High-technology employment: a NAICS-based update

Among high-technology industries—those with a high proportion of scientists, engineers, and technicians—some are projected to grow rapidly; overall, however, this group of industries is expected to continue to grow slowly

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High technology receives a great deal of attention due to its association with new products and new production processes and its implications for productivity, international competitiveness, overall economic growth, and the creation of well-paying jobs. Numerous studies have resulted in the publication of high-tech rankings of States and metropolitan areas, while State and local governments have established task forces to assess the potential of high technology to stimulate their economies and have developed strategies to lure high-technology firms.[1]

It is important to define the term *high tech(nology)*, both to assess the claims about its effect on the economy and to develop policies and programs. Four articles previously published in the *Review* presented definitions of high-technology industries and occupations and analyzed high-tech employment trends and projections.[2] Because there are a number of methods of identifying high-tech industries, the lists of such industries produced in the literature differ from one another. Using BLS data, this article presents one particular method, lists the resulting industries, discusses employment in those industries, and examines several other approaches. Along with describing employment in high-tech industries in 2002, the article considers employment in 1992, projected employment for 2012, and growth over the 1992–2002 and 2002–12 periods, as well as earnings in high-tech industries and occupations in 2004. The updated list of high-tech industries is based on the 2002 North American Industry Classification System (NAICS), which replaces the Standard Industrial Classification System (SIC) used in earlier articles. The article describes the criterion used to select the industries and, in the final section, examines other selection criteria that were suggested in a March 2004 interagency conference on defining high technology.

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Definitions and data

The term *high tech* has been used broadly to describe not only industries, but also occupations and products. A Congressional Office of Technology Assessment document describes high-technology firms as those "engaged in the design, development, and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technical knowledge."[3] The document also points out that high-technology firms typically use state-of-the-art techniques and, in terms of quantifiable resources, devote a "high" proportion of expenditures to research and development (R&D) 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 to measures of R&D activities as "two of the most important parameters of innovation" and uses those two parameters "as surrogates for measuring the broader concept of innovation."[4] Articles in the *Review*, as well as other sources, have used one or both of these input-based criteria to identify high-tech industries. Studies specify thresholds for

these measures, such as a percentage of total employment in science, engineering, and technician occupations or spending on R&D as a percentage of sales or value added. Industries that exceed these thresholds are identified as high tech.[5] Other studies rely on judgment, generally about output, to identify high-tech industries. For example, the American Electronic Association defines an industry as high tech if it was a "maker/creator of technology."[6] Using the judgment of industry analysts, the Census Bureau identifies high-tech products as those embodying new or leading-edge technologies.[7]

A March 2002 *Review* article by Christopher Kask and Edward Sieber points out that both input-based and output-based methods have advantages and drawbacks.[8] Input-based approaches rest on easily obtainable nonsubjective data, but in the absence of an obvious threshold above which an industry is deemed high tech, the resulting lists must be considered arbitrary. Furthermore, such methods suffer from a failure to take account of the products of an industry and may include industries with products not commonly thought of as high tech (although, of course, an industry using high-tech production methods might be considered high tech even if its output is not). In contrast to input-based definitions, output-based definitions tend to provide lists that match popular conceptions of high tech, but rely on judgments that smack of subjectivity.

In March 2004, the Bureau conducted an interagency seminar to evaluate its most recent methodology for defining high-tech industries, as described in a June 1999 review article.[9] The attendees concluded that many factors contribute to an industry's high-tech nature and that the Bureau should explore all of those factors, including the following:

- high proportion of scientists, engineers, and technicians (science, engineering, and technician occupation intensity), as defined in the Bureau's 1999 study;
- high proportion of R&D employment (R&D employment intensity), as defined in the Bureau's 1999 study;
- production of high-tech products, as specified on a Census Bureau list of advanced-technology products;
- use of high-tech production methods, including intense use of high-tech capital goods and services in the production process.

In addition, it was recommended that the relationship between high-tech industries and productivity growth, discussed in Kask and Sieber's article,[10] be explored for the NAICS-based list of industries.

Due to data and conceptual problems, only science, engineering, and technician occupation intensity was used to develop a list of industries in the analysis that follows. R&D employment intensity was not used, because the Occupational Employment Statistics (OES) survey no longer collects data on R&D employment and because National Science Foundation (NSF) R&D employment data, discussed later in this article, have only limited comparability to Bureau data. Had comparable R&D data been available, industries might have been considered high tech only if they met an R&D criterion as well. This was the approach used in the 1999 BLS study.[11] If better information had been available, other combinations of criteria, as well as alternative lists of high-tech industries, also would have been possible. However, all information available on the high-tech nature of industries, as well as on productivity growth, is tabulated and discussed in this article.

Defining high-technology employment

High-technology occupations are scientific, engineering, and technician occupations, the same group of occupations used to define high-tech industries in this and earlier studies. They include the following occupational groups and detailed occupations: computer and mathematical scientists, Standard Occupational Classification (SOC) 15-0000; engineers, SOC 17–2000; drafters, engineering, and mapping technicians, SOC 17–3000; life scientists, SOC 19–1000; physical scientists, SOC 19–2000; life, physical, and social science technicians, SOC 19–4000; computer and information systems managers, SOC 11–3020; engineering managers, SOC 11–9040; and natural sciences managers, SOC 11–9120. Workers in these occupations need an in-depth knowledge of the theories and principles of science, engineering, and mathematics underlying technology, a knowledge generally acquired through specialized post-high school education in some field of technology leading up to an award ranging from a vocational certificate or an associate's degree to a doctorate. Individuals employed in these occupations are collectively referred to as *technology-oriented workers.* Some technology-oriented workers are engaged in R&D, increasing scientific knowledge and using it to develop products and production processes; others apply technology in other activities, including the design of equipment, processes, and structures; computer applications; sales, purchasing, and marketing; quality management; and the management of these activities.[12]

Data for calculating industries' technology-oriented worker intensity are from the BLS National Employment Matrix, which shows occupational employment by four-digit NAICS industry for 2002.[13] The 2002 staffing patterns in the matrix are based on employment data from the 2000, 2001, and 2002 OES surveys, while earnings are from the May 2004 survey.[14] An industry is considered high tech if employment in technology-oriented occupations accounted for a proportion of that industry's total employment that was at least twice the 4.9-percent average for all industries. With this relatively low threshold, 46 four-digit NAICS industries are classified as high tech.[15] Within that group, three levels of high technology were specified. Level I

includes the 14 industries in which these occupations accounted for a proportion that was at least 5 times the average or greater and constituted 24.7 percent or more of industry employment. Level II includes the 12 industries in which the high-tech occupations were 3.0 to 4.9 times the average (constituting 14.8 percent to 24.7 percent of total employment), and Level III includes the 20 industries with a proportion that was 2.0 to 2.9 times the average (making up 9.8 percent to 14.7 percent of total employment).[16]

These high-tech industries are a heterogeneous group in terms of production processes and output, covering a broad range of industries. Level I includes the computer and electronic products, aerospace, and pharmaceutical and medicine manufacturing industries; the computer software, Internet, and data processing industries in the information sector; and three professional, scientific, and technical services industries, as shown in table 1. Levels I, II, and III combined cover all four-digit industries within computer and electronic products manufacturing (NAICS 334), as well as merchant wholesalers of professional and commercial equipment and supplies (a category that encompasses wholesalers of computers, software, and some electronic instruments). Levels I, II, and III combined also include all but one of the telecommunications industries within the information sector, four machinery-manufacturing industries, and all but one industry in chemical manufacturing.[17] Finally (but not exhausting the list), included as well are (1) four industries within professional, scientific, and technical services; (2) the Federal Government, except the Postal Service; (3) all three pipeline industries in NAICS 486; and (4) management of companies and enterprises, a category with no equivalent in the SIC.[18] Biotechnology and nanotechnology are not on the list of high-tech industries, because they are not identified as industries in the NAICS. Most biotech companies are located in scientific R&D services or pharmaceutical and medicine manufacturing industries, according to a recent Commerce Department survey.[19] No similar information has been found regarding nanotechnology.

Strictly defined, the preceding industries should be called industries that are technology-oriented-occupation intensive. However, data discussed later suggest that almost all Level-I industries are also R&D intensive and that some in Levels II and III may be as well. In addition, all Level-I goods-producing industries have some products defined as high tech by the Census Bureau, as do some Level-II industries. Because of this supporting evidence—and for brevity—the 46 industries on the list are referred to as high tech. Lists of industries based on criteria other than their proportion of technology-oriented occupations would differ from this one.[20]

Employment in 2002

High-tech industries accounted for 14.4 million wage and salary jobs in 2002, about 11 percent of total nonfarm wage and salary jobs in the economy.[21] (See table 1.) Level-I industries accounted for 5.9 million jobs, 4.5 percent of the total. Level-II industries accounted for 4.5 million jobs, 3.4 percent of the total, and Level-III industries accounted for 4 million jobs, 3.1 percent of the total. About 3.8 million (26 percent) of the 14.4 million jobs in high-tech industries in 2002 were in manufacturing. High-tech manufacturing industries made up nearly a quarter of all manufacturing employment that year. Level-I manufacturing industries accounted for 2.2 million jobs.

Employment trends, 1992, 2002, and 2012. Employment in high-tech industries increased 7.5 percent over the 1992–2002 period, compared with 19.7 percent for the economy as a whole, and accounted for 5 percent of total employment growth. (See table 1.) During the same period, high-tech employment declined from 12.2 percent to 11 percent of total employment. Projections for the 2002–12 period show high-tech employment continuing to grow more slowly than the economy overall, at 11.4 percent compared with 16.5 percent. By 2012, high-tech employment is projected to add 1.6 million jobs, about 8 percent of all projected growth, and account for 10.5 percent of total employment. Growth for Level-I industries, at 23.0 percent from 1992 to 2002 and projected at 15.6 percent from 2002 to 2012, is closer to the total for the economy. Employment change among the 46 high-tech industries varies widely. As the following tabulation shows, most projected growth is in eight service-providing industries, including five computer and related industries:

	Projected change in employment, 2002–12	
Industry	*Number (thousands)*	*Percent*
Computer systems design and related services	635	54.6
Management, scientific, and technical consulting services	406	55.4
Management of companies and enterprises	195	11.4
Software publishers	174	67.9
Merchant wholesalers of professional and commercial equipment and supplies (including computers)	130	19.8
Data processing, hosting, and related services	125	40.8
Wireless telecommunications carriers (except satellite)	99	50.5
Internet service providers and web search portals	91	64.2

All of these industries except management of companies and enterprises also are projected to grow faster than the average for all industries. Twenty of the 46 industries are projected to contract. The largest declines are expected for four Level-I manufacturing industries, as well as one Level-III communications industry:

Table 1. High-technology employment, 1992, 2002, and projected 2012

[Levels in thousands]

NAICS code	Industry	Employment			Employment change				Median annual wage, May 2004[1]
		1992	2002	2012	Change in level, 1992–2002	Change in level, 2002–12	Percent change, 1992–2002	Percent change, 2002–12	
...	Total nonfarm wage and salary, all industries[2]	109,526	131,063	152,690	21,537	21,627	19.7	16.5	$28,770
...	Total, three levels of high-technology industries	13,415	14,422	16,067	1,006	1,646	7.5	11.4	([3])
...	Level-I industries	4,783	5,883	6,804	1,100	921	23.0	15.6	
3254	Pharmaceutical and medicine manufacturing	225	293	361	68	68	30.2	23.2	43,930
3341	Computer and peripheral equipment manufacturing	329	250	182	–79	–68	–24.0	–27.1	61,830
3342	Communications equipment manufacturing	210	191	201	–19	10	–9.0	5.4	45,520
3344	Semiconductor and other electronic component manufacturing	519	531	452	12	–79	2.3	–14.9	39,210
3345	Navigational, measuring, electromedical, and control instruments manufacturing	549	451	396	–98	–55	–17.8	–12.2	47,960
3364	Aerospace product and parts manufacturing	711	468	386	–242	–83	–34.1	–17.6	51,990
5112	Software publishers	114	256	430	142	174	125.0	67.9	69,880
5161	Internet publishing and broadcasting	16	35	49	19	14	116.1	41.1	53,470
5179	Other telecommunications	16	10	8	–6	–2	–39.2	–21.9	45,470
5181	Internet service providers and Web search portals	39	142	233	103	91	265.3	64.2	52,780
5182	Data processing, hosting, and related services	220	305	430	86	125	39.0	40.8	45,570
5413	Architectural, engineering, and related services	902	1,251	1,306	349	54	38.7	4.3	48,570
5415	Computer systems design and related services	445	1,163	1,798	718	635	161.3	54.6	63,350
5417	Scientific research-and-development services	490	537	573	47	36	9.7	6.7	57,890
...	Level-II industries	4,760	4,528	4,998	–231	470	–4.9	10.7	([3])
1131, 32	Forestry	10	10	10	0	0	.0	4.0	–
2111	Oil and gas extraction	182	123	88	–60	–34	–32.8	–27.8	49,290
2211	Electric power generation, transmission, and distribution	537	436	405	–101	–31	–18.8	–7.1	53,330
3251	Basic chemical manufacturing	246	171	140	–76	–31	–30.8	–18.0	45,970
3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	151	114	89	–37	–26	–24.5	–22.6	42,730
3332	Industrial machinery manufacturing	142	132	125	–10	–6	–7.1	–4.7	39,480
3333	Commercial and service industry machinery manufacturing	138	132	141	–6	9	-4.6	6.6	35,940
3343	Audio and video equipment manufacturing	58	42	38	–16	–3	–27.7	–7.7	32,460
3346	Manufacturing and reproducing, magnetic and optical media	44	57	63	13	6	30.5	11.1	35,720
4234	Professional and commercial equipment and supplies, merchant wholesalers	584	659	790	76	130	13.0	19.8	41,770
5416	Management, scientific, and technical consulting services	358	732	1,137	374	406	104.4	55.4	45,610
...	Federal Government, excluding Postal Service	2,311	1,922	1,972	–389	50	–16.8	2.6	([4])
...	Level-III industries	3,8723	4,010	4,265	137	255	3.5	6.3	([3])
3241	Petroleum and coal products manufacturing	152	119	102	–33	–18	–21.8	–14.8	48,340
3253	Pesticide, fertilizer, and other agricultural chemical manufacturing	54	45	35	–10	–10	–17.7	–21.3	39,680
3255	Paint, coating, and adhesive manufacturing	81	72	62	–8	–11	–10.3	–14.7	35,110
3259	Other chemical product and preparation manufacturing	144	112	79	–32	–33	–21.9	–29.4	35,390
3336	Engine, turbine, and power transmission equipment manufacturing	111	100	100	–11	0	–9.6	.2	37,310
3339	Other general-purpose machinery manufacturing	317	288	339	–29	51	–9.0	17.7	35,320
3353	Electrical equipment manufacturing	219	176	180	–43	4	–19.4	2.2	32,520
3369	Other transportation equipment manufacturing	36	40	40	4	0	10.3	.5	34,230
4861	Pipeline transportation of crude oil	10	7	7	–3	0	–27.0	–2.7	52,020
4862	Pipeline transportation of natural gas	42	29	30	–13	1	–31.0	2.1	49,650
4869	Other pipeline transportation	7	5	5	-2	0	–25.7	–7.7	50,570
5171	Wired telecommunications carriers	637	662	600	25	–62	4.0	–9.4	50,940
5172	Wireless telecommunications carriers (except satellite)	48	196	295	148	99	309.8	50.5	38,480
5173	Telecommunications resellers	173	1856	188	13	2	7.6	1.3	49,400
5174	Satellite telecommunications	19	19	17	0	–2	1.6	–10.4	50,780
5211	Monetary authorities, central bank	24	23	23	–1	0	–2.5	.9	40,840

Table 1. Continued—High-technology employment, 1992, 2002, and projected 2012

[Levels in thousands]

NAICS code	Industry	Employment			Employment change				Median annual wage, May 2004[1]
		1992	2002	2012	Change in level, 1992–2002	Change in level, 2002–12	Percent change, 1992–2002	Percent change, 2002–12	
5232	Securities and commodity exchanges	10	10	10	0	1	–4.0	7.3	$61,620
5511	Management of companies and enterprises	1,623	1,711	1,906	88	195	5.4	11.4	43,400
5612	Facilities support services	68	104	146	36	42	52.9	40.4	28,910
8112	Electronic and precision equipment repair and maintenance	99	105	101	6	–4	6.1	–3.8	32,750

[1] Annual earnings rates are hourly rates times 2,080 hours. Data do not cover the Federal Government or forestry.

[2] See Jay M. Berman, "Industry output and employment projections to 2012," ***Monthly Labor Review***, February 2004, pp. 58–79, table 3.

[3] Not calculated.

[4] The average salary for full-time nonpostal Federal employees as of March 31, 2004, was $60,517. (See ***Pay Structure of the Federal Civil Service*** (U.S. Office of Personnel Management, May 2005), p. 2.)

NOTE: Employment data for 1992 in NAICS 4861, 4862, 4869, 5174, 5232, 1131, and 1132 are estimated. Dash indicates industry not surveyed.

SOURCES: Employment data are from Berman, "Industry output," table 3; National Employment Matrix, 2002–12; and unpublished sources. Earnings data are from the Occupational Employment Statistics Survey.

Industry	Projected change, 2002–12, in— Employment Number (thousands)	Employment Percent	Output, average annual rate of change
Aerospace products and parts	–83	–17.6	0.1
Semiconductor and other electronic components	–79	–14.9	1.1
Computer and peripheral equipment	–68	–27.1	24.2
Wired telecommunications carriers	–62	–9.4	4.9
Navigational, measuring, electromedical, and control instruments	–55	–12.2	3.2

Despite the projected employment declines, only 3 of the 46 high-tech industries are anticipated to have output declines; in addition, 7 Level-I computer and communications-related industries have the fastest-growing output among all industries for the 2002–12 period.[22] The following tabulation shows the average annual rate of growth for the 7:[23]

Industry	Rate of growth
Computer and peripheral equipment manufacturing	24.2
Communications equipment manufacturing	10.4
Internet publishing and broadcasting	10.3
Internet service providers and web search portals	10.3
Data processing, hosting, and related services	10.3
Computer systems design and related services	9.0
Software publishers	8.4

High-tech manufacturing industries. Employment in the 20 high-tech manufacturing industries, in total, is projected to decline 7 percent from 2002 to 2012, compared with a 1-percent decline in overall manufacturing. Over the 1992–2002 period, these 20 industries declined 15 percent, as opposed to a 9-percent decline for total manufacturing. Employment in the 6 Level-I high-tech manufacturing industries is projected to decline 9 percent during 2002–12; over the 1992–2002 period, employment in these industries declined 14 percent. The only high-tech manufacturing industry with faster-than-average projected employment growth from 2002 to 2012 is Level-I pharmaceuticals and medicine, which is expected to add 68,000 jobs.

The 5 computer information and computer systems design industries (all Level I), including 4 of the 8 with the most growth (see tabulation on page 59), attracted much attention during the late 1990s. As a group, their employment more than doubled from 1992 to 2002 and is projected to grow 54.6 percent during 2002–12. (See table 2.) Despite its prominence, this group is relatively small, with employment of 1.9 million in 2002, less than 1.5 percent of the total. Nevertheless, without these industries, Level-I employment is projected to decline 3.0 percent, compared with 15.6-percent growth with them. Also, without these industries, total high-tech employment is projected to grow only 4.8 percent, as opposed to 11.4 percent with them. Finally, without the 5 industries, neither Level-I nor total high-tech employment changed much over the 1992–2002 period.[24]

High-tech earnings

A number of studies have stated that high-tech jobs are high-paid jobs.[25] Clearly, that was the case for the industries and occupations in this article. The Occupational Employment Statistics survey collected data on 44 of the 46 high-tech

Table 2. High-technology employment, 1992, 2002, and projected 2012, in five computer information and computer systems design industries

[Levels in thousands]

NAICS code	Industry	Employment			Employment change			
		1992	2002	2012	Change in level, 1992–2002	Change in level, 2002–12	Percent change, 1992–2002	Percent change, 2002–12
…	Total, three levels of high-technology industries	13,415	14,422	16,067	1,006	1,646	7.5	11.4
…	Level-I industries	4,783	5,883	6,804	1,100	921	23.0	15.6
…	Five computer industries	834	1,901	2,940	1,067	1,039	127.9	54.6
5112	Software publishers	114	256	430	142	174	125.0	67.9
5161	Internet publishing and broadcasting	16	35	49	19	14	116.1	41.1
5181	Internet service providers and Web search portals	39	142	233	103	91	265.3	64.2
5182	Data processing, hosting, and related services	220	305	430	86	125	39.0	40.8
5415	Computer systems design and related services	445	1,163	1,798	718	635	161.3	54.6
…	Total, three levels of high-technology industries, except for five computer industries	12,581	12,521	13,127	–61	606	–.5	4.8
…	High-technology level I, except for five computer industries	3,949	3,982	3,864	33	–118	.8	–3.0

SOURCE: Jay M. Berman, "Industry output and employment projections to 2012," ***Monthly Labor Review***, February 2004, table 3; and National Employment Matrix.

industries; all had median earnings greater than the median for all industries in May 2004. (See table 1.) In 5 of the industries, wages were at least twice the median for all industries, and in 21 more industries, wages exceeded the median for all industries by 50 percent to 99 percent. Only in facilities support services were they close to the median for all.

Median earnings in all of the 71 technology-oriented occupations exceeded the median for all workers in May 2004, except for forest and conservation technicians, as shown in table 3. In 6 occupations, earnings exceeded 3 times the median; in 34 more, earnings were twice the median; and in another 17, earnings exceeded the median by 50 percent to 99 percent. Thirteen other occupations, almost all technicians and drafters, had earnings that exceeded the median by less than 50 percent.

In sum, high tech is projected to grow more slowly than the average for all industries, but some high-tech industries, including computer-related services, management and technical consulting, and wireless telecommunications, are projected to grow very rapidly. High-tech manufacturing is expected to decline faster than overall manufacturing; however, output in many high-tech industries is projected to grow rapidly, and most high-tech industries and occupations have high earnings.

Other selection criteria

As noted earlier, there is no single widely accepted criterion for defining high-technology industries; accordingly, the interagency group recommended three criteria for selecting lists of such industries, besides the criterion of technology-oriented occupation intensity. The information that follows may be useful to those desiring to amend the list presented in this article or to those wishing to develop their own list. Both R&D employment intensity and having products on a Census Bureau list of high-tech products were judged to be useful criteria, but due to data problems, neither was used to rank industries in terms of being high tech. For a number of reasons, the R&D data were not comparable to BLS data. As for high-tech products, there are no data showing the proportion these products are of each industry's output, and the list of products provides little information about service industries. Still, both sources can provide information which

- supports the inclusion of specific industries on the BLS high-tech list.
- raises doubts about the inclusion of specific industries on the list.
- suggests that some industries not on the list might nonetheless be considered high tech.

All available information on high-tech industries for all criteria is presented in table 4, which ranks industries by their percentage of employment in technology-oriented occupations in 2002.

The R&D data show (on a company basis—see the more detailed discussion of the data that follows) that almost all Level-I industries have a high R&D intensity. The data also suggest that R&D takes place in some Level-II and Level-III industries, but at a lower intensity than in Level-I industries. (See table 4.) Further, the data suggest that several Level-II and Level-III industries have a low intensity of R&D. Among goods-producing industries, all those at Level I have products on the Census Bureau high-tech list, as do some Level-II, but

Table 3. Median annual wages of wage and salary workers in technology-oriented occupations, May 2004

SOC code	Occupation	Median wages
...	All occupations	$28,770
11–3021	Computer and information systems managers	92,570
11–9041	Engineering managers	97,630
11–9121	Natural sciences managers	88,660
15–1011	Computer and information scientists, research	85,190
15–1021	Computer programmers	62,890
15–1031	Computer software engineers, applications	74,980
15–1032	Computer software engineers, systems software	79,740
15–1041	Computer support specialists	40,430
15–1051	Computer systems analysts	66,460
15–1061	Database administrators	60,650
15–1071	Network and computer systems administrators	58,190
15–1081	Network systems and data communications analysts	60,600
15–2011	Actuaries	76,340
15–2021	Mathematicians	81,240
15–2031	Operations research analysts	60,190
15–2041	Statisticians	58,620
15–2091	Mathematical technicians	38,460
17–2011	Aerospace engineers	79,100
17–2021	Agricultural engineers	56,520
17–2031	Biomedical engineers	67,690
17–2041	Chemical engineers	76,770
17–2051	Civil engineers	64,230
17–2061	Computer hardware engineers	81,150
17–2071	Electrical engineers	71,610
17–2072	Electronics engineers, except computer	75,770
17–2081	Environmental engineers	66,480
17–2111	Health and safety engineers, except mining safety engineers and inspectors	63,730
17–2112	Industrial engineers	65,020
17–2121	Marine engineers and naval architects	72,040
17–2131	Materials engineers	67,110
17–2141	Mechanical engineers	66,320
17–2151	Mining and geological engineers, including mining safety engineers	64,690
17–2161	Nuclear engineers	84,880
17–2171	Petroleum engineers	$88,500
17–3011	Architectural and civil drafters	39,190
17–3012	Electrical and electronics drafters	43,180
17–3013	Mechanical drafters	43,000
17–3021	Aerospace engineering and operations technicians	52,500
17–3022	Civil engineering technicians	38,480
17–3023	Electrical and electronic engineering technicians	46,310
17–3024	Electromechanical technicians	41,440
17–3025	Environmental engineering technicians	38,550
17–3026	Industrial engineering technicians	43,590
17–3027	Mechanical engineering technicians	43,400
17–3031	Surveying and mapping technicians	30,380
19–1011	Animal scientists	49,920
19–1012	Food scientists and technologists	50,840
19–1013	Soil and plant scientists	51,200
19–1021	Biochemists and biophysicists	68,950
19–1022	Microbiologists	54,840
19–1023	Zoologists and wildlife biologists	50,330
19–1031	Conservation scientists	52,480
19–1032	Foresters	48,230
19–1041	Epidemiologists	54,800
19–1042	Medical scientists, except epidemiologists	61,320
19–2011	Astronomers	97,320
19–2012	Physicists	87,450
19–2021	Atmospheric and space scientists	70,100
19–2031	Chemists	56,060
19–2032	Materials scientists	72,390
19–2041	Environmental scientists and specialists, including health	51,080
19–2042	Geoscientists, except hydrologists and geographers	68,730
19–2043	Hydrologists	61,510
19–4011	Agricultural and food science technicians	29,730
19–4021	Biological technicians	33,210
19–4031	Chemical technicians	38,170
19–4041	Geological and petroleum technicians	40,260
19–4051	Nuclear technicians	59,200
19–4091	Environmental science and protection technicians, including health	35,340
19–4092	Forensic science technicians	44,010
19–4093	Forest and conservation technicians	27,330

NOTE: Data are for all industries except agriculture (minus agricultural services, which are covered) and the Federal Government. Data are not shown for eight "all other" occupation categories.

Annual rates are hourly rates times 2,080 hours.

SOURCE: Occupational Employment Statistics Survey.

no Level-III, industries. There also are four industries that are not on the high-tech list, but that produce high-tech products. However, without information on how large a part they are of industry output, it is not possible to make a case for their inclusion within the high-tech sector.

The data on the use of high-tech capital goods and services in the production process is only partially consistent with the technology-oriented occupation-based list. A list based on such data ranks as high some industries designated high tech, others as very low. Also, some industries that neither are on the high-tech list, nor meet an R&D or high-tech product criterion, nor are mentioned on other lists in the high-tech literature rank high by this standard.[26] Therefore, those data were not considered useful in identifying high-tech industries. The discussion that follows covers each criterion in more detail, as well as the connection between high-tech industries and growth in output per hour.

Table 4. Ranking of industries by percent of employment in science, engineering, and technician (technology-oriented) occupations in 2002, along with data for other criteria, by industry

NAICS code	Industry	Total employment, all occupations (thousands)	Percent in technology-oriented occupations	R&D scientists and engineers[1,2]		Output on census trade product list[3]	Investment from Level-I industries in 1997[1]		Average annual percent change in output per hour, 1987–2001, 1987–2002, or 1987–2003[4]
				Employment, January 2003 (thousands)	Per thousand employees in R&D-performing companies[1]		Percent	Rank	
	Total, wage and salary workers, all industries[5]	132,279	4.9	1,066.1	65	…	…	…	…
	Level I								
5415	Computer systems design and related services	1,163	60.2	90.8	[7]259	4	73.6	2	–
5112	Software publishers	256	56.4	80.8	245	4	70.6	3	17.2
5413	Architectural, engineering, and related services	1,251	51.5	32.2	104	–	66.3	5	–
5417	Scientific research and development services	537	46.4	50.0	302	1	58.9	7	–
5181	Internet service providers and web search portals	142	43.8	[6]23.3	[6]98	–	[6]55.6	12	–
3341	Computer and peripheral equipment manufacturing	250	42.9	15.1	170	3, 4	57.4	8	24.9
5161	Internet publishing and broadcasting	35	38.7	[6]23.3	[6]98	–	[6]55.6	12	–
3345	Navigational, measuring, electromedical, and control instruments manufacturing	451	34.7	75.9	[7]126	2, 4	43.0	28	3.9
5182	Data processing, hosting, and related services	305	34.3	[6]23.3	98	–	70.0	4	–
3364	Aerospace product and parts manufacturing	468	31.3	32.5	[7]43	8	44.2	27	2.2
3342	Communications equipment manufacturing	191	29.2	[7]40.9	[7]264	4	[6]49.4	19	10.5
3344	Semiconductor and other electronic component manufacturing	531	28.7	73.3	180	3,5,7	22.6	77	20.7
3254	Pharmaceutical and medicine manufacturing	293	28.4	51.8	137	1, 2	39.4	30	.9
5179	Other telecommunications	10	27.7	[6,7]8.5	([6,8])	–	[6]56.7	10	–
	Level II								
2111	Oil and gas extraction	123	21.3	([6,8])	([6,8])	No	7.5	116	2.6
1131, 32	Forestry	10	20.3	….		No	[6]5.1	118	–
3333	Commercial and service industry machinery manufacturing	132	20.0	[6]56.5	[6]72	No	37.2	33	.8
3346	Manufacturing and reproducing magnetic and optical media	57	19.6	[6]4.4	[6]171	4, 7	47.0	24	.6
3251	Basic chemical manufacturing	171	18.9	8.5	54	10	32.3	44	1.4
4234	Professional and commercial equipment and supply merchant wholesalers	659	18.5	[6]134.5	[6]84	–	–	–	13.4
3332	Industrial machinery manufacturing	132	17.9	[6]56.5	[6]72	6	25.2	64	2.4
…	Federal Government, excluding Postal Service	1,922	17.3	–	–	–	–	–	–
5416	Management, scientific, and technical consulting services	732	17.2	[6]8.9	[6]28	–	55.9	11	–
3343	Audio and video equipment manufacturing	42	15.9	[6]4.4	[6]171	No	[6]49.4	19	5.4
2211	Electric power generation, transmission, and distribution	436	15.7	[6]–	[6]2	–	22.8	76	3.1
3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	114	15.3	12.8	97	–	40.7	29	2.2
	Level III								
5171	Wired telecommunications carriers	662	14.5	[6,7]8.5	([6,8])	–	[6]56.7	10	5.8
5511	Management of companies and enterprises	1,711	14.3	1.5	66	–	50.7	18	–
4862	Pipeline transportation of natural gas	29	13.5	([6,8])	([6,8])	–	[6]32.4	43	–
5211	Monetary authorities—central bank	23	13.3	[6]18.9	[6]24	–	–		–
5172	Wireless telecommunications carriers (except satellite)	196	13.3	[6,7]8.5	([6,8])	–	[6]56.7	10	6.2
5173	Telecommunications resellers	186	13.2	[6,7]8.5	([6,8])	–	[6]56.7	10	–
5174	Satellite telecommunications	19	13.1	[6,7]8.5	([6,8])	–	[6]56.7	10	–
3353	Electrical equipment manufacturing	176	12.9	[6]14.0	[6]40	No	32.7	42	2.8
3259	Other chemical product and preparation manufacturing	112	12.9	[6]13.9	[6,7]68	No	39.0	31	2.8
3339	Other general-purpose machinery manufacturing	288	12.6	[6]56.6	[6]72	No	29.6	49	2.0
3336	Engine, turbine, and power transmission equipment manufacturing	100	12.3	[6]56.6	[6]72	No	28.7	53	3.5
3255	Paint, coating, and adhesive manufacturing	72	12.2	[6]13.9	[6,7]68	No	35.6	35	1.2
3241	Petroleum and coal products manufacturing	119	12.0	[6,7]4.3	[6,7]20	No	28.0	56	3.2
8112	Electronic and precision equipment repair and maintenance	105	11.5	–	–	–	–		–

Table 4. Continued—Ranking of industries by percent of employment in science, engineering, and technician (technology-oriented) occupations in 2002, along with data for other criteria, by industry

NAICS code	Industry	Total employment, all occupations (thousands)	Percent in technology-oriented occupations	R&D scientists and engineers[1,2]		Output on census trade product list[3]	Investment from Level-I industries in 1997[1]		Average annual percent change in output per hour, 1987–2001, 1987–2002, or 1987–2003[4]
				Employment, January 2003 (thousands)	Per thousand employees in R&D-performing companies[1]		Percent	Rank	
5612	Facilities support services	104	11.3	–	–	–	–	–	–
3253	Pesticide, fertilizer, and other agricultural chemical manufacturing	45	11.2	[6]13.9	[6,7]68	No	38.2	32	1.1
5232	Securities and commodity exchanges	10	–	[6]18.9	[6]24	–	–	–	–
4861	Pipeline transportation of crude oil	7	10.3	([6,8])	([6,8])	–	[6]32.4	43	–
3369	Other transportation equipment manufacturing	40	10.0	[6,7]7.3	[6,7]50	No	[6]30.9	45	5.1
4869	Other pipeline transportation	5	10.0	([6,8])	([6,8])	–	[6]32.4	43	–
	Other industries meeting at least one criterion								
3329	Other fabricated metal product manufacturing	296	9.3	[6]13.1	[6]26	9	[6]29.7	48	.5
3359	Other electrical equipment and component manufacturing	152	9.0	[6]14.0	[6]40	7	25.2	65	2.7
3363	Motor vehicle parts manufacturing	731	8.8	[6]83.2	[6]76	No	[6]26.7	60	2.8
3361	Motor vehicle manufacturing	267	8.3	[6]83.2	[6]76	No	[6]26.7	60	2.6
3335	Metalworking machinery manufacturing	217	8.0	[6]56.5	[6]72	6	34.0	40	1.3
3324	Boiler, tank, and shipping container manufacturing	95	4.9	[6]13.1	[6]26	10	24.0	70	1.4
3362	Motor vehicle body and trailer manufacturing	154	4.7	[6]83.2	[6]76	No	[6]26.7	60	1.1

[1] Data are for 1997 NAICS industries.

[2] Data are for full-time equivalent employment of scientists and engineers. The reporting unit for the survey in which the R&D data were collected is the company. The reporting unit for the Occupational Employment Survey data used to develop the ranking in this table is the establishment. Ratios are based on industry employment during the week containing March 12 and on scientist and engineer employment the following January.

[3] Products were assigned to NAICS industries by the Bureau of Labor Statistics. (See exhibit 1.) Numbers refer to 1 of 10 major technology areas.

[4] Data are available through 2001 for manufacturing industries, through 2002 for service-producing industries and for mining and utilities industries, and through 2003 for wholesale trade, retail trade, and food services and drinking places industries, at **http://www.bls.gov/lpc/**. Data are not available for all four-digit NAICS industries.

[5] Includes 1.216 million primary (but not secondary) jobs in agriculture, forestry, logging, fishing, and hunting that are not included in table 1.

[6] Data are for an industry grouping that is broader than this four-digit NAICS industry.

[7] Imputation of more than 50 percent.

[8] Data have been withheld to avoid disclosing operations of individual companies.

NOTE: Dash indicates data not available or not surveyed.

SOURCES: Data on total employment and on percent in tech-oriented occupations are from the 2002–12 National Employment Matrix; research and development data are from 2002 Survey of Industrial R&D, National Science Foundation, Division of Science Resources. Studies are available at **http://www.nsf.gov/sbe/srs/indus/start.htm**. High-tech investment data are calculated from Douglas S. Meade, Stanislaw J. Rzeznik, and Darlene C. Robinson-Smith, "Business Investment by Industry in the U.S. Economy for 1997," ***Current Business***, November 2003, pp. 18–70. Productivity data are from the BLS Office of Productivity and Technology. The Census Bureau list of industries is published in National Science Board, ***Science and Engineering Indicators—2002***, NSB-02-1 (Arlington, VA, National Science Foundation, 2002), p. 6–11, and is developed in the BLS Foreign Trade Division.

Proportion of R&D employment. As noted earlier, the R&D data used to define high-tech industries in the 1999 BLS study are no longer collected in the OES survey—the survey that provides data on employment by occupation and industry. The National Science Foundation's annual Survey of Industrial Research and Development collects data on the employment of R&D scientists and engineers, but that survey's definitions and coverage severely limit comparisons with OES-based data.

Nevertheless, data from the 2002 Industrial Research and Development survey are analyzed and presented in table 4. The key differences between the two surveys are as follows:

- The reporting unit for the OES survey (and other BLS industry employment surveys) is the establishment, which generally is a single physical location where business is conducted or where services or industrial operations are performed. Examples of establishments are a factory, a store, a sales office, and a hotel. By contrast, the reporting unit for the NSF survey is the company, firm, or enterprise, a designation that includes all establishments under common ownership or control. All information about each company is classified under a single NAICS code. Therefore, an establishment that falls under one industry in the OES survey may appear in a different industry in the NSF survey, creating doubts about the comparability of industry data from the two surveys. Corresponding data from each survey are thus useful in supporting or questioning whether industries listed in this article are

high tech only to the extent that there is some reasonably close comparability between the data.

- While most Level-I industries have corresponding four-digit-industry NSF survey data, most Level-II and Level-III industries do not. The most comparable data are for the NAICS industry sectors designated with two digits, industry subsectors (three digits), or other groupings of four-digit industries to which they belong. Since R&D employment could be unevenly distributed among a group's component four-digit industries, the data are only suggestive of R&D for those industries. Nevertheless, if little or no R&D is evident in a broader group, it can reasonably be concluded that there is not much R&D in any four-digit high-tech industries in that group—assuming reasonable comparability between establishment and company data.
- NSF data are for full-time-equivalent employment, rather than being a job count, as are Bureau data, and include scientists and engineers, but not technicians or other R&D workers.
- Data are classified according to the 1997 NAICS, instead of the 2002 NAICS used for the OES employment data. However, there are no significant problems in matching data, except for some industries within NAICS 51, information.
- NSF's calculated ratios of R&D scientists and engineers per 1,000 employees apply to R&D-performing companies only, rather than to all companies in an industry, so that unless all companies perform R&D, the ratio of R&D scientists and engineers to all employees would be lower. The preceding ratios, along with numbers of full-time-equivalent R&D scientists and engineers, are presented in table 4.[27]

Almost all of the high-tech Level-I industries show ratios of R&D scientists and engineers that are well above the average for all industries, suggesting that those industries are among the most R&D intensive. In many Level-II and Level-III industries, data for their broader industry group show significant R&D employment, as well as ratios ranging from well above the average to well below it. However, some broader groups show very low R&D employment: NAICS 22, utilities (which includes NAICS 2211, electric power generation, transmission, and distribution); NAICS 48 and 49, transportation and warehousing (which includes NAICS 4861, 4862, and 4863, pipeline transportation);[28] and NAICS 55, management of companies and enterprises (consisting only of NAICS 5511). This situation suggests that their component four-digit industries have low R&D employment and might be excluded, as were industries with low R&D ratios in the 1999 BLS study. In addition, data for the five telecommunications industries combined exhibit relatively low R&D employment. The data show no four-digit industries with high R&D that are not on the high-tech list, except for three motor vehicle manufacturing industries combined: NAICS 3361, 3362, and 3363. However, it is not clear how much of the reported R&D is in establishments classified within those three industries in the BLS data.[29]

Production of high-tech products. The Census Bureau developed a classification system for exports and imports that embody new or leading-edge technologies, allowing trade to be examined in 10 major technology areas. The system focuses on specific advanced-technology products, rather than the total output of high-tech industries. The Bureau of Labor Statistics assigned products in the 10 categories to four-digit NAICS industries that produce them, as shown in exhibit 1 and table 4. Because there are no data on the proportion these products make up of each industry's output, and because service industry output has limited coverage, no industry ranking can be developed. However, it is possible to identify the goods-producing industries among the 46 that produce high-tech products.

Every Level-I goods-producing or software industry made at least some products on the Census Bureau list. (Some service industries on the list provided services related to the products.) Among level-II goods-producing industries, oil and gas extraction, NAICS 2111; forestry, NAICS 1131 and 1132; commercial and service industry machine manufacturing, NAICS 3333; and audio and video equipment manufacturing, NAICS 3343, had no products on the list, and neither did any level-III industry. Four industries that are not classified as high tech—other fabricated metal products manufacturing, NAICS 3329; other electrical equipment and component manufacturing, NAICS 3359; metalworking machinery, NAICS 3335; and boiler, tank, and shipping container manufacturing, NAICS 3324—produce some high-tech products. However, without data on high-tech products' share of output, it is not possible to make a case for classifying those industries as high-tech industries.

Use of "high-tech" production methods. There do not appear to be any earlier studies that define industries as high tech solely on the basis of their innovative or state-of-the art manufacturing processes. Industries using high-tech production methods could be identified by judgment, by the intensity of their use of high-tech capital goods, or by the intensity of their technology-oriented-occupation employment in production and production-related R&D. Although there do not appear to have been any systematic efforts to list industries judged to be users of high-tech production methods, individual industries, such as mining

Exhibit 1. Industries producing products in 10 new or leading-edge technology areas

Major technology area	NAICS code	NAICS title
1. *Biotechnology*—the medical and industrial application of advanced genetic research to the creation of drugs, hormones, and other therapeutic products for both agriculture and human uses.	3254 5417	Pharmaceutical and medicine manufacturing Scientific R&D services
2. *Life science technologies*—the application of nonbiological scientific advances to medicine. For example, advances such as nuclear magnetic resonance imaging, echocardiography, and novel chemistry, coupled with the manufacture of new drugs, have led to new products that help control or eradicate disease.	3345 3254	Navigational, measuring, electromedical, and control instrument manufacturing Pharmaceutical and medicine manufacturing
3. *Optoelectronics*—the development of electronics and electronic components that emit or detect light. Among such devices are optical scanners, optical disk players, solar cells, photosensitive semiconductors,and laser printers.	3341 3344	Computer and peripheral equipment manufacturing Semiconductor and other electronic component manufacturing
4. *Information and communications*—the development of products that process increasing amounts of information in shorter periods of time. Among such products are fax machines, telephone switching apparatuses, radar apparatuses, communications satellites, central-processing units, and peripheral units such as disk drives, control units, modems, and computer software.	3341 3342 3345 5112 5415	Computer and peripheral equipment manufacturing Communications equipment manufacturing Navigational, measuring, electromedical, and control instrument manufacturing Software publishers Computer systems design and related services
5. *Electronics*—the development of electronic components (other than optoelectronic components), including integrated circuits, multilayer printed circuit boards, and surface-mounted components, such as capacitors and resistors, that result in improved performance and capacity and, in many cases, reduced size.	3344	Semiconductor and other electronic component manufacturing
6. *Flexible manufacturing*—the development of products for industrial automation that permit greater flexibility in the manufacturing process and reduce human intervention. Among such products are robots, numerically controlled machine tools, and automated guided vehicles.	3332 3335	Industrial machinery manufacturing Metalworking machinery manufacturing

Exhibit 1. Continued—Industries producing products in 10 new or leading-edge technology areas

Major technology area	NAICS code	NAICS title
7. *Advanced materials*—the development of materials, including semiconductor materials, optical fiber cable, and videodisks, that enhance the application of other advanced technologies.	3344 3346	Semiconductor and other electronic component manufacturing Manufacturing and reproducing magnetic and optical media Other electrical equipment and component
8. *Aerospace*—the development of aircraft technologies, such as the newest military and civilian airplanes, helicopters, spacecraft (with the exception of communications satellites), turbojet aircraft engines, flight simulators, and automatic pilots.	3364	Aerospace product and parts manufacturing
9. *Weapons*—the development of technologies with military applications, including guided missiles, bombs, torpedoes, mines, missile and rocket launchers, and some firearms.	3329	Other fabricated metal products manufacturing
10. *Nuclear technology*—the development of nuclear production apparatuses, including nuclear reactors and parts, isotopic separation equipment, and fuel cartridges. (Nuclear medical apparatuses are included in life sciences rather than this category.)	3324	Boiler, tank, and shipping container manufacturing Basic chemical manufacturing

and textile mills, have been referred to as high tech because they use highly automated production techniques.[30] Note that, although there are no data on the employment of technology-oriented workers in production activities by industry, these workers are included in the employment totals used to define high-tech industries in this article. Therefore, this measure of high-tech production intensity *is* reflected in the industry rankings.

The intensity of high-tech capital-goods use in the production process cannot be measured directly, but can be inferred from data developed by the Commerce Department's Bureau of Economic Analysis. The data show the flow of new capital goods and services between industries in 1997 and permit a calculation of the proportion of each industry's investment in equipment, software, and structures that consisted of high-tech industry output. Absent an independent definition of *high tech*, industries were ranked by the proportion of their investment in equipment, software, and structures that was from Level-I industries. Data generated on the basis of this criterion are mixed. Many of the 46 industries on the high-tech list invest heavily in the output of Level-I industries, as shown in table 4. However, some on the high-tech list, such as Level-I semiconductor and other electronic component manufacturing and Level-II oil and gas extraction and industrial machinery manufacturing, rank low. In general, goods-producing industries rank lower than service-producing industries, due to their fairly high proportion of purchases from non-high-tech construction and machinery industries. However, if industries are ranked by the proportion of their investment that was from both Level-I and Level-II industries, some manufacturing industries rank higher, due primarily to purchases from Level-II industrial machinery manufacturing. By this standard, semiconductor and other electronic com-

ponent manufacturing ranks 7th out of 123 (compared with 77th on the basis of purchases from Level I alone), largely because industrial machinery manufacturing includes semiconductor-making machinery manufacturing. Industrial machinery manufacturing also includes textile machinery, printing machinery, and cigarette-making machinery, so that textile mills, tobacco manufacturing, and printing and related support activities rank much higher by this standard as well. Interestingly, the standard does not rank mining industries higher, because agricultural, construction, and mining machinery manufacturing is not on the high-tech list.

Twelve of the 30 industries with the most intense investment in equipment, software, and buildings are not on the high-tech list. (See table 5.) Air transportation ranks highest because it invests primarily in aerospace products and navigational and other instruments, with little invested in products from non-high-tech industries. Other highly ranked service industries, including travel arrangement and reservation services and accounting and bookkeeping services, invest primarily in computers and software. Both cable networks and program distribution, on the one hand, and radio and TV broadcasting, on the other, ranked high because they are heavy purchasers of communications equipment.

These industries do not have significant R&D, have few technology-oriented workers, and are not on other lists of high-tech industries.[31] For example, only 2.2 percent of the air transportation industry workforce and 2.6 percent of the travel arrangement and reservation services industry's workforce consisted of technology oriented workers in 2002, well below the 4.9-percent average for all industries. It is difficult to make a case for classifying these industries as high tech solely on the basis of their intense investment in the output of high-tech industries.

Growth in output per hour. In their 2002 *Review* article, Kask and Sieber, of the BLS Office of Productivity and Technology (OPT), examined the 10 most high-tech manufacturing (SIC) industries from the 1999 list and found that only the 3 information technology industries—computer and office

Table 5. Ranking of industries by proportion of total purchases of new equipment, software, and structures that were from high-tech Level-I industries, 1997

NAICS code	Industry	Percent	High-technology status or level
[1]481	Air transportation	77.4	not
5415	Computer systems design and related services	73.6	I
5112	Software publishers	70.6	I
[2]5142	Data processing services	70.0	I
5413	Architectural and engineering services	66.3	I
5412	Accounting and bookkeeping services	59.0	not
5417	Scientific research and development services	58.9	I
3341	Computer and peripheral equipment manufacturing	57.4	I
5615	Travel arrangement and reservation services	57.1	not
[3]5133	Telecommunications	56.7	I and III
5416	Management and technical consulting services	55.9	II
5141	Information services	55.6	I
5132	Cable networks and program distribution	54.1	not
[4]5131	Radio and television broadcasting	54.0	not
5331	Lessors of nonfinancial intangible assets	52.7	not
[1]523	Securities, commodity contracts, and investments	52.4	part is III
5613	Employment services	51.9	not
55	Management of companies and enterprises	50.7	III
3342, 43	Audio, video, and communications equipment manufacturing	49.4	I and II
521, 522	Monetary authorities, credit intermediation, and related activities	48.6	part is III
[1]524	Insurance carriers and related activities	47.7	not
5411	Legal services	47.5	not
[1]483	Water transportation	47.1	not
3346	Magnetic media manufacturing and reproducing	47.0	II
5418	Advertising and related services	45.1	not
3122	Tobacco manufacturing	44.9	not
3364	Aerospace product and parts manufacturing	44.2	I
3345	Electronic instrument manufacturing	43.0	I
3252	Resin, rubber, and artificial fibers manufacturing	40.7	II
3254	Pharmaceutical and medicine manufacturing	39.4	I

[1] Data are for the three-digit industry only.
[2] NAICS 5182 in 2002.
[3] NAICS 5171, 5172, 5173, 5174, and 5179 in 2002.
[4] NAICS 5151 in 2002.

SOURCE: BLS calculation from Douglas S. Meade, Stanislaw J. Rzeznik, and Darlene C. Robinson-Smith, "Business Investment by Industry in the U.S. Economy for 1997," ***Survey of Current Business***, November 2003, pp. 18–70, using data available at **www.bea.gov/bea/pub/1103cont.htm**.

Table 6. Ranking of industries by average annual percent change in output per hour, 1987–2001, 1987–2002, or 1987–2003[1]

NAICS code	Industry	1987–2001	1987–2002	1987–2003	High-technology status or level	Communications or electronics status
…	Nonfarm business sector	1.9	2.1	2.2	…	…
…	Manufacturing sector	3.2	3.4	3.5	…	…
3341	Computer and peripheral equipment manufacturing	24.9	–	–	I	yes
3344	Semiconductors and other electronic components manufacturing	20.7	–	–	I	yes
5112	Software publishers	–	17.2	–	I	yes
4431	Electronics and appliance stores	–	–	14.0	not	yes
4234	Professional and commercial equipment and supplies, merchant wholesalers	–	–	13.4	II	yes
4541	Electronic shopping and mail-order houses	–	–	12.5	not	yes
3342	Communications equipment manufacturing	10.5	–	–	I	yes
4236	Electrical and electronic goods, merchant wholesalers	–	–	9.3	not	yes
4529	Other general merchandise stores	–	–	7.9	not	no
5172	Wireless telecommunications carriers (except satellite)	–	6.2	–	III	yes
3365	Railroad rolling stock manufacturing	6.0	–	–	not	no
5171	Wired telecommunications carriers	–	5.8	–	III	yes
4532	Office supplies, stationery, and gift stores	–	–	5.7	not	no
3343	Audio and video equipment manufacturing	5.4	–	–	II	yes
3369	Other transportation equipment manufacturing	5.1	–	–	III	no
2122	Metal ore mining	–	4.8	–	not	no
4481	Clothing stores	–	–	4.7	not	no
3152	Cut and sew apparel manufacturing	4.6	–	–	not	no
3162	Footwear manufacturing	4.6	–	–	not	no
4511	Sporting goods, hobby, and musical instrument stores	–	–	4.3	not	no
4251	Wholesale electronic markets and agents and brokers	–	–	4.5	not	yes
2121	Coal mining	–	4.4	–	not	no
4483	Jewelry, luggage, and leather goods stores	–	–	4.2	not	no
4482	Shoestores	–	–	4.1	not	no
3352	Household appliances manufacturing	4.0	–	–	not	no
3345	Navigational, measuring, electromedical, and control instruments manufacturing	3.9	–	–	I	yes
3131	Fiber, yarn, and thread mills	3.7			not	no
3311	Iron and steel mills and ferroalloy production	3.7	–	–	not	no
2212	Natural gas distribution	–	3.7	–	not	no
3336	Engine, turbine, and power transmission equipment manufacturing	3.5	–	–	III	no

[1] Data are through 2001 for manufacturing industries, through 2002 for service-producing industries and for mining and utilities industries, and through 2003 for wholesale trade, retail trade, and food services and drinking places industries, at **http://www.bls.gov/lpc/**. Data are not available for all four-digit NAICS industries.

SOURCE: BLS Office of Productivity and Technology.

equipment, communications equipment, and electronic components manufacturing—exhibited particularly strong growth in output per hour over the 1987–99 period.[32] The current article analyzes OPT data, covering all sectors, on average annual percent change in output per hour for 1987–2001, 1987–2002, or 1987–2003, depending on the sector.[33] Growth is greater than 10 percent for 7 NAICS industries, corresponding to the 3 noted by Kask and Sieber—the computer and peripheral equipment, semiconductor and other electronic components, and communications equipment industries—as well as for high-tech software publishers and for merchant wholesalers of professional and commercial equipment and supplies. (See table 6.) Also included in the 7 are 2 non-high-tech electronics-related retail trade industries. Both wired and wireless telecommunications carriers ranked high as well. (Data on some computer-related service industries, such as computer systems design, on the one hand, and Internet service providers and web search portals, on the other, are not available.) However, as Kask and Sieber found, growth in output per hour was at or below average for many high-tech NAICS industries, including the aerospace, pharmaceutical and medicine, and several machinery and chemicals manufacturing industries.[34] (See table 4.) Nineteen of the 30 industries with the fastest growth in output per hour, including electronic shopping and mail-order houses, other general merchandise stores (including warehouse clubs and supercenters), and cut and sew apparel manufacturing, are not on the high-tech list, and few, if any, have significant technology-oriented or R&D employment, produce high-tech products, or are on other high-tech industry lists.[35]

These results are not surprising. Rapid growth in industry output per hour could result from factors unrelated to whether an industry is high tech, while an industry that uses technology-oriented workers intensively, relies heavily on R&D, and generates products judged to be high tech could have low growth in output per hour.

In sum, the high-tech-investment criterion is not an unequivocal measure of whether an industry should be classified as high tech. Nor do the R&D and Census Bureau product lists provide any strong evidence for adding industries to the list of 46, although the R&D data suggest that at least some parts of motor vehicle manufacturing might be categorized as high tech. The R&D data also suggest that *neither* electric power generation, transmission, and distribution pipelines *nor* management of companies and enterprises should be so categorized. Finally, the Census Bureau product list suggests that oil and gas extraction, forestry, audio and video equipment manufacturing, and all 8 Level-III goods-producing industries be excluded, while the R&D data, although not completely applicable, suggest that some R&D activity goes on in all of these industries except forestry, which is not covered. □

Notes

[1] *The Dynamics of Technology-Based Economic Development, State Science and Technology Indicators*, 4th ed. (Office of Technology Policy, Technology Administration, U.S. Department of Commerce), p. 1-1.

[2] 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; Paul Hadlock, Daniel Hecker, and Joseph Gannon, "High technology employment: another view," *Monthly Labor Review*, July 1991, pp. 26–30; William Luker, Jr., and Donald Lyons, "Employment shifts in high-technology industries, 1988–96," *Monthly Labor Review*, June 1997, pp. 12–25; and Daniel E. Hecker, "High-technology employment: a broader view," *Monthly Labor Review*, June 1999, pp. 18–28.

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

[4] *Science and Technology Resources in U.S. Industry*, special report NSF 88–321 (Arlington, VA, National Science Foundation, December 1988), p. vii.

[5] Some studies exclude service industries or industries with little employment.

[6] *Cyberstates 2005: A State-by-State Overview of the High-Technology Industry* (Washington, DC, American Electronic Association, 2005), p. 161.

[7] See National Science Board, *Science and Engineering Indicators—2002*, NSB-02-1 (Arlington,VA, National Science Foundation, 2002), pp. 6-11; see also the last section and exhibit 1 of the current article.

[8] Christopher Kask and Edward Sieber, "Productivity growth in 'high-tech' manufacturing industries," *Monthly Labor Review*, March 2002, pp. 16–31.

[9] See Hecker, "High-technology employment." Attendees were from the BLS Office of Employment and Unemployment Statistics and from other Federal organizations with an interest in defining high-tech industries, including the Department of Commerce, the Employment and Training Administration of the Department of Labor, and the National Science Foundation (NSF).

[10] Kask and Sieber, "Productivity growth."

[11] Hecker, "High-technology employment"; R&D alone was used as the criterion in the 1991 BLS study; see Hadlock, Hecker, and Gannon, "High technology employment."

[12] BLS surveys do not collect data separately for these categories, but the National Science Foundation does. (See Scientists and Engineers Statistical Data System by SRS; on the Internet at **http://srsstats.sbe.nsf.gov/docs/source.html#instruments**.)

[13] Data are available at **http://www.bls.gov/emp**.

[14] Data are available at **http://www.bls.gov/oes**. Federal employment data are from the U.S. Office of Personnel Management, and forestry employment data are from the Bureau's Current Population Survey (CPS).

[15] What one ordinarily might think of as one industry—forestry—is viewed as two industries in NAICS: 1131, timber tract operations; and 1132, forest nurseries and gathering of forest products. Data in the CPS (see previous footnote) are for the two industries combined, which are treated as a single industry in the analysis that follows.

[16] There was a significant break between the lowest-ranked Level I and the highest-ranked Level II industry. This methodology is similar to the one used in Karen Chapple, Ann Markusen, Greg Schrock, Daisaku Yamamoto, and Pingkang Yu, "Gauging Metropolitan 'High-Tech' and 'I-Tech' Activity," *Economic Development Quarterly*, February 2004, pp. 10–29. Using 1998 OES (SIC-based) data, the authors defined high-tech industries as those employing scientists and engineers, but not technicians, at a proportion that was at least 3 times the national average. The 1999 BLS study by Hecker considered industries high tech if employment in both R&D and technology-oriented occupations accounted for a proportion of total employment that was at least twice the average for all industries. The 1999 study also defined a subset of high-tech industries that were even "more" high tech, namely, those industries with both ratios at least 5 times the average.

[17] Cable and other program distribution, NAICS 5175; and soap, cleaning compounds, and toilet preparations (NAICS 3256, within the category of chemical manufacturing) are excluded. Level-I pharmaceutical and medicine manufacturing is part of that industry.

[18] This four-digit industry, NAICS 5511, is the only industry in the category NAICS 55.

[19] "A Survey of the Use of Biotechnology in U.S. Industry" (U.S. Department of Commerce, Technology Administration, October 2003). Data are on a company, rather than establishment, basis.

[20] Data discussed later in this article suggest industries that might be deleted from or added to the list just set forth. For information on other lists of high-tech industries, see table 5 in Hecker, "High-

technology employment." Post-June 1999 lists include those in *Cyberstates 2005*; Chapple, Markusen, Schrock, Yamamoto, and Yu, "Gauging Metropolitan High Tech"; Joseph Cortright and Heike Mayer, "High Tech Specialization: A Comparison of High Technology Centers," survey series (Washington, DC, The Brookings Institution, Center on Urban and Metropolitan Policy, January 2001); and Ross DeVol, *America's High-tech Economy: Growth, Development, and Risks for Metropolitan Areas*, (Santa Monica, CA, Milken Institute, July 13, 1999). Although most of these lists are formulated on an SIC basis, many industries have coverage that is close to that of high-tech NAICS industries. The Organization for Economic Cooperation and Development (OECD) also has developed a list that the NSF has used in National Science Board, *Science and Engineering Indicators—2002*, pp. 6-6, 6-7.

[21] The 31 three-digit SIC industries covered in Hecker's 1999 *Review* article had 9.3 million employment in 1996, which was 7.8 percent of total nonfarm wage and salary employment. Employment in those industries was projected to reach 11.4 million in 2006, 8.4 percent of total employment. The addition of "Federal Government, excluding Postal Services," with 1.9 million employment, to the 2002 list is a major factor in the difference, as is the addition of the industry titled "management of companies and enterprises," which has no equivalent in the SIC.

[22] See Jay M. Berman, "Industry output and employment projections to 2012," *Monthly Labor Review*, February 2004, pp. 58–79, especially table 5, p. 74. The three industries in question are oil and gas extraction; basic chemical manufacturing; and resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing. (See table 3, pp. 62–70.) Some output projections are for more aggregated industries—for example, pipeline transportation (NAICS 486) and wholesale trade (NAICS 42).

[23] Data for Internet publishing and broadcasting; Internet service providers and web search portals; and data processing, hosting, and related services are for the three industries combined, plus other information services industries.

[24] A description of the methods and assumptions used to develop all of the foregoing projections is presented in the February 2004 *Monthly Labor Review* in a series of articles collectively titled "Employment outlook: 2002–12." Outsourcing is not specifically projected. However, the aforementioned projections are based on an analysis of data that incorporate trends in overseas outsourcing of high-tech jobs through 2002. (For further discussion, see Michael W. Horrigan, "Concepts and content," *Monthly Labor Review*, February 2004, pp. 13–14.

[25] See *Science and Engineering Indicators 2002*, pp. 6-5, 6-16; *Cyberstates 2005*; and Hecker, "High-technology employment."

[26] See notes 2, 6, 16, and 20 for other studies.

[27] Ratios are based on industry employment during the week containing March 12 and on R&D scientist and engineer employment the following January. Data are available at **http://www.nsf.gov/sbe/srs/indus/start.htm**.

[28] Low R&D employment for NAICS 48 and 49 is shown in the 2001 Survey of Industrial Research and Development.

[29] Motor vehicle manufacturing, SIC 371, was included among other high-technology industries in Hecker, "High-technology employment."

[30] Coal mining, NAICS 2121; metal ore mining, NAICS 2122; and fiber, yarn, and thread mills, NAICS 3131, have exhibited rapid increases in output per hour, as shown in table 5.

[31] See notes 2, 6, 16, and 20 for other studies.

[32] Kask and Sieber, "Productivity growth."

[33] Data are available through 2001 for manufacturing industries, through 2002 for service-producing industries and for mining and utilities industries, and through 2003 for wholesale trade, retail trade, and food services and drinking places industries, at **http://www.bls.gov/lpc/**. Data are not available for all four-digit NAICS industries.

[34] Kask and Sieber, "Productivity growth."

[35] See notes 2, 6, 16, and 20 for other studies.