# Scientific and technical employment, 1990–2005

*Alternative employment projections of scientists, engineers, and technicians indicate growth ranging widely— from 9 percent to 59 percent over the 1990–2005 period*

Douglas J. Braddock

Our Nation's economic progress and general well-being depend in considerable measure on the work of scientists, engineers, and technicians. These men and women contribute to the development of new products, improvements in productivity, enhanced defense capabilities, environmental protection, and advances in communications and health care. Because of the importance of scientific and technical workers, information about the current and future labor market for scientists and technicians has great significance. The National Science Foundation's Division of Science Resources Studies, charged with the responsibility for monitoring the adequacy of the supply of scientific and technical workers in meeting the Nation's needs, supported a Bureau of Labor Statistics study of employment prospects for these workers. This article summarizes the results of that study.

The BLS study focused on the development of alternative employment projections for scientists, engineers, and technicians[1] covering the period 1990–2005. The study also analyzed alternative future supply and demand scenarios for these workers.

The Bureau of Labor Statistics develops alternative projections of the labor force, economic growth, industry output and employment, and occupational employment every other year. The most current projections, covering 1990–2005, were published in the November 1991 issue of the *Monthly Labor Review*. Each set of projections consists of a low, moderate, and high growth alternative, developed through a series of models that relate economic theory to economic behavior.[2] While these alternative projections indicate a wide range of employment growth in most occupations, including the scientific and technical occupations, the range of growth for each is determined primarily by variations in the growth of the labor force and in the factors affecting aggregate economic variables, such as the gross national product (GNP), exports and imports, and national defense.

For any single occupation or occupational group, however, the Bureau's regular alternative projections program is not designed to provide a comprehensive analysis of the full range of possible employment alternatives. Variations in the major assumptions and associated aggregate economic variables cannot cover all the conditions that could affect employment in each of the 500 occupations included in the program. Thus, the potential range of projected employment for any specific occupation is much wider than that shown in the alternatives regularly prepared by BLS. Consequently, in developing the high and low alternatives for scientists, engineers, and technicians discussed in this ar-

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ticle, the Bureau's projection methodology was modified so that the procedures could account for economic and other factors most likely to have a significant impact on employment in scientific and technical occupations.

## Highlights of the projections

The alternatives prepared by BLS with the support of the National Science Foundation indicate a wide potential range of employment growth in scientific and technical occupations. For scientists, engineers, and technicians as a group, growth over the 1990–2005 period is projected to range from 9 percent to 59 percent. Among the individual scientific and technical occupations, engineers have the widest projected range of employment, from a decline of 2 percent in the low alternative to an increase of 54 percent in the high alternative. In each alternative, the fastest growth among the groups of scientific and technical occupations is for computer, mathematical, and operations research analysts, ranging from an increase of 46 percent in the low alternative to an increase of 97 percent in the high alternative. Social scientists show the least variation in growth among the alternatives.

Over the 1990–2005 period, the college-aged population is expected to grow more slowly than during the 1970's and 1980's, raising concerns about the adequacy of the future supply of natural scientists, mathematical and computer scientists, and engineers. Alternative projections of college degrees in these fields (the primary source of supply) were developed based on assumptions that 4 percent, 5 percent, and 6 percent of the 22-year-old population would be awarded bachelor's degrees in these fields. The relationship of degrees awarded to job openings in the 1984–90 period was then compared with data from the alternative employment and degree projections.

In general, the analysis presented here indicates that supply and demand in the 1990–2005 period are very likely to approximate supply and demand in the 1984–90 period. Relationships in the projected high employment-high supply, moderate employment-moderate supply, and low employment-low supply scenarios are similar to employment-supply relationships that existed in the mid- to late 1980's. However, the analysis shows that supply-demand imbalances are possible under each of the demand alternatives if the choices of college students to study science and engineering do not reflect labor market conditions—that is, if high demand and low supply or low demand and high supply should prevail. Nonetheless, past experience shows that supply tends to react to demand, although often with a time lag in between.

## Analytical procedure

Employment in most occupations is greatly affected by the industries in which it is concentrated. Therefore, the first step in the analysis was to identify the industries in which scientific and technical workers are concentrated and in which they represent a large share of all workers. From this assessment, it was found that 50 industries[3] employed about 65 percent of all scientists, engineers, and technicians in 1990. Furthermore, more than two-thirds of these workers were employed in 10 industries, namely, computer and office equipment manufacturing, electronic components and accessories manufacturing, aircraft and parts manufacturing, search and navigation equipment manufacturing, computer and data-processing services, public and private education, engineering and architectural services, the Federal Government, State governments, and local governments. In addition, the share of employment accounted for by scientific and technical workers in nearly all of these industries was at least twice as great as their share of employment in the economy as a whole. With this information, the assumptions used in developing the alternatives could focus on economic variables that have a significant impact on employment in industries with a high concentration of scientists, engineers, and technicians.

Employment in an occupation also is affected by its utilization within industries, as measured by the proportion of employment accounted for by the occupation. Thus, another step in establishing the analytical procedures used was to identify factors that affect the future proportion of scientific and technical workers within industries. Fortunately, these factors had already been identified in ongoing BLS research on occupations and were used in developing the projected industry-occupation matrix[4] for the regular BLS projections. However, all of the regular BLS alternatives—low, moderate, and high—used the same projected occupational staffing patterns. Hence, in developing the high and low alternatives for scientific, engineering, and technical occupations, the staffing patterns were modified from the moderate or baseline alternative to account for variations in utilization that would reflect factors that changed the overall demand for workers in each industry. In general, the high alternative had greater utilization and the low alternative lower utilization of workers in scientific and technical occupations than did the moderate alternative developed by BLS.

## Developing the alternative scenarios

The moderate growth alternative developed as part of the regular BLS projections program was established as the baseline projection for the special alternatives. In addition, the macroassumptions used in the regular high growth and low growth BLS alternatives were used, with only slight modification to assure consistency with the specific assumptions posited to affect employment in the industries in which scientific and technical personnel are concentrated. Thus, factors such as the overall unemployment rate, productivity growth, prices, labor force growth, and so on in the regular projection alternatives were used in the special alternatives. In addition, the general pattern of final demand in the regular high and low alternatives was used as the starting point for developing the high and low alternatives for scientific, engineering, and technical occupations.

*Special assumptions.* Of the 50 industries in which scientists, engineers, and technicians were concentrated, 39 were in manufacturing. Thus, the focus of the special assumptions for the high and low alternatives for scientific, engineering, and technical occupations was on factors that would affect manufacturing employment. Assumptions were made in the high alternative that consumer demand would shift to goods produced by industries with a high concentration of scientists, engineers, and technicians and in the low alternative that demand would shift away from these industries, relative to the assumptions in the moderate alternative. In addition, in the high and low special alternatives, it was assumed that exports of goods produced by the industries with a high concentration of scientists, engineers, and technicians would vary from the moderate alternative in a manner similar to that in which exports of goods produced in the high and low regular BLS alternatives would vary from the moderate regular BLS alternative.

Because several manufacturing industries employing significant numbers of scientists and engineers were, as expected, engaged in defense-related activities, the regular BLS assumptions on defense expenditures were carefully evaluated. In all the alternatives, a decline in defense expenditures was projected. In the high alternative, however, it was assumed that a greater proportion of defense activity would be devoted to research into new weapons systems and less into procuring these weapons systems in vast quantities than would be the case in the moderate alternative. Conversely, in the low alternative, the proportion of expenditures devoted to research and development (R&D) was assumed to be less than in the moderate alternative, and purchases were assumed to be greater.

Purchases of manufactured goods by businesses for investment purposes were also increased in the high alternative and lowered in the low alternative, relative to the moderate projection. In both alternatives, it was assumed that the need for investment would increase if production were to be higher, and conversely, less investment would be needed with lower manufacturing production.

One major economic activity that is not accounted for in a statistical sense in the BLS projections is R&D. While it is implicitly included in demand and in the input-output models used by the Bureau, it is not specifically identified. However, to accommodate higher exports, increased consumer spending on domestically produced goods, and greater investment in manufactured goods in the high growth alternative, as compared with the moderate growth alternative, higher levels of R&D activity would be necessary. Similarly, lower levels of R&D activity would be implied in the low growth alternative. In 1990, R&D was estimated to account for about 2.7 percent of GNP.[5] In the moderate BLS alternative, the assumed economic conditions are consistent with a similar level in 2005. In the high special alternative, R&D expenditure levels 25 percent higher, and in the low special alternative, R&D expenditure levels 25 percent lower, than corresponding expenditures in the moderate alternative were estimated to be consistent with the other assumptions in the respective alternative.

Among nonmanufacturing industries, State government (excluding education), local government (again, excluding education), and engineering and architectural services have large numbers of scientific and technical workers. To develop a high growth alternative for these industries, it was assumed that higher expenditures would be devoted to improving the country's infrastructure than would be the case in the regular BLS moderate alternative, and, of course, for a low growth alternative, it was assumed that lower expenditures would be given over to improvement of the infrastructure than would obtain in the BLS moderate alternative. For example, the high alternative assumes that considerable effort will be devoted to rebuilding the Nation's highways and bridges. Because modest improvements to the infrastructure are implied in the moderate alternative, the low projection implies, not significant deterioration, but minimal improvements to the infrastructure.

Specific assumptions affecting overall demand and output were not made for education, although the industry employs large numbers of scientific and technical workers. However, the impact of higher and lower levels of R&D in the high and low alternatives were considered in developing projections for the education industry.

*Input-output tables.* The methodology the Bureau uses in its projections employs input-output tables, so that the total output and associated employment of industries account for the intermediate production of goods and services that go into purchases of final demand. Input-output tables for the base year of the projections are projected to the target year, in this case 2005, to account for technological changes and other factors that alter inputs over time. Thus, the production and associated employment of the steel industry that go into the production of consumer purchases of automobiles are accounted for in the BLS methodology. For the BLS regular alternatives, however, the same input-output table for the target year of the projections is used in each alternative.

In the high and low special alternatives, modifications were made to the input-output tables for 2005 used in developing the moderate BLS regular alternative. In general, the high alternative increased the row coefficients of the input-output tables from the moderate alternative that specified purchases of intermediate goods from high technology industries. For example, one of the industries identified as having a high concentration of scientists, engineers, and technicians was communications equipment manufacturing. In the high growth alternative, the purchases of this industry's products were increased relative to what they were in 2005 in the moderate alternative. In this manner, the high growth alternative accounts for employment stemming from improved products that likely would be generated by higher R&D activity in that alternative. In a similar manner, input-output coefficients were lowered in the low growth alternative.

*Utilization.* In the regular BLS moderate alternative, occupational staffing patterns of industries in the industry-occupation matrix are projected to the target year of the projections to account for such factors as technological change, changes in business practices, and changes in goods and services produced. However, the same projected staffing patterns are used in the regular high and low alternatives. A modification to that methodology was used in developing the high and low alternatives for scientific, engineering, and technical occupations. In this modification, the staffing patterns of scientific, engineering, and technical occupations in the high and low alternatives were altered to account for differences implied by the assumptions tied to each alternative.

The basic factor accounted for in the modification was R&D activity. As mentioned above, an assumption was made that R&D would be 25 percent higher as a share of GNP in the high alternative and 25 percent lower in the low alternative than in the regular BLS moderate alternative. Levels of R&D-related employment implied in the moderate alternative were adjusted accordingly. The implied levels in the moderate projection for 2005 were estimated on the basis of data from the National Science Foundation indicating the proportion of all workers in each occupation engaged in R&D.[6] In the high alternative these levels were increased, and in the low they were decreased, by 25 percent. The differences in levels for each occupation in the economy as a whole were then distributed by industry based on the distribution of employment in R&D in the BLS Occupational Employment Statistics (OES) survey for each scientific and technical occupation.[7] The resulting increment for each occupation was added to employment in each industry, and the staffing pattern for the industry was adjusted accordingly.

## Framework of alternative scenarios

*Regular moderate alternative.* As mentioned, the regular BLS moderate alternative was developed as part of the Bureau's employment projections program. This alternative is characterized by a projected slowing in the growth of the GNP, influenced by slowing labor force growth and some improvement in labor productivity. In addition, there are several key shifts in the distribution of final demand components of the GNP, improvements in the balance of foreign trade, and a gradually improving Federal budget deficit. In this scenario, a continued contraction in defense spending is assumed throughout the coming decade, with real spending on military goods and services dropping at an average annual rate of 1.2 percent between 1990 and 2005. (For more details of the moderate alternative, see table 1.)[8]

*Low scientific alternative.* The low projection for scientific, engineering, and technical occupations was designed to illustrate a possible future set of economic, technological, and other factors likely to be unfavorable to the employment of scientists, engineers, and technicians. Of necessity, this alternative is less favorable in other ways as well. Critical macroeconomic assumptions in this scenario include below-trend growth in population, the labor force, capital stocks, and productivity. (See table 1.)

Under the low alternative, R&D becomes a lower priority for business and government. As a result, there are fewer competitive products from American manufacturing industries, and, as a consequence, the trade deficit widens, putting further pressure on the economy—especially high technology manufacturing industries. This in turn leads to lower output and employment in industries that have a high concentration of scientists, engineers, and technicians. Another major cause of a reduction in R&D expenditures over the projection period is a major reduction in defense expenditures and, in particular, a major reduction in R&D devoted to new weapons systems.

For this alternative, R&D expenditures are assumed to decline by about 25 percent as a percentage of GNP. In 1990, R&D expenditures were 2.7 percent of GNP. Thus, R&D expenditures are projected to decline to about 2.0 percent of GNP by 2005. A decline in the ratio of R&D expenditures to GNP of almost this magnitude last occurred during the period 1965–75. Therefore, although there has never been a decline of such magnitude in this ratio over a 15-year period, a decrease of this amount does have some historical precedent.

Table 1. **Major assumptions affecting alternative projections for scientific, engineering, and technical occupations, 1975, 1990, and projected to 2005**

| Category | 1975 | 1990 | 2005 Low | 2005 Moderate[1] | 2005 High |
|---|---|---|---|---|---|
| Total population (millions) | 216.1 | 251.4 | 275.6 | 281.6 | 281.6 |
| Civilian labor force (millions) | 93.8 | 124.8 | 141.8 | 150.8 | 156.2 |
| Civilian unemployment rate (percent) | 8.5 | 5.5 | 7.0 | 5.5 | 4.0 |
| Military force level (millions) | 2.1 | 2.1 | 1.6 | 1.7 | 1.8 |
| Federal surplus (billions of 1982 dollars) | $-69.4 | $-161.3 | $-175.2 | $-59.2 | $52.5 |
| Gross national product (billions of 1982 dollars) | $2,695.0 | $4,155.8 | $5,223.7 | $5,842.6 | $6,385.5 |
| Percent distribution: | | | | | |
| Personal consumption | 63.5 | 64.5 | 66.2 | 64.3 | 64.7 |
| Exports | 9.6 | 15.2 | 20.9 | 20.8 | 20.8 |
| Imports | -8.9 | -16.1 | -21.6 | -19.8 | -20.4 |
| National defense | 6.0 | 6.2 | 3.8 | 3.7 | 3.5 |
| Federal nondefense | 2.4 | 2.0 | 2.0 | 1.9 | 1.9 |
| State and local government | 13.2 | 11.5 | 11.8 | 11.5 | 11.4 |
| Gross private domestic investment | 14.2 | 16.6 | 16.9 | 17.5 | 18.1 |

[1] Regular BLS moderate projection from employment projections program.

*High scientific alternative.* The high projection for scientific, engineering, and technical occupations was designed to illustrate a possible future set of economic, technological, and other factors likely to be favorable to the employment of scientists, engineers, and technicians. This alternative is also more favorable than the other alternatives for the economy as a whole. Macroeconomic assumptions in this scenario include somewhat stronger growth in labor force participation, a major shift toward the production of investment goods, and a general moderation of inflation. (See table 1.)

Under the high alternative, the Federal Government devotes a greater proportion of its funds to nondefense R&D. Federal outlays concentrate on supporting broad-based basic research and emerging technologies that tend to be too risky or expensive for the private sector. In addition, U.S. firms become more willing to commit resources to long-term research projects and more efficient methods of production.

Although overall defense expenditures decline, defense-related research continues at about its present level. Many weapons systems continue to be developed, although relatively few of the weapons are produced in large quantities. Programs such as the Strategic Defense Initiative are assumed to be continued.

In addition, concern over any further deterioration of the Nation's infrastructure leads to increased expenditures in this area, adding to the employment of scientists, engineers, and technicians in industries related to construction.

For this alternative, R&D expenditures are assumed to increase by about 25 percent as a percentage of GNP, from 2.7 percent in 1990 to about 3.4 percent by 2005. During the period 1975–85, the ratio of R&D expenditures to GNP increased by about 29 percent. Therefore, an increase of this amount in the ratio has historical precedent. (In fact, the argument could be made that the favorable conditions for R&D postulated under this alternative could justify an even higher increase in the ratio.) However, the 1975–85 period was a time of large increases in defense expenditures, which are not foreseen under this alternative.

## Industrial projections perspective

Like most occupations, scientific and technical occupations are disproportionately distributed across industries. Consequently, the growth of certain industries has a significant impact on the employment growth of these workers. In 1990, 4.7 million scientists, engineers, and technicians were employed as wage and salary workers. Nearly two-thirds, or 3.1 million, were employed in 50 industries that accounted for only one-fourth of total wage and salary worker employment in the economy. In almost all of these industries, scientists, engineers, and technicians accounted for a higher proportion of employment than they did in the economy as a whole. Thirty-nine of the 50 industries with a high concentration of scientists, engineers, and technicians were in manufacturing.

On average, projected employment growth in the 50 industries with heavy concentrations of scientific, engineering, and technical workers is not conducive to rapid employment growth for these workers. With 3.4-percent growth in the low alternative, 15.0-percent growth in the regular BLS moderate alternative, and 24.6-percent growth in the high alternative, the projected employment growth in these 50 industries is slower than the total growth in the employment of wage and salary workers in the economy in all three alternative scenarios. (The corresponding figures for total growth are 11.8 percent in the low alternative, 20.7 percent in the regular BLS moderate alternative, and 27.3 percent in the high alternative.)

In the moderate growth alternative, employment is projected to decline in 29 of the 50 industries with a high concentration of scientists, engineers, and technicians. For the low growth alternative, the number of these industries projected to decline is 39, and for the high growth alternative, it is 21. In all three alternatives, all but two or three of the industries projected to decline are in manufacturing. (See table 2.)

Few of the industries with high concentrations of scientists, engineers, and technicians are projected to experience employment growth that is faster than the growth of total employment. Only 7 such industries in the low alternative, 9 in the regular BLS moderate alternative, and 10 in the high alternative are projected to increase faster than the average of all industries in the corresponding alternative. In all of the alternatives, only four industries—forestry, highway and street construction, medical instruments and supplies manufacturing, and computer and data-processing services—are projected to increase significantly faster than average. In the moderate and high alternatives, the engineering and architectural services industry also is projected to grow significantly faster than average.

The total numerical growth of the industries with high concentrations of scientists, engineers, and technicians is projected to be 983,000 in the low alternative, 4.3 million in the moderate projection, and 7.1 million in the high scenario. A highly significant proportion of the growth in each alternative is contributed by only five industries: computer and data-processing services, education, engineering and architectural services, State government, and local government. The numerical growth of these five industries is actually greater than the growth of all the industries with high concentrations of scientists, engineers, and technicians in both the low and the moderate alternative.

In the low alternative, the employment of scientists, engineers, and technicians in the highly concentrated industries will decline slightly from 1990 to 2005, despite the economywide growth in the numbers of these workers. In the moderate alternative, 55 percent of the growth projected for scientists, engineers, and technicians will be in these industries. In the high alternative, 64 percent of the growth is projected to be in these industries.

## Occupational projections

The alternative scenarios present a broad band of employment growth for scientists, engineers, and technicians between 1990 and 2005, ranging from an increase of only 9 percent in the low alternative to 35 percent in the regular BLS moderate alternative and 59 percent in the high alternative. (See table 3.) Under the moderate and high scenarios, the employment of scientists, engineers, and technicians will grow much faster than total employment. In the low alternative, however, the employment growth of scientists, engineers, and technicians will be less than the total employment growth.

The high and the low alternatives encompass a divergence of 2.8 million in the employment of scientists, engineers, and technicians in 2005. From a figure of 5.6 million in 1990, total employment is projected to range from 6.2 million in the low alternative to 9.0 million in the high alternative. This wide disparity in the projected demand for scientists, engineers, and technicians has a significant impact on possible supply-and-demand scenarios, as will be illustrated in a later section.

*Engineers.* Of all the scientific, engineering, and technical occupations, engineers have the widest range of projected growth among the alternatives. In the moderate growth alternative, the employment of engineers is projected to increase from 1.5 million in 1990 to 1.9 million in 2005, or 26 percent (1.6 percent a year, on average). Although this rate of growth is faster than the average for all occupations, it

Table 2. **Employment in industries with a high concentration of scientists, engineers, and technicians, 1990 and projected to 2005, low, moderate, and high alternatives**

[Numbers in thousands]

| Industry | Total employment | | | | Percent change | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2005 | | | 1990–2005 | | | From moderate projection | |
| | | Low | Moderate | High | Low | Moderate | High | Low | High |
| Total, all industries | 112,053 | 125,223 | 135,280 | 142,696 | 11.8 | 20.7 | 27.3 | –7.4 | 5.5 |
| Total, all special industries | 28,718 | 29,701 | 33,027 | 35,783 | 3.4 | 15.0 | 24.6 | –10.1 | 8.3 |
| Manufacturing | 8,067 | 6,465 | 7,672 | 8,478 | –19.9 | –4.9 | 5.1 | –15.7 | 10.5 |
| Ordnance and accessories, n.e.c.[1] | 75 | 40 | 46 | 50 | –46.5 | –38.6 | –33.2 | –13.0 | 8.7 |
| Engines and turbines | 89 | 59 | 72 | 81 | –33.1 | –19.2 | –8.5 | –17.2 | 13.2 |
| Farm and garden machinery | 106 | 99 | 113 | 120 | –7.1 | 6.4 | 12.9 | –12.7 | 6.1 |
| Construction and related machinery | 228 | 183 | 212 | 230 | –19.6 | –7.2 | .8 | –13.3 | 8.6 |
| Metalworking machinery | 330 | 268 | 316 | 346 | –18.9 | –4.4 | 4.6 | –15.2 | 9.4 |
| Special industry machinery | 159 | 122 | 145 | 156 | –23.3 | –9.0 | –2.0 | –15.7 | 7.7 |
| General industrial machinery | 248 | 173 | 212 | 230 | –30.4 | –14.7 | –7.4 | –18.4 | 8.6 |
| Computer and office equipment | 439 | 304 | 377 | 421 | –30.9 | –14.2 | –4.2 | –19.4 | 11.6 |
| Refrigeration and service machinery | 177 | 177 | 200 | 217 | .1 | 13.0 | 22.8 | –11.5 | 8.7 |
| Industrial machinery, n.e.c.[1] | 317 | 271 | 295 | 312 | –14.6 | –7.0 | –1.8 | –8.2 | 5.5 |
| Electric distributing equipment | 97 | 72 | 84 | 93 | –26.2 | –13.8 | –4.0 | –14.3 | 11.4 |
| Electrical industrial apparatus | 169 | 114 | 141 | 159 | –32.3 | –16.5 | –5.5 | –18.9 | 13.2 |
| Household appliances | 125 | 89 | 93 | 95 | –29.0 | –25.3 | –24.5 | –4.9 | 1.1 |
| Electric lighting and wiring equipment | 189 | 165 | 191 | 211 | –13.0 | 1.0 | 11.6 | –13.8 | 10.6 |
| Household audio and video equipment | 83 | 32 | 74 | 90 | –61.6 | –10.9 | 8.8 | –56.9 | 22.1 |
| Communications equipment | 263 | 187 | 226 | 245 | –29.0 | –14.3 | –6.9 | –17.1 | 8.6 |
| Electronic components and accessories | 581 | 428 | 599 | 712 | –26.2 | 3.1 | 22.6 | –28.4 | 19.0 |
| Miscellaneous electrical equipment and supplies | 166 | 139 | 160 | 178 | –16.7 | –3.5 | 7.0 | –13.7 | 10.8 |
| Motor vehicles and equipment | 809 | 664 | 744 | 796 | –18.0 | –8.1 | –1.6 | –10.8 | 7.0 |
| Aircraft and parts | 706 | 609 | 715 | 789 | –13.7 | 1.2 | 11.8 | –14.8 | 10.4 |
| Ship and boat building and repairing | 187 | 161 | 180 | 195 | –14.1 | –3.7 | 4.4 | –10.8 | 8.4 |
| Railroad equipment | 33 | 30 | 34 | 35 | –9.3 | .9 | 6.3 | –10.1 | 5.4 |
| Guided missiles and space vehicles | 186 | 140 | 164 | 181 | –24.7 | –11.7 | –2.5 | –14.8 | 10.4 |
| Miscellaneous transportation equipment | 58 | 51 | 52 | 54 | –12.4 | –9.8 | –7.1 | –2.9 | 3.1 |
| Search and navigation equipment | 284 | 252 | 295 | 321 | –11.2 | 4.1 | 13.1 | –14.7 | 8.7 |
| Measuring and controlling devices | 324 | 220 | 261 | 284 | –31.9 | –19.4 | –12.4 | –15.5 | 8.8 |
| Medical instruments and supplies | 244 | 300 | 331 | 356 | 22.8 | 35.5 | 46.0 | –9.4 | 7.8 |
| Ophthalmic goods | 42 | 35 | 45 | 51 | –16.4 | 7.6 | 21.9 | –22.3 | 13.2 |
| Photographic equipment and supplies | 100 | 64 | 76 | 84 | –35.9 | –24.1 | –16.2 | –15.6 | 10.4 |
| Industrial inorganic chemicals | 142 | 86 | 110 | 131 | –39.8 | –22.5 | –7.5 | –22.3 | 19.4 |
| Plastics materials and synthetics | 181 | 142 | 175 | 200 | –21.5 | –3.2 | 10.8 | –18.9 | 14.4 |
| Drugs | 238 | 250 | 293 | 327 | 4.9 | 23.3 | 37.5 | –14.9 | 11.5 |
| Soap, cleaners, and toilet goods | 160 | 155 | 179 | 202 | –3.0 | 12.0 | 26.0 | –13.4 | 12.5 |
| Paints and allied products | 62 | 47 | 56 | 65 | –24.3 | –9.2 | 4.5 | –16.6 | 15.2 |
| Industrial organic chemicals | 154 | 106 | 136 | 162 | –31.6 | –12.0 | 5.1 | –22.3 | 19.4 |
| Agricultural chemicals | 56 | 33 | 38 | 43 | –40.4 | –31.4 | –23.8 | –13.0 | 11.2 |
| Miscellaneous chemical products | 100 | 90 | 109 | 126 | –10.1 | 9.4 | 25.6 | –17.8 | 14.8 |
| Petroleum refining | 118 | 75 | 85 | 90 | –36.4 | –28.1 | –23.6 | –11.6 | 6.3 |
| Miscellaneous petroleum and coal products. | 40 | 34 | 37 | 39 | –13.9 | –5.8 | –.8 | –8.6 | 5.3 |
| Nonmanufacturing | 20,651 | 23,236 | 25,355 | 27,305 | 12.5 | 22.8 | 32.2 | –8.4 | 7.7 |
| Forestry | 25 | 30 | 32 | 34 | 18.8 | 28.0 | 34.8 | –7.2 | 5.3 |
| Crude petroleum, natural gas, and gas liquids | 196 | 136 | 172 | 188 | –30.5 | –12.0 | –4.0 | –21.0 | 9.2 |
| Highway and street construction | 241 | 289 | 315 | 337 | 20.1 | 30.9 | 40.3 | –8.3 | 7.1 |
| Heavy construction, except highway and street | 522 | 591 | 644 | 690 | 13.1 | 23.3 | 32.1 | –8.3 | 7.1 |
| Pipelines, except natural gas | 18 | 17 | 19 | 20 | –9.7 | 1.1 | 7.6 | –10.7 | 6.4 |
| Computer and data-processing services | 784 | 1,257 | 1,494 | 1,690 | 60.3 | 90.6 | 115.5 | –15.9 | 13.1 |
| Education, public and private | 9,440 | 10,846 | 11,756 | 12,604 | 14.9 | 24.5 | 33.5 | –7.7 | 7.2 |
| Engineering and architectural services | 793 | 853 | 1,083 | 1,310 | 7.6 | 36.6 | 65.3 | –21.3 | 21.0 |
| Federal government | 2,266 | 2,223 | 2,236 | 2,246 | –1.9 | –1.4 | –.9 | –.6 | .5 |
| State government | 2,148 | 2,318 | 2,520 | 2,713 | 7.9 | 17.3 | 26.3 | –8.0 | 7.7 |
| Local government | 4,217 | 4,677 | 5,084 | 5,473 | 10.9 | 20.5 | 29.8 | –8.0 | 7.7 |
| Total, all other industries | 83,336 | 95,522 | 102,253 | 106,912 | 14.6 | 22.7 | 28.3 | –6.6 | 4.6 |

[1] n.e.c. = not elsewhere classified.

Table 3. **Employment[1] of scientists, engineers, and technicians, 1980 and projected to 2005, low, moderate, and high alternatives**

[Numbers in thousands]

| Occupation | Total employment | | | | Percent change | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2005 | | | 1990–2005 | | | From moderate projection | |
| | | Low | Moderate | High | Low | Moderate | High | Low | High |
| Total | 5,650 | 6,177 | 7,606 | 8,964 | 9.3 | 34.6 | 58.7 | –18.8 | 17.8 |
| Engineering, mathematical, and natural science managers | 315 | 337 | 423 | 505 | 6.8 | 34.2 | 60.0 | –20.4 | 19.2 |
| Engineers | 1,519 | 1,489 | 1,919 | 2,332 | –2.0 | 26.3 | 53.5 | –22.4 | 21.5 |
| Aeronautical and astronautical engineers | 73 | 64 | 88 | 112 | –12.2 | 20.5 | 53.3 | –27.1 | 27.2 |
| Chemical engineers | 48 | 41 | 54 | 67 | –15.9 | 11.6 | 38.8 | –24.6 | 24.3 |
| Civil engineers, including traffic engineers | 198 | 214 | 257 | 302 | 7.9 | 30.0 | 52.7 | –17.0 | 17.4 |
| Electrical and electronics engineers | 426 | 425 | 571 | 715 | –.3 | 34.1 | 67.8 | –25.7 | 25.1 |
| Industrial engineers, except safety engineers | 135 | 131 | 160 | 185 | –2.6 | 18.9 | 36.8 | –18.1 | 15.1 |
| Mechanical engineers | 233 | 219 | 289 | 358 | –6.3 | 23.9 | 53.6 | –24.4 | 24.0 |
| Metallurgists and metallurgical, ceramic, and materials engineers | 18 | 17 | 22 | 27 | –7.5 | 21.3 | 48.8 | –23.7 | 22.3 |
| Mining engineers, including mine safety engineers | 4 | 4 | 4 | 5 | –11.4 | 4.2 | 19.0 | –15.0 | 14.2 |
| Nuclear engineers | 18 | 15 | 18 | 21 | –16.3 | –.3 | 15.0 | –16.1 | 15.3 |
| Petroleum engineers | 17 | 14 | 18 | 20 | –20.1 | 1.2 | 13.8 | –21.1 | 12.4 |
| All other engineers | 347 | 346 | 436 | 519 | –.3 | 25.8 | 49.7 | –20.7 | 19.0 |
| Life scientists | 174 | 194 | 230 | 264 | 12.0 | 32.3 | 52.4 | –15.3 | 15.2 |
| Agricultural and food scientists | 25 | 28 | 32 | 35 | 11.2 | 26.6 | 41.0 | –12.1 | 11.4 |
| Biological scientists | 62 | 71 | 83 | 95 | 13.9 | 33.9 | 52.8 | –14.9 | 14.2 |
| Foresters and conservation scientists | 29 | 31 | 32 | 33 | 8.4 | 12.5 | 15.9 | –3.6 | 3.0 |
| Medical scientists | 19 | 26 | 31 | 37 | 36.9 | 66.0 | 94.1 | –17.5 | 17.0 |
| All other life scientists | 39 | 39 | 51 | 64 | .2 | 31.8 | 65.6 | –24.0 | 25.7 |
| Computer, mathematical, and operations research analysts | 571 | 835 | 987 | 1,127 | 46.2 | 72.8 | 97.3 | –15.4 | 14.1 |
| Actuaries | 13 | 17 | 18 | 18 | 25.9 | 33.6 | 38.2 | –5.8 | 3.4 |
| Systems analysts and computer scientists | 463 | 694 | 829 | 954 | 49.9 | 78.9 | 105.9 | –16.2 | 15.0 |
| Statisticians | 16 | 15 | 18 | 20 | –1.9 | 11.7 | 23.8 | –12.2 | 10.8 |
| Mathematicians and all other mathematical scientists | 22 | 19 | 24 | 28 | –10.7 | 9.5 | 29.0 | –18.4 | 17.8 |
| Operations research analysts | 57 | 89 | 100 | 108 | 55.1 | 73.2 | 87.4 | –10.5 | 8.2 |
| Physical scientists | 200 | 187 | 241 | 294 | –6.4 | 20.5 | 47.6 | –22.3 | 22.4 |
| Chemists | 83 | 72 | 96 | 120 | –12.8 | 15.6 | 44.5 | –24.6 | 25.1 |
| Geologists, geophysicists, and oceanographers | 48 | 47 | 58 | 68 | –.8 | 22.3 | 42.7 | –18.9 | 16.6 |
| Meteorologists | 5 | 6 | 7 | 8 | 7.1 | 29.5 | 51.2 | –17.3 | 16.7 |
| Physicists and astronomers | 20 | 16 | 21 | 26 | –20.2 | 5.1 | 30.6 | –24.1 | 24.2 |
| All other physical scientists | 44 | 46 | 59 | 73 | 4.5 | 33.9 | 65.9 | –21.9 | 23.9 |
| Social scientists | 224 | 296 | 320 | 342 | 32.3 | 42.8 | 52.6 | –7.4 | 6.8 |
| Economists | 37 | 41 | 45 | 49 | 9.7 | 21.4 | 31.9 | –9.6 | 8.6 |
| Psychologists | 125 | 191 | 204 | 216 | 53.1 | 63.6 | 73.3 | –6.4 | 5.9 |
| Urban and regional planners | 23 | 26 | 28 | 30 | 9.7 | 18.8 | 27.4 | –7.7 | 7.2 |
| All other social scientists | 38 | 39 | 43 | 46 | .2 | 10.8 | 20.6 | –9.6 | 8.9 |
| Technicians, engineering and science, and computer programmers | 2,647 | 2,839 | 3,486 | 4,099 | 7.2 | 31.7 | 54.9 | –18.6 | 17.6 |
| Engineering technicians | 755 | 762 | 965 | 1,161 | .9 | 27.8 | 53.8 | –21.0 | 20.3 |
| Electrical and electronics technicians/ technologists | 363 | 378 | 488 | 594 | 4.2 | 34.4 | 63.6 | –22.5 | 21.7 |
| All other engineering technicians and technologists | 392 | 384 | 477 | 568 | –2.1 | 21.7 | 44.9 | –19.6 | 19.0 |
| Drafters | 326 | 299 | 370 | 439 | –8.2 | 13.4 | 34.6 | –19.1 | 18.7 |
| Science and mathematics technicians | 246 | 243 | 305 | 366 | –1.5 | 23.6 | 48.5 | –20.4 | 20.1 |
| Computer programmers | 565 | 773 | 882 | 972 | 36.9 | 56.1 | 72.1 | –12.3 | 10.2 |

[1] Includes wage and salary and self-employed workers.

represents a slowdown from the 1984–90 growth rate of 2.2 percent a year gleaned from national industry-occupation matrix data. Some of this slowing is due to the projected overall slowing of employment growth, but the assumption of lower defense spending also has a significant impact on the expected employment growth of engineers.

In the low alternative, the employment of engineers is projected to decrease by 2 percent over the 1990–2005 period due to the heavy involvement of engineers in research and development in manufacturing and due to their dependence on defense expenditures. All engineering specialties except civil engineering are projected to decrease in employment under the assumptions used in this alternative. Because significant numbers of civil engineers are employed in State and local government activities that are not affected adversely in the low scenario, the occupation is not projected to shrink in numbers.

In the high alternative, the employment of engineers is projected to increase a healthy 54 percent due to the heavy involvement of engineers in research and development, particularly the product development that is emphasized in this alternative. Nevertheless, the employment growth of engineers is very concentrated, with nearly 40 percent of the total growth of 813,000 from 1990 to 2005 found in four industries: engineering and architectural services, computer and data-processing services, electronic components and accessories, and aircraft and parts. All engineering specialties except mining, nuclear, and petroleum engineering are projected to grow rapidly under this alternative. These three specialties are concentrated in areas outside the predominantly manufacturing industries, which are projected to be affected positively by the assumptions used in the high growth alternative.

*Life scientists.* In the regular BLS moderate alternative, the employment of life scientists is projected to increase from 174,000 in 1990 to 230,000 in 2005, or 32.3 percent. Much of this growth is attributable to growth in medical and biotechnological research, as well as to employment gains in activities related to environmental protection. Very rapid growth is projected in the medical instruments and supplies industry and in drug manufacturing. More than half of the employment growth of life scientists is in industries that do not have a high concentration of scientists, engineers, and technicians.

In the low scenario, the employment of life scientists is projected to increase 12 percent, about the same as the economy as a whole in this alternative. In general, the industries in which life scientists are employed are not affected as severely by the assumptions in the low alternative as the industries in which engineers and physical scientists are employed.

The employment of life scientists grows rapidly—52 percent—in the high scenario. Within the life scientist group, medical scientists and all other life scientists benefit from the increased R&D funding assumed under this alternative. All other life scientists grow faster in number than biological or agricultural scientists because all other life scientists is the category under which new life science specialties, which tend to grow more rapidly than traditional life science specialties, are classified. Only foresters grow relatively slowly under the high growth alternative.

*Physical scientists.* The three alternative scenarios present a wide range of employment growth for physical scientists over the period 1990–2005. In the regular BLS moderate alternative, employment is projected to grow only 21 percent—from 200,000 to 241,000—about the same as employment in the economy as a whole. Growth is restricted because of below average growth projected in industries in which physical scientists are concentrated (such as chemicals and oil and gas exploration and extraction), as well as by assumed reductions in defense expenditures.

In the low growth scenario, the employment of physical scientists is projected to decline by 6 percent. Of all scientists, engineers, and technicians, physical scientists are the group most affected by this alternative. The reason is that they are heavily involved in research and that, even in the moderate alternative, their growth is projected to be only average. Physicists in particular are affected severely, with a projected decrease of 20 percent due to their heavy involvement in the type of research that would be curtailed in the low growth alternative. Meteorologists and all other physical scientists, a group that includes new specialties, are the only physical science occupations projected to grow in the low alternative.

In the high alternative, the employment of physical scientists grows by 48 percent from 1990 to 2005, more than double the growth rate in the moderate alternative. Of all the scientific, engineering, and technical occupational groups, physical scientists in the high alternative are projected to have a larger employment increase than their counterpart in the moderate alternative projection. This rapid growth, of course, is due to their heavy involvement in R&D. Physicists, a group that decreased 20 percent in the low alternative, are projected to do much better in the high alternative, growing 31 percent. Chemists and the occupational grouping of geologists, geophysicists, and oceanographers, both of which would experience decreased numbers under the assumptions used in the low alternative, are projected to have rapid growth in the high alternative. Chemists are expected to increase their numbers by 45 percent, and geologists, geophysicists, and oceanographers are projected to grow by 43 percent.

*Computer, mathematical, and operations research analysts.* In each of the alternatives, computer and mathematically related occupations are projected to grow faster than all other scientific, engineering, and technical occupations. In the regular BLS moderate alternative, the employment of computer, mathematical, and operations research analysts is expected to grow very rapidly, from 571,000 to 987,000, or 73 percent. This rapid growth would be due mainly to the extremely rapid growth expected for computer systems analysts and operations research analysts, which are projected to be among the 10 fastest growing occupations in the economy. In contrast, mathematicians and statisticians are expected to grow more slowly in numbers than the average in this alternative.

The general slowing of employment growth in the low alternative is less for computer, mathematical, and operations research analysts than for other scientific, engineering, and technical occupation groups because of the lower involvement of computer, mathematical, and operations research analysts in R&D and the higher involvement of these workers in activities related to general economic and demographic conditions. Despite the overall slowing of employment growth, this group is still projected to grow rapidly, by 46 percent, chiefly by virtue of the rapid employment growth of systems analysts and operations research analysts.

In the high alternative, computer, mathematical, and operations research analysts as a group are projected to almost double their employment. This is due mainly to the extremely rapid employment growth of systems analysts and computer scientists, fueled more by the economic and demographic assumptions underlying the high alternative than by R&D expenditures. Mathematicians and all other mathematical scientists, however, are projected to grow by only 29 percent—a respectable growth rate, but not in the class of their less research-oriented occupational relatives.

*Social scientists.* The employment growth of social scientists varies much less among the alternatives than that of other scientific, engineering, and technical groups. In the low alternative, the growth rate is only about 10 percentage points lower, and in the high alternative about 10 percentage points higher, than the 43-percent growth in the regular BLS moderate alternative. This is both because a relatively small proportion of social scientists are employed in the types of research that are assumed to be curtailed under this alternative and because their employment is less affected by broad economic conditions than are many other occupations. In each alternative, the employment growth of social scientists is above the average for the economy, due mainly to very rapid employment growth projected for psychologists. Accounting for more than half of all social scientists in 1990, psychologists are the only social scientists whose employment is projected to grow faster than the total employment in all three alternatives.

*Technicians.* Technicians are the most numerous of the scientific, engineering, and technical occupational groups, with an employment of more than 2.6 million in 1990. In general, employment among technicians is expected to roughly parallel that of their related scientific and engineering professional occupations. For example, the employment of engineering technicians is projected to grow at about the same rate as that of engineers, while the employment of science technicians is projected to grow at about the same rate as that of life and physical scientists. Employment among computer programmers, although projected to grow more slowly than that among systems analysts and computer scientists, is nevertheless expected to grow faster than employment in other occupations in the technician group in each alternative.

In the regular BLS moderate alternative, technicians are projected to increase in number from 2.6 million to 3.5 million, or 32 percent. This rate of growth is higher than that of total employment but slightly lower than the average for all scientific, engineering, and technical occupations. Computer programmers lead the technician group, with a projected employment growth of 56 percent from 1990 to 2005. Drafters are projected to grow in number by only 13 percent, more slowly than average, as their employment is affected profoundly by technological change in the form of computer-assisted drafting systems.

In the low scientific, engineering, and technical alternative, the employment of technicians (except computer programmers) is curtailed drastically, compared with the projected growth in this occupation in the regular BLS moderate scenario. Both engineering technicians and science and mathematics technicians are projected to have little change in employment over the 1990–2005 period. Employment among computer programmers is expected to grow much faster than the average in this alternative because computer programmers have relatively little direct involvement in R&D, but their growth rate, 37 percent, is still less than the very strong growth projected for the occupation in the moderate alternative.

In the high scientific, engineering, and technical alternative, the employment of technicians is projected to grow at a rapid 55-percent pace. Engineering technicians, especially in the field of electrical engineering, will benefit from the expanded R&D assumed under this alternative. As in the low alternative, computer programmers are projected to have the greatest employment growth (72 percent) of all technicians.

*Engineering and science teachers.* Employment statistics on college and university teachers of science, engineering, and related technical subjects are not identified separately from such statistics on all other college and university teachers in the data system used to make BLS projections. However, these workers comprise an important segment of the demand for scientists and engineers, especially for those having graduate training.

The employment of teachers of science, engineering, and related technical subjects in colleges and universities would likely vary among the alternatives. In the assumptions underlying the projections, total college enrollment would not vary much among the regular alternatives prepared by BLS. However, enrollment in science and engineering curriculums would likely be higher in the high alternative and lower in the low alternative than it would be in the regular BLS moderate alternative, as changes in market demand influence the choices of fields of study of college students. Additional research is needed to develop the BLS projections so that they can disaggregate science and engineering teachers from all college and university teachers and include statistics on them in estimates of employment growth among scientific and technical workers.

## Supply-and-demand analysis

Analysis of the future supply of workers in occupations requiring a college education is a very complex undertaking. Not only does it have to account for changes in the population of college age and trends in college enrollment rates, but also, it must explain the choices of fields of study among students. Enrollments in fields of study reflect current and prospective supply and demand among occupations. However, they often are also influenced by non-economic factors, such as concern with the environment and social needs. Therefore, conclusions about future supply and demand are tenuous at best. Nevertheless, some insights into possible labor market conditions can be gleaned by using historical relationships among key factors that are the determinants of supply among occupations.

Population projections indicate that the size of the college-aged population will decline at least through 1998, before beginning an increase as the children born to the baby-boom generation reach college age. Further, the proportion of 22-year-olds obtaining natural science, engineering, and mathematics and computer science degrees has remained relatively constant over time. The question arises as to whether job openings due to replacement needs and projected employment growth will outpace the current levels of degree production.[9] The analysis presented next addresses the question of whether the number of natural science and engineering degrees earned by the population of 22-year-olds in the United States will be adequate to fill the future demand for scientists, engineers, and technicians. The analysis cannot be considered definitive, because it does not examine all determinants of supply, but it does deal with alternative scenarios for both supply and demand.

In 1990, about 5 percent of the U.S. 22-year-old population received degrees in science and engineering, down slightly from a high of 5.2 percent in 1987. About 200,000 degrees were granted annually, on average, in science and engineering from 1984 through 1990. Because the number of 22-year-olds is projected to decline until the end of the 1990's (see table 4), an assumption that 5 percent of the 22-year-old population will receive degrees in science and engineering from 1990 to 2005 implies that the number of degrees awarded in science and engineering will decline to an annual average of about 182,000 over that period. For purposes of comparison, an assumption that 6 percent of 22-year-olds will receive science and engineering degrees from 1990–2005 yields an annual average of 219,000 such degrees awarded during the period, and an assumption that 4 percent of 22-year-olds will receive science and engineering degrees from 1990–2005 yields an annual average of 146,000 such degrees awarded during the period.

The employment projections developed in this article indicate that annual openings due to employment growth for engineers, physical scientists, life scientists, and mathematics and computer scientists[10] over the 1990–2005 period will range from 16,000 in the low alternative to 104,000 in the high alternative, with 61,000 the figure for the regular BLS moderate alternative. However, there will be additional job openings for scientists and engineers to replace those who move to other occupations or who die or retire. Recently developed BLS data on replacement needs indicate that about 51,000 net openings will be created in engineering, natural science, and computer and mathematical science occupations due to replacement needs.[11] Therefore, over the projection period, job openings in these occupations would average 68,000 in the low alternative, 112,000 in the regular BLS moderate alternative, and 155,000 in the high alternative. These figures compare with 121,000 job openings in science and engineering occupations due to growth and replacement needs during the period 1984–90.

Table 4. **Population of 22-year-olds and number of technical degrees[1] awarded, actual 1970-89, estimated 1990, and projected to 2005**

| Year | Population of 22-year-olds[2] | Technical degrees awarded | Percent of 22-year-olds awarded technical degrees |
|---|---|---|---|
| 1970 . . . | 3,495,000 | 144,477 | 4.1 |
| 1971 . . . | 3,510,000 | 145,703 | 4.2 |
| 1972 . . . | 3,511,000 | 147,624 | 4.2 |
| 1973 . . . | 3,655,000 | 154,866 | 4.2 |
| 1974 . . . | 3,757,000 | 159,613 | 4.2 |
| 1975 . . . | 3,863,000 | 157,056 | 4.1 |
| 1976 . . . | 3,970,000 | 159,723 | 4.0 |
| 1977 . . . | 4,056,000 | 163,400 | 4.0 |
| 1978 . . . | 4,119,000 | 167,649 | 4.1 |
| 1979 . . . | 4,285,000 | 172,838 | 4.0 |
| 1980 . . . | 4,315,000 | 177,204 | 4.1 |
| 1981 . . . | 4,311,000 | 182,735 | 4.2 |
| 1982 . . . | 4,300,000 | 189,343 | 4.4 |
| 1983 . . . | 4,370,000 | 196,927 | 4.5 |
| 1984 . . . | 4,282,000 | 205,680 | 4.8 |
| 1985 . . . | 4,213,000 | 213,918 | 5.1 |
| 1986 . . . | 4,152,000 | 213,971 | 5.2 |
| 1987 . . . | 3,981,000 | 207,628 | 5.2 |
| 1988 . . . | 3,771,000 | 193,521 | 5.1 |
| 1989 . . . | 3,671,000 | 183,557 | 5.0 |
| Estimated: | | | |
| 1990 . . . | 3,641,000 | 182,031 | 5.0 |
| Projected: | | | |
| 1991 . . . | 3,716,000 | 185,820 | 5.0 |
| 1992 . . . | 3,805,000 | 190,245 | 5.0 |
| 1993 . . . | 3,882,000 | 194,076 | 5.0 |
| 1994 . . . | 3,588,000 | 179,412 | 5.0 |
| 1995 . . . | 3,411,000 | 170,534 | 5.0 |
| 1996 . . . | 3,338,000 | 166,924 | 5.0 |
| 1997 . . . | 3,415,000 | 170,765 | 5.0 |
| 1998 . . . | 3,369,000 | 168,436 | 5.0 |
| 1999 . . . | 3,517,000 | 175,870 | 5.0 |
| 2000 . . . | 3,549,000 | 177,450 | 5.0 |
| 2001 . . . | 3,659,000 | 182,960 | 5.0 |
| 2002 . . . | 3,788,000 | 189,410 | 5.0 |
| 2003 . . . | 3,849,000 | 192,446 | 5.0 |
| 2004 . . . | 3,898,000 | 194,902 | 5.0 |
| 2005 . . . | 3,921,000 | 196,040 | 5.0 |

[1] Includes degrees in the natural sciences, engineering, mathematics, and computer science.

[2] Rounded to nearest thousand.

Not all students granted degrees in science and engineering actually enter the field. A large proportion of those receiving bachelor's degrees in natural science become teachers or enter medical or dental school, and despite high entry rates of engineering graduates into engineering jobs, some do not enter engineering for a variety of reasons. Therefore, simple comparisons of projected degrees with estimates of job openings cannot be used to identify supply and demand imbalances. However, comparisons of the differences between degrees awarded and job openings in a past period with these same variables projected into the future can provide some indication about how past features of supply and demand compare with similar features that can be anticipated to exist in the future.

From 1984 to 1990, there were about 79,000 annual job openings due to employment growth, based on data in the Bureau's industry-occupational matrix. This was a time of generally high demand for scientists and engineers, although there was a softening in demand toward the end of the period. For the same period, annual replacement needs are estimated by BLS to have been 42,000, indicating that job openings over the period averaged about 121,000 annually. Because, on average, there were 200,000 degrees in science and engineering granted annually over the period, the ratio of degrees to job openings for the period was about 1.6 to 1. Another way of viewing the data would be to note that, on average, 79,000 of these graduates annually did not enter science and engineering occupations. Some were aliens who returned to their country. Many were bachelor's degree recipients who delayed entry into the field until receiving advanced degrees, but their numbers would have been about offset by entrants with advanced degrees who received their bachelor's degrees before 1984.

These data are compared with data on projected openings due to growth and replacement and on projected degrees for the 1990–2005 period under the low, regular BLS moderate,

Table 5. **Bachelor's degrees versus job openings in natural science, engineering, mathematics, and computer science, 1990–2005**

| Percent of 22-year-olds receiving degrees in the field | Employment growth alternative | | |
|---|---|---|---|
| | Low | Moderate | High |
| | Ratio of bachelor's degrees to job openings | | |
| 6 | 3.2 | 1.9 | 1.4 |
| 5 | 2.7 | 1.6 | 1.2 |
| 4 | 2.2 | 1.3 | .9 |
| | Difference between bachelor's degrees and job openings (thousands) | | |
| 6 | 151 | 107 | 64 |
| 5 | 114 | 70 | 27 |
| 4 | 78 | 34 | -9 |

and high growth alternatives in table 5. Notice that, in the moderate growth alternative, for 5 percent of 22-year-olds obtaining degrees in science and engineering, the ratio of degrees awarded to job openings and the difference between job openings and degrees awarded are very similar to the figures for these same quantities for the 1984–90 period. This implies that the levels of supply and demand for the period 1990–2005 are projected to be similar to the levels that prevailed during 1984–90 under the moderate growth alternative and the 5-percent supply assumption.

If the high growth scenario prevails, either a much higher proportion of those who receive degrees in science and engineering would need to enter the field, or more degrees in science and engineering would need to be granted. To approximate the levels of supply and demand existing in the 1984–90 period under the high alternative, slightly more than 6 percent of 22-year-olds would have to receive degrees in science and engineering. Although this figure is higher than has ever been reached, it could be attained if trends from the 1970's and 1980's continue into the 1990's. (See table 4.)

Under the low growth alternative, there probably would be an oversupply of scientists and engineers if the proportion of 22-year-olds earning degrees in technical fields remained at 5 percent. However, if the proportion continued downward to below 4 percent, supply and demand would not be significantly different than during the 1984–90 period. Although the proportion of 22-year-olds receiving degrees in science and engineering has headed downward recently, it is likely that it will not go as low as 4 percent without a period of poor employment prospects occurring to discourage enough students from entering the field.

## Summary

In general, the analysis presented in this article has indicated that, for the period 1990–2005, supply and demand could approximate the levels existing in the late 1980's, assuming reasonable adjustments to supply under the high or low growth alternatives. However, the analysis also shows that supply-and-demand imbalances are possible under each of the alternatives advanced.

It should be emphasized that the analysis presented covers the very broad area of natural science and engineering. Individual science and engineering occupations are not examined, and they could be affected differently. Nor is the special case of potential shortages of Ph.D.'s examined. Such issues cannot be addressed currently with available data. The analysis presented also does not address potential college faculty shortages, an area that has received much attention. Furthermore, the analysis does not address questions about the quality of new science and engineering graduates or the decline in the availability of technically trained workers for a variety of nonprofessional occupations, from mechanics to health technicians. □

## Footnotes

[1] Scientists include life scientists, physical scientists, social scientists, and mathematical, computer, and operations research analysts. Technicians include engineering and science technicians and computer programmers. The detailed occupations in each group are listed in table 3, as are the detailed engineering specialties. Engineering and science managers were also included in the analysis.

[2] Details on the methodology used to develop the projections will be published in *Outlook: 1990–2005*, Bulletin 2402 (Bureau of Labor Statistics, forthcoming).

[3] Industries covered in the national industry-occupation matrix were used in the analysis. Most are three-digit industries within the Standard Industrial Classification (SIC).

[4] An industry-occupation matrix is the basic analytical tool used to develop occupational employment projections. For information on how a current and projected matrix is developed, see *Outlook:1990–2005*.

[5] National Science Foundation, *National Patterns of R&D Resources: 1990*, NSF 90–316 (National Science Foundation, 1990).

[6] National Science Foundation, *Science and Technology Resources in U.S. Industry*, NSF 88–321 (National Science Foundation, 1989).

[7] The OES survey is the primary source of employment data used to develop the national industry-occupation

matrix. For information about this survey, see *Handbook of Methods*, Bulletin 2285 (Bureau of Labor Statistics, 1988).

[8] See also *Monthly Labor Review*, November 1991. The entire issue is devoted to projections.

[9] See R. C. Atkinson, "Supply and Demand for Scientists and Engineers: A National Crisis in the Making," *Science*, Apr. 27, 1990, pp. 425–32; and National Science Foundation, *Future Scarcities of Scientists and Engineers: Problems and Solutions*, working draft, April 25, 1989.

[10] For the purposes of this discussion, the term "science and engineering" includes the natural sciences, mathematics, computer science, and engineering. The number of degrees earned in these fields is taken from National Science Foundation, "Science and Engineering Degrees, 1966–89, a Source Book," NSF 91–314 (National Science Foundation, 1991). Because data were not yet available on science and engineering degrees earned in 1990, this figure was estimated by assuming that 5 percent of 22-year-olds would earn such degrees in 1990.

[11] For this article, net occupational replacement rates were developed that eliminate replacement needs for movements within scientific, engineering, and technical occupations. For further information on replacement needs, see Alan Eck, "Improved estimates of future occupational replacement needs," *Monthly Labor Review*, November 1991, pp. 95–102.

### A note on communications

The *Monthly Labor Review* welcomes communications that supplement, challenge, or expand on research published in its pages. To be considered for publication, communications should be factual and analytical, not polemical in tone. Communications should be addressed to the Editor-in-Chief, *Monthly Labor Review*, Bureau of Labor Statistics, U.S. Department of Labor, Washington, DC 20212.