High-technology employment: a broader view

High technology employment, 14 percent of total employment, is projected to grow much faster than in the past due to employment gains in high-tech services and among suppliers to computer and electronic components manufacturers

Daniel Hecker

High technology enjoys high visibility. Industry developments are tracked closely in the United States and abroad and the implications for productivity, international competitiveness, national defense, and the general standard of living are of increasing interest.[1] This statement, presented in a 1983 *Monthly Labor Review* article, is still true, as is clear from a number of recent pronouncements. For example, according to the testimony of Alan Greenspan, Chairman of the Federal Reserve Board, dramatic improvements in computing power and communication and information technology are resulting in higher rates of productivity growth and higher real wages, and are helping to control costs.[2] Also, a 1998 National Science Foundation report describes the success of U.S. high-tech industries in foreign markets.[3] Other recent publications report that biotechnology is revolutionizing medicine, agriculture, and environmental fields; miniaturization and new materials are likely to bring major changes in manufacturing, and automobiles are incorporating even more advanced technology.[4] These developments, which suggest that high technology is creating many jobs in the economy, prompted this review of employment trends.

Three previously published articles in the *Review* presented definitions of high-technology industries and occupations and analyzed employment trends and projections.[5] Based on current data, this article updates the lists of high-tech industries used in those articles. It also uses an expanded concept of high-tech employment consisting of three categories. The first category, similar to the earlier concept used by the Bureau of Labor Statistics, includes all employment in industries defined as high technology. The second category includes employment in non-high-tech industries, generated by the purchases of goods and services by high-tech industries for use as inputs to their production processes. This high-tech-generated employment is included because it, like employment in high-tech industries, is derived from the demand for the goods and services produced by high-tech industries.

The third category is an effort to account for the substantial high-tech activity in industries that do not qualify, based on generally accepted criteria, as high tech, or are not suppliers to high-tech industries. While it is not possible to identify all employment in high-tech activities, it is possible to count employment of all scientists, engineers, and technicians–workers who create and apply new technologies–regardless of their industry of employment. This category, therefore, includes all scientists, engineers, and technicians in non-high-tech industries, except for those already included because of employment generated by purchases of high-tech industries.[6]

Based on this concept, this article identifies the number of workers employed in high-tech activities in 1996. It also shows high-technology employment in 1986, its projections for 2006, and its growth over the 1986–96 and 1996–2006 periods. Because high tech is often depicted as a source of "good jobs," information also is presented on earnings in high-tech industries and occupations. Much of the data in the analysis is based on information developed by BLS in producing the 1996–2006 employment projections. Those projections are published in a series

Daniel Hecker is an economist in the Office of Employment Projections, Bureau of Labor Statistics.

of articles in the November 1997 *Monthly Labor Review.*[7]

Definitions and data

The term "high tech" is used very broadly to describe not only industries, but also occupations and products. There is fairly wide agreement on the general characteristics of high-technology industries and the criteria for developing lists of such industries. A good example is a document from the Congressional Office of Technology Assessment.[8] It describes high-technology firms as those "that are engaged in the design, development, and introduction of new products and innovative manufacturing processes, or both, through the systematic application of scientific and technical knowledge." This document also points out that high-technology firms typically use state-of-the-art techniques, and, in terms of quantifiable resources, such firms devote a "high" proportion of expenditures to research and development and employ a "high" proportion of scientific, technical, and engineering personnel. A National Science Foundation report on science and technology resources also refers to the employment of scientists, engineers, and technicians and measures of research and development activities as "two of the most important parameters of innovation," and uses them "as surrogates for measuring the broader concept of innovation."[9]

Despite general agreement on the concepts of high tech, there is no general acceptance of precisely which industries to include, because identifying "new" products or "innovative" manufacturing processes and associated industries is very subjective. One approach, adopted by the Bureau of the Census, uses the judgment of industry analysts to identify products embodying new or leading-edge technologies falling within 10 advanced technology areas.[10] A more widely used approach has been to list high-tech industries based on two broad measures of resources used—employment of scientific and technical personnel and research and development intensity. In this approach, studies specify criteria for these measures, such as a specific percent of total employment in scientific and technical occupations and research and development spending, or both, as a percent of sales or value added. Industries that meet those criteria are identified as high tech.[11] This article uses the latter procedure. It uses data on the proportion of employment in an industry accounted for by scientific, technical, and engineering personnel and on the proportion of employment in an industry accounted for by scientific, technical, and engineering personnel engaged in research and development.[12]

Identifying high-tech employment

High-technology occupations are scientific, technical, and engineering occupations, the same group of occupations used to define high-tech industries. They include the following occupational groups and detailed occupations: engineers; life and physical scientists; mathematical specialists; engineering and science technicians; computer specialists; and engineering, scientific, and computer managers. Individuals who are employed in these occupations are collectively referred to as technology-oriented workers.[13] Workers in these occupations need in-depth knowledge of the theories and principles of science, engineering, and mathematics, which is generally acquired through specialized post-high school education in some field of technology—ranging from an associate degree to a doctorate. Some technology-oriented workers engage in research and development to increase scientific knowledge, or to develop products and production processes. Other technology-oriented workers apply technology in other work activities, such as in design of equipment, processes, and structures; computer applications and systems development; sales, purchasing, and marketing; productions and operations; and management and administration.[14]

Occupational Employment Statistics survey data were used in the analysis. This survey provides data on occupational employment of wage and salary workers by industry. It covers all industries except agriculture (minus agricultural services which are covered), forestry, fishing, private households, and the Federal Government. The survey also provided data on occupational employment of workers in research and development for all occupations defined in this article as technology oriented, plus communication, transportation, and utilities operations managers; industrial production mangers; all other managers and administrators; social scientists; most health occupations; and the residual category all other professional, paraprofessional, and technician occupations. These data were collected for mining, construction, manufacturing, communications, public utilities, education, health, and some other service industries. Data are from 1993, 1994, and 1995 Occupational Employment Statistics surveys.[15] Estimates for most industries are for the three-digit industry group level in the 1987 edition of the *Standard Industrial Classification Manual*.[16]

For this analysis, industries are considered high tech if employment in both research and development and in all technology-oriented occupations accounted for a proportion of employment that was at least twice the average for all industries in the Occupational Employment Statistics survey. (Industries with employment of less than 30,000 were excluded from the analysis because of their small size and because data are not available to calculate employment generated by their purchases). Twenty-nine industries, 25 in manufacturing and 4 in the services division, met both criteria.[17] (See table 1.) These industries have at least 6 research and development workers per thousand workers and 76 technology-oriented workers per thousand workers. A subset of 10 high-tech industries, those with both ratios at least 5 times the average, are referred to as high-tech intensive industries. These indus-

Table 1. High technology employment, 1986, 1996, and 2006

(Employment in thousands)

SIC	Industry	Employment			Employment change				Median annual wage in 1997[1]
					Number		Percent		
		1986	1996	2006	1986–1996	1996–2006	1986–1996	1996–2006	
...	Total nonfarm wage and salary employment	98,727	118,731	136,318	20,004	17,587	20	15	$22,734
....	Total high technology	14,482	16,366	21,528	1,884	5,162	13	32	—
	High-technology industries	8,563	9,307	11,431	744	2,124	9	23	—
	High-technology intensive industries	4,433	4,549	6,055	116	1,506	3	33	—
281,6	Industrial chemicals	290	263	261	–27	–2	–9	–1	[2]40,976
283	Drugs	208	259	319	51	60	25	23	31,886
357	Computer and office equipment	469	363	314	–106	–49	–23	–13	37,960
366	Communications equipment	296	269	255	–27	–14	–9	–5	29,494
367	Electronic components and accessories	610	610	700	0	90	0	15	26,187
372,6	Aerospace[3]	855	550	596	–305	46	–36	8	[4]38,292
381	Search and navigation equipment[3]	349	161	110	–188	–51	–54	–32	42,661
382	Measuring and controlling devices	312	297	265	–15	–32	–5	–11	30,306
737	Computer and data processing services	588	1,208	2,509	620	1,301	105	108	40,602
873	Research, development, and testing services	456	569	726	113	157	25	28	34,882
	Other high-technology industries	4,130	4,758	5,376	628	618	15	13	—
282	Plastics materials and synthetics	168	159	145	–9	–14	–5	–9	34,320
284	Soaps, cleaners, and toilet goods	146	154	157	8	3	5	2	26,998
285	Paint and allied products	63	53	52	–10	–1	–16	–2	28,350
287	Agricultural chemicals	54	52	52	–2	0	–4	0	31,824
289	Miscellaneous chemical products	93	93	84	0	–9	0	–10	29,661
291	Petroleum refining	131	100	80	–31	–20	–24	–20	43,202
348	Ordnance and accessories[3]	76	48	42	–28	–6	–37	–12	27,248
351	Engines and turbines	99	84	73	–15	–11	–15	–13	32,885
353	Construction and related machinery	224	232	247	8	15	4	6	27,248
355	Special industrial machinery	150	177	175	27	–2	18	–1	30,472
356	General industrial machinery	234	257	250	23	–7	10	–3	28,392
361	Electric distribution equipment	103	82	68	–21	–14	–20	–17	24,315
362	Electrical industrial apparatus	182	156	122	–26	–34	–14	–22	23,941
365	Household audio and video equipment	82	83	73	1	–10	1	–12	23,546
371	Motor vehicles and equipment	872	963	929	91	–34	10	–4	36,878
384	Medical equipment, instruments, and supplies	213	268	310	55	42	26	16	26,562
386	Photographic equipment and supplies	114	85	65	–29	–20	–25	–24	31,658
871	Engineering and architectural services	681	839	1,052	158	213	23	25	38.210
874	Management and public relations services	445	873	1,400	428	527	96	60	31,970
…	Employment in non-high technology industries generated by purchases of high-technology industries	4,004	4,856	7,488	852	2,632	21	54	—
…	Employment in technology-oriented occupations, but not in high-tech industries or in generated employment	1,915	2,203	2,609	288	406	15	18	—

[1] Wage data are for all industries except agriculture (minus agricultural services which are covered) and the Federal Government. Annual rates are hourly rates times 2,080 hours.

[2] Data shown are for SIC 286. Earnings in SIC 376 were $37,419.

[3] In 1987, the year defense spending reached a post-Viet Nam War high, more than half of employment was defense-related.

[4] Data shown are for SIC 372. Earnings in SIC 376 were $43,680.

NOTE: Dash indicates data not calculated.

tries have at least 15 research and development workers per thousand workers and 190 technology-oriented workers per thousand workers.

Employment in some high-tech industries is very dependent on defense spending. In ordnance and accessories, search and navigation equipment, and aerospace manufacturing, defense-related employment was more than half the total in 1987—the year defense spending reached a post-Vietnam War

high.[18] In this article, these three industries are referred to as highly defense-related industries.

Data on employment generated by purchases of high-tech industries from supplying industries was developed using the Bureau's input-output model. This model provides information on the purchase of commodities by each industry as inputs to its production process. These inputs include raw materials and parts and components that are transformed or physically incorporated into final high-tech products, as well as supplies and services. The employment data generated by the model include not just suppliers to high-tech industries, but their suppliers as well, through subsequent tiers in the production process. Data for the BLS model were derived from 1987 input-output benchmark estimates. Purchase patterns were projected to 1996 and to 2006.

Employment in 1996

High-tech employment accounted for 16.4 million wage and salary worker jobs in 1996 or about 14 percent of all wage and salary jobs in the economy. (See table 1.) High-tech industries employed 9.3 million workers, 4.5 million of them in high-tech intensive industries. Employment of 4.9 million workers was generated in non-high-tech industries to produce the goods and services purchased by high-tech industries. (High-tech industries also made purchases from each other, but the employment generated by those purchases is already included in the 9.3 million in high-tech industries.)[19] An additional 2.2 million technology-oriented workers were employed outside of high-tech industries or their suppliers.

High-tech industries. About 5.8 million (or 63 percent) of the 9.3 million jobs in high-tech industries were in manufacturing industries in 1996. High-tech intensive industries accounted for 2.8 million jobs in manufacturing. High-tech manufacturing industries accounted for nearly one-third of all manufacturing employment in 1996. High-tech service industries made up a much smaller proportion of employment in the services division, 10 percent.[20] High-tech employment is fairly concentrated, with the largest 5 of the 29 high-tech industries accounting for 4.5 million high-tech industry jobs, nearly half of the total. The following tabulation shows those five industries and their employment totals:

Largest high-tech industries	*Employment*
Computer and data processing services	1,208,000
Motor vehicles and equipment manufacturing	963,000
Management and public relations services	873,000
Engineering and architectural services	839,000
Electronic components and accessories manufacturing	610,000

Table 2. Employment in non-high-technology industries generated by purchases of high-technology industries, by largest suppliers, 1986, 1996, and 2006

(Employment in thousands)

Industry	1986		1996			2006		Percent change	
	Employment	Rank	Employment	Rank	Percent distribution	Employment	Rank	1986–1996	1996–2006
Total generated by high-tech industries	4,004	...	4,856	...	100.0	7,488	...	21	5
Wholesale trade	707	1	889	1	18.3	1,209	1	26	36
Miscellaneous business services	157	2	246	2	5.1	440	3	57	79
Personnel supply services	73	12	238	3	4.9	550	2	225	131
Trucking and warehousing	138	3	192	4	3.9	309	6	39	62
Miscellaneous plastics products, n.e.c.	132	4	189	5	3.9	347	4	43	84
Eating and drinking places	109	8	186	6	3.8	319	5	70	72
Metal forgings and stampings	131	5	138	7	2.8	116	13	6	–16
Retail trade, except eating and drinking places	62	15	128	8	2.6	176	8	106	37
Industrial machinery, n.e.c.	118	6	113	9	2.3	81	22	–4	–28
Air transportation	45	30	88	10	1.8	161	9	96	83
Hotels and other lodging places	60	16	86	11	1.8	216	7	43	151
Communications	82	9	82	12	1.7	102	16	–1	25
Accounting, auditing, and other services	65	14	81	13	1.7	137	11	26	69
Depository institutions	80	10	77	14	1.6	157	10	-3	103
Metal coating, engraving, and allied services	55	20	76	15	1.6	102	15	39	35
Blast furnaces and basic steel products	78	22	75	16	1.5	69	27	–5	–7
Fabricated structural metal products	47	29	69	17	1.4	96	19	49	39
Crude petroleum, natural gas, and gas liquids	110	7	69	18	1.4	48	39	–38	–30
Commercial printing and business forms	65	13	68	19	1.4	98	17	5	45
Iron and steel foundries	58	18	63	20	1.3	71	26	9	13
All other industries	1,633	…	1,702	…	35.1	2,682	…	2	52

NOTE: n.e.c. = not elsewhere classified.

Table 3. Output in high technology industries, 1986, 1996, and 2006

(Output in billions of 1992 dollars[1])

SIC	Industry	Output			Output change			
					Number		Percent	
		1986	1996	2006	1986–96	1996–06	1986–1996	1996–2006
...	All nonfarm industries	9,167	11,789	15,252	2,622	3,463	29	29
...	High-tech industries	1,281	1,988	3,231	707	1,243	55	63
...	High-tech intensive industries	512	913	1,915	401	1,002	78	110
281,6	Industrial chemicals	87	89	102	2	13	2	15
283	Drugs	49	74	98	25	24	51	32
357	Computer and office equipment	26	159	636	133	477	512	300
366	Communication equipment	37	63	101	26	38	70	60
367	Electronic components and accessories	38	141	285	103	144	271	102
372,6	Aerospace[2]	113	94	120	–19	26	–17	28
381	Search and navigation equipment[2]	41	28	31	–13	3	–32	11
382	Measuring and controlling devices	27	43	55	16	12	59	28
737	Computer and data processing services	66	166	403	100	237	152	143
873	Research and testing services	28	56	84	28	28	100	50
	Other high-tech industries	769	1,075	1,316	306	241	40	22
282	Plastic materials and synthetics	40	57	64	17	7	43	12
284	Soaps, cleaners, and toilet goods	36	39	49	3	10	8	26
285	Paint and allied products	14	16	19	2	3	14	19
287	Agricultural chemicals	13	19	24	6	5	46	26
289	Miscellaneous chemical products	18	22	24	4	2	22	9
291	Petroleum refining	125	156	204	31	48	25	31
348	Ordnance and accessories, n.e.c.[2]	8	5	5	–3	0	–37	0
351	Engines and turbines	17	21	26	4	5	24	24
353	Construction and related machinery	29	39	56	10	17	34	44
355	Special industry machinery	17	31	34	14	3	82	10
356	General industrial machinery	28	37	42	9	5	32	14
361	Electric distribution equipment	10	12	11	2	–1	20	-8
362	Electrical industrial apparatus	17	25	27	8	2	47	8
365	Household audio and video equipment	12	15	20	3	5	25	33
371	Motor vehicles and equipment	219	320	372	101	52	46	16
384	Medical instruments and supplies	23	42	59	19	17	83	40
386	Photographic equipment and supplies	19	22	25	3	3	16	14
871	Engineering and architectural services	70	91	119	21	28	30	31
874	Management and public relations services	54	106	136	52	30	96	28

[1] Chained 1992 dollars. See James C. Franklin, "Industry output and employment projections to 2006," *Monthly Labor Review*, November 1997, pp. 39–57.

[2] In 1987, the year defense spending reached a post-Viet Nam War high, more than half of employment was defense-related.

NOTE: n.e.c. = not elsewhere classified.

Non-high-tech industries. About 18 percent of the 4.9 million jobs *generated by purchases of high-tech industries* were in the wholesale trade industry. (See table 2.) This industry includes not just independent merchant wholesalers, but also sales branches and offices operated by manufacturers who market their products in establishments apart from their plants.[21] Other industries with large numbers of jobs generated by high-tech industries include the personnel supply services (primarily temporary help supply services), miscellaneous business services, and trucking and warehousing industries. Miscellaneous plastics products ranks high, largely because of purchases by the motor vehicle and equipment, computer and office equipment, and electronic components industries. Metal forging and stampings and the industrial machinery (not elsewhere classified) manufacturing industries rank high, largely because of purchases by the motor vehicle and equipment manufacturing industry and the machinery industries.

Technology-oriented workers. Of the 2.2 million technology-oriented workers employed outside of high-tech industries or their suppliers, about 630,000 were employed in Government (excluding State and local education). The Federal Government accounted for about half of this number, 312, 000. Other industries with large numbers of technology-oriented workers include wholesale trade, 180,000; public and private education, 139,000; and personnel supply services, 94,000.

Employment trends, 1986, 1996 and 2006

High-tech employment increased 13 percent, compared with 20 percent for the economy as a whole over the 1986–96 period. This accounted for 9 percent of total employment growth. (See table 1.) During this period, high-tech employment declined from 14.7 percent to 13.8 percent of total employment. Projections for the 1996–2006 period show high-tech and related employment growing more than twice as fast as employ-

ment in the economy as a whole (32 percent, compared with 15 percent). For the same period, high-tech employment is expected to account for 29 percent of all projected growth. In 2006, high-tech employment is projected to account for 15.8 percent of total employment.

From 1986 to 1996, employment in the 29 high-tech industries grew slower (9 percent) than total employment growth (20 percent).[22] However, over the 1996–2000 period, these industries are projected to increase faster (23 percent), despite the slowing of total employment growth (15 percent). The 10 high-tech intensive industries, which grew only 3 percent from 1986 to 1996, are projected to grow by 33 percent.

Employment generated by purchases of high-tech industries has and is projected to continue to grow faster than employment in the high-tech industries. Employment generated by purchases of the 29 industries increased by 21 percent from 1986 to 1996. It is projected to grow by 54 percent over the 1996–2006 period. Employment of technology-oriented workers not included in the industry data increased by 15 percent from 1986–96 and is projected to increase by 18 percent from 1996 to 2006.[23]

High-tech industries. Almost all growth in high-tech industries is in the four service division industries that are considered to be high-tech. Employment in computer and data processing services and management and public relations services roughly doubled from 1986 to 1996. Over the 1996–2006 period, computer and data processing services is projected to double again, while management and public relations services is projected to grow by 60 percent. (See table 1.) The other two high-tech service industries—research, development, and testing laboratories and engineering and architectural services—also have and are projected to grow faster than overall employment in the economy.

Cuts in defense spending over the 1986–96 period caused employment in some high-tech manufacturing industries to decline, and retarded growth in other industries.[24] The three most highly defense-related non-Federal industries in the economy—aerospace, navigation and guidance instruments, and ordnance and accessories manufacturing—had a combined loss of 521,00 jobs, or a 41-percent decline. The other 26 high-tech industries grew 17 percent. Defense is expected to decline much less over the 1996–2006 period.

Except for the three highly defense-related industries, employment in high-tech manufacturing industries, as a group, declined 1 percent over the 1986–96 period and a 1-percent decline also is projected over the 1996–2006 period. Employment in most of the 25 high-tech manufacturing industries has and is projected to decline, and this is the pattern in most manufacturing industries. Noteworthy is the decline in computer and office equipment manufacturing, "an industry that many regard as having *begun* the 'high tech revolution' of the 1970s and 1980s."[25] The only high-tech manufacturing industries with employment growth faster than that for the economy overall are health-related drugs and medical equipment, instruments, and supplies.[26]

Non-high-tech industries. Employment *generated by purchases of the high-tech industries* has grown and is projected to grow much faster than that in the high-tech industries, themselves. Such employment makes up roughly half of all high-tech job growth. Most generated employment growth, both past and projected, is caused by the purchases of just two industries—computer and office equipment and electronic components and accessories manufacturing. These industries accounted for 57 percent of growth generated by high-tech industries between 1986 and 1996 and 88 percent of projected 1996–2006 growth. Purchases grow rapidly to support the several-fold increase in computer and office equipment and in electronic component and accessories output. (See table 3.) Most supplying industries, such as wholesale trade and miscellaneous business services, have relatively modest improvements in labor productivity, so rapid growth in output to supply the computer and components industries results in rapid employment growth. For the other 27 high-tech industries combined, output growth is about the same as that for the total economy, and the employment they generate grows slower than the average for the total economy.

Table 4. Median annual wages of wage and salary workers in selected technology-oriented occupations, 1997

Occupation	Median wages
All occupations	$22,734
Engineering, mathematical, and natural sciences managers	72,675
Electrical and electronics engineers	59,155
Mechanical engineers	50,606
Computer engineers	58,386
Systems analysts, electronic data processing	49,899
Operations and systems researchers and analysts, except computer	49,795
Biological scientists	43,701
Chemists	43,971
Geologists, geophysicists and oceanographers	52,395
Computer support specialists	35,895
Electrical and electronic engineering technicians and technologists	34,237
Chemical technicians and technologists	29,994

NOTE: Data are for all industries except agriculture (minus agricultural services which are covered) and the Federal Government. Annual rates are hourly rates times 2,080 hours.

SOURCE: Occupational Employment Statistics Survey.

High tech, high pay

A number of studies have stated that high-tech jobs are well paid.[27] It clearly is the case for the industries and occupations in this study. Median wages in every high-tech industry in 1997 exceed the median for all industries. (See table 1.) In

Table 5. Varying definitions of high technology

(X indicates included in definition)

SIC	Industry	BLS studies of high technology							Other studies of high technology			
		A broader view, 1999		Another view, 1991		Today and tomorrow, 1983			Emerging digital economy II, 1999	Cyber states 3.0, 1999	Science and engineering indicators, 1998	High tech America, 1986
		High-tech	High-tech intensive	Levels I and II	Level I	Group I	Group II	Group III				
		Selection criteria										
		R&D and technology-oriented employment		R&D employment		Tech-oriented employment	R&D spending	Both tech-oriented and R&D	Judgment	Judgment	R&D spending	Tech-oriented employment
...	Number of three-digit industries, 1987 SIC[1]	[2] 31	[2] 12	40	30	48	6	28	[3] 14	[3] 13	[4] 6	29
...	Industry coverage limits	none	none	none	none	none	manufacturing	none	digital	electronics	manufacturing	manufacturing
131	Crude petroleum and natural gas	...	...	X	X	X	...	...	...	...	...	...
162	Heavy construction, except highway	...	...	...	...	X	...	...	...	...	...	...
211	Cigarettes	([5])	...	X	X	...	...	...	...	...	...	...
229	Miscellaneous textile goods	...	...	X	...	...	...	...	...	...	...	...
261	Pulp mills	([5])	...	X	...	...	...	...	...	...	...	...
267	Miscellaneous converted paper products	...	...	X	...	...	...	...	...	...	...	...
281	Industrial inorganic chemicals[2]	X	X	X	X	X	...	X	...	...	...	X
282	Plastics materials and synthetics	X	...	X	X	X	...	X	...	...	...	X
283	Drugs	X	X	X	X	X	X	X	...	...	X	X
284	Soap, cleaners, and toilet goods	X	...	X	X	X	...	X	...	...	...	X
285	Paints and allied products	X	...	X	X	X	...	X	...	...	...	X
286	Industrial organic chemicals	X	X	X	X	X	...	X	...	...	...	X
287	Agricultural chemicals	X	...	X	X	X	...	X	...	...	...	X
289	Miscellaneous chemical products	X	...	X	X	X	...	X	...	...	...	X
291	Petroleum refining	X	...	X	X	X	...	X	...	...	...	X
299	Miscellaneous petroleum and coal products	...	...	X	X	...	...	...	...	...	...	...
301	Tires and inner tubes	...	...	...	...	X	...	...	...	...	...	...
303	Reclaimed rubber[6]	...	...	...	...	...	...	...	...	...	...	X
324	Cement, hydraulic	...	...	...	...	X	...	...	...	...	...	...
335	Nonferrous rolling and drawing	...	...	X	X	...	...	...	...	...	....	...
348	Ordnance and accessories, n.e.c.	X	...	X	...	...	...	X	...	...	...	X
351	Engines and turbines	X	...	X	...	X	...	X	...	...	...	X
352	Farm and garden machinery	...	...	...	...	X	...	....	...	...	...	...
353	Construction and related machinery	X	...	...	...	X	...	...	...	...	...	X
354	Metalworking machinery	...	...	...	...	X	...	...	...	...	...	X
355	Special industry machinery	X	...	X	X	X	...	X	...	...	...	...
356	General industrial machinery	X	...	X	...	X	...	...	...	...	...	X

See footnotes at end of table.

Table 5. Continued–Varying definitions of high technology

(X indicates included in definition)

SIC	Industry	BLS studies of high technology							Other studies of high technology			
		A broader view, 1999		Another view, 1991		Today and tomorrow, 1983			Emerging digital economy, II, 1999	Cyber states 3.0, 1999	Science and engineering indicators 1998	High tech America, 1986
		High-tech	High-tech intensive	Level I and II	Level I	Group I	Group II	Group III				
		Selection criteria										
		R&D and technology-oriented employment		R&D employment		Tech-oriented employment	R&D spending	Both tech-oriented and R&D	Judgment	Judgment	R&D spending	Tech-oriented employment
357	Computer and office equipment	X	X	X	X	X	X	X	X	X	X	X
358	Refrigeration and service machinery	...	...	...	...	X	...	...	...	...	...	...
359	Industrial machinery, n.e.c.	...	...	X	...	...	...	...	...	...	...	...
361	Electric distribution equipment	X	...	...	...	X	...	X	...	...	...	X
362	Electrical industrial apparatus	X	...	X	X	X	...	X	...	...	...	X
363	Household appliances	...	...	...	...	X	...	...	...	...	...	...
364	Electric lighting and wiring equipment	...	...	...	...	X	...	...	...	...	...	...
365	Household audio and video equipment	X	...	X	...	X	...	X	X	X	...	X
366	Communications equipment	X	X	X	X	X	X	X	X	X	X	X
367	Electronic components and accessories	X	X	X	X	X	X	X	X	X	X	X
369	Miscellaneous electrical equipment	...	...	X	...	X	...	X	X	...	...	...
371	Motor vehicles and equipment	X	...	X	X	X	...	...	...	...	...	...
372	Aircraft and parts[2]	X	X	X	X	X	X	X	...	...	X	X
374	Railroad equipment	...	...	...	...	...	...	...	...	...	...	X
376	Guided missiles, space vehicles	X	X	X	X	X	X	X	...	...	X	X
379	Miscellaneous transportation equipment	...	...	X	...	...	...	...	...	...	...	...
381	Search and navigation equipment	X	X	X	X	X	...	X	...	X	...	X
382	Measuring and controlling devices	X	X	X	X	X	...	X	X	X	...	X
383	Optical instruments and lenses[7]	...	...	...	...	X	...	X	...	...	...	...
384	Medical instruments and supplies	X	...	X	X	X	...	X	...	X	...	X
386	Photographic equipment and supplies	X	...	X	X	X	...	X	...	X	...	X
481	Telephone communications	...	...	...	...	...	...	...	X	X	...	...
482	Telegraph and other communications	...	...	...	...	...	...	...	X	X	...	...
483	Radio and television broadcasting	...	...	...	...	X	...	...	X	...	...	...
484	Cable and other pay TV services	...	...	...	...	...	...	...	X	X	...	...
489	Communications services, n.e.c.	([5])	...	...	...	X	...	...	X	X	...	...
491	Electric services	...	...	...	...	X	...	...	...	...	...	...
493	Combination utility services	...	...	...	...	X	...	...	...	...	...	...
504	Wholesale professional and commercial equipment[8]	...	...	...	...	X	...	...	X	...	...	...

See footnotes at end of table.

Table 5. Continued–Varying definitions of high technology

(X indicates included in definition)

SIC	Industry	BLS studies of high technology							Other studies of high technology			
		A broader view, 1999		Another view, 1991		Today and tomorrow, 1983			Emerging digital economy II, 1999	Cyber states 3.0, 1999	Science and engineering indicators, 1998	High tech America, 1986
		High-tech	High-tech intensive	Levels I and II	Level I	Group I	Group II	Group III				
		Selection criteria										
		R&D and technology-oriented employment		R&D employment		Tech-oriented employment	R&D employment	Both tech-oriented and R&D	Judgment	Judgment	R&D spending	Tech-oriented employment
506	Wholesale electrical goods	...	...	...	...	X	...	...	...	...	...	...
508	Wholesale machinery, equipment, and supplies	...	...	...	...	X	...	...	...	...	...	...
573	Radio, television, and computer stores	...	...	...	...	...	...	...	X	...	...	...
737	Computer and data processing services	X	X	X	X	X	...	X	X	X	...	...
871	Engineering and architectural services	X	...	X	X	X	...	...	...	...	...	...
873	Research and testing services	X	X	X	X	X	...	X	...	...	...	...
874	Management and public relations	X	...	X	X	...	...	...	...	...	...	...
89	Services, n.e.c.	...	...	X	X	X	...	...	...	...	...	...

[1] Studies prior to 1987 used the 1977 SIC system.

[2] This study combines SICs 281 and 286 (Industrial chemicals) and SICs 372 and 376 (Aerospace).

[3] Identified industries at the 4-digit SIC, and may not include all constituent 4-digit SICs.

[4] The Organisation for Economic Co-operation and Development industries, on which the definition is based, may not correspond exactly to SIC industries. OECD combines SICs 372 and 376 (Aerospace) and SIC 366 and 367 (Electronics-communications).

[5] Met the criteria for high technology, but excluded because of small size and because employment generated by purchases could not be determined.

[6] SIC 303 appears in the 1977 SIC only; in the 1987 SIC, it is part of SIC 306, Miscellaneous rubber products, n.e.c.

[7] This industry appears in the 1977 SIC system only. In the 1987 SIC, it is part of SIC 384.

[8] In the 1977 SIC, it was part of SIC 508, Wholesale machinery, equipment, and supplies.

n.e.c. = not elsewhere classified.

10 of the industries (6 within high-tech intensive), wages were more than 50 percent higher than the median for all industries. However, industries with the lowest wages, such as SIC 365, Household audio and video equipment and SIC 362, Electrical industrial apparatus were not much higher. Median wages in 7 out of the 12 technology-oriented occupations shown in table 4 were more than twice the median for all occupations and even for chemical technicians and technologists, the lowest paid, the median was about a third higher.[28]

Data issues

Quality. Standard sources of employment and related data were used to identify and analyze high-tech employment in this article. Nevertheless, these data sources have many deficiencies when used in this manner. For example, ratios of scientific and technical employment to total employment used to measure technologic intensity in an industry were derived from the Occupational Employment Statistics survey. This survey collects data on employment of technology-oriented workers and on research and development workers primarily for three-digit industry groups. Therefore, these selection criteria provide a measure of average intensity for three-digit industry groups. However, industries identified as high tech may have establishments employing few research and development workers or other technology-oriented workers and fall short of the ratios used as cutoff points. These establishments also may produce low-tech products. For example, the high-tech industry, Computer and office equipment manufacturing (SIC 357) includes Office machines, not elsewhere classified (SIC 3579), which has establishments primarily producing low-tech products, such as paper cutters, pencil sharpeners, and staple removers, and it most likely employs few technology-oriented workers.

Conversely, industries not identified as high tech may have establishments that individually do meet the high-tech crite-

ria. Obvious cases are Government research and development laboratories, college and university research and development laboratories, and personnel supply firms specializing in technology-oriented workers. None of these are separately identified in the Occupational Employment Statistics survey. However, as indicated earlier, the inclusion of all technology-oriented workers within high-tech employment, regardless of industry, at least captures the key technology-oriented workers in these activities.

Judgment. In addition to data quality issues, clearly there are judgmental issues that have a bearing on the analysis of high-tech employment. For example, as indicated earlier, the proportion of employment in technology-oriented occupations that was used as the cut off for defining high-tech industries is very subjective. Using only scientific and technical occupations as technology-oriented occupations to include in high-tech employment also is somewhat subjective. A contention could be made to include many other occupations involved in repairing or operating the products of high-tech industries. Although these workers usually require a more limited knowledge of technology than do scientific and technical workers, their work may have more technologic content than many workers employed in high-tech industries. In 1996, an estimated 2.4 million workers not included in the industry totals were employed in occupations that repair products produced by high-tech industries. Half of the workers repaired the output of the motor vehicle and parts manufacturing industry. Other workers, such as aircraft pilots, telephone operators, and radiologic technologists and technicians operated the output of high-tech industries as their primary duty. Workers selling high-tech products also are related logically to high tech, but available data do not permit a count of them.

Comparison with other analyses

The industries meeting the definition of high tech in this study are very similar to those in previous BLS analyses and, like the other BLS analyses, are more inclusive than most other studies. (See table 5, pages 24–26.) The 1983 BLS analysis developed three high-tech industry lists based on different definitions.[29] One was based on employment of technology-oriented workers as a proportion of total employment, another was based on the ratio of research and development expenditures to net sales, and the other combined the two criteria. The 1991 BLS analysis used data on research and development employment, then newly available from the Occupational Employment Statistics survey.[30] More recently, the National Science Foundation used a definition from the Organisation for Economic Co-operation and Development (OECD) which was based solely on an industry's research and development spending to value added.[31] OECD experimented with various other criteria for that study, including employment of all scientific and technical personnel, but because of the absence of data for some countries, it did not use any other criteria, and the coverage was limited to manufacturing industries. Another study, published in 1986, also covered only manufacturing industries.[32] In that analysis, employment of all technology-oriented workers was the only criteria used to define an industry as high tech. One analysis by the American Electronic Association in 1999, and another, prepared by the U.S. Department of Commerce in 1999, relied on judgment to identify high-tech industries, rather than statistical measures of technologic intensity derived from survey data.[33]

THE LIST OF 29 HIGH-TECH INDUSTRIES used in this study is similar to lists in other BLS studies. Using the most inclusive list in the 1983 study would identify high-tech industry employment in 1996 at 13.3 million, and using the more inclusive list in the 1991 study, would put employment at 10.2 million. This compares with 9.3 million for the 29 high-tech industries in this study. The 1983 study-definition is 3.9 million higher and the 1991 study is 0.9 million higher than the definition of high-tech industries in this study. The 1983 study-definition includes several wholesale trade industries, which had 2.1 million workers in 1996. These industries include establishments that sell the output of high-tech manufacturers. In addition, 812,000 were in communications and utilities industries, 534,000 were in heavy construction, and some were in smaller industries. However, the 1983 study does not include management and public relations services or ordnance and accessories. The 1991 definition counts 240,000 high-tech workers in miscellaneous converted paper products, 168,000 in nonferrous rolling and drawing, and 153,000 in miscellaneous electrical equipment, however, it does not include construction machinery or electrical distribution equipment. □

Notes

[1] 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, p. 50.

[2] Monetary Policy Testimony and Report to Congress, Testimony of Alan Greenspan, Chairman, Board of Governors of the Federal Reserve System Before the Subcommittee on Domestic and International Monetary Policy of the Committee on Banking and Financial Services, U.S. House of Representatives, Feb. 24, 1998.

[3] "Industry, Technology, and Competitiveness in the Marketplace," *Science and Engineering Indicators* (Arlington, VA, National Science Board, National Science Foundation, 1998), ch. 6, and Lawrence M. Rausch, "High-tech drives global economic activity," *National Science Foundation Issues Brief*, NSF 98–319 (Arlington, VA, Division of Science Resources Studies, July 20, 1998).

[4] See *U.S. Industry and Trade Outlook* (DRI/McGraw-Hill, Standard and Poor's and U.S. Department of Commerce/International Trade Adminis-

tration, 1999), pp. 11–13 through 11–15, 16–1, and ch. 36; "John Carey, "We Are Now Starting the Century of Biology," and Neil Gross and Otis Port "The Next Wave for Technology," *Business Week*, Aug. 24–31, 1998, pp. 80–87; David Stipp, "Engineering the future of food," *Fortune*, Sept. 28, 1998, pp. 128–44; and Daniel McGinn and Adam Rogers, "Operation: Supercar," *Newsweek*, Nov. 23, 1998, pp. 48–53.

[5] Riche and others, "High technology today and tomorrow," pp. 50—58; Paul Hadlock, Daniel Hecker, and Joseph Gannon, "High technology employment: another view," *Monthly Labor Review*, July 1991, pp. 26–30; and William Luker, Jr. and Donald Lyons, "Employment shifts in high-technology industries, 1988–96," *Monthly Labor Review*, June 1997, pp. 12–25.

[6] High tech also has spill-over effects that benefit other commercial sectors and lead to productivity gains, business expansion, and creation of high wage jobs. See *Science and Engineering Indicators*, 1998, pp. 6–5.

[7] In *Monthly Labor Review*, see James C. Franklin, "Industry output and employment projections to 2006," pp. 39–57; and George T. Silvestri, "Occupational employment projections to 2006," November, 1997, pp. 57–83.

[8] *Technology, Innovation, and Regional Economic Development* (U.S. Congress, Office of Technology Assessment, Sept. 9, 1982).

[9] *Science and Technology Resources in U.S. Industry*, Special report NSF88–321 (Arlington, VA, National Science Foundation, December 1988), p.vii.

[10] The Bureau of the Census listed 10 advanced technology product areas to track and understand international trade. These areas are: biotechnology, life sciences technologies, opto-electronics, computers and telecommunications, electronics, computer-integrated manufacturing, materials design, aerospace, weapons, and nuclear technology. See *Science and Engineering Indicators*, 1998, pp. 6–12 and 6–13. However, no employment data are collected by product or product categories, so the employment associated with production of these products cannot be determined. The Organisation for Economic Co-operation and Development also has developed a list, see Thomas Hatzichronoglou, "Revision of the High-technology Sector and Product Classification," STI working papers (Paris, OECD, 1997), pp. 7–10. Also see Riche and others, "High technology today and tomorrow," pp. 50–53.

[11] Some, however, exclude service industries or industries with little employment.

[12] The category, research and development workers, is a subset of technology-oriented workers.

[13] See Riche and others, "High technology today and tomorrow," pp. 54–55, which also defined these occupations as technology-oriented. However, it did not include engineering, scientific and computer managers, an occupation not surveyed separately at that time.

[14] Data are not collected separately in BLS surveys for these categories, but are collected by the National Science Foundation. See the National Science Foundation website: **http://sestat.nsf.gov**

[15] Until 1996, the Occupational Employment Statistics program followed a 3-year cycle.

[16] *Standard Industrial Classification Manual, 1987* (Executive Office of the President, Office of Management and Budget).

[17] Excluded industries are SIC 211 Cigarettes, SIC 261 Pulp mills, and SIC 489 Communications services, not elsewhere classified. Two industries consist of two 3-digit SICs: Aerospace, which consists of SIC 372, aircraft and parts and SIC 376 Guided missiles and space vehicles; and Industrial chemicals, which consists of SIC 281, Inorganic and SIC 284, Organic. These were combined because the system used to provide employment generated by an industry's purchases cannot provide separate data.

[18] Allison Thomson, "Defense-related employment and spending, 1996–2006," *Monthly Labor Review*, July 1998, pp. 14–33.

[19] About 983,000 jobs were generated in high-tech industries by purchases from each other. The three largest suppliers were electronic components manufacturing (234,000 jobs generated), computer and data processing services (108,000 jobs), and management and public relations services (88,000 jobs).

[20] This division is part of the services-producing sector. No other divisions within the services-producing sector—trade, communications, utilities, transportation, finance, or government had high-tech industries.

[21] Industry data used in this article are collected on an establishment basis. An establishment is defined as an economic unit, such as a factory or office, generally at a single physical location, where business is conducted.

[22] High-tech industry growth from January 1988 to January 1996 is discussed in Luker and Lyons, "Employment shifts in high-technology industries," pp. 12–25, with some detail by 4-digit SIC industry.

[23] In all industries, technology-oriented workers grew 24 percent and are projected to grow 35 percent.

[24] See Thomson, "Defense-related employment and spending;" and Ron L. Hetrick, "Employment in high-tech defense industries in a post cold war era," *Monthly Labor Review*, August 1996, pp. 57–63, and Luker and Lyons, "Employment shifts in high technology industries."

[25] See Luker and Lyons, "Employment shifts in high technology industries," pp. 16 and 21. Employment trends in computer manufacturing are discussed in Jacqueline Warnke, "Computer manufacturing: change and competition," *Monthly Labor Review*, August 1996 pp. 18–29.

[26] Employment trends in drugs manufacturing are discussed in Stephen Heffler, "Drugs manufacturing: a prescription for jobs," *Monthly Labor Review*, March 1995 pp.12–22.

[27] See *Science and Engineering Indicators*, pp. 6–5 and 6–16; *Cyberstates 3.0* (Washington, DC, American Electronics Association, 1999), p. 7, and Hadlock, Hecker, and Gannon, pp. 27 and 28.

[28] Data are from the Occupational Employment Statistics Survey.

[29] Riche and others, "High technology today and tomorrow."

[30] Hadlock and others, "High technology employment: another view; Luker and Lyons used this definition."

[31] *Science and Engineering Indicators*, 1998; and Rausch, "High-tech drives global economic activity." Data, which are for all OECD countries, are presented in Hatzichronoglou, "Revision of the High-technology Sector."

[32] Ann Markusen, Peter Hall, and Amy Glasmeier, *High Tech America, the what, how, where, and why of the sunrise industries* (Boston, Allen and Unwin, 1986), pp. 14–15. It also used Occupational Employment Statistics data; research and development data were not then available from this survey.

[33] See *Cyberstates 3.0*, pp. 103–4; and *The Emerging Digital Economy II* (U.S. Department of Commerce, June 1999), p. 15.