Chapter 13.
Employment Projections

For about 60 years, the U. S. Bureau of Labor Statistics (BLS) has developed long-term projections of likely employment patterns in the U.S. economy. Since the early 1970s, projections have been prepared on a 2-year cycle. The projections cover the future size and composition of the labor force, aggregate economic growth, detailed estimates of industry production, and industry and occupational employment. The resulting data serve a variety of users who need information about expected patterns of economic growth and the effects these patterns are expected to have on employment. For example, information about future employment opportunities by occupation is used by counselors, educators, and others helping people choose a career and by officials who plan education and training programs.

BLS previously developed projections in which the target year always ended in a zero or a five. Projections were prepared every other year, resulting in at least two—and sometimes three—sets of projections being prepared for the same target year. As a result, the projection horizons were as short as 10 years or as long as 15 years. In 1997, BLS changed its procedures. Beginning with the 1996–2006 projections, BLS began developing projections for a 10-year period, still on a 2-year cycle.

IN THIS CHAPTER

Projection Procedures

Over the years, the procedures used to develop the employment projections have undergone many changes, as new data series became available and as economic and statistical tools improved. Since the late 1970s, however, the basic methodology has remained largely the same. Procedures have centered around projections of an interindustry or input-output model that determines job requirements associated with production needs.

Projecting employment in industry and occupational detail requires projections of the total economy and its sectors. BLS develops its projections in a series of six steps, each of which is based on separate procedures and models, and on related assumptions. These six steps examine:

- Size and demographic composition of the labor force
- Aggregate economic growth
- Commodity final demand
- Input-output
- Industry output and employment
- Occupational employment

These components provide the analytical framework needed to develop detailed employment projections. BLS analysts solve each component sequentially. And each step includes several iterations to ensure internal consistency as assumptions and results are reviewed and revised.

Labor force

BLS projects the future supply of labor by applying population projections produced by the Census Bureau to the labor force participation rate projections made by BLS.

The Census Bureau carries out long-term population projections of the resident U.S. population. The projection of the resident population is based on the current size and composition of the population and includes assumptions about future fertility, mortality, and net international migration. The con-

version from the resident population concept of the Census to the civilian noninstitutional population concept of the BLS Current Population Survey (CPS) takes place in three steps. First, the population of children under 16 years is subtracted from the total resident population. Then, the population of the Armed Forces, broken down into different age, sex, race, and ethnic categories, is also subtracted. Finally, the institutional population is subtracted from the civilian population for all categories.

For more than 136 age, sex, race and ethnic groups, BLS maintains a data base of annual averages of CPS labor force participation rates. BLS analysts examine the trends and past behavior of participation rates for all the categories. First, the historical participation rates for these groups are smoothed. Second, the smoothed data are transformed into logits, or natural log of the odds ratio.[1] Finally, the logits of the participation rates are extrapolated linearly by regressing against time and then extending the fitted series to or beyond the target year. When the series are transformed back into participation rates, the projected path is nonlinear.

In addition, projected labor force participation rates are reviewed for consistency. The time-path, cross-section in the target year, and cohort patterns of participation are all reviewed and, if necessary, modified. Projected labor force participation rates are applied to the population projections, producing labor force projections for each of the different age, sex, race, and ethnicity groups. The groups are then summed to obtain the total civilian labor force, which becomes an input to the next stage of the projections.

Aggregate economic growth

The second stage of the BLS projections process develops projections of the gross domestic product (GDP) and the major categories of demand and income. The results of this stage provide aggregate measures that are consistent with each other and with the various assumptions and conditions of the projections. The values generated for each demand sector are then used in the next stage: developing detailed commodity purchases for personal consumption, business investment, foreign trade, and government.

Recent projections have been based on a macroeconomic model developed by St. Louis-based Macroeconomic Advisers, LLC (MA). This model has 744 variables descriptive of the U.S. economy. Of these, 134 are behavioral equations, 409 are identities, and the remaining 201 are exogenous variables, including key assumptions such as monetary policy, fiscal policy, energy prices and supply, and demographic changes.

Besides being governed by general assumptions, the projections are generally approached with specific goals or targets. The goals used to assess the behavior of a given set of projections include the rate of growth and demand composition of real GDP, the rate of growth of labor productivity, the rate of inflation, the unemployment rate, and international trade related issues. Many solution rounds may be necessary to arrive at a balanced set of assumptions, which yield a defensible set of results. When the aggregate economic projection is final, the components of GDP are supplied to the commodity component of the projections process.

Commodity final demand

The macroeconomic model provides forecasts of final demand sectors, including personal consumption expenditures (PCE), gross private fixed investment, change in private inventories, exports and imports of goods and services, Federal and state and local governments, and more detailed sectors within many of these categories. The next step in the projections process is to further disaggregate the results from the macro model into detailed categories that are supported by data from both the National Income and Product Accounts[2] and the Input-Output Accounts.[3] These accounts are used to break out the types of commodities produced or consumed within each of the categories. The process yields a matrix comprising about 200 rows of commodity sectors and 190 columns of final demand categories [4]

For example, BLS forecasts 88 product classes within PCE using the Houthakker Tayler model. These sub-model estimates are then chain weighted[5] to each of the six categories of the personal consumption sector from the macroeconomic model and adjusted as necessary to insure consistency between aggregate controls and the detailed estimates. The final step is to allocate these PCE product classes to detailed commodities via a commodity-by-final demand category matrix. The matrix allows the PCE analyst to provide for shifts in the commodity of a given demand category.

Because the demand for each of the foreign trade categories and change in private investment are estimated by the macroeconomic model, regression models are instead used to forecast demand directly within the detailed commodities. The commodities are then constrained to chain weight up to the macroeconomic model result. The methods used to derive the final demand data vary by GDP component and include economic methods and statistical techniques. The resulting detailed distribution of GDP provides the demand component of an interindustry model of the U.S. economy.

Input-output

The creation of an input-output model is the next stage in developing the BLS projections. Each industry within the

[1] For more information on labor force methodology, see Paul F. Velleman, "Definition and Comparison of Robust Nonlinear Data Smoothing Algorithms," *Journal of the American Statistical Association,* September 1980, Volume 75, Number 372, Theory and Methods Section, pp. 609-615.

[2] For more detailed discussion on concepts and methods of the U.S. National Income and Product Accounts, see the publication on the Internet at **www.bea.gov/national/pdf/NIPAhandbookch1-4.pdf**.

[3] For more detailed discussion on concepts and methods of the U.S. Input-Output Accounts, see the publication on the Internet at **www.bea.gov/papers/pdf/IOmanual_092906.pdf**.

[4] The number of commodity sectors and final demand categories may vary from one projection study to the next depending on data availability.

[5] The U.S. National Income and Product Accounts have adopted a chain-weighted Fisher Index to calculate real aggregates. The chain-weighted methodology calculated the prices of goods and services in order to use weights that are appropriate for the specific periods or years being measured. As a result, for a particular year, the details do not necessarily add to their higher level aggregates.

economy relies on other industries to supply inputs–intermediate products or services—for further processing. By definition, GDP reflects only sales to final purchasers, such as car buyers; intermediate material inputs, such as the steel incorporated into cars, are not explicitly reflected in the GDP estimates. Therefore, to derive an industry-level estimate of the employment and capital needed to produce a given level of GDP, it is first necessary to translate that GDP to a total output concept. An input-output model provides just such a translation and, at the same time, allows BLS analysts to consider other expected phenomena, such as technological changes, shortages or surpluses, and any other factors that may affect the production process.

The BLS input-output model consists of two basic matrices for each year, a "use" table and a "make" table. Both tables are expressed in coefficient form. The use table, the principal one, shows the use of commodities by each industry as inputs into its production process. In coefficient form, each column of this table shows the pattern of commodity inputs per dollar of industry output. Projecting this table must take into account the changes in the input pattern or the way in which goods are produced or services are provided by each industry. In general, two types of changes in these input patterns are made in developing a future input-output table: those made to the inputs of a specific industry (such as the changes in inputs in the publishing industry) and those made to the inputs of a specific commodity in all or most industries (such as increased use of business services across a wide spectrum of industries).

The make table shows the commodity output of each industry. The table allocates commodity output to the industry in which it is the primary commodity output and to those industries where it is secondary. This table shows the industry distribution of production for each commodity. Unlike the use table, the make table is generally held constant or changed very little over the projections decade.

When projected values of the "use" and "make" relationships are available, the projection of commodity demand developed in preceding steps is converted into a projection of domestic industry output using the relationships obtained from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). These relationships are summarized briefly below.

$$g = D(I - BD)^{-1}e$$

where,

g = vector of domestic industry output by sector

B = "use" table in coefficient form

D = "make" table in coefficient form

I = identity matrix, and

e = vector of final demand by commodity sector.

In sum, matrix multiplying the inverse of the coefficient forms of the make and use tables by a vector of final demand commodity distribution, as represented by "*e*" above, yields industry outputs.

Industry output and employment

The industry total output derived from the previous stage includes both sales to final users, as GDP, and to other industries as intermediate inputs. The detailed industry output is then used to derive the industry employment necessary to produce the given level of output. The BLS industry employment is modeled as a function of industry output, wages, prices, and time. Industry employment is then projected using the estimated historical relationship between the variables.

Industry employment is projected in both numbers of jobs and hours worked, both for wage and salary workers and for self-employed and unpaid family workers. Projections are developed according to the following procedure implemented for each industry.

Through a system of equations, employment for wage and salary workers is solved independently over the projections decade for each industry. The individual industry estimates of employment must be consistent with the total employment level derived from the macroeconomic solution. The employment equation relates an industry's labor demand (total hours) to its output, its wage rate relative to its output price, and a trend variable to capture technological change within that industry. A separate set of equations, describing average weekly hours for each industry, are estimated as a function of time and the unemployment rate. The equations are then used to predict average weekly hours over the projections decade. An identity relating average weekly hours, total hours, and employment yields a count of jobs by industry.

The number of self-employed and unpaid family workers is derived by first extrapolating the ratio of the selfemployed to the total employment for each industry. This equation is a function of time and the unemployment rate. The extrapolated ratio is used to derive the level of self-employed and unpaid family workers given the number of wage and salary jobs in each industry. The total hours for self-employed and unpaid family workers are calculated by applying the estimated annual average weekly hours to the employment levels for each industry. Finally, total hours for each industry are derived by summing hours for wage and salary workers and for selfemployed and unpaid family worker hours.

Together with the industry output projections, the employment results provide a measure of labor productivity. BLS analysts examine the implied growth rates in productivity for consistency with historical trends. At the same time, analysts attempt to identify industries that may deviate from past behavior because of changes in technology or other factors. Where appropriate, changes to the employment estimates are made by modifying either the employment demand itself or the results from earlier steps in the projections process.

The final estimates of the projected employment for about 200 industries are then used as inputs to determine the occupational employment over the projections decade.

Occupational employment

The technique for developing the occupational employment projections is based on an industry-occupation matrix showing the distribution of employment for over 300 industries and 750 detailed occupations. Occupational staffing patterns for the industries are based on Occupational Employment Statistics (OES) data collected by State Workforce Agencies and analyzed by BLS. In coefficient terms this matrix represents industry staffing patterns where each column represents the occupational distribution of employment in a specific industry. The change in occupational requirements is jointly determined by shifts in these coefficients and by the structure of industry employment developed in the preceding step.

Because staffing patterns of industries may change over time, the projection method must account for shifts through a series of steps. First, historical data are reviewed to identify trends. Next, factors underlying these trends are then identified through analytical studies of specific industries and occupations, technological change, and a variety of other economic data. Finally, projected staffing patterns are produced based on judgments of how the pattern is expected to change in the future. Numerous factors underlying these changes include technological developments affecting production and products, innovations in the ways business is conducted, modifications of organizational patterns, responses to government policies, and decisions to add new products and services or to stop offering existing ones.

Some expected trends may not be evident in the historical data. For example, an analysis of the past would not point toward the impact of radio frequency identification (RFID) on staffing patterns for cashiers because this technology has not been widely used in most industries. However, as more stores track their inventory and purchases through RFID, this technology may have a significant impact on cashiers, especially in industries in which RFID is easiest to implement.

The projected change in a specific occupation's share of industry employment may be small, moderate, or large; the precise percentage reflects the judgment of the BLS analyst who studies that occupation. In general, changes in coefficients of 5 to 14 percent are considered small; changes of 15 to 27 percent are moderate; and changes of 28 percent or more are large. Documentation released with the projections provides detail on the assumptions developed for each of the occupations for which changes to the base-year coefficients are made.

When projected staffing patterns are available they are used to allocate each industry's projected employment to detailed occupations. These estimates can then be summed across industries to yield total employment for each detailed occupation as follows:

$o = Sl$

where,

o = vector of wage and salary employment by occupation

l = vector of wage and salary employment by industry, and

S = staffing pattern matrix in which each column contains the allocation of industry employment to occupations in percent terms.

The estimates described above relate only to wage and salary employees. Other classes of workers, primarily the self-employed, are analyzed separately. The analyses of these other workers are then combined with that of wage and salary workers to produce a projection of total occupational demand for the United States.

Final review

An important element of the projection system is its comprehensive structure. To ensure internal consistency and reasonableness of this large structure, the BLS projections process encompasses detailed review and analysis of the results at each stage. For example, the close relationship between changes in staffing patterns in the occupational model to changes in technology is also an important factor in determining industry labor productivity. Specialists in many different areas from inside and outside the projection group review all of the relevant results from their particular perspective. In short, the final results reflect innumerable interactions among BLS analysts who focus on particular sectors in the model. Through this review, the projection process at BLS converges into an internally consistent set of employment projections across a substantial number of industries and occupations.

Assumptions

BLS makes many underlying assumptions to carry out the projection process. The projections themselves should be considered as likely outcomes in light of the assumptions. First, assumptions are made about general economic or social conditions. Recent projections, for example, have included the following assumptions:

- Work patterns will not change significantly over the projections decade; for example, the average workweek will not change markedly.
- Broad social and educational trends will continue.
- There will be no major war.
- There will not be a significant change in the size of the Armed Forces.
- Fluctuations in economic activity due to the business cycle will continue.

The assumptions that fall into this first category have both an overall and a particular effect. For example, the assumption that social trends will continue implies that our society will continue to provide for the education of the young in a way that is broadly similar to current practices: this would be considered the overall effect. The particular effect of this

assumption would be to influence the projected level of local government expenditures for education and, consequently, the demand for teachers.

Second, BLS analysts try to identify factors, that in the past have exerted a strong influence on the structure of employment. Once such factors have been identified, analysts judge whether those factors will continue to have a similar influence in the future. Conversely, analysts try to identify new or emerging forces that may prove important in future years. Every attempt is made to document these types of assumptions and to indicate how they might influence future employment growth. During the 1970s and early 1980s, for example, retail stores began to centralize their cashier services; as a result, employment of cashiers in retail stores grew while employment of other sales occupations in these stores declined. This factor, in the judgment of BLS economists, will no longer cause changes in the types of workers that retail stores hire because the shift to centralized cashier operations in these stores has been completed.

Finally, it should be noted that BLS uses these assumptions to create the projections, but unexpected changes may modify results. Shifts in technology, consumer preferences, or trade patterns, as well as natural disasters, wars, and other unpredictable events, may alter the path of the projections.

Presentation

The projections are released online and subsequently appear in BLS bulletins, the *Monthly Labor Review*, and the *Occupational Outlook Quarterly*. The *Quarterly* also publishes articles related to career preparation, such as occupational profiles, jobseeking information, and understanding wage and benefits data.

Part of each biennial projection study is the release of two publications with extensive information about occupational change: the *Occupational Outlook Handbook* and *Occupational Projections and Training Data*. The *Handbook* covers hundreds of occupations. In addition to outlook data for each occupation, it includes information on the nature of the work, training requirements, working conditions, and earnings. The *Handbook* is used as a primary source of information for people choosing a career and is available in many career centers of high schools and colleges, as well as in libraries. *Occupational Projections and Training Data* presents detailed statistics on employment, occupational separations, and education and training completions. Most of the data presented are for the occupations in the *Handbook* and supplement that resource.

Accuracy

The BLS projection process does not end at publication. BLS is constantly working to improve the accuracy of the projections. To ensure that the projections are reliable and of the highest quality, BLS typically evaluates its projections after the target years have passed. Projections of the labor force, industry employment, and occupational employment are evaluated using metrics that provide measures of accuracy. These metrics were developed from a review of methods used by BLS and other agencies in evaluating projections.

The evaluations benefit BLS and external users. Identifying sources of errors helps BLS improve the models used in developing the employment projections. And publishing the results allows users to gauge the accuracy of statements about future economic conditions, industry activity, and employment growth.

Projections Data Base

The BLS approach to employment projections requires specialized data, much of which is assembled especially for this purpose. But all of the data used in the projections process comes from existing general-purpose statistical surveys and programs. The task of BLS in this case is to adapt these sources to the particular needs of the projections system and, most importantly, to meld them into a coherent overall picture of the industrial and occupational structure of the economy.

The data requirements of the system fall into four broad areas: population and labor force, Gross Domestic Product (GDP) by detailed product, interindustry production, and industry and occupational employment. Data on the size and work status of the population by age, sex, race and ethnicity are available through the decennial population census and the monthly Current Population Survey (CPS), a survey of households. Only minor adjustments are required to provide the demographic data base, which supports the labor force projections. These sources, particularly the CPS are also important in assembling other types of data.

Final demand by detailed product is mostly extracted from the U.S. National Income and Product Accounts. The BLS system uses time series data on more than 200 product groupings derived from this source.

The U.S. Input-Output Accounts are the source of two critical items, the use and make tables and the bridge tables. The use and make tables define the structure of interindustry production, and the bridge tables allocate the final demand product groups to detailed commodities. Input-output tables like these are the area of greatest difficulty in data development. The United States, like many other countries, does not produce detailed annual input-output tables; its benchmark tables are released every 5 years and analyze the survey period from about 5 years earlier. Generally, BLS updates the latest benchmark tables (currently 2002) to a more recent year or years by estimating the commodity and industry sums and then applying a balancing procedure, commonly referred to as RAS,[6] in order to adjust the base matrix to the new sums. Although a procedural update is not ideal, it does provide a more up-to-date starting point for the projections and can yield information about trends in the technical coefficients that is useful for the projections process.

[6] Ronald E. Miller and Peter D. Blair, *Input-Output Analysis: Foundations and Extensions* (Prentice-Hall, Inc., Englewood Cliffs, NJ, 1985), 276-294.

The bridge tables are an integral part of the input-output accounts and share the same problem of lack of timely data. The approach to updating them is also similar except that explicit adjustments are used in place of the more mechanical RAS balancing technique. In addition to updating the input-output and bridge tables, numerous adjustments are made to provide consistency with the industry and occupational employment data.

A time-series data base on commodity and industry output is maintained for each sector in the BLS system. These time-series are key variables in the projection system and are also used in updating the benchmark inputoutput table. The series are based on a variety of primary source data, such as annual surveys of manufacturers, of wholesale trade, and of service, as well as other annual and monthly surveys conducted by the Bureau of the Census. Additional data sources include estimates of revenue and various output that come from the Energy Information Agency, the Department of Agriculture, and the Internal Revenue Service. BLS assembles these data sources into a set of industry output measures that are consistent both over time and with the benchmark inputoutput table.

Time series on employment and hours by industry generally are derived from two BLS sources for different groups of workers: (1) The Current Employment Statistics survey, an establishment survey, for nonagricultural wage and salary employment, production worker employment, and weekly hours and (2) the Current Population Survey, a household survey, for agricultural employment, self-employed and unpaid family worker jobs and hours, and private household workers.

Data needed to develop the occupational staffing pattern matrix are derived from several sources. For all except a few industries, information on the occupational distribution of wage and salary workers by industry (staffing patterns) is derived from the Occupational Employment Statistics (OES) survey conducted by State workforce agencies under a BLS-State cooperative program. The OES program surveys about 200,000 establishments per panel (every 6 months), taking 3 years to fully collect the sample of 1.2 million establishments. About 800 detailed occupations from the Standard Occupational Classification (SOC) are surveyed across more than 450 industries. The industry classifications correspond to the sector, which are 3-, 4-, and 5-digit North American Industry Classification System (NAICS) industrial groups. In developing the base-year matrix, occupations that have fewer than 5,000 workers generally are aggregated into similar larger occupations or appropriate residuals. Also, industries with staffing patterns that are comparable to the residual employing fewer than 50,000 workers are aggregated into residuals within the same 3-digit NAICS group.

In some industries, adjustments are made to OES survey staffing patterns because some occupations are not listed separately in the survey questionnaire but are included in a residual category. To develop economy-wide employment estimates for these occupations, it is necessary to disaggregate data from OES survey residuals. Data from the decennial census are used for these adjustments.

Adjustments also must be made to staffing patterns derived from sources other than the OES survey. For example, the occupational classifications used to group Federal Government workers are more detailed than those used in the matrix. Similarly, estimates of occupational employment for workers who are self-employed, unpaid family members, and in the private household industry and agriculture, except agricultural services, are derived from the CPS and must be adjusted to make them comparable to the occupational classification used in the matrix.

After these data have been assembled, they are grouped in a matrix showing occupational employment distribution by industry. Because these percentages are derived from surveys conducted in different years, they are applied to total industry employment estimates for the base year to develop occupational employment estimates.

BLS is committed to maintaining and improving this data base. For example, ongoing efforts include making the data comparable and using crosswalks to account for changes in industry and occupational classification systems.

Technical References

(Note: Projections are biennial and normally appear in the November issue of the *Monthly Labor Review* in odd-numbered years. New BLS bulletins related to the projections are released shortly thereafter.)

Howard N. Fullerton, Jr. "Evaluating BLS projections to 2000," *Monthly Labor Review*, October 2003, pp. 3-12.

Andrew Alpert and Jill Auyer. "Evaluating the BLS 1988-2000 employment projections," *Monthly Labor Review*, October 2003, pp 13-37.

H.O. Stekler and Rupin Thomas. "Evaluating BLS labor force, employment, and occupation projections for 2000," *Monthly Labor Review,* July 2005, pp. 46-56.

-Information about the Census Bureau's U.S. Population Projections is on the Internet at http://www.census.gov/population/www/projections/index.html (visited June 16, 2009).

U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Outlook Quarterly*, Fall 2007.

U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Outlook Handbook*, BLS Bulletin 2700, January 2008.

U.S. Department of Labor, Bureau of Labor Statistics. *Career Guide to Industries*, BLS Bulletin 2701, January 2008.

U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Projections and Training Data*, BLS Bulletin 2702, February 2008.

U.S. Department of Labor, Bureau of Labor Statistics. *Monthly Labor Review*, November 2007 (issue devoted to the 2006–16 projections).