assumed to reflect self-interest. The "interest group" variables include median family income and the proportion of the electorate who are property owners.

Although the variables generally tend to behave as predicted, and the authors conclude that the results were favorable to their intent to indicate the fruitfulness of a political approach to the theory of public expenditure, their observation that they do not claim to have described the actual process by which expenditure decisions are made, or to have developed a completely adequate theory is not likely to be debated.

Peter Steiner has suggested on the evidence that can be drawn from empirical studies of consumer choice framed in the market analogy and from the critiques of Arrow and Buchanan, that the techniques and theorems of formal welfare theory cannot be applied," directly and fruitfully to political decision making."[36] He suggests that individual voters do influence and constrain political choices but only within limits so broad that they leave a substantial discretionary role to government. In his view, the preferred strategy is to infer dominant collective social priorities from social actions and the repudiation or non-repudiation of them by the electorate, and to examine the potential stability of these "revealed social preferences" over the long term.

This view is reflected in the recent development of goals and priority analysis, quality of life studies, social accounting and social monitering and in the recent increase in "scientific" future studies. Viewed in conjunction, these studies are trying to specify revealed social preferences, extend the parameters of a social welfare function and evaluate the long term stability of a structure of social goals and priorities.

The current state of the art in each of these areas is rudimentary. Not by virtue of inherent methodological or substantive constraints, but because a national goals consciousness has only recently emerged in a society marked by a combination of political pragmatism and a philosophic commitment to a market mechanism. Gerhard Colm suggests that the awareness of a need for goal specification emerged initially from the crisis generated by the diffusion of the 1930's and by the second World War. Both conditions created concerns with the performance of the system rather than with its end purposes and measurement techniques and public policy have been oriented toward performance standards.[37]

The current concern with "achievement goals" or social priorities has developed in the post-war period as a product of frustration with the complexity of modern society and growing uncertainty concerning the value of traditional, implicit goals in a post-industrial era. These conditions have produced a proliferation of ad hoc social experiments and a consequent sensitivity to the need for priority criteria for social choice.

Goal and priority analysis.-- An initial response to this felt need was the establishment by President Eisenhower of the Commission on National Goals and its attempt to define through "expert" consensus, a set of National objectives. These statements were quantified in cost terms by the NPA Center for Priority Analysis in 1965, in order to provide feasibility criteria for the evaluation of priorities or goal trade-offs.[38] The NPA study projected a rate of growth to 1975 on the assumption that the current public policies and business attitudes would prevail. After evaluating the potential effects of changes in policy and attitudes, they estimated a target rate of growth as a function of feasible changes in employment and productivity. This target rate was then modified downward to account for policy lags, producing a "judgment" rate of growth as the framework for priority analysis.

The study took as a starting point the goals defined by the Commission and specified them in program terms. They were evaluated in this form by a panel of specialists representing each area and costed out at two quantitative levels: a simple growth level and an "aspiration" goal representing the experts estimate of desirable standards. The aggregate costs of the growth goal activity proved to be considerably less than projected capacity output, while those of the aspiration goal set were substantially more.

In a subsequent extension of this study, Lecht has translated the two sets of final demand estimates into the final demand for producing sectors and used the 1958 input-output matrix to estimate the intermediate

and total demand for target outputs at the sectoral level. In allocating final demand to sectors, the consumer expenditures derived from goal related benefit payments to individuals were distributed on the basis of the BLS surveys of consumer expenditures by age and income.[39] The value added estimates from the input-output analysis were consolidated to the one-digit SIC level and employment was estimated for each sector by the use of projected rates of change in sector productivity. Finally occupational distributions were estimated for each sector from 1950 and 1960 census data and applied to the sector employment estimates to obtain an estimate of manpower requirements. The employment distributions have two implications; one as a feasibility check on the goal specification and the other as an estimate of the impact of change in the structure of final demand on the skill mix of labor inputs. The conclusions of the manpower analysis suggest that the expenditure targets in the initial study could conceivably be achieved by an annual growth rate of 5.5 percent for a ten year period, but that they would require about 10 million more persons than the number projected in the terminal year labor force, given estimated changes in productivity.

This brief description neglects a number of methodological problems treated in the analysis because they are discussed elsewhere and are not limiting on the present purpose. The important implications of this study are not methodological or operational. Rather it has initiated a growing interest in goals analysis and in attempts to specify a social welfare function. Most of the subsequent studies have focused on goals associated with public sector activity and expressed as government expenditures in view of their immediate policy implications.

These include a near replication of the NPA study by the National Urban Coalition.[40] In their analysis of social priorities, they first set forth a set of value statements as broad criteria for program analysis. These statements reflect positions concerning employment, equality of opportunity, welfare minimums, the Federal-State power balance, national security and assistance to developing countries. These general objectives are rationalized and made explicit in specific program proposals structured in the form of the Federal budget. Finally, they are projected as alternative Federal budget proposals for each year from 1971 to 1976.

By virtue of the nature of the institution, the priority structure of the budget proposal reflects the "revealed social preference" of a broad segment of the society, although clearly it is a biased estimate. The potential importance of studies of this type depend on the extent to which they provide a media for communication among disparate groups and interests in moving toward consensus positions and consequently providing welfare criteria to the decision system.

As in the NPA study, the Counterbudget study has been extended by Roger Bezdek,[41] to evaluate its employment and manpower effects, using a methodology very similar to that of Lecht. Both studies are discussed in following sections of this study in greater detail than is relevant here. Their importance here is in the extent to which they specify some of the

distributional aspects of priority analysis rather than as criteria for manpower policy. The level and distribution of employment is one of the distributional variables in the social welfare function and the Lecht study, in particular, explores this dimension.

A potentially more useful form of priority analysis than the one-time studies of the NPA or Urban Coalition is the analysis of the priority implications of the Federal budget by the Brookings Institution. The primary objective of these studies, published annually since 1971, is to communicate to the general public the priority decisions and strategies that are implicit in the Federal budget and to do so in a holistic form that facilitates general evaluation rather than fragmented discussion of components. Both the complexity of the budget and the incremental nature of year-to-year change obscure the shifts in priorities that are often subtly generated by budget decisions and revealed to voters only through their ultimate consequences.

The studies examine each expenditure or program component of the current year budget, structured in terms of goal strategies. The 1974 report also examines alternative budgets for the next five years, in view of the radical nature of the 1974 budget proposals. It notes that "if the philosophy in those proposals were consistently applied over a period of several years, the budget would be profoundly altered," and that "these moves by the President clearly open the possibility of a major debate about alternative paths down which the Federal government should travel in the next few years."[42] The study projection of alternatives is based on three alternative assumptions: (1) a continuation of the "current posture" of no tax reform and no defense cuts; (2) a moderate increase in resources, attributable to moderate defense reductions and tax reforms; and (3) a large increase in resources, attributable to major tax reform and defense cuts. These three assumptions produce an estimated budget surplus in 1978 of 22 billion in the Nixon budget, 44 billion in the moderate change budget and 77 billion in the large change budget. These compare with a deficit of 8 billion in the pre-reduction budget.

Two variants of allocation strategy are projected to 1978 for the "current posture" budget and four variants are projected for each of the two resource alternatives (moderate and large additional resources). The "current posture" variants consider the alternatives of allocating the projected surplus to tax reductions and revenue sharing versus restoring funds cut from domestic programs. In general, the first variant for the additional resource alternative explores quantitative extensions of the "current posture" strategy. The second variant places emphasis on income redistribution by cash transfers, tax cuts on low incomes, social security benefits, public service jobs and related poverty oriented activities. The third variant proposes redistribution by the extensive use of voucher systems for purchasing essential services in the private sector; while the fourth variant concentrates on Federal grants for social programs. In this allocation, about three-fourths of the projected surplus in the terminal year would be social program support or environmental investments.

In the aggregate, this study provides ten alternative specifications of the level and allocation of Federal government expenditures in a five year time frame. Each specification is feasible and each reflects a position on a spectrum of values or priorities. They offer a fairly clear agenda for public evaluation and debate and consequently a mechanism for moving toward social consensus. Their efficiency in this role will depend, obviously on the rate and pattern of diffusion.

It is evident in this brief description that attempts to estimate social values and to specify a complete social welfare function for purposes of long term forecasting or policy formation are limited in scope, simplistic and highly subjective. Their value in the decision process currently depends on the credibility of the generating institution and the sources of their value estimates. One requirement for improving the state of the art is an extension of the data base to provide better measures of the objectives and impacts of public expenditures on equity and other intangible objectives of public policy, and to provide a frame of reference for evaluating changes in these components over time and relative to other component goals. It seems self evident that historical allocations of resources have been biased in favor of tangible products because they are readily measured and incorporated into the decision calculus. In the current conflict between energy and environmental concerns, the former is at an advantage in allocation decisions because it is both immediate and measurable. Many of the current sources of social concern and of apparent shifts in values reflect an increasing but lagged sensitivity to less tangible determinants of the social welfare.

Social indicators and the quality of life.--The recent development of a system of social accounts by the Office of Management and Budget and the publication of a comprehensive set of social indicators as the initial report in a statistical series describing social conditions is a response to this need.[43] Social Indicators, 1973 attempts to measure the products of social systems relating to health, public safety, education, employment, income, housing, leisure and recreation, and population. In each area, the data are structured around an area of social concern and are selected on the basis of their relevance to policy formation.

Although the publication of this periodic series is a significant step in the relatively brief history of social indicators, an evaluation of their potential utility in manpower forecasting or planning is limited by the lack of an appropriate conceptual framework for integrating them in policy decisions. Whereas, the current system of economic accounts was developed in the framework of macro-economic theory and in response to a specific social concern, the current state of social accounting is more nearly analogous to the state of business cycle analysis prior to Keynes. In the absence of a general theory of economic fluctuations, economists generated a vast stock of empirical data, descriptive of economic behavior, but with little explanatory or predictive power.

The present state of the art in the social indicator case is even more constrained than the analogy suggests, in that the objective of description is less clear. Wilcox and associates[44] have observed that the impetus to the development of social indicators has come from a variety of needs and consequently the structural criteria for their specification are not consistent across areas of concern. They note that much of the current activity dates from 1966, with Biderman's[45] attempt to identify indicators for sub-goals implicit in the report of the Eisenhower Commission on National Goals, with Bauer's[46] concern with the social impact of the NASA space program, and with the concern of the Commission on Technology, Automation and Economic progress with the social costs of technological change.[47] Subsequently, social indicators have been related to the evaluation of social programs, to planning and social monitering, and to the development of micro-models of society in the development of social theory.

This diversity of purpose has limited the development of general criteria for evaluating the statistical properties of specific measures and for aggregating them in indices of change. From the perspective of manpower forecasting or planning, social indicators ar essential to the specification of outputs that are not included or adequately specified in income accounts, and to the specification of costs that condition the choice of outputs or the means of production. The demand for educational and health services are specified in existing planning models as expenditures and have limited value for allocation decisions. Obviously, the same level of expenditure can reflect a variety of outcomes in terms of health status or learning experience. Alternatively, many external costs, in particular psychological costs and environmental costs are not priced out in transactions.

Given a better specification of outputs, there remains considerable uncertainty as to how they can enter or be integrated in planning and policy models. The National Planning Association is currently attempting to develop a "Goals Accounting System." It is described as an application of economic theories of production and allocation to the questions of production of incremental social change over a given time interval.[48] In brief, they have developed an activity-output matrix relating 28 activities to 22 indicators representing 6 areas of public concern. The activities are presumed to be technically and institutionally feasible and with latitude for discretionary change within projected resource constraints. Ineffect, the discretionary term is the difference between the level of activity that the resource base would allow after accounting for "fixed" uses.

The potential value of this research is in the linking of potential supplies from known "production" systems to specific social goals, the use of indicators as measures of goal states and in the ability to estimate maximum rates of change in goal achievement. On the other hand, the goal indicators are conventional and limited to those that can be interpreted in goods terms, and the linkage between activities or effects and indicators are not currently verifiable; as, for example, the relationship

between employment opportunities for youth and the number of violent crimes. Further, its ultimate value in a planning context is limited to descriptive or informational roles in the current state of demand theory.

A second current research thrust for the integration of social indicators is the NSF/NBER pilot project for the measurement of economic and social performance with the objective of developing a "coherent, integrated conceptual and statistical framework for the measurement of social performance with both aggregative and distributional dimensions."[49] In a brief description of the project structure, Ruggles and Ruggles suggest that the dissatisfaction with social indicators stems from the fact that they are a miscellaneous collection of social statistics and that they should be fitted into a common framework that permits aggregation and comparative analysis. They argue that it is important to relate social indicators directly to national income accounts in order to assure correspondence between the social statistics and economic transactions data and to specify the linkage between economic and social information. The essence of the research objective is therefore to develop the national income accounting framework to include non-market activity, improve the measurement of intermediate goods and services and evaluate the impact of environmental factors. They believe that the strategy of using the national economic accounts as the framework for an economic and social data system is justified by the progress that has been made in the past in the development of the current system.

A third area of concurrent research by the Urban Institute reflects a concern with the neglect of conceptual structure and the consequent inability to specify the relationship between outcomes, implementation and organization.[50] The research attempts to develop paradigms that bridge the conceptual and methodological concerns of several relevant disciplines. Although the report cited here was a discussion draft and cannot be quoted, the general outlines of their working model involve the relation of an economic transformation model to a welfare transformation model and an organizational or environmental model. This linkage assumes that production systems do not produce welfare directly but provide inputs that are transformed into satisfaction or welfare by consumers, and that outcomes vary with the perceptions of consumers and with the techniques they employ. In view of the fact that this research is responding to the major constraint on the development and use of social indicators, the limits of information currently available are unfortunate.

Long-term changes in social preferences.--Another recent development in research relevant to forecasting the structure of output is an expanding interest in futures analysis. The current belief that the society is at the threshold of rather fundamental changes in values and priorities, the growing sensitivity to a need for a long-term frame of reference for social decisions, and an increasing awareness of the interaction of economic, technological and social phenomena have

stimulated efforts to probe the future in terms that have current operational value.

The objectives of future research are of a quite different order than empirical estimates of demand functions or the development of a system of social accounts. Both types of analysis take as given, the institutional structure, the basic system of values and the set of production possibilities. Forecasts as long as ten years are considered as long-term because of the assumption of stability in these environmental assumptions; yet it is obvious that an important segment of the human resource stock now in the development stage will not enter the labor force by 1985 and will not leave it before the year 2040. In terms of the life cycle of human resources, a projection to the year 2000 is a medium-term forecast in which all of the current environmental assumptions are variables. The objective of future analysis is to anticipate changes in the basic parameters of social processes and to distinquish, on the basis of current information or judgments, between those that are persistent and those that are transitory.

The development in the last decade of "scientific" futures analysis, as contrasted with utopian prediction, has been stimulated by real events, such as environmental depreciation, energy constraints and the population "explosion"; by apparent subtle changes in values and priorities; and by a growing suspicion in the United States that present institutions, organizations and information systems are inadequate in an increasingly complex society. The result has been an explosion of futures studies, many of which are based in a specific phenomenon--usually technological--and leading to simplistic solutions, as for example, zero population growth or zero economic growth.

As a generalization, one can describe the current state of the art as consisting of an explosion of interest in conventional forecasts of technical change and interpretations of specific, economic, social and environmental effects, on the one hand, and a search for a conceptual framework for treating long term change in a systemic, holistic mode, on the other. The former are relevant to the current discussion only to the extent that one perceives changes in goals and priorities as responses to change in the range of transformation possibilities. This interpretation views technology as autonomous within a set of resource constraints and public policy as reactive to it. Virtually all of the research cited above reflects this view of impact analysis.

The alternative view, that future studies should be directed toward the choice of futures rather than outcomes, is expressed by Jantch in Technological Planning and Social Futures.[51] In that view, futures analysis can only be useful to decision making in a process of "rational creative action." In this context, objectives, strategies and implementing decisions must be integrated in a systemic process, in which normative thinking and valuation are elements of planning and make it "futures creative" rather than deterministic. Forecasting is a normative function dealing with what "ought to be" through the "invention of anticipation."

More simplisticly, forecasting should be concerned with defining future "desirable" social positions or targets and planning should be concerned with the strategy of achieving them.

The argument for normative planning stems from the fact that a future social welfare function will be determined simultaneously with technological and institutional change, within a set of constraints imposed by the rate of change in individual and social values, i.e., by the stickiness of current values. The function of planning is normative in the sense that it identifies likely permutations and selects those to be pursued or avoided. In a democratic society, the concept of normative planning raises philosophic questions concerning the identity and role of the planner, questions currently debated in terms of participatory, advocacy and similar planning paradigms. If the social welfare function includes participatory decision-making as an element, then planning institutions and the planning process must reflect that fact.

Tavis suggests that because of the interdependence between value change and environmental change the specification of future preferences will require an iteration process involving evaluation, prediction and evaluation because these re-evaluations and re-definitions are essential to the process by which individuals act in a new way and respond to new stimuli.[52] She suggests further that there are three possible techniques for predicting value change. One is to assume a deterministic correspondence between structural change and value change and project value changes in conjuction with or as a function of structural change. The second uses a model of modes of value change to forecast value change in response to projected social change, and the third is to identify those values which need to change because of current inconsistencies between social requirements and traditional value patterns, as for example the persistence of individualism in the United States.

The first of these approaches is reflected in The Year 2000, by Kahn, Weiner and Associates of the Hudson Institute.[53] This study also illustrates one of the two primary approaches to goal specification--the use of scenarios. In brief outline, the authors have attempted to specify trend elements that have been persistent in Western society for long periods and appear likely to continue at least until the end of the century. The thirteen elements of what they call a "multi-fold trend" include cultural, political, technological, institutional, economic, sociological and demographic trends.

On the basis of the trend assumption, they have projected a most probable world state or "surprise free" pattern of change, and three "canonical" variations or alternatives assuming varying degrees of international integration or conflict. The surprise free projection of the multi-fold trend leads to a post-industrial society with a decline in the social valuation of efficiency, an erosion of "national interest, work oriented, achievement oriented and advancement oriented values," and an increase in "sensate, humanist and secular values."

This shift in value structures is derived from and consistent with the technological, organizational and economic changes which define the post-industrial society in an integrated world.

Tavis' second alternative approach to value prediction is illustrated in Rescher's hypothesis that currently obvious environmental changes, acting on the circumstances of life will, "exert pressures upon the extent to which a certain value can be realized."[54] As a result, the value will be re-evaluated (upgraded or down graded) as the cost of maintaining it or the benefit from changing it indicates.

Rescher argues that the values explored by the working party on "values and rights" of the AAAS Commission on the Year 2000, are all values that are either "markedly threatened" by or "badly needed" in the society being shaped by environmental trends. It follows that social policy should act to enhance the development of needed values and mitigate both the individual and social costs of maintaining inconsistent values. This involves, on the one hand, the development of the means for value change and on the other the development of change criteria.

The major current technique for estimating the rate and direction of changes in social values and the relative importance of change among values is the delphi technique. Delphi was developed as an instrument for future analysis by Helmer and Gordon at the Rand Corporation, and has been used in a variety of applications relating to future demand, technology, the quality of life and general futures analysis. The technique solicits the opinion of experts on specific topics through a sequence of questionnaires and opinion feedback that should move toward and reveal an opinion concensus regarding future events. The questionnaire may provide both probability estimates and importance rankings or ratings for the changes explored.

One application that tests the possibility of bringing the expectations of a panel of experts with diverse skills and experience to bear on future social development and value changes is the Brigard and Helmer[55] study of the period 1970-2000. It examines future developments in ten areas of concern including social processes, institutions and values. It also examines a set of societial indicators and the probability and importance of breakthroughs in physical and biological technology. In the analysis of consensus, it relates consensus-probable technological breakthroughs to consensus-probable impacts on societal developments including values and attitudes. Although the outcomes are obviously biased by the composition of the panel, the methodological extension does suggest a potentially useful instrument for mobilizing and rationalizing judgmental data for long-term forecasting.

Although the Delphi technique seems incredibly simplistic, there are no obvious alternative techniques for evaluating long-term environmental changes as a basis for evaluating the relevance of value systems or the inter-actions of values and environmental change. Further, it

may have a function in communicating alternatives as well as soliciting judgments about them. For example, Decker's[56] use of the technique to solicit the judgments of 300 "eminent" economists concerning future economic developments revealed a strong tendency to extrapolate the future from the present and a limited perception of potential change agents. A conclusion of the study is that economists are not adequately trained for futures analysis and the use of Delphi as a learning process for the panel may be a valid use.

The technical limitations of Delphi appear to be mainly those relating to its scale limitation, the relevance criteria for panel selection and the necessity of integrating the technique into broader analytic systems. The environmental change--social impact matrix discussed above is one extension in this direction. Another partial extension is demonstrated in Enzer's[57] combination of Delphi and cross-impact techniques, which attempts to estimate the interdependence of predicted changes in probability terms. Delphi evaluations are put in matrix form and a panel responds to the question of the probability of the event and the likelihood of its impact on each other event in the set. The results suggest that decision criteria may be significantly enhanced by combining the contributions of two distinct techniques and similar extensions should be explored.

Projecting Intermediate Output

The final stage in the projection of the level and structure of output is the estimation of intermediate demand by producing sectors, in order to estimate total sectoral output and subsequently future labor requirements. The process involves the transformation of commodity estimates of final demand into the outputs of producing sectors, a projection of the inter-industry transactions coefficients over the time period of the forecast and the use of the projected inout-output matrix to estimate intermediate requirements.

Given the commodity composition of final demand by major components, it must be transformed to producing sector outputs, as commodity classifications are generally not identical to producing sector classifications. The BLS methodology relies on a set of conversion factors produced by the Office of Business Economics for the transformation of PCE. The conversion factors are empirical estimates of the detailed commodity mix within a commodity category. Illustratively, the final demand estimate for footwear is distributed among the leather, rubber and plastics industries on the basis of historical patterns of consumption. Investment expenditure for durable goods and net inventory changes are estimated from the detailed data in the national income and product accounts. For public sector expenditures, the residual expenditure, after accounting for construction and compensation of employees is allocated to producer

sectors on the basis of the distribution in the 1958 input-output matrix, and exports are distributed on the basis of an analysis of the industry composition of balance of payments categories and projected to the terminal year. Competitive imports are allocated as inputs in the sector producing the same product and non-competitive imports are allocated to the using or consuming sector.

In the transformation process, final demand is converted from consumer values to producer values by removing trade margins and transportation costs from the final value. These "margins" are estimated empirically and allocated to the trade and transportation sectors. After adjusting the "projection" outputs to the prices of the input-output matrix, intermediate requirements are estimated by inverting the input-output matrix.

In view of the fact that the development of the input-output matrix requires several years, the technical coefficients of the matrix do not reflect the effects of interim changes in the commodity mix of inter-sectoral transactions, changes in technology and other factors. The use of an input-out matrix for projections requires an updating of the matrix to the base year of the projection and the projection of changes in the technical coefficients to the terminal year of the forecast. The procedure for updating involves the estimation of actual intermediate demand for each sector from current accounting data and its comparison with a "derived" estimate calculated by applying the direct coefficients matrix to the bench-year total outputs. The differences reflect the effects of coefficient changes and are used in ratio form to adjust the technical coefficients of the matrix. This process is reiterated with judgmental adjustments until the differences between actual and derived estimates are minimal and balanced by scaling the coefficients in each sector by its ratio factor.

The projection of technical coefficients to the terminal year is accomplished, in the BLS analysis, by examining the growth rates for each sector implicit in this initial year (adjusted) matrix. Judgmental adjustments are made in the coefficients as a function of the logical properties of these growth rates in an iterative analysis, until the gaps between matrix generated output estimates and target outputs are relatively small. The coefficients are then adjusted and balanced by the same procedure used in the updating process.

As noted earlier, changes in technical coefficients arise both from changes in sectoral production functions and changes in the commodity mix of the aggregate commodity classifications used in the projections of final demand. The first of these two problems is the subject of the following Chapter. The only potential solution to the aggregation problem is the further disaggregation of the initial demand projections and the inclusion of technological forecasts of changes in the commodity composition of material inputs in the production of specific outputs, i.e., raw material substitutions. In view of the prior discussion of the capacity to project final demand for consumer goods and

public goods, it seems probable that the forecasting errors in more disaggregate projections are likely to offset any potential improvement in the specification of inter-industry transactions.

Conclusions

The rather depressing conclusion of this brief examination of the forecasting of sectoral output is that in a highly decentralized decision system, detailed long term manpower forecasts of the BLS type have limited policy utility. The questionable validity and narrow scope of the current theory of collective choice, the random character of technical change and the absence of linkage between ultimate goals and policy formation, make complex predictions little more than best guesses.

It is doubtful that additional research, in the present mode and in the narrow specification of process elements conventionally used, will contribute more than marginally to the state of the art. Manpower policy and planning will necessarily begin at the opposite end of the time spectrum with the specification of social goals and goal criteria and with the development of preferred strategies for achievement. In this context, those elements of analysis and methodology which currently appear the least sophisticated and scientific are the areas of dominant importance: attempts to identify and rationalize the arguments of a social welfare function, the development of long term structures for policy analysis and public choice, and the analysis of interaction and interdependencies between environmental and value changes are among them.

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CHAPTER III

TRANSFORMATION: ANALYSIS OF PRODUCTION RELATIONSHIPS AND TECHNOLOGICAL CHANGE

Some Preliminaries

Suppose for the purposes of this Chapter that estimates of final demand and gross output by sector have been prepared for a specified planning period. The next step is to "transform" these output statements into input statements. Typically, this involves the estimation of a vector or vectors of manpower categorized by skill level associated with the target vector of outputs. As such, it constitutes the heart of manpower forecasting procedure. This Chapter examines the knowledge base which bears upon the transformation aspect of planning activity. It is designed to complement the assessment contained in Chapter II and, in similar fashion, to generate criteria for the evaluation of planning practice in subsequent Chapters. Not unlike that Chapter, a reasonable amount of preparatory work is necessary to place the knowledge base in perspective.

Conceptually, it is possible to distinguish at least two primary methods or avenues for output/input transformation. On the one hand, inputs may be defined in terms of specific programs or policy variables of operating systems and related directly to changes in output. This may be thought of as the compressed method; it is illustrated primarily by input/output and programming models which link school system variables directly to forecasts of output.[1] For example, the educational planning model developed by Correa and Tinbergen relates student flows and teacher requirements of a school system directly to forecast changes in output, through a set of linear (difference) equations which makes the number of (economically active) school graduates proportional to the level of output.[2] The advantage of compressed models is that a variety of inter-related policy changes can be analyzed or simulated simultaneously; they avoid the need for tedious and sometimes inconsistent iterative procedures. The drawback is that they either ignore or "squash" a large number of important and complicated relationships, many of which are of central concern to manpower planners.

On the other hand, target output can be transformed into labor inputs categorized by occupational function. After appropriate analysis of the relationship between output and the occupational distribution of employment associated with that vector, the occupational array can, in turn, be transformed into a set of educational attainment equivalents. These figures, in turn, can be examined for their implications with respect, say, to changes in school system policy.[3] Such an extended model has

been used far more frequently than the more aggregate, compressed models for fairly straightforward reasons: it provides significantly more detailed information for policy purposes and is more flexible in the range of issues to which it can be put. This being so, we shall concentrate primarily on the knowledge and applied research base which effects operational efforts to carry out the manpower/output transform, especially that dimension of it concerned with the relationship between output and labor categorized by occupation.

As a way of setting the stage, it must be pointed out that the extended model turns on our ability to identify and measure the forces effecting changes in the amount of labor input per unit of output. This point is hardly novel, but it implies more than is usually acknowledged in the forecasting literature. Consider initially the fact that the typical transform procedure is to use the simple ratio of a given or ith input (X_i) to output in the jth industry (Q_j) at a particular point in time and multiply it to target output to obtain the associated target input. This ratio incidentally is measured either as the input coefficient, i.e., the amount of input per dollar of output ($\frac{X_{ij}}{Q_j}$) or as its reciprocal, the productivity rate, i.e., the number of dollars of output per factor input ($\frac{Q_j}{X_{ij}}$). If we use the second of these measures and write it as $\P_{ij}$ ($= \frac{Q_j}{X_{ij}}$), the simplist transform may be represented symbolically as:

$$X_{ijt} = Q_{jt} \P_{ijo}^{-1}$$

and

$$X_{it} = \sum_j X_{ijt} \qquad \text{(III.1a)}$$

where the additional subscripts t and o refer to the terminal and beginning date of the planning period respectively.[4] In (III.1a), the productivity rate is assumed to be constant. A somewhat more realistic procedure is to allow ¶ to change over the planning period at some specified rate. In this case, (III.1a) may be written as:

$$X_{ijt} = Q_{jt}[\P_{ijo} e^{r\tau}]^{-1}$$

and

$$X_{it} = \sum_j X_{ijt} \qquad \text{(III.1b)}$$

where r = the (continuous) rate of change in productivity and τ is the length of the planning period. In either case, however, much depends on the measurement, projection, and interpretation of ¶.

Although ¶ has frequently been used as an indicator of technological change, it really must be viewed as a summary measure of the myriad factors affecting the utilization rate of a particular input in a given industry. It accounts for changes in the scale of activity of firms in the industry or in the scale of the industry itself, changes in the amount and quality of other productive inputs, changes in managerial efficiency,

and in certain cases changes in qualitative standards as well as changes in the state of technological knowledge and shifts in the rate of which such knowledge is incorporated into the productive process. It also reflects changes in the supply conditions of the factor. The productivity rate, therefore, reflects both too much and too little. On the one hand, it would be desirable to have a transform procedure that is independent of factor supply, since the results will be used to evaluate needed changes in supply policies. On the other, it would be desirable to separate the differential impacts of different kinds of change because each is likely to assume greater or lesser importance over the course of a given planning period and because each has rather different policy implications.

One way out of this impasse is to view ¶ as a poorly specified, surrogate measure of the production function--an economic concept which refers to the technical relationship between all input sets and output. The primary advantage of this view is that it suggests the ways in which the typical transform procedures might be expanded or improved such that the transformation step yields more useful results. It suggests, in other words, a framework for the analysis of output/manpower relationships; the next section explores the nature of this framework.

Analytic Framework: An Overview

Economists define the production function as a technical relationship between productive inputs and output. In theoretical terms, it is presumed to be a relationship between the maximal amount of output obtainable from a given level and configuration of inputs. It is thus written as:

$$Q = F(X_1, X_2, X_3, \ldots X_n) \qquad \text{(III.2)}$$

where, as before, Q is output and the X's are inputs. The number and type of X's accounted for in the function depend both upon the technical conditions presumed to exist in a specific industry and the purposes of the analysis. In terms of our immediate interest, some subset of the X's might represent labor inputs categorized by occupation and another subset, the capital equipment that these workers use. These subsets might be arrayed in disaggregate form or combined into two scalar indices representing the amount of "labor" and "capital" used in the production of Q. Furthermore, it is possible to assume that one of these indices always stands in fixed relationship to the other, such that only one need be used to represent the level of inputs. It is in this sense that the productivity coefficient might be viewed as either a production function itself under highly restrictive assumptions or as some partial reflection of the underlying production function. Note for example that simple re-arrangement of (III.1) yields a possible linear (partial) specification of (III.2), viz.,

$$Q_j = \P_{ij} X_i \qquad \text{(III.3a)}$$

And if all relevant factors are included, a special form of the production function may be derived:

$$Q_j = (\P_{1j}X_1, \P_{2j}X_2, \ldots, \P_{nj}X_n) \quad (i \neq n) \qquad \text{(III.3b)}$$

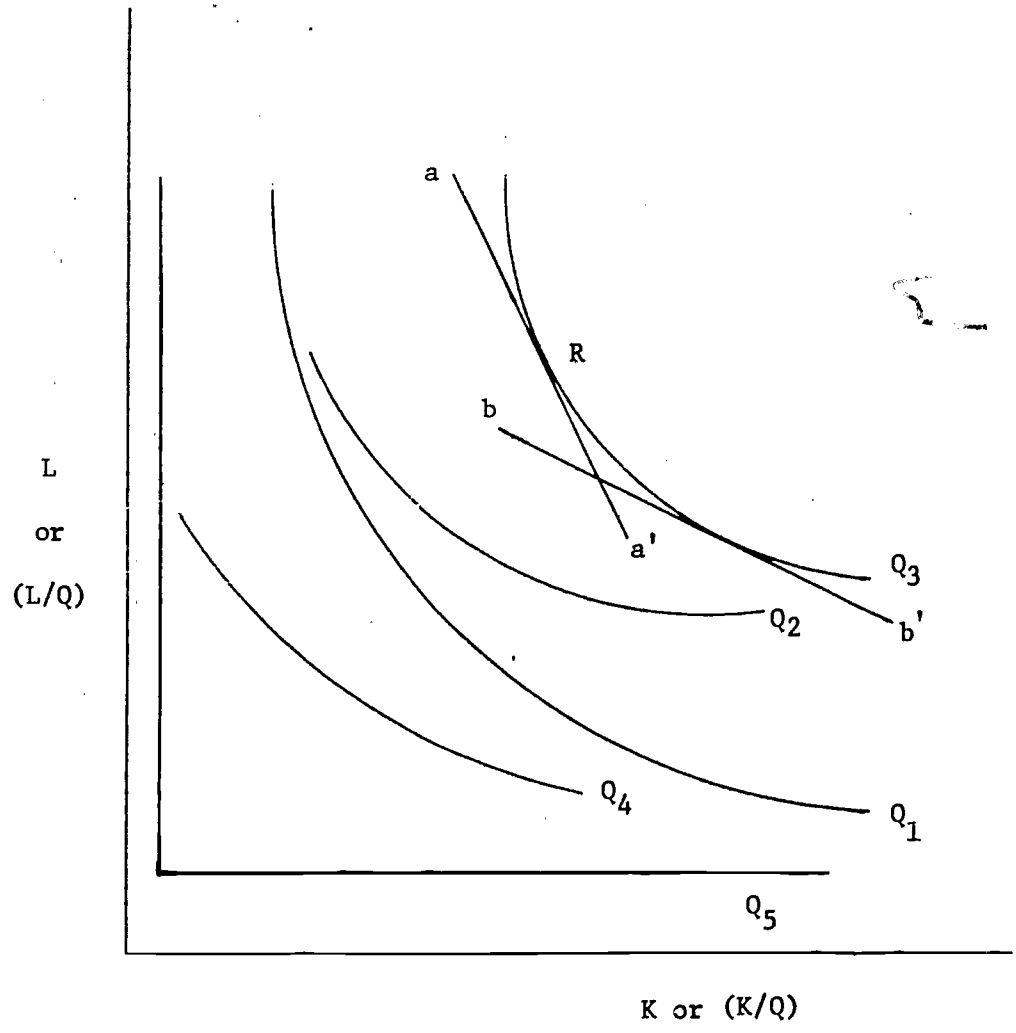
The partial nature or errors of ommission stemming from a reliance on the simple linear model are particularly apparent when the problem is viewed in these terms. Of particular concern is that (III.3) necessitates the unreasonable assumption that any Q can be produced in only one way and/or that changes in the function must be explained by factors "outside" of the model. In economic parlance, (III.3) does not allow for movements along the production function (holding output constant) and fails to incorporate enough to analyze or explain shifts in the function. As we shall see, the distinction between movements along and shifts in the function is a vital, albeit ambiguous, one; it lies, in our judgment, at the root of the output/manpower transform procedure. In view of this, it is necessary to review briefly some basic economic theory.

Traditional economic theory suggests that, under specified technological and market conditions, the employment of a particular factor of production depends upon its own price, the relative amounts of all other factors employed and their prices, and the level of production. As is well known, in theory all quantities are determined simultaneously by equating the ratio of relative factor contributions to product at the margin to the reciprocal of the factor price ratio. What concerns us here, however, is not the behavioral characteristics of the theory of the firm, but the technical underpinnings of the theory. Initially, this may be illustrated by the familiar (three dimensional) production function diagram, where the two horizonal axes measure the quantities of two factors of production (say, capital and labor) and the vertical axis, output, i.e., a production function of the form, Q=F(L,K). Neo-classical theory assumes this function to be smooth, continuous and (twice) differentiable, such that the product curve in three dimensional space resembles a bowl set upside down. When this diagram is sketched in two dimensions, so that we view it "from above" the familiar contours of production theory (isoproduct curves or isoquants) emerge, so called because they show the trade-off relationship between each of the factors for a set of given levels of output. These contours are illustrated in Figure III.1 in general and in the curves labeled Q_1 and Q_3 in particular, where Q_3 is a level of output greater than Q_1.

Now, assuming a constant technological environment (and the absence of scale effects momentarily) unit requirements for a given factor input may increase or decrease (or conversely, the productivity of that factor may decrease or increase) only by adjustments in the relative combinations of the factors. If, for example, factor price ratios changed from aa' to bb' in Figure III.1, the relative use of L would fall, K would increase, and the productivity of L would increase because Q_3 refers to the same output at all points along the curve. Correspondingly, the quantity of capital per worker would increase. This theoretical point presumably lends credence to the widespread notion that increases in labor productivity

FIGURE III.1

The Two-Factor Production Surface



are invariably linked to more intensive use of capital equipment. We shall see momentarily that the relationship is far more complex than this, but it is clear that changing factor proportions do effect factor requirements. This implies, inter alia, that projections of requirements for given factors must either be linked to similar projections for other factors or implicitly assume that all past-relationships hold, particularly that all factor inputs not under study will continue to grow and be utilized as they have in the recent past.

Note, however, that these implications follow only under conditions of given technology and the assumption that such technology permits trade-offs between (and among) productive factors at constant rates of output. The technology, in fact, need not allow fully for factor substitution or even at all--this is an empirical question, the answer to which will surely be different for different industries at any point in time and for the same industry at different points in time. In the real world, the substitution possibilities need not necessarily resemble those depicted in Figure III.1.

Indeed, even in theory, economists characterize different technologies and production functions by the extent to which (or the ease with which) factors may be substituted for one another. This essential property of the production function is referred to as the elasticity of substitution (σ) and is defined as the quotient of a proportional change in the factor utilization ratio (for any pair of factors) divided by a corresponding proportional change in the ratio of the marginal products of these factors (or factors prices, assuming perfect competition) along a given isoquant. Diagramatically, σ can be measured as the change in the slope of a line drawn from the origin to a point (R) on the isoquant (e.g., OR in Figure III.1) divided by the change in the tangent gradient of the isoproduct curve at the point (e.g., the line aa') as R moves through all points on the curve. This being so, the elasticity of substitution may be thought of as measuring the degree of curvature of the isoquant. Since it (σ) can take values ranging from zero to infinity, it implies different geometric shapes for these curves ranging from right angles to a straight line. In the first of these extremes, the factor use ratio is technically fixed and thus invariant to changes in factor prices; consequently, $\sigma = 0$, the factors are considered to be perfect complements, and the isoquant is a right angle, e.g., Q5 in Figure III.1. In the second, even infinitisimally small changes in factor prices induce infinitely large changes in the factor use ratio; consequently $\sigma = \infty$, the factors are considered perfect substitutes and the isoquant is a straight line. Typically, economic theory holds that the technical conditions of production lie somewhere in between these two extremes: factors are substitutable for one another in a range within which it becomes increasingly difficult (and then perhaps impossible) to increase one factor at the expense of the other while maintaining output at a predetermined level, i.e., $o < \sigma < \infty$.

It seems clear, then, that the value of σ presumed to prevail in an industry at a particular point in time is theoretically and practically of some moment: it requires that the growth rates or paths of the pool of

productive factors effecting industry output be specified and balanced together in the planning forecast. At the minimum, it requires that the projected growth path of a single input imply a plausible coefficient for the elasticity of substitution. The fact that neither form of this stricture appears to have been followed in many practical forecasting exercises explains, in some measure, the substantial criticism leveled against manpower forecasting over the past decade. We shall examine these criticisms in greater detail below; at this point, it will be sufficient to note only that the elasticity of substitution between pairs of factors does (theoretically) influence projections of factor requirements, and hence must be accounted for (in some fashion or another) in forecasting activity.

But if this were the only important property of the production function, the point would be a trivial one. After all, the forecaster can almost as easily provide a set of projections for factor requirements at a target level of industry output, each corresponding to a pair-wise growth rate differential predicated upon assumed or simulated values of σ. In fact, there are several other important characteristics of the production function, all of which are likely to be as important as the substitution parameter. One is that changes on the scale or size of firms in an industry or the industry itself can effect the unit requirements for a factor of production. The impact may be viewed as a shift in the unit isoquant inwards toward the origin of the production function, say from Q_3 to Q_1 in Figure III.1 where the axes are now re-labeled L/Q and K/Q, and $Q_1 > Q_3$. Depending upon certain characteristics of the production function, (viz., its degree of homotheticity), this shift might be a radial projection of the original isoquant, or the shift might be rather more to one side of the plane than the other, e.g., the shift from Q_3 to Q_2, again provided $Q_2 > Q_3$. This implies not only that increasing returns to scale can effect, say, the requirements for labor inputs, but could also be "biased" against the relative use of labor as the industry expands. Only under the conditions of constant returns to scale, where all isoquants in effect collapse into one unit isoquant (and a homothetic production function) would scale not effect factor requirements.

Another and perhaps more important effects are shifts in the production function due to technological change which improves the productivity of all factors simultaneously. This may also be represented as a shift in the unit isoquant toward the origin such as from Q_3 to Q_1 in Figure III.1, but in this case $Q_3 = Q_1$. The point is probably more easily made if we view the production function as having a shift parameter (A) which indexes changes in the state of technical knowledge and the rate at which it is incorporated into the productive process. Thus, in abstract form, we might write:

$$Q = A(X_1, X_2, X_3, \ldots X_n) \qquad \text{(III.4a)}$$

Now, if empirical estimates or even assumptions about A were then coupled to similar information on σ, then it would be possible to disentangle the effects subsumed in equation (III.3) above.

Unfortunately, the matter is not quite this simple. Most significant is that (III.4) assumes technological change is (in economic parlance) disembodied and neutral.[5] That is, it implies inter alia that shifts in the unit isoquant toward the origin will be radial projections of one another, e.g., shifts from Q_3 to Q_1 in Figure III.1 where $Q_3 = Q_1$. As before, these shifts might be "biased" in favor of or against some particular factor, e.g., the shift from Q_3 to Q_2 in favor of labor where $Q_3=Q_2$. Alternatively, we might view the production function as incorporating a set of technology indices, each of which effect factor inputs differently, or:

$$Q = (a_1X_1,\ a_2X_2,\ a_3X_3 \ldots a_nX_n) \quad (a_i \neq a_n) \qquad \text{(III.4b)}$$

In either case, however, the point is that there may be an interaction between movements along and shifts in the production function, such that isolating these different changes becomes exceedingly difficult. This complexity again calls into question the character of the assumptions necessarily imbedded in a simple transform procedure such as (III.3) above.

This sketchy review has meant, however, only to suggest the scope of input/output relationship when variables are defined in traditional economic terms, and a framework for analyzing the relationship. We have seen that unit requirements for any productive factor may change with movements along an isoquant, movements to another (higher) isoquant, and technical shifts in the production surface which may or may not be biased.[6] We believe that the effects of each of these relationships or their summary measures such as σ and A should not only be appreciated by the forecaster but also incorporated in explicit fashion into any set of projections. This might normally take the form of a set of assumptions, but it does not rule out the possibility of empirical analysis prior to the transformation step. To be sure, this would necessitate relatively extensive analysis of individual industries, and in its most complete form, would place the forecaster at the research frontier. We do not wish to imply that such extensive investigations need always to be carried out, but that at least the scope of the problem be kept in mind when making methodological choices and reaching policy conclusions. When empirical analysis is to be undertaken, however, the framework in this section suggests a particularly relevant knowledge base: the methodological and empirical research carried out by economists on the production function. A critical question, then, is the adequacy of this knowledge base for manpower planning purposes. The next several sections are designed to provide an answer.

Knowledge Base for Transformation: Production Function Research

The purpose of this section is to review and evaluate the research relating to the shape and characteristics of the production function, especially its substitution and technological parameters. Needless to say, any such a review can hardly be encyclopedic in nature, because the concept of and research on the production function has occupied for many years a central position in economics, and has been used in answering

virtually all kinds of economic questions. Fortunately in this regard, our particular slant requires an examination of only some of the methodological facets of the research and only certain types of empirical applications. Since much of the recent research has dealt only with the refinement of a limited number of alternative econometric forms of the function, and investigated empirically only a limited number of economic sectors, a relatively brief review is both possible and profitable.

Let us begin by pointing out the few empirical estimates of the production function (industry level or aggregate) correspond to the microtheoretic notion of a technical relationship between a set of inputs combinations and the maximal output as discussed above. This is so because the concept in its pure, technical form would require experimentally derived data, i.e., recorded observations on output given incremental changes in factor proportions, or scale of activity, etc. With the exception of Heady's research on agricultural production functions, no studies have generated such experimental data per se.[7] There were, however, some attempts in the past to use engineering data in the formulation of production and process functions, a procedure akin to generating experimental data, but few, if any, studies of this sort have been conducted since the early 'sixties.[8] Rather, the typical study has proceeded by relating (via time series or cross-sectional regression models) observations on output and inputs for the same period of time.

This method is now understood to create biased statistical estimates, because at a given point in time, economic units jointly or simultaneously determine the level of output and the configuration of inputs; the simultaneous nature of these decisions violates one of the principle assumptions of the linear statistical model--independence of the predictor variables and the error term.[9] The statistical problem may be overcome by specifying a more complete production "model" or perhaps by techniques other than ordinary least squares estimates, e.g., two stage least squares or covariance methods.[10] Yet, few complete models have been constructed, and efforts to use two stage models have frequently been abandoned for the lack of usable "instrumental" variables.[11] In the absence of such changes in estimating technique, it becomes extremely difficult to interpret the empirical results. More particularly, observed differences in, say, input sets may simply reflect differences in managerial ability and efficiency, or differences in market conditions faced by the group of firms under study, or the fact that some firms may indeed be "on" different production surfaces.[12]

Strictly speaking, then, econometric analysis cannot shed all of the necessary light on the technical conditions of production for purposes of manpower transformation. These studies, however, should be able to say something about the parameters of the productive process implied in simultaneous input/output decisions. As such, this body of research permits us to learn something about the state of our knowledge of the production relationship as well as the considerable problems of methodology and technique involved in investigating it. Since the overwhelming bulk of this literature deals with the "specification" of production functions, we begin there.

Specification of the Production Function

Formidable problems are encountered in specifying an appropriate form of the production function for purposes of empirical analysis of production relationships. Methods for handling these problems have preoccupied economic theorists and econometricians for the better part of the past three decades, and a very extensive literature has accumulated on the topic. This section reviews some of this literature with a view towards understanding the potential for developing a framework for manpower planning analysis. Of necessity, it begins near the beginning with the celebrated work of Paul Douglas.[13]

Douglas and his associates carried out (more than 40 years ago) a series of studies in which they fitted observations on man-years, value of capital, and output to a specific functional form. The results of the procedure constitute an estimate of the "average" relationship between the flow of output and input bundles across observational units. The algebraic form of the production function introduced by Douglas (and his associate, the mathematician Cobb) is written in multiplicative fashion as:

$$Q = A \prod_{i=1}^{n} X_1^{\alpha_i} \qquad \begin{array}{l} i = 1, 2, 3 \ldots n \\ A, \quad \alpha > 0 \\ \Sigma \alpha_i = 1 \\ i \end{array} \qquad \text{(III.5)}$$

where Q represents output, the X's represent n number of inputs, and A and the α's are the technology and input/output elasticity parameters to be estimated.

The Cobb-Douglas (C-D) function has been frequently used in examining input/output interactions because of its mathematical and statistical convenience. For instance, the function is easily "linearized" for purposes of regression analysis by means of logarithmic transformation. Noting lower case variables as the natural logarithms of the upper case variables in (III.5), the estimating equation becomes:

$$q = a + \sum_{i=1}^{n} \alpha_i x_i + u \qquad \text{(III.6)}$$

where u is a random disturbance term with zero mean and constant variance. As we shall see later on, the fact that the function is additive in logerithmic form also lends itself to the use of aggregate measures of the variables.

But the Cobb-Douglas function has a number of economic properties which tend to limit its usefulness in research on production relationships. For one thing, the exponents of the function--the elasticities of output with respect to each of the specified inputs--were restricted initially to sum to unity. This restriction assures that the function is linearly homogenous from a mathematical view point. In economic terms, it both simplifies the analysis and assures a necessary condition for the assumption about competitive markets, viz., constant returns to scale.

Recent applications, however, have dropped this restriction, allowing the exponents to vary such that $\Sigma\alpha_i=r$. This function is also homogenous, but to degree r rather than one, i.e., $Q^r\lambda=(\lambda X_i, \lambda X_j)$. A measurement of r, therefore, constitutes an indicator of scale effects in the economy or industry under study. The fact that the exponents are nonetheless constant implies that all technical change represented by the function must be "neutral", i.e., in its standard form, it is impossible to model "bias" in technological change. When the exponents are both constant and restricted to unity, scale effects and changes in technology are subsumed in the intercept term, A; consequently, these different kinds of impacts cannot be separated in the analysis.

More important perhaps are the properties of the C-D function relating to the behavior of the marginal products of the inputs and to the implied quotient of the factor utilization ratio (for any pair of inputs) divided by the ratio of marginal products of those inputs at given levels of output (and use of other inputs) i.e., the elasticity of substitution. In the first instance, the function implies positive rates of input use for any positive rate of output, together with the implication of positive (although monotonically decreasing) marginal products for each input at any positive level of output. This may be illustrated by taking the first partial derivative of the function with respect to any factor input. In the two factor case, for example, the marginal product of factor X_i is:

$$\frac{\partial Q}{\partial X_i} = f_{x_i} = \alpha_i (AX_j^{\alpha j} X_i^{\alpha i-1}) = \alpha_i \left(\frac{Q}{X_i}\right) \quad (i\neq j) \qquad \text{(III.7)}$$

and will be positive for any positive output. As we shall see below, this feature limits the use of the C-D function in cases where the analyst wishes to represent the possibility of positive rates of output in the absence of positive use rates of certain classes of inputs (non-use of a factor) and/or where he wishes to represent the possibility of zero or negative marginal products for certain classes of inputs within specified ranges.

Fundamentally, however, the function is of limited use because it implicitly assumes a substitution elasticity of one between any pair of inputs. This follows by definition, and is easily seen in the two factor case. If X_i and X_j are the inputs in a C-D function, and output is held constant, then the standard measure of the elasticity of substitution, σ_{ij} is:

$$\sigma_{ij} = \sigma_{ji} = -\frac{d \log (X_i/X_j)}{d \log (f_j/f_i)} \quad (i\neq j) \qquad \text{(III.8a)}$$

And, if the function is linearly homogenous, it may be written:[14]

$$\sigma_{ij} = \frac{f_i f_j}{Qf_{ij}}, \quad (i\neq j) \qquad \text{(III.8b)}$$

Where $f_{ij} = \frac{\partial^2 Q}{\partial X_i \partial X_j}$

We find, then, that σ_{ij} for the C-D function (III.5) is:

$$\sigma_{ij} = \frac{\alpha_i X_i \alpha_j X_j Q^2}{\alpha_i X_i \alpha_j X_j Q^2} = 1 \quad (i \neq j) \qquad \text{(III.8c)}$$

at all points.[15] In the case of more than two factors, the measure is a bit more complicated, but we can postpone a consideration of it momentarily.

While this does not tell the entire story, the fact that the C-D function requires the assumption of an unitary σ goes some distance in explaining why economists have devoted such a significant amount of time and effort to the formulation of different algebraic expressions for production function research. The functional form, in other words, has implicit in it an unacceptable or (at best) questionable economic characteristic, viz., that a one percent change in the ratio of marginal products (or, under purely competitive conditions, factor prices) will always be matched be a one percent change (in the opposite direction) in the employment ratio of a pair of factors. As it happens, this continuous function is more amenable to most economic research than is, say, the fixed coefficient function (III.3b above), but neither offers a choice to the researcher other than an a priori assumption of one or zero. And, if the flexibility between factor inputs is to be explained, the formulation offers no possibility for reaching an empirical conclusion. This created an intensive effort (especially in the 'sixties) to expand the available, analytic options.

One of the earliest and most discussed of these efforts was the formulation of the Constant Elasticity of Substitution (CES) function by Arrow, Minhas, Chenery and Solow[16] and independently by Brown and de Cani.[17] In its most general form, the CES function may be written as:

$$Q = A\left[\sum_{i=1}^{n} \alpha_i X_i^{-\rho}\right]^{-\frac{r}{\rho}} \qquad \begin{matrix} i = 1, 2, 3 \ldots n \\ A, \ \alpha_i > 0 \end{matrix} \qquad \text{(III.9a)}$$

where Q, the X_i's, A, and the α's represents the same variables or their equivalents as before, ρ is the "substitution" parameter which is equal to $(1/\sigma)-1$, and r is the degree of homogeneity of the function. In fact, the CES function has rarely been used in anything more than the two variable case, frequently with the restriction that constant returns to scale prevail, so its more familiar notation is:

$$Q = A[\gamma X_i^{-\rho} + (1-\gamma)X_j^{-\rho}]^{-\frac{1}{\rho}} \qquad (X_i \neq X_j) \qquad \text{(III.9b)}$$

In III.9b, the γ's are equivalent to the α's in (III.5), for when ρ approaches a limit of zero, $(\rho \to 0)$ the γ's approach a limit making them identical to the C-D α parameters and $\sigma = 1$. Moreover, if ρ approaches infinity $(\rho \to \infty)$ the function approaches a limit that is identical to the fixed coefficient (Leontief) function, $\sigma = 0$. Thus, the CES function

contains both the C-D and fixed coefficient functions as special cases, depending upon the value of ρ.[18] The general behavior of the marginal products is also similar to these functions. For example, the marginal product of X_i in III.9b may be written:

$$f_{x_i} = A^{-\rho(1-\gamma)} \left(\frac{Q}{X_i}\right)^{1+\rho} \qquad \text{(III.10)}$$

But unlike these special cases, the CES function permits the non-use of some productive factors and the possibility that σ can assume some value other than zero or one. Indeed, the virtue of the CES formulation is its ability to provide a direct estimate of the elasticity of substitution. This stems from the fact that the function contains within it a log-linear relationship between the average and marginal product of a factor, the slope of which turns out to be the substitution elasticity. The function was originally formulated, in fact, by starting with the "reduced form" relationship between marginal and average product, and deducing the general function from which it is derived. The procedure involves the assumption that (first order) profit maximization conditions hold, so that observations on factor prices may be used for empirical estimates of marginal products. Given this assumption, the following regression equation is used for estimating, say, the substitution elasticity between labor and some other factor input, e.g., capital:

$$\log \frac{Q}{L} = \alpha + \beta \log W + u \qquad \text{(III.11)}$$

where Q/L is the average product of labor, W the wage rate or marginal product of labor, and β the elasticity of substitution.[19] A considerable rash of studies have been conducted over the past decade to estimate σ by this method.[20]

It seems apparent, however, that the assumptions necessary to use this short-cut technique are unduly harsh. In particular, the assumption that factor price equals marginal product rules out meaningful results in industries operating at decreasing or increasing returns and/in or imperfectly competitive conditions, i.e., most industries. Recent studies have attempted to skirt the problem by using cost minimization conditions which do not require assumptions about scale effects or degree of competition.[21] For reasons to be discussed in the next two sections, it is unlikely that these attempts have been any more successful than their earlier counterparts. Furthermore, they estimate only one parameter of the production function (σ) and thereby shed very little light on the other properties of the relationship affecting factor utilization. The current direction in the literature, therefore, appears to favor abandoning such efforts and concentrating, instead, on the direct estimation of the CES function or even more complicated, albeit flexible, functions. The progress and problems encountered in this regard are instructive and require brief discussion.

To begin with, it has proved to be very difficult to generalize the CES function beyond the two factor case in ways that do not place

unacceptable economic restrictions on the function. A major difficulty is the measurement of and restrictions placed upon the partial elasticity of substitution, denoted hereafter as σ^*. This new concept is needed because once we move beyond the two factor case, all other factor inputs as well as output must be held constant in measuring the substitution elasticity between any pair of factors.[22] It turns out that there are a variety of different ways of measuring σ^* depending upon the manner in which other factors are held constant and the use to which the measure is to be put.[23] The classical and perhaps most appropriate measure of σ^* for the kind of analysis of present concern is the direct partial σ, although some use has been made of Allen's formulation as well as McFadden's "shadow" elasticity.[24]

Perhaps more important is that, for any of the available measures, CES generalizations typically have imposed unacceptable restrictions on the relative σ^*'s between pairs of factor inputs. For instance, the generalized CES [equation (III.9a) above] implicitly assumes that all pairs of partial elasticities have the same constant value, i.e., $\sigma^*_{ij} = \frac{1}{1+P}$ for all $i \neq j$. Generalizations proposed by Uzawa and McFadden (among others) which partitioned the function into n classes of inputs necessitated the assumption that $\sigma^* = 1$ for any pair of factors from different classes while σ^* = constant for any pair within a class.[25] Mukerji's generalizations managed to eliminate this problem and allows the (Allen) σ^*'s be constant.[26]

The only CES generalization which appears to have overcome these difficulties is the formulation proposed by Sato.[27] Using the concept of the "functional separability of variables" Sata develops a multi-factor function which does not impose constant σ^*'s or constant ratios of σ^*. It involves partitioning the function of the variables into n subsets and correspondingly each subset into s bundles (Y) of inputs. Sato interprets each of the s bundles as an index of the elements of that bundle and proposes that the indices be constructed by means of a generalized CES function, viz.,

$$Y_s = [\sum_i \alpha_i^s (X_i^s)^{-\rho}]^{-\frac{1}{\rho}} \qquad \text{(III.12a)}$$

Then, each of the bundles are included as factors into the production function, again assumed to be CES in character:

$$Q = [\sum_s \beta_s (Y_s)^{-\rho}]^{-\frac{1}{\rho}} \qquad \text{(III.12b)}$$

Assuming, in other words, that the function is strongly separable and therefore additive, Sato's construct is composed of two levels or tiers, one of which is in the Y_s's and the other built up from the individual elements. It permits the estimation of a set of elasticity coefficients--

within bundles and between them--none of which is required to stand in fixed relationship to one another. When, however, all of the intra-class σ's are equal to all of the inter-class coefficients, the function reduces to (III.9a) above.

The number of tiers of the function can be expanded beyond two, as Sato demonstrates. The number and type chosen would depend upon the research objective; presumably, one of the decision criteria would be for the elements of a given input bundle to be highly substitutable for one another, i.e., the intra-class elasticities should be significantly higher than the inter-class coefficients. From the viewpoint of manpower analysis, however, this procedure produces some circularity in the sense that we wish to develop the function, in part, to discover which manpower and manpower/capital combinations are either highly complementary or substitutable. The multi-level function presupposes precisely such information prior to empirical estimation. It may, however, be possible to simulate alternative sets of input bundles, and choose the specification of the second (or higher) level of the function on the basis of these results.

It is also important to indicate that the "separability" assumption may be far too stringent to provide reasonable estimates. Briefly put, it requires one to assume that the allocation of elements within a given bundle (however specified) depends solely upon the relative economic conditions in that bundle. This is not only limiting, but may well tend to assume away all that is really important. Clearly, the economic and technical ties or interactions between and among factor inputs is what we wish to understand. It is not obvious that the two-level function permits us to obtain such an understanding.

Generalization aside, a more profitable avenue of research appears to have been opened up by attempts to estimate the parameters of the CES function directly. The technique stems, in large measure, from a note by Kementa who showed that the CES function (as opposed to its reduced form relationship in (III.11) above) could be estimated directly by using a Taylor series expansion around p=o.[28] A logarithmic function (that is linear in p) can then be derived which represents an approximation to the true (but unknown) function. When third and higher order terms of the Taylor expansion are ignored, the approximation amounts to adding a "correction" term due to the departure of p from zero, viz., the square of the logarithm of the factor use ratio divided by 2, to a Cobb-Douglas function which is homogenous of degree r. The approximation yields, in other words, a quadratic function in the logarithms of the variables

While Kementa clearly wished to use the log-quadratic form to approximate the CES function and thereby circumvent the need for estimating (III.9b) by nonlinear regression techniques, the specification has increasingly been used as if it were the production function itself.[29] The function used by Sargent as well as Berndt and Christensen's "trans log" production function are of this type. This may be written as:

$$q = a + \sum_i \alpha_i x_i + \frac{1}{2} \sum_i \sum_j \beta_{ij} x_i x_j \qquad \text{(III.13)}$$

where the lower case variables are the natural logarithms of the upper case variables as before. The use of (III.12) as an exact production function rather than as a CES approximation has the advantage of not requiring the input variables to be rescaled in empirical application. Furthermore, it has some attractive properties of its own: it does not require assumptions about the "separability" of the inputs, and it imposes no a priori restrictions on the σ*'s. Estimates of (Allen) σ*'s, however, involve calculating functions of the coefficients of (III.13) and the function itself has a large number of parameters with which to deal. This leads to a variety of statistical problems in using the function, but not necessarily to difficulties associated with economic content or interpretation.[30] Some of these problems will be reviewed below.

Two additional avenues of attack on the specification of the production function should be mentioned. One has been simply to form hybrid functions which include different kinds of terms of reasonable order. These forms also encounter difficulty in statistical use because they enhance the probability of multi-collinearity and use up valuable degrees of freedom, but less so than the problems associated with some other functions. One such hybrid that has been used in several studies is the "transcendental" function.[31] It may be written as:

$$Q = A(\prod_i X_i^{\alpha_i} e^{-\beta X_i}) \quad \exp(\sum_j \gamma X_j) + \theta(\sum_j X_j)^2 \qquad \text{(III.14)}$$

The function has the advantage of not imposing restrictions on either the elasticity of substitution or the scale coefficient; both can vary over the production surface. Furthermore, it does not require positive rates of inputs for any positive rate of output, and can easily be estimated by linear regression techniques after appropriate logarithmic transformation. It seems particularly well suited to substitution research directed at evaluating a particular class of inputs relative to all other inputs into the productive process. We shall review such a study later on.

A second avenue, and one which curiously brings the field full circle, is work developing on variable elasticity of substitution (VES) production functions.[32] Stemming principally from the dissatisfaction with the constancy of σ generated by other functional forms as well as the empirical finding that σ tends to vary with capital intensity, this work has been designed to develop functions in which σ is, quite literally, a variable. As before, there are several variants from which to choose; one that has received some attention is the VES formulation of Revankar.[33] His construct amounts to a generalization of the C-D function. In it, however, σ is allowed to vary in linear fashion with the capital-labor ratio i.e., $\sigma = \alpha + \beta \frac{K}{L}$. This procedure, unlike the CES function, permits σ to vary along given isoquants, although it is constant along any ray (drawn from the origin) intersecting increasingly higher isoquants along a path on the production surface. Unfortunately, there have been few empirical uses of the VES function. To a considerable extent, this is because of the data requirements of the method, e.g., it requires data on the price of capital.

Furthermore, the results of the available studies are somewhat at odds with one another. For these reasons it appears worthwhile to ignore the somewhat complicated mathematics of the function and turn our attention, instead, to the measurement techniques and data to which the other function discussed above have been fitted.

Empirical Application

While the foregoing has indicated the functional forms of the production function, it has said little about the measurement or specification of the variables incorporated in actual empirical applications. Of central concern in this context is the number (and type) of factor inputs typically accounted for in empirical studies--specifically whether or not disaggregated labor variables were included. By like token, if these variables are not disaggregated, then of concern is the methods used for aggregation and an evaluation of how well the aggregation technique works. Much of this, of course, turns on data sources and statistical technique. Since a detailed study-by-study account would be tedious and unrewarding, we summarize in this section the general drift of the literature over the past decade. Subsequent sections review some illustrative studies and findings.

To begin with, a disproportionate amount of the recent literature has grappled with the form and econometric specification of the production function as discussed above; other than brief, empirical illustrations of a proposed form, few intensive studies at the sectoral or industry level have been carried out. Professional interest, in other words, has been overwhelmingly methodological in nature, the consequence of which is that our knowledge of the technical conditions of production remains shallow and (by and large) theoretical. This is not meant to disparage methodological research--indeed, more needs to be done--but rather to suggest that the approach to the problem has been unbalanced and that less rigorous (albeit more insightful) empirical studies of the sort conducted more than a decade ago by Salter have not been surpassed.[34]

There has also been quite uneven coverage in the research that has been conducted in terms of the number or kinds of industries studied. Ignoring momentarily the aggregate (total economy) studies and research in the agricultural sector (which for the reasons discussed above is in a different class) a disportionate share of these studies have dealt with the manufacturing sector at either the one or two digit (SIC) level.[35] Our bibliographic search, in fact, uncovered only a handful of studies of the utilities or transport sectors and even fewer in the service sectors.[36] And of those in the service sector, several with seemingly relevant titles turned out to examine different questions via a cost/benefit framework.[37]

Much of this seems to be simply a function of data availability: the absence of reliable information on outputs and inputs, particularly at the level of the establishment or firm, is widespread and is nowhere being remedied. In large measure, researchers have been forced to rely

on aggregate data generated through various censuses, with a consequent loss in information coverage, and (ultimately) insight. For instance, one of the data sources that has been much used is the 1958 Census of Manufactures. It included information on capital for the first time in more than a half century--a fact that may explain the rash of manufacturing studies. But observations on individual plants or firm are not generated in the Census; rather, researchers have available only State totals which can then be analyzed in a cross-sectional framework. Frequently, the State totals have not been adjusted for the number of firms included in the observation, but analyzed under the convenient (albeit obscure) concept of a "state plant."[38] Simultaneous equation bias and other statistical problems aside, the results so obtained are hardly consistent with the micro-economic concept of the production function; consequently, it is extremely difficult to know how to interpret the results or how much confidence one can place in specific interpretations of such findings. Moreover it is unlikely that this problem can be remedied by more complicated statistical techniques. Indeed, only through the generation of better, firm level data can analyses of this sort be carried forward. It strikes us that this is an area in which both economic theorists and manpower planners may be able to work jointly.

Impressionistic evidence suggests, nevertheless, that because production function research is rooted in distribution theory, economists believe that they must work on highly capitalized sectors such as manufacturing to test meaningful hypotheses and reach generalizable conclusions. This is an unfortunate legacy of the development of economic thought, which ignores the considerable structural changes in both the economy and the labor force in the direction of the service sectors. The need to analyze the productive capacity of the service sectors has been recognized by some but not much progress along these lines has been made.[39] One reason is that there are still few adequate measures of output in the service industries, (a sine qua non for assessing input/output relationships) although the problem can be approached by use of activity measures of output as a way, at least, of extending the search.[40] In any event, the coverage of recent empirical studies has been limited in general and highly concentrated in manufacturing. The knowledge base for manpower planning is correspondingly limited.

Finally, and clearly of greatest concern is that by and large empirical applications have been highly aggregate with respect both to inputs and outputs. Aggregation, economists have learned, is not necessarily bad, provided certain rules are followed. For instance, the so called Nataf-Klein aggregation rule that macro-variables should be geometric averages of the micro-variables is met when functions are estimated in logarithmic-linear form.[41] But even though statistical criteria are met, the interpretation of aggregate variables (and hence the knowledge generated by such studies) creates considerable difficulty in a number of ways.

For one thing, the aggregation of outputs not only encounters familiar index number problems but when extended beyond the bounds of a

reasonably well defined industrial category, tends to violate the notion of output imbedded in the concept of the production function. Theoretically, the output side of the function is to be measured in physical terms, while empirically it is almost always measured in value terms. When functions for narrowly defined sectors, i.e., collections of firms producing equivalent if not homogeneous products, are estimated, the use of output valued in real dollars does not place undue strain on the concept. But when industries are more globally classified or the "aggregate" economy is under study, the use of value output is significantly different: not only is there a myriad of outputs produced (even at the two digit SIC level) but they grow at differential rates and improve qualitatively in differential fashion. The estimation of a single production surface for these processes is, at best, obscure and it is likely that no small amount of our difficulty in understanding input/output relations stems from our treatment or measurement of output.

For another, and clearly of higher order concern to manpower planners, empirical applications even at the sectoral level have typically aggregated inputs into a two factor model, labor and capital. The difficulties associated with such aggregation have not, of course, escaped attention; indeed, one of the liveliest and most serious debates in the economics profession over the past several decades stems precisely from these procedures. The issue centers particularly on the concept and appropriate measurement of the capital variable--a notion which remains as mystifying to Nobel Laureates as it does to students of basic economics.[42] In the past few years, the aggregation of labor inputs has also been subject to evaluation and debate. Since any number of articles are available on the capital controversy we concentrate for obvious reasons here on the measurement of the labor variable.[43]

The bulk of two-factor production function studies have utilized an aggregated index of man-hours of homogeneous labor as the labor input variable. Occasionally, e.g., in studies of the manufacturing sector, the index is developed only for "production" workers, and a few studies have used hours weighted by the structure of relative wages. With the possible exception of the latter, this means that the diversity of labor inputs has been ignored or, alternatively, been dealt with by assuming that different labor inputs are highly substitutable--if not perfect substitutes--for one another. Now should labor inputs be perfectly substitutable, then aggregation causes no difficulty; but should they be imperfectly substitutable (or complementary) then aggregation problems diminish the usefulness and relevance of two factor model research to manpower planners. This suggests the possibility that little, if any, of this body of research is useful for present purposes. Fortunately, however, some research has recently emerged which attempts to test the hypothesis that nothing is lost by aggregation of labor inputs, i.e., that labor aggregation functions lose little information because σ is high. Simultaneously, research has also been launched which attempts simply to use disaggregate measures of labor in the production function. Both lines of research provide useful information in their own right, while also helping us to interpret the value of the two-factor models. They are discussed, in turn, in the next section.

Some Empirical Evidence: Movements Along the Production Function

Recent research on labor aggregation stems primarily from experiments conducted by Bowles on a Sato-like two level CES function of the form:

$$Q = F[K, f(l_1 \ldots l_n) \qquad \text{(III.15)}$$

where K is capital and the l's are various categories of labor.[44] Pair-wise substitution elasticities were then computed (equation (III.8a) above) by assuming first-order profit maximization conditions and separability, i.e., the marginal products of any pair of l's is unaffected by all other labor inputs, capital input and/or technology. Furthermore, Bowles assumes that the pair-wise σ's are unaffected by product mix. Armed with these rather restrictive assumptions, Bowles then runs cross-sectional regressions of the relative wage rates (marginal products) for labor inputs categorized by (three) levels of schooling against the proportions of each labor category employed. In log-linear form, the resultant slope estimate β (more correctly, $-1/\beta$) is the elasticity of substitution. In an international cross section of 12 countries. Bowles finds fairly large slope estimates, and thus concludes "that for many purposes, there may be no significant empirical loss in accepting as a working assumption the propositions that the elasticities of substitution (between pairs of labor inputs) are infinite."[45] Estimates of σ are then incorporated into a function aggregated in a two-tier CES fashion and tested against other aggregation techniques. Again Bowles concludes that $\sigma = \infty$ is not an unreasonable working assumption.

Several other studies conducted along the lines of Bowles' work have come to approximately the same conclusion. Psacharapoulos and Hinchliffe, ran nearly identical regressions but included a fourth educational category and the capital-labor ratio.[46] The resulting estimates of σ are reasonably high, except that the inclusion of the capital in the estimating equation reveals considerable complementarity between highly skilled workers and capital.[47] Dougherty uses both cross-sectional and time series data for the United States to examine labor inputs categorized both by occupation and education.[48] His results also tend to support Bowles, although his results suggest that σ is generally lower than infinity. This implies that while substitution is considerable, it is not so great as to make wage-weighted labor aggregates appropriate; rather Dougherty argues that CES functions with estimated values of σ incorporated into the aggregation would be an improvement.

The findings of these "experiments" are difficult to accept for a variety of reasons. To begin with, the entire line of attack depends heavily on the assumption that wages reflect relative differences in the marginal productivity of factor inputs. There are numerous reasons to suppose that this assumption is unwarranted generally; when one considers factor market rigidities in the less developed nations (included in the international cross sectional data set) it is difficult to consider the results as saying anything quite meaningful about σ (conceived as a property of a production function). Furthermore, such cross-sectional

data tell us little about the underlying educational content or utilization of relative job functions in countries at different levels of development, such that in "efficiency" terms, there would not be as much room for substitution as the data suggest. Finally, the fact that substantial differences in product mix (either cross-sectionally or overtime) are not adequately accounted for obscures precisely the relationships in which we have interest. Bowles, for example, does attempt in a feeble way to adjust for the composition of output by adding the proportion of national product accounted for by the agricultural sector as a proxy variable in one of his estimating equations. It is perhaps significant that even this simple adjustment has the effect of reducing the estimated value of σ by more than 25 percent.

It should also be noted the conclusions of Bowles and his colleagues have been rejected by recent research using the trans-log or log quadratic production function (equation (III.13) above). More particularly, Berndt and Christensen have shown that labor aggregation functions can be statistically and economically meaningful if (and only if) pair-wise, partial σ*'s between diverse labor inputs and non-labor inputs are equal.[49] Bowles separability assumption is, of course, equivalent to this condition. But in empirical tests of the hypothesis, Berndt and Christensin find little evidence that the values of the σ*'s are equal (as between, for example, white collar workers and capital and between blue collar workers and capital). In fact, they find that the σ* between capital and high skilled workers is significantly lower than that of lesser skilled workers. They conclude that consistent aggregation of labor inputs is impossible, therefore, and imply that significant information is lost when such aggregation is used in empirical work.[50]

This finding, coupled to the comments above, suggest a dilemma in evaluating much of the production function literature, for clearly it implies that both economy-wide and sectoral studies using aggregate indices of labor inputs have likely failed to capture the real flow of labor services into the productive process. In turn, the results of these studies are open to question. An alternative approach, thus far perhaps not fully exploited, is to use disaggregate labor inputs as individual arguments in the production function. Recent research has approached such disaggregation in one of the following two ways. On the one hand, an aggregate, homogeneous labor input variable is conjointed with one or several other variables presumed to affect the efficiency of different labor inputs, e.g., educational level. This amounts to entering qualitative differences in the work force separately.[51]

On the other hand, the more straightforward procedure is to incorporate a vector of labor inputs differentiated by skill level (occupation or educational attainment). This has the advantage of allowing partial σ*'s between different labor inputs and between labor and non-labor inputs, to be computed.[52] It has, however, encountered various problems in empirical applications, primarily because of the difficulty in specifying the manner in which properties such as σ are to be incorporated (as discussed above) and because of statistical problems, especially

multi-collinearity amongst the labor variables. Powers, for example, used a three variable (labor inputs) model but encountered severe problems.[53] The statistical estimates were confused, with σ's close to zero and not statistically significantly different from zero but with algebraic signs in conflict with theoretical expectation.

Sargent's work with five labor categories (based upon educational qualifications) also ran into difficulty, particularly in fitting more complicated functions to data on the electrical engineering industry in England, viz., the log-quadratic and a variant of the generalized CES function (see equations (III.13) and (III.9a) above).[54] Econometrically, Sargent's work is a tour de force; consequently, the problems he faced may well indicate the state-of-the-art in this regard. Briefly put, many of Sargent's statistical results were too poor to report; of those which were, most produced non-significant (input) parameter estimates, the signs of which were not only different between successive regressions, but were never all positive. The calculated σ*'s between pairs of factors in these models are above unity, but the statistical estimates are such that it is difficult to place any confidence in these findings. Indeed, the results prompted Sargent to suggest that it is not profitable to attempt separate estimation of the marginal products of so many labor variables. More important, he concludes that:[55]

> Traditional method of estimating a Cobb-Douglas function using net output as dependent variable (sic) yields as good results as the attempt to fit a more complicated production function, and the estimation procedure is simple . . . (moreover) . . . it would possibly be better to abandon the attempt to estimate production functions from cross-section data, especially where the total number of 'observations' is small and the output of the industry heterogeneous, rather relying upon the direct study of the technology of the industry.

It should be noted, nevertheless, that not all studies using disaggregated labor variables have drawn Sargent's conclusion. Reinhardt's research on physician production functions has produced somewhat more reasonable results on the relative utilization of physician and physican aides or assistants in the delivery of primary medical care.[56] Reinhardt appears to have had a somewhat better data set than Sargent, and he used a different functional form, viz., the "transcendental function" in equation (III.14) above. Ordinary least square regressions produced input coefficients with the proper sign and many were statistically significant at conventional confidences levels. Yet, the coefficients of of determination were typically on the order of only 0.5. Moreover, the "transcendental" exponent dropped out of several runs (obviously due to multicollinearity). This modified the estimating equation to a different type of hybrid, the economic properties of which are somewhat difficult to interpret. The opportunities, then for obtaining usable information on the technical linkages between output and disaggregated labor inputs remains quite limited.

Given the discussion thus far, it is possible to summarize the general results of much of the recent research in the area rather quickly. Studies focusing primarily on the magnitude of σ -- the largest proportion of which use the CES short-cut method--find coefficients for the two-factor case hovering near unity or slightly lower. These results tend to be highly sensitive to sources of data and estimation technique. For instance, there are significant differences between cross-sectional and time series results, the former typically being close to unity and the latter somewhat less than half the magnitude, i.e., in the neighborhood of 0.5 or 0.6. Evaluations of some of the earlier literature suggest support both ways.

Lucas, for example, argued that factors such as price of output and unaccounted for differences in the quality of labor act in a way to bias the cross-sectional results towards unity.[57] Griliches, among others, however, has argued that short-run cyclical changes in the economy and insufficient allowance for adjustment lags probably bias the time series estimates downward.[58] These counter arguments are difficult to evaluate because it appears that both kinds of estimates are highly sensitive to and unstable over the time periods chosen for analysis.[59] Moreover, small sample sizes both cross-sectionally and over time confuse the picture: the amount of variability amongst observations has frequently proved insufficient to obtain an accurate reading of the relevant relationships.

The issue, then, is far from resolved, even in the aggregate two-factor case. The weight of opinion appears to be that neither the linear nor Cobb-Douglas assumptions about σ can be used without considerable caution, and that in the aggregate the true value probably lies somewhere between these two values.[60] If this opinion is correct, it implies that the flexibility of capital and labor in the productive process may not be as great as a literal reading of economic textbooks suggests. Consequently, a substantial proportion of changes in factor requirements and average productivity must be explained by conditions other than movements along a given production surface, i.e., simple changes in technique. Recall that ever smaller values of σ in effect extend the distance between observed and explained changes in factor productivity relative to changes in factor proportion. To the extent that any confidence can be placed in the empirical research in this area, the conclusion seems to be that the "distance" is greater than what might have been anticipated a priori.

It is difficult to reach even this level of generalization with respect to the multi-factor case, especially in terms of the relative substitutability or complementarity between pairs of diverse labor inputs. In this case, the empirical results thus far obtained have been both inconclusive and even somewhat mis-leading. As discussed above, work on both labor aggregation functions and production studies with disaggregated labor have concluded variously that the σ^* between, say, lesser and more skilled workers, is extremely high or extremely low. Table III.1 summarizes these studies and a few more. The findings are mis-leading because quite different definitions of the (partial) σ^*'s, categories of labor inputs, and algebraic forms of the production function have been

TABLE III.1

Elasticity of Substitution Between Diverse Labor Inputs: Selected Estimates

Study (Functional Specification)	Method of Estimation	Observational Units	Labor Categories	Estimated Value of σ[a]
1) Bowles[b] (Two Level CES)	Standard σ via log-linear regression by Taut Equation (8a)	12 country international cross-section; total economy	Educational Attainment: 1 = workers with 0-7 years school 2 = workers with 8-11 years of school 3 = workers with 12+ years of school	$\sigma_{12} = 12.8$ $\sigma_{13} = 6.4$ $\sigma_{23} = 202.0$ $\sigma_{1(23)} = 8.0$
2) Pascharopulos[c] & Hinchliffe (Two Level CES)	Standard σ via log-linear regression by Taut Equation (8a)	18 country cross-section, divided by Development Status; Total Economy	Educational Attainment 1-3 = same as (1) 4 = no schooling	$\sigma_{12} = 4.8$ $\sigma_{14} = 50.8$ $\sigma_{23} = 2.2$ Less Developed country and Inclusion of capital industry $\sigma_{23} = 2.5$
3) Powers[d] (Multi-level CES)	Standard σ via log-linear regression by Taut Equation (8a)	69 SMSA cross-section U.S., 1960, construction and 12 2-digit manufacturing sub-sectors	Functional Categories 1 = unskilled 2 = semi-skilled workers 3 = skilled workers	Construction: $\sigma_{12} = .39$ $\sigma_{23} = -.51$ Manufacturing: $-.45 \leq \sigma_{12} \leq 1.8$ $-1.48 \leq \sigma_{23} \leq 1.09$
4) Welch[e] (CES)	Standard σ via log-linear regression by Taut Equation (8a)	49 state cross-section; U.S. Agriculture	Educational Attainment 1 = college graduate 2 = high school graduate 3 = less than 12 years of schooling 4 = all others	$\sigma_{13} = 2.8$ $\sigma_{14} = 1.4$
5) Dougherty[f] (Multi-level CES)	Marginal productivity side relationship of Taut Equation (9a); equivalent to Allen Partial σ	28 state cross-section, U.S. 1960; total economy	Occupational Category 1 = professional & technical 2 = administrator 3 = clerical 4 = sales 5 = craftsmen 6 = operatives 7 = service workers 8 = laborers	$\sigma_{47} = 95.1$ $\sigma_{14} = 51.9$ $\sigma_{44} = 42.4$ $7.1 \leq \sigma_{45}, \sigma_{48}, \sigma_{57}, \sigma_{56}, \sigma_{25}, \sigma_{16}, \sigma_{13}, \sigma_{12} \leq 12.3$ $\sigma_{45} = -2.5$ $\sigma_{23} = -15.2$ All Other Values: $2.5 \leq \sigma_{ij} \leq 5.5$
6) Boskin[g] (CES)	CES reduced form variant for i^{th} occupation, i.e., residual not partial σ	38 SMSA cross-section for U.S., circa 1960; 9 2 digit SIC manufacturing sector	same as 5, all divided by sec. 1 = all other factors	$\sigma_{1j} = -.65$ $1.16 \leq \sigma_{3j}, \sigma_{2j}, \sigma_{4j}, \sigma_{5j} \leq 1.79$ $\sigma_{5j} = 0.63$ $\sigma_{4j} = 0.68$
7) Berndt[h] & Christensen (log quadratic Taut Equation (13))	Allen Partial σ computed from estimated coefficients of function	Time Series 1929-1968; U.S. manufacturing	Functional Categories 1 = production workers 2 = non-production workers 3 = capital	Mean Values 1950-68 $\sigma_{12} = 7.9$ $\sigma_{13} = 3.7$ $\sigma_{23} = 3.77$
8) Sargent[i] (log quadratic Taut Equation (13))	Direct Partial σ computed from estimated coefficient; See Text Footnote (14).	68 Firm cross-section; British Electrical Engineering Industry	Educational Attainment Classified by type of degree taken: 1 = highest degree . . . 6 = lowest degree 5 = all others	$\sigma_{12} = -.38$ $\sigma_{13} = -.62$ $\sigma_{16} = -.28$ $\sigma_{15} = -.35$ $\sigma_{23} = 3.15$ $\sigma_{26} = -.04$ $\sigma_{25} = -3.83$ $\sigma_{34} = -.24$ $\sigma_{35} = -.18$ $\sigma_{45} = -1.3$
9) Reinhart & Yett[j] (Transcendental, Taut Equation 14)	Allen σ computed from estimated parameters of function	Approximately 800 general practitioners cross-section, U.S. 1965-67, primary medical care sector	1 = physician hours 2 = all others	$0.3 \leq \sigma_{12} \leq 2.5$ over range of typical input use rates

TABLE III.1

Notes

a. "Statistically significant" coefficients have not been identified because of differences in test statistics and the form of the underlying hypothesis. Interested readers are referred to the original publication.

b. Samuel Bowles, "Aggregation of Labor Inputs in the Economics of Growth and Planning: Experiments with a Two-Level CES Function," Journal of Political Economy, LXXVIII (January-February, 1970), 68-81.

c. George Psacharopoulos and Keith Hinchliffe, "Further Evidence on the Elasticity of Substitution Among Different Types of Educated Labor," Journal of Political Economy, LXXX (July, 1972), 786-792.

d. T. Powers, "Elasticities of Substitution Between Different Types of Labor: Theoretical Analysis and Empirical Examples," (unpublished Ph.D. Thesis, Princeton, 1972).

e. F. Welch, "Education in Production," Journal of Political Economy, LXXVIII (January-February, 1970), 35-59.

f. C. R. S. Dougherty, "Estimates of Labor Aggregation Functions," Journal of Political Economy, LXXX (November-December 1972), 1101-1119.

g. Bernard Daniel Rostker, "Manpower Theory and Policy and the Residual Occupational Elasticity of Substitution," (Ph.D. Thesis, Syracuse University).

h. Ernst R. Berndt and Laurits R. Christensen, "The Translog Function and the Substitution of Equipment, Structures, and Labor in U.S. Manufacturing 1929-68," Journal of Econometrics, I (March 1973), 81-114.

i. J. Sargent, "Production Functions," in Qualified Manpower and Economic Performance, ed. by P. Layard, et al. (England: The Penguin Press, 1971), pp. 145-206.

j. U. Reinhart and D. Yett, "Physician Production Functions Under Varying Practice Arrangements," (U.S. PHS., Community Profile Data Center, Technical Paper No. 11), Mimeographed.

used in this range of studies. In none of the studies reviewed can the conclusions, in other words, be compared, much less confirmed. Indeed, the scantiness of the evidence is such that it would be foolhardy to suggest anything more than that the question deserves further examination. Additional empirical work, however, should use comparable forms of the production function and employ establishment level data. Only in this way can we shed the needed light on the substitution parameter of the function. It bears repeating, however, that σ relates only to movements along a given isoquant under conditions of static technology. Given the objectives of manpower planning, it is not clear that any magnitude of σ will be as critical to changes in factor requirements as will changes in the technological environment, i.e., shifts in the function itself. We examine the empirical evidence on this score next.

Some Empirical Evidence: Shifts in the Production Function

Any discussion or presentation of results on changes in the technology parameter of the production function is difficult for the reason that relevant research is highly compartmentalized along various facets of the problem and, as before, overwhelmingly methodological in nature. Some progress, however, is discernable along three important fronts: the importance of technological change in the process of economic growth, the correlates of technological change, and the impact of such change on the utilization of factor inputs. Each of these is examined in turn.

First, some effort has gone into a re-examination of the early findings which attributed almost the whole of changes in output to technological change. The problem is that many of the early studies imposed rather stringent conditions on the production function in an attempt to highlight the rate of technological change. One of the most important was that constant returns to scale prevail, either throughout the economy or in the industry under study.[61] Together with assumptions about the correct specifications and measurement of the model, this has the effect of forcing all shifts in the function into the intercept term, A.[62] Technological change so measured will undoubtedly be of considerable magnitude, including as it does a variety of residual effects such as scale changes, learning by doing, and the like as well as measurement errors. It is little wonder, then, that the early and now celebrated studies of technical change, especially those by Solow, found no more than 10 percent of the growth in output explained by the growth in labor and capital.[63]

For instance, if one assumes that a Cobb-Douglas correctly specifies the production relation, that all variables are included and correctly measured, and that constant returns to scale prevail, then the expectation for short periods of time is that the rate of change in A will be small, if not close to zero. That is:

$$\frac{dA}{A} = \frac{dQ}{q} - \left[\alpha_\ell \frac{dL}{L} + \alpha_k \frac{dK}{K} \right] \cong 0 \qquad \text{(III.16)}$$

The early studies, however, found exactly the opposite, i.e., dA/A=50-90 percent of dQ/Q; consequently, an overwhelming proportion of the recent research has been directed at the problems of specification and measurement of inputs as discussed in earlier sections of the Chapter. But, in turn, this work has tended to modify the framework, such that the production function is no longer estimated per se, but rather used as an organizing device for the research. Growth "accounting," as it has become known, has shed some important light on the process and determinants of economic change, but not in a fashion that makes the results easily comparable to other production function studies.[64] Furthermore, the "accounting" studies have typically been carried out for the entire economy, so few industry results are currently available for scrutiny.

These limitations aside, the general conclusion that seems to have emerged in the past few years is that the "unexplained" residual of the growth in output is nowhere near the magnitude originally thought and that, in fact, appropriate measurement of the inputs probably reduces the residual to no more than 5-20 percent of the observed growth in output, if even that much. These results stem principally from the aggregate analysis of Griliches and Jorgensen.[65] They showed that over the period 1945-65, the residual might be as little as 3 percent of the growth in output if the data are corrected for measurement error, but is almost 50 percent if these corrections are not made. Griliches has also shown that conventional measurement techniques would place the residual or growth in output due to technical change at roughly 60 percent in U.S. manufacturing over the period 1947-60, but that corrections to the measurement of capital, quality adjustments to labor and adjustments for economics of scale reduces the residual to about 18 percent.[66] Denison, among others, has disputed these findings, but this has not detracted from the widespread suspicion that too much importance had previously been attached to technological change as an independent explanation of economic growth.[67]

This shift in perspective runs the risk, however, of ignoring the potentially important effects of advances in knowledge on the economy. Furthermore, in its extreme form, it would appear to rule out the possibility that the production surface itself might shift, relying rather on the view that technical knowledge and innovations are simply adopted in incremental fashion at ever higher levels "on" the same production function. To the extent that the traditional theory of production has ignored the possibility of continuous, incremental adjustments and has stressed the major, discrete changeovers, the new view of technological change may be more appropriate than it appears at first blush.[68] A suitable theoretic framework needs to be developed, however, to place these factors in perspective.

Secondly, a relatively intensive research effort has gone into the question of the mechanisms which induce shifts in the production function. For many years, it was commonplace to assume that technological change was autonomous or exogenous to the economic system--being fundamentally a product supplied by creative individuals.[69] More recently, this view

has changed, due in large measure to research on patents by Smookler.[70] Most economists now accept the proposition that technical change is endogenous to the economic system i.e., it is induced by economic conditions, although some have argued that the newer and older view constitute a kind of demand and supply theory of invention, the outcome of which is influenced by the interaction of both forces. Be that as it may, a disproportionate amount of the research in this area has been concerned, in general, with the implications of inventive and innovative activity as an "economic" activity and, in particular, with the extension of the theory of the firm to include such activity.[71] What is important in the present context, however, is the empirical investigation of the determinants of innovative activity as well as the rates of diffusion of major process innovations in time in a fashion which permits their incorporation into the production function framework. There appears, however, to be a paucity of this type of empirical study.

A notable exception is the series of econometric studies conducted over the past decade by Mansfield. The range of these studies is sufficiently great to preclude anything more than brief comment. Fortunately, several summaries of this work are available, including Mansfield's own.[72] Hence, we need briefly point to some of the highlights. Mansfield finds, for example, that technological change and the level of R&D expenditures are highly correlated. Moreover, the level of R&D expenditures is reasonably well explained by expected rates of return on R&D activity, although there is no necessary relationship between these expenditures and the size of the firm. For short-term forecasting purposes, he also finds that the firm's desired research and development expenditures, as a percent of sales, are a quadratic function of time. The estimated returns from R&D however, depend heavily on the presumed slope of the production function, whether one assumes technological change is embodied or not, and whether or not industry "spillovers" are considered. Nonetheless, the rate of technological change is directly related to the rate of growth of its accumulated research and development expenditures, suggesting the possibility of incorporating this variable in the production function itself.[73]

Mansfield's studies indicate that large firms do not necessarily introduce a disproportionally large share of innovations, although the results here are mixed and vary considerably among industries. In those industries, e.g., where size does make a difference, e.g., petroleum refining, bituminous coal, it does because:[74]

> (1) the investment required to innovate was large relative to the size of the potential users, (2) the minimum size of firm required to use the innovations profitably was relatively large, and (3) the average size of the largest firms was much greater than the average size of all potential users of the innovation.

Perhaps most important, Mansfield finds a significant lag period between invention and innovation, i.e., there is a lengthly diffusion period, averaging for the industries he studied, somewhere between 10-15

years. The lag is shorter for consumer products than for industrial products and, interestingly, shorter for innovations developed with government funds as opposed to private funds. Mansfield confirms the well known finding that the rate of diffusion or spread of adoption at the industry level is approximated by the logistics ("S shaped") curve.[75] He also finds evidence that the rate of imitation is positively related to the proportion of firms already using the innovation and to the profitability of using it, and negatively related to the magnitude of investment requirements. Large firms, therefore, tend to adapt more rapidly than small ones.

Thirdly, some research has been conducted on whether or not there appears to be systematic effects of technical change. Unfortunately, not as much progress as might be desired has been made in this regard. One reason is that it is extremely difficult empirically to disentangle technological "bias" from factor substitution per se. Moreover, if technical change is "embodied" in capital and labor, the bias will depend upon the magnitude of the elasticity of substitution. The discussion of the findings with respect to σ in the previous sector suggests the difficulties involved. Another problem is that so many definitions of models of technical bias abound that it becomes difficult to interpret the few empirical works that have been done in any consistent fashion.

One exception perhaps is an early study conducted by Lau and Hildebrand in the manufacturing sector.[76] The manner in which the study was formulated was appropriate to analyzing the effects of technological change on the employment of labor, viz., a simultaneous equation model in which demand functions for production and non-production workers are incorporated. The production function forming the bases of the model was a Cobb-Douglas function, but with technical change embodied in the function's exponential terms. Formally, the function was specified as:

$$Q = AL^{\alpha} e^{\log M} K^{\log R} \qquad \text{(III.17)}$$

where M is the ratio of technical personnel to production workers and R is the ratio of net value to gross value of capital assets--both proxy variables for embodied technological change. As it turned out, data limitations precluded the use of R in this fashion. Nonetheless, Lau and Hildebrand did find that scale effects and shifts in the function stemming from improvements to the capital stock were not only extremely important, but also had the effect of reducing the demand for production workers.

Another notable exception is Beuchner's dissertation research which attempted to analyze the impact of technological change on the occupational composition of the labor force in the U.S. economy.[77] More particularly, Buechner's objectives were to analyze both the effects of changes in technology on the occupational structure of the demand for labor over time and the responsiveness of changes in technology to changes in the relative wages of occupational groups. These questions were investigated with the aid of the national input/output model categorized by 65 industries

and over 200 occupations--a methodological choice not typically available to those interested only in the substitution parameters of the (continuous) production relationship--and a set of conventional simplifying assumptions, viz., constant returns to scale, identical production functions for individual firms, and autonomous technological change.

Somewhat unfortunately, Buechner adopts a definition of technological change that is tantamount to measuring it as all supply-related effects on the occupational composition of employment. To the extent that he was interested in the relative importance of changes in the product mix and technology as forces effecting the distribution of occupations, this procedure yields interesting results. It is also true that he is able to separate the cumulative supply-related effects of changes in labor productivity, input/output effects (materials) and skill coefficients. The procedure, however, makes it difficult to interpret the results in a fashion altogether consistent with other research studies in the production field. Nevertheless, he is able to show that the impact of changes in the product mix are considerable, and of the supply effects, productivity changes appear to be signficantly more important than any other of the supply effects.[78]

Of interest is Buechner's test as to whether technological change is functionally related to changes in relative wages (substitution of techniques in the input/output framework) or simply the introduction of new technological forms per se.[79] The test consists of a comparison of factor combinations representing different technologies between two points in time (1950 and 1960) weighted by the wage ratios prevailing at the beginning and end of the period. Allow W to represent a (row) vector of relative wages, F to be a (column) vector of labor inputs per unit of output by occupation, and subscripts to represent the points in time, Beuchner reasons that substitution induced by wage change would yield $W_{50} F_{60} > W_{50} F_{50}$ and $W_{60} F_{60} < W_{60} F_{50}$, while change dominated by technological improvements irrespective of wage changes would be indicated by $W_{50} F_{60} < W_{50} F_{50}$ and $W_{60} F_{60} < W_{60} F_{50}$. This test indicates that technological change most often took the form of new techniques which dominated the old technology, implying that relative wages did not influence, in any substantial way, the technology decision.

In view of this, Buechner also tests whether the impact of technological shifts was neutral or "biased" with respect to the occupational distribution. The test was predicated on the theoretical expectation that an inverse correlation between factor prices ratios and factor proportions would exist if technological change is neutral and would not if it were biased. He finds that technical change is biased with respect to occupations and that it is likely that such change determines wage changes rather than vice versa. Methodological problems abound here, however, and it is difficult to reach confident conclusions. For example, wage expectations as opposed to actual factor supply conditions may (as Buechner recognizes) induce changes in technique. Furthermore, it remains unclear, (even theoretically) whether factor costs per se, cost minimization, or even non-economic forces induce biased technical designs. The

only available evidence in this regard is the case study conducted by Piore which suggests that the search for new techniques is rarely influenced by labor scarcities or costs, although the process (which is highly institutionalized) seems to be consistent with the assumptions of cost minimization.[80]

In this connection, a few studies bearing on the question of "biasedness" in technological change but not carried out in the production function framework should be noted. We refer principally to the studies conducted by Crossman and his associates as well as earlier studies by Bright and Horowitz which (in some ways) motivated their work.[81] This research uses mean skill "profiles," i.e., scores derived from job evaluation schemes, and direct analysis of various techniques to assess whether technological change in the form of more automated processes, e.g., computerization, continuous processing, numerical control methods, etc., tends to raise or lower skill requirements. Briefly stated, they find that technological change so defined does not cause "major changes" in skill demand, although the results vary considerably between direct and indirect labor categories among industrial processes. There was in some cases an upwards drift in a number of the mean skill levels, but this movement tended to flatten out a fairly high level of mechanization. That is, the changes in many cases could be represented by a "S" shaped curve. It is possible to interpret this as evidence of some degree of "biasedness" in technological change, but extreme caution must be exercised to do so. The reason is the methodological differences in measurement, the limited number of processes and industries studied and the absence of the effects of the capital variable per se. The conclusion in nonetheless provocative, and further study in this direction appears to be warranted.

The Knowledge Base: An Evaluative Statement

What may we conclude from this very rapid review of the literature? We have seen that recent empirical research in the field of production economics is, by and large, disjointed in scope, uneven in coverage, and applied generally at a level of aggregation insufficient for the immediate purposes of manpower planning and analysis. Moreover, the considerable number of methodological and statistical problems associated with the specification and estimation of production functions have yet to be satisfactorily resolved. The knowledge base, in other words, is far from ideal, and a number of significant gaps need to be closed before this research can be utilized directly and profitably by manpower planners. We do not mean to imply, however, that there is little or nothing in this body of research of value to manpower planners; indeed, the contrary is true. The trick is to draw upon relative strengths while simultaneously attempting to remedy weaknesses. This has implications for manpower planning practice, methodology, and research.

To begin with, we believe that there is considerable heuristic value in viewing the output/manpower transform as an identification of the underlying production function, and correspondingly that the knowledge

base is sufficiently well grounded to permit such a view. The reasons are that it focuses attention on the interactions among factor sets in the provision of some good or service and it holds out the possibility of separating a number of quite different forces effecting the potential use of any factor set. Consider in this respect current forecasting procedure. A sizable proportion of forecasting activity, as we shall see in a later chapter, is accounted for by studies of single occupations or a relatively homogenous set of occupational categories without adequate recognition of the technical linkages between the occupation(s) and other labor and non-labor inputs. In addition to providing a rather flimsy base for decision-making, these partial studies also run the risk of ignoring a range of important policy options because of their limited scope. Even in those cases where the occupational distribution of employment is projected for a number of well defined industry groups, however, the absence of a suitable framework weakens the policy value of the estimates. As suggested earlier, the procedure here is to use the productivity coefficient and target outputs to estimate sectoral employment and then to use either the productivity rate as an indicator of the likely occupational structure of that employment or simple ratios between sectoral employment and specific occupational groups to disaggregate the employment estimate. In neither case is any substantial and consistent effort made to understand the forces at work in shaping the direction and magnitude of change in the productivity coefficient. Much depends simply on the development of "reasonable" rates or change factors from both a statistical and intuitive point of view.

In fairness, it must be emphasized that data resources have so frequently been inadequate (or non-existent) that the better part of the time available to the forecaster has been absorbed in estimating the base productivity figure or employment ratio, leaving little time for the analysis of the data. But the practical exigencies of forecasting activity should not rationalize the nature of the work, nor should it lead to misplaced emphasis with respect to the priorities for developing knowledge useful to the forecaster. For instance, some parts of the forecasting literature lay great stress on the statistical manipulation of time series data on productivity or employment ratios, while others are content to assume that most increases in productivity stem from technological change characterized by innovative uses of new technical and scientific knowledge.[82] Needless to say, neither position is necessarily wrong, but they do tend to emphasize solutions that are unlikely to improve the state of the art to any substantial degree. Improvements might be forthcoming, however, if forecasters used an analytic framework which forced them to raise the difficult questions about the implications of their projections and to deal, in explicit fashion, with the assumptions necessary to make the estimates in the first place.

The production function framework is useful because it forces the transform procedure to be carried out in "technical space." That is, the theoretical construct focuses attention on the technical relationships between inputs and output as well as among diverse inputs themselves, and permits the transformation to represent a feasible point or set of

points on the production surface toward which supply policies should be directed. Unfortunately, the existing knowledge base can not be employed to operationalize this notion fully for at least two reasons: On the one hand, the character and detail of the data used in most empirical, production function studies preclude confident statements that the technical conditions of production have, in fact, been identified. On the other, even given the sources of data, the empirical evidence thus far gathered is far from convincing on the "correct" values of the important parameters of the production function.

The first of these difficulties may be overcome by more intensive efforts to generate dis-aggregate data on inputs and output, especially at the level of the establishment or firm. This is clearly not an easy matter, nor is it an inexpensive one. But it appears that the point of diminishing returns has been reached in the use of aggregate information and, correspondingly, that the time is ripe for efforts to refine the data rather than the statistical techniques used to handle them. Some component part of this effort should be devoted to the generation of "engineering" production functions. As indicated earlier, this line of research has largely been abandoned over the past decade, but developments over that period suggest the need to revive it. In addition to the fact that such estimates correspond more closely to the theoretical notion of the production function, they also lend themselves more easily to optimization models, e.g., linear programming constructs, and thereby extend the range of planning analysis.[83]

The ambiguity of the empirical findings on the properties of the production function argues for a reasonable amount of caution in evaluating manpower planning practice and methodology. This point is somewhat more important than it appears at first blush. The reason is that manpower planning in general and the typical planning transform procedure in particular have come under heavy attack by economists in recent years, most of whom are able to prove, with the use of a few simple economic postulates, that forecasting activity is inappropriate, invalid or both. An oft repeated criticism, for instance, is that manpower planning activities assume zero or near zero elasticities of demand for labor or zero elasticities of substitution.[84] Strictly speaking, these points are equivalent only under very special circumstances, but we may take them to mean that manpower forecasts frequently use the linear transform discussed at the outset of this Chapter. To be sure, if the productivity coefficients are fixed, the substitution elasticity between pairs of inputs will be zero. But this will not necessarily invalidate the forecast.[85] In fact, such a conclusion could emerge only after a detailed examination of the scope and consistency of a particular forecasting study as well as the sensitivity of the results or policy conclusion to alternative specifications of the underlying production function.

A similar point can be made with respect to forecasts which allow the productivity coefficient to vary over time, although the case is slightly more complicated. The reason is that it is not possible to

specify, a priori, the elasticity of substitution; of necessity, one must examine the projected growth paths of all factor inputs and (assuming that the industry is "on" the same production function) then deduce the implied elasticity of substitution. The point is most easily illustrated in reference to the kinds of forecasting studies which prompted the criticisms in the first place, viz., planning studies which derived manpower requirements from economic development plans.[86] In these studies, manpower projections were made only after both output and capital targets had been specified. As such, the forecast was equivalent (in the individual industry, two factor case) to estimating a line perpendicular to the labor axis connecting an output/capital coordinate in three dimensional space. It is not evident a priori what magnitude the elasticity of substitution would be at this point, since it can take any set of values along an isoquant. It could, of course, be zero, but not by definition; only by sheer coincidence would the weighted total of individual industry elasticities be zero. The implied coefficient, nonetheless, should be plausible. The literature on two factor models suggests, at least, a range of general values from which such a judgment might be made.

The research base offers significantly less counsel, however, in the multi-factor case. The critics have correctly pointed out that many forecasts have treated the skill distribution of employment as if the elasticity of substitution between pairs of occupations was zero. This stems, however, from the fact that a relationship between the level of productivity and occupational structure has been discerned in cross-section studies, and the relationship has frequently been used as a convenient way of disaggregating sectoral employment targets. Under ideal circumstances it would be preferable to carry out this disaggregate transform in reference to a multi-factor function which could identify both substitution and shift parameters. But as the considerable discussion in earlier sectors has shown, it has thus far proved to be extremely difficult to specify and estimate such functions. Moreover, the empirical research which might point to a plausible range of values or assumptions has serious methodological weaknesses; consequently, it cannot be used with any degree of confidence. Planning practice and methodology cannot be improved, in other words, until the knowledge base itself is improved. Until that time, many of the older techniques, buttressed perhaps by better data, will have to be employed. This fact must be borne in mind in evaluating forecasting activity.

NOTES TO CHAPTER III

[1]See, for example, H. Correa and J. Tinbergen, "Qualitative Adaptation of Education to Accelerated Growth," Kyklos, XV, No. 4 (1962), 776-86; J. Tinbergen, et al., Econometric Models of Education, (Paris: Organisation for Economic Cooperation and Development, 1965); T. Thonstand, Education and Manpower: Theoretical Models and Empirical Applications, (Canada: University of Toronto Press, 1968). For a review of the literature, see J. McNamara, "Mathematical Programming Models in Educational Planning," Review of Educational Research, XLI, No. 5 (1971), 419-46; or A. Hammond, "Mathematical Models in Education and Training," (Rand Report RM-6357-PR, September, 1970). For extensions of the approach, see S. Bowles, "The Efficient Allocation of Resources in Education," Quarterly Journal of Economics, LXXXI, No. 2 (1967), 189-219; I. Adelman, A Linear Programming Model of Educational Planning, in The Theory and Design of Economic Development, ed. by I. Adelman and E. Thorbecke, (Baltimore: Johns Hopkins Press, 1964).

[2]op.cit.

[3]Once this step has been completed, it will be necessary to work iteratively "back" to the output figures until a consistent set of targets is achieved. The complications stemming from the use of iterative techniques to approximate a "simultaneous" determination of inputs and outputs is ignored in this Chapter. We concentrate, instead, on the empirical analysis essential to getting the process started.

[4]At least two simplifying assumptions have been built into this formulation and hence, into the entire discussion which follows. One is that input utilization rates, particularly labor utilization, reflect changes in the average work week. The other is that an appropriate scheme for classifying factor inputs exists. The question of classification systems and data sources for them is examined in detail in Chapter IV.

[5]For a variety of different interpretations of the concept of neutrality, see M.J. Beckman and R. Sato, "Aggregate Production Functions and Types of Technical Progress: A Statistical Analysis," American Economic Review, LIX, No. 1 (1969), 88-101.

[6]We ignore here less identifiable forces which may push economic units closer to the efficiency frontier. Cf. T. Shen, "Technology Diffusion, Substitution, and X-Efficiency," Econometrica, IV, No. 2 (1973), 263-84.

[7]See, E.O. Heady and J.L. Dillon, Agricultural Production Functions (Ames: Iowa State University Press, 1962).

[8]See, in particular, the early work by H. Chenery, "Process and Production Functions from Engineering Data," in Studies in the Structure of the American Economy, ed. by W. Leontief, et al., (New York: Oxford University Press, 1953), pp. 297-325; and one more recent work of M. Kurz and A. Manne, "Engineering Estimates of Captial-Labor Substitution in

Metal Machining," American Economic Review, LIII, No. 4 (1963), 662-81. For some of the analytic extensions stemming from the use of such data, see A. Manne and H. Markowitz, eds., Studies in Process Analysis (New York: John Wiley & Sons, 1963).

[9]J. Marshak and W.H. Andrews Jr., "Random Simultaneous Equations and the Theory of Production," Econometrica, XII, No. 3-4 (1944), 143-205; but also see H.S. Konijn, "Estimation of an Average Production Function From Surveys," Economic Record, XXXV, No. 70 (1959), 118-25.

[10]A.A. Walters, "Production and Cost Functions: An Econometric Survey," Econometrica, XXXI, No. 1-2 (1963), 1-66, especially 18-22.

[11]A notable exception is the "simultaneous equation" model developed by L. Lau and G. Hildebrand. See their Manufacturing Production Functions in the United States, 1957 (New York: The New York State School of Industrial and Labor Relations, 1965). The problem of instrumental variables is illustrated in U. Reinhardt, "Production Function for Physician Services," Review of Economics and Statistics, LIV (February, 1972), 55-66.

[12]Marschak and Andrews, op.cit. It should also be noted here that regression estimates invariably fit the function to all data such that known cases of exceptionally "low" efficiency are allowed to affect the estimate. There are procedures, however, for restricting the algebraic signs of the estimates to obtain an "efficiency frontier." See D. Aigner and S. Chu, "On Estimating the Industry Production Function," American Economic Review, LVIII, No. 4 (1968).

[13] See P. Douglas, "Are There Laws of Production," American Economic Review, XXXVIII, No. 1 (1948), 1-41.

[14]If it is not, or as we shall see below if there are more than two factors, Eulors Theorem cannot be used and it must be written as:

$$\sigma_{ij} = \frac{f_i f_j (X_i f_i + X_j f_j)}{-(f_{ii} f_j^2 - 2 f_{ij} + f_{jj} f_i^2) X_i X_j}$$

[15]For further discussion and for a proof, see R.G. Allen, Mathematical Analysis for Economists (New York: St. Martin's Press, 1960), p. 343ff.

[16]K. Arrow, et al., "Capital-Labor Substitution and Economic Efficiency," Review of Economics and Statistics, CLIII, No. 3 (1961), 225-50.

[17]"Technological Change and The Distribution of Income," International Economic Review, IV, No. 3 (1963), 289-309. For another early attempt, see J. Minasian, "Elasticities of Substitution and Constant-Output Demand Curves for Labor," Journal of Political Economy, LXIX, No. 3 (1961), 261-70.

[18]For the mathematical derivations, see C. Ferguson, The Neo-Classical Theory of Production and Distribution, (Cambridge: The University Press, 1969), Chapter 5.

[19]See Arrow, et al., loc.cit., for the derivation.

[20]See, for instance, P. Zarembka, "On the Empirical Relevance of the CES Function," Review of Economics and Statistics, LII, No.1 (1970), 47-53. P. Dhrymes and P. Zarembka,"Elasticities of Substitution for Two-Digit Manufacturing Industries: A Correction," Review of Economics and Statistics, LII, No. 1 (1970), 115-17; R. Solow, "Capital, Labor, and Income in Manufacturing," in The Behavior of Income Shares, Studies in Income and Wealth, XXVII, (Princeton: Princeton University Press, 1964), 101-28; F. Bell, "The Role of Capital-Labor Substitution in the Adjustment of An Industry Across Regions," Southern Economic Journal, XXXI, No. 2 (1964), 123-31; and J. Moroney, The Structure of Production on American Manufacturing (Chapel Hill: University of North Carolina Press, 1972). Reviews of these studies can be found in D. Jorgenson, "Investment Behavior and the Production Function," Bell Journal of Economics and Management Science, III (Spring, 1972), 220-51; and M. Nerlove, "Recent Empirical Studies of the CES and Related Production Functions," in The Theory and Empirical Analysis of Production, ed. by M. Brown, (New York: Columbia University Press, 1967), pp. 55-121, and the literature cited therein.

[21]Moroney, loc.cit.; J. Moroney, "Identification and Specification Analysis of Alternative Equations for Estimating the Elasticity of Substitution," Southern Economic Journal, XXXVI (January, 1970), 287-99; and J. Moroney and C. Ferguson, "Efficient Estimation of Neo-Classical Parameters of Substitution and Biased Technological Progress," Southern Economic Journal, XXXVII (October, 1970), 125-31.

[22]This is true for all multi-factor production functions. In the case of the Cobb-Douglas, of course, $\sigma = 1$ for any and all pairs of factors.

[23]See, for instance, the catalogue of concepts in R. Sato and T. Korzumi, "The Production Function and the Theory of Distributive Shares," American Economic Review, LXIII, No. 3 (1973), 484-89. Also see the rebuke by P. Samuelson, "Relative Shares and Elasticities Simplified: Comment," American Economic Review, LXIII, No. 4 (1973), 770-71. In addition, see Y. Mundlak, "Elasticities of Substitution and The Theory of Derived Demand," Review of Economic Studies, XXXV, No. , (1968), 222-35.

[24]The direct σ^*, is measured by holding output and all factors other than the pair under consideration constant. It may be computed from the formula given in Footnote 14 above. Allen's partial σ is computed, in effect, by holding output and cost conditions constant and measuring changes in the derived demand for one factor stemming from changes in the price of the other factor, all other factor quantities allowed to adjust. See Allen, op.cit., pp. 500-05, for a detailed discussion. McFadden's, shadow concept is, in some ways, a hybrid of these two which computes σ^* by holding all imputed factor prices and total costs constant. See D. McFadden,

"Constant Elasticity of Substitution Production Functions," Review of Economic Studies, XXX (June, 1963), 73-83.

[25]See H. Uzawa, "Production Functions with Constant Elasticities of Substitution," Review of Economic Studies, XXIX (4), No. 81 (1962), 291-99; and McFadden, loc.cit.

[26] V. Mukerji, "A Generalized SMAC Function with Constant Ratios of Elasticities of Substitution," Review of Economic Studies, XXX (3), No. 84 (1963), 233-36.

[27]K. Sato, "A Two Level Constant-Elasticity-of-Substitution Production Function," Review of Economic Studies, XXXIV, No. 2 (1967), 201-18.

[28]J. Kmenta, "On Estimation of the CES Production Function," International Economic Review, VIII, No. 2 (1967), 180-89.

[29]See, for instance, J. Sargent, "Production Functions," in, Qualified Manpower and Economic Performance, ed, by P. Layard, et al., (England: The Penguin Press, 1971), pp. 145-206; E. Berndt and L. Christensen, "The Translog Function and the Substitution of Equipment, Structures, and Labor in U.S. Manufacturing 1929-1968," Journal of Econometrics, I, No. 1 (1973), 81-114; E. Berndt and L. Christensen,"Testing for the Existence of a Consistent Aggregate Index of Labor Inputs," American Economic Review, LIX, No. 3 (1974), 391-404, and L.Christensen, D.Jorgenson, and L. Lau,"Transcendental Logarithmic Production Frontiers," Review of Economics and Statistics, LV, No. 1 (1973), 28-45; and S. Chu, D. Aigner, and M. Frankel, "On The Log-Quadratic Law of Production," Southern Economic Journal, XXXVII, No. 1 (1970), 32-39.

[30]It should be noted that it is possible for the log-quadratic to violate the traditional assumption of convex isoquants. The studies thus far completed suggest, however, that the function is relatively "well behaved" over the normal range of input utilization, and thus provides a reasonable (economic) representation of the input/output relationship. Cf., Sargent and Brandt and Christensen.

[31]Reinhardt, op.cit., and U. Reinhardt and D. Yett, "Physician Production Functions Under Varying Practice Arrangements," (United States Public Health Service, Community Profile Data Center, Technical Paper No. 11), Mimeographed. Where multiple outputs are also to be considered, see the generalization in Y. Mundlak, "Transcendental Multi-product Functions," International Economic Review, V, No. 3 (1964), 273-84.

[32]See, for example, A. Zellner and N. Revankar, "Generalized Production Functions," Review of Economic Studies, XXXVI, No. 106 (1969), 241-50; Revankar, "A Class of Variable Elasticity of Substitution Production Functions," Econometrica, XXXIX, No. 1 (1971), 61-69; and C.K. Lovell, "CES and VES Production Functions in a Cross-Section Context," Journal of Political Economy, LXXXI, No. 3 (1973), 705-20. It should be noted that there has been yet another avenue of research based upon the "duality" conditions between production and cost functions. We have excluded comment

on this work because there has been only limited empirical work done using this notion and because our interest is in factor inputs measured in "real" terms. See nonetheless, R. Shepard, Theory of Cost and Production Functions (Princeton: Princeton University Press, 1970); R. Hall, "The Specification of Technology with Several Kinds of Output," Journal of Political Economy, LXXXI, No. 4 (1973), 878-92; and W. Diewert, "An Application of the Shepard Duality Theorem: A Generalized Leontief Production Function," Journal of Political Economy, LXXIX, No. 3 (1971), 481-507.

[33]op.cit.

[34]W. Salter, Productivity and Technical Change, 2nd Ed., (Cambridge: Cambridge University Press, 1966).

[35]For instance, Z. Griliches, "Production Functions in Manufacturing: Some Preliminary Results," in Brown, (ed.), loc.cit., pp. 275-321; Lau and Hildebrand, loc.cit.; Moroney, loc.cit., and most of the other citations given in Footnote 18 above.

[36]With respect to the latter, for instance, only one study of the service sector broadly defined could be found, viz., P. Dhrymes, "A Comparison of Productive Behavior in Manufacturing and Service Industries," Review of Economics and Statistics, XLV, No. 1 (1963), 64-70. There is an emerging literature, however, in certain service sub-sectors. An extremely important illustration is the work carried out in medical services. See Reinhardt, op.cit.; Reinhardt and Yett, op.cit.; U. Reinhardt, "Manpower Substitution and Productivity in Medical Practice: Review of Research," Health Services Research, VIII (Fall, 1973), 200-27; A. Maurizi, "The Economics of the Dental Profession," (unpublished Ph.D. dissertation, Stanford University, 1972); and M. Feldstein, Economic Analysis for Health Service Efficiency (Chicago: Markam Publishing Co., 1960). For an activity analysis which is directed at the same kinds of problems, see K. Smith, et al., "An Analysis of the Optimal Use of Inputs in the Production of Medical Services," Journal of Human Resources, VII (Spring, 1972). For an interesting but not altogether successful attempt at specifying a production function for postal services, see L. Merewitz, The Production Function in the Public Sector: Production of Postal Services in the U.S. Post Office (Berkeley: University of California, Institute of Urban and Regional Development, Monograph No. 14, 1971).

[37]C.f., S. Mehay, "Production Functions for Crime-Deterrent Police Services," Ph.D. Dissertation. (Los Angeles: University of California, University Microfilms, 1973). Also included here are a number of interesting studies attempting to discern the "effectiveness" of medical services and school systems. The substantial differences in the definitions of both output and input sets preclude their inclusion in the present discussion. In the health area, see R. Auster, et al., "The Production of Health: An Exploratory Study," Journal of Human Resources, IV, No. 4 (1969), 411-36; and M. Larmore, "An Inquiry into an Econometric Production Function for

Health in the United States," (unpublished Ph.D. Dissertation, Northwestern University, 1967). For school systems, see M. Katzman, "Distribution and Production in a Big City Elementary School System," Yale Economic Essays, VIII, No. 1 (1968), 201-60; and the literature review in G. Copa, "Identifying Inputs Toward Production Function Applications in Education," (Minneapolis: Minnesota Research Coordinating Unit, 1971), Mimeographed.

[38]C.f., Moroney, loc.cit.

[39]See, for instance, V. Fuchs, (ed.), Production and Productivity in the Service Industries (New York: Columbia University Press, 1969).

[40]C.f., H. Lytton, "Measuring Output in the Public Administration Field," Productivity Measurement Review, XXI (May, 1960), 59-73.

[41]See, A. Walters, loc.cit., for a review of the problem.

[42]C.f., J. Hicks, "Capital Controversies: Ancient and Modern," American Economic Review, LXIV, No. 2 (1974), 307-16.

[43]See J. Robinson, "The Production Function and The Theory of Capital," The Review of Economic Studies, XXI (1953-54), 81-106, for the origins of the debate and G. Harcourt, "Some Cambridge Controversies in The Theory of Capital," Journal of Economic Literature, VII, No. 2 (1969), 369-405, for an evaluative essay.

[44]S. Bowles, "Aggregation of Labor Inputs in the Economics of Growth and Planning: Experiments with a Two-Level CES Function," Journal of Political Economy, LXXVIII (January-February, 1970),68-81.

[45]Ibid., p. 69.

[46]G. Psacharopoulos and K. Henchliffe, "Further Evidence on the Elasticity of Substitution Among Different Types of Educated Labor," Journal of Political Economy, LXXX (July, 1972), 786-92.

[47]C.f., Z. Griliches, "Capital-Skill Complementarity," Review of Economics and Statistics, LI, No. 4 (1969), 465-68.

[48]C.R. Dougherty, "Estimates of Labor Aggregation Functions," Journal of Political Economy, LXXX (November-December, 1972), 1101-1119.

[49]"Testing for the Existence of a Consistent Aggregate Index of Labor Inputs," loc.cit.

[50]Berndt and Christensen argue, however, that labor and capital aggregates can still be used with some profit in explaining aggregate output time series.

[51]See, Griliches, "Manufacturing Production Functions," loc.cit.

[52]We should point out that dis-aggregated labor inputs have also been used as arguments in Cobb-Douglas functions. In this case, σ's cannot be computed, but one can examine the statistical "fit" as a method of testing the C-D hypothesis. Of the studies we have encountered, C-D functions tend to fit the data quite well. A notable exception is M. Feldstein's study of hospital production functions in England. Feldstein found very high standard errors in a C-D model with physicians (M.D.), nurses (N), and several forms of capital, and concluded $\sigma_{MD-N} < 1$. A hybrid model incorporating fixed-proportion terms tended to confirm this finding. See M. Feldstein, loc.cit., Chapter 4.

[53]T. Powers, "Elasticities of Substitution Between Different Types of Labor: Theoretical Analysis and Empirical Examples," (unpublished Ph.D. Thesis, Princeton, 1972).

[54]Sargent, loc.cit.

[55]Ibid., pp. 198-99.

[56]Reinhardt, loc.cit., and Reinhardt and Yett, loc.cit.

[57]Cited in Griliches, "Manufacturing Production Functions," loc.cit. Also see T. Mayer, "Some Theoretical Difficulties in the Estimation of the Elasticity of Substitution from Cross-Section Data," Western Economic Journal, VII, No. 2 (1969), 153-63.

[58]op.cit.

[59]Zarembka, op.cit., disputes this conclusion.

[60]It is important to note here Nelson's conclusion that in the aggregate σ is a second order parameter and its value makes very little difference for most practical purposes relating to the explanation and projection of growth patterns. Nelson shows, for instance, that aggregate growth projections (predicted output) using $\sigma = 0.5$ will differ by no more than 0.001 percentage point from those using $\sigma = 1$, and hence little is to be gained, say, from using a CES rather than a Cobb-Douglas function. It is difficult to know, however, whether, the same conclusion would emerge for sectoral projections with disaggregate inputs. His argument, relating to aggregate analysis, nonetheless, is well worth reading. See R. Nelson, "Aggregate Production Functions and Medium-Range Growth Projections," American Economic Review, LIV, No. 5 (1964), 575-606; "The CES Production Function and Economic Growth Projections," Review of Economics and Statistics, ILVII, No. 3 (1965), 326-28; and "Recent Exercises in Growth Accounting: New Understanding of Dead End?" American Economic Review, LXIII, No. 3 (1973), 462-68.

[61]This explains, in part, why we have excluded specific comment on the empirical value of the scale coefficient. Another reason is that in the few cases where the scale coefficient was estimated directly from a production function, the value turns out to be quite high or it

hovers around one. Methodological problems preclude an easy choice of either of these findings. For work on manufacturing sector, see Griliches, op.cit.; Moroney, op.cit.; Lau and Hildebrand, op.cit.; S. Bensen, "Elasticities of Substitution and Returns to Scale in the United States Manufacturing: Some Additional Evidence," Southern Economic Journal, XXXIV (October 1967), 280-82; and R. Brite,"Scale and Elasticity of Substitution in Cross-Section Production Functions," Journal of Economics and Business, XXV, No. 2 (1972), 101-106.

[62]C.f., A. Shaikh, "Laws of Production and Laws of Algebra: The Humbug Production Function," and reply by R. Solow, "Law of Production and Laws of Algebra: The Humbug Production Function: A Comment," Review of Economics and Statistics, LV, No. 1 (1974), 115-21.

[63]For example, R. Solow, "Technical Change and the Aggregate Production Function," Review of Economics and Statistics, XXXIX, (August 1957), 312-20.

[64]C.f., E. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us (New York: Committee for Economic Development, 1962); Z. Griliches and D. Jorgensen, "The Explanation of Productivity Change," Review of Economic Studies, XXXIV, No. 3 (1967), 249-84; and R. Nelson, "Recent Exercises in Growth Accounting," loc.cit.

[65]op.cit.

[66]Z. Griliches, "Manufacturing Production Functions," Table 9, p. 317.

[67]E. Denison, "Some Major Issues in Productivity Analysis: An Examination of Estimates by Jorgenson and Griliches," Survey of Current Business, XLIX, No. 5 (1969), 1-28.

[68]C.f., Salter, op.cit.

[69]This was the Schumpeterian argument.

[70]J. Schmookler, Invention and Economic Growth (Cambridge: Harvard University Press, 1966).

[71]See, in particular, W. Nordhaus, Invention, Growth and Welfare (Cambridge: The Massachusetts Institute of Technology Press, 1969). Also see, National Bureau of Economic Research, The Rate and Direction of Inventive Activity (Princeton: Princeton University Press, 1962), and N. Rosenberg (ed.) The Economics of Technological Change, (England: Penguin Books, 1971), Part II.

[72]See M. Nadiri, "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey," Journal of Economic Literature, VIII, No. 4 (1970), 1137-76; C. Kennedy and A. Thirlwall, "Surveys in Applied

Economics: Technical Progress," Economic Journal, LXXXII, (March, 1972), 11-72; and E. Mansfield, Industrial Research and Technological Innovation: An Econometric Analysis (New York: W.W. Norton, 1968). Also, see, L. Lave, Technological Change: Its Concept and Measurement (New York: Prentice Hall, 1966).

[73] C.f., J. Minasian, "Research and Development Production Functions and Rates of Return," American Economic Review, LIX (May, 1969); and F. Raines, "The Impact of Applied Research and Development on Productivity," Working Paper, No. 6814, (St. Louis: Washington University, Department of Economics, 1968).

[74] op.cit., p. 107.

[75] As did, for instance, Griliches. See his "Hybrid Corn and the Economics of Innovation," reprinted in Rosenberg, op.cit., pp. 211-28.

[76] op.cit.

[77] W. Buechner, "Technological Change and the Occupational Composition of the American Labor Force, 1950-1960," Ph.D. dissertation, Harvard University, U.S. Government Report No. PB 210 631.

[78] Ibid., Chapter III.

[79] Ibid., Chapter VI.

[80] M. Piore, "The Impact of the Labor Market Upon the Design and Selection of Productive Techniques Within the Manufacturing Plant," Quarterly Journal of Economics, LXXXII, No. 4 (1968), 603-20.

[81] E. Crossman, et al., The Impact of Technological Change on Manpower and Skill Demand: Case Study Data and Policy Implications (University of California, Berkeley, Department of Industrial Engineering and Operations Research; Manpower Administration, Department of Labor, Washington, D.C., 1969); and Evaluation of Changes in Skill-Profile and Job-Content Due to Technological Change, Methodology and Pilot Results from the Banking, Steel and Aerospace Industries (University of California, Berkeley, Department of Industrial Engineering and Operations Research, 1966).

[82] C.f., J. Morton, On Manpower Forecasting, (Michigan: W.E. Upjohn Institute, 1968); and P. Haase, "Technological Change and Manpower Forecasts," Industrial Relations, V, No. 3 (1966), 59-71.

[83] It should be noted that linear programming analysis, generally ignored here because of the paucity of relevant empirical applications, can be used to examine many of the crucial parameters of interest to manpower planners. In terms of substitution parameters, for instance, the assessment of alternative "techniques" or "activities" traces out, in effect, points on the unit isoquant. Hopefully, these techniques may be used in the manpower field with greater frequency in the near future.

[84]See both C. Anderson, and M. Bowman, "Theoretical Considerations in Educational Planning," in Educational Planning, ed. by D. Adams, (Syracuse: Syracuse University Press, 1964), and B. Ahamad and M. Blaug, (eds.), The Practice of Manpower Forecasting (San Francisco: Jossey-Bass, 1973), Chapter I. Facing the matter squarely, the critics deduce the form of the production function from the fact that prices play no necessary role in manpower projections. Recall that if the isoquant is right-angled ($\sigma=0$) any expansion path over the production surface may be invariant to the factor price ratio. They argue that since factor prices are not explicitly considered, this must imply $\sigma=0$. The argument is erroneous in several ways. The most important is that the transform theoretically should be conducted in "technical space," so as to provide a reasonable basis or criteria for supply strategies designed to balance the system. Theoretically, if such a balance is struck, there is little reason to suppose that the factor price and factor use ratios would not be tolerably close to one another, i.e., factor prices will be determined by but not necessarily determinants of the factor use ratio. Dougherty has recently carried out some research which suggests that differences in supply conditions will indeed lead to differences in factor utilization. See his "Substitution and the Structure of the Labour Force," The Economic Journal, LXXXII, (March, 1972), 170-82. He concludes, curiously, that this vitiates the need for manpower planning. Quite the contrary would appear to be true. More particularly, what is at least partially at issue here is not factor "demand" theory, but rather the theory of factor supply. The manpower projection framework (as discussed earlier) is related to an expanded but as yet underdeveloped theory of factor growth and utilization. This theory is differentiated sharply from the exogenous (and frequently infinite) factor supply mechanism so often used in the theory of the firm. When such a theory is worked out, it may well be that these objections to manpower planning will disappear.

[85]It should be noted here that the critics also emphasize the fact that productivity and output targets are treated independent of one another. It is true that if equation (III 3b) is differentiated fully with respect to time, then interactions between Q and $\Delta\P$ as well as $\P$ and ΔQ are obtained. Given the methods typically employed in "projecting" $\P$, however, it is not clear that these interactions are of any great importance. C.f., Ahamad and Blaug, op.cit.

[86]For example, the work conducted under the aegis of the Mediterranean Regional Project.

CHAPTER IV

SPECIFICATION OF HUMAN RESOURCE INPUTS

Introduction

The discussion of a policy oriented forecasting model in Chapter I suggested that manpower models assume complementarity between a set of performance functions and a set of human attributes, expressed as an identity in terms of an occupational category. The attribute or qualifications set is a partial specification of the outputs of human resource supply systems and the set of performance functions is a partial specification of the technical coefficients of the production function. The occupational term is the link between the supply side and the demand side of the analysis, and hence the criterion for decisions concerning the need for policy intervention.

It is obvious that the quality of the specification of the identity term has great importance for policy formation. It is also obvious in practice that existing systems of occupational classification are limited in this role. They are partial products of prior conditions of demand or supply and of institutional constraints on the labor market. They are often too aggregate for the specification of some functional roles or sources of supply, and occasionally too specific for the operating systems to which they are applied. More important, most are incapable of specifying the full range of relevant functions and qualifications and often underspecify those of primary importance to policy decisions.

This Chapter is concerned, therefore, with evaluating existing knowledge about qualifications for specific occupations in light of the various uses of manpower forecasts. Toward this end, it is first necessary to discuss the adequacy of existing occupational classification systems because they define the way in which jobs are aggregated into smaller and more manageable numbers of occupations, and hence the framework in which the forecaster must work. Next, the criteria for specifying qualifications are discussed and evaluated with respect to the different uses of manpower forecasts. Finally, accomplishments in specifying appropriate qualifications according to these different sets of criteria are reviewed.

Occupational Classification Systems

Manpower forecasters do not design occupational classification systems; rather, they use systems that were originally designed for other purposes. As a consequence, the occupational categories for which forecasts are prepared are frequently inappropriate to the needs of users. For example, Department of Labor forecasts of future requirements for computer programmers are included in a residual

Census category entitled "Professional, Technical and Kindred Workers, not elsewhere classified."[1] This category includes such dissimilar categories as Tree Surgeons, Securities Analysts, Guidance Counselors and Television Announcers. Although future forecasts will treat computer programmers as a separate occupation, the illustration is sufficient to demonstrate the critical importance of occupational classification to manpower forecasting activity. Accordingly, this section discusses different systems of classification, and appraises their value to forecasting efforts.

Census Classification System

The Census classification system is dominant in manpower forecasting, because it is used not only to arrange Decennial Census data but also occupational information gathered in the Current Population Survey.[2] Although the Census classification is revised at 10 year intervals, historical comparability of Census data has played an important role in revision decisions. Consequently, the Census system continues to reflect an interest in classifying by social status as well as by the nature of work performed.[3] Thus, the Census classification tends not to satisfy the needs of either economists interested in a work function classification or sociologists interested in a classification by socio-economic status.[4]

The Census classification system involves aggregation of detailed occupation titles at two critical levels. First, 23,000 occupational titles are aggregated into "homogeneous" 3-digit occupational categories. These 3-digit categories (which currently number 417) provide the greatest detail available since data are never published for more detailed groups of job titles. The 3-digit categories are also "building blocks" because more aggregate groupings consist simply of combinations of the 3-digit categories. The second critical level of aggregation is the combination of the 417, 3-digit categories into 12 major groups, viz.,

Professional, Technical and Kindred Workers
Managers and Administrators, except Farm
Sales Workers
Clerical and Kindred Workers
Craftsmen and Kindred Workers
Operatives, except Transport
Transport Equipment Operatives
Laborers, except Farm
Farmers and Farm Managers
Farm Laborers and Farm Foremen
Service Workers, except Private Household
Private Household Workers

When occupational data are presented in terms of the 1970 Census classification system, they are usually shown in tables with more than 12 but fewer than 417 occupational groupings. In these cases, 2-digit categories and groups of 3-digit categories are broken-out and shown as components of the 12 major groups. Since detailed sub-groups are not published, it is usually difficult for users to shift categories between major groups. The classification scheme, therefore, tends to limit data analysis.

The Census occupational classification system has been subject to considerable criticism over the past decade. From the viewpoint of manpower forecasting, the most serious of these criticisms is that Census categories are not homogeneous. John Dunlop states this forcefully in discussing the major groupings of the 1960 Census classification scheme:[5]

> This eleven-fold occupational scheme has no analytical base. It is not related to job content or any of its major components, such as skill, responsibility, or working conditions. The categories of "clerical and kindred workers" or "sales workers" run the full range of skills and responsibility. These categories are not fruitfully related to training, education, or to compensation levels. In a word, they are a hodgepodge.

The lack of homogeneity in Census major groups remains basically unchanged in the 1970 Census system. This seriously limits forecasting efforts because it is not feasible to change the Census system and frequently difficult to obtain data disaggregated to the 417 3-digit categories.

Even when detailed data are available, another complaint has been that the detailed categories themselves are either too few in number or inappropriately chosen. Many users of forecasts would like information on specific occupations which are not dealt with separately in the Census classification, e.g., waste water treatment plant operators. This is inevitable in a system which groups 23,000 jobs into only 417 occupational groups. More significant criticism of the Census classification is that the limited number of detailed groups could be reorganized to provide more useful information. It is obvious that the categories should be homogeneous in the sense that the similarity of jobs within categories should be high relative to the similarity of jobs between categories. Yet, there is no agreement on the operational methods for assuring homogeneity of occupational categories. For example, Glen Cain, Lee Hansen and Burton Weisbrod have suggested that:[6]

> Each class of jobs should be such that the elasticity of substitution among jobs in that class (or, rather,

> among various workers who can perform those jobs) will on average be higher than the elasticity of substitution between jobs in different classes. We use the term, 'elasticity of substitution,' in its conventional sense--as a measure of the technical ease with which one input may be substituted for another to obtain a given output. The higher the elasticity, the greater are the substitution possibilities.

We agree that this would be an appropriate basis for defining homogeneity in 3-digit Census categories. But our literature review on the empirical estimation of the elasticity of substitution in Chapter III suggests that the possibilities here are limited. Moreover, since necessary data are nowhere available, the suggestion is not operationally feasible. It should be noted, however, that some limited work along these lines has begun. For instance, Winnick's attempt to approximate classification via the elasticity of substitution by using principal-components analysis to reclassify technicians according to reported job activities is a case in point.[7] Cain and Hansen think that Winnick's work may serve as a starting point for future efforts to classify occupations according to substitution criteria.[8]

Critics do agree that the Census categories have included far too many jobs in residual "not elsewhere classified" groups. Scoville gives an idea of the magnitude of this problem. He calculated that 1960 Census estimates of employment by detailed occupation include 32.9 percent of all employed persons in "not elsewhere classified" categories. But the situtation has been improved, e.g., when the 1960 Census data on employment are classified using the 1950 detailed classification, more employed persons (36.5 percent) are placed in "not elsewhere classified" categories; but when the 1960 data are classified using the 1970 Census classification scheme, considerably fewer (17.7 percent) are placed in "not elsewhere classified" categories.[9] The improvement in the 1970 version of the Census classification is perhaps more substantial than is indicated by these figures. The "not elsewhere categories," for example, now consist of 31 distinct 3-digit categories, some of which are sufficiently homogeneous with respect to job function to be useful for manpower forecasting purposes (e.g., computer specialists, n.e.c.). Even so, earlier classification schemes impose limits on the use of historical series in manpower forecasting. For example, detailed BLS requirements projections based (in part) on extrapolations of historical data are severely limited by the fact that 7 of the 160 detailed occupations are "not elsewhere classified" categories.[10] These categories contain 39.3 percent of the total occupational "requirements" projected for 1980.

D.O.T. Classification System

Another important classification system in use in this country is outlined in the Dictionary of Occupational Titles (D.O.T.) prepared by the U.S. Employment Service. This scheme differs from the Census classification in several important respects. First, the basic unit of analysis--the detailed job category-- is accompanied by a detailed description of duties. The D.O.T. also specifies worker traits associated with individual job titles. These are defined as the ". . . abilities, personal traits, and individual characteristics required of an individual to achieve average successful job performance." Further, the D.O.T. identifies each detailed job's relationship to Data, People and Things, using a one 1-digit numerical scale to identify the complexity of the relationship along each of these three dimensions. The information on detailed jobs is used to classify jobs in two different ways: an Occupational Group Arrangement (which is similar to the Census classification categories), and a Worker Traits Arrangement.

The Occupational Group Arrangement of the D.O.T., although similar to the Census classification, gives greater emphasis to job content, and assigns job titles to occupational groups in a more clearly defined and consistent manner. The differences between the two systems are greatest perhaps in the "blue collar" job area where the D.O.T. tends to emphasize the production process. This is obvious even at the level of major groups where the D.O.T. distinguishes between the four major groups: Processing occupations, Machine Trades occupations, Bench Work occupations, and Structural Work occupations. These groups together include most of the jobs in the Census groups: Craftsmen and Kindred Workers, and Operatives, except Transport. The criteria for establishing detailed categories within the major divisions of the D.O.T. are reasonably precise, but differ among major groups and thus are too lengthy to describe here. There are a total of 603 detailed (3-digit) occupational groups and, within each group, job titles are ranked by code numbers on job complexity in terms of People, Data, and Things. According to the D.O.T. this ". . . provides information on entry and progression possibilities in the form of a job ladder."[11] For example, the following jobs (and their accompanying code numbers) are listed under the 3-digit occupation group labeled Librarians:

100.118 Library Director
100.168 Chief Librarian, Branch or Department
100.288 Acquisitions Librarian
100.388 Cataloger

All of the above jobs have the same 3-digit code number, 100. Since the 4th, 5th, and 6th digits indicate the complexity of the relationship to Data, People, and Things, this implies that the Library Director's job entails a more complex relationship to people (1 vs. 6 in the 5th digit) than does the Branch Chief, and that both of these have

a more complex relationship to data than does the Acquisitions Librarian (1 vs. 2 in 4th digit).

The Worker Traits Arrangement of the D.O.T. parallels the Occupational Group Arrangement. Here ". . . jobs are grouped according to some combination of required general educational development, specific vocational preparation, aptitudes, interests, temperaments, and physical demands."[12] This classification contains only 114 detailed categories which are organized into 22 major groups. An example of one of the detailed groups in this arrangement is "Appraising and Investigating Work" which includes art appraisers and diamond experts together with forest cruisers, real estate appraisers, and customs examiners. This stems from the similarity in worker traits required for the successful performance of each of these jobs.

A general criticism of the D.O.T. is that it tends to abstract from technology and thus suppresses valuable information about specific training and substitutability.[13] In the example above, art and real estate appraisal turn out to require similar worker traits because the area where these jobs differ--specific vocational training--is defined in the D.O.T. only in terms of training time, not content. The Worker Traits Arrangement is limited even more seriously by the fact that it contains only 114 categories. But, most criticism and comment on the D.O.T. has focused on the People, Data, Things ratings that are part of the Occupational Group Arrangement. Scoville comments that the "identification of absolute and relative levels of relationship to data, people and things may say very little about what the worker really does in his job. Thus, the following jobs, drawn from a longer list, have identical levels of involvement with (data, people and things): university registrar, park ranger, coroner, taxi cab starter, and head chef. Such a grouping suppresses important information about the technical focus of the job. . ."[14] This criticism perhaps goes too far because the D.O.T. nowhere groups together all jobs with the same data, people, things ratings. These ratings are useful to disaggregate 3-digit occupational groups, although they only provide a rough approximation of job ladders, e.g., a theoretical physicist's job is ranked lower than the other specialities in physics within the 3-digit category, "Occupations in Physics" because the job is assigned a low rating on complexity of involvement with things.

We have encountered little criticism of the 3-digit occupational classification groups of the D.O.T., perhaps because the system is seldom used to collect and present data. We conclude, however, that the 3-digit D.O.T. classification may be more appropriate for manpower forecasting than the comparable 3-digit Census classification. The reasons are fourfold: First, the D.O.T. is somewhat more detailed, e.g., it has 603 vs. 417 job categories. Second, it is less

ambiguous, especially because the duties associated with each job title are clearly defined. Third, it is more flexible: the data, people, things ratings and worker trait ratings provide a basis for rearranging or disaggregating categories. Finally, the 3-digit categories in the D.O.T. appear to be more homogeneous with respect to job function.

Other Classification Systems

There are several other occupational classification systems in use in the United States, but none of these are designed to classify the entire labor force in comprehensive fashion. For instance, each branch of the Military Service has developed an occupational classification for its enlisted personnel.[15] We exclude a description of them because they focus on a specialized set of occupations. The same is true of the occupational classification systems used by the National Science Foundation and the U.S. Civil Service Commission. Brief mention should be made, however, of the specialized classification system used by the U.S. Office of Education because it is strongly linked to manpower forecasting.[16]

The Office of Education Classification System is primarily a scheme for classifying vocational-technical instructional programs. But since the publication, Vocational Education and Occupations, provides a matching of detailed D.O.T. job titles with vocational-technical instructional programs, it provides indirectly a system for classifying jobs by vocational education subject area. This system is very appealing: its use allows forecasts for job clusters that share the common characteristic that all can be performed by persons graduating from the same vocational education program. Unlike most other systems, the criteria for grouping jobs into "homogeneous" groups is relatively unambiguous here. If an occupation is related to more than one subject area, it is assigned to the area which contributes to the major or critical competencies needed to perform the job. Occupations for which existing vocational education programs do not provide relevant training are not classified in the Office of Education system.

One problem with this system is that it does not purport to be complete, i.e., it does not purport to classify all occupations associated with vocational education programs. However, this disclaimer appears not to be taken very seriously because the system categorizes about 4,000 jobs and is used for a host of vocational education planning purposes. Another problem is that there are many jobs which are only weakly related to a vocational education program, either because there is no close correspondence between curriculum and job duties, or because it is customary for persons employed in the occupation to acquire vocational skills outside the school system. For example, the jobs of hotel manager, baggage porter, and doorman are

assigned to the Hotel and Lodging vocational education category. The latter two jobs are relatively simple, however, and are not likely to be filled by graduates of vocational education programs in Hotel and Lodging. There are jobs classified in this system, moreover, which often require a baccalaureate degree, e.g., market research analyst, rather than graduation from a vocational educational program. These problems, of course, are not inseparable. Yet, there is danger that the classification system can be used to produce inflated forecasts of the demand for graduates of vocational education programs because it avoids the question of alternative means of acquiring vocational qualification.

Mention should also be made of the occupational classification system proposed by Scoville and his methodology for classifying workers by skill level.[17] Data limitations preclude Scoville from building an occupational classification from scratch. Rather, he confines himself to rearranging 204, 3-digit occupations in the 1960 Census classification into more appropriate groupings. He begins by clustering the 204 census categories into 18 job families. A job family may contain a wide range of skill levels, e.g., Health Services, but (as far as possible) jobs with the same technical focus are assigned to the same job family. Thus, Scoville has categories such as Vehicle Operation and Tools, specialized.

Within job families, Scoville proposes to classify jobs into categories based on skills, abilities and required training. To do this, he attempts to reduce skills, abilities, and training by using price as a common denominator. The idea is to estimate the market price of these skills, abilities, etc., which permit workers to earn more than the minimum wage. This is accomplished by regressing D.O.T. ratings of worker traits required in specific jobs on earnings by occupation. With these results, Scoville has a dollar price for different kinds of skill and ability. He then simply computes the value of each job by summing the prices associated with job-related attributes. He next categorizes jobs in each job family into one of the five levels depending on the ratio of the computed value of the job to the unweighted mean earnings of all occupations. Thus, Scoville's computations result in sub-categories within job families that are stratified by (what he refers to as) job content level. The system has the added advantage of permitting aggregation across job families by content level.

In carrying out the calculations necessary to stratify jobs by skill, abilities, etc., Scoville makes a number of very questionable assumptions. These may be overlooked here, however, because most were shortcuts which could be remedied by using currently available data. The important question is whether the concept is useful for creating occupational job groupings to serve manpower forecasting work. In brief, we judge Scoville's method to provide little improvement

over existing ad hoc methods for classifying occupations. The most serious limitation is that persons who possess characteristics with equal monetary value in the labor market are not necessarily substitutable from the point of view of the technological conditions of the productive process, even if they are in the same job family. Moreover, by including only 18 broad job families in his system, Scoville ends up classifying accountants and librarians at the same level in the "clerical" family as well as mechanics, carpenters, electricians, plumbers and several other "craftsmen" occupations at the same level of the Tools (nonspecialized) job family. Even if Scoville's proposed system were greatly expanded and refined, the placement of jobs with very different schooling requirements in the same category can occur. The reason is that he follows the D.O.T. method of describing specific vocational preparation in terms of required training time, irrespective of training content. Since manpower forecasts are frequently used to guide decisions about investment in vocational training, Scoville's aggregation of jobs within broad families is not an appealing method.

Improvement of occupational classification systems for manpower forecasting purposes is unlikely to be accomplished by the creation of yet another schemata. Since forecasting techniques usually draw upon data from a variety of sources and build upon historical time series data, a unification of existing systems which preserves historical comparability may be the most practical approach to improvement. This might be facilitated by the development of a standardized system. While at present there is no standard occupational classification--similar, say, to the Standard Industrial Classification--there is an ongoing effort to create one.

The Office of Management and Budget's Standard Occupational Classification project was created at the recommendation of the Federal Interagency Committee on Occupational Classification. The purpose of this project is to produce a Standard Occupational Classification (SOC) for use by all Federal agencies collecting occupational statistics. A preliminary draft of the SOC is not expected to be released for public review until late 1975, but it is possible to comment on some aspects of the ongoing work of this project. The guiding principle of the SOC project is to group jobs into categories that are homogeneous with respect to work performed. There is, however, no single criterion used for defining homogeneity. Rather, education and training, skill level, material, product, service, subject matter, and industry are all taken into consideration in defining homogeneous groups. The structure of the SOC will be similar to other systems in the sense that detailed job titles will be aggregated into occupational groupings at three successively more detailed levels. In comparison to the Census and D.O.T. systems, the SOC will probably have 19 major groups with increased detail in the area of "professional-technical" jobs. In the "blue-collar" occupation groups, there is an

attempt to develop skill level distinctions, but the details have not yet been worked out.[18]

It is impossible to evaluate the SOC for manpower forecasting purposes before it is fully elaborated. Even so, there is reason for optimism that the SOC will facilitate the improvement of manpower forecasts. The SOC project staff are aware of the criticisms of existing classification systems outlined above, and are attempting to avoid similar problems with the SOC. Even if the SOC were to constitute little or no improvement over existing systems from the point of view of the users of manpower forecasts, the promulgation and widespread adoption of a Standard Occupational Classification will ease the task of forecasters who use data from different sources.

Specification of Qualification Standards

In practice, appropriate qualification standards for specific occupations must be specified in the context of a particular occupational classification system. For working purposes, however, it is useful to abstract from the problems of classifying occupations in order to discuss the meaning of appropriate qualifications standards. In the context of using forecasts for specific occupations, we are concerned with three related questions: (a) what kind of qualifications matter; (b) what level of qualifications is appropriate; and (c) how might the kind and level of appropriate qualifications be specified in operationally useful ways?

Some Definitions

Clearly, education and training qualifications are most critical to the performance of specific occupational functions. In operational terms, the vocabulary of the Dictionary of Occupational Titles (D.O.T.) is useful in understanding the sense in which these factors relate to the qualification question. The D.O.T., for instance, distinguishes between General Educational Development and Specific Vocational Preparation.[19] General Educational Development is defined as:[20]

> Those aspects of education (formal and informal) which contribute to the worker's (a) reasoning development and ability to follow instructions, and (b) acquisition of "tool" knowledges, such as language and mathematical skills. It is education of a general nature which does not have a recognized, fairly specific, occupational objective. Ordinarily such education is obtained in elementary school, high school, or college. It also derives from experience and individual study.

Specific Vocational Preparation refers to acquisition of the techniques, information and facility needed in specific job situations. The D.O.T. includes in this category:[21]

> . . . training given in any of the following circumstances:
> a. Vocational education (such as high school commercial or shop training, technical school, art school, and that part of college training which is organized around a specific vocational objective);
> b. Apprentice training (for apprenticeable jobs only);
> c. In-plant training (given by an employer in the form of organized classroom study);
> d. On-the-job training (serving as learner or trainee on the job under the instruction of a qualified worker);
> e. Essential experience in other jobs (serving in less responsible jobs which lead to the higher grade job or serving in other jobs which qualify).

Because of the widespread use of the D.O.T., we use the terms, General Educational Development (GED) and Specific Vocational Preparation (SVP) in the sense conveyed by the definitions given above. We note two important implications of the use of these terms. First, GED is not synonomous with years of formal schooling completed. Second, SVP (and GED) can be acquired by a variety of different methods. Conceptually, it is important to distinguish between qualifications per se, e.g., GED or SVP, and the methods or "inputs" used to achieve qualification, i.e., years of formal schooling completed, participation in training programs, etc. Employers and personnel administrators frequently use the latter as proxies for the former. For example, they may require that applicants for positions hold a High School diploma. Such practices have been attacked as discriminatory against persons possessing the necessary skills and abilities but not having the stipulated credentials. Employers, however, respond that they use schooling level as a proxy not only for general and specific knowledge but also for the presence of desirable behavioral characteristics such as the "ability to get along with others and to make the most of opportunities."[22]

Whether education levels serve as a good proxy for desirable non-skill related behavioral characteristics is open to question, but work habits, aptitudes, attitudes and values are increasingly recognized as important determinants of labor market success. Unless the implausible assumption is made that the influence of non-skill related behavioral characteristics on worker effectiveness is unrelated to job function, (i.e., occupation), this broad category of personal attributes should be included along with education and training as relevant kinds of qualifications. It is also true, of course, that physical characteristics such as height, strength, and acuteness of sensory perception are relevant qualifications for a large number of specific occupations.

As might be expected, specification of the appropriate level of qualification has been a subject of controversy. Some difficulties may be resolved, however, if it is understood that there are different

uses of qualification information. Thus, Sidney Fine's discussion of "education and training requirements" for specific occupations, distinguishes between three uses of the concept of requirements:[23]

> Functional or Performance Requirements: These are the requirements determined by objective job analysis as necessary and sufficient to achieve average performance in the specific tasks of the jobs. Such estimates try to focus on the tasks performed in relation to the things, the data, or the people involved in those tasks. For example, they do not include the requirements for promotion to another job. The estimated requirements for the apprentice carpenter are for the man performing apprentice duties; they are not the duties of the journeyman. This approach was used in arriving at the educational and training requirements in the Estimates [of Worker Traits for 4000 Jobs Defined in the D.O.T.] and in the present supplement to the D.O.T.
> Employer or Hiring Requirements: These requirements reflect conditions in the labor market and may or may not be related to the functional requirements described above. Thus, for example, in a loose labor market such as existed during the Depression, the educational requirement for a salesgirl was often 'some college' or even, in some instances, 'college graduation.' Today, in many factories, the requirement for an ordinary assembly or fabricating job is 'high school graduation,' largely because this amount of education is possessed by a great many workers who are available in the labor market. It is not necessarily related to the performance requirements of the job tasks. Indeed, tasks for which high school graduation may now be required are in many instances being performed by workers with much less education and training who were hired in an earlier period.
> Educational Attainment: The median educational attainment of workers obtained from a sample census frequently is presented in tables for various occupational groups. This attainment is then interpreted as being the same as 'requirements' --an interpretation which is, of course, incorrect and which can be extremely confusing.

Although Fine simplifies the issue somewhat by dealing only with "education and training requirements," he makes explicit two important distinctions and suggests a third. First, the average educational attainment of persons currently employed in a specific occupation is not necessarily the same as the educational attainment currently specified by employers for entry into employment in that occupation. The two can, and frequently do, differ significantly when new entrants are required to have completed more education that the average attainment of older workers already employed in the occupation. Second, and perhaps more important, Fine distinguishes between

employers' hiring requirements determined by market forces and the functional requirements necessary for average performance in the specific tasks of the job. While employers' hiring requirements might be easier to specify empirically with a high degree of confidence, the notion of functional requirements is both relatively unambiguous and different.

It is instructive to inquire why employers might require higher levels of education and training than those which are necessary and sufficient to achieve reasonable performance in the specific job tasks. It may be, for instance, that the supply of labor qualified to meet earlier entry requirements for a specific occupation has increased, and with wages "sticky downward," employers respond by demanding a higher qualification level. Employers may ration jobs by increasing education requirements because they believe this will increase the average performance level. Employers may wish to increase the <u>average</u> level of performance because technical changes leading to greater interdependence suggest that it is worthwhile from an economic point of view. It may also be, of course, that professional associations and/or licensing authorities have increased entry requirements and employers are forced to go along, or that employers believe there is some prestige value of having a highly qualified labor force. Finally, it is possible that employers set entry requirements higher than the functional requirements for a particular occupation because they view that occupation as a lower rung on a career ladder, and they wish to have a pool of employees in their firms from which they can select candidates for promotion to higher level positions.

Another important distinction (only alluded to by Fine) is the difference between the level of qualification necessary for success in a specific occupation and the level necessary for a reasonable probability of success in a career. Since many careers involve movement up a "job ladder" involving many different but related occupations, the level of qualification necessary for career advancement may be higher than either the functional requirements or employers' hiring requirements for specific occupations at the lower end of the "job ladder." The concept of functional job requirements specifically excludes requirements for promotion to other jobs. Employers' hiring requirements may be based in part on the requirements for promotion to higher level occupations, but this is not always the case.

At the risk of oversimplification, it is possible to argue that there are only three levels of qualification for specific occupations which are relevant to users of manpower forecasts. In ascending order, these are functional requirements, employers' hiring requirements, and requirements for career advancement. Clearly, the level of qualification which is most appropriate depends on particular manpower forecasting applications and use of qualification information. For instance, students and vocational counselors are important users of manpower requirements forecasts. In the setting of school guidance

counseling, students need information about the level of qualification necessary for career advancement, but they also need information about employers' hiring requirements for entry level positions.

During the past decade, manpower programs designed to train and place "disadvantaged and displaced" workers have also created a large number of users of forecasts with somewhat different aims than those of the formal school system. Persons with a history of unsuccessful labor market experience, the so-called "disadvantaged" and participants in "secondary labor markets" may find career advancement a somewhat unrealistic and elusive goal. Employers' hiring requirements are obviously the most appropriate level of qualification for efforts to train and place "disadvantaged workers" in positions where they must compete with other workers in the hiring process. Yet, because "disadvantaged" workers in some cases are given preference in hiring if they possess minimum qualifications, and because some efforts to assist the disadvantaged involve changing employers' hiring requirements where they are judged to be unrealistic and discriminatory, functional requirements are also relevant to this type of use of manpower forecasts.

Finally, there has been over the past several decades a large number of manpower forecasts for specific occupations judged to be critical to the achievement of social goals, e.g., scientists and engineers, physicians and allied health occupations, teachers, etc. In this case, because the concern of users centers on the adverse social effects of a shortage of qualified manpower, licensing is common and employers' hiring requirements are frequently the same as the minimum qualifications established by licensing authorities. In the event that manpower shortages to occur, employers' requirements are likely to be identical with minimum license requirements and consequently of obvious importance to the user of the forecast. But the user will also be interested in knowing whether the functional requirements of these occupations are in fact equivalent to licensing requirements in situations when shortages are projected since it has implications for the manner in which requirements may be satisfied.

Specification of Qualifications

By all odds, the foremost and most comprehensive attempt to specify qualification standards is the Dictionary of Occupational Titles and its Supplements. The D.O.T. provides qualification specifications for 14,000 detailed occupations in terms of functional job requirements. It deals with several dimensions of qualification: General Educational Development; Specific Vocational Preparation; Physical Demands; Working Conditions; Aptitudes; and Temperaments. The first four of these dimensions are specified in the 1966 Supplement to the D.O.T. while the latter two dimensions are specified in Vol. II of the 1965 Edition of the D.O.T.

While impressive in its detail, the D.O.T. specification of required qualifications is not always well suited to the objectives of manpower planning in terms of the functional requirements of jobs. For example, the description of specific Vocational Preparation required by the 14,000 different jobs is limited to a simple scale indicating the amount of time required to acquire occupational-specific skills. Thus, the D.O.T. indicates that the occupations of demographer and stonemason both require about 2-4 years of specific training, but indicates little about the content of such training or how it might differ between two such dissimilar occupations. Another difficulty is that the specified aptitudes, interests, and temperaments (and even the specified level of General Educational Development) are of limited value to the practitioner unless he has access to the results of individual's performance on specialized tests. In employment counseling--the purpose for which the D.O.T. specifications were originally developed--this is not a serious problem because the specifications are based on the widely used General Aptitude Test Battery (GATB). When test data are not available, it is possible to make limited use of the D.O.T. specifications by using a set of simplifying assumptions.

A common approach for using GED specifications, for instance, has been to convert arbitrarily to years of school completed.[24] Years of schooling completed is obviously a less refined measure of educational attainment. Other attempts to use the D.O.T. ratings in the absence of test scores for the population under study are more controversial. Scoville, for example, attempted to estimate the prices paid in the labor market for each of the characteristics included in the D.O.T. In so doing, he assumed that persons employed in a given occupation possess (on average) the same level of each of the traits as is specified in the D.O.T. as a minimum requirement--in spite of the fact that D.O.T. specifications are minimum "functional requirements" and do not necessarily correspond to the actual traits and abilities possessed by employed workers.[25]

Scoville reported that the D.O.T. specifications for required GED in specific occupations do not appear to correspond closely to the actual educational attainment of workers classified by occupation as reported in the Census.[26] Scoville encountered difficulties in comparing Census data with D.O.T. specifications because of differences in the two classification systems and the problem of assigning appropriate weights to D.O.T. categories in the absence of survey data classifying the entire work force by detailed D.O.T. code. The October 1966 Current Population Survey, however, collected information on the educational attainment of occupation of workers (D.O.T. classification) and the results of this survey tend to support Scoville's conclusion.[27] Nevertheless, the D.O.T. purports to specify functional jobs requirements and this finding indicates little about the validity of the D.O.T. specifications of requirements. Hence, the validity of these requirement specifications remains an important and largely unanswered question.

The D.O.T. specifications of GED and SVP are based on the description of job tasks derived by the technique of job analysis.[28] GED and SVP ratings produced by different job analysts for the same jobs were compared for consistency and found to be highly correlated. So far as we know, however, the GED and SVP ratings have not been validated by means of any empirical study of differential performance on the job. Measurement of performance on the job does provide a partial basis for the D.O.T. specifications of aptitudinal requirements. These requirement specifications are based on the General Aptitude Test Battery (GATB) in its occupational-specific form, i.e., the Specific Aptitude Test Battery (SATB).[29] The GATB is the only aptitude test for the measurement of latent skills which has been extensively related to working populations.[30] The U.S. Employment Service has conducted numerous test development studies to establish relationships between GATB scores and job-performance variables in specific occupations. The result has been the development of about 450 SATBs which can be used to test the aptitudes of individuals for as many specific occupations. The SATBs use only those subtests of the GATB with proven ability to predict performance. The primary use of SATBs is in employment counseling but the data collected in test development studies is also used to specify aptitude requirements in the D.O.T.

The D.O.T. specifies requirements for 11 kinds of occupationally relevant aptitudes, e.g., intelligence, verbal, motor coordination, etc. Data on nine of these aptitudes are available from the test development studies. The requirements for specific occupations are expressed in terms of test score levels required for satisfactory (average) performance on the job. It is difficult to determine the exact relationship between such "requirement" specifications and the test development studies. The reason is that some of the occupations in the D.O.T. were rated via direct test results while other occupations (for which there were no test development studies) were rated by analysts on the basis of their similarity to tested occupations. In those cases where studies of performance on the job provided the data directly, the mean test scores achieved by the sample group of workers were used as job requirements.[31] The D.O.T. reports such test score requirements for each of the 11 aptitudes in each rated occupation group, indicating which of the 11 aptitudes have been found to be significantly related to performance, in bold face type.

There appears to be no question that D.O.T. aptitude requirements relative to job performance are based on more solid empirical evidence than alternative specifications based on other available psychological tests. Indeed, our search of the literature yielded no tests of attitudes, motivation, or personality designed for the purpose of predicting occupational performance.[32] Yet, while the aptitude requirements may be considered "state-of-the-art" specifications, they must nonetheless be used with caution. For one thing, as we have seen, the D.O.T. specifications for a large number of occupations are

based simply on judgments of analysts. For another, the user who accepts the validity of the D.O.T. aptitude specifications must be careful in interpreting them. More particularly, the "requirement" specifications are probably best interpreted as approximations to, or estimates of, the mean aptitude level of persons working in a given occupation. This is useful information, especially when accompanied by indications that aptitude test scores are significantly correlated with performance among workers in the specified occupation. It is clear, however, that they are not "requirements" in the usual sense of that term.

Apart from the D.O.T., the only other comprehensive source of information on appropriate qualifications for specific occupations is the Occupational Outlook Handbook published by the U.S. Department of Labor. Whereas the D.O.T. emphasizes "functional job requirements," the Handbook provides information on current entry requirements and normal patterns of career progression. The Handbook has become an indispensible reference tool for vocational counselors throughout the country. It is kept current by the biennial publication of new editions and by supplementary information in a companion publication, the Occupational Outlook Quarterly. The Handbook and the Quarterly appear to be used more for information on job openings and working conditions than for qualification specifications, but there is no other source that gives such comprehensive information on employers' hiring "requirements."

One difficulty with the Handbook is that it is often vague. It abounds with statements such as: most employers prefer than new entrants to this occupation complete ( ); or, a ( ) degree is not necessary but persons who possess only ( ) will face increasing competition in the years ahead. Obviously, unequivocal statements about qualifications invite exceptions, but the few specific statements that are to be found in the Handbook suggest that the general lack of precision indicates a general absence of recent information on the qualifications of new entrants to given occupations. For example, the description of training, other qualifications, and advancement in the accounting occupation is quite detailed, and indicates (among other things) the number of States which require CPA's to hold college degrees, and the proportion of successful CPA candidates in some recent year who were, in fact, college graduates.[33] But this detail is the exception, rather than the rule. Frequently, it appears that insufficient data are available to support the Handbook's generalizations.

There is no question that the Occupational Outlook Handbook provides information on qualifications for entry and career progression that is useful to users of manpower forecasts. Many users, however, may desire greater precision and completeness than is available in the Handbook. In large measure, the most important problem with the

Handbook's descriptions of required qualifications is that persons with quite different qualifications do, in fact, enter most occupations in the Handbook. That is, while the Handbook indicates the variety of qualifications which may permit entry into a specific occupation, it seldom provides any indication of the degree to which success varies with qualification within that occupation. It is possible, however, that the growing literature on the returns to investment in education and training may be useful to the analysis of this question.

An Alternative Means to Specification

This section deals with a sub-group of the body of literature referred to earlier as "rate of return" studies, especially that portion focused on individual occupations. Insofar as such studies claim to measure the social rate of return to different levels of education (within a given occupation) they offer an alternative means of specifying the appropriate qualification levels for specific occupations. Occupationally disaggregate studies of the returns to education have been few in number, but a sufficient amount of work has been completed to indicate the potential value of the approach.[34] That is, at present the results of such investigations are no doubt inadequate for operational purposes, but it is likely that with further improvements the approach may provide useful results in the future.

Reference to "the approach" in the singular is not wholly appropriate because there are a variety of different assumptions employed in such studies, and their results differ significantly with respect to these assumptions. In many cases, there are few satisfactory guidelines for choosing one assumption over another and, even if there is, limited data may force a compromise. More significant is that these occupationally disaggregate estimates are limited in precisely the same way as aggregate estimates of returns to education; viz., the use of cross section data to approximate lifetime earnings profiles, the difficulty in controlling for ability, family background, etc., the choice of the appropriate measure of earnings, and so forth. In addition, there are problems which are unique to the study of specific occupations. One difficulty, for instance, is that data requirements are immense. This is so because of the need to study a large number of different occupations, and because of the need to compare the earnings of persons with different qualification levels within each occupation. Further, estimates can be no better than the quality of the data upon which they are based, and there is evidence that a significant number (and proportion) of persons provide biased responses to questions about their occupation.[35]

Another problem is that part of the payoff to relatively high levels of schooling within a given occupation may be a higher probability of upward mobility to employment (at higher wages) in another oc-

cupation. In aggregate estimates, the existence of a correlation between occupational mobility and education leads to the uncontroversial practice of excluding occupation as a "control" variable in regression analysis.[36] However, it is not clear how one handles occupational mobility in the case of occupationally disaggregate studies of the returns to schooling. For example, it may be that the return to university education for accountants is low, but that accountants who have completed their university studies are more frequently promoted to high paying managerial occupations than are accountants with less schooling. Thus, the estimated return to university education accountants would be low because the most successful accountants move into other occupational categories. In this sense, rate of return calculations may be quite misleading.

One obvious way to deal with the problem posed by mobility in the study of return to education and training for a specific occupation is to expand the definition of occupational employment to include not only those currently employed but also those previously employed in the occupation with the expectation of subsequent movement up a career ladder. The problem here is that there are no data sets currently available which are appropriate for this purpose, i.e., which include job histories in addition to other needed information or which contain a sufficient number of observations for reliable estimates.

It should be noted here that in certain professions the problem posed by mobility is amenable to analysis because of a close correspondence between occupation and professional identity. Dodge's study of the returns to university training of accountants in Canada, for example, included accountants working in other occupations at the time of the survey because the sample was drawn from the population of accountants registered with the Canadian Institute of Chartered Accountants in 1967.[37] Yet it is generally true that in those professions where membership can be readily identified through professional associations or inventories, entry requirements are often high and rigidly enforced. Thus, there is considerable homogeneity and little opportunity to compare the "return to investment" in alternative levels of qualification.

Alternative Paths to Qualification

For many purposes, a more satisfactory approach to the qualification question is to focus on a description of the alternative paths to qualification for a specific occupation. In this case, research may follow one of two different modes, depending upon the definition of occupation under study. If the occupation is defined in broad functional terms, e.g., carpenter, economist, or accountant, persons having followed different qualification paths may well be performing at different skill levels such that it would be difficult to conclude

treatment of different training and job experiences. Maton examined mixed experiences, and used judgment to assign them to appropriate categories. He excluded previous job experience which was not relevant to the current job, using a procedure which involved considerable subjective judgment. Classification of the relevance of previous job experience to a person's current job is clearly a pitfall which threatens any attempt to study on-the-job experience as a training experience. Moreover, experience in apparently dissimilar occupations can build towards a job ladder in subtle ways that are difficult to discern from anything but detailed job descriptions. Even if detailed job histories are available, the variety of previous job experience is often surprisingly large and the task of evaluating relevance correspondingly formidable.

NOTES TO CHAPTER IV

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[20]Ibid., III, Appendix C, p. A-5.

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[40]J. Maton, "Experience on the Job and Formal Training as Alternative Means of Skill Acquisition: An Empirical Study," International Labor Review, C, No. 3 (1969), pp. 239-255.

CHAPTER V

THE PRACTICE OF MANPOWER FORECASTING: AN OVERVIEW

Setting the Stage

The task of the next several chapters is to describe the essential characteristics of manpower forecasting practice and to appraise its value to the policy process. Chapter V considers the general nature and scope of forecasting activity in the United States over the recent past and discusses its relative strengths and weaknesses. Subsequent chapters probe more deeply into two important subsets of planning experience: Chapter VI considers in some detail the projections of the Bureau of Labor Statistics, especially those prepared in the framework of the National Industry/Occupation Matrix; and Chapter VII provides a detailed assessment of manpower projections in the health field. These Chapters are designed to complement each other, and the trio should be read as a single unit. As before, some preliminary work is essential to set the stage for the discussion.

It should be noted at the outset that our task is made considerably more difficult by the amorphous character of manpower planning experience in this country. This difficulty requires initial emphasis on the limits of the assessment, particularly those that have been imposed arbitrarily for purposes of achieving focus and direction. For instance, the evaluation of forecasting practice is based almost entirely on a critical reading of the "practice literature." That is, we relied heavily on published documents, technical memoranda, etc., which contain projections to ascertain and appraise the nature of the activity. Even the casual observer will recognize the methodological pitfalls of this procedure; the problem is compounded by the fact that projection studies are notorious for their lack of substantive and methodological exposition. Furthermore, our ability to understand the intended and unintended uses of projections in the formulation of policy is limited by virtue of our reliance on the literature. Although precluded a priori from the scope of the present study, direct observation of the preparation and utilization of manpower forecasts is an idea which warrants serious attention for future research.

The practice literature, moreover, was limited to studies containing projections of occupational requirements that were completed over the period 1965-73. This narrowed the scope of the inquiry to a considerable extent: not only did it exclude a number of studies conducted prior to the mid sixties, but also a large number of items which are only peripherally related to the subject matter. This latter group

includes (current period) job vacancy studies and regional "economic base" and macro-economic analyses which provide estimates of aggregate/sectoral employment and/or labor force but do not distribute these estimates by occupational function. It also includes some studies relating specifically to partial dimensions of manpower supply mechanisms, such as population projections and forecasts of school enrollment or student flows which ignore manpower criteria as well as estimates of potential clients for certain delivery systems, e.g., estimates prepared in the framework of recent CAMPS plans.[1] Simply stated, studies were included in the practice literature if (and only if) they contained some forecast of the number of workers classified by occupation for a point in time beyond the data at which the forecast was prepared. It is remarkable that even under this somewhat stringent guideline, our search identified more than 300 forecasting studies conducted over the period 1965-73. We discuss next the procedures used in the literature search and then the criteria used for evaluating the practice literature.

Practice Literature: Search Procedures and Product

As should be apparent, the "literature" relating to manpower forecasting is seldom (if ever) published in formal academic channels. Indeed, by its very nature, it is unsuitable for such distribution. An important implication is that there has been no orderly theoretical development of the activity and, indeed, very little cumulative impact of learning from previous experience. A more prosaic, but nonetheless important, implication is that the practice literature cannot be identified through conventional bibliographic control networks for the purpose of identifying projection studies. Consequently, we attempted to tap less academic but nonetheless relevant bibliographic networks for the purpose of identifying projection studies.

More specifically, we used three network systems, the most important of which was the Educational Resources Information Center (ERIC), located in the National Institute of Education. ERIC maintains a series of clearinghouses for the acquisition, cataloging, indexing, and abstracting of educational literature, defined broadly. Within the ERIC system, we relied heavily on the Abstracts of Instructional and Research Materials in Vocational and Technical Education (AIM/ARM).[2] A complement to this source was ERIC documentation available through the Ohio State University's Mechanized Information Center (MIC).[3] Items identified here, however, lacked abstracting, which made the task of evaluating the nature of a given item more difficult. The second network utilized was the National Technical Information Service (NTIS), an agency of the U.S. Department of Commerce.[4] The vast resources of NTIS were assessed through MIC and Government Reports Index, a semimonthly publication of NTIS. Finally, the Medical Literature Analysis and Retrieval System (MEDLARS), a bibliographical information service of the National Library of Medicine was used. We turned to this specialized bibliographic tool for identifying some studies in the health sector as discussed in Chapter VII.

Another way of identifying relevant literature is to conduct a survey of agencies which might be expected a priori to prepare and/or use manpower projections. Such a survey was undertaken as a second stage complement to the bibliographic search described above. It was complementary in the sense that a computer generated list of identified items for (given) states was included in the survey letter to agencies in these states, such that each agency was requested to identify missing studies, i.e., studies which escaped our search, conducted in their State or region. Survey letters were sent to all State Manpower Planning Councils, Bureaus of Employment Security (Service), and D.O.L. Manpower Administration Regional Offices, i.e., more than 100 survey letters.[5] Responses were received from 35 percent of the agencies contacted, which was a sufficient number to assure that some direct response was received from all regions and all but 7 states.

Generally speaking, replies to the survey letters tended to fall into two classes. On the one hand, a large number of respondents indicated that they were aware of no local studies beyond those contained in the computer list--and not a few intimated that, in fact, they themselves had been unaware of some local studies listed in our letter. On the other, respondents identified additional local studies, the references having escaped all of the report networks utilized in the first stage of the search. It is somewhat reassuring to note that a large proportion of these items escaped attention because they were either too recent to have been included in the report network or too preliminary in format to be used outside the planning office. Nonetheless, the fact that some studies escaped our search procedure (at least initially) implies strongly that we were able to obtain, at best, a "sample" of the practice literature. As will be clear below, we believe this "sample" to be both large and representative. Accordingly, we believe that the materials available to us are more than adequate for general evaluative purposes.

The search procedure yielded citations for more than 500 studies and reports. Clearly, not all were included in the assessment. For instance, since we did not initially have detailed abstracts of a large number of studies, many were acquired but were excluded because they failed to meet the criteria for the practice literature as discussed above. This "winnowing" process reduced the number of items included in the relevant literature by almost a third. A small number of additional items were excluded either because the complete study (unlike its abstract) was not available to us, e.g., in cases where the study had been conducted by a private consulting firm and/or had not been reproduced in quantity, or because the study omitted suitable text materials relating to its objectives or methods. The number of studies ultimately included in the evaluation, then, totaled 376; these studies are listed in the "practice literature" bibliography appended to this report.

It seems clear that the sheer size of the practice literature requires taxonomic compression and a set of easily applied evaluative criteria for purposes of facilitating the assessment. Taxonomically, we require a relatively homogenous classification scheme for studies, which precludes the need for a tedious study-by-study approach as well as permits a broad gauge statement of the relative pattern of recent manpower planning efforts. We shall discuss this momentarily. The need for evaluative criteria is also straightforward, although considerably more difficult to specify. The next section considers this difficulty in some detail.

Evaluative Criteria

By definition, all of the studies included in the practice literature ultimately contain some statement about projected "requirements" of persons performing given occupational roles (in given industrial settings). More particularly, these studies include statements which may be interpreted as forecast ratios between "required" use of human resources at some future point in time and their present rate of utilization. Indeed, such a ratio is the common element in all of these studies; it may be represented symbolically as:

$$\frac{\sum_i \sum_j R^t_{ij}}{\sum_i \sum_j E^o_{ij}} \qquad \text{(V.1)}$$

where R and E represent "required" and observed utilization respectively the subscripts i and j represent industry and occupation respectively, and the superscripts refer to the beginning and terminal dates of the planning period. Fundamentally, what is at issue is the manner in which the R's and E's (but particularly the R's) in (1) are to be interpreted, the ways in which these interpretations differ among forecasting studies and (as should be clear from the discussion in Chapter I) the extent to which different computations serve the policy process differently. The objective of this section is to clarify this point; at the outset, it is critical to push beyond what frequently constitutes a major stumbling block in such discussions, viz., whether or not manpower forecasts should be evaluated in reference to their predictive accuracy.

It may be acknowledged at the outset that if manpower forecasts are conceived to be predictions (even certain kinds of conditional predictions) of future employment, then a principal criterion for evaluative purposes might be the accuracy of the estimates, i.e., the closeness of estimated and observed values for given points in time. That is, if R in (1) is interpreted to be identical to E, (i.e., $R^t_{ij} = E^t_{ij}$),

then tests for closeness between estimated values of E_{ij}^{t} and the observed value of E_{ij} at period t would be an appropriate criterion. And a rich literature is in the process of developing which could be exploited for methodological purposes.[6] There is a flaw in the argument, however, which relates to the objectives in making manpower projections in the first place.

Specifically, the projection qua employment estimate provides forecast interactions between the requirements for and the supply of given personnel. Although it is common to assume that employment data represent equilibrium positions in the current period, i.e., that they reflect simultaneously the number of workers required and supplied, there is no compelling reason to make this assumption for future projections. Indeed, the principal purpose of projections should be to detect interactions which are necessary to produce the value of the employment variable (i.e., balance) suggested by the criterion function. And it follows from our discussion in the first several Chapters that these interactions are conceived to involve trade-offs amongst the variables affecting requirements and supply as well as the interactions between the two. If we assume simply that requirements will be influenced by the level and composition of output (Q), technology (T) and policy (Pr) and that supply will be affected by individual behavior (I) and policy (Ps), then symbolically:

$$E_{ij}^{t} = F(Q_{i}^{t}, T_{ij}^{t}, P_{rij}^{t-o}; I_{j}^{t}, P_{sij}^{t-o}) \qquad (V.2)$$

where both subscripts and superscripts are identical to (V.1). Projections of employment per se, therefore, must be considered beginning not end points in the analysis, because they subsume all that is important for the manpower planner, viz., determining the necessary values of the P's. It is not clear, in other words, that there is any real informational value to the manpower planner in predictions of E_{ij}^{t}, because they fail to delineate the forces which ultimately shape the magnitude of this variable over time.

The implied use of projections in (V.2) differs significantly from the use of which predictive accuracy obtains. Yet, if predictions are made, it may be of interest to evaluate the "closeness" of predicted and actual values of some particular variable and, in particular, to evaluate its efficiency relative to a simple trend extrapolation. The latter, of course, is the principle purpose of the mean square deviation measure proposed by Theil.[7] This approach has been pursued in at least one case in the manpower projections field, and is perhaps illustrative of the problems involved. We refer to the study conducted by Moser who set for herself the task of evaluating the accuracy of area skill survey projections relative to the results of the naive model.[8]

Not surprisingly, Moser found that employer survey projections are rarely "better" or more efficient than trend extrapolations.[9]

But it is not apparent (to us) that this finding has any substantial meaning. The reason is that the comparison involves an employer's prediction of the number of workers he "wishes" to hire over short periods of time and the number actually hired. Strictly speaking, this comparison can be meaningful only if the employer assumes an infinite supply of such workers over the planning period, i.e., if employment decisions are independent of relative supply conditions. The difficulty is that employment decisions are unlikely to be independent in this sense, which implies that relative supply conditions (particularly in terms of responses to the projections themselves) must be accounted for in the evaluation. Moser's assessment, however, simply compares employer forecasts of job openings with future employment; consequently the effects (if any) of the intervention stemming from the forecast cannot be discerned. This casts doubt on both the conception of forecasting activity and on the validity of the evaluative criterion.

It follows from these comments that we are not persuaded predictive accuracy should be considered an over-riding criterion in evaluating manpower forecasts. Even if we were, it would be clearly difficult to evaluate the current state of the art in reference to this criterion, since a substantial number of recent studies have made projections for periods of a decade and longer. This implies either that attention be riveted on early studies, say, those conducted circa 1960, or that only some partial set of short-term studies be considered; neither is a particularly attractive alternative. On practical grounds alone, other criteria are required. Stated briefly, we believe that these criteria should reflect policy effectiveness rather than predictive efficiency, i.e., reflect the probable value of the projection exercise to the policy process which it serves. The question then is one of deciding which facets of projection studies indicate policy effectiveness. Our discussion in earlier chapters suggests at least three such indicators: a) the general relationship between the projection model and the policy issue(s); b) the internal consistency and relative completeness of the projection model; and c) the extent to which relevant costs and benefits are incorporated into the analysis. Each is discussed briefly in turn.

To begin with, as our comments in Chapter I suggest, all projections imply concern for some type of policy problem or issue. Such concern may be general or quite specific, and its effect on geographic focus, occupational and industry coverage, and time varies to a considerable degree. Nonetheless, policy concern is imbedded in projection studies, and it is essential that it be understood and evaluated. An obvious reason is that there is a set of policy questions that might well be handled more effectively by other analytic frameworks.[10] A less obvious, but perhaps more important, reason is that the nature and scope of forecasts, particular projections of requirements, may differ depending on the issues addressed. For in-

stance, estimates of future employment prospects (under ceteris paribus assumptions) for job matching purposes should differ from the kinds of forecasts used in assessing the manpower implications of alternative growth strategies. As will be seen, it proved extremely difficult to ascertain (except in indirect fashion) the policy intent of many projections studies. Thus, the extent to which studies manifest policy intent and demonstrate sensitivity to the relationship between the issue and the choice of projection technique becomes itself an important criterion of the policy-effectiveness of the study.

A second indicator relates primarily to the extent to which relevant components or facets of the analysis have been included, and may be referred to as the balance criterion. Of particular significance here is the question of whether or not "supply" estimates have been included in the analysis, and compared with forecasts of manpower requirements for purposes of determining the need for corrective policy actions. That is, projections of aggregate requirements per se indicate little that is worthwhile from a policy viewpoint; at a minimum, they must be compared to "supply" estimates to ascertain whether or not balance is likely to be achieved over the time period of the projection. As will be seen, many studies are ambiguous on this point.[11] In some cases, supply projections simply have not been made. In other cases, several types of "supply" estimates are included, but the differences amongst them are not carefully defined. In most studies, requirements are computed in a manner which is <u>not</u> independent of supply or policy response; comparison of these estimates against supply projections tends to confuse the analysis and probably leads to policy errors.

To clarify this point, it is important to recognize initially that all projections include some estimate of the potential size of the labor force over the planning period. In many cases, this estimate is implicit; in others, it is explicit and typically joined to both an employment target and productivity estimate to reach a first-round approximation of gross output. When the total labor force is accounted for in explicit fashion, forecasts of requirements must be interpreted as relating to occupational/industrial distributions; they cannot be compared to aggregate supply except through alternative policy simulations in which both employment and productivity are conceived to be policy variables. The <u>other</u> supply estimates needed for analytic purposes then refer to the supply of persons to specific industries and occupations. While we have omitted the detailed discussion of the literature which bears on this topic, the nature of the analysis is reasonably straightforward: losses from death, retirement, net migration and occupational mobility must be jointly determined and subtracted from supply or added to requirements. As suggested, a number of studies fail to include even this rudimentary component of the analysis. Nonetheless, these studies do contain assumptions about the size of the work force, and questions of policy effectiveness depend on the character of this assumption and the fashion in which it is used in the analysis.

By like token, it is important to recognize that requirements should be estimated in ways that are free of supply effects and policy responses. The difficulty here may be illustrated again in the reference to the use of employment data in forecasting exercises. As discussed above, employment figures per se and their use in projections, (typically, in the computation of productivity ratios) are ambiguous in the sense that they represent the outcome of interactions between supply and demand forces. When such data are utilized--particularly in trend extrapolations--they contain implicitly the assumption that supply will grow at a rate equal to its rate of change over the recent past. Stated differently, they contain some implicit notion about the direction of policy, prior to the point at which policy implications can be derived. This is akin to simultaneous equations bias in statistical analysis, and is important to the policy process because it presupposes ex ante something about ex post relationships. This implicit supposition violates the policy value of the exercise, e.g., it is possible that projected differences between "requirements" and supply can be misinterpreted and in attempting to achieve balance, policy responses may either over-shoot and under-shoot the target. From the point of view of both individual users of projections and social policy, this would clearly be an undesirable consequence of relying on forecasting activity. For this reason, it is an especially important indicator of policy effectiveness.

A final indicator of policy effectiveness relates to the extent to which projection studies emphasize the formulation and evaluation of alternative policy options designed to achieve balance, particularly in cases where substantial discontinuity with past relationships may be expected, and especially in terms of changes in goal structure, technology, and the configuration of supply policies. As a short hand expression, we refer to this as the cost-benefit criterion, and use it as an indicator of the fashion in which projections play a role in policy formation. The criterion is important because it stresses the volitional dimension of policy design in reference to manpower projections. That is, there does not appear (to us) to be any implicit requirement that policies, general or specific, must respond to projected situations of imbalance. Rather, as we argued earlier, projections assist in identifying areas where corrective policies may be needed and, in so doing, provide a framework for evaluating alternative programs designed to achieve balance.

Stated more strongly, there is no requirement that balance must always be achieved or achieved by changes in the same policy instruments that were used in the recent past. Practically speaking, the problem is that the fulfillment of almost any manpower goal can be interpreted as essential and that any policy or program can be interpreted as necessary to their achievement. Something beyond simple assertions, therefore, appears to be required. Ideally, projections studies would include an evaluation or "case" for attempting to achieve

balance or ignoring potential imbalance (or some choice in-between) as well as the use of specific combinations of policy instruments for achieving the prescribed goal. The evaluation, moreover, would be quantitative and comparable across program categories. This would, however, impose an unrealistically high standard on forecasting practice; an acceptable minimum might be simply that the need for rationalizing a decision to seek balance/imbalance and the means toward it be recognized. As will be seen, even this minimal condition is rarely met in most forecasting studies.

The indicators discussed above constitute the operational criteria for the state-of-the-art evaluation. Since they represent an amalgam of conceptual and methodological factors, they cannot be applied in separate fashion nor can they be quantified, ranked, etc., with any precision. Applied broadly, however, the criteria did prove to be sufficient to the task of distinguishing "best-practice" from "average-practice" studies, and thereby insights about the relative worth of projections to the policy process. Yet, it must be admitted that our conclusions would likely have emerged in similar fashion under almost any reasonable set of criteria. The reason is that the ambiguous and primitive nature of manpower projections simply cannot escape attention. It is important, nonetheless, to understand the ways in which projections are limited for policy purposes. We believe that the criteria set forth in this section help focus the discussion of these problems, and thus assist directly in the assessment of the state-of-the-art.

The Practice of Manpower Forecasting

As noted earlier, we identified more than 300 projection studies that had been completed over the period 1965-73. At first glance, there appears to be considerable diversity in this experience. The differences are more apparent than real, however, and the practice literature divides itself into a few relatively homogenous sub-sets along several different lines or dimensions. We have opted to classify studies along several dimensions, which (in our judgment) reflect essential policy and methodological characteristics. More particularly, we have categorized studies by their geographic focus and by the extent or scope of their occupational coverage. Within each of these classes, we have also tended to distinguish between studies using employer estimates of requirements and studies providing analytic projections of manpower needs. In addition to separating the literature into more homogenous sub-sets, the latter distinction is useful because it helps to pinpoint the recent pattern of manpower forecasting activity in the United States.

For instance, when one includes employer or skill surveys carried out over the past several years, manpower forecasting emerges principally as an activity conducted at the state/local level and dominated by

a concern for short-term training criteria. Indeed, as Table V.1 shows, slightly more than one half of all items in the "practice literature" are employer survey studies (the vast majority of which are "area skill surveys") and almost 42 percent of all studies were carried out in local areas or labor markets.

TABLE V.1

Percentage Distribution of the Practice Literature by Methodological Approach and Geographic Scope

Geographic Scope	Methodological Approach		Total
	Employer Survey	Analytic Projection	
Nation	2.7	9.4	12.1
State	19.8	26.5	46.3
Local	28.9	12.7	41.6
Total	51.4	48.6	100.0

In some ways, however, this is a misleading picture. For instance, and as we shall see, the employer survey method may be the least effective means for establishing manpower criteria. If we ignore this type of study, the relative amount of forecasting activity at the local level decreases substantially. On the other hand, studies using independently derived or "analytic" projections are dominated, numerically and otherwise, by the Bureau of Labor Statistic's Cooperative Industry/Occupation Matrix Program. Indeed, roughly two-thirds of the State level studies, and a slightly higher proportion of local studies (characterized as "analytic") have emerged from this program. While the remainder of the "practice literature" is quite varied, there is nonetheless a large block of studies that deal with health-related occupations.

Thus, it is difficult to provide easy generalizations about the direction and focus of recent manpower forecasting efforts, except to suggest that there are a number of relatively homogeneous but overlapping categories of activity which emerge in reference to geographic, methodological and substantive distinctions. In order to simplify the analysis, it seemed desirable to discuss as many of these categories as possible. Consequently, the remainder of this Chapter considers forecasting practice at the national level and at the level of State/local area. In each case we distinguish those studies which treat all occupations (i.e., global or economy-wide studies) from partial assess-

ments of a limited set of occupational categories. Subsequent Chapters consider the BLS Matrix Program and forecasting for health occupations in greater detail.

Manpower Forecasting at the National Level

The nature and scope of manpower forecasting at the national level reflects a major shift in emphasis in Federal policy since 1960. Early experience reflected a dominant concern with manpower constraints on economic growth or other, more specific national objectives and consisted of a diverse set of independent, partial projections of requirements in "shortage" occupations or dynamic economic sectors. In contrast, current practice reflects a dominant public concern with the incidence of unemployment on disadvantaged workers and the need for criteria for investment in "manpower" programs to enhance employability. These needs are reflected in the development of the BLS Industry/Occupation Matrix (hereafter referred to as the BLS Matrix) and other "global" (or economy-wide) projections of the industrial and occupational distribution of (total) employment.[12] Although these two sets of practice of experience are discussed here in sequence, they are not completely independent. Some of the more recent partial studies draw on the BLS Matrix or other global projections for estimates of the general parameters of change. Conversely, the BLS Matrix has drawn on prior sectoral studies for judgmental adjustments of trend data.

Global studies.--Experience in forecasting the occupational distribution of employment for the national economy is so recent and so limited that it is dominated by the projections program of the Bureau of Labor Statistics. As suggested above, it is for this reason that Chapter VI of this study is devoted to detailed description and evaluation of the Matrix approach. For present purposes, it is sufficient to note that the BLS Matrix approach is a requirements or capacity projection that is largely independent of the conditions of manpower supply; it is based, in large measure, on trend analysis and extrapolation.

More particularly, the Matrix is a four stage projection involving: a) a projection of output (GNP) based on historical trends in labor force growth and productivity, assumed unemployment of 3-4 percent and a set of environmental assumptions; b) the distribution of GNP among major components of final demand and among producing sectors within major components, on the basis of disaggregate consumption functions, historical trends and the environmental assumptions; c) a projection of terminal year sector output based on a 1965 input-output model derived from the 1956 OBE matrices, and the estimation of sector employment based on trend computations or regression analysis of sectoral changes in labor productivity; and d) the distribution of sector employment by occupation based on an extrapolation of inter-Censal changes in sectoral occupational structures.

In its present form, the policy value of the BLS Matrix is extremely limited. The major limitations are, on the one hand, the lack of any relationship between the estimates of requirements and the conditions of manpower supply and, on the other, the assumption of incremental change in technology and in the structure of final demand. When used as policy criteria, the approach implies that only supply conditions are subject to policy intervention (i.e., are dependent variables) and that they are variable without constraint. The approach tends to reinforce the supply focus of current manpower policy and, consequently, provides few, if any, explicit criteria for policy intervention in regard to the rate and pattern of technical change or changes in the structure of final demand. Much of the current dissatisfaction with manpower policy and programs stems from this limited prescription of the problem and related intervention strategy.

Although not extensive, there has been some experience gained in assessing the manpower implications of policy interventions directed at the structure of demand. The experience is illustrated by the National Planning Association (NPA) goal studies discussed in Chapter II and in the more recent studies of Roger Bezdek and Bezdek and Getzel.[13] For instance, the initial objective of the NPA study was to indicate the necessity of evaluating alternative goals and priorities in view of resource constraints; Lecht then extended the analysis into employment and occupational requirements. Unfortunately, his extension has had a very limited operational value perhaps because of the rather eclectic nature of the analysis. But it has demonstrated rather vividly the impact that alternative specifications of the social welfare function has on both employment and occupational structures. It showed, for example, that the social priorities suggested in the goals study would augment requirements for low-level and middle-level skills and provide relatively tight labor markets for currently disadvantaged workers.

The goals model has been extended in the Bezdek studies in more formal ways by positing two alternatives to the BLS Forecasts of the American Economy in 1980. The general forecasting procedure is sufficiently similar to the BLS projections that a description is not warranted here. The environmental assumptions used in the forecast are similar to those of the BLS projections and difference in outcomes are the results of differences in the specification of objective functions. One specification approximates the BLS projection, a second approximates the welfare or goals specification of the NPA study, and the third assumes a high level of expenditures for defense versus nondefense programs, in particular, social welfare, foreign aid, health and public housing. Comparison of the three projections indicate that both total employment and the occupational structure of employment are subject to significant variation as a function of differences in the functional distributions of GNP. Variance in employment between the

trend projection and the two alternatives was nearly 5 percent and between the alternatives, nearly 7 percent. Differences for some individual occupations were as high as 38 percent between trend and alternatives, and more than 70 percent between alternatives.

In both the NPA and Bezdek studies, structural effects of changes in final demand are products of public sector decisions, rather than changes in consumer tastes or product innovation. Both studies suggest the limitations of manpower forecasting in the absence of a long-term specification of national goals and priorities and the irrationality of investing in sophisticated estimates of individual preference functions without a similar effort in estimating collective preferences.

But all of these projection models incorporate technical progress simply through extrapolation, viz., as it is implied in changes in sectoral labor productivity ratios. The BLS projections of occupational change ratios are based largely on inter-censal extrapolations but are adjusted in the light of sectoral analysis of technical change in the development of the Occupational Outlook Handbook and in the detailed technological inventory in the BLS projection made for the National Commission on Technology, Automation and Economic Progress in 1964.[14] Although a more explicit specification of sectoral productions functions could improve the quality of the forecast, projections must treat alternative patterns of technical change if they are to provide operational criteria for rationalizing science policy and employment or manpower policy. It is obvious that macro-economic policies, particularly monetary and fiscal policies, have implicit effects on both the pattern and rate of technical change. Since these effects are not specified in explicit form, they cannot be evaluated internally or against other policy objectives. Thus, if both the commodity structure of output and the technical structure of production are treated as exogeneous to policy analysis, manpower policy is limited to interventions concerning the conditions of supply, and employment policy is constrained.

It is paradoxical that although these forecasting models treat the manpower supply as the principal policy variable, they limit the analysis of supply and demand relationships to the aggregate constraint imposed on requirements by the projected size of the labor force and the unemployment assumption. Clearly, the assumptions concerning the terminal year structure of production and the rate of productivity assume the availabilities of manpower with the prescribed mix of skills, and thus "successful" policy interventions. The difficulty is that the requirements criteria are communicated in aggregate fashion to a highly decentralized system of manpower institutions and labor markets. Each institution or individual is presumed to respond rationally to these criteria with little, if any, information relating to current supplies or the probable (supply) responses of other individuals or agencies over time. In the absence of any analytic link between requirements and supply, forecast information might well contribute to imbalance rather than reduce it.

The current practice of treating the link between requirements estimates and labor market and educational institutions is the Occupational Outlook Handbook which is the oldest manpower forecasting model in the United States and is (without question) the primary formal source of information for practitioners. It combines estimates of demand for more than 800 occupations, discounted for attrition, to job openings, combined with limited estimates of current supply rates and qualification standards. Estimates of demand are largely judgmental and based on trend analysis supplemented by establishment surveys and existing data from a variety of sources. The most recent editions of the Handbook are linked to the BLS Matrix although the nature of the linkage is rather difficult to discern from published sources.

A recent study by the same division of the BLS provides a more explicit statement of the sources of supply for more than 200 occupations and projected job openings in these occupations.[15] Requirements are based on the BLS projections and the supply estimates are derived from a variety of sources. The report notes that, "a major problem confronting manpower analysts is the paucity of data on current output of educational and training programs." and that, "data gaps in training statistics are the most severe restrictions to occupational analysis."[16] These gaps are most limiting in regard to highly decentralized programs such as private vocational schools and public manpower programs, and informal sources of supply such as on the job training and dropouts from the formal educational system. All such data are also limited qualitatively. They relate to training at entry rather than to career profiles and they provide no information concerning occupational entry rates or utilization rates.

The current state-of-the-art of global manpower forecasting may be reflected generally in the current programs of the Department of Labor designed to generate an institutional framework at the State level to enhance the distribution of occupational information. Although that program establishes elaborate guidelines for the dissemination of existing information on manpower requirements, it provides no stimulus for the generation of supply data. In the absence of a coordinated effort to rationalize requirements with supply flows, manpower forecasts can have only limited value for the labor market decisions of individuals or for program planning by supply institutions.

Partial projections.--Manpower projections for specific occupations or industries that are national in scope generally reflect the existence of a national labor market for these occupations or a strong public interest in the industry or activity. Typically, these projections are indicative of anticipated manpower shortages acting as constraints on Federal policies or programs, although some recent studies have been concerned with problems of excess supply. The latter include, in particular, the general class of college graduates and occupations characteristic of defense industries. The discussion in this section is limited to a few recent projections representative of

two principal types of partial projections: those generally treating broad classes of occupations, and those treating specific occupations unique to an industry of public interest.

National manpower policy prior to the 1970's focused on the supply of scientific and technical manpower, and with few exceptions, emphasized engineers and physical scientists and hence higher education as the principal source of supply.[17] This concern was initially stimulated by the cold war competition with the Soviet Union in space technology and the defense industry. It has been sustained by the interpretation of science policy as the rate of expenditure for research and development activities, and the diffusion of technology as labor embodied scientific knowledge and technical skills. This emphasis was reinforced in the early interpretation of the theoretical form of the human capital construct as the residual or third factor in economic growth. Education, in this interpretation, was a proxy for technology and consequently reflected in investment in high level skills.

The ensuing Federal Support for higher education and a high income elasticity of demand combined to produce an extraordinary growth in University enrollments and capacity and, in effect, a massive overadjustment to an apparent imbalance. The most recent of the series of projections by the National Science Foundation of the supply and utilization of doctorates in science and engineering indicates an excess supply in all included fields other than physical sciences.[18] The basic methodology of this study was to extrapolate degrees awarded in each sub-field as a ratio of projected bachelors degrees. Bachelors degrees awarded were projected by the Office of Education as a function of changes in the demographic structure and participation rates. The functional relationship was estimated by regression analysis of historical data to estimate the share of total bachelors degrees in the science area, the proportion of bachelors entering graduate study in the field, first year retention rates and degree completion rates. With these parameters, projections were computed for each field and adjusted on the basis of extrapolated data to 1969. The domestic additions to supply were adjusted for the effects of immigration, emigration and attrition to obtain the incremental supply.

The projections of requirements or utilization were disaggregated to four functional categories in each of the five sub-areas: academic utilization, non-academic R&D, other non-academic use, and replacement. Academic requirements were estimated as a function of graduate and undergraduate enrollments and of R&D funding in the academic area. Non-academic R&D utilization was projected as a function of the ratio of R&D expenditures to GNP. The expenditures ratio was extrapolated from historical or base period data and projected on the GNP estimates of the BLS Economic Growth model. Other non-academic utilization was estimated as field-specific growth rates in the ratio of this use to use in non-academic R&D. Two alternative projections were made for non-

academic utilization; one based on the 1970 ratio of R&D expenditures to GNP; the other based on the peak period ratio occurring in 1964.

A critique and extension of this study was published in 1974 by the National Board on Graduate Education, (NBGE) which among other things, adjusted the NSF projections for market effects.[19] This analysis has both technical and philosophic interest. It provides a rationalization for the use of manpower forecasts in policy formation that is markedly different from the report published by the NBGE in 1973 which rejected manpower forecasting as inconsistent with consumer sovereignty in the educational market.[20] While it raises the conventional complaint of market economists concerning the failure to use wages or prices as variables in the forecasting model, the (1974) NBGE critique also questions the NSF study's failure to treat interactions between supply and "demand" conditions. The point relates to the estimation of technical coefficients by linear extrapolation, particularly on the supply side, and hence the failure to adjust outcomes for supply responses to observed market surplus. Finally, it criticizes the NSF analysis for the exclusion of any policy variables, specifically subsidies and other social interventions to influence supply. The NBGE study then attempts to estimate the effects of the first two of these constraints by postulating a decline in average salaries, estimating price elasticity coefficients for both supply and demand, and adjusting the NSF projections to reflect the inverse effects on both sides of the market. Both the salary trend and the elasticities appear to be rather "rough and ready" approximations and hardly justify the derivation of precise quantitative conclusions. They do, however, illustrate the importance of treating system interdependence and, by implication, a major limitation of partial manpower forecasts.

A somewhat different treatment of market adjustment is illustrated in the Carnagie Commission study of college graduates.[21] Although this study contains projections of requirements for college graduates in 1980, it is essentially a labor market analysis rather than a structured forecast. Its requirements estimates are based on demographic factors or BLS estimates,[22] and its policy conclusions are extensive relative to their analytic and empirical base. It does, however, underscore an analytic component of importance to long-term forecasting--i.e., changes in qualification standards. It suggests that the market may be balanced by upgrading jobs or by an under utilization of college graduates in jobs with lower skill requirements. This type of substitution is particularly important in the United States because of the technician level gap in the educational system and reliance on the supply of "dropouts" from higher education to serve this labor market. An upgrading of technician level functions in response to a surplus of graduates would have important secondary effects on lower skill markets.

The overriding limitation of the partial studies treating broad categories of occupations is in their specification of the general parameters of change. Their assumptions concerning the structure of economic activity are derived from or parallel the BLS economic growth projections which are based on extrapolation of recent trends. The Lecht and Bezdek studies cited above demonstrate the demand effects of shifts on national priorities, in particular on the market for professional and technical manpower. The "future" and "quality of life" studies discussed in Chapter II above all suggest a society on the threshold of significant change in both goal structures and institutional forms. The least dramatic of these anticipated changes could reverse the shortage/surplus condition reflected in current forecasts and the majority of such changes will be implemented through collective action in the public sector. This failure to treat potential policy intervention in the determinants of requirements seriously limits the utility of these forecasts.

Unfortunately, the weaknesses of manpower forecasting in the absence of a long term framework for priority and policy analysis are also clearly evident in most of the partial forecasts of specific occupations reviewed for this analysis. Since similar studies are discussed below and in greater detail in Chapter VII we consider here four representative national level studies: two are derived from the NPA priorities analysis study and two reflect the manpower implications of crisis response to public concerns.[23] The former include an assessment of the manpower implications of the "poverty" and social welfare programs implicit in the NPA goal study.

The poverty study by Frumkin, for instance, attempts to specify the goal function for an anti-poverty program in the period 1965-1975, in terms of the (program) configuration of public expenditures designed to impact on some aspect of the poverty condition. These programs include income maintenance, education and training, health services, urban and area development, housing and other related activities. The employment effects of these "target" program budgets are calculated for all economic sectors by use of 1958 input-output matrix and distributed by occupations. Two target levels are estimated for the program set: one considered feasible if an only if the international environment permits a relative reduction in military expenditures; the other, a feasible target under current international conditions. The high alternative would require 75 billion dollars per year by 1975, and employment of 6.1 million workers. The low alternative would require annual expenditure of 59 billion and employment of 4.7 million compared to 2.8 million in the base year. Employment is disaggregated to 31 specific occupations and the supply estimated for each occupation from the current stock and from new entrants by conventional and admittedly simple techniques. The analysis suggests that goal attainment would be constrained by manpower shortages, particularly in professional and technical occupations, in the absence of supply interventions or the reduc-

tion of other social goals. These shortages could include more than 100,000 professional nurses, 50,000 teachers and 40,000 social welfare and recreational workers.

The second study in this set by Teeple concentrates on the requirements for social welfare workers implicit in the Frumkin study, placing greater emphasis on the effects of alternative technologies in the delivery system on the structure of manpower requirements.[24] It considers, for example, the substitution of a negative income tax for existing distributional procedures, the computer processing of information, the use of social worker aids, and other possible changes in delivery techniques. It also considers the potential development of community action programs and other forms of service delivery systems. Using the high growth assumption of the basic NPA Study, the author then distributes projected employment by field of practice and by function. These requirements are specified by source of supply. The principal conclusion of the study is that with anticipated changes in the structure and techniques of the delivery system, nearly half of all additional manpower requirements could be derived from high school graduates, associate degree programs and University drop-outs. The study is almost unique in its focus on the substitution possibilities in service delivery systems.

The second set of partial studies reflect the difficulties inherent in examining manpower requirements in reference to very short term specifications of the objective function. A study of the demand for highway safety specialists implicit in the Highway Safety Act of 1966, offers three alternative projections.[25] The study involves a very precise specification of the program elements set forth in the Act, the specification of job functions in each program element, the specification of job clusters in each set and the qualification standards associated with them. The study proceeds to inventory the current activity in each of the 50 states and evaluate the potential program structure (component weights) in each, through extensive interviews. Respondent estimates of manpower requirements in 1977 totaled 95,000 for the Nation in 1977, compared with a base period employment of 65,000. The interviews suggested a limited awareness among the officials of most States of the program implications of the Act and consequently the Act would not be implemented at a maximum level of effectiveness. The authors then estimated a production function for each program element and projected requirements associated with maximum and minimum effectiveness standards. The target year estimates of total employment for these assumptions ranged from 248,000 for the maximum effectiveness standard to 87,000 for the minimum standard, a difference that is nearly 250 percent of current employment.

In regard to this study, it may be noted that in contrast to the care devoted to the estimation of the program production functions and the specification of qualification standards, the estimation of

potential supply is extraordinarily simplistic. In brief, they estimated the proportion of high school, post-secondary and college graduates who would be "available" in each State as a function of the ratio of persons in each level of educational attainment to the population and the ratio of public sector employment to the population. On this basis, they conclude that there are potential shortages of high school graduates without University degrees and a surplus of persons with some college experience.

A methodically similar study estimates requirements for scientific and technical manpower requirements of selected segments of the atomic energy field.[26] A description of the methodology employed is not warranted here, other than to note that requirements are establishment estimates derived by survey. The study concludes that, in the projection period to 1973, a surplus of Ph.D. nuclear scientists and engineers is apparent while minor shortages exist in production engineers and technicians. They argue that, "with drastic cuts in government funds for research in the atomic energy field, these employment markets, at least in the near future, will not constitute a major source of demand for scientists and engineers in general or of nuclear degreed scientists in particular." The current dominance of energy problems and the importance attached to nuclear energy as a long-time solution, reflects both the limitation of public policy based on short-term criteria and manpower forecasting based on partial, short-term market estimates of future demand.

Manpower Forecasting at the State and Local Level

As suggested earlier, a majority of all manpower projection studies carried out over the past decade have been conducted at the level of the State or local (regional) area. Given the locus of educational decision-making in the United States and the requirement of recent Federal manpower and vocational education legislation that program development can be guided by assessments of occupational requirements, this is hardly surprising. The task of this section is to describe and evaluate this experience.

Our task is complicated by virtue of the diversity of State/local planning experience and performance. In particular, situational characteristics appear to lead to differences in both the nature and scope of projection studies, such that there is not one but several "typical" (modal) classes of analysis. While we expected that this might reflect differences in geographic focus, examination of the materials suggest otherwise. Indeed, as a result of recent efforts to link projections for various geographic areas or perhaps because of similarities in policy questions and technical planning capacity, there appeared to be insufficient reason to warrant treating local and State studies in separate fashion.

Differences between classes of studies, then, stems from characteristics other than geographic focus. As before, one difference which seems most striking relates to the degree of comprehensiveness or scope of these studies, defined in terms of the coverage of industries and/or number of occupations. Accordingly, subsequent sections of the discussion consider (in turn) studies which project total occupational requirements simultaneously and studies which project some partial set or subset of occupational requirements. As we shall see, comprehensive and partial studies differ in important respects, including the types of policy questions they address, their policy value, and their implications for effective organization for planning institutions.

Global projection studies.--A large number of global projection studies have been conducted by State Bureau's of Employment Service. One reason is that the Employment Service regularly compiles employment statistics by detailed industry category, and hence has available the requisite data base for such purposes. More important perhaps is that the State Bureau's of Employment Service receive Federal funding for the dissemination of labor market information, and have been instructed specifically in this regard to provide information on the employment "outlook" for specific occupations. As discussed earlier, it is difficult to interpret the results of projections carried out for such purposes. The difficulties, however, need not concern us for the moment.

What must be noted here is that there is considerable uniformity, methodologically and contextually, in State and local "economy-wide" projections. In our review of more than 100 such studies, we found that about half were remarkably similar applications of the Bureau of Labor Statistic's current industry-occupation matrix approach for long-run occupational employment projections. As Table V.2 shows, another quarter of the studies reviewed are closely related to this approach. Indeed, most of these studies can be though of as precursors to the major group of studies which follow the BLS Matrix approach, because

TABLE V.2

Number of State and Local
Global Projections Studies

Type of Study	Publication Dates	Number Reviewed
Total Number of Global Studies		107
BLS Matrix Approach	1969-1974	54
Precursors of BLS Matrix Approach	1963-1969	20
Variants of BLS Matrix Approach	1969-1974	5
Skill or Establishment Surveys	1964-1974	22
Other	1965-1970	6

most were completed before the publication of Tomorrow's Manpower Needs in 1969.[27] A few of these studies, however, were published since 1969 and represent conscious departures from Matrix approach.[28] The remainder of the studies included in our review are "skill" or establishment surveys. Although quite different from matrix studies in terms both of method and concept, many such surveys have been carried out by the Employment Service and, consequently, tend to vary little from state to state. Our search produced only a few global state and local studies which do not fall into any of the aforementioned categories.

As might be expected, there appears historically to have been a clear turning point in the development of global projection studies which coincides with the 1969 publication of the BLS's Tomorrow's Manpower Needs. The principal objective of this publication was to outline a method for State and local areas to produce manpower forecasts which account for national trends and local deviations from those trends. The method proposed for use by State and local practitioners has components identical to the national BLS analysis, viz., a set of detailed industry employment forecasts and an industry/occupation matrix which describes the projected occupation distribution of industry employment. The appealing feature is that both components can be constructed with only a fraction of the effort required at the national level.

For instance, projections of an area's employment by industry can be obtained by first extrapolating the area/national employment ratio over time for each industry and then applying target year ratios to national forecasts of employment by industry. An inexpensive method for a local estimate of the occupational distribution of employment is simply to assume that national patterns prevail in the local area. This is accomplished by applying national occupational coefficients to local estimates of employment by industry, adjusted in light of the errors that are produced when the coefficients are used to "estimate" current employment by occupation in the area. At slightly greater cost, an area can estimate base year occupational distributions and apply projected national "change" factors to these distributions to obtain a more reliable estimate of future staffing patterns.

These methods have been adopted rapidly over the past few years not only because they are relatively simple to carry out and draw upon the more extensive national analyses, but also because more traditional approaches, viz., the skill survey, have come under increasing attack. It should be noted that the availability of technical assistance from the Department of Labor has also contributed to the increasing reliance on the approach. Indeed for these reasons, it seems clear that the BLS matrix approach is now the dominant approach used to produce such forecasts at the State and local level. This underscores the need to treat the BLS approach in greater detail, and explains why we devote Chapter

VI to a case study of the approach and its various applications. Accordingly, the remainder of this section discusses the studies that are variants of the BLS method (since they are not treated in the next Chapter) and other techniques used in State/local global projection studies.

Studies characterized as variants of the BLS approach share with it the use of both an industry/occupation employment matrix and separate employment by industry projections, but differ to the extent that they incorporate additional detail or facets of policy problems, particularly on the supply side of the market. Recall that the BLS Matrix permits only the derivation of requirements; for many purposes, these figures must be joined to "supply" forecasts to produce an estimate of imbalance. A number of studies, therefore, have attempted to integrate labor "supply" and "requirements" projections, particularly to assess the implication of manpower "shortages" for the school system.[29]

Such studies tend, characteristically, to be limited in several important respects. One problem is that it is extremely difficult to interpret the meaning of balance or imbalance, because of the ambiguity surrounding the meaning of "requirements" or (stated differently) because of the absence of an explicit criterion function. As our discussion above suggested, the possibility that such projections may not, in fact, specify requirements casts some doubt on comparing them to "supply" estimates as a way of assessing corrective policy actions. Another limitation is that many of these studies define qualification standards simply in terms of the years of formal schooling; and they base requirements on the observed educational attainment of workers performing given occupational functions in the current period. For reasons suggested in Chapter IV, this procedure is likely to produce biased estimates of requirements defined in terms of educational equivalents.

It is worth noting in this regard a New York Study of requirements for technical occupations which provided a detailed description of job qualifications preferred by employers, as well as an assessment of hiring practices, promotional lines, and tests and licenses for specific occupational groups.[30] This information was derived from a 1962 employer's survey, and its use made the accompanying forecasts much more useful to educational planners than is typically the case. The New York study also made an interesting and somewhat unique effort to account for occupational mobility patterns in estimate "replacement needs." Again, data from the employer's survey was used: in this case the information related to the use of promotion versus outside hiring to fill job openings. Unfortunately, this interesting analysis has not been replicated, much less refined, over the course of the past decade, even by the agency that carried out the work.[31]

There is, however, a feature of the New York study which has been replicated; it deserves mention because it represents another kind of

departure from or variant of the standard BLS matrix approach. Specifically, it relates to the use of data generated from employers or establishment surveys to estimate the occupational distribution of industry employment. Several points are noteworthy in this regard. To begin with, while the establishment or skill survey has been the dominant form of forecasting activity at the State/local level over the past two decades, the number of global studies using this method appears to be significantly smaller now than it was even a few years ago. Indeed, it appears that BLS Matrix projections are replacing skill surveys, even though the two are designed for somewhat different purposes. More particularly, Matrix forecasts are long run (e.g., 10 year) trend projections, while skill surveys attempt to measure job openings expected in the much shorter time period (e.g., 1-2 years). Program planners, the most common users of both types, need short-run projections to indicate placement possibilities for current enrollees. Increasingly they seem to be using an interpolation of a longer run trend forecast for this purpose. This may be no less accurate than the skill survey forecasts available in the past, but does nothing to relieve pressures for needed labor market information in the current period.

Second, and perhaps more important, is the fact that skill survey data may be used as a complement to Matrix projections. An early recognition of this is reflected in the approach to local forecasting proposed by Norman Medvin.[32] Medvin's schemata involves using a long range national forecast together with current information on existing job vacancies for specific occupations. The job vacancy data are obtained from establishment surveys or, alternatively, from employment service records on unfilled job openings.[33] Although this approach may compromise too much, it must be given a high rating in cost-effectiveness terms. It is inexpensive compared to the studies mentioned above and provides a straightforward method for utilizing available data to a maximum extent.

More relevant to the current discussion, however, are studies which utilize establishment survey data to estimate current and future occupational distributions (not direct occupational forecasts), and thereby avoid the use of national BLS industry-occupation Matrix.[34] Clearly, State level projections using this method may not be altogether reliable because the design and sampling procedures typically used in skill surveys do not lend themselves easily to this use. But the use of local area data for projecting changes in local occupational distributions is quite appealing, particularly since measurement of the occupational distribution of employment during intercensal periods is almost non-existent in such areas. As we shall see, it is increasingly possible for local areas to use this method, especially those in States currently participating in the Occupational Employment Survey Program.[35] These surveys provide occupational information that is probably superior to the national data set available to the BLS. The reason is that the surveys are repeated a 3 year intervals. Unfortunately, at the

time of this writing, studies utilizing this new data source had yet to be completed; consequently, their evaluation must be deferred.

Finally, data from establishment surveys have been integrated with inter-industry forecasting models in ways designed to account more fully for the relationship between occupational structure and technological change. One of the most interesting efforts in this regard is the Kansas study conducted by Spellman.[36] Of interest here is that a State inter-industry model was initially used to project output and thence employment by detailed industry category. Then establishment survey data were utilized to obtain occupational distributions corresponding to technologically advanced or "best practice" firms, the coefficients of which were then used to project future occupational distributions of employment in specific industries. While Spellman fails to include supply estimates and hence precludes statements about potential imbalances, his requirements projections appear to represent substantial improvements over the use of standard BLS Matrix projections at the State/local level. Unfortunately, too few applications of this type of variant approach have been made to date to permit a fully adequate assessment. Given that the use of input-output and econometric forecasting models is increasingly common at the State level, it is hoped that further work along these lines will be carried out in the future.

Partial projection studies.--Manpower forecasting experience is nowhere more diffuse than in the number and type of partial analyses conducted at the State and local level. One might legitimately expect to find a large number of such studies because, in the absence of a highly developed set of planning institutions, they represent the only possible response to questions of immediate policy concern. To the extent that our search procedure yielded a representative sample of recent forecasting studies, this expectation seems to be borne out. Not unlike the studies discussed above, however, partial analyses frequently are inadequate for policy purposes. For example, important facets of the policy problem are ignored, components of requirements and supply projections are omitted, and alternative policy options and the relative costs and benefits (broadly defined) of achieving policy solutions are rarely included. Some doubt, in other words, may be expressed at the outset about the policy "worthiness" or value of such exercises. Given the foregoing, we may limit our remarks to the following points.

To begin with, this class of forecasting studies is concerned almost exclusively with developing limited criteria for immediate and non-recurrent formal educational decisions, i.e., projections are undertaken to guide the direction and magnitude of changes in specific formal school programs or courses, typically to establish lower limits on the expansion path of enrollments.[37] An immediate implication is that alternative policy responses are rarely, if ever, considered. The underlying premise (frequently implicit) appears to be that if requirements

are forecast to increase over time, they must be matched by additions to educational capacity. In mirror image terms, this implies that educational program activity must adjust pari passu to projected changes in labor market activity. Requirements, however, are not assumed to be subject to policy manipulation, i.e., they are typically assumed to be exogenous, and there is rarely an analysis of alternative sources of supply. The latter assumes greater significance, of course, the smaller the geographic focus of the analysis--given the observed differential in migration patterns of trained personnel. If for no other reason, these omissions cast doubt on the value of the forecasts to policy makers and individual users.

In the case of supply, for example, the absence of alternative policy responses unquestionably leads to imprecise estimates of the change in educational capacity required to achieve balance over time. In the case of (exogenous) requirements, the difficulty is that almost any policy can be considered essential to its achievement, irrespective of its relative costs and benefits. Generally speaking, partial studies are quite ambiguous on this point. Many appear to product indirect estimates of future demand for output or direct estimates of derived demand, under the assumption of constant economic and technological conditions. Since impact or goal statements are infrequently specified, the forecasting studies find it difficult to clarify why supply must necessarily equal demand, i.e., why balance must be struck. Stated differently, it is rare to encounter a statement of the costs associated with failure to achieve balance or the benefits stemming from its achievement in these studies. The implicit dictate appears simply to be that balance should be achieved where feasible. The dictate, of course is both inefficient and inconsistent with the notion of the policy model.

It is possible--indeed, highly probable, in terms of the studies at hand--that the omission of relevant policy variables stems from the use of projections as rationalizations for program expansion. In fact, in many cases it appears that projections are employed ex post to document a policy position that had been arrived at earlier on different grounds. There are at least two possible reasons for this: First, forecasts have the appearance of scientific "evidence," which can be used to buttress a case for shifting policy. And when the nature of the forecast is ambiguous, the odds favor "positive" findings, i.e., figures need not be purposely manipulated to show that program expansion is essential. Second and more important, groups engaged in preparing these forecasts are frequently those who will be most affected by changes in policy.[38] This is an unfortunate by-product of the weak institutional base for manpower planning, i.e., the absence of continuing institutional support creates a need to rely on ad-hoc groups to sponsor and conduct studies. All too frequently these ad hoc groups are composed entirely of representatives of the professional group and/or the training institutions which prepare persons for the occupation in

question: committees charged with the responsibility of projecting requirements for some occupational group (or cluster) x are typically persons performing occupational function x or currently involved in training students for a career in x. Surely few would deny such groups the right to participate in policy deliberations, but their control of forecasting activities precludes the incorporation of the broader set of community values or relevant technical expertise in the analysis.

Several characteristic weaknesses of this class of forecasts are perhaps explained by these factors. For one thing, partial projection studies are technically and methodologically quite weak. In fact, we were unable to identify a "best practice" technique in any of the analyses under review.[39] For another, there are few (if any) follow-up evaluations of either forecasts or policies, principally as a result of the ad hoc nature of these activities. This also contributes to the general absence of cumulative experience of "learning" in projections work. For instance, not only is experience gained at the national level or in other local areas frequently absent from studies in a given area, but we encountered several cases where forecasts had been prepared for a given area, but were ignored, or at least unexploited by, a study group in that area charged with the responsibility of forecasting similar manpower requirements. Clearly, none of this augers well for the value or relevance of forecasting studies to the decision process.

Some additional comment about the methodological deficiencies of this class of studies appears warranted. More particularly, the problems relate to the projection of requirements for personnel which are independent of an explicit and defensible output strategy. The problem is manifested, in the first instance, in the extensive use of the employer survey as a means of forecasting requirements. Since we have already discussed this technique (and will return to it) little needs to be said here, except to indicate that the range of specific occupations or policy areas for which it has been used is considerable. For instance, establishment surveys have been used to estimate requirements for public administration manpower in Iowa and Illinois, architects in Florida, librarians in Appalachia, and data processing and related personnel in Indianapolis.[40] It is not clear that such methods provide reasonable results, because of the mobility patterns of highly-trained occupational groups as well as their pattern of self-employment. Given the long lead time necessary to prepare persons for these occupational roles, a greater difficulty is caused by the short time-frame typically used in the employer survey design. Each of these factors casts doubt on the results of these studies.

More important in this regard is that partial studies typically forecast requirements in reference to ratios, e.g., occupation/population, or trend analyses of employment. Although these methods are not

uncommon, their use in these studies seems relatively more frequent. Indeed, no analytic projections of requirements in the set of partial studies under review here were based on methods other than ratios or trend extrapolations. This somewhat surprising result implies that none of the studies reviewed here was based upon an explicit consideration of output, i.e., all projection exercises were carried out in terms of input variables. The principal disadvantage of these techniques are clear from a policy view. There are also problems, strictly speaking, with them in methodological terms. The most important is that the estimates include undetermined effects of both past supply and demand forces. Both, of course, lead to dubious policy results.

The State of the Art: An Interim Judgment

Rashi Fein has observed that many manpower studies:[41]

> . . . have been subject to the criticism that they have set manpower goals without sufficient analysis of the benefits and costs of achieving those goals and of alternative ways of reaching (them). . . It has never been clear, however, that the critic's framework and methodology, however sophisticated and rigorous, could be applied to the data that were currently available. Public policy was forced either to rely on the statistics that could be mustered and on observation and judgment or to 'do nothing.' Doing nothing, however, is a positive act: a rejection of the data and the judgments, the adoption of wait and see policy. . .
>
> This is not an argument for bad research rather than no research, bad methodology rather than no methodology, bad advice rather than no advice. Rather, it is a recognition that criticism of methodology or of research is of little immediate assistance to the policy maker unless a better methodology is available and can be used.

Surely Fein's admonition to the critic is appropriate, and a point that we have attempted to bear in mind throughout our assessment of the practice literature. His comments provide here a point of departure for some general conclusions from the assessment thus far, particularly in the sense that not a great deal that is "wrong" with recent forecasting activity relates to information, methodology or technique per se. Rather, much relates to the concepts involved, beginning with the perceptions of policy issues themselves and the role to be played by projection exercises in the design of policy responses. We have seen, for instance, that the dominant forms of forecasting activity, especially the BLS Matrix approach, provide only partial pieces of information needed for decision making and, in so doing, tend to beg the question of why such information is required in the first place. Stated some-

what differently, too many forecasts are prepared for either "all" purposes or specific purposes that are only vaguely stated, such that they violate the necessary and sufficient conditions for assisting in policy deliberations. It is clear (at least thus far) that this conclusion is deduced from the completeness and cost-benefit characteristics of the forecasts reviewed; although indirect, we believe that the conclusion is important and worth emphasizing.

Let us stress that this criticism does not imply that manpower forecasts are inappropriate and should be abandoned in favor of stricter reliance on market solutions or other types of analytic or process tools for decision making. To the contrary, we believe that there is substantial benefits to be gained--from the viewpoint of both social and institutional policy as well as individual users--from an adequate flow of such information. This need not blind us, however, to the fact that the quality of existing forecasts is infrequently sufficient to serve these needs. And in certain important respects, the quality of the forecasts will not be enhanced by narrow refinements in forecasting technique per se. Indeed the juxtaposition of the knowledge base assessment in Chapters II-IV and the description in the present Chapter suggests that, weak as it may be, a substantial amount of what we already know (methodologically and empirically) has not been exploited for planning purposes. This implies, on the one hand, that there are limiting factors which must be sought outside the framework of analytic refinement and, on the other, that questions of methodology necessarily depend upon the manner in which the limiting factors are dealt with. Simply put, our general reading of the practice literature suggests that forecasting activity is limited principally in terms of its conceptual and institutional framework.

By this is meant that forecasts are limited by the manner in which they are used in policy deliberations and by the absence of a set of organized and stable institutional relationships which link the preparation and use of forecasts. In the first case, manpower forecasts too frequently emphasize expectation rather than intention and, in so doing, turn a potentially useful policy tool into an unsophisticated "guessing game" which likely misleads more than it enlightens. Furthermore, as was observed repeatedly in the discussion, many projection studies omit important components, such that they fail to establish meaningful criteria for policy purposes. To be sure, one reason for these omissions is the absence of appropriate data; in particular, the difficulties encountered in obtaining program information for supply calculations are real and costly to overcome. In some measure, however, the omissions reflect the perceived role of forecasts as a set of general criteria or guidelines to which independent policy makers and individuals may respond. Presumably, these responses are made as if they have no (interdependent) consequences or, stated differently, that they are always consistent with one another. The presumption

appears realistic because forecasts are used, in this country, in reference to a predominantly decentralized set of actors and institutions. The issue is whether forecasts can serve any useful purpose in such a framework or whether their use depends on a different conception of their role.

The concept of forecasting roles is manifested in and buttressed by the set of institutions which prepare and use manpower projections. We have seen that, with the exception of BLS Cooperative Matrix Program, the vast majority of forecasting studies are ad hoc in nature, and conducted as a substitute for institutional linkage. Although this is, at best, an inference from our reading of the practice literature, the absence of systematic relationships among institutions affecting the balance between human resource uses and endowments creates conditions which simultaneously foster the need for forecasts and misuse them. This paradox can be resolved only by recognizing that institutional development and coordination, especially the creation of planning institutions which have sufficient resources to carry out forecasting activities on a continuing basis, is required. In the absence of such an institutional commitment, forecasting is unlikely to improve nor is it likely to serve the policy process more effectively than it has over the recent past.

NOTES TO CHAPTER V

[1]It should be noted that an extensive review was made of recent State CAMPS Plans in preparing this Chapter. The review suggested that manpower forecasts were infrequently used as criteria in CAMPS programming activities. Although some reports included sets of occupational forecasts, the projections were invariably prepared by other governmental divisions and were available in the form of special reports, technical documents, etc. For this reason, we excluded CAMPS Plans from further consideration; reference reports containing occupational forecasts, however, are included in the "practice literature" as defined below and listed in the bibliography.

[2]AIM/ARM is published by the Center for Vocational Education, The Ohio State University. This Center was, until 1973, an ERIC clearinghouse.

[3]MIC is a computerized information source accessed through the use of "key-words" in a fixed thesaurus.

[4]NTIS houses, indexes, abstracts, and makes available for sale all Federally funded research.

[5]Also included were Offices of the Governor and other governmental divisions responsible for manpower planning activity.

[6]See, for example, H. Theil, Applied Economic Forecasting, (Amsterdam: North-Holland Publishing Company, 1971), especially Chapter 2.

[7]Ibid.

[8]C. Moser, "An Evaluation of Area Skill Surveys as a Basis for Manpower Policies." Ph.D. Disseration, University of Wisconsin, 1971). In this regard also see J. Wellemeyer, An Appraisal of Area Skill Surveys in Battle Creek, Michigan and Trenton, New Jersey, (Washington, U.S. Department of Labor, Bureau of Employment Security, 1965); A. Weber et al., Labor Market Information and the Federal-State Employment Service System. Report by the Advisory Committee on Research to the U.S. Employment Service, (Washington, D.C.: February 1968); and Macro Systems, Inc., Evaluation of the Occupational Training Information System, (OTIS), (Silver Springs, Md.: n.d.)(A project report prepared for the U.S. Department of Commerce, Economic Development Administration.)

[9]Moser, op. cit.

[10]It should be noted that the policy effectiveness of manpower forecasting must ultimately be evaluated with respect to other types of policy models or tools, e.g., cost benefit studies. Clearly, this task is beyond the scope of the present study.

[11]C.f., W.L. Hansen, "Labor Force and Occupational Projections," IRRA Proceedings of the 18th Annual Winter Meetings (1966), pp. 10-20.

[12]See U.S. Department of Labor, Bureau of Labor Statistics, Tomorrow's Manpower Needs, I-IV (Washington, D.C.: 1972).

[13]National Planning Association, Manpower Requirements for National Objectives in the 1970's, Summary. National/Regional Economic Projections Series Report No. 68-J-2, (Washington, D.C.: 1968); R. Bezdek, "Alternate Manpower Forecasts for the Coming Decade: Second Guessing the U.S. Department of Labor," Socio-Economic Planning Sciences, VII (1973), 511-21; and R. Bezdek and B. Getzel, "Alternate Forecasts of the Job Content and Skill Requirements of the U.S. Economy in 1980," Technological Forecasting and Social Change, V (1973), 205-214. It should be noted here that the Bezdek studies are considered primarily to be methodological probes; accordingly, we have excluded them from the "practice literature" per se.

[14]See, America's Industrial and Occupational Requirements, U.S. National Commission on Technology, Automation, and Economic Progress Outlook for Technological Change and Employment. Technology and the American Economy, Appendix, Vol. I (Washington, D.C.: 1966).

[15]U.S. Bureau of Labor Statistics, Occupational Manpower and Training Needs: Information for Planning Training Programs for the 1970's. Bulletin 1701 (Washington, D.C.: 1971).

[16]Ibid., pp. 2-3.

[17]Emphasis was also placed on health service personnel. Since we deal with these occupational groups in Chapter VII, we exclude specific comment on them in this section.

[18]U.S. National Science Foundation, 1969 and 1980 Science and Engineering Doctorate Supply and Utilization (Washington, D.C.: 1971).

[19]R. Freeman and D. Breneman, Forecasting the Ph.D. Labor Market: Pitfalls for Policy (Washington, D.C.: National Board on Graduate Education, 1974).

[20]National Board on Graduate Education, Doctorate Manpower Forecasts and Policy (Washington, D.C.: 1973).

[21]Carnegie Commission of Higher Education, College Graduates and Jobs, (New York: McGraw-Hill, 1973).

[22]Bureau of Labor Statistics, op. cit.

[23]Norman Frumkin, Manpower Implications of Alternative Priorities for Coping With Poverty (Washington, D.C.: National Planning Association, 1969); John Teeple, Implications of Career Openings in Social Welfare Occupations for Priorities in Vocational-Technical Education. Working Paper (Washington, D.C.: National Planning Association, 1968); Booz, Allen and Hamilton, Safety Specialist Manpower (3 vols.), (Washington, D.C.: 1968); Keith L. Voight, Scientific and Technical Manpower Requirements of Selected Segments of the Atomic Energy Field, Final Report, (Oak Ridge, Tenn.: Atomic Energy Commission, 1970).

[24]Teeple, op. cit.

[25]Booz, Allen and Hamilton, op. cit.

[26]Voight, op. cit.

[27]Bureau of Labor Statistics, op. cit.

[28]For instance, see R. Spellman, Projections for Occupational Requirements for Kansas in 1980 Ph.D. Dissertation, Kansas State University, 1970).

[29]See, for example, Battelle Memorial Institute, The Michigan Manpower Study, (Columbus, Ohio: 1966); and C. Palomba, Occupational Requirements for Iowa, 1975 (Ames, Iowa: Ph.D. Dissertation, Iowa State University, 1969).

[30]New York Department of Labor, Division of Research and Statistics, Technical Manpower in New York State, 2 volumes with supplements (1964).

[31]C.f., H. Solomon, Manpower Needs in Health Services, (Albany: New York State Department of Labor, 1969).

[32]Norman Medvin, "Occupational Job Requirements: A Short Cut Approach to Long Range Forecasting," Employment Service Review, Vol. (January/February, 1967), pp.

[33]C.F., Virginia Employment Commission, Annual Report on State and Selected Areas Occupational Requirements for Vocational Education.

[34]See, Alaska State Department of Labor, Employment Security Division, Alaska's Manpower Outlook, 1970's (Juneau: 1970); Oregon State Department of Human Resources, Employment Division, A Presenta-

tion of Oregon's Current Occupational Employment Statistics Program, (1972).

[35]Harold Goldstein, "The New Federal-State Occupational Employment Statistics Program," Monthly Labor Review, XCIV, No. 10 (October, 1971), and Robert Glenney, "The Occupational Employment Statistics Survey Redirection--Status and Plans," Selected Papers from the North American Conference on Labor Statistics, June 18-21, 1973, Miami Beach, Florida (U.S. Bureau of Labor Statistics: U.S. Government Printing Office.

[36]Loc. cit. See also D. Watson, An Input-Output Model for State Manpower Projections (Eugene: Oregon University, Bureau of Business and Economic Research, 1970).

[37]This type of analysis is illustrated by the numerous studies conducted by Lisack and his associates in Indiana.

[38]Indeed, we encountered (in published form) few advisory or ad hoc committees charged with the responsibility of conducting forecasting studies which did not appear to be composed entirely of persons or institutions most affected by possible changes in policy.

[39]The fact is that a considerable number of partial studies represented substantial departures from "average" practice.

[40]E.R. Czarnecki, Planning for Public Manpower Requirements (Iowa City: University of Iowa, 1969); T. Vocino, Professional, Administrative, and Technical Manpower in Illinois Local Government (Carbondale: Southern Illinois University, 1969); B. Mitchell and D. Wittenberg, Study of Florida's Future Needs for Architects: 1973 (Tallahassee: Board of Regents, State University System, 1974); J. Ayers, Library Staff Needs in Southern Appalachian Schools (Cookeville: Tennessee Technological University, 1972); and J. P. Lisack and A.R. Sadaka, Computer and Electronic Data Processing Manpower Requirements for Indianapolis, Indiana. Manpower Report 67-2 (Lafayette, Indiana: Purdue University, 1972).

[41]The Doctor Shortage (Washington, D.C.: The Brookings Institution, 1967), p. 5.

CHAPTER VI

THE BLS MATRIX APPROACH TO MANPOWER FORECASTING: A DETAILED EXAMINATION

Introduction

The BLS matrix approach to manpower forecasting is based on the simple observation that long run changes in the occupational structure stem from two distinct sources: changes in the composition of output and changes in the technology and organization of the productive process. This observation is used to justify the separation of the BLS forecasting methodology into two component parts: one dealing with the projection of industrial output and employment and the other dealing with the projection of the occupational structure within each industry in the economy. This Chapter extends the description of the BLS approach given in Chapter V by discussing these methodological components in considerably greater detail. It does so because the validity and usefulness of the BLS forecasts depend very much on implementation details. Chapter VI also discusses State and local applications of the BLS matrix approach in more detail, and attempts to evaluate it from the point of view of the principal users of manpower forecasts in these areas. In both cases, the principal objective is to further our understanding of one of the dominant forms of manpower forecasting in this country, and thus provide a more detailed basis for the state of the art evaluation.

A Closer Look at the National BLS Matrix Methodology

Most of the work of the BLS in implementing its Matrix methodology is summarized in a multi-volume publication, Tomorrow's Manpower Needs (TMN).[1] Our discussion of the methodology draws heavily upon this publication. It also draws upon other reports and on interviews with BLS personnel. One problem encountered in attempting to describe the BLS Matrix methodology is that it changed somewhat in detail as projections were revised using more recently generated data. Generally speaking, the discussion relates to current practices of the BLS. The one exception to this is some preliminary work recently carried out which uses 1970 Census data. Since this work was done under the pressure of time constraints and used less sophisticated methods than had been used with the earlier data, we deal mainly with the earlier methods on the plausible assumption that they will again be used in future work.

The Size of the Matrix

The choice of an occupational classification system and the level of occupational aggregation was largely dictated to the BLS

by the practical consideration of data availability. The Decennial Census is the only comprehensive national data source currently available to describe the existing pattern of employment by occupation within detailed industries. The Matrix now used by the BLS is as large as is permitted by the Census classifications, i.e., slightly more than 400 occupations by more than 200 industries. The BLS decision to forecast employment for more than 400 occupations was influenced by feed-back from users. Many users complained that earlier forecasts (based on a modified 1960 Census Occupational Classification) were of limited use because of excessive aggregation of occupations. For example, the revised projections published in the 1971 volume of TMN included only 160 occupation categories. Furthermore, 40 percent of total national employment in 1980 was projected to occur in seven broad "not elsewhere classified" categories. Other things equal, the more detailed occupational classification system now in use by the BLS should increase the utility of the BLS projections to users who depend on them for vocational education planning, career counseling, etc.

However, other things are not equal. There is strong reason to believe that occupational disaggregation carries with it a greater margin of error. One simple reason is that projection errors tend to "cancel out" when two or more detailed categories are combined into one group. Another reason is that disaggregation increases data problems. We know that household survey data on the occupation of employed persons is not wholly accurate and, further, that the probability of misclassification increases with the level of occupational disaggregation. For example, the problem of a technician identifying himself as an engineer vanishes when engineers and technicians are lumped together in the same occupational group. Another data problem is the difficulty in obtaining historical series for projection purposes when a highly detailed classification system is used. Since the BLS uses the extrapolation of historical trends to project changes in the occupational distribution of industrial employment, it needs both base year data and historical time series. Since it uses the detailed 1970 occupation classification system, it must disaggregate the 1960 (occupation by industry) Matrix to be comparable with the 1970 classifications. This involves greater error in estimation than would result from aggregating the 1970 data up to the 1960 Census categories.

Projecting Employment by Industry

The procedures used by the BLS to derive industry employment projections from a projection of aggregate potential GNP for the target year are complex. Since a fairly detailed description is available elsewhere, and discussed in Chapter II, it is necessary here only to recall that the industry employment projections are based on an assumed level of total employment. Thus, it is really only the distribution of total employment among detailed industry categories that

is being projected. It is also useful to recall that the occupational employment forecasts published by the BLS (and the industry employment projections upon which they are based) are intended to describe long run trends--not cyclical deviations from those trends.

The BLS uses two quite different methods of analysis to project employment by industry. One of these uses input-output analysis and depends heavily on the work of the Interagency Economic Growth Project. This approach separates changes in industry employment into two components: output change and labor productivity change. Industry output change is projected with the aid of an input-output model comprising 80 industries with interindustry coefficients projected to the target year as discussed above. Industry output forecasts are combined with projections of the level of output per worker to project total employment in each of the 80 industries.

In attempting to evaluate the reliability of these employment projections we may note, as others have, that of the three sources of change in industry employment, (final demand, unit labor requirements, and interindustry relationships) the last two are very difficult to project.[2] The projection of future input-output coefficients faces a number of well-known problems, e.g., anticipating changes in technology and product mix for detailed industrial categories), but there is at least some evidence to suggest that variations in these coefficients (within plausible ranges) are likely to have only a minor impact on the industrial distribution of total employment. However, the study which suggests this conclusion, viz., the work by Kutscher and Jacobs, also indicates that projections of the distribution of total employment among detailed industries are quite sensitive to plausible variations in the projection of unit labor requirements.[3] This is cause for concern because BLS efforts to develop statistical models for projecting output per manhour for detailed industries have been largely unsuccessful. As a consequence, the BLS still uses simple extrapolation techniques to project output per manhour in most industries.

In addition to the method just summarized, the BLS also projects detailed industry employment using multiple regression analysis of time series data. The independent variables in these regressions include, among others, the major components of GNP. The regression analysis method of projecting industry employment generally ignores interindustry relationships and treats labor productivity implicitly, but does allow for forecasts of more detailed industry categories than is possible with the 80 industry input-output table. This is important because the BLS manpower matrix is now disaggregated to more than 200 industry categories so the employment projections produced with the aid of the input-output table cannot be used without further disaggregation.

The BLS, however, does not simply use the regression method projections alone to disaggregate the industry employment projections produced by the input-output method. All of the models used to project employment by industry are recognized as imperfect. The standard error of the estimate of the regression models used to project individual industries, together with the differences between the regression method results and the results of the input-output method for specific industries, help to indicate to the analysts the margin of error that is involved. Analysts then distribute the assumed total employment for the target year with the help of projections produced by both of these methods as well as qualitative information about changes in technology and the industrial structure which is not specifically incorporated in the projection models.

Projecting the Occupational Distribution of Employment

The projection of the occupational composition of employment in given industries clearly is a key element of the BLS Matrix approach. It assumes greater significance when one considers the fact that changes in product mix probably account for less than half of the variation in growth rates among detailed occupational categories.[4] Juxtaposed to the increasing demands of users for more occupational detail, it is easy to understand why the BLS devotes considerable energy to the task, and why it has decided to use the full level of occupational detail available in the 1970 Census for forecasting purposes.

BLS projections of employment by occupation are made in a sequence of three steps. First, data are gathered to provide an accurate description of the occupation composition of employment in the base year of the forecasting period, and at least one earlier point in time. Second, changes in the occupational structure are extrapolated into the future to produce tentative projections for the target year of the forecast period. Finally, the extrapolated projections are adjusted by labor market analysts with detailed knowledge of given industries. Recent efforts by the BLS to project the occupational structure in 1980 focused primarily on the development of an accurate statistical description of the 1960 and 1970 occupational structure. A brief account of the procedures followed in estimating employment by occupation in 1970 may indicate the complexity of the process.

The BLS begins with Decennial Census data on the distribution of employment among 417 occupations for each of 215 industries. An initial requirement is to adjust Census figures so that they will reflect annual average employment in 1970 instead of employment during the April Census week. Unfortunately, it is not possible to adjust Census data to an annual basis without relying on other data sources. Since there is no other single source of detailed occupational data by industry category, this means that a number of disparate sources must

be used. The list of non-Census sources used by the BLS to make these adjustments is extensive: it includes the Current Population Survey; establishment surveys of non-agricultural wage and salary employment conducted by the BLS and cooperating State agencies; BLS annual surveys of occupational wage rates or employment by occupation in the telephone, railroad and air transportation industries; U.S. Civil Service Commission statistics on employment by occupation in the Federal Government; statistics on selected professional occupations based on licensing data and membership records of professional societies; and surveys of employers by the BLS and other agencies to obtain estimates of employment in a limited number of important occupations such as scientists, engineers, teachers and policemen.

Since there are differences between the Census and these other data sources in terms of occupation and industry classification, coverage, and time periods, a good deal of effort is expended to adjust Census figures to conform with these other sources. But, when separate adjustments are made to industry employment totals, occupation employment totals, and some of the details of the occupational detail within industries, rows and columns in the occupation and industry matrix no longer sum to occupation and industry employment totals. To assure consistency, the BLS makes further adjustments using an iterative, forcing procedure. Similar procedures were followed in adjusting the 1960 Census data set, but the task was even more complicated given the differences in the Census classification systems used in 1960 and 1970.

In comparison with the data assembly effort, the extrapolation of historical trends in changes in the occupations distribution is simple. The historical record consists of a time series with only two observations so there is no payoff from sophisticated curve fitting procedures. The BLS computes both the absolute and proportional change in occupation $\underline{i}$ in the j^{th} industry over the period 1960-1970, and projects that change to occur again between 1970-1980. Understandably, with more than 400 occupations, most cells in each industry will be very small. Under these circumstances, use of absolute changes for extrapolation purposes can produce absurd results when the absolute change is negative and larger than the 1970 value. Since use of the percentage change also produces extreme results if the percentage change is positive and very large, the BLS uses the percentage change when the change is negative and the absolute change when the change is positive. Nonetheless, the mechanical extrapolation process is simple in both execution and conception. Whatever may have been the causes of changes in the occupational structure over the recent past, these changes are assumed to continue into the future.

The final step in the projection method is the adjustment of the projected occupational structure by labor market analysts who are called upon to question the reasonableness of the extrapolation.

Clearly, this is an almost overpowering job: analysts must evaluate the projected change in each cell of a matrix with almost 90,000 cells. To do the job correctly, analysts must call on their detailed knowledge of particular industries to explain why past changes in occupation distributions occurred and to judge how past trends may be modified by current and expected future developments in the industry. To make this job manageable, the analysts concentrate their attention on only a fraction of the 417 cells in each industry: those which are relatively large and those which, though small, have changed significantly in the past. Further, each analyst specializes in the study of a small number of industries in the normal course of his duties at the BLS, and thus has the advantage of years of relevant experience. For the particular industry in question, the analyst maintains a file of specialized reports and studies performed in the past by the BLS and others, assists in the preparation of new BLS studies, helps to update relevant sections of the Occupational Outlook Handbook, and generally attempts to keep abreast of all kinds of industry conditions and changes relevant to his duties. In some cases the analyst will have the benefit of recent studies which contain detailed analyses of the way current changes in technology and products are affecting the skill-mix of a particular industry.[5]

With this kind of background and information, analysts are frequently able to identify the causes of significant changes in staffing patterns which have occurred over the recent past. Frequently, when some historically significant change is examined in detail, its projection into the future will be modified if the primary reason for the change is identified as a change in operating procedure for a majority of particular types of establishments in the industry. Since few other establishments might be affected, it is unreasonable to project the changes to continue at the same rate as in the past.

It should be acknowledged, however, that the BLS analysts do not attempt more than a partial adjustment of occupational projections produced by extrapolation methods. For instance, matrix cells which have experienced little or no change in the past are not modified as a rule. The analyst does not adjust the extrapolation of stable cells unless he has strong reason to believe that the past pattern of stability will change in a predictable manner. Thus it is unlikely that the BLS will anticipate an abrupt departure from previously stable elements in employment by occupation. Indeed, this is a fundamental assumption which underlies the BLS projections, viz., that the occupational structure of many industries is relatively stable over time, even for periods as long as a decade. If this is interpreted to mean that changes in the occupational structure occur slowly and are thus predictable, it may be considered a plausible and useful assumption which facilitates the BLS projections work. Yet we must recognize that the historical record is less helpful than it might be, because as used by the BLS it amounts to only two observations in time.

If the Occupational Employment Survey (as described in Chapter IV) had proceeded as intended, the BLS would have more frequent observations of existing occupational distributions. Regretably, plans to produce national data from this survey were discontinued. Thus the BLS must continue to project employment by occupation with heavy reliance on the inadequate data base afforded by the Decennial Census.

It should be noted here that the BLS projects certain occupational requirements independently of the Matrix, though they are later coordinated with the Matrix forecasts of other occupations. A partial list of the occupations projected outside the Matrix framework includes: teachers, physicians, dentists, airplane pilots and business machine repairmen. In each of these cases, the BLS attempts to relate future employment directly to the factors affecting employment rather than indirectly via staffing patterns and industry employment changes. For example, teacher requirements are projected directly as a function of the size of the student population and student-teacher ratios. Physician requirements are projected using the ratio of practitioners to a historical time series on per capita consumption expenditures for health services, an independent projection of per capita consumption expenditures on health services in the future, and a population projection. Requirements for medical record technicians and clerks are projected as a function of hospital admissions and outpatient visits which, in turn, are projected as a function of population size. Since these occupations are "critical" ones, projections are available from a variety of other sources. Generally speaking, it seems curious that the BLS attempts independent, and often less sophisticated, projections for these occupations because those available from other sources are frequently more publicized and more widely accepted by users.

The methods of these "direct" projections of a dozen or so occupations, however, are of only incidental interest to our discussion. Of greater significance is the fact that the BLS can and does incorporate such independent projections into the matrix approach in two distinct ways. One is simply to compare "direct" projections for an occupation with projections derived via the Matrix method and then attempt to reconcile the two. The other is to accept the projection via direct methods as superior from the start, and to force the Matrix method to produce this outcome. This is done by distributing the target year projection for the occupation among industries, computing the proportion of total projected employment in each industry accounted for by the occupation, and adjusting the occupational distribution of employment in each industry accordingly.

Estimating Replacement Needs

Thus far, only projections of total employment have been discussed. Users of manpower forecasts, however, are more interested in the

projected number of job openings (by occupation) than in total employment. The calculation of new openings due to growth is a simple matter of subtracting base year employment from target year employment. But this constitutes somewhat less than half of all job openings. "Replacement demand," i.e., openings due to withdrawals from the labor force, is equally important to most users of manpower forecasts, although it usually receives less attention from those who prepare manpower forecasts. Strictly speaking, replacement demand for an occupation can stem not only from labor force withdrawals but also from occupational mobility (net transfers out of the occupation by continuing members of the labor force). However, occupational mobility is so complex and difficult to project that it usually is ignored in estimates of replacement demand.

If one ignores occupational and geographic mobility, the components of replacement demand are death, retirement, disability, and temporary withdrawal from the labor force for personal reasons such as childcare. Following standard nomenclature we use "death and retirement" to describe labor force withdrawals for all of these reasons. Estimates of labor force withdrawals can be made from the Tables of Working Life constructed by the BLS. These Tables are established on an actuarial basis, and can be used to estimate deaths and retirements at each age for both males and females.[6] As such, they are widely used in preparing labor force projections. Estimation of total future job openings due to labor force withdrawals, then, is fairly straightforward, and follows many of the same steps involved in labor force projections. But projection of openings due to withdrawal by occupation is a relatively cruder procedure, because the BLS has not developed working life tables for specific occupations.

Indeed, the procedure used to project occupational separations is simply to apply age and sex-specific separation rates to the age-sex distribution of persons performing given occupational functions. That is, the procedure is based on the implicit assumption that death and retirement rates do not differ among occupations except to the extent that the age and sex composition of employment by occupation differs. Another difficulty is that the age-sex distribution prevailing in the base year is used to project separations over the forecasting period. Since sex and age distributions of occupational employment do change over time, it would clearly be better to project age and sex distributions of occupational employment. The BLS considers this to be impractical, however, because of insufficient data.[7]

When one considers the manifold problems associated with national BLS projections of occupational separations, it must be concluded that they are, at best, crude indicators of likely future replacement demand. Unfortunately, the problem is exacerbated by the fact that projections of replacement demand at the State level have been based on the simplifying assumption that the age-sex distribution of occu-

pational employment in the State was identical to the national average. Not unexpectedly, BLS sensitivity tests have shown that the magnitude of replacement demand will change substantially if State-specific age-sex distributions of occupational employment are used instead of national averages.[8] Accordingly, the BLS now publishes annual labor separation rates by State for detailed occupational categories, based on State specific age-sex distributions of employment by occupation in each state.[9] Thus, State estimates of job openings due to replacement at present are more comparable to the national estimates. What is needed now is further work to improve the quality of both State and national estimates.

The need for improved methods for projecting replacement demand stems, in large measure, from the quantitative importance of labor force separations as a source of new job openings. The degree of importance is illustrated in Table VI.1. For obvious reasons, the differences among the separations projected for different occupational groups in Table VI.1 must be interpreted with caution. Yet, most of these problems do not apply to the projections of total separations for the combined total number of occupations. This projection, i.e., line 1 of Table VI.1, indicates that fully two-thirds of projected future job openings will stem from labor force separations rather than growth in the total number of jobs.

Given the large relative importance of separations in determining the total number of job openings, and the problems associated with present methods used to project separations, it seems clear that this should be a high priority area for further research. One approach might be to develop occupational-specific tables of working life. This need not be done for all 400 occupations in the Census classification system, but could be confined to broader aggregations of occupations composed of detailed occupation categories which are judged to be similar with respect to the conditions affecting the separation rate. A variety of different data sources could be used to aggregate occupations into groups that are relatively homogeneous with respect to age and sex specific separation rates. These data sources, e.g., the 1970 Census 1/100 sample, U.S. Social Security Commission Data, the National Longitudinal Survey data, might also be used to create adjustment formulas to be used with existing Tables of Working Life.

Even if such occupation-specific tables were not forthcoming, it appears that improvements in projections of labor force separations could be made at reasonable cost through the use of information which is designed to compensate for their static character. Working Life Tables purport to do no more than to describe past experience. In this sense, it is curious that they have yet to draw upon the large, existing literature on the correlates of labor force participation, especially that dimension dealing with long run trends in labor force

TABLE VI.1

Job Openings Due to Growth and Separation of Workers
By Major Occupational Group, 1972-85

Occupational Group	Total	Growth	Separations
Total	61,200	19,800	41,400
White-collar workers	38,800	14,600	24,200
Professional and technical	12,000	5,600	6,400
Managers, officials & proprietors	5,900	2,400	3,500
Sales workers	3,800	1,100	2,700
Clerical and kindred	17,000	5,400	11,600
Blue-collar workers	13,800	4,200	9,500
Craftsmen and kindred	5,300	2,200	3,100
Operatives[1]	7,200	1,800	5,500
Nonfarm workers	1,300	200	1,000
Service workers	8,500	2,400	6,000
Private household workers	700	-400	1,100
Other service workers	7,800	2,800	4,900
Farm workers	50	-1,400	1,400

[1]Includes operative, except transport and transport equipment.

NOTE: Details may not add to totals because of rounding.

SOURCE: USDL/BLS, Tomorrow's Manpower Needs: Supplement No. 4, Estimating Occupational Separations from the Labor Force for States, 1971, p. 1.

participation rates for some segments of the labor force.[10] It is true that many of the factors that help to "explain" differences in labor force participation among individuals (e.g., marital and health status) are not very useful in projecting long run changes in separation rates. However, other findings have more direct applicability and should be considered for use in future projections of separation rates. For example, there is evidence that early retirement of older workers tends to occur most frequently in those industries with high proportions of workers in the middle age categories.[11]

The Cooperative Matrix Program: State and Local Forecasting

Consistency of the Forecasts

As discussed in Chapter V, the Matrix approach has become a dominant form for projections at the State/local level as a direct result of the promotion and assistance offered by the BLS, together with the Regional Offices of the Manpower Administration. By mid 1974 all States were participating to some degree in the Cooperative Projection Program of the BLS. This Program promises several advantages over the alternative of uncoordinated State efforts using mutually incompatible techniques. For instance, cost savings result from the use of identical occupation and industry definitions. Furthermore, cost savings result from the elimination of duplication of effort in methodological work, and from the collective processing of Census data. In addition to cost savings, the Cooperative Program offers a mechanism for ensuring consistency, i.e., ensuring that the sum of State estimates of employment equals the national estimate.

Consistency between regional and national projections is important for the very practical reason that the U.S. does not have a centralized decision process for policies affecting labor supply. While human resource endowments are subject to collective decision making, this process is played out principally at the State and local level. To be sure, Federal financing has come to have a significant impact on the supply of a few professional occupations with high geographic mobility (e.g., physicians), but in general the expansion of vocational education, manpower and apprenticeship programs, etc., is most heavily influenced by decisions taken at the State and local levels. There is a positive advantage, then, if these decisions are based on manpower projections which, although less reliable, are at least consistent in the sense that the sum of the parts equals the whole. Among other things, errors in projecting State and local area employment in such a framework will tend to be offsetting. A set of State and local employment projections with offsetting errors might well lead to policies which result in geographic imbalances between the supply and demand for particular types of labor, but this type of imbalance can at least be accommodated via migration. Local area projections which do not sum to national projections can lead to more serious problems.

National projections are generally more reliable than local projections. The primary reason is that national projections can ignore inter-regional movements of workers, while local projections are highly sensitive to the assumptions made about such movement. Coupled to the fact that local area data are sometimes more difficult to compile in detailed form (and that local forecasting efforts usually operate with smaller budgets than national efforts) it is easy to understand why forecasts of local employment trends usually begin with projections of national trends and concentrate on identifying how the local area may deviate from these trends. One of the simplest ways to do this is to measure the ratio of local employment in a given occupation to national employment in the same occupation, extrapolate past changes of that ratio into the future, and project future local employment as the product of the ratio so extrapolated and the forecast of future national employment. The simple ratio method for projecting local employment, however, can be improved upon by the use of the BLS national manpower Matrix.

More specifically, the BLS has outlined two methods for adopting Matrix projections to the projection of local area employment. The simplest of these assumes that differences between local and national growth rates in employment by occupation can be explained by differences in the industrial composition of employment and differing rates of growth in employment by industry. This approach (referred to by BLS as "Method A") assumes that the occupational structure in each local industry will be identical to the national structure in both the base year and the target year of the forecasting period. Local employment by industry is projected to the target year and forecast national (target year) occupational distributions are applied to estimated local employment by occupation in the target year. Of course, local area distribution may differ from the national average in many or in all industries. In order to reduce errors arising from these differences, Method A adjusts the estimates of employment by occupation to account for actual deviations between the local and national occupational structure in the base year. Thus, national base year distributions are applied to actual local industry employment totals in the base year. The resulting "estimates" of employment by occupation in the base year are then compared to actual local employment by occupation totals in the base year. The percentage deviations between actual local employment and that which would have occurred had the local occupational structure been identical to the national structures in the base year is then applied to target year projections to assure conformity with local characteristics. An obvious advantage of this approach is that it requires a minimum of local data (employment by occupation in the base year and a time series of employment by industry), yet it yields projected changes in occupational structures. Clearly, adjustments introduced to reduce error resulting from deviations between local and national distributions does not completely eliminate errors from this source. For this reason, many States in the Cooperative Program use another approach which involves the identification of local area occupational distributions.

Method B, as it is called by the BLS, requires a local area matrix of employment by occupation and industry in the base year. This is most frequently developed by a special tabulation of Census data, but may also be based on Area Skill Surveys or on the new Occupational Employment Survey. While Method B does not assume identical occupational distributions between the nation and the local area, it does assume that the (independently estimated) local structure will change in the same direction and at the same rate as the nation. Thus, creation of a local occupational matrix for the target year is a simple and somewhat mechanical process of multiplying the local base year matrix by a matrix of "change factors" indicating the percentage changes projected in national occupational distributions. In principle, there is nothing to prevent local labor market analysts from modifying the projected changes in staffing patterns to conform with special characteristics of local industry. In practice, however, this is quite difficult because local analysts have no way of familiarizing themselves with the detailed considerations and judgments which underlie the projections of national occupational patterns.

Although it is more realistic, Method B (like Method A) is a short-cut approach involving considerably less effort than would be required to replicate the procedure used by BLS at the national level. Specifically, it does not require the development of historical data on local occupational distribution nor the detailed industry expertise needed to assess and perhaps modify the extrapolation of these historical trends. However, a few States have attempted a more complete replication of BLS methods.[12] And there will probably be more States attempting this in the near future, for in a few years the States participating in the Occupational Employment Statistics program will have the requisite data base.

Neither of the methods proposed by BLS requires any special technique for projecting employment by industry. However, the method used to project local area employment by industry must allow considerable industry detail--otherwise it is necessary to compress the occupational matrix to fit the industry projections. One of the methods suggested by the BLS is the use of simple ratios, i.e., extrapolating the ratio of local employment to national employment in each industry, and applying it to the BLS national industry projections for the target year. While a simple extrapolation of such ratios could easily be carried out for all States in one central location, the BLS has rejected this on grounds that trends in industry employment are best projected with the assistance of local labor market analysts who are presumed to have the knowledge of current local developments necessary to modify trend extrapolations. In practice, then, there is a considerable variation in the techniques used to project employment by industry for use in Matrix projections.

In most States, employment projections are made via time series regressions of the following forms:

$$Y/X = \alpha + \beta T$$

or

$$Y = \alpha + \beta T + \psi X$$

where Y = local industry employment, X = national industry employment, T = time, and α, β, ψ are coefficients to be estimated. In most States, more than one form is used, and the one giving the best "fit" is then chosen to project target year employment.[13] These projections represent one instance where data do not constrain the analysis. The reason is that the Employment Service in each State has generated annual employment statistics for more than a decade for nearly all detailed industry categories. Where existing industrial detail is not sufficient, data can nonetheless be disaggregated by relying on other existing sources such as unemployment compensation records, County Business Patterns, Census data, etc. Nevertheless, the projections are extrapolations and are based on the implicit assumption that past trends in industry employment will continue in the future. In most States, the extrapolations are modified by local labor market analysts charged with keeping abreast of current and anticipated future developments in employment by industry. In this respect, the projections do depend significantly on the analysts' ability to understand past changes, learn about pending future changes, and exercise reasonable judgment in adjusting extrapolated estimates.

Thus, State projections of industry employment are difficult to evaluate because, in the final analysis, they depend on the quality of subjective judgment exercised by local labor market analysts. When the present or recent past deviates from long run trends, analysts attempt to identify the causes for such deviations and usually modify trend extrapolations if the causes appear to represent something other than cyclical fluctuation. While this procedure probably captures impending changes in the aggregate, it does little to help anticipate interregional shifts in economic activity. This is an important problem because Ashby's research on the factors explaining past changes in employment among region, States, and counties in the U.S. indicates that ". . . regional share effects are the dynamic elements in change and therefore the more important over the long run."[14]

More specifically, Ashby identified three distinct sources of change in a region's employment: national growth trends (the weighted sum of national growth trends in each detailed industry); deviations from national growth trends due to a region's employment being concentrated in industries which are growing faster than the national average; and deviations from national trends stemming from a region obtaining an increasing share of total national employment within specific industries. Historically, the third element seems to be most important in explaining regional growth rate differentials. However, there does not appear to be much stability in the relationships. For instance, when Ashby aggregated share changes for all industries in a State to describe the State's performance in maintaining or in-

creasing its share of national industry employment, he found that eleven States which had increased their relative shares during the decades of the 1940's experienced a decline in the 1950's, while four States experiencing declining shares in the 1940's increased their shares during the 1950's.[15] Consequently, past changes in a State's share of national employment in specific industries may be an imperfect guide to future changes in that share.

Accordingly, it is extremely difficult to assess the overall quality of analysts' judgments in modifying historical trend extrapolations of industry employment changes in states and local areas. It must be noted, however, that dependence on the exercise of judgment raises the possibility of systematic bias in local employment projections. While the Cooperative Program is designed to avoid gross inconsistencies between State and national projections, two factors interfere with effective consistency controls. One is that the States do not make projections at the same time. For example, Montana's 1973 projection of stable employment in the coal industry was based on assumptions that surely differed from those used by coal-producing states making projections after the 1973 Arab oil embargo and the announcement of Project Independence by the Federal government.[16] A second factor inhibiting effective control is that the BLS has taken the position that local labor market projections are best prepared by local labor market analysts and hence has not developed any machinery to resolve possible inconsistencies among projections prepared in different areas. It is instructive, therefore, to examine state projections for consistency with national projections.

We have made a simple consistency check on State employment projections to test the hypothesis that there may be systematic bias, such that State employment projection totals will exceed BLS national employment projections. We have included all State projections which were based upon the BLS Matrix, except for a few which did not use regression techniques in projecting industry employment. We chose the most recently completed study for those States which published more than one. Since some States have not yet completed such studies, our sample is composed of projections for 28 States. The time period of the projections contained in these studies varies considerably, but all fall into or near one of the two following spans: 1970-1975 or 1970-1980. Accordingly, we converted each to a ten year 1970-1980 projection using the annual rate of growth implicit in each of the projections. The weighted average of the ten year growth rates was calculated separately for two groups of states: those which produced projections corresponding most closely to 1970-1975 time period, and those corresponding to the 1970-1980 time period.

Since we are interested in the consistency of the State projections with BLS national projections, we have computed projected State employment as a share of projected national employment. These shares

are compared to the corresponding shares measured by the 1960 and 1970 Census figures. The results, shown in Table VI.2 indicate a very high degree of consistency between the collective results of 28 separate State projections and the BLS national projection. Collectively, the 28 States forecast their total employment to increase at a slightly slower rate than the national rate of change projected by BLS in 1971. This is consistent with past experience: their share of total national employment declined from 59.9 percent in 1960 to 59.1 percent in 1970. It is projected to decline by roughly the same amount to 57.9 in 1980.

The Use of Matrix Projections at the State and Local Level

Matrix projections have become part of the existing labor market information program of the Employment Service and hence are readily available to a host of users, including planners, policy-makers, and employment counselors. Although no systematic effort was made to survey these users of manpower forecasts, our impression is that few of them are in a position to make maximal use of the forecasts. In part, this stems from the general problem of BLS projection techniques discussed in Chapter V. But there are also more specific difficulties associated with the Cooperative Program. The most serious of these is that planning and policy making jurisdictions have been established with little or no reference to labor market criteria. There are both geographic and functional dimensions to this problem. For instance, utilization problems occur because of a mis-match between the geographic boundaries of labor markets and jurisdictional boundaries of policy makers. State forecasts are available from the Employment Service as inputs into Statewide planning processes, but State plans in functional areas such as education, health, training, etc. must take local area jurisdictions and plans into account. Clearly, local area jurisdictions are usually small and typically cover only a part of the local labor market. In most States, consequently, there are as many different users of manpower forecasts as there are different sets of local area districts.[17]

Although Employment Services usually regionalize their projections, they do not (and probably should not) attempt to custom-make projections for each user's particular planning district or for very small areas that comprise only portions of a local labor market. This means that users are often required to adapt existing forecasts to smaller areas. Even if they succeed in disaggregating existing forecasts, the results are inevitably crude. Since Matrix forecasts indicate only long term trends, corroboration with current or short-run projections of job openings is necessary. Small areas, however, encounter extreme difficulty in this task. One reason is that the magnitude of commuting to work between small areas results in discrepancies between information obtained from employers and Matrix (and Census) information based on the place of residence rather than the

TABLE VI.2

Share of National Employment 28 States
1960, 1970 and Projected 1980

	1960	1970	1980
Group I 17 States with '70-'80 Projections	37.1%	35.8%	34.7%
Group II 11 States with '70-'75 Projections	22.8	23.3	23.2[a]
Group I & II 28 States (Sum of Rows 1 & 2 above)	59.9	59.1	57.9

[a]Computed by calculating the annual growth rate implicit in the 1970-1975 projections and extrapolating this to 1980.

SOURCES: Census of Population, 1960 and 1970; the 1980 projections were based and computed by extending 1970 Census employment figures by the 10 year growth rates contained in the following sources: a) USDOL/ BLS, Tomorrow's Manpower Needs, Vol. 4, 1971 (Revised) Bulletin 1737, p. 14 (for projection of national employment); b) State Projections as listed below.

NOTES TO TABLE VI.2

GROUP I:

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Maine Manpower Research Division, Maine Manpower Projections to 1980 by Industry and Occupation, (Augusta, 1972).

Maryland Department of Employment and Social Services, Office of Program Planning and Evaluation, Research and Analysis Division, Interim Manpower Projections 1975 and 1976; State of Maryland and Baltimore Metropolitan Area, (Baltimore: June, 1974).

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Colorado Division of Employment, Research and Analysis Section, Interim Report: Occupational Outlook for Colorado, 1970-1975, (n.p.: June, 1972).

Georgia Department of Labor, Employment Security Agency, Georgia: Jobs for the Future: Industries and Occupations, 1960-1967-1975, (n.p.: n.d.)

Hawaii Department of Labor and Industrial Relations, Research and Statistics Office, Manpower Directions to 1975, State of Hawaii: A Report on Industry and Occupational Manpower Needs CY 1971-1975, (Honolulu: April, 1972).

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Oregon State Department of Employment, Research and Statistics Section, A Presentation of Oregon's Current Occupational Employment Statistics Program, with Projected Occupational Employment Statistics for Oregon and Selected Governor's Planning Districts, (Eugene: January, 1969).

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Tennessee Department of Employment Security, Research and Statistics Section, Tennessee Employment Outlook: Industries and Occupations 1969-1975, Part I, (n.p.: April, 1972).

Washington Employment Security Department, Research and Statistics, Occupational Trends: Washington State, 1970-1975, (Olympia: October, 1971).

place of employment. Most users recognize the absurdity of this situation: they cannot change their jurisdictional boundaries, but yet they are required by Federal regulations to use manpower forecasts to justify program expansion. State Manpower Planning Councils operating under the Comprehensive Employment and Training Act of 1973 are caught in this dilemma in almost every State, because their jurisdiction is "the balance of State," i.e., those parts of a State where local governments do not form consortia to deal directly with the U.S. Department of Labor as "prime sponsors."

Other deficiencies in the current use of manpower forecasts relate to the fragmentation of functional and administrative jurisdictions. Most users of manpower forecasts have responsibility for some program of vocational education. Responsibility for publicly supported training programs, however, is highly fragmented. Real coordination and exchange of information among different jurisdictions in the public sector is uncommon; it is almost non-existent between the public and private sector. Yet educational planners use manpower forecasts to compare "demand" for particular skills with the projected supply of persons possessing such skills. The "demand" estimates derived from Matrix projections may be imperfect, but at least they have the virtue of consistency. However, supply projections, if they exist at all, tend typically to be underestimated. The difficulty stems from the fact that programmers in one jurisdiction (say, a secondary level vocational education district) may have data on current and projected future enrollments in programs under their control, but lack similar data for neighboring districts. They may also judge these other programs to be qualitatively inferior to their local programs. For either or both reasons, only some portion of supply is estimated. Not unexpectedly, the result is that projected "demand" exceeds projected supply in specific vocational programs. Indeed, in many programs, projected demand exceeds projected supply by such a margin that policy implications (i.e., that program expansion is warranted) are insensitive to reasonable variations in the projected growth rate in demand.

The 1974 State Plan for the Administration of Vocational Education in the State of Ohio is perhaps a case in point. It includes one and five year projections of job openings and "supply output" for 107 specific vocational programs offered in high schools throughout the State. The one year projected total increase in job openings is almost 2.5 times greater than the projected increase in supply. This large discrepancy does not appear to be the result of a tremendous skill shortage in Ohio. Rather it stems from a decision to define the market for the High School program graduates so broadly as to include virtually all non-professional occupations. It also stems from the failure of planners to gather complete information on enrollments in those training and education programs supplying identical labor markets but lying outside of their jurisdiction, e.g., proprietary schools, community college programs, "manpower programs," etc.

If the demand and supply projections for specific vocational programs are examined, it is clear that manpower forecasts provide policy guidelines, irrespective of the undercounting of supply. Thus, about 10 percent of the programs projected demand to exceed their projected supplies. For most of the remaining programs, however, projected supply falls so far short of demand that the discrepancy would not have been eliminated by any plausible change in manpower forecast itself.[18] In fairness, the difficulties planners face in obtaining usable supply data are considerable. The inescapable conclusion, nonetheless, is that manpower forecasts are not being used effectively by educational planners. Until planners improve the collection of supply information, manpower forecasts will continue to have only a minor impact on policy formation.

NOTES TO CHAPTER VI

[1]The original four volume work was published as, U.S. Department of Labor, Bureau of Labor Statistics, Tomorrow's Manpower Needs, Vols. 1-4, Bulletin 1606 (Washington, D.C.: 1969). Subsequent publications in the series include: Supplement No. 1, Revised Projections of Construction Manpower Requirements, Bulletin 1606 (1970); Supplement No. 2, New and Revised National Industry Projections to 1975 and Procedures for Adjusting Wage and Salary Employment to Total Employment, Bulletin 1606 (1970); Vol. IV-Revised 1971, The National Industry-Occupational Matrix and Other Manpower Data, Bulletin 1737 (1972); Research Report on Manpower Projection Methods, Bulletin 1769 (1973); Supplement No. 3 Matching Occupational Classifications to Vocational Education Program Codes (1973); Supplement No. 4, Estimating Occupational Separations from the Labor Force for States (1974).

[2]Bashir Ahamad and Mark Blaug, Practice of Manpower Forecasting: A Collection of Case Studies (San Francisco: Jossey Bass, 1973), p. 73.

[3]Ronald E. Kutscher and Eva E. Jacobs, "Factors Affecting Changes in Industry Employment," Monthly Labor Review, XC, No. 4 (April 1967), 6-12.

[4]U.S. Department of Labor, Bureau of Labor Statistics, Tomorrow's Manpower Needs: Research Report on Manpower Projection Methods, Bulletin 1769 (1973).

[5]E.g., U.S. Department of Labor, Bureau of Labor Statistics, Technology and Manpower in the Textile Industry of the 1970's, Bulletin 1578 (Washington, D.C.: 1968).

[6]U.S. Department of Labor, Manpower Administration, Working Life Expectancy and Training Needs of Women, Report No. 12. These 1960 working life tables are the most recent available for women. For men, however, the BLS has constructed unpublished 1970 tables.

[7]U.S. Department of Labor, Bureau of Labor Statistics, "Estimating Occupational Separations from the Labor Force for States," Tomorrow's Manpower Needs, Supplement No. 4 (Washington, D.C.: 1974)

[8]Tomorrow's Manpower Needs, Bulletin 1769, Chapter II.

[9]Tomorrow's Manpower Needs, Supplement No. 4 (1974), op.cit.

[10]C.f., Herbert S. Parnes, "Labor Force and Labor Markets," in A Review of Industrial Relations Research, I (Madison, Wisconsin: Industrial Relations Research Association, 1970), pp. 1-33.

[11]A.J. Jaffe and Joseph Froomkin, Technology and Jobs (New York: Praeger, 1968).

[12]See, for example, Oregon Department of Human Resources, Employment Division, "A Presentation of Oregon's Current Occupational Employment Statistics Program," (1972). For a description of Colorado's plans to integrate data from Occupational Employment Survey into the BLS Matrix methodology see, Robert C. Young, Manpower Demand: Information Guidelines for Educational, Vocational Education, and Manpower Planning (Columbus: Center for Vocational and Technical Education, The Ohio State University, 1973).

[13]See, for example, New York State Department of Labor, Manpower Requirements: Interim Projections, New York State 1968-1980, Publication B-185, (New York: 1971).

[14]Lowell D. Ashby, "The Geographical Redistribution of Employment: An Examination of the Elements of Change," Survey of Current Business, XLIV, No. 10 (U.S. Department of Commerce, 1964), p. 19.

[15]Ibid.

[16]Montana State Employment Service, Montana Manpower: Projected Montana Employment by Industry and Selected Occupations, Second Edition, (February, 1973).

[17]Ohio, for example, presently has 107 Vocational Education Planning Districts and the Ohio Department of Education prepares manpower forecasts for each. In the same State, manpower planning under the Comprehensive Employment and Training Act of 1973 is carried out by 13 "prime sponsors" and by the State Manpower Services Council for the scattered, remaining areas not covered by "prime sponsors." As a result, manpower and vocational education planners are working with small geographic units that do not conform to local labor markets.

[18]Ohio Department of Education, Division of Vocational Education, Ohio State Plan for the Administration of Vocational Education, (1974).

CHAPTER VII

MANPOWER FORECASTING IN THE HEALTH FIELD: AN APPRAISAL OF RECENT PRACTICE

Preliminary Remarks

Nowhere perhaps is manpower planning capacity under greater stress than in the health field. In large measure, the stress stems from a substantial increase over the past decade in the "demand" for manpower criteria in the formulation of health care strategies. While manpower projections traditionally have been used to guide educational policies for the health professions, continuing concern about the "crisis" in health care, changes in the occupational distribution of health employment, and shifts in the public/private distribution of health-related educational budgets have contributed to a growing interest in the preparation of health manpower plans. Unfortunately, the institutional and technical capacity to design such plans has failed to keep pace: data resources are notoriously poor, planning responsibility is fragmented, and methodological dispute postpones refinement of both the knowledge base and tools for planning. Briefly put, the response to demand pressures has been little more than the continued production of piece-meal studies of dubious value to policy makers.

The objective of this Chapter is to examine recent planning practice in the health field, and to explore the essential limitations of planning performance. That our capacity to plan health manpower is limited is widely acknowledged in the field; the nature and scope of these limitations as well as necessary corrective actions, however, are not. One view, popular in some quarters, is that forecasting activity lacks appropriate methodological guidelines and efforts to strengthen it must necessarily produce new techniques. Others hold that improvements in information or organization are necessary prerequisites to more effective planning. Clearly, important questions of research strategy, data priorities, institutional support, and the like turn on these different interpretations. For this reason, it seems worthwhile to evaluate recent experience with a view toward understanding areas of past weakness and potential improvement. Since current activity appears to be heavily conditioned by both the perception of health manpower problems and early forecasting exercises, we begin with a sketch of these topics as a way of framing the discussion.

Health Manpower: Policy Problems and Options

In 1970, approximately one out of every 18 working persons in the United States was employed in the health service industry as defined by

the Bureau of the Census. The last few decades have witnessed the sector develop into one of the principal employers of the American labor force. Nationally, the industry employs more persons than does the entire agricultural sector and almost as many as the total construction industry. It has grown at an annual average rate of 4.8 percent over the past two decades, which is approximately three times faster than the rate at which total employment has increased.[1] Prospects are that this growth will extend over the next decade.

Of greater moment is the shift that has occurred in the occupational and skill composition of health-related employment over the past several decades. While roughly one-third of all workers performing health-specific occupational functions were "core practitioners" such as physicians and dentists in 1950, this proportion had fallen by 1970 to 18 percent of the total.[2] The remainder is accounted for by such "allied" health workers as nurses, medical technicians, therapy personnel and the like; the group includes as many as 150 different occupational titles. Not only is the manpower mix increasingly more specialized, but these new and rapidly growing jobs generally require less education and training than those traditionally identified with the health field. Weiss has shown, for example, that "low" level health jobs--defined by job content and job family--grew at a substantially higher rate than either "middle" or "high" level jobs over the recent past.[3] Not unexpectedly, the substantial changes in the occupational composition of health employment has had a concomitant impact on the training system. Increasingly fewer health workers are now trained in doctoral programs or in ad hoc, short courses in health institutions. Rather, an enormously complex network of formal schooling activities ranging from secondary education to post-baccalaureate programs has emerged over the past decade to train persons for health careers.

Despite the considerable changes in the stock and flows of trained health workers, there has been persistent concern over the past two decades that health personnel (particularly high-level personnel such as physicians and dentists) are in short supply. Although widely discussed, the underlying evidence has never been well-established; indeed, much was fragmentary and anecdotal--usually related to the difficulty and/or expense of gaining access to the delivery system. Other indications, repeated to the point of litany, include the rise in the medical care component of the Consumer Price Index at a rate several times greater than the total index; the unfavorable health status position of the U.S. relative to other advanced nations in terms of such traditional measures as male life expectancy and infant mortality, and the increasing concentration of health resources in urban areas and in secondary/tertiary levels of care. For the moment what is significant is that these concerns called forth a substantial public sector response at all governmental levels, especially by the Federal government. In all cases, efforts were focused upon increasing the (absolute) supply of specific types of manpower as a means of achieving balanced growth in the health delivery system and factor markets.

More particularly, in roughly the same way that the widely discussed shortage of hospital facilities several decades ago resulted in the Hill-Burton Program, the presumed shortages of health manpower in the early 'sixties produced a Federal commitment to provide assistance for training and deploying health personnel. The Health Professions Educational Assistance Act of 1963 was watershed legislation; it provided funds for the construction of teaching facilities for institutions offering degrees in medicine, optometry, dentistry, pharmacy, podiatry, and professional nursing, and a student loan program for medical and dental students. This Act was quickly followed by a number of others, including The Nurse Training Act of 1964, the Allied Health Professions Personnel Training Act of 1966, and ultimately the Comprehensive Health Manpower Training Act of 1971. The latter extended not only the level of assistance, but (for certain occupations) its form in terms of scholarships and direct institutional support.[4] Despite present uncertainty about continued Federal support, these past enactments are important indicators of the nature of the policy response to manpower problems.

As might be expected, the public sector commitment to expanded supply has intensified concern about health manpower problems. The experience has also been responsible for a gradual change in the perception of the nature and scope of the problem. At the moment, for instance, there is considerable discussion about the "maldistribution" of health manpower, in terms both of geography and speciality.[5] While many consider this a novel departure from the earlier view that manpower was in short supply, it is not. Clearly, it is possible to examine either the mean or the variance of a frequency distribution, depending on the objectives of the exercise. A decade ago, aggregate (mean) numbers were important because the primary issue was considered inadequate training capacity. Substantial additions to educational capacity have been made, however, and the present emphasis recognizes that further reliance on marginal increases to capacity are not likely to be effective. What perhaps is novel is that simple expansion of the training system was believed to be a necessary and sufficient policy response in the first place.

Indeed, for working purposes, it is important to recognize that the public sector might have responded to the problem in a number of different ways. These responses may be conveniently grouped under the rubrics of education, labor market, and utilization strategies. In the first case, manpower supply is augmented simply via attempts to increase the numbers of graduates from relevant, accredited training institutions; local supplies are increased by graduating class sizes which are numerically greater than the reciprocal of the area-specific labor force participation rate of new graduates. Clearly, this is a long-run strategy. Somewhat at the opposite end of the continuum are labor market policies designed to augment supply conditions in the short-run. These policies are predicated on the assumption that the stock of personnel with requisite skills is relatively fixed. Their objective is to promote the maximal employment of those with such skills via efforts to increase the rates of labor

force participation and/or the geographical distribution of the stock. Policies designed to make jobs more attractive--both from an economic and non-economic point of view--thus fall under this general category of supply policies.

Utilization policies lie somewhere between these two types of strategies. They are primarily geared to improving manpower productivity relationships (subject to quality constraints) by augmenting the flow of services delivered by a given stock of manpower or modifying the use of given services produced by those personnel. Since there are many possible sources of productivity growth, these policies conceptually encompass a variety of areas, including organizational changes in the manner in which health services are delivered, technological shifts in resource usage, and legislative changes, say, with respect to licensure of specific health personnel. Organizational effects on manpower efficiency, for instance, may be illustrated with reference to the recent interest in promoting pre-paid, group practice mechanisms for delivering primary medical care. Inter alia, these mechanisms are presumed to shift the use of certain kinds of care, e.g., away from hospital services, and to deliver a larger volume of services per input through an organizational framework which facilitates the division of labor and economizes on the use of highly skilled personnel.[6] As such, they purport to expand the real supply of needed services without necessarily expanding the manpower stock per se.

Generally speaking, health manpower policy in this country has relied almost exclusively on "educational strategies" designed to expand the supply of trained personnel. The reason, in our judgment, is that policy questions have rarely been focused in adequate fashion. Put differently, manpower issues have been defined in ways that fail to identify alternative courses of action. A critical shortcoming has been the past emphasis on shortages defined essentially in terms of means rather than ends, e.g., physicians rather than primary medical care services, and shortages of personnel defined in educational-specific terms, e.g., shortages of M.D.'s or R.N.'s, etc. Clearly, such emphasis ignored alternative methods of delivering medical care services induced by manpower substitution and technological change as well as alternatives to the use of such services per se. Failure to account for these possibilities led inexorably to recommended increases in the capacity of educational programs. To be sure, current emphasis on maldistribution of manpower is indicative of some policy avenues lying outside of the formal school system, but the fact that it too is discussed in occupational or educational-specific terms leads to confusion about the nature or scope of these alternative policies. In both cases, the fundamental issue would appear to be imbalance between desired and observed patterns of manpower utilization. In this sense, current concern is little different from what it was in the recent past, except that it emphasizes a slightly different dimension of desirable use patterns. The fact that these points have been obscured in recent discussion suggests lacunae in planning concept and technique, a topic to which we now turn.

Health Manpower Planning: Conceptual and Methodological Issues

Ideally, health manpower plans would indicate necessary and sufficient policy actions for achieving balance in health care market over specified time periods. They would be predicated simply on the assumption that market forces may not produce desired results over acceptable time periods or at acceptable levels of cost, i.e., the existence of "shortages," "maldistribution," or other manpower problems in the current period need not be demonstrated to provide a raison d'etre for plan formulation. Plans would, nevertheless, specify the potential benefits associated with success in achieving balance at given points in time as well as the costs associated with alternative configurations of policy which may be used to achieve such balance; policy sets worthy of recommendation would maximize the ratio between benefits and costs. In the language of this Chapter, plans would constitute statements of strategy for achieving specified goals by particular means.

Difficulty is encountered in the health field, however, because there are different types or concepts of balance and hence different paths to plan formulation, i.e., there are different ways of specifying desirable patterns of manpower utilization.[7] Ambiguity about this difference contributes to our inability to define health manpower problems in meaningful ways and to prescribe useful additions to planning knowledge. It relates principally to the nature of the underlying criterion function from which system targets and manpower requirements are derived. Stated another way, it relates to the concept of sectoral output and the determinants of the level and composition of this output over time. The point may be illustrated initially in reference to the historical debate about the appropriate concept and measurement of "shortages" of and requirements for health personnel.

At root, two positions have been espoused. One is that shortages represent the difference between the supply of particular types of personnel and some normative statement of what is medically required, usually expressed as a ratio of personnel to population or patients. The other defines and measures shortages against market criteria, such as the difference between estimates of market demand for health services and the supply of those personnel technically linked to the provision of those services;[8] the difference between the relative costs and benefits of obtaining necessary educational qualifications to permit entry into the occupation;[9] changes in relative factor prices;[10] or the structural characteristics of the factor market.[11] Not unexpectedly, the second set of criteria is favored by economists; the difference is frequently characterized as being economic or non-economic. This has several unfortunate consequences, not the least being its frequent interpretation as a methodological difference. It is not; the debate carried out in these terms, accordingly, has been fruitless.

Surely the use of normative ratios leaves much to be desired. To understand the difficulty involved, recall simply the complicated web of

factors associated with both the estimates of the demand for (any) service and particularly the amount of any given input utilized per unit of output. When constant norms are applied, all of these factors are assumed either to be unimportant or to remain unchanged. When ratios shift in time, either by extrapolation or adoption of norms prevailing elsewhere, all factors are assumed to shift by like amounts; the nature or magnitude of these shifts, however, is rarely investigated. Furthermore, since the ratios have "qualitative" implications, they are permitted typically to shift in only one direction, viz., upwards; in other words, they rarely if ever imply productivity of efficiency relationships.

The use of ratios is explained by the common belief that a linkage exists between the health resource availability and the health status of defined populations. They represent, however crudely measured, health status goals. This interpretation is an artifact of early work in the field. One of the earliest studies--perhaps the classic study--conducted by Lee and Jones estimated physician requirements as a function of estimated morbidity and the number of physician hours needed to diagnose and treat each type of morbid condition.[12] Physician hours so obtained were then divided by average hours worked per year and, in turn, by population. The resulting "norm" was calculated to be roughly 1.35 physicians per 1,000 population. Since fewer physicians per capita were then available, Lee-Jones concluded that a "shortage" existed. A large number of ratio studies have been conducted as if they had undertaken an analysis similar to Lee-Jones. To our knowledge, no replicative study has been conducted, but clearly the legacy continues.

Ratio qua health goal definitions of "shortages" or requirements have come under attack by economists who question the wisdom of providing additional resources in situations where there are economic or socio-cultural barriers to care. They also question the implicit assumption of fixed technical coefficients in the provision of services.[13] Economists urge instead using estimates of the demand for health care services as expressed in the market linked to (alternative) estimates of input bundles as a gauge of shortage conditions. In a sense, the recommendation simply attempts to plug the gaps mentioned above. But in doing so, it changes both the nature and scope of health manpower planning activity. This occurs because the use of market criteria shifts the nature of the underlying preference function and hence the objectives of health manpower policy. Simply put, there are differences between shortages defined in reference to health goals and shortages defined as disequilibria in health care markets. Clearly, one difference is the implicit criterion function: health goals presumably relate to maximizing changes in health status, while market goals relate to optimal allocative positions in the sense of Pareto. It is not altogether clear that these criteria would coincide even if health care markets were perfectly competitive. But the widespread recognition that health care markets are not purely competitive (and the fact that health status is functionally related to instruments lying outside of the health care industry) suggests that the distinction is more meaningful than it appears at first blush.[14]

A significant dimension of this difference relates to the underlying structure of preferences. The use of market criteria necessarily carries with it the assumption that independent, individual preferences (expressed through the market) and only such preferences count. The use of health status criteria, among other things, would attempt to account for the absence (non-existence) of certain kinds of markets as well as various external (neighborhood) effects. In so doing, it would specify a "community" preference function, which might not necessarily resemble a function composed strictly of individual utilities (or, for that matter, professional medical opinion). In operational terms, this implies different data sources and uses in the specification of goal statements. For example, specification of health status goals cannot rely on (market) expenditure data, while market goals need not employ information about health problems of defined population groups.[15] Substantial differences in the technical capacity essential for planning, in other words, occur as a result of this conceptual distinction.

While it is extremely difficult to argue that the use of manpower/population ratios constitute reasonable measures of health-related goals, it is possible to interpret their intent in this fashion. If one grants this possibility, it follows that encouraging the use of economic criteria as a methodological alternative or improvement misses the point.[16] Rather, what is required is the development of more refined techniques for specifying health status goals and relating them to relevant policy instruments. Progress has been hampered along these lines because of the absence of an operational definition or measure of health status. Recent years, however, have witnessed considerable research activity designed to provide operational health indicators.[17] Unfortunately, research products are not yet available.

Equally important is our limited ability to relate changes in health indicators to changes in policy variables and (thence) factor inputs. These crucial transformations define the range of relevant policy instruments that can be used to achieve balance, and thereby the scope of the plan. Knowledge base limitations here perhaps explain both the inappropriate interpretation of the ratio approach and the continuing perception of health manpower planning as a unique or independent activity. That is, what is objectionable about the use of manpower ratios is not that they employ health status or "need" criteria, but that they fail to specify actions other than the provision of personnel which are necessary to achieve stated objectives. Clearly, when complementary policy actions are accounted for, health manpower planning ceases to be an independent activity; rather, it emerges as an interdependent component of a more broadly conceived planning effort.

More particularly, the knowledge base for transformation purposes is limited in several important respects: First, considerable difficulty has been encountered in disentangling the relationship between changes in health status and medical care variables at both micro and macro analytic levels.[18] Macro studies, employing regression techniques and mortality rates as measures of health status (i.e., as dependent variables) have

not been altogether successful in identifying the consequent impacts of changes in available health resources, although they do suggest that the relationship is weaker than is commonly supposed.[19] Second, problems are encountered in modeling the health care system, i.e., specifying the policy inputs. Although several "system" models have been proposed in the literature, they remain primarily methodological probes without empirical content.[20] Even methodologically, however, the "system" is typically treated as a set of relatively independent subsystems, e.g., physician services, hospital services, nursing homes, etc.; interactions among subsystems are frequently ignored. Only Navarro's "patient flow" model allows for direct interactions between and among system components; but the demands of the model on data collection and processing preclude its operational use.[21] Finally, only limited progress has been made toward measuring the relevant parameters of the production function underlying the delivery of given health services. Research activity is increasingly being directed to questions of scale effects and manpower substitution in the provision of health care, and the situation may improve in the near future.[22] At the moment, however, there is a limited analytic capacity to derive alternative manpower implications of health plans.

With the exception of production function research, most economists have tended to ignore these knowledge base deficiencies because they assume that only market criteria are relevant to plan formulation. That such criteria relate to different (narrower) problem sets and operate on different theoretical principles apparently does not concern them. To be sure, much of the debate about health manpower policy seems consistent with the economist's more limited concern for market equilibrium, irrespective of substantive (health status) effects or options. Since the only suitable way of judging which criterion function to use is in reference to the expressed policy concerns of the community, it is difficult to object to the choice of economic models on grounds of relevance. But it is possible to argue that this does not constitute a methodological choice per se.

Even if the more limited economic notions of deriving manpower shortages/requirements from estimates of market "demand" for health services are used, numerous problems are encountered. For instance, while a number of increasingly sophisticated models of health care markets have been proposed in the literature, including econometric constructs which solve for market clearing price-quantity relationships and programming models which optimize certain health service variables, our ability to make simple estimates of aggregate demand for and the product (service) mix of the health care sector is limited.[23] For instance, we still have a limited understanding of both the income and price elasticities for various health care services as well as the cross elasticities between types of services. In the case of price and income elasticities, a range of estimates have been produced, but there is little agreement between and among them.[24] We know of only one study of substitution in the demand for services: Davis and Russel's study of impatient/outpatient care tradeoffs.[25] It would appear that substantially more research needs to be carried out here.

In the absence of such research, most economic models proceed simply by estimating potential use on the basis of observed utilization rates. This procedure creates a more fundamental problem: all signs point to the possiblity that utilization of health services is affected more by supply conditions than by demand. Studies of the use of hospital beds and physician services, for example, suggest a distinct pattern of Say-like behavior.[26] In part, this reflects conditions of pent-up demand from earlier periods of disequilibria. But Feldstein has suggested, in the case of physicians, that much of it stems apparently from market imperfections and corresponding discretionary power of physicians, such that excess demand for physician services can be maintained irrespective of relative supply conditions.[27] The implication is that there may not be a set of price/quantity relationships which will clear the market, i.e., it implies that some type of manpower imbalance may continually be in evidence. It may also imply that even if the market approaches equilibrium, it will do so in ways that may be unacceptable from a social point of view.

The only effective way out of this impasse is to employ health-related criteria in determining the level and type of resources to be provided to the sector. In this sense, there may not be a choice between types of policy criteria or types of balance to be achieved after all. And this implies that the general lines of methodological thinking about health manpower over the past decade has been mis-directed. For present purposes, however, it is not essential that a choice be made. Rather, it is sufficient to recognize simply that manpower requirements can be derived from different sets of policy criteria and that the delineation of policy problems and solutions must be consistent with those criteria. As we shall see, such consistency is not always evident in actual planning experience. Indeed, what is conspicuously absent in forecasting practice is the concept of balance itself and thereby the policy uses of projections of manpower requirements. We shift our attention to an examination of recent health manpower planning activity in order to substantiate the point.

Health Manpower Forecasting: The Practice

It should be noted at the outset that our examination focuses on planning practice at the State level and relies almost exclusively on the "practice literature," as defined in an earlier Chapter. Reliance on published work affects our results in obvious ways, but impressionistic evidence suggests that the documents examined are reasonably representative of the current activity in the field. Our focus on State-level planning exercises is explained by the fact that several earlier studies have examined national projections, especially those relating to physicians.[28] Although our analysis proceeds in somewhat different fashion, it did not seem worthwhile to re-tread much of the same ground. We have included some discussion of national studies for purposes of comparison, particularly for analyses which appeared to differ from the norm. Furthermore, given the intent of recent legislative enactments such as the Comprehensive Health Planning Program, the capacity to plan at the level of the

region/state assumes equal if not greater importance than our ability to plan at the national level. As things stand at present, in other words, we must be able to plan at both levels if such activity is to have any substantial impact.

Given these objectives, we attempted to obtain a representative cross-section of State-level projection studies for the period 1966-1973. In addition to the bibliographic search and agency survey described in Chapter V, we sought documents listed in a recent bibliography on health manpower studies prepared under the auspices of the National Health Council and based on a nationwide survey of State and local health planning agencies.[29] What is noteworthy about this procedure is that a sizable number of documents identified in one survey were not identified in the other. This suggests that the practice literature as well as the practice itself is balkanized. A number of States, for instance, appear to have supported roughly identical studies in isolation from one another. Such weak institutional linkages do not auger well for the development or execution of health manpower plans.

Of the materials collected, several features are so striking that they warrant immediate comment. First, a substantial proportion of this literature contains either policy statements derived in the absence of data analysis or, more commonly, data summaries without corresponding analysis or policy use of the data. It may appear improper to emphasize this point, but we do so because it is an indicator of the state of the art. The situation probably reflects a long history of neglect at the State level for quantitative policy information. Considerable effort has thus gone into generating the requisite base set of data for planning purposes. What is difficult to understand is that this material invariably deals in disjointed fashion with facets of the health system and categories of health manpower. For instance, the most common type of "study" is the inventory of some particular type of health worker. But inventories are typically prepared in independent fashion and frequently use different occupational definitions, geographic divisions, service categories, and the like: they rarely reflect the notion of a manpower pool utilized in the provision of specific services. A priori, the policy value of such data, exploited or not, is questionable.[31]

Second, even those studies which went beyond data inventory, i.e., those which estimated manpower requirements, invariably treated health occupations in independent fashion. Klarman's recent evaluation of the health manpower requirements literature concluded that there is now "a tendency to examine requirements for several health occupations at a time, rather than singly."[32] We find little evidence to support this conclusion. Increasing numbers of studies of course, do include forecasts for sets of occupations, but for methodological reasons, the projections do not account for interdependence. Stated differently, few of these estimates account for substitution possibilities or complementarities. This criterion alone suggests that the state-of-the-art is not now substantially more advanced than it was several decades ago.

Finally, despite the long history of technical and conceptual dispute, the most common projection methodology at the State level is neither ratios nor "economic" analysis; rather it is the use of employer or establishment surveys. This somewhat surprising result suggests, in the first instance, a convenient taxonomy of the practice literature, viz., studies using either employer estimates or independent, analytically derived estimates of requirements. Each is discussed in turn.

Requirements Studies: Establishment Surveys

We had not anticipated an extended discussion of the employer or establishment survey method because of the widespread presumption in manpower circles that such assessments do not yield meaningful results. But almost one-half of the projection studies identified in our search were conducted by this method, suggesting that this view is not widely shared in the health field. Some discussion appears to be warranted; accordingly, we examine eleven State studies carried out over the past few years which (in our judgment) typify the method.[33] In particular, we examine the objectives and results of these studies as a means of making inferences about their policy relevance.

Let us note initially that all of these studies were carried out for the expressed purpose of providing guidelines and/or base line data useful to educational policy-makers, generally those concerned with vocational and baccalaureate level schooling. The reasons given for using the employer survey method to generate such guidelines tended to vary in each of the reports. In the majority of cases, the implication clearly seemed to be that such surveys were a desirable and efficient method for projecting manpower requirements. In a few instances, however, this was of secondary concern, because the primary purpose was to evaluate employment opportunities in the current period, i.e., to estimate budgeted vacancies. Such information was then supplemented or extended by requesting information on "expected vacancies" or "additional needs" for a year or several years beyond the base period. (We have characterized these estimates below as "equilibrium" projections.) In either case, these studies accepted the premise that establishments are equipped to provide reasonable and useful manpower policy information.

That is a doubtful premise, for several reasons. To begin with, the choice of time periods in the studies under review appear to be inconsistent with the objectives of the analysis. With few exceptions, they specify a planning horizon or no more than five years, and in some cases, only 1-2 years, (See Table VII.1 below). The choice of these time periods presumably stems from the belief that employers will have difficulty enough in estimating requirements for short-periods of time; longer time horizons are thereby eliminated a priori. The difficulty is that the studies invariably included occupational groups for which upwards of four years of post secondary school training is required. This implies either an absence of concern about achieving balance over the course of the planning period or an implicit assumption that the rate of change in variables stabilizes beyond the terminal year of the projection period. Neither contributes to the formulation of consistent policy.

Similarly, the policy value of the studies is diminished by the absence of supply estimates and comparisons between supply and requirements, i.e., they are not policy models as discussed above. Indeed, only several studies incorporated any supply data, e.g., one included the numbers of persons employers expected to train internally and another included the number of "graduates" from programs in the State.[34] Although we have excluded comment on supply estimation techniques, the general lines of such analysis are straightforward and widely understood: projected supplies must account for occupation specific labor force participation rates and be adjusted for the geographic specific net migration rate. Clearly, comparisons must also account for attrition due to death, retirement, occupational mobility, etc. But these factors can be treated on the demand side, i.e., by estimating "replacement" demand. In the studies under review, this was the typical procedure. The use of graduation data or internal training data hardly come close to fulfilling these analytic requirements. For this reason, it is difficult to understand how useful these studies might have been to policy-makers.

Finally, employer surveys appear to yield biased estimates of manpower requirements. In order to see this, annual average growth rates for selected health occupations implied by the projections were calculated; they are displayed in Table VII.1. While this Table is designed only for comparative purposes, it has limitations which must be acknowledged. For one thing, the underlying samples of establishments are different: although most major hospital facilities are included in all studies, several also contacted offices of physicians, independent laboratories, etc. For another, some studies adjust (pro-rate) for non-respondents, others did not. Of this latter group, the response rate was never above two-thirds, implying that the absolute values of the projections cannot be used with any confidence. Finally, the calculation of growth rates assumes equilibrium conditions in factor markets in the base period. Put simply, the only justification for a comparative display of the projections is that these are the data with which policy makers must work. It is likely that they would proceed, implicitly or explicitly, to manipulate the data in the manner indicated in Table VII.1. The question, then, is what the projections indicate.

Not unexpectedly, the projections indicate an enormous potential demand for various classes of health manpower. As can be seen, the rates of (expansion) demand for all occupations are rarely less than 2.5 percent per year, which is minimally 1.5 times the rate at which over-all employment increased during the 'sixties. Employment in most occupations is forecast to be roughly 3-4 times this rate. Similarly, most States project potential demand to be higher than projected increases for the nation as a whole. For instance, the total pool of allied health manpower--the occupations included in Table VII.1 may be considered a representative sample of the total pool--was forecast to grow at approximately 4.0 percent per year over the period 1966-75.[35] Interestingly, the relative priorities of the State studies seem generally to be consistent with the national projections; e.g., the consistently higher forecast demand for occupational and physical therapists.

TABLE VII.1

Projected Requirements for Selected Health-Related Occupations From Employer Surveys, Selected State Studies, Circa 1970
(Annual Average Growth Rates)

State (Time Period of Projections)	Projected Annual Average Growth in Requirements by Occupational Category							
	Nursing Personnel			Technologists & Technicians			Therapy Personnel	
	RN	LPN	Aides & Orderlies	Medical & Medical Laboratory[a]	Medical Records	Radiology[b]	Occupational & Physical Therapists	Therapy Technicians Aides & Assistants[c]
Five Year Projections								
Colorado[e] (1971-76)								
Gross Requirements	12.0	11.5	12.1	9.7	9.5	13.3	na	10.0
Replacement	9.5	8.2	9.4	6.1	5.9	8.8		7.3
Expansion[d]	2.5	3.3	2.7	3.6	3.6	4.5		2.7
Hawaii[f] (1968-73)								
Expansion	4.3	5.8	6.9	na	na	na	na	na
Montana[g] (1968-73)								
Gross Requirements	na	5.4	6.1	5.1	7.4	6.0	na	13.1
Replacement		2.2	4.1	2.4	5.0	3.1		4.9
Expansion[d]		3.2	2.0	2.7	2.4	2.9		8.2
New Mexico[h] (1971-76)								
Expansion	4.7	4.7	3.1	5.8	10.2	5.1	11.8	9.2
New York[i] (1966-71)								
Gross Requirements	12.4	12.0	8.2	10.0	11.6	9.8	18.5	18.1
Replacement	3.8	6.2	3.8	3.4	3.3	3.4	3.6	3.6
Expansion[d]	8.6	5.8	4.4	6.6	8.3	6.4	14.9	14.5
N. Carolina[j] (1967-73)								
Gross Requirements	8.9	10.9	7.2	10.3	10.3	12.2	16.0	15.9
Replacement	3.5	3.8	2.8	3.3	5.3	6.1	5.3	1.2
Expansion	5.4	7.1	4.4	7.0	5.0	6.1	10.7	14.7
Oklahoma[k] (1973-78)								
Gross Requirements	8.5	9.4	6.9	8.3	9.9	9.4	11.5	11.3
Replacement	5.0	5.3	5.2	4.1	5.4	3.8	4.8	4.5
Expansion[d]	3.5	4.1	1.7	4.2	4.5	5.6	6.7	6.8
One-Two Year Projections								
Arizona[l] (1972-73)								
Expansion/Equilibrium	9.7	11.5	9.0	9.5	8.9	8.3	13.6	13.6
Kentucky[m] (1971)								
Expansion/Equilibrium	15.3	14.4	6.0	8.2	20.5	6.6	51.9	15.2
Tennessee[n] (1971)								
Expansion/Equilibrium	na	12.8	na	13.3	55.5	16.7	75.5	218.1
Virginia[p] (1971-73)								
Expansion	7.6	8.2	5.3	14.7	12.9	9.9	12.8	13.6

NOTES
TABLE VII.1

[a]Includes medical technologists and technicians, medical laboratory technologists, technicians and assistants, cytotechnologists, histologic technicians, electrocardiograph and electroencephalograph technicians.

[b]Includes radiologic technicians, radiation therapists, and nuclear medicine technicians.

[c]Includes occupational and physical therapy assistants and aides, and inhalation or respiratory therapists and assistants.

[d]Because of rounding errors and interaction effects associated with the use of geometric growth rates, the expansion component of the gross requirement rate has been approximated by subtracting the growth rate needed for purposes of replacement from the 5 year annual rate of change necessary to meet gross requirements.

[e]State Board for Community and Occupational Education, Colorado State Employment Service, Colorado Health Occupations Manpower Survey, 1972, (Denver, 1972), calculated from Table 5, p. 43.

[f]Harriette Joesting, Nursing in Hawaii-1968, Report No. 4 (Honolulu: University of Hawaii, Legislative Reference Bureau, 1969), calculated from Tables 12a-12c, pp. 31-33.

[g]Wayne Grames, et al., Paramedical and Allied Health Service Occupations in Montana: A Survey of the Occupations, Manpower Requirements, and Training Needs Essential to the Support of General Health Services in the State of Montana, (Helena: Montana Occupational Research Coordinating Unit; and Washington, D.C.: Department of Health, Education and Welfare, Office of Education, September 1968), calculated from Table 5, p. 13.

[h]Manpower Survey Committee, New Mexico Hospital Association, Manpower Survey Report, 1971, (1971), calculated from pp. 3-5.

[i]Herman S. Soloman, Manpower Needs in Health Services, (Albany: New York State Department of Labor, 1969), calculated from Table 2c, p. 17.

[j]North Carolina Employment Security Commission, Health Manpower Needs in North Carolina 1967-73, (Raleigh: 1967), calculated from Table II, pp. 10-11.

[k]State Department of Vocational-Technical Education, Oklahoma Health Manpower Needs, (Stillwater: 1973), calculated from Table II, pp. 49-51.

[l]Arizona Regional Medical Program; Arizona Health Planning Authority; Comprehensive Health Planning Council of Maricopa County; and Pima Health Systems, Inc., Allied Health Manpower Survey, 1972, (July, 1972), calculated from Table 2, p. 6. These calculations use full-time equivalents as the base employment figure and include both current and anticipated vacancies in 1973 as requirements.

[m]Comprehensive Health Planning Manpower Study Committee, Kentucky Comprehensive Health Planning Commission, The Dix Report, (Frankfort, Kentucky: 1971), calculated from Summary Table pp. 6-10. Calculation of requirements based upon budgeted vacancies and "needed positions" in current period.

[n]Tennessee Higher Education Commission, Tennessee Allied Health Education Study, (April, 1973), calculated from Text Tables, p. 64, 69, 75, 81, 94, 106, 110. Definition of "requirements" identical to m.

[p]Coordinated Health Survey Committee, Health Manpower, Virginia 1971, (1971). calculated from pp. 6-7. Since "requirements" were measured in terms of full-time equivalents, we manipulated the base year figures to approximate full-time equivalents. This was calculated by adding one-half of reported part-time employment to the number of full-time employees. Requirements were calculated by adding "additional personnel needed by 1972" to "additional personnel needed by 1973".

Nevertheless, estimates of gross requirements rates are extremely high--probably too high. This appears to be an unavoidable, albeit highly undesirable, by-product of the approach. Briefly put, simple requests to employers for information on "expected need," "anticipated vacancies," and the like fail to discriminate between stocks and flows.[36] From the perspective of the employer, for instance, simple labor turnover will be treated as a "requirement." That such turnover is included seems evident, because even allowing for the characteristic differences in the labor force behavior of health workers, most of the replacement estimates of the "five year" studies seem exceptionally high.[37] But these needs may be satisfied by movements of workers between establishments; from the viewpoint of the community, they clearly are not additive. Stated differently, employer estimates involve double-counting. If the figures are interpreted with care, perhaps no problem results. But if they are interpreted literally and linked to school system policy, there is significant danger that implied policy needs will be over-stated.

Roughly similar problems mar the use of budgeted vacancy rates, e.g., in the "one-two" year studies cited in Table VII.1. The difficulty here, in the first instance, is to know how to interpret these figures, since employers were asked simply to list vacancies and "additional needs." The high rates perhaps suggest the answer. But even if budgeted vacancies are estimated with precision, it is possible that they will over-state training requirements. The reason, as Archibald and Yett have shown, is that the existence of budgeted vacancies are consistent with market equilibrium, if the market itself is imperfectly competitive.[38] Many of the health and hospital facilities included in these samples unquestionably operate in less than perfectly competitive markets; consequently, the level of reported vacancies may be invariant (highly inelastic) with respect to changes in supply conditions. As such, they are unreliable guides to manpower policy.

We conclude, therefore, that employer surveys, despite their apparent popularity, are unlikely to provide reasonable criteria for manpower planning purposes. Coupled to the obvious problem that even a complete census of establishments in the current period fails necessarily to include establishments that will exist at some future time, it is difficult to place any confidence in the figures derived from such studies. It should be noted that a priori the method holds out the promise of being able to provide consistent, simultaneous estimates of different factor inputs; i.e., projected requirements for given personnel would reflect planned expansion, capital expenditure, changes in "product" mix, and the potential for substitution between classes of manpower. It is possible that some of these effects were captured in the studies under review, but our impression is that the number is small. The reason is that the mechanical process of filling-in long columns of figures on a survey questionnaire does not prompt thinking along these lines. Furthermore, to the extent an increasing number of areas have adopted certification of need legislation which require community approval of expansion plans, it is not clear that estimates by individual establishments are necessarily meaningful.[39] Unless one believes they are, or believes

they can be designed to yield useful information or insight on substitution effects, it is probably better to abandon the use of establishment projections and turn, instead, to the use of analytic projection methods. We examine these methods next.

Analytic Projections

Once we leave the comparatively simple case of employer survey projections, however, taxonomy, description, and evaluation of the practice literature becomes exceedingly difficult. Stemming perhaps from limitations in data, time, or resources, a variety of methods have been employed to project health manpower requirements. Generally speaking, differences in method do not stem from differences in objectives or conceptual framework--they are similar to those studies discussed above. And with few exceptions, dimensions other than school policy seem to be ignored.[40] Furthermore, considerations of scope do not seem to influence the choice of technique since, in virtually every case, occupational categories are treated in independent fashion.

The disparate avenues of attack imply that any attempt to classify the practice literature for purposes of comparative evaluation must be arbitrary. For reasons that will be clearer below, we have opted to divide the analytic projection studies into two groups: those which base estimates of manpower requirements on forecast changes in the services delivered by these productive factors and those which do not.[41] We refer to the former as the service model, and the latter as the employment model. It is perhaps sufficient commentary on the current state-of-the-art that such a distinction should be necessary at all, much less constituting the principal dividing line between practice methodologies.

Service models.--The prototypical analysis is Fein's study of the U.S. physician shortage published in 1967.[42] Its purpose was to improve upon earlier health manpower studies which failed to distinguish between the demand and supply of medical services and the demand/supply of medical personnel. The analysis begins, therefore, by estimating the "demand" for physician services, which is accomplished by forecasting the impact of changes in socio-economic variables on the physician utilization or visit rate as measured by the U.S. National Health Survey. Assuming constant (1964) utilization coefficients across socio-demographic categories, Fein calculates the impact of socio-demographic shifts on the volume of physician visits over the period, 1965-1975. He finds that the demand for physician visits will likely increase at 2.0-2.3 percent per annum over the period, more than half of that growth being attributable to population growth, and the remainder (in descending order of importance) to education and income effects, changes in public policy (Medicare), changes in the age-sex distribution of the population, changes in racial composition, and changes in the regional/residential distribution of the population.[43] Concomitantly, Fein estimates that the supply of physicians (including an inflow of foreign physicians) will increase at roughly 1.7 percent per annum. He concludes that unless productivity increases on

the order of 0.3-0.7 percent per year are forthcoming, a "shortage" of physicians will be in evidence.[44] Note, however, that productivity enters only as an implication of the forecast imbalance between the demand for physician services and the supply of physicians. Fein's failure to incorporate a direct estimate of productivity stems, in large measure, from gaps in the relevant knowledge base. We shall return to the point momentarily.

The service model has gained increasing acceptance in the health field. A particularly important application is currently underway at the national level relating to the manpower implications of alternative (national) health insurance proposals.[45] This research uses a straightforward sectoral model comprised of 18 types of health care (sub-sectors) and roughly 20 manpower specialities.[46] Population use of these care types, categorized by age, sex, and income, are estimated for the base year, and projected changes in these variables multiplied to constant utilization coefficients yield a forecast of changes in the volume of services by type. In this sense, it is identical to Fein's model, except that it accounts for more types of care and is generally more disaggregate in form.

The model is different, however, in at least three ways: First, allowance is made for certain kinds of shifts in utilization coefficients by type of care. The specific nature of these shifts presumably varies among policy problems and analytic objectives.[47] Second, the model differentiates population groups served by prepaid, group practices (HMO's) and those served by more traditional delivery mechanisms. The different treatment is (presumably) designed to reflect differences in both the utilization patterns of HMP panels and the general population as well as differences in the efficiency parameters of the productive process. Finally, the model accounts for productivity shifts in the delivery of services, which are used to assess relative manpower requirements. The productivity coefficient (more correctly, its reciprocal) enters multiplicatively, and accounts (presumably) for shifts in efficiency stemming from some forms of factor substitution. Thus, the model is a simple analogue to the traditional manpower projection model applied to health care. As such, it does not address directly the problem of the appropriate use patterns, the extent to which current use rates are influenced by past supply conditions, or the probabilities that market equilibrium can be achieved. These limitations aside, it has considerable hueristic value and represents a best practice technique.

The same cannot be said for the use of the service model at the State level. The reason is that it has been used in highly aggregate and limited fashion and, hence, has not been fully exploited for policy purposes. For instance, Berkowitz, et al., used a few, aggregate service measures to project (independently) the requirements for various classes of health manpower in New Jersey.[48] The procedure begins with calculated changes in the volume of services as a function of changes in population and income. More particularly, utilization is written as a function of the income elasticity of demand for each service, population change, and

an "interaction" term, which is necessary because they use absolute percentage changes of the variables over time.[49] But the spirit of the approach is violated by the fact that productivity rates are not calculated; rather, projected percentage increases in services are applied directly (and equally) to the number of personnel available in the base period.[50] Thus, the estimate that demand for physician "visits" in the State will increase by 37.5 percent over the period 1965-75 results in the conclusion that the number of active physicians must increase by 37.5 percent over the same period.[51] The omission is rationalized as follows:[52]

> Acknowledging the substitution effect and predicting its magnitude are separate problems. Prediction requires estimates of future change in staffing patterns and the capital labor ratio . . . Extrapolation of past trends, sometimes used as an estimate of future technological change, is risky and often implies greater accuracy in projections than exists. Sometimes it is better to make no estimate of the effects of technological change than a bad one.

The procedure clearly appears to produce an "upward bias" to educational policy. To illustrate, Berkowitz estimates an impending shortage of physicians on the order of 2.2 percent per annum.[53] If productivity increased by as little as one percent per year, the projected deficit would be reduced by approximately 70 percent. The fact that even such a conservative estimate was absent from the analysis contributed substantially to a later recommendation that a third medical school be built in the State.[54] Recommended additions to educational capacity have also emerged from other studies using equivalent techniques.[55]

The point is not a specific criticism of these studies as much as it is a general question of the relevance of planning activity to the decision process. If forecasts are to be useful to policy makers, they must reflect the extent to which the results are sensitive to important parameters. While the knowledge base frequently limits confident estimates, the analysis nonetheless should seek a plausible range of values for key variables.[56] This might be accomplished by simulating the range of impacts resulting from the adoption of particular values. Such exercises should be able to demonstrate to policy makers what is at issue. The failure to try "bad" assumptions avoids this difficult task, but does so (in our judgment) at considerable cost to the formulation of efficient policies.

Moreover, it is not altogether clear that anything is gained by going to detailed projections of activity levels if the rate of productivity is to be treated as a constant and applied directly to occupational aggregates. In a sense, the procedure amounts to little more than using a population ratio adjusted for aggregate changes in community income. It seems plausible to argue that such detail is fruitful if and only if estimated changes in the underlying production function are to be taken into account.

Employment model.--Unfortunately, this is a residual category, which includes "pure" ratio studies, studies which "manipulate" ratios or complement them with other types of analysis and studies which establish criteria by other more eclectic means.[57] Despite these differences, they share several common elements and problems, viz., they tend to be partial studies which ignore the concept of balance and fail to use available data to maximum advantage. Brief descriptions of several studies may clarify the point.

An illustrative case is Wechsler's study of dental manpower in New York State, which was designed to assess whether or not current or future "shortages" of dentists exist in the State.[58] His analysis suggests no evidence of a current shortage, but does conclude that the regional distribution of dental personnel is less than desirable. The conclusion emerges from an examination of dentist/population ratios and results of a survey of professional opinion about the adequacy of regional supply and a survey of practitioners with respect to waiting time, willingness to accept new patients, patient load, employment of ancillary personnel, age, etc.[59]

Wechsler then examines trends in the demand for dental services, including the effects of population growth, changes in insurance coverage, flouridation, etc. The projection applies 1980 estimates of national average visits per person to State population projections. This "educated guess" (as he refers to it) shows a potential increase in service demand of roughly 2.5-3.7 percent per year. He then examines dentist supply as measured by the dentist/population ratio. Since this ratio decreased over the recent past, Wechsler points to the probability of increasing regional imbalance in the State. Corrective action is considered to depend upon the recruitment of students from shortage regions, rather than the location of new dental schools in those areas--a recommendation "developed in consultation with the project's Advisory Committee."[60] It is not clear exactly how this conclusion emerges, however, since supply and demand over time are not compared; indeed, they are incomparable.

Moreover, simple manipulation of Wechsler's data suggests that the region with potentially the least favorable supply conditions could obtain about half of the "needed" dentists over the next decade if one assumes that productivity grows at a rate equal to the (estimated) national rate.[61] This being so, there is a possibility of substantial gluts of dentists in other regions, which might easily shift the entire pattern of locational preference. While Wechsler acknowledges the limitations imposed by the general absence of knowledge about the migration patterns of professional workers, he does not explore the implications. Indeed, the study is less a case of "planning without facts" than it is a failure to examine "the facts" in any detail. It seems clear that such failure detracts from the policy value of the exercise.

Ambiguity in the handling of data is also evident in a supply/demand study of physician manpower in Pennsylvania.[62] This study measures both demand and supply in utilization or employment terms; demand estimates

are calculated as the algebraic sum of "growth," "unmet needs" and "replacement" components. The first two are of particular interest. For instance, growth requirements were based upon time series regressions of physicians practicing in the State. This is not an ideal method, of course, but it is permissible under certain circumstances. A difficulty arises here because these linear extrapolations are then adjusted for forecast changes in supply conditions. In the author's words:[63]

> It is obvious that projections of growth without regard to the impact of increases in medical school output and in-migration, due to demands and factors not operating in the historical past, must be, of necessity, in error to some degree. For this reason, an effort was made by the author to project what might be called ahistorical growth based upon the discrepancy between . . . (alternative supply projections). This discrepancy is, in effect, the difference between the projection of supply if Pennsylvania physicians continued to be produced, be retrained, and in-migrate at the same rate as in the 1960's . . . and the projections of supply based on the medical schools conception of their future growth in the 1970's . . .

Such adjustments might be undertaken with respect to the relatively sophisticated notion of Say-like effects and simultaneous equations bias in the physician market, but neither the text nor references of the report suggests this possibility. In fact, since "demand" estimates are ultimately compared to "supply" estimates, the procedure seems to suggest confusion about the appropriate nature the "growth" component of a "demand" projection. The error is compounded in this case by adding "growth" demand to "unmet need" as measured by published opinion on optimal MD/population ratios by speciality.[64] It is hardly surprising that these estimates lead to a recommendation that the capacity of medical schools in the State be expanded. Many would agree, however, that the basis for this recommendation is quite weak.

Another illustrative case is a class of studies which favor abandoning efforts to estimate requirements, and rely instead on a detailed examination of supply forces. At the State level, the approach is typified by work done by RAND in the State of Illinois.[65] In a series of studies purporting to be useful to "educational planners," Rand consultants construct supply models, geared principally to educational flow constraints, for a variety of higher-level health manpower categories. While several of these analyses include crude estimates of current manpower deficits as well as simulations of the effects of productivity growth, forecasts per se are limited to impacts stemming from rates of graduations, migration, retirement, and death. Surely such forecasts assist policy making, but the absence of both requirement projections and alternative policies for augmenting supply casts doubt on their general value to the decision process.

Policy relevance.--In order to ascertain the extent to which analytic projection studies employ the concept of balance and are therefore relatively complete statements of manpower strategy as well as to assess whether or not differences in technique leads necessarily to differences in result, we have computed projected rates of change in the suppy of and requirements for various occupational categories. These computations are analogues to those given in Table VII.1; they are displayed in Tables VII.2 and VII.3. As before, several features of the construction of these Tables warrant comment. One is that only a limited sample of studies are included. Many were excluded, for instance, because they failed to describe the methods used or to incorporate relevant data in the published report.[66] Studies included here, however, are also incomplete and omit important component parts of the analysis. In some cases, this is because the studies had limited objectives; they have been included primarily for comparative purposes.[67] This is particularly true of the projections prepared under the auspices of the BLS Cooperative Matrix program, which have been grouped together in Table VII.3.[68] In Table VII.2, components omitted by design are noted as not applicable (na). Component parts of projections which were ignored, i.e., should have been included given the objectives of the study, are noted as not computed (x). A large number of x's or empty "cells" is an important indicator of the state-of-the-art.

Another feature is that some of the estimates were "re-worked" to make them as comparable with one another as possible. Since most analyses included attrition as an additive term in total requirements (as opposed to a negative term in the supply estimate), we undertook (where possible) the necessary calculations to treat it in this fashion. For purposes of consistent algebraic signs, productivity increases are included as a positive term in the supply equation. Given the limited use of the productivity term, however, this treatment may be considered a formality.

Some interesting patterns emerge from these computations. For instance, it is remarkable that a large proportion of studies use manpower/population ratios as a method for projecting requirements. While this proportion stems partially from selection procedures, it is noteworthy that the method is used at all. Of greater significance is that few of the non-ratio studies probe relationships in sufficient depth to draw significantly different conclusions than do the ratio studies. Thus, few projections using visit data account for changes in productivity or for changes in visit coefficients, i.e., age, sex and income specific utilization is assumed to remain constant over the planning period. The resulting change in the volume of visits reflects little more than changes in population, population distribution, and income levels; coupled to constant productivity, it accounts for only slightly more than the population/physician ratio. It is possible, therefore, to anticipate that the projected requirements might be similar to one another; Tables VII.2 and VII.3 show such similarity.[69] The inescapable conclusion is that the service model (as presently used) does not yield better or more confident projections of requirements.

TABLE VII.2

Projections of Requirements For and Supply Of Selected Health Occupations, Selected State Studies, Circa 1970-80

(Average Annual Growth Rates)

Occupation and State/Study	Projection Period	Principal Projection Method	Requirements			Supply			
			Total	Expansion	Replacement	Total	Educational Policy (State Specific)	Net Migration	Productivity
Physicians									
California[a]	1970-80	Volume of visits (with Comprehensive Health Plan visit coefficient adjustments) divided by constant productivity rate.	x	1.5	x	x	x	x	constant
Georgia[b]	1968-85	Ratio: 1967 national average number of active physicians/population.	3.4	x	x	x	1.7	x	x
Illinois[c]	1970-80	Projected changes in volume of visits based on national visit rate coefficients and applied to base period manpower stock.	x	2.0	x	1.5	na	na	x
Minnesota[d]	1971-85	Ratio: 1971 State ratio of active physicians/population.	3.6	1.6	2.2	3.5	3.5	0	x
Minnesota[e]	1970-80	Projected changes in volume of visits adjusted for conditional changes in insurance coverage and other system variables.	x	3.5	x	na	na	na	x
New Jersey[f]	1965-75	Projected changes in volume of visits applied to base period manpower stock.	3.8	3.1	0.7	1.5-2.0	x	x	x
Ohio[g]	1971-80	Ratio: national average patient care physicians/population.	4.2	2.6	1.6	x	1.7-3.3	na	x
Ohio[h]	1970-80	Projected changes in volume of visits vis a vis changes in state educational policy.	3.8-4.0	na[h]	na[h]	1.5-2.0 (3.8-4.0)	na[h]	na[h]	implied (1.3-2.0)
Pennsylvania[i]	1970-80	Utilization/trend analysis; ratios.	5.1-5.8	2.3-3.0	2.8	2.5	2.4	0.1	x
Tennessee[j]	1967-80	Ratio: 1967 national average number of active physicians/population	4.5	2.5	2.0	1.7-4.5	5.3	-3.6 to -0.8	x
Dentists									
Illinois[k]	1969-80	Projected changes in volume of visits.	1.9-3.7	ns	na[k]	1.1 (4.3)	na[k]	na[k]	simulated (3.2)
Maryland[l]	1964-80	Projected changes in volume of visits.	6.0	4.0	2.0	2.8	2.7	x	0.9
New York[m]	1970-80	Projected changes in volume of visits based on national visit rate.	x	2.5-3.7	x	0.9	na	x	x
Pennsylvania[n]	1970-80	Projected change in national dentist/population ratio plus judgmental improvements.	3.6-6.0	1.1-3.5	2.5	4.1	5.0	-0.9	x
Registered Nurses									
Georgia[o]	1967-75	Ratio: active nurse/population (national recommendation, 1956).	x	10.8	x	x	x	x	x
Illinois[p]	1969-80	Projected and simulated changes in bed/service requirements.	x	0.9-5.4	x	x	x	x	simulated
Maine[q]	1971-85	Alternative ratios: "registered" nurse/population.	2.2-2.8	0.2-0.8	2.0	x	2.2-2.8	x	x
Maryland[r]	1966-80	Ratio: active nurse/population subject to judgmental improvements.	5.9	1.9	4.0	7.9	6.1	1.8	x
Minnesota[s]	1970-80	Derived demand equation subject to simulated changes in delivery system.	x	2.0-2.1	x	na	na	na	na
Ohio[t]	1970-80	Employment trends coupled to BLS Matrix.	5.4	2.7	2.7	4.5	4.5	0	x
New Jersey[u]	1965-75	Ratio: active nurses/population subject to judgmental improvements.	4.2-5.7	0.2-1.7	4.0	x	4.0	x	x
Texas[v]	1973-85	Projected changes in volume of visits.	6.8	2.5	4.3	x	x	x	x
Medical Technologists									
Maryland[w]	1967-80	Projected changes in hospital beds.	4.4-5.2	1.1-1.9	3.3	4.1	4.1	0	x
Minnesota[s]	1970-80	Derived demand equation subject to simulated changes in delivery system.	x	5.2-4.9	x	na	na	na	na
Ohio[t]	1970-80	Employment trends coupled to BLS Matrix.	7.6	4.9	2.7	7.4	7.4	0	x
Texas[v]	1973-85	Projected changes in volume of visits.	6.1	2.4	3.7	x	x	x	x
Physical Therapists									
Maryland[w]	1967-80	Projected changes in hospital beds.	5.1-6.3	1.8-3.0	3.3	na	6.5	0	x
Minnesota[s]	1970-80	Derived demand equation subject to simulated changes in delivery system.	x	1.5	x	na	na	na	na
Ohio[t]	1970-80	Employment trends coupled to BLS Matrix.	10.0	8.1	1.9	5.0	5.0	0	x
Texas[v]	1973-85	Projected changes in volume of visits.	6.8	2.7	4.1	x	x	x	x

na = not applicable
x = not computed by (or computable from) study

NOTES
TABLE VII.2

[a]Paul M. Press, Estimating Appropriate Physician Supply, (Sacramento, California: State Department of Public Health, 1970), calculated from Table 10, p. 50.

[b]Georgia Department of Public Health, Office of Comprehensive Health Planning, Physician Manpower in Georgia, (Atlanta: 1969), calculated from text, p. 12, p. 15ff.

[c]J.A. Dei Rossi, et al., An Analysis of Medical Manpower and Education in Illinois, A Working Note prepared for the Health Education Commission of the Illinois Board of Higher Education, (Santa Monica: Rand Corporation, June, 1971), calculated from text and tables, pp. 47-54.

[d]H. Mead Covert, "Projections of Future Need for Physicians in Minnesota," Minnesota Medicine, (June, 1973), pp. 529-533, calculated from text.

[e]Festur Davidson and Tor Dahl, A Macro-Statistical Model of the Health Sector for the State of Minnesota, Vol. II, No. 3-2 (14), a final report submitted to the Comprehensive Health Planning Program, Minnesota State Planning Agency, (Minneapolis: Minnesota Systems Research Inc., February, 1973), calculated from Table 67, p. 211, Conditional Forecast #1. We have used the simple average of projected changes in primary and secondary care physicians.

[f]Monroe Berkowitz, et al., Medical Care Prices and Health Manpower in New Jersey: An Exploratory Study, prepared for the Comprehensive Health Planning Agency of New Jersey, (New Brunswick: Bureau of Economic Research, Rutgers University), calculated from text and tables, p. 193ff.

[g]Edgar Lee, A Report to the Ohio Board of Regents of the Study on Expanded Medical Education, (December, 1972), calculated from Table 2.

[h]Thomas N. Chirikos, "The Simple Arithmetic of a Health Manpower Policy for Ohio: A Summary Report," in Governor's Task Force on Health Care, Final Report of the Governor's Task Force on Health Care, (Columbus: Ohio Department of Health, December, 1973), Technical Appendix, text material, pp. 4-12. Note: disaggregation of components marked (h) not possible; replacement demand was subtracted from and included in supply growth rate.

[i]George E. Brehman, Jr., A Study of Physician Manpower Demand and Supply in Pennsylvania: Methodology and Findings, (Pennsylvania Department of Education, Bureau of Information Systems, Division of Research, 1973), calculated from Table 66, p. 139.

[j]Jerry Boone, et al., Medical Education for Tennessee, (Nashville: Higher Education Commisaion, February, 1971), calculated from text materials, p. 17, 34.

[k]J.A. Dei Rossi, et al., An Analysis of Dental Manpower and Education in Illinois, a report prepared for the Health Education Commission of the Illinois Board of Higher Education, (Santa Monica: Rand Corporation, June, 1971), calculated from text and tables, pp. 38-44. Note: disaggregation of components marked (k) not possible.

[l]Maryland Council for Higher Education, A Projection of Maryland's Health Manpower Needs Through the 1980's, (Baltimore: January, 1969), calculated from text and tables, pp. 3-71 and 3-84.

[m]Henry Wechsler, New York State Dental Manpower Study, (Albany: State Education Department, Bureau of Research in Higher and Professional Education, The University of the State of New York, Autumn, 1971), calculated from text materials, pp. 35 and 60.

[n]Frank M. Durkee, A Study of Dental Manpower Demand and Supply in Pennsylvania, (Pennsylvania Department of Education, Higher Education Research Section, September, 1973), calculated from text material, p. 52.

[o]Pat Malone, Nursing Education in Georgia 1969, (Atlanta: Georgia Educational Improvement Council), calculated from p. 19.

[p]J.A. Dei Rossi and G.F. Mills, Short-term Health Facilities and Registered Nurse Requirements in Illinois: A Prototype Study. A working note prepared for the Health Education Commisaion of the Illinois Board of Higher Education, WN-7397-IHEC, (Santa Monica, California: Rand Corporation, June, 1971), calculated from p. 28. Simulated changes in productivity reflected in expansion demand.

[q]Statewide Planning for Nursing Education in Maine, Nursing Education in Maine 1970-1985, (June, 1972), calculated from Tables 36, 39-42; pp. 46-47.

[r]Maryland Council for Higher Education, loc.cit., calculated from Table 3.11, p. 3-57 and pp. 3-58 and 3-59.

[s]Gestur Davidson and Tor Dahl, loc.cit., calculated from Table 68, p. 212. Estimates refer to conditional forecasts #1 and #2.

[t]Thomas N. Chirikos, Allied Health Manpower in Ohio: Employment Trends and Prospects, (Columbus: Ohio Advisory Council for Vocational Education and The Ohio State University, Center for Human Resource Research, August, 1972), calculated from Table III.4, p. 67, Table III.5, p. 73 and Table III.6, p. 76.

[u]Monroe Berkowitz, et al., loc.cit., calculated from text pp. 211-29.

[v]Texas Hospital Association and Texas Medical Foundation, Allied Health Manpower in Texas, 1973: A Report on Manpower Requirements, Resources and Education, (Austin: 1973), calculated from Table II, pp. 21-23.

[w]loc.cit., calculated from Table 5-8, pp. 3-11.

TABLE VII.3

Selected State (BLS) Matrix Projections of Manpower Requirements, Selected Health Occupations, Circa, 1970-80

STATE (Projection Period)	Projected Annual Average Growth In Requirements By Occupational Category			
	Physicians	Dentists	Registered Nurses	Medical Lab Technologist & Technicians
California[a] (1972-75)				
Gross Requirements	5.9	5.6	9.2	8.1
Replacement	3.0	3.0	5.5	4.2
Expansion	2.9	2.6	3.7	3.9
Maine[b] (1969-80)				
Gross Requirements	5.9	5.4	6.6	8.4
Replacement	3.0	3.2	4.4	4.5
Expansion	2.9	2.2	2.2	3.9
Massachusetts[c] (1970-76)				
Gross Requirements	4.8	5.3	6.9	6.9
Replacement	3.3	3.3	5.6	5.3
Expansion	1.5	2.0	1.3	1.6
Montana[d] (1970-80)				
Gross Requirements	4.0	3.8	6.0	6.4
Replacement	3.0	2.7	4.9	4.4
Expansion	1.0	1.1	1.1	2.0
New Hampshire[e] (1972-80)				
Gross Requirements	7.8	7.4	8.9	8.1
Replacement	4.5	3.9	5.9	4.9
Expansion	3.3	3.5	3.0	3.2
New York[f] (1968-80)				
Gross Requirements	3.7	3.2	5.0	na
Replacement	2.7	2.7	3.3	na
Expansion	1.0	0.5	2.7	na
Wisconsin[g] (1970-80)				
Gross Requirements	4.3	4.8	6.9	8.7
Replacements	3.3	4.4	5.7	6.4
Expansion	1.0	0.4	1.2	2.3

[a]California Health and Welfare Agency, Employment Development Dept., California Manpower 1972-75, (Sacramento: January, 1974); Tables 3-4, (B Methodology).

[b]Maine Dept. of Manpower Affairs, Manpower Research Division, Maine Manpower Projections to 1980: By Industry and Occupation, (Augusta: January, 1974), Table 5, p. 46, (B Methodology).

[c]Massachusetts Division of Employment Security, Occupation/Industry Research Dept., Manpower Requirements for Massachusetts by Occupation, by Industry 1970-76; An Interim Projection of Labor Demand, (Boston: 1973), Table 3, (A Methodology).

[d]Montana State Employment Service, Research and Analysis, Montana Manpower: Projected Montana Employment by Industry and Selected Occupations 1970-1980, Second Ed., (Helena: February, 1973), pp. I:18-I:31, (B Methodology).

[e]New Hampshire Dept. of Employment Security, Economic Analysis and Reports, New Hampshire Occupations in 1980, (N.P., N.D.), pp. 32-33, (B Methodology).

[f]New York State Dept. of Labor, Division of Research and Statistics, Manpower Requirements: Interim Projections New York State 1968-80, (N.Y.: July, 1971), Table I-D, pp. 71-78, (B Methodology).

[g]Wisconsin Dept. of Industry, Bureau of Research and Statistics, Wisconsin Work Force Occupational Projections, (April, 1974), pp. 9-13, (A Methodology).

More striking is that a significant number of studies did not estimate potential supply or important sources of potential supply. Of special importance here is the expected magnitude of (occupation-specific) net migration rates. It is important because most high-level health practitioners operate in national markets. Required flows from local (state or region) school systems should be adjusted, therefore, for potential inflows and outflows of personnel with relevant training over the planning period. This must be done if the impact of changes in local educational policy on the local supply of active practitioners is to be ascertained. As Table VII.2 shows, most studies fail to provide explicit treatment of these flows. Clearly, one reason for this failure is the absence of appropriate data. Another may be (e.g., in the case of physicians) conflicting research results relating to the factors responsible for locational patterns and preferences.[70] But the fact is that most studies were content to concentrate on but one source of supply, i.e., they were generally insensitive to the complexity of the supply mechanism. Two illustrations may clarify the point.

In the case of physicians, local supply is a function not only of local, undergraduate medical school output (and the inflow/outflow of persons similarly trained elsewhere) but also the output of graduate medical training, i.e., internship and residency programs, and the net migration of persons so trained. Supply response will also be effected by the time lags associated with graduate training and (at least in recent years) military service commitments. With rare exception, most studies ignored the factors associated with graduate programs; indeed, attention was typically riveted upon undergraduate medical education.[71] For instance, while net migration was considered in the Tennessee study, it was only in the context of the relative retention of (undergraduate level) medical school graduates. The study failed to account for changes in supply stemming from net migration flows of graduate students. Similarly, time lags tend to be ignored, such that all supply (educational) variables appear to be treated as adjusting instantaneously. These omissions cast some doubt on the conclusions of the studies and the policy recommendations which flow from them.

Roughly similar problems obtain in the case of nurses. The difficulty here relates to both migration effects and the impact of labor force participation rates. While these relationships have been subjected to increasing study, there is little evidence that they were incorporated into supply estimates in the studies under review.[72] While "replacement" demand tends generally to be higher--a partial recognition of the different labor force behavior of nurses--these rates probably do not allow sufficiently for the patterns of attrition to the nursing stock. Particularly important is the failure of some studies to make any adjustment to estimates of educational output for the reciprocal of the prevailing or assumed labor force participation rate.[73] Again, this means that policy statements derived from the projections are of doubtful validity.

Finally, the weaknesses of both supply and requirement estimates hardly auger well for policy statements emerging from comparisons between the two. Nonetheless, it is significant that an overwhelming majority of the studies point to potential supply deficits in the absence of appropriate policy responses. These conclusions are questionable in light of the large number of omissions in the studies. But an equally remarkable feature is that these conclusions led to a limited number of policy recommendations. Generally speaking, projected "deficits" called forth (major) recommendations either to expand educational capacity and/or improve the retention of graduates of local educational institutions while attracting similarly trained persons from other geographic areas. That is, these analyses have rarely considered courses of action beyond expanded schooling or "beggar thy neighbor" efforts. It is not clear that such policies are necessary and sufficient actions to achieve balance over time nor that they are even consistent elements of manpower strategy in the aggregate. But it does seem clear that they are only two of many possible policies. That the limited scope and depth of these studies did not lead to the identification and evaluation of alternatives is perhaps the most telling indicator of the current state of the planning art. Stated differently, the value of the forecasting studies to the policy process does not appear to have been maximized.

The State of the Art

The foregoing suggests that the current capacity to plan health manpower is limited in several important ways. Projections of required patterns of manpower utilization fail to account for interdependence among input variables or for changes in the composition of sectoral output; they rarely include an assessment of the costs and benefits associated with achieving manpower goals. Once targets have been specified, forecasting studies tend, characteristically, to omit important analytic components and to delimit the range of effective alternative policies designed to achieve balance. These factors cast doubt on the conclusions which emerge from health manpower planning studies and hence on the wisdom of policy actions taken in reference to them. Improvements in planning practice require closing these gaps in ways that make projections increasingly more useful to policy makers. In the near term, this may be accomplished without major changes in planning methodology and perhaps with only minor improvements in planning data. Over the longer run, it requires efforts to strengthen the knowledge base for planning.

More specifically, substantial improvements in the short-run can be effected by assuring that all relevant elements of the analysis are included and pieced together in ways that enhance the policy value of the forecast. Ignoring momentarily the question of how manpower targets are to be specified, the essential planning task remains one of analyzing alternative policies designed to fulfill targets. It is clear that the principal limitation of the studies reviewed here is their failure to carry out this task or even to provide requisite analyses to permit others to do so. In other words, few (if any) were policy models as defined above, and policy guidelines generated from them are probably

misleading. Since the results of these studies have no doubt contributed to the "evidence" that imbalances exist in health manpower markets and thereby to substantial, if not excessive, increases in educational capacity, the need for developing policy models is not an academic concern. Their development can be facilitated by focusing on the range of factors likely to affect the supply of specific health services. While the availability of data surely precludes easy or mechanical analyses, there are few methdological barriers to accomplishing such a task. Indeed, a little more may be needed than resolve, sufficient time, and relatively aggregate information about rates of labor force participation, net migration and productivity. Perhaps of greater importance then is the need to sensitize users of projections as well as the planners who prepare them to the importance of these variables.

Over the longer run, the technical capacity to project health manpower requirements hinges on our ability to specify the target level and composition of health care activity or output. In the general case, the choice between the development of plans which use health criteria and those which use market criteria (as those terms were used above) must be confronted. In the present context, the importance of the choice lies in its implications for developing base knowledge and information for manpower planning purposes as well as for the responsibility of planning institutions. While we do not wish to overstate the point, it seems clear that if health criteria are accorded relative priority, research should be directed at the development and refinement of health status indicators and their manipulation in planning activity. If market criteria are to be employed, research should be directed elsewhere because work on health indicators will not be helpful or at least will not be priority concern. In that case planning research should concentrate on issues such as price and income elasticities of demand, cross-elasticities, and the like.

It should be noted in this regard that the choice of criterion functions also needs to be considered in light of the tasks of different planning institutions. Strictly speaking, if market criteria are to be used in assessing the level and structure of output, there is no compelling reason why planning should be maintained as an independent or separate activity, either in technical or institutional terms. Technically, if market criteria are used, health manpower analysis should emerge from and complement other sectoral analyses of manpower requirements and supply. Institutionally, there is little reason for this work to be housed separately, e.g., in health agencies. We argued earlier that the adoption of health related criteria implies that health manpower planning ceases to be an independent concern. The conclusion is that under either set of preference functions, there is little reason to maintain health manpower planning as a independent function. The institutional responsibility for such planning, however, will depend upon its perceived nature and scope.

Although the specification of levels and composition of output is the greatest constraint on planning capacity, there appears to be little

question about data and research needs once output targets have been established. Specifically, increasingly disaggregate "activity" data must be generated, and the pool of inputs technically linked to the provision of such activities must be investigated. Activity data are essential, even if health status criteria are employed, because they provide a convenient method for measuring (albeit not evaluating) output. Appropriate rules for and decisions about the aggregation and use of such data are now absent from the practice literature, but will have to be confronted once data resources are expanded. More significant is that "input-output" relationships must be investigated such that the notions of substitution and technical change can be accounted for in the design of manpower strategies. Until such research is forthcoming, planning capacity will remain as limited as it is at present.

NOTES TO CHAPTER VII

[1] Rates computed from R. Prindle, and M.Y. Pennell, "1960 Industry and Occupation Data," Health Manpower Source Books, Section 17 (Washington, D.C.: U.S. Department of Health Education and Welfare, Public Health Service, 1963), Table 6, p. 13, and Tables 13-A to 13-C, pp. 23-25; and U.S. Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, Series PC(1)-C, U.S. Summary, Table 92.

[2] Computed from Prindle and Pennell, op.cit., selected Tables, pp. 31-95; and U.S. Bureau of the Census, op.cit., Table 91. Occupations are counted irrespective of industry attachment. The distinction between "core practitioners" and allied health workers was used originally by Harry Greenfield. See his Allied Health Manpower (New York: Columbia University Press, 1969), especially Chapter 2.

[3] Jeffrey H. Weiss, "The Changing Job Structure of Health Manpower," IRRA Proceedings (December, 1970), 162-72.

[4] For a brief account of the legislative history in the health manpower field, see J. Grupenhoff and S. Strickland, Federal Laws: Health/Environment Manpower (Washington, D.C.: Science and Health Communications Group, 1972). Also see, U.S. Department of Health, Education and Welfare, Public Health Service, Inventory of Federal Programs Supporting Health Manpower Training (Washington, D.C.: Government Printing Office, 1972). Estimates suggest that the Federal commitment alone to health training was running at a rate of $1.3 billion in 1974. See, U.S. Office of Management and Budget, Special Analyses: Budget of the United States Government, Fiscal Year 1974 (Washington, D.C.: 1973), Table j-13, p. 144.

[5] See, among others, Charles C. Edward, "A Candid Look at Health Manpower Problems," Journal of Medical Education, XLIX, No. 1 (January, 1974), 19-26; U.S. Department of Health, Education and Welfare, Towards a Comprehensive Health Policy for the 1970's (Washington, D.C.: Government Printing Office, 1971); Carnegie Commission on Higher Education, Higher Education and the Nation's Health, Policies for Medical and Dental Education (New York: McGraw-Hill, 1970); American Medical Association, Council on Health Manpower, Expanding the Supply of Health Services in the 1970's, Report of the National Congress on Health Manpower (Chicago: The Association, 1970); H. Wechsler, et al., "Maldistribution of Dental Manpower: A Cause for National Concern," Journal of the American College of Dentists, Vol. 39, No.3(1972), 151-60. The present concern over distribution and earlier notions of shortage have been wedded in recent efforts to identify health service scarcity areas. See, U.S. Department of Health, Education and Welfare, Health Services Administration, "Health Service Scarcity Area Identification Program, Background Paper," (August, 1973), mimeo.

[6]But, see R.M. Bailey, "Economies of Scale and Medical Practice," in H. Klarman (ed.) Empirical Studies in Health Economics (Baltimore: Johns Hopkins Press, 1970), pp. 255-77.

[7]For further discussion of this point, see V. Navarro, "Systems Analyses in the Health Field," Socio-Economic Planning Sciences, III, No. 3 (1969), 179-89; A.J. Culyer, "Appraising Government Expenditure on Health Services: The Problems of 'Need' and 'Output,'" Public Finance, XXVII, No. 2 (1972), 205-211; Government Studies and Systems, Inc., An Advanced Health Planning System, A Report to: New Jersey Department of Health and New Jersey State Comprehensive Health Planning Agency (Philadelphia: January, 1972); I. Fahs, et al., "Indicators of Need for Health Care Personnel," Medical Care, IX, No. 2 (March/April, 1971), 144-51; and J. Jeffers, et al., "On the Demand Versus Need for Medical Services and the Concept of 'Shortage,'" American Journal of Public Health, LXI, No. 1 (January, 1971), 46-63.

[8]C.f., R. Fein, The Doctor Shortage (Washington, D.C.: The Brookings Institution, 1967).

[9]See W.L. Hansen, "'Shortages' and Investment in Health Manpower," in S. Axelrod, (ed.) The Economics of Health and Medical Care (Ann Arbor: The University of Michigan, 1964), pp. 75-91.

[10]See, E. Rayack, "The Supply of Physician Services," Industrial and Labor Relations Review, XVII, No. 2 (January, 1964), 221-37.

[11]C.f., D. Yett, "The Chronic 'Shortage' of Nurses: A Public Policy Dilemma," in Klarman (ed.) loc.cit., pp. 357-97.

[12]R. Lee and L. Jones, The Fundamentals of Good Medical Care (Chicago: University of Chicago Press, 1933).

[13]See, for example, T. Baker, "Dynamics of Health Manpower Planning," Medical Care, IV (October, 1965), 205-11; and D. Yett, et al., "Health Manpower Planning: An Econometric Approach," Health Services Research, VII, No. 2 (Summer, 1972), 134-47. As will be seen, we agree fully with the notion that the shape of the underlying production function needs to be delineated for planning purposes; the discussion here concentrates only on the issue of the appropriate criterion function for specifying the level and composition of health care output.

[14]C.f., K. Arrow, "Uncertainty and the Welfare Economics of Medical Care," American Economic Review, LIII, No. 5 (December, 1963), 941-73.

[15]Compare, for instance, the use of expenditure data qua output in N. Jones, et al., "Health Manpower in 1975-Demand, Supply, and Price," Appendix V, Report of the National Advisory Commission on Health Manpower, II (Washington, D.C.: Government Printing Office, 1967), pp. 229-64.

[16]The argument that economic models constitute a methodological improvement has been dominant in the theoretical literature for more than a decade. C.f., D. Yett, et al., op.cit. See also H. Klarman, "Economic Aspects of Projecting Requirements for Health Manpower," Journal of Human Resources, IV, No. 3 (Summer, 1971), 360-376, and the literature cited therein.

[17]See, among others, R. Berg, (ed.) Health Status Indexes (Chicago: Hospital Research and Educational Trust, 1973); J. Bush, and S. Fanshel "A Health Status Index and Its Application for Health-Services Outcomes," Operations Research, XVIII; No. 6 (November/December, 1970), 1021-66; and S. Goldsmith,"The Status of Health Status Indicators," Health Services Reports, LXXXVII, No. 3 (March, 1972), 212-26.

[18]See, for instance, V. Fuchs, "The Contribution of Health Services to the American Economy," in D. Mainland (ed.) Health Services Research (New York: Melbank Memorial Fund, 1967), pp.327-63; and A. Cochrane, Effectiveness and Efficiency, Random Reflections on Health Services (London: The Nuffield Provincial Hospitals Trust, 1972).

[19]In particular, see R. Auster, et al., "The Production of Health, An Exploratory Study," Journal of Human Resources, IV, No. 4 (Fall, 1969), 411-36. Also see M. Larmore, "An Inquiry into an Econometric Production Function for Health in the United States," (Unpublished Ph.D. Dissertation, Northwestern University, 1967).

[20]See, among others, R. Zemach, "A Model of Health-Service Utilization and Resource Allocation," Operations Research, XVIII, No. 6 (November/December, 1970), 1071-87; V. Navarro, "A Systems Approach to Health Planning," Health Services Research, IV, No. 2 (Summer, 1969), 96-111; P. Feldstein and S. Kelman, "A Framework for an Econometric Model of the Medical Care Sector," in H. Klarman (ed.), loc.cit., pp. 171-94; and F.D. Kennedy, The Development of a Simulation Model of a Community Health Service System, Vol. 1, Introduction and Summary (North Carolina: Research Triangle Institute, 1968). Also see, C. Stewart, "Allocation of Resources to Health," Journal of Human Resources, VI, No. 1 (Winter, 1971), 103-22; and L. Shuman, et al., "Manpower Mix for Health Services: A Prescriptive Regional Planning Model," Health Services Research, VI, No. 2 (Summer, 1971), 104-13.

[21]Navarro, op.cit.

[22]C.f., U. Reinhardt, "A Production Function for Physician Services," The Review of Economic and Statistics, LIV, No. 1 (February, 1972), 55-66; K. Smith, et al., "An Analyses of the Optimal Use of Inputs in the Production of Medical Services," Journal of Human Resources, VII (Spring, 1972), 208-25; U. Reinhardt, "Manpower Substitution and Productivity in Medical Practice: Review of Research," Health Services Research, VIII, No. 3 (Fall, 1973) 200-27; K. Kilpatrick, "Expanded-Functions Auxiliaries in General Dentistry: A Computer Simulation," Health Services Research, VII, No. 4 (Winter, 1972), 288-300; and R. Zeckhauser, and M. Eliastam, "The Productivity Potential of the Physician Assistant," Journal of Human

Resources, LX, No. 1 (Winter, 1974), 95-116. Also see H. Strum, Technology and Manpower in the Health Service Industry, 1965-75 (Washington, D.C.: U.S. Department of Labor, Manpower Research Bulletin, 14, 1967), as well as our discussion of the general research focus in this area in Chapter III above.

[23]C.f., D. Yett, et al., op.cit.; Feldstein and Kelman, loc.cit.; D. Maki, A Forecasting Model of Manpower Requirements in the Health Occupations (Ames: Iowa State University, Industrial Relations Center, 1967); and M.S. Feldstein, "Health Sector Planning in Developing Countries," Economica, XXXVII, No. 146, (May, 1970), 139-63.

[24]C.f., R. Rosett, and L. Huang, "The Effect of Health Insurance on the Demand for Medical Care," Journal of Political Economy, LXXXI, No. 2 (March/April, 1973), 281-305; and H. Joseph "Empirical Research on the Demand for Health Care," Inquiry, VIII, No. 1 (March, 1971), 61-71, and the literature cited therein.

[25]K. Davis and L. Russel, "The Substitution of Hospital Outpatient Care for Inpatient Care," Review of Economics and Statistics, LIV, No. 2 (May, 1972), 109-20.

[26]M.S. Feldstein, Economic Analyses for Health Service Efficiency (Chicago: Markham, 1968), Chapter 7; and M.S. Feldstein, "The Rising Price of Physician Services," The Review of Economics and Statistics, LII, No. 2 (May, 1970), 121-33.

[27]"The Rising Price of Physician Services"

[28]In particular, see I. Butter, "Health Manpower Research: A Survey," Inquiry, IV, No. 4 (December, 1967), 5-41; W.L. Hansen, "An Appraisal of Physician Manpower Projections," Inquiry, VII, No. 1 (March, 1970), 102-13; and B. Ahamad, "Doctors in the United States, Britain and Canada," in B. Ahamad and M. Blaug, (eds.) The Practice of Manpower Forecasting (San Francisco: Jossey-Bass, 1973), pp. 285-309. In general terms, these studies are marred by their insistence that predictive accuracy is the most important criterion for evaluating manpower projections. Also, see, J. E. Eckles and G.C. Sumner, "Health Manpower Requirements Analysis: A Review," A Working Note prepared for the Health Education Commission of the Illinois Board of Higher Education, WN-7046-HEC (Santa Monica, California: Rand, October, 1970).

[29]E. Sax, Distribution of Health Manpower; An Annotated Bibliography (New York: National Health Council, 1973). It should be noted here that health plans (per se) developed by CHP "A" agencies were not included in our search. This decision was made because of the limited number of states which had completed plan documents at the time the search was undertaken.

[30]The following items are representative of this subset of the literature: Norman L. Armondino, Comprehensive Health Plan (Hartford, Connecticut: Office of Comprehensive Health Planning, 1973), Vol. 1; Mario F. Bognanno, James R. Jeffers, and Calvin D. Siebert, Health Manpower Resources: Patterns and Trends: A Study of Health Manpower in Iowa, a study jointly sponsored by: The Standing Committee on Health Manpower, Comprehensive Health Planning Council-State of Iowa, Iowa Office of Comprehensive Health Planning, The Iowa Regional Medical Program, The Health Economics Research Center-University of Iowa, (n.p., 1970); Pete Boughn and Sandra L. Benson, "Physician Manpower in Nebraska," Nebraska Medical Journal, LVII (May, 1972), 181-84; Russell Hill, Winston Miller, and Laurie Sonderegger, The Changing Dimensions of Physician Manpower in Minnesota 1940 to 1969 (St. Paul: Northlands Regional Medical Program, April, 1970); Sara S. Hirakis and Norman L. Armondino, "Distribution of Physicians in Connecticut," reprinted from the Connecticut Health Bulletin, LXXXVI, No. 5 (May, 1972); Idaho Mountain States Regional Medical Program, Idaho Division, Idaho Health Profile (Boise: July, 1969); John C. MacQueen, "A Study of Iowa Medical Physicians: Section 1 - The Number and Distribution of Doctors of Medicine," reprinted from the Journal of Iowa Medical Society, (November, 1968), 1129-1135; Institute for Interdisciplinary Studies, Planning for Allied Health Personnel in Minnesota, report to State Planning Agency, Comprehensive Health Planning Program (Minneapolis: November, 1972); Montana Mountain States Regional Medical Program, Montana Division, Montana Health Profile (Great Falls: July, 1969); Northern New England Regional Medical Program, An Inventory of Health Manpower in the State of Vermont, 1972, Report #3 to the State Health Planning Advisory Council (n.p., 1972); Northern New England Regional Medical Program, Physician Manpower in Vermont (Burlington: University of Vermont, October, 1971); Oregon State Board of Dental Examiners and The American Association of Dental Examiners, 1965 Survey of Dentists Licensed in Oregon, a study supported under contract with the Department of Health, Education and Welfare (September, 1967); South Carolina Regional Medical Program, South Carolina Health Data Profile (Charleston: Medical University of South Carolina, 1972); Tennessee Department of Public Health, Office of Comprehensive Health Planning, Selected Health Manpower in Tennessee, 1970 (Nashville: December, 1972); George K. Tokuhata, et al., Licensed Health Personnel in Pennsylvania Geographic Distribution (Harrisburg: Pennsylvania Department of Health, Division of Research and Biostatistics, Bureau of Planning, Evaluation and Research; February, 1972); Utah Comprehensive Health Planning, Department of Social Services, Health Manpower in Utah (Salt Lake City: July, 1972); Kelly M. West, "Physician Manpower in Oklahoma," reprinted from The Journal of the Oklahoma State Medical Association, (December, 1969), 574-585; Wisconsin Department of Health and Social Services, Division of Health, Health Occupations Inventory by County and Comprehensive Health Planning Areas, Wisconsin 1971-1973 (November, 1973); Wyoming Mountain States Regional Medical Program, Wyoming Divison, Wyoming Health Profile (Cheyenne: July, 1969).

[31]Recent proposals for developing health data "banks" and data systems are clearly worrisome in this regard, since experience suggests that available data are used as the core of the bank or system.

[32]"Economic Aspects of Projecting Requirements for Health Manpower," p. 373. To be sure, there is an increasing research tendency in this direction, but the discussion here concerns planning practice.

[33]References are given in the notes to Table VII.1.

[34]The Colorado, North Carolina, and Oklahoma studies include supply data.

[35]Computed from M. Pennell and D. Hoover, Health Manpower Source Book 21, Allied Health Manpower Supply and Requirements: 1950-80 (Bethesda, Maryland: U.S. Department of Health Education and Welfare, Public Health Service, 1970), Table 14, p. 33. There are, of course, substantial differences in the projected rate of growth in employment for different health occupations. For instance, while the entire health manpower stock was projected to increase by 3.3 - 4.1 percent per year over the period in question (ibid., Appendix Table E-1, p. 74), core practitioners such as physicians were projected to increase by only 1.9 percent per annum and registered nurses by only 2.4 percent per year, (ibid., Table 14, p. 33). For a more detailed account, see ibid., and U.S. Department of Labor, Bureau of Labor Statistics, Health Manpower 1966-75, A Study of Requirements and Supply, Report No. 323 (Washington, D.C.: June, 1967).

[36]C.f., C. Holt and M. David, "The Concept of Job Vacancies in a Dynamic Theory of the Labor Market," in The Measurement and Interpretation of Job Vacancies, A Conference Report of the National Bureau of Economic Research (New York: Columbia University Press, 1969), pp. 73-110.

[37]Only the North Carolina study provided separate estimates of labor turnover.

[38]See, D. Yett, "The Chronic 'Shortage' of Nurses: A Public Policy Dilemma."

[39]See Anne R. Somers, Health Care in Transition: Directions for the Future (Chicago: Hospital Research and Educational Trust, 1971), p. 116, ff., and C. Havighurst, "Regulation of Health Facilities and Services by 'Certificate of Need,'" Virginia Law Review, LIX, No. 7 (October, 1973).

[40]A notable exception to this is illustrated in, United Community Services of Metropolitan Detroit, Health Manpower Committee, Health in Manpower in Metropolitan Detroit: A Study of Needs and Problems, (November, 1970).

[41]That is, the studies are divided with respect to their use of the concept of derived demand or requirements. The distinction does not, however, account for differences in the nature of the underlying criterion function.

[42]op.cit.

[43]Ibid., Chapter II.

[44]Ibid., Chapter III-IV.

[45]We refer to Project SOAR (supply, output, and requirements) currently being carried out by the (now defunct) Division of Manpower Intelligence, Health Resources Administration, Public Health Service. Although the Project has yet to be completed (and hence cannot fully be evaluated) it has produced several interesting studies dealing with the national supply of and demand for health personnel. See U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration, The Supply of Health Manpower, 1970 Profiles and Projections to 1990 (Washington: Human Resources Administration, Pre-Publication Edition, 1974), and L. Huang and E. Shomo, Assessment and Evaluation of the Impact of Archetypal National Health Insurance Plans on U.S. Health Manpower Requirements (Washington, D.C.: U.S. Department of Health, Education and Welfare, Health Resources Administration, 1974).

[46]L. Huang and E. Shomo, op.cit., Appendix C, pp. 110-13.

[47]Ibid., Chapter I.

[48]Medical Care Prices and Health Manpower in New Jersey (New Brunswick: Bureau of Economic Research, Rutgers University, n.d.)

[49]Ibid., pp. 154-59.

[50]Similar procedures were used in other service model applications. See Table VII.2 below.

[51]Berkowitz, et al., p. 193.

[52]Ibid., p. 136, emphasis added.

[53]Our computation based upon text materials.

[54]See, Office of Health Professions Education, New Jersey Department of Higher Education, Health Professions Education Master Plan, a part of Phase III of the New Jersey Master Plan for Higher Education (Trenton: May, 1973).

[55]C.f., Texas Hospital Association and Texas Medical Foundation, Allied Health Manpower in Texas, 1973, A Report on Manpower Requirements, Resources, and Education (n.p. n.d.).

[56]We know, for instance, that however crudely measured, productivity has increased in the medical care sector. See Y. Barzel, "Productivity and the Price of Medical Services," Journal of Political Economy, LXXVII, No. 6 (1969), 1014-27; and V. Fuchs and M. Kramer, Determinants of Expenditures for Physicians' Services in the United States 1948-68 (Washington, D.C.: Department of Health, Education and Welfare, Publication No. 73-3013, 1972)

[57]See Table VII.2 below.

[58]New York State Dental Manpower Study (Albany: State Education Department, Bureau of Research in Higher and Professional Education, 1971).

[59]Ibid., Chapter 3.

[60]Ibid., p. 59.

[61]The region in question is St. Lawrence. The productivity estimate was taken from J. Weiss, op.cit.

[62]George E. Brehman, Jr., A Study of Physician Manpower Demand and Supply in Pennsylvania: Methodology and Findings (Pennsylvania Department of Education, Bureau of Information Systems, Division of Research, 1973).

[63]Ibid., p. 86.

[64]Ibid., Table 66, p. 139.

[65]See, in particular, J. Dei Rossi, et al., An Analysis of Medical Manpower and Education in Illinois, a Working Note prepared for the Health Education Commission of the Illinois Board of Higher Education (Santa Monica: Rand, June, 1971); J. Dei Rossi, et al., An Analysis of Dental Manpower and Education in Illinois, a report prepared for Health Education Commission of the Illinois Board of Higher Education (Santa Monica: Rand Corportion, June, 1971); J. Dei Rossi and G. F. Mills, Short-Term Health Facilities and Registered Nurse Requirements in Illinois: A Prototype Study, a Working Note prepared for the Health Education Commission of the Illinois Board of Higher Education, WN-7397-IHEC (Santa Monica, California: Rand Corporation, June, 1971); G.F. Mills, P.D. Fleischauer and N.S. King, Manpower Analysis for Illinois Health Professions: Optometry, Osteopathy, Pharmacy, Podiatry, Veterinary Medicine, a Working Note prepared for the Health Education Commission of the Illinois Board of Higher Education, WN-7505-IHEC (Santa Monica, California: Rand Corporation, June, 1971); Jan Acton and Robert Levine, State Health Manpower Planning: A Policy Overview, Rand R-724-RC (Santa Monica, California: Rand Corporation, May, 1974).

[66]For instance, a number of studies failed to include base employment figures; consequently, growth rates could not be computed.

[67]This is particularly true, for instance, in the case of Davidson and Dahl's macro-statistical model of Minnesota's health sector.

[68]For a complete discussion of the BLS program, see Chapter VI above.

[69]There is also reasonable similarity between these rates and national projections for equivalent occupational groups. See above, especially Footnote 35.

[70]C.f., P.J. Held, The Migration of the 1955-1965 Graduates of American Medical Schools (Berkeley: University of California-Berkeley, 1973); L. Benham, A. Maurizi, and M. Reder, "Migration, Location and Renumeration of Medical Personnel: Physicians and Dentists," Review of Economics and Statistics, L (August, 1968), 332-47; D. Yett, F. Sloan, "Migration Patterns of Recent Medical School Graduates," Inquiry, XI (June, 1974), 125-42; and C. Bishop, "Manpower Policy and the Supply of Nurses," Industrial Relations, XII, No. 1 (February, 1973), 86-74.

[71]Studies conducted in Ohio are exceptions to this rule.

[72]See, for instance, S. Altman, Present and Future Supply of Registered Nurses (Washington, D.C.: Department of Health, Education and Welfare, 1971); and L. Benham, "The Labor Market for Registered Nurses: A Three-Equation Model," Review of Economics and Statistics, LIII, No. 3 (August, 1971), 246-52.

[73]E.g., the Maine study of nursing requirements.

CHAPTER VIII

THE STATE OF THE ART

Summing Up

This study has attempted to appraise the state of the art of manpower forecasting by examining the capacity of the applied social sciences to sustain forecasting activities, the extent to which current practice is limited by this capacity, and thereby the adequacy of forecast information in the decision process. A major conclusion is that while both the relevant knowledge base and forecasting practice are extremely limited, these limitations appear to bear little relationship to each other. In particular, the primary constraint on practice is not related to the information base and knowledge of technical relations as much as it is to the concept or the objectives and uses of manpower forecasts in the formulation of policy. Needless to say, such a broad generalization does not necessarily apply to every forecasting study, but it does apply to a sufficiently large number of them to require emphasis and careful consideration.

Among other things, this implies that incremental additions to the knowledge base--helpful as they might be--are unlikely to have immediate or substantial impact on the policy effectiveness of forecasts. Their effectiveness, in our judgment, can only be enhanced by improved understanding of the critical role of policy criteria in a decentralized decision process and, correspondingly, a strengthening of institutional relationships in ways that facilitate the use of such criteria. In this sense, the observed failure of manpower forecasting is little more than a manifestation of a larger failure in this country to come to grips with an approach to collective decision-making in a decentralized environment, particularly for long-term decisions affecting interdependent public systems.

Given the indirect nature of the argument, it may be helpful here to summarize the principal points of the evaluation which lead us to this conclusion. It perhaps bears repeating that the circuity of the argument stems primarily from the fact that the initial study design assumed that the state of the art hinged on the adequacy of the knowledge base. Even if this turned out to be somewhat less significant than initially supposed, there are benefits to be gained from examining planning practice in the light of the knowledge base. Accordingly, we begin by summarizing the relative strengths and weaknesses of the knowledge base as revealed in our assessment.

Specification of the principal elements of manpower forecasts, i.e., preference fields and transformation functions, draws heavily on the field of economics. For this reason, our ability to specify these elements in adequate fashion tends to be limited in roughly similar ways to the acknowledged limitations of the discipline itself. An important problem in this regard is the extreme commitment of economic analysis to market allocative processes via the neoclassical model. This commitment generally intrudes in terms of ranking problem priorities, but more specifically in terms of the nature or scope of the hypotheses to be devised and tested in empirical form. The assessment of both output specification and transformation in Chapters II and III demonstrated, in particular, that empirical research focused on a limited number of instrumental variables and narrowly conceived forms of testable hypotheses.

For instance, while a substantial amount of theoretical and empirical work has been devoted to projecting commodity demand, it has concentrated almost entirely on the econometric estimation of price elasticity coefficients. While these estimates are surely not irrelevant, neither are they entirely sufficient. Moreover, it is unlikely that they are altogether relevant for output specifications in important human resource using sectors producing "public" or quasi public goods or services: price in these cases is unlikely to be an important control variable, and expenditure data is unlikely to reflect social preference. Similarly, production function research has tended to emphasize certain properties over others, e.g., the rather substantial emphasis on substitution parameters as opposed to the estimation of disaggregated shift coefficients. More significant perhaps is that in examining this parameter, the possible existence of complementarities between and among factor inputs or the form of complementarity is rarely examined in direct fashion. Rather, most studies are content to employ the hypothesis that substitution elasticities differ from zero, since that is the most elemental step in testing the tenets of neoclassical theory. These difficulties are not likely to be resolved by more disaggregate or refined data sets, although better data are clearly required.

By like token, the knowledge base is limited in terms of its ability to assimilate concepts and techniques from other disciplines, and to build in cumulative fashion from experience in application. On the one hand, this reflects the deepening rift and lack of interaction among the various social and decision science specialities. The recent interest in Delphi techniques and "technological" forecasting as discussed in Chapter II are cases in point: while they bear complementary relationship to a number of different forecasting procedures, e.g., econometric models, they are rarely used (or even discussed) in such fashion. The literature on these topics is highly compartmentalized, and hence rarely examined in context. These highly specialized developments, moreover, allow certain problems to remain unattended. As the discussion in Chapter IV indicated, for instance, little research on alternative paths to occupational qualification has been conducted. The reason perhaps is that each specialty area assumes that these relationships lie outside of its jurisdiction, and

are therefore of marginal importance to its research agenda. On the other hand, there is little feed-back from practical application, in terms both of forecasts per se and of certain methodological alternatives relating to facets of forecasting activity. This stems not only from the balkanization of forecasting practice and academic research, but also from the curious manner by which such research is evaluated and distributed. In particular, the observation that marginal methodological refinements appear always to be more "interesting" and "publishable" than actual tests of received methodology tends to de-emphasize the feed-back of useful planning information and, in turn, contributes to the observed vacuum between theory and practice.

Yet, despite its inherent limitations, the knowledge base does afford the possibility of examining some of the consequences of alternative social strategies relating to output-input combinations, and thereby the formulation of some useful policy criteria. The burgeoning interest in econometric forecasting models and disaggregate multi-factor production functions, chronicled in earlier Chapters, illustrates areas of possible application. But even a detailed reading of the "practice literature" failed to uncover much recognition that these developments are unfolding or that they are potentially useful to forecasting activity. In fact, much of the practice literature failed to recognize that there is a relevant knowledge base which can be exploited for both substantive and methodological purposes. Our inability to encounter such recognition fundamental to the findings of this evaluation. It implies that the existing knowledge base has not been fully exploited, and that substantial improvements in "average" practice might be forthcoming if available knowledge were used to a greater extent. It also implies that the reasons for the failure of forecasting activity lie beyond knowledge constraints. The conclusion is based on the following set of inferences.

To begin with, as our examination of the "practice literature" demonstrated, an extraordinary number of projection studies were conducted exclusively in terms of "input variables", i.e., they omitted estimates of output and thereby criteria for evaluating alternative manpower configurations. Stated differently, they were not predicated on a defensible strategy for delineating manpower requirements. Clearly, the extent to which such omissions effected manpower requirements (and hence the wisdom of policies designed in reference to them) differed between global and partial analysis and between State/local and national studies. The fact, however, that policy conclusions were rarely tempered by these omissions provides an important inference about the perceived nature of the activity and the knowledge base which supports it. Secondly, few studies were encountered which considered alternative combinations of inputs in the provision of given levels of output. And, in roughly similar ways, policy conclusions were rarely adjusted in light of such rigid transformation procedures. Finally, and most important, a large number of studies failed to undertake sufficient analysis to forecast potential imbalance between system requirements and human resource endowments, or to evaluate alternative policy responses in cases where future imbalance was considered likely. These omissions strongly suggest

that the policy uses of manpower forecasts are widely mis-interpreted and, correspondingly, that the analytic ingredients necessary to evaluate policy proposals are not everywhere apparent.

Some may argue that the omissions in current practice reflect little more than the absence of data, and surely part of the reason that forecasts have been prepared in this fashion is inadequate data resources. But inadequate information cannot explain the substantial gaps in the forecasting art, for there are data available that permit limited attempts to include relevant components, e.g., supply estimates. Nor can data availability necessarily explain the ad hoc nature of much manpower forecasting activity. In fact, the problems can only be explained by the observed ambiguity with respect to a useful conceptual framework or paradigm for forecasting, and the absence of a suitable set of institutional arrangements within which such activity can be carried out. The sizable number of short-term, ad hoc arrangements made to conduct forecasting studies is perhaps an important clue in this regard, because there is insufficient time or expertise available in such exercises to locate existing information or to analyze it. In the absence of a suitable and sustained institutional base for forecasting, the continued production of piece-meal studies will not only provide limited (if not misleading) advice to policymakers, but will also tend to emphasize inappropriate avenues to improvement. Briefly stated, quantitative and qualitative improvements in the data base alone will do little to enhance the current state of the art.

Rather, as the evaluation in Chapters V-VII suggests, current practice fails because it lacks suitable focus and institutional support. The state of the art, therefore, might be more rapidly improved by employing a conceptual framework that draws on existing knowledge and by developing the institutional base for planning. The first will assure both that appropriate questions are raised in the preparation of forecasts and that results will be qualified in terms of specific assumptions and empirical findings. The second is more important, but less amenable to detailed prescription. An important guideline, however, is that institutional form follows from conceptual framework and must be consistent with it. This principle seems repeatedly to be violated in current practice, which perhaps explains why the few serious attempts to build an appropriate institutional base for forecasting have yet to enjoy considerable success, e.g., the BLS Matrix Program. It is not altogether clear in this sense that such program development should be continued in the absence of suitable agreement on goals and institutional linkages between forecast preparation and use.

As should be apparent, we believe that the policy model described in Chapter I (and used to structure the discussion in Chapter II-VII) provides a suitable paradigm for policy-relevant manpower forecasting. Although its application in comprehensive form is generally limited by the knowledge base, it is sufficiently flexible to permit partial uses based on existing knowledge. Potential refinement is assured by incremental additions to the knowledge base. Although this may appear to be a normative conclusion that could have been arrived at a priori, we believe that it emerges from or is substantiated by the state of the art evaluation for the following reasons: First, the manpower forecasting field is amorphous and ambiguous

with respect to purpose and accomplishments--so much so, in fact, that only the imposition of some framework permits viewing these activities en toto. In the second place, the most common failures of forecasting practice are remedied in the policy model, in particular, the repeated failure of forecasting practice to account for trade-offs between and among outputs, inputs, and the relationship between inputs and outputs. Finally, a framework for future work, both practical and theoretical, is identified by the model. The next section considers these needs in greater detail.

Research Priorities

Institutional Research

The dominant conclusion of this study, that the gap between the average practice of manpower forecasting in the United States and the methodological, theoretical and empirical basis for forecasting is a function of institutional rather than technical constraints, suggests that the greatest returns on investment in additional research will come from the search for and evaluation of institutional alternatives. These alternatives involve the development of a decision framework for the coordination of both public and private policy formation in a long term perspective.

The human resource paradigm and the policy planning model discussed in Chapter I implies that a rational long term human resource policy involves the coordination of macro-economic policy, science policy, education policy, health policy, and manpower policy at the minimum. Policy and program responsibility in these areas is now dispersed between the Federal and local governments, and among semi-autonomous agencies at both levels. Although manpower and health legislation has imposed planning requirements at the State and local level of government, much of the potential value of these activities has been reduced by the current commitment to decentralized decision making and the absence of any broader planning framework in which to rationalize sectoral planning. As a consequence, planning in each area is limited to short-term budget analysis.

An extensive experience with the use of planning as a complement to a market mechanism exists in other democratic industrial societies, notably France and the Scandanivian countries. Much of that experience appears potentially applicable to the United States, in particular, the role of planning in coordinating public policy and in linking public to private decision making. It also offers rather clear evidence that there is no inherent conflict between an extensive use of planning in policy formation and a strong commitment to the principles of consumer sovereignty. There appears to be no fundamental reason why the United States cannot utilize this experience in developing a policy structure that permits long term decision making.

The policy model on which the current analysis of forecasting is based assumes a planning and coordinating agency closely linked to decision making institutions and to operating agencies. The iterative character

of the model implies that the planning organization is continuously offering the policy-maker alternative specifications of social welfare functions and their strategic and tactical implications. Similarly, it derives from operating agencies information concerning transformation possibilities and their implications for input requirements and efficiency.

In this institutional framework, forecasting is a continuous process of specification, evaluation and respecification. The actors include those who elaborate policy, whether public or private, and those who design and implement policy-consistent programs. The process requires a continuous flow of information and feedback between planning technicians and the political and market institutions that interpret the social utility function and select and translate optimal strategies into policy decisions. It also requires an operational link between planning and operating institutions to provide technical input information including evaluation criteria for selecting an optimal means strategy.

The institutional inadequacies of the United States for rational, long-term decision making are demonstrated in the current crisis concerning unemployment, inflation, energy constraints and environmental damage, and in the inability to define trade-off positions concerning goal conflicts. The Inter-Agency Growth Project is the only meaningful source of long-term forecasts or analysis, and the limited form in which it is able to specify a social welfare function reflects its isolation from decision institutions. The strategic alternatives that it can consider are limited by the absence of any operational link with those institutions that can influence the important policy variables. The actions of those institutions are not functions of the analysis and can only be treated in the analysis as exogenously determined. Similarly, the employment and manpower components of the analysis are not derived in conjunction with operating agencies or supply institutions. Consequently, the BLS manpower-Matrix does not reflect interaction between requirements and supply or any optimal supply process. The resultant forecasts are technically inadequate and largely irrelevant as objective criteria for a non-systemic set of human resource institutions.

The potential for elaborating an institutional structure adequate to perspective planning in the United States is not clear. The role and value of planning in a decision system is neither currently appreciated nor well understood and few of the institutions currently designated as planning agencies contribute to understanding in any positive way. As a beginning, an agency for long-term forecasting could be developed to serve jointly the new Congressional Budget Office and the Office of Management and Budget, thus providing common criteria for policy analysis in both legislative and Executive branches. Comparable activities could be encouraged in State governments by the tactics employed in CETA and in recently enacted health planning legislation. Research to test both the institutional and political feasibility of long-term planning, and to define the role of planning in the decision system should have a very high priority.

Methodological Research

The general hypothesis of this study was that the primary methodological or substantive constraints on manpower forecasting were contained in the process of projecting system outputs, in estimating sectoral production functions, and in linking input requirements to the labor supply through the use of occupational classification systems. The findings of the study appear to support that hypothesis. While the knowledge base in each area does appear to be generally adequate for manpower forecasting in the short-term, it is not adequate for long-term analysis. Each area has been the object of a very extensive body of research and the literature is much too extensive to be adequately treated in the framework of a study of this type. Nevertheless, it is apparent even in the cursory review that is feasible here, that each area is constrained by both theoretical and empirical factors as a basis for long-term forecasting and for the development of growth policies and strategies that can resolve conflicts between employment and other social objectives.

The Estimation of Future Structures of Output.--In our opinion, the first priority for research intended to enhance the state of the art of manpower forecasting is research relating to the specification of an aggregate long-term social welfare function. The evaluation of the theoretical and empirical basis for projecting final demand and the dominant reliance on static and partial specifications in current practice as discussed in preceeding Chapters suggest that the major constraint on the current state of the art is the limited capacity for projecting dymanic change in the structure of output. Virtually all current techniques of forecasting are based on extrapolation of historical relationships. They are frequently independent of any received theory and they are generally specified in terms of price or income elasticities of substitution, assuming stability in consumer tastes and in the range of alternatives. The "futures" studies explored in Chapter II anticipated substantial change in the product mix as a function of radical change in both real and psychological variables affecting allocation decisions. Some reflect fundamental shifts in the structure of values underlying consumer preference and in institutional factors affecting consumer behavior. Others reflect the effects of change in resource endowments and technology on the conditions of supply and consequently on demand.

Reliance on market specification neglects three aspects of consumer behavior of particular importance to long term forecasts. One is the increasing importance of public goods in the social welfare function and the lack of an appropriate market analogy for evaluation. The second is the importance in the set of collective preferences of intangible products or states and the limited capacity to quantify and incorporate them directly as arguments in the welfare function. The third constraint is the currently limited basis for the analysis of interaction between individual and collective values and technological and other environmental factors.

The current state of the art in treating the specification and evaluation of collective preferences is reflected in the dominant use of extrapolation of public sector employment or expenditures as aggregate output statements, the use of income elasticities of demand for specific expenditures as in the Houthakker-Taylor consumption functions, and in the extensive use of cost-benefit analysis. Attempts to extend the methodology in order to permit direct valuation are represented by a limited experience in goals and priority analysis, social accounting and the numerous Delphi applications discussed in Chapter II. In the main, these approaches have no systemic form and can only be considered as exploratory attempts to underscore a need for more extensive and ordered research.

Further, the extensive use in these techniques of input terms as proxies for outputs reflect the constraints imposed on forecasting by the importance of qualitative differences in the outputs of many public sector activities and by the presence of many intangible products or externalities in both private and public sector production. The use of cost-benefit and cost-effectiveness analysis in the evaluation of education and training programs is a limited response to this need. In each case the technique is limited by the inability to specify the output term in a form that is adequate for valuation or for adequate evaluation of alternative transformation processes.

All of these current attempts at extending the analysis of social choice abstract from the technological, social and political environment in which preferences structures are formed and changed. The current impact of resource constraints and environmental costs on the social welfare demonstrate the costs of reliance on partial and static analysis. The limited reference in preceeding Chapters to studies of value shifts and of systemic change in large social systems indicated the paucity of experience in responding to this need. The priority need is for large-scale, holistic, dynamic models of social change that will permit the analysis of interaction between values and preferences and the full range of environmental variables. The most that can be said of the current state of the art is that it reflects an awareness threshold that is far removed from any operational utility.

The Estimation of Labor Inputs.--Chapter I has argued that the basic assumptions of manpower forecasting are that functional complementarities of inputs are characteristic of production processes, and that, given the structure of output, changes in the composition of inputs is a function of changes in technology. Chapter III suggests that the production function is a useful construct for examining complementarities and parametric shifts but that much of the recent research is not appropriately structured either to test the assumptions or specify the functional forms of the relationship.

These limitations of the knowledge base are attributable in part to the limited availability of establishment level data and in part to a preoccupation with the estimation of substitution parameters in the

framework of equilibrium analysis. Both factors have led to analysis at a level of aggregation that obscures complementarities, places emphasis on methodological questions, is concentrated in the manufacturing sector, and ignores parametric shifts.

A research focus relevant to the needs of manpower forecasting and planning should concentrate on substantive questions concerning the technical conditions of production at the level of the firm. It should give much greater weight to production relationships in the service sector, in particular the public sector, and to the determinants of technological change.

The ability to move research in this direction will depend on the development of highly disaggregate establishment-level data--no small prerequisite given the strength of the concern for confidentiality in in the United States. It will also require a long-term perspective in the treatment of parametric shifts. One recent development of interest here is the growth of interest in technological forecasting and the development of formal, judgmental techniques for evaluating probable or alternative patterns of technical change; as for example, technological applications of Delphi techniques. Unfortunately there appears to be a very limited linkage between engineering and managerial interest in technological shifts and economic research concerning the specification of production functions.

Finally, the policy utility of research in this area will depend on the development or identification of appropriate means for social intervention in the choice of technology. Research related to the diffusion of technology, the relationship between R&D expenditures and the rate of technical change or the determinants of technological bias has not achieved appreciable operational utility. In the absence of any intervention policy that treats technical change as a policy variable, manpower policy is constrained to adjusting manpower supplies to exogenously determined requirements.

Qualification Standards and the Labor Supply.--The review of current practice and of current research concerning the extension of occupational classification systems suggests an increasing concern with the limitations of prevailing systems for manpower forecasting and for the design of specific manpower policies and programs. It underlines three important aspects of the qualification-performance relationship that deserves research priority because of their definitional and policy implications.

One relates to the level of aggregation at which performance functions are specified and consequently the functional homogeniety of the specification. The limited research that has been made at very disaggregate levels of analysis suggest that aggregate classification of many important occupations obscure great functional heterogeneity, i.e., a degree of functional specialization that is not reflected in the job title and which requires unique qualifications.

A second constraint is the cross-sectional nature of occupational classification systems and the failure to treat career patterns or profiles.

Consequently they obscure the sources of supply to the occupation and the qualification standards that are associated with entry occupations. Career patterns appear to be particularly important in managerial or supervisory occupations in highly technical areas of production or service. Research on career profiles for specific occupations would permit more adequate specification of substitution elasticities between formal education and job experience as well as job-specific qualification standards.

Finally, occupational classification systems are particularly limited in regard to the specification of behavioral attributes and non-technical functions. Excepting the aptitude ratings of the D.O.T., the current review found no tests of attitudes, motivation or personality designed for the purpose of predicting occupational performance, and many of the D.O.T. specifications are based on judgmental criteria.

Clearly, behavioral attributes are functionally important in many occupations as requirements of the occupation rather than as determinants of differences in performance. The neglect of behavioral aspects in functional specification has focused education and training on skill acquisition and accounts for an important part of the failure rate in manpower training programs. This neglect is largely attributable to the problem of specifying behavioral characteristics and the means of developing and measuring non-skill attributes.

Although this study has concentrated on the forecasting of labor requirements, the policy model emphasizes the interdependence of requirements and the conditions of supply. Further, the discussion of current practice notes the limited ability of most manpower forecasts to specify the supply system or estimate the magnitude of a supply response to a requirements estimate in a decentralized decision process. Clearly, forecasts of requirements have little policy utility unless they can be linked to the supply system in operational forms.

Research concerning the labor supply has been heavily concentrated on economic specification and market determinations in the framework of human capital theory. These constructs are not suitable to the analysis of system interdependence or of alternative supply systems. The first priority for research in this area is for descriptive studies to elaborate the systemic characteristics of formal education and its linkage with non-formal systems of training and other sub-systems concerned with human resource development. While descriptive research may not excite scholarly interest, the simple fact is that we cannot currently specify the supply system. It is obviously a sine qua non for manpower forecasting and planning.

Given the characteristics of the existing supply mechanisms, there is a critical need for research concerning alternative forms of human resource development and in particular research on the form and time-frame of the developmental process. The magnitude of structural imbalance in human resource systems is, in large part, a current function of highly specialized forms of skill development and the concentration of investment prior to entry into the labor force. The very high costs of obsolescence are obscured in unemployment estimates and ignored in rate

of return analysis. Development concepts that emphasize adaptive capacity and human resource maintenance or conservation rather than simple binary allocation decisions would facilitate response to economic and social change and expand the policy alternatives.

Similarly a large part of manpower policy is based on the assumption that the structure of supply can be shifted simply by changes in investment allocations. The operational validity of that assumption depends on the determinants of individual occupational choice. The existing knowledgc base suggests that the utility maximizing assumptions of conventional economic theory are not sufficient to explain the choice of entry occupation and consequently not adequate for policy formation. Research concerning the institutional determinants of choice is essential to the development or evaluation of instruments for policy intervention.

APPENDIX

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