

## METHODS OF PROJECTING SUPPLY AND DEMAND IN HIGH-LEVEL OCCUPATIONS

Harold Goldstein, U. S. Bureau of Labor Statistics

The use of statistics as a guide to action often requires that they be drawn upon to make long-term projections. This is one of their most challenging uses because it implies the analysis of causation of economic and social events through the statistics. Not only do we gain insight into the underlying laws operating, but we also find out the inadequacies of the existing bodies of statistical data themselves. Thus, research on projections contributes to the never-ending reevaluation and improvement of the Nation's statistical programs. It is in this context that I want to review the research methodology in manpower projections.

Projections of supply and demand in high-level occupations (which I take to mean occupations for which higher education is the usual means of preparation) are used for several purposes: (1) planning educational programs and estimating what expansions in enrollments must be provided for in order to meet the Nation's needs for trained workers; (2) evaluating the feasibility of launching new programs requiring high-level personnel (studies were made, for example, before the United States launched the space program and the national communities mental health program); (3) evaluating the feasibility or the implications of attaining certain standards of services--such as reducing the pupil-teacher ratio in secondary schools or attaining a desirable ratio of engineers to technicians in industry; and (4) the vocational guidance of individuals.

Questions have been raised as to the value of such projections, in view of the substantial technical difficulties in making accurate projections and the considerable amount of flexibility that individuals have shown in adapting themselves to occupations for which they had not been trained, and that institutions have shown in adapting their operations to shortages of certain occupations. However, this flexibility, while it should be encouraged, has its limitations: we cannot easily make physicians and physicists out of lawyers and social workers, and the process of retraining or reeducating can be costly in time and resources. Prudence requires that an educational establishment on which billions of dollars are spent annually be shaped with some regard to the best appraisal that can be made of future manpower requirements. The same is true with respect to attempts to launch immense new programs requiring specialized personnel or to achieve substantial changes in standards of service. In view of the vast frictions, chaos, and costs, to individuals and to society, which could result if these expensive programs were launched simultaneously with no regard to their manpower implications, a modest investment in research on projections will clearly more than pay for itself.

Kinds of Projections

Different kinds of projections are required to meet the different needs outlined above. In planning educational programs, we need to know how many people should be provided with each kind of training. In this context we should assume that the demand is independently determined, reflecting society's needs. The unknown for which this equation is being solved is the inflow to the supply from training programs. It is sometimes useful in such studies to illustrate the implications for our ability to meet future demand of a continuation of the present trend in the number receiving training; this would answer the question, What would happen if we did nothing to change our educational effort? Such a computation would be useful in showing how much of a change in enrollments in each field of study would have to be accomplished in order to meet the projected demand.

In another context, it may be the demand that is projected illustratively and the supply that is projected independently. For example, when the government is considering a large new program or a great expansion in an existing one, the question arises, Will we have the necessary manpower supply without taking any special steps to assure it? In this case the supply should be projected on the basis of current trends, and the total demand projected on the basis of the addition of demand resulting from the proposed program to the demand already existing in the economy projected in the absence of such a program.

One must recognize that in reality demand and supply are not independent, but rather interact on each other; that a short supply of workers in an occupation forces industry to adapt work processes and manning arrangements, and thus affects the demand for labor; and that, conversely, demand creates supply by drawing in workers from other occupations or from outside of the labor force who can qualify in the shortage occupation.

For vocational guidance, a student needs a realistic appraisal of the extent of employment opportunity. Both supply and demand should, therefore, be projected on the basis of the most probable course of events in the judgment of the analyst. This type of projection is most nearly like a "forecast."

For all of these purposes, projections are needed for years in advance, usually at least five, and often 10 to 20 years. For educational planning they are also needed at a State or local level, although this need is considerably less with respect to the high-level occupations considered in this paper, since they seek jobs in a nationwide market.

The same general body of techniques and data are required for all these types of projections. They are, therefore, best made by a staff which is working continuously in the field and which develops the necessary expertise. At the same time it is essential that whoever makes projections keeps clearly in mind the questions each projection is designed to answer and the kind of projection that is needed.

#### Methods of Projecting Demand

The following discussion will be based on the experience of the Bureau of Labor Statistics in this area of work over the past two decades, and on studies by other government agencies and international organizations. There has been a great interest in this subject in recent years, arising in part out of the greater investments in education being made in all countries. Work has gone on in many different countries, and the OECD, UNESCO, and ILO have attempted to develop and encourage improvements in techniques through international conferences, technical assistance, and publications. 1/, 2/, 3/\*

If one may define a general analytical approach to projections of manpower demand, it follows a logic something like this:

1. Ascertain the factors affecting demand for the occupation, and study how they have operated. Identify, if possible, any economic variables that measure or serve as a proxy for each factor and that are capable of being projected independently, and study their past relationship to demand for the occupation.
2. Project the factors or the variables, and their relationship to demand for the occupation.
3. Project demand for the occupation on the basis of these relationships.

This procedure has been followed over the years for many occupations. In most cases it is found that the factors affecting demand for the occupation are the level of demand for the goods and services produced by the occupation (or the institutions in which the occupation is employed), and the way in which the work of the occupation is organized and combined with that of other occupations to produce the goods or services. This leads us to project (a) the demand for the products of each sector

of the economy in which the occupation is employed; (b) total employment in each sector (on the basis of a study of the relationship of output to employment); and (c) the changing patterns of use of the various occupations by each industry sector (affected by technological change and reflected in the changing occupational composition of that sector's work force). 4/, 5/, 6/ In order to project the demand for the products of each sector, we need a system of general projections of the patterns of economic growth and of the relationships between levels of income and general economic activity and patterns of expenditure of each type of goods and services.

If I have seemed to be leading the college president, who simply wants to know whether he should expand his engineering school, down the garden path of an elaborate system of economic analysis that takes in the Nation's whole economy in all its complexity, I make no apologies. No occupation can be considered in and of itself; its demand arises out of the complex fabric of our society, out of the growth or decline of industries, the dramatic changes in technology, the availability of workers in other occupations related in the work process. Its supply, too, is not independent, but depends upon the total supply of educated workers, and the numbers entering other occupations.

Having described above the logical steps leading us to making broad-scope economic analyses as a basis for projections, let me briefly outline the analytical steps currently followed in the work of the Bureau of Labor Statistics, and in that of many other agencies engaged in similar projections

1. The general level of economic activity is projected.--This way involves a projection of the population, a projection of the labor force, a computation of the number of persons who would be employed if this labor force is fully utilized (allowing for some minimum, inescapable level of frictional unemployment), and a projection of the gross national product that would be turned out by this number of employed workers, given an assumed growth in output per man-hour and an assumed change in the number of hours worked by each person.

2. The general character of the economy is projected.--This involves establishing a reasonable relationship between such strategic variables as investment, consumption, government expenditure, net foreign trade, net inventory change, and income payments to the various factors of production.

3. Patterns of consumption are projected.--This involves development of information on the expenditure patterns of families of different income levels, and projections of the numbers of such families.

---

\* References are at the end of the paper.

4. Industry production levels are projected.--The production generated in each industry by final consumption of each of certain quantities of each product or service is estimated by means of regression analysis or input-output analysis.

5. Employment levels in each industry are projected.--This requires a projection of the change in output per man-hour and of the change in annual hours of work per employee.

6. Employment by occupation in each industry is projected.--This requires development of information on the past and present occupational composition pattern of each industry and an appraisal of how this will change under the impact of changing technology. The way in which the occupational composition of each industry is changing cannot always be projected by means of a study of the industry itself. Patterns of occupational use, particularly in relation to new technology, are introduced from one industry to another, and one can learn much from the experience of other industries. Thus, the managerial occupations and the way they are used in industry have certain elements common in all industries. Similarly, the introduction of a new technology, such as numerical control of machine tools, spreads from industry to industry, and these phenomena have to be examined independently of the study of changing occupational patterns of individual industries. Also, the relative employment of members of different occupations whose work is related (such as engineers and technicians, or nurses and hospital attendants) is affected by considerations of supply of the other occupations involved, and these factors have to be considered across the board and outside of the data we can accumulate on the occupational composition of each industry.

There are cases in which a projection for an occupation can be made with considerably less than the elaborate analysis described above. Occupations directly serving people, for example, can be projected on the basis of the growth and changing characteristics of the population. Thus, demand for teachers has been projected on the basis of projections of population of school age, trends in the proportion of this population enrolled in school, and trends in the ratios of teachers to pupils, which have to be analyzed in terms of the many institutional factors affecting these ratios. 7/ In the same way the typical method followed in projecting demand for medical personnel has been to project past ratios of personnel to population, allowing for the effects of such factors as changing age composition and urbanization. But for the very large number of occupations whose employment is in industry, particularly those widely scattered in different industries, such as engineers, chemists, accountants, administrative workers, etc., a more elaborate economic analysis is needed.

In addition to the projections that can be made of population-serving occupations, there are other individual projection approaches that can be made independently of the general system described above. For example, the demand for automobile mechanics has been projected on the basis of the potential number of cars and trucks in use, which is related to the number of families and the average number of cars per family. Employment of scientists and engineers has been projected on the basis of expenditures on research and development. 12/ However, these projections are not completely independent of a general economic analysis for many of the ingredients that enter them derive from considerations of income levels, corporation expenditure levels, etc. As a general principle, any means of alternative independent projection is worth pursuing as a check against the systematic projections and to get some sense of the range of error in the latter. Many cross-checks should be built into the system itself; e.g., employment or production in the building materials manufacturing industries ought to have some reasonable relationship with employment in construction or the volume of construction put in place.

Recent developments in data collection and analytical techniques make possible some improvements in the projection of demand. An extensive research project on economic growth, in which the Bureau of Labor Statistics, the Office of Business Economics of the Department of Commerce, and several other government agencies and university groups are engaged, applies analyses of consumer expenditures, investment expenditures, and input-output relationships among industries in a systematic approach to economic projections. 8/ New research by BLS and by some university groups on the interdependence of the size of the labor force and the level of employment opportunity has led to improved methods in this area. 9/ A major remaining gap is the lack of statistics on employment by occupation. An outline for a system to provide this is being developed by BLS; this would provide data for successive years on the occupational composition of individual industries, and aid in the projection of changing patterns.

New data are also becoming available that will help in the projection of demand in certain occupations. This may be illustrated by a single example. The traditional approach to projections of demand for medical personnel outlined above has some obvious weaknesses, but has been followed for many years, lacking a better one. Ratios of physicians to population need not be constant. On the one hand, rising standards of medical care and rising ability to purchase it (as a result of per capita income growth, prepaid medical plans, etc.) make for an increase in the ratio of physicians to population. On the other hand, changing medical practices and improvements in method may reduce the need for physicians in relation

to population. An example of the latter is the rapid cure of many diseases by antibiotics, reducing the number of doctors' visits for each illness. In view of these considerations, when one makes projections of medical manpower requirements on the basis of ratios to population he is on exceedingly marshy ground. We may get some new light on this problem from the experience of prepaid full-service medical plans, such as that of the various Group Health Associations which have developed through experience the necessary ratios of doctors required to serve their populations.

These new sources of data and techniques of analysis will enhance the accuracy of projections of demand.

It should be clear from the above description that the techniques for projection of demand are analytical in their orientation: they depend on the understanding of causes of economic change, not on any mechanical projection of past trends in employment in any occupation.

In view of all the difficulties I have described, I should not leave the subject of projections of demand without the reassuring note that it is indeed possible; that it has been done as part of a continuing research program and these projections are reviewed and revised repeatedly. The most recent general projection was published early this year in the Manpower Report of the President, and spelled out in more detail in a later publication. 11/

In this study requirements for professional, technical, and kindred workers, of whom over 8.5 million were employed in 1964, were projected to rise by more than two-fifths by 1975, almost twice as fast as the one-quarter increase projected for total employment. Demand in the technical fields was found to be rising most rapidly: needs for scientists and engineers (of whom 1.3 million were employed in 1963) were expected to rise by 50 percent by 1975; for science and engineering technicians (825,000 employed in 1963) demand was projected to rise by two-thirds by 1975. The same rate of increase was projected for college teachers; but demand for elementary and secondary school teachers and most health professions was expected to rise more slowly.

The growth in demand for managerial personnel was projected at about one-fourth from 1964 to 1975, with more rapid increase in needs for salaried managers and officials; slower growth for self-employed businessmen.

#### Methods of Projections of Supply

Although not all the problems of projected demand have been adequately solved, the art of projection demand is far more developed than that of projecting supply. The latter is the

great neglected field in the area of manpower projections. This arises in part from the pre-occupation of economics with the various kinds of studies and the development of the kinds of data that lend themselves to demand analysis. It also arises because of some of the severe conceptual and measurement problems in the area of labor supply. One group of these problems centers around the inherent flexibility and adaptability of human beings. People have multiple skills, and are capable of working in many occupations other than those for which they have had specific training or in which they have been previously employed. Most people actually do move, during the course of their working lives, among a number of occupations, and this mobility is found not only among the less-skilled but even among the most-skilled and specialized occupations. 10/ From this it follows that the labor supply in any occupation is difficult to quantify. If the analysis of the supply of labor is viewed as a system of stocks and flows, not only is the stock impossible to measure accurately, but also the flows into and out of each occupation are difficult to predict.

For high-level personnel, the major inflows are persons who complete training (e.g., receive a degree), those who enter without having received the formal training (a significant proportion of persons employed as engineers, for example, have never received an engineering degree), or come into the country as immigrants. The major outflows are deaths, retirements, withdrawals of women from the labor force for family reasons, movement to other occupations, and emigrants from the country.

For the inflows we have good measures of the number of persons receiving degrees at various levels. On the other hand, there is very little information on interoccupational mobility--the number of people who enter each occupation without having received formal training. Such studies in broad terms have shown that the quantity of such mobility, even among professional occupations, is considerable. 13/, 14/

For the outflows we have reasonably accurate measurements of the impact of deaths and retirements by using tables of working life for men and women developed by the Bureau of Labor Statistics, which can be applied to the present members of each occupation separately by age to make estimates of the prospective losses resulting from deaths and retirements over the next 10 or 20 years. There are greater difficulties in developing techniques for estimating losses from occupations resulting from occupational mobility. A series of two-year followup surveys of persons reported in certain occupations in the 1960 population census has provided some insights, but misclassification of these persons by occupation in the census makes the results difficult to interpret. 16/

Followup studies of people who receive degrees in each field have found a substantial movement out of many occupations, even in the period immediately after graduation. 15/

One of the hopeful new developments in this area of measuring occupational mobility is the National Education Association's annual surveys of public education systems, in which they get data on the number of teachers who leave the system (classified by whether they went to another teaching job, retired, or withdrew from the labor force, etc.), and the number of teachers who entered the system (classified by whether they were new graduates, reentrants, or persons who moved to other teaching jobs). These surveys help to sort out the great amount of mobility from place to place within the teaching profession from the inflows and outflows from the profession, and also help to deal with the question so important in occupations in which large numbers of women are employed: What is the pattern of inflows and outflows associated with women's family responsibilities?

#### References

1. "Employment Forecasting." Final report on the International Seminar on Employment Forecasting Techniques, Organization for Economic Cooperation and Development, Brussels, 4th-7th June, 1962.
2. "Forecasting Manpower Needs for the Age of Science," Office for Scientific and Technical Personnel, Organization for European Economic Cooperation, Paris, September 1960.
3. "Mediterranean Regional Project: Forecasting Educational Needs for Economic and Social Development," OECD, Paris, October 1962.
4. U. S. Department of Labor, Bureau of Labor Statistics, "Changing Manpower Requirements in Banking," by Rose Wiener, Monthly Labor Review, September 1962.
5. "Employment Requirements and Changing Occupational Structure in Civil Aviation." BLS Bulletin No. 1367, June 1964.
6. "Employment Outlook and Changing Occupational Structure in Electronics Manufacturing." BLS Bulletin No. 1363, October 1963.
7. "A New Look at Manpower Needs in Teaching," by Maxine G. Stewart, Occupational Outlook Quarterly, May 1964.
8. "The Federal Government's Program of Economic Growth Studies," by Jack Alterman, Monthly Labor Review, August 1965.
9. "Labor Force Projections for 1970-80," by Sophia Cooper and Denis F. Johnston, Monthly Labor Review, February 1965.
10. U. S. Department of Labor, Bureau of Labor Statistics, "Occupational Mobility of Scientists," BLS Bulletin No. 1121, February 1953.
11. "Manpower Needs in 1975," by Howard Stambler, Monthly Labor Review, April 1965.
12. National Science Foundation, "Scientists, Engineers and Technicians in the 1960's--Requirements and Supply," NSF 63-34, 1964.
13. "Labor Mobility in Six Cities," by Gladys Palmer. Social Science Research Council, New York, 1954.
14. U. S. Department of Labor, Manpower Administration, Office of Manpower, Automation and Training, "Formal Occupational Training of Adult Workers," Monograph No. 2, December 1964.
15. "Two Years After the College Degree," by Laure M. Sharp, Bureau of Social Science Research, Inc. National Science Foundation Bulletin 63-26, 1963.
16. "Education and Training of Technicians," by Howard V. Stambler and Annie Lefkowitz, Monthly Labor Review, November 1964.
17. National Science Foundation, "Scientific and Technical Manpower Resources," NSF 64-28, 1965.

The whole subject of projections of supply may be summarized by saying that, with the exception of deaths and retirements, our methods of projection are exceptionally weak and in need of considerable research. A good deal more information is available on the supply in some occupations than in others; the scientific and technical, medical and teaching fields are among the better-documented occupations. 17/

A general final comment might be made about all the elements of manpower requirements and supply projections: these cannot be done effectively on an ad hoc basis; they require instead the development of a staff responsible for continuing work in this area. This is true not only because the techniques are complex, but also because a well-thought-out program of research to fill major gaps in our knowledge and techniques is needed, and also because the very nature of projections requires that they be reviewed at frequent intervals in the light of changing developments, and that the necessary lessons be learned from past mistakes and applied to future work.