High technology employment: another view

A novel definition of high technology yields some interesting statistics on employment, pay, and projected growth in this vital component of American industry

Paul Hadlock,
Daniel Hecker,
and
Joseph Gannon

Employment opportunities in high technology industries have been a source of interest among economists for many years. However, notions of what makes an industry high technology vary widely, making analyses of industry and occupational changes difficult. This article presents one method by which high technology industries can be identified and discusses employment in these industries.

One often-used definition of high technology limits the term to the aerospace, computer, and telecommunications industries. This is perhaps the most popular use of the locution. Another definition describes high technology industries as those "that are engaged in the design, development, and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technical knowledge."[1] Still another uses research and development (R&D) expenditures as a percentage of industry value added and industry employment of scientists, engineers, and technicians as a porportion of the industry work force.[2] In 1983, BLS analysts introduced three measures of high tech employment—utilization of technology-oriented workers, expenditures for R&D, and utilization of technology-oriented workers and R&D expenditures combined.[3] The following analysis, by contrast, presents a definition of "high technology" based on an industry's percentage of R&D employment, which is defined as the number of workers who spend the *majority* of their time in R&D, as determined by their employer. Hence, we define a high technology industry as one with a significant concentration of R&D employment.

Data on R&D employment are derived from the Bureau of Labor Statistics Occupational Employment Statistics (OES) program, which provides current occupational employment data on wage and salary workers by industry.[4] This program follows a 3-year survey cycle: manufacturing industries and hospitals are surveyed in the first year; mining, construction, finance, and service industries in the second; and trade, transportation, communications, public utilities, education, and government services industries in the third. However, only manufacturing industries and selected nonmanufacturing industries are surveyed for R&D employment. The data used in this study were collected in 1987, 1988, and 1989 and are based on industries classified at the three-digit level in the 1987 edition of the *Standard Industrial Classification (SIC) Manual.*

Using the OES data, we identify industries as high technology if their proportion of R&D employment is at least equal to the average proportion for all industries. The industries that meet this criterion are then divided into two groups: If an industry's proportion of R&D employment is at least 50 percent higher than the average proportion for all industries surveyed, it is a Level I, or R&D-intensive, industry; all other such industries are from the Level II, or R&D-moderate, group. Classifications based on these criteria resulted in 30 Level I industries and 10 Level II industries.

While defining industries on the basis of the proportion of their employment in R&D is a proxy measurement of high technology, the use of occupational employment data at specific industry levels is a unique refinement that yields

Paul Hadlock is an economist in the Division of Occupational and Administrative Statistics and Daniel Hecker is an economist in the Division of Occupational Outlook, Bureau of Labor Statistics. Joseph Gannon is a science research analyst with the National Science Foundation.

results that are in line with popularly held expectations. The industries classified as high technology in this analysis are ranked according to their percentage of R&D employment. (See table 1.) Of the top five industries with the highest percentage of R&D employment, four are part of chemical manufacturing (SIC 28). Other top-ranked high tech manufacturing industries include guided missiles, space vehicles, and parts manufacturing; petroleum refining; and computer and office equipment manufacturing. Level I high technology manufacturing industries also include many of the instruments and related products industries (SIC 38), including search and navigation equipment, measuring and control devices, medical instruments and supplies, and photographic equipment and supplies.

Research and testing services and computer and data-processing services are the highest ranked service-related high tech industries. Engineering and architectural services, miscellaneous services, and management and public relations services are also classified as high technology service industries.

Table 1. **High technology industry employment and average pay, total and by level, 1989**

SIC code	Industry	Total high tech employment	Percent research and development employment	Average annual pay
	Total	10,012,500	100.0	$34,626
	Level I industries:[1]	8,666,900	86.6	35,597
131	Crude petroleum and natural gas operations	193,100	1.9	45,822
211	Cigarettes	38,400	.4	46,273
281	Industrial inorganic chemicals	134,100	1.3	39,611
282	Plastics materials and synthetics	183,200	1.8	38,432
283	Drugs	231,300	2.3	39,986
284	Soap, cleaners, and toilet goods	159,900	1.6	32,781
285	Paints and allied products	63,100	.6	30,536
286	Industrial organic chemicals	149,000	1.5	43,519
287	Agricultural chemicals	52,500	.5	33,167
289	Miscellaneous chemical products	100,200	1.0	33,101
291	Petroleum refining	118,500	1.2	43,452
299	Miscellaneous petroleum and coal products	11,900	.1	30,758
335	Nonferrous rolling and drawing	176,700	1.8	31,462
355	Special industry machinery	161,900	1.6	30,388
357	Computer and office equipment	455,000	4.5	40,409
362	Electrical industrial apparatus	177,100	1.8	27,028
366	Communications equipment	270,600	2.7	24,238
367	Electronic components and accessories	614,000	6.1	29,387
371	Motor vehicles and equipment	847,100	8.5	37,191
372	Aircraft and parts	708,600	7.1	37,216
376	Guided missiles, space vehicles, parts	195,000	1.9	39,540
381	Search and navigation equipment	302,500	3.0	38,491
382	Measuring and controlling devices	331,100	3.3	30,940
384	Medical instruments and supplies	238,800	2.4	28,836
386	Photographic equipment and supplies	104,300	1.0	40,755
737	Computer and data-processing services	732,700	7.3	35,787
871	Engineering and architectural services	774,900	7.7	35,438
873	Research and testing services	528,600	5.3	32,088
874	Management and public relations	577,200	5.8	35,280
899	Services, n.e.c.[2]	35,600	.4	41,649
	Level II industries:[1]	1,345,700	13.4	28,373
229	Miscellaneous textile goods	52,100	.5	23,035
261	Pulp mills	16,800	.2	39,800
267	Miscellaneous converted paper products	240,100	2.4	27,697
348	Ordnance and accessories, n.e.c.[2]	75,100	.8	29,766
351	Engines and turbines	90,800	.9	36,549
356	General industrial machinery	243,300	2.4	29,223
359	Industrial machines, n.e.c.[2]	321,700	3.2	26,303
365	Household audio and video equipment	87,200	.9	28,595
369	Miscellaneous electrical equipment and supplies	170,700	1.7	28,315
379	Miscellaneous transportation equipment	47,900	.5	25,278

[1] See text for definition of Level I and Level II industries.
[2] n.e.c. = not elsewhere classified.

Employment and pay

The OES program collected data on R&D for specific managerial, professional, paraprofessional, and technical occupations. Engineering, mathematical, and natural sciences managers account for most of the R&D employment in managerial and administrative occupations. Among professional occupations, engineers, physical and life scientists, and computer scientists and related occupations, as well as various health professional specialties, have the heaviest concentrations of R&D employment. Engineering and science technicians also are employed in R&D in significant numbers in high tech industries.

Although 24 of the 30 Level I high tech industries are manufacturing industries, the six nonmanufacturing industries in the Level I group (20 percent of the total) represent 32.8 percent of total employment. Computer-related industries accounted for a significant portion of that figure. Fully 21 percent of all Level I industry employment is attributed to computer and office equipment manufacturing, computer and data-processing services, and electronic components and accessories (semiconductors) manufacturing industries. Motor vehicles and equipment manufacturing and aircraft and parts manufacturing together accounted for 18 percent of Level I high tech industry employment.

Annual pay. Total employment in high tech industries is not that large in relation to the entire economy, but these industries show an *above-average* annual pay level. Examining average annual pay for 1989, derived from wage data for workers covered by unemployment insurance programs, one can discern a strong relationship between higher pay and the degree of technological development activity of an industry.[5] In 1989, the average annual pay per employee for all industries, excluding government and education, was $22,302; employees in Level I averaged $35,597, while Level II employees averaged $28,373.

Those high tech industries with the highest average annual pay were cigarette manufacturing, crude petroleum and natural gas operations, industrial organic chemicals manufacturing, and petroleum refining. In the petroleum and chemicals industries, concentrations of highly paid engineering staff, together with specialized technical support personnel, are factors in the high average pay in these industries. The high average pay in the relatively small cigarette manufacturing industry can be attributed in part to an increased percentage of professional and technical workers in the industry. This increase stems in part from the introduction of more automation in the industry, resulting in a decreasing number of lower paying jobs.

Table 2. **Regional distribution of employment in high technology industries, 1989**

Region and level	High technology employment[1]	Percent of all employment in region	Percent of all high technology employment
United States			
Level I	8,666,900	9.8	.....
Level II	1,345,600	1.5	.....
Levels I and II	10,012,500	11.3	100.00
Northeast[2]			
Level I	2,000,300	10.4	.....
Level II	304,100	1.6	.....
Levels I and II	2,304,400	12.0	23.0
Midwest[3]			
Level I	2,110,400	9.7	.....
Level II	506,000	2.3	.....
Levels I and II	2,616,400	12.0	26.1
South[4]			
Level I	2,472,700	8.6	.....
Level II	350,900	1.2	.....
Levels I and II	2,823,600	9.8	28.2
West[5]			
Level I	2,083,500	11.2	.....
Level II	184,700	1.0	.....
Levels I and II	2,268,200	12.2	22.7

[1] Excludes government and education industry employment.

[2] Northeast—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont.

[3] Midwest—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin.

[4] South—Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia.

[5] West—Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.

NOTE: See text for explanation of Level I and Level II employment.

Area distributions

Level I and Level II high tech industries comprised only 11.3 percent of total nongovernment and noneducation employment in 1989. The concentration of employment in these industries varies little regionally, ranging from 12.2 percent in the West to 9.8 percent in the South. (See table 2.) The Northeast and Midwest regions both have 12.0 percent of their employment in these industries.

Although the South has the lowest percentage of all regions of high tech industry employment (as defined here) relative to the total work force, it has the largest proportion of national high tech employment; that is, 28.2 percent of all workers employed in high tech industries are in the South. The Midwest region employs 26.1 percent of all high tech industry workers. The Northeast, popularly viewed as a bastion of high technology, ranks third with 23.0 percent, and the West

Table 3. **Percentage of States' work force employed in high technology industries and States' percentage of total employment in high technology industries, 1989**

State	Percent in high technology employment	Percent of U.S. high technology employment
New England		
Connecticut	16.0	2.3
Maine	6.4	.3
Massachusetts	16.3	4.2
New Hampshire	15.5	.7
Rhode Island	8.5	.3
Vermont	11.7	.2
Mid-Atlantic		
New Jersey	13.6	4.2
New York	10.2	6.7
Pennsylvania	10.0	4.2
East North Central		
Illinois	10.4	4.5
Indiana	13.7	2.8
Michigan	16.7	5.4
Ohio	12.5	5.0
Wisconsin	10.1	1.9
West North Central		
Iowa	7.8	.7
Kansas	12.7	1.1
Minnesota	12.3	2.1
Missouri	11.0	2.1
Nebraska	7.5	.4
North Dakota	3.6	.1
South Dakota	5.0	.1
East South Central		
Alabama	9.6	1.2
Kentucky	9.2	1.0
Mississippi	7.2	.5
Tennessee	10.0	1.8
South Atlantic		
Delaware	19.7	.6
District of Columbia	13.0	.5
Florida	7.1	3.1
Georgia	7.9	1.9
Maryland	10.6	1.8
North Carolina	9.8	2.5
South Carolina	10.6	1.3
Virginia	11.0	2.5
West Virginia	7.8	.4
West South Central		
Arkansas	8.3	.6
Louisiana	9.1	1.1
Oklahoma	11.9	1.0
Texas	11.9	6.5
Mountain		
Arizona	11.3	1.4
Colorado	12.5	1.5
Idaho	8.9	.3
Montana	3.3	.1
Nevada	4.9	.2
New Mexico	11.1	.5
Utah	11.9	.6
Wyoming	5.8	.1
Pacific		
Alaska	7.1	.1
California	13.6	14.8
Hawaii	2.6	.1
Oregon	7.6	.7
Washington	13.8	2.3

accounts for 22.7 percent of total high tech industry employment. Employment data show little dispersion among the regions, with 2.3 million high technology workers in the West being the low figure and 2.8 million in the South the high figure.

Among the States, Delaware, with significant chemical industry employment, has the highest percentage of its work force employed in high tech industries—19.7 percent. Michigan ranks second with 16.7 percent, due to a concentration in automobile manufacturing and other major manufacturing industries. The next three States in order are located in New England: Massachusetts, Connecticut, and New Hampshire. The States with the lowest percentages of their work force employed in high tech industry are located in the West North Central, Mountain, and Pacific regions. They are, in order, from the lowest percentage up: Hawaii, Montana, North Dakota, Nevada, and South Dakota.[6] (See table 3.)

California employs 14.8 percent of the Nation's high tech industry workers, more than twice the proportion of any other State. Following California are New York, Texas, Michigan, and Ohio. Unlike the other States, Texas is not known as an industrial manufacturing giant; however, its overall size and its concentration of petroleum-refining and crude petroleum and natural gas exploration industries, along with aircraft, electronics, and chemicals manufacturing, give it its place among the leading States in high technology employment.

Trends, 1988–2000

High tech industries constituted a relatively small proportion of wage and salary employment in the economy in 1988—7.1 percent for Level I and 8.4 percent for Levels I and II combined. In comparison, the earlier BLS analysis reported that employment in high technology industries in 1982 ranged from 2.8 percent to 13.4 percent.[7]

Every other year, the Bureau of Labor Statistics develops projections of employment growth. The latest projections present low-, medium-, and high-growth scenarios from 1988 to the year 2000.[8] Perhaps surprisingly, as a group, high technology industries are projected to grow more *slowly* than the average for all industries in the low- and medium-growth scenarios. In the high-growth scenario, Level I industries are projected

Table 4. **High technology industry employment, 1988 and projected to 2000**

Level[1]	1988	2000			Percent change		
		Low growth	Medium growth	High growth	Low growth	Medium growth	High growth
Total employment (thousands)	118,104	127,118	136,211	144,136	7.6	15.3	22.0
Level I:							
Number (thousands)	8,332	8,649	9,476	10,487	3.8	13.7	25.9
Percent	7.1	6.8	7.0	7.3	.....	.....	.....
Level II:							
Number (thousands)	1,561	1,329	1,473	1,583	-14.9	-5.6	1.4
Percent	1.3	1.0	1.1	1.1	.....	.....	.....
Levels I and II:							
Number (thousands)	9,893	9,978	10,949	12,069	.9	10.7	22.0
Percent	8.4	7.8	8.0	8.4	.....	.....	.....

[1]See text for explanation of Level I and Level II employment.

to grow more rapidly than the average for all industries, and Levels I and II combined are projected to increase at the same rate as the average. (See table 4.)

A projection of relatively slow growth for the high technology industries in, for example, the medium-growth scenario is not surprising upon closer examination. High tech industries are primarily manufacturing industries (24 of 30 in Level I, and all in Level II), and total manufacturing employment in the economy is projected to decline slightly in the medium-growth scenario. Output in manufacturing is expected to grow 31 percent in this scenario, as fast as output in the economy as a whole, but large increases in productivity will keep total employment from growing.

Even among Level I industries, the manufacturing industries' employment as a whole is projected to decline slightly in the medium-growth scenario, just as is total manufacturing. All growth in Level I (and in Levels I and II combined) is attributed to the service industries, which are projected to grow 50 percent. □

Footnotes

ACKNOWLEDGMENT: The authors thank Ken Lavish of the Division of Industrial Prices and Price Indexes and Richard Riche of the Division of Industry Productivity and Technology Studies, Bureau of Labor Statistics, for their assistance in the preparation and editing of this article.

[1] From *Technology, Innovation, and Regional Economic Development* (Washington, U.S. Congress, Office of Technology Assessment, Sept. 9, 1982), a 14-page report that assesses the implications of high technology in order to promote the development of high tech industries in States and other areas.

[2] Michael Boretsky, "Concerns About the Present American Position in International Trade," *Technology and International Trade* (Washington, National Academy of Sciences, 1971).

[3] Richard W. Riche, Daniel E. Hecker, and John U. Burgan, "High technology today and tomorrow: a small slice of the employment pie," *Monthly Labor Review*, November 1983, pp. 50–58.

[4] For more information about the Occupational Employment Statistics program, see *BLS Handbook of Methods*, Bulletin 2285 (Bureau of Labor Statistics, 1988), pp. 28–30.

[5] Annual pay data are compiled from reports submitted by employers under unemployment insurance programs covering 107 million full- and part-time workers. Average annual pay is computed by dividing the total annual payrolls of employees covered by unemployment insurance programs by the average monthly employment of these employees. See *Employment and Wages, Annual Averages, 1989*, Bulletin 2373 (Bureau of Labor Statistics, 1990), pp. 531–32, and *BLS Handbook of Methods*, pp. 35–40.

[6] State data were compiled from the Covered Employment and Wages Program, which collects information on the employment and wages of workers covered by unemployment insurance programs. Each quarter, covered employers submit mandatory reports of employment and wages to the appropriate State Employment Security Agency. These reports, supplemented by multiple worksite reports for employers engaged in a variety of activities, are edited and summarized by county, State, and detailed industry and forwarded to the Bureau of Labor Statistics. Self-employed persons are not included.

[7] Riche, Hecker, and Burgan, "High technology today and tomorrow," p. 53.

[8] For more details on industry employment projections in particular, see Valerie A. Personick, "Industry output and employment: a slower trend for the nineties," *Monthly Labor Review*, November 1989, pp. 25–41.