High technology today and tomorrow: a small slice of the employment pie

High tech industries are expected to provide only a small proportion of the jobs created between 1982 and 1995, under three concepts which embrace from six to 48 industries

Richard W. Riche, Daniel E. Hecker, and John U. Burgan

High technology enjoys high visibility. Industry developments are tracked closely in the United States and abroad, and the implications for productivity, international competition, national defense, and the general standard of living are of increasing interest. Many States and some major cities have established task forces to assess the potential of high technology to provide employment opportunities and to develop incentives to attract high tech industries.

Although industries that manufacture computers and office equipment, electronic components and new drugs and medicines generally are among those classified as high tech industries, experts differ as to the makeup of the high tech group. There is no widely accepted definition of high technology industries, and they have been defined in many ways. In this article, we set forth various concepts of high technology and consider its effect on employment during the 1970's and through the mid-1990's.

The criteria generally used to classify high tech industries are research and development (R&D) expenditures, the use of scientific and technical personnel relative to total employment, and product sophistication. Employing these criteria, we developed three definitions of high tech to analyze employment trends in these industries. Our analysis indicates that:

- Employment in high tech industries increased faster than average industry growth during the 1972–82 period.
- High tech industries accounted for a relatively small proportion of all new jobs nationwide, but provided a significant proportion of new jobs in some States and communities.
- About 6 out of 10 high tech jobs are located in the 10 most populous States.
- States with relatively high proportions of employment in high tech industries are generally small; most are in the Northeast.
- Through 1995, employment in high tech industries is projected to grow somewhat faster than in the economy as a whole.
- High tech industries, even broadly defined, will account for only a small proportion of new jobs through 1995.
- Scientific and technical workers, while critical to the growth of industry and the economy, will account for only 6 percent of all new jobs through 1995.

A look at the concepts

Our examination of published reports on high technology prepared by private organizations and Federal and State agencies indicates a variety of approaches to identifying high

Richard W. Riche is an economist in the Office of Productivity and Technology, Daniel E. Hecker is an economist in the Office of Economic Growth and Employment Projections, and John U. Burgan is an economist in the Office of Employment and Unemployment Statistics, Bureau of Labor Statistics.

technology industries. One approach used by a State agency, for example, involved a review of the U.S. Government's Standard Industrial Classification (SIC) manual in which 20 industry groups were designated as high tech based on the perceived degree of technical sophistication of the products.[1] One limitation of this method, and others which focus on the nature of the product, is that it is highly subjective. Moreover, as Robert Vinson and Paul Harrington point out in an article on high technology industries in Massachusetts, the degree of technical sophistication of the product is of less significance than the complexity of the production process for those interested in the implications of high tech for capital and labor force requirements.[2]

A concept of high technology included in a document prepared by the Congressional Office of Technology Assessment illustrates a much broader and complex approach in which a series of factors are considered in developing a concept of high tech firms and industries.[3] The office describes high technology firms as ". . . companies that are engaged in the design, development, and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technical knowledge . . .". It points out that these companies typically use state-of-the-art techniques, have a high proportion of R&D costs; employ a high proportion of scientific, technical and engineering personnel; and serve small, specialized markets. The report goes on to say, "A high technology industry is a group of firms, producing similar or related products, that includes a high proportion of high technology firms."

As suggested earlier, definitions of high technology vary considerably. Federal agencies, including the Department of Defense, the Securities and Exchange Commission, and the Department of Commerce have formulated definitions of high technology to suit their own particular research needs.

An example: the set of definitions included in a report by the International Trade Administration, Department of Commerce, which examines U.S. competitiveness in high technology industries.[4] Four techniques for defining technology intensive trade are presented; one identifies industries and three focus on products.

The industry-based definition of technology intensive trade, developed by Michael Boretsky, uses the two measures frequently employed in examining high technology: R&D expenditures as a percentage of industry value added, and industry employment of scientists, engineers, and technicians as a proportion of the industry work force.[5] He identified two groups of industries based on the magnitude of R&D expenditures and employment of scientists, engineers, and technicians: technology intensive industries and high technology industries. Technology intensive products and others are not separately identified. The three product-based definitions also help in evaluating competitiveness in high technology industries. In the mid-1970's, Regina Kelly used R&D expenditures by product field and value of product shipments to develop intensity ratios.[6] She ranked products by R&D "intensity" and classified them by technology. Kelly designated the first quartile of R&D intensities as high technology goods. Subsequently, she refined her analysis and considered product groups with above average R&D intensities as technology intensive. In 1980, C. Michael Aho and Howard Rosen basically used the Kelly methodology to identify technology-intensive product groups.[7] These researchers used more recent data and the Standard International Trade Classification. More recently, Lester Davis used input-output analysis and R&D expenditure and shipment data by product group to develop an index of technological intensity.[8] Using an input-output matrix, Davis determined the value of R&D embodied in the various inputs used to make the products and the percentage of R&D embodied in the final product. He then arrived at total R&D by combining the indirect R&D (R&D contributed by inputs) with the value of direct R&D (R&D expenditures on product development). Davis ranked product groups according to total R&D to shipments intensity, with only those goods showing a significant R&D intensity (rather than simply above average) designated as high tech products.

A definition by Ann Lawson in an article in the Department of Commerce's *Industrial Economic Review* includes industries "possessing above average levels of scientific and engineering skills and capabilities, compared to other industries; and currently experiencing the accelerating technological growth associated with the germination and evolution stages along their respective S-curves."[9]

Selecting three groups of industries

Because there is no widely accepted definition of high technology industries, we believe it is useful to illustrate employment trends under a range of concepts. As indicated, the concepts underlying most definitions of high technology use one or a combination of three factors (1) the utilization of scientific and technical workers, (2) expenditures for research and development, and (3) the nature of the product of the industry. We have selected three groups of high technology industries based on these concepts.

We have defined industries according to the Standard Industrial Classification (SIC) at the 3-digit detail. We would have preferred to use 4-digit detail, but data were not available. We made an exception for R&D laboratories (SIC 7391), because, for this industry, data were available, and the other industries in SIC 739 have high levels of employment but little or no involvement with high technology. We defined scientific and technical workers as engineers, life and physical scientists, mathematical specialists, engineering and science technicians and computer specialists. We refer to these workers as *technology-oriented workers*. We excluded government, colleges, and universities, although some of their activities are no doubt high tech-oriented, such as some research conducted in higher educational institutions and in some government agencies. There was no realistic way to estimate the small proportion of employment associated with these activities.

Data on research and development expenditures are compiled annually through surveys conducted by the National Science Foundation. The most recent data available are for 1980. Statistics on employment of scientific and technical workers by industry are presented in the Bureau's national industry-occupation matrix. The most current matrix available presents data for 1982.

Group I. The criterion for inclusion in this group is solely the utilization of technology-oriented workers. We included an industry if technology-oriented workers accounted for a proportion of total employment that was *at least one and a half times the average for all industries*. (See table 1.)

To provide a reasonable definition but very broad coverage, we set the cutoff at 5.1 percent of total employment.

Table 1. Employment in high technology industries, 1972, 1980, and 1982
[In thousands]

SIC	Industry	High-tech group[1]			Employment			Percent change	
		I	II	III	1972	1980	1982	1972–80	1972–82
131	Crude petroleum and natural gas	X			139.3	219.6	281.7	57.7	102.2
162	Heavy construction, except highway and street	X			495.1	658.5	633.9	33.0	28.1
281	Industrial inorganic chemicals	X		X	141.2	161.1	153.5	14.1	8.7
282	Plastic materials and synthetics	X		X	228.7	204.8	182.7	-10.0	-20.1
283	Drugs	X	X	X	159.2	196.1	199.8	23.2	25.5
284	Soaps, cleaners, and toilet preparations	X		X	122.4	140.9	145.3	15.1	18.7
285	Paints and allied products	X		X	68.6	65.1	59.7	-5.1	-13.0
286	Industrial organic chemicals	X		X	142.8	174.1	174.3	21.9	22.1
287	Agricultural chemicals	X		X	56.4	72.0	67.1	27.7	19.0
289	Miscellaneous chemical products	X		X	90.0	93.3	91.5	3.7	1.7
291	Petroleum refining	X		X	151.4	154.8	169.0	2.3	11.6
301	Tires and inner tubes	X			122.1	114.8	101.9	6.0	-16.5
324	Cement, hydraulic	X			31.9	30.9	28.5	-3.1	-10.6
348	Ordnance and accessories	X		X	81.9	63.4	71.4	-25.6	-12.8
351	Engines and turbines	X		X	114.6	135.2	114.8	18.0	0.2
352	Farm and garden machinery	X			135.0	169.1	130.8	25.3	-3.1
353	Construction, mining, and material handling machinery	X			293.7	389.3	340.9	32.6	16.1
354	Metalworking machinery	X			286.0	373.1	320.3	30.5	12.0
355	Special industry machinery, except metalworking	X		X	176.9	207.3	179.4	17.2	1.4
356	General industrial machinery	X			267.5	323.7	283.2	21.0	5.9
357	Office, computing, and accounting machines	X	X	X	259.6	432.2	489.7	66.5	88.6
358	Refrigeration and service industry machinery	X			164.4	174.2	161.3	6.0	-1.9
361	Electric transmission and distribution equipment	X		X	128.4	122.5	110.1	-4.6	-14.2
362	Electrical industrial apparatus	X		X	209.3	239.9	211.8	14.6	1.2
363	Household appliances	X			186.9	163.2	142.0	-12.7	-25.0
364	Electric lighting and wiring equipment	X			204.4	209.2	186.9	2.4	-8.6
365	Radio and TV receiving equipment	X		X	139.5	108.8	94.6	-22.0	-32.2
366	Communication equipment	X	X	X	458.4	541.4	555.7	18.1	21.2
367	Electronic components and accessories	X	X	X	354.8	553.6	568.7	56.0	60.3
369	Miscellaneous electrical machinery	X		X	131.7	152.1	141.3	15.5	7.3
371	Motor vehicles and equipment	X			874.8	788.8	690.0	-9.8	-21.1
372	Aircraft and parts	X	X	X	494.9	652.3	611.8	31.8	23.6
376	Guided missiles and space vehicles	X	X	X	92.5	111.3	127.3	20.3	37.5
381	Engineering, laboratory, scientific, and research instruments	X		X	64.5	76.8	75.7	19.1	17.4
382	Measuring and controlling instruments	X		X	159.6	245.3	244.3	53.7	53.1
383	Optical instruments and lenses	X		X	17.6	33.0	32.5	87.5	84.7
384	Surgical, medical, and dental instruments	X		X	90.5	155.5	160.4	71.8	77.2
386	Photographic equipment and supplies	X		X	117.1	134.6	138.3	15.0	18.1
483	Radio and TV broadcasting	X			142.7	199.6	216.4	39.9	51.6
489	Communication services, n.e.c.[2]	X			29.7	66.1	91.0	122.6	206.4
491	Electric services	X			312.0	391.0	415.1	25.3	33.0
493	Combination electric, gas and other utility services	X			183.4	196.7	198.4	7.3	8.2
506	Wholesale trade, electrical goods	X			331.2	421.4	434.9	27.2	31.3
508	Wholesale trade, machinery, equipment, and supplies	X			868.6	1,307.7	1,344.9	50.6	54.8
737	Computer and data processing services	X		X	106.7	304.3	357.5	185.2	235.1
7391	Research and development laboratories	X		X	110.7	163.1	162.7	47.3	47.0
891	Engineering, architectural, and surveying services	X			339.3	544.9	568.7	60.1	67.6
892	Noncommercial educational, scientific and research organizations	X			111.8	113.5	117.8	1.5	5.4

[1] *Group I.* Includes industries with a proportion of technology-oriented workers (engineers, life and physical scientists, mathematical specialists, engineering and science technicians and computer specialists) at least 1.5 times the average for all industries.

Group II. Includes industries with a ratio of R&D expenditures to net sales at least twice the average for all industries.

Group III. Includes manufacturing industries with a proportion of technology-oriented workers equal to or greater than the average for all manufacturing industries, and a ratio of R&D expenditures to sales close to or above the average for all industries. Two nonmanufacturing industries which provide technical support to high tech manufacturing industries also are included.

[2] Not elsewhere classified.

However, we excluded industries with fewer than 25,000 workers. A total of 48 industries makes this the broadest of the three groups. As indicated in table 1, manufacturing industries account for 3 of every 4 industries in this category, with the remainder in mining, construction, transportation and public utilities, and trade and services.

Group II. R&D expenditures were the factor used to select this group of industries. We included an industry if its *ratio of* R&D *expenditures to net sales was at least twice the average for all industries.* The cutoff point, 6.2 percent, was set high to capture only those industries, such as drugs and communication equipment, heavily involved in developing new products. Because the National Science Foundation data show little R&D outside of manufacturing, we excluded other industries. This group, with only six industries, is the narrowest of the three groups of high tech industries. The industries, as expected, fall into all three groups.

Group III. The criteria for this group are both the utilization of technology-oriented workers and R&D expenditures. In addition, we excluded some industries based on their major products.

We included manufacturing industries if the proportion of technology-oriented workers relative to total employment in the industry was *equal to or greater than the average for all manufacturing industries (6.3 percent) and the ratio of* R&D *expenditures to sales was close to or above the average for all industries (3.1 percent).* We added two industries which provide technical support to manufacturing industries, computer and data processing services (SIC 737) and R&D laboratories.

Group III, with 28 industries, provides a scope of coverage between groups I and II. It excludes most nonmanufacturing industries that are in group I but which have little R&D activity (and therefore little new product development), such as engineering and architectural services and radio and TV broadcasting. The exclusion of nonmanufacturing industries is common in definitions of high tech industries. Group III also excludes some manufacturing industries found in group I, such as motor vehicles, which did not meet both criteria, and certain machinery industries, which met the criteria, but whose products we did not consider high technology. However, using both criteria, we included some manufacturing industries not in group II, such as those in the instruments, chemicals, and electrical equipment groups, industries with moderately high R&D to sales ratios that appear on many lists of high technology.

Employment trends during 1972–82

Employment in high technology industries, no matter which of the three definitions is used, increased faster than all wage and salary employment between 1972 and 1982. (See table 2.) Group II employment, however, increased significantly faster, 39.8 percent, nearly twice as fast as the 20.1-percent increase in total employment. Group III employment increased 27.3 percent and group I, only 23.6 percent. Over the period, each group increased slightly as a percentage of total wage and salary employment, group I from 13.1 to 13.4 percent, group II from 2.4 to 2.8 percent, and group III, from 5.8 to 6.2 percent.

The contribution of high tech industries to total employment growth over this period, no matter how high tech is defined, was relatively small. Group I accounted for 15.3 percent of new wage and salary jobs, group II, 4.7 percent, and group III, 7.9 percent.

Growth was not steady. For example, when wage and salary employment declined below its 1980 level during the 1981–82 recession, employment in group I, which includes some *cyclical* industries, also declined. During this period, employment in group III held steady, and group II continued to grow, despite the recession.

Among the industries included in the high technology groups, growth rates varied widely during 1972–82. Computer and data processing services had the fastest growth, 235.1 percent, followed by communication services, 206.4, crude petroleum and natural gas extraction, 102.2, office,

Table 2. Employment in three groups[1] of high technology industries, 1972, 1980, 1982, and projected 1995
[In thousands]

Employment grouping	Employment			Projected 1995 employment alternatives			Percent change							
	1972	1980	1982	Low	Moderate	High	1972–80	1972–82	1980–95			1982–95		
									Low	Moderate	High	Low	Moderate	High
All wage and salary workers	76,547.0	92,611.2	91,950.1	115,382.9	117,744.9	120,531.1	21.0	20.1	24.6	27.1	30.1	25.5	28.1	31.1
Group I	9,989.7	12,550.1	12,349.6	16,260.7	16,612.9	16,931.6	25.6	23.6	29.6	32.4	34.9	31.7	34.5	37.1
Percent of total employment	13.1	13.6	13.4	14.1	14.1	14.0	—	—	—	—	—	—	—	—
Group II	1,819.4	2,486.9	2,543.0	3,517.5	3,409.6	3,452.9	36.7	39.8	41.4	37.1	38.8	38.3	34.1	35.8
Percent of total employment	2.4	2.7	2.8	3.0	2.9	2.9	—	—	—	—	—	—	—	—
Group III	4,468.9	5,694.8	5,691.1	7,746.6	7,719.8	7,890.0	27.4	27.3	36.0	35.6	38.5	36.1	35.6	38.6
Percent of total employment	5.8	6.2	6.2	6.7	6.6	6.5	—	—	—	—	—	—	—	—

[1]Each group equals the sum of employment in detailed industries listed in Table 1.

computing, and accounting machines, 88.6, and optical instruments, 84.7. Radio and TV receiving equipment declined by 32.2 percent, household appliances by 24.0, motor vehicles by 21.2, and plastic materials and synthetics, by 20.1 percent. Some of the declines in employment are directly attributed to the 1981–82 recession.

Employment through 1995

Every other year, the Bureau prepares employment projections of roughly 12 years by industry under alternative scenarios. The latest projections of moderate, high, and low growth extend through 1995.[10] Because of employment declines in certain industries in 1981 and 1982, projected growth in wage and salary employment and employment in groups I and III is actually greater from 1982 to 1995 than from 1980. In group II, which had increasing employment from 1980 to 1982, this is not the case. For each of the three groups, using either 1980 or 1982 as a base, high tech employment is projected to grow somewhat faster than total wage and salary employment under all three alternatives. (See table 2.)

For group II, the low growth alternatives shows higher 1995 employment than the moderate alternative. This is because higher defense spending is assumed in the low alternative than in the moderate alternative, and group II has a high proportion of its employment in three defense-related industries, communication equipment, aircraft and parts, and guided missiles and space vehicles. In addition, these projections indicate that certain industries which grew very rapidly over the 1972–82 period, including computer and data processing services and office, computing, and accounting machines, will grow at a slower rate over the 1982–95 period, although still well above the average for all industries.

High tech and displaced workers. The Bureau's projections indicate that between 23.4 and 28.6 million new wage and

Table 3. Occupational distribution in selected *rapidly growing* high-technology industries and the motor vehicle manufacturing and blast furnaces and basic steel industries, 1980
[In percent]

Occupation	Office, computing, and accounting machines	Electronic components	Computer and data processing services	Blast furnaces and basic steel products	Motor vehicles
Total	100.0	100.0	100.0	100.0	100.0
White-collar	66.3	37.7	96.0	17.7	20.2
Tech-oriented	27.3	15.0	26.0	3.9	5.9
Engineers	11.9	7.2	1.7	1.8	3.4
Life and physical scientists	.1	.2	.1	.2	.1
Mathematical specialists	(1)	(1)	(.3)	(1)	(.2)
Engineering and science technicians	8.8	6.4	2.7	1.5	1.7
Computer specialists	6.5	1.2	21.2	.4	.5
Blue-collar	32.7	61.0	3.4	80.2	76.8
Service	1.0	1.3	.6	2.1	3.0

[1]Less than 0.1 percent.

Table 4. Projected 1982–95 growth in technology-oriented occupations
[In thousands]

Occupational group	Employment				Change 1982–95					
	1982	Projected 1995			Number			Percent		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
All occupations	101,510	124,846	127,110	129,902	23,336	25,600	28,392	23.0	25.2	28.0
Professional	16,584	21,545	21,775	22,325	4,961	5,191	5,741	29.9	31.3	34.6
Technology oriented	3,287	4,777	4,795	4,907	1,490	1,508	1,620	45.3	45.9	49.3

salary jobs will be created between 1982 and 1995. We estimate that between 1.0 and 4.6 million of these jobs will be in high technology industries. Growth in group I will account for 16 or 17 percent of all new jobs, depending on the projection used, while growth in group II will account for 3 or 4 percent and group III, 8 or 9 percent. The great majority of new jobs will be in industries other than high technology. Therefore, displaced workers and others seeking jobs, and governmental and community organizations seeking to attract jobs to their regions, would be well advised not to limit their search to high tech industries only.

One additional factor may have a negative effect on the ability of high tech industries to save economically depressed industries and provide jobs for displaced workers. The occupational composition of many rapidly growing high tech industries is significantly different from other manufacturing industries that have suffered in recent years. For example, about three-fourths of the workers in the blast furnaces and basic steel industry and the motor vehicles industry are blue-collar workers. These are the workers who have been displaced. However, many high tech industries, especially those projected to grow the fastest, have a much smaller proportion of their workers in these occupations. (See table 3.)

High technology occupations

High technology occupations have also been the subject of much concern recently, although here too data on current and projected employment and clear definitions of what occupations are included have been lacking.

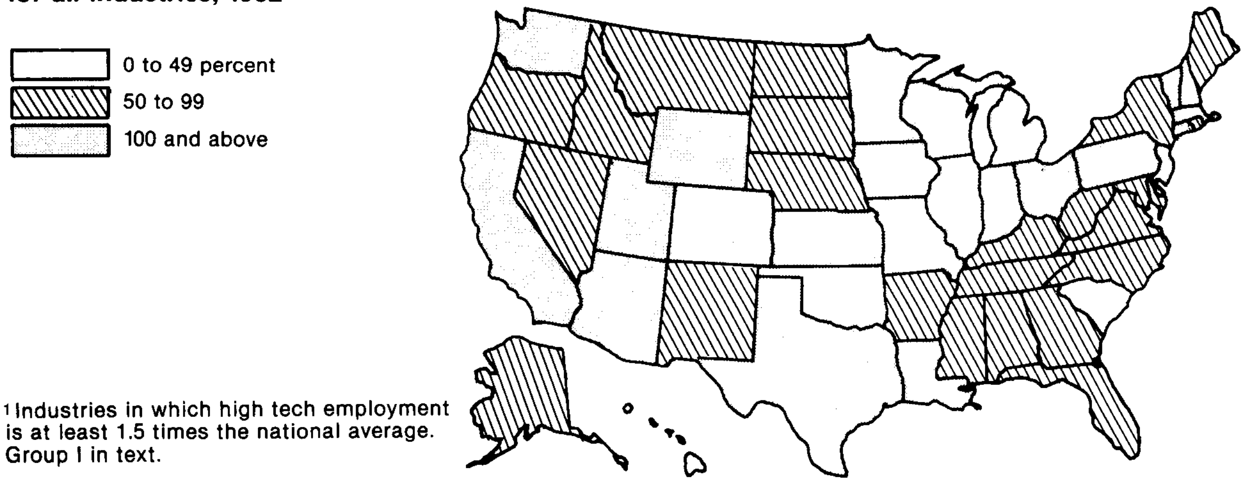
Occupations which clearly meet the definition of high technology workers are engineers, life and physical scientists, mathematical specialists, engineering and science technicians, and computer specialists. Most workers in these technology-oriented occupations are directly involved in developing or applying new technologies.[11] Their work requires in-depth knowledge of theories and principles of science, engineering, and mathematics underlying technology—a knowledge which distinguishes them from computer operators, computer service technicians and other high tech machinery repairers, or workers in a wide range of occupations who use word processing machines, computers or other high technology products, but rarely have—or need—such in-depth knowledge. Workers in these technology-oriented occupations generally need specialized post-high school education in some field of technology—ranging from an associate degree or its equivalent to a doctorate—education with a thorough high school preparation in science and mathematics as a prerequisite.

Technology-oriented workers, while essential to the development of technology, are relatively few in number and will account for a relatively small proportion of new jobs through 1995. In 1982, technology-oriented employment totaled 3.3 million, or about 3.2 percent of total employment. (See table 4.) Through 1995, this employment is projected to show growth ranging from 45.3 to 49.3 percent, much faster than the 23- to 28-percent increase projected for all wage and salary workers. This growth is expected to generate between 1.5 and 1.6 million new jobs over the 13-year period. These occupations are projected to account for 6 percent of all new jobs in the economy, roughly the same proportion as during the 1970's.

Local employment levels

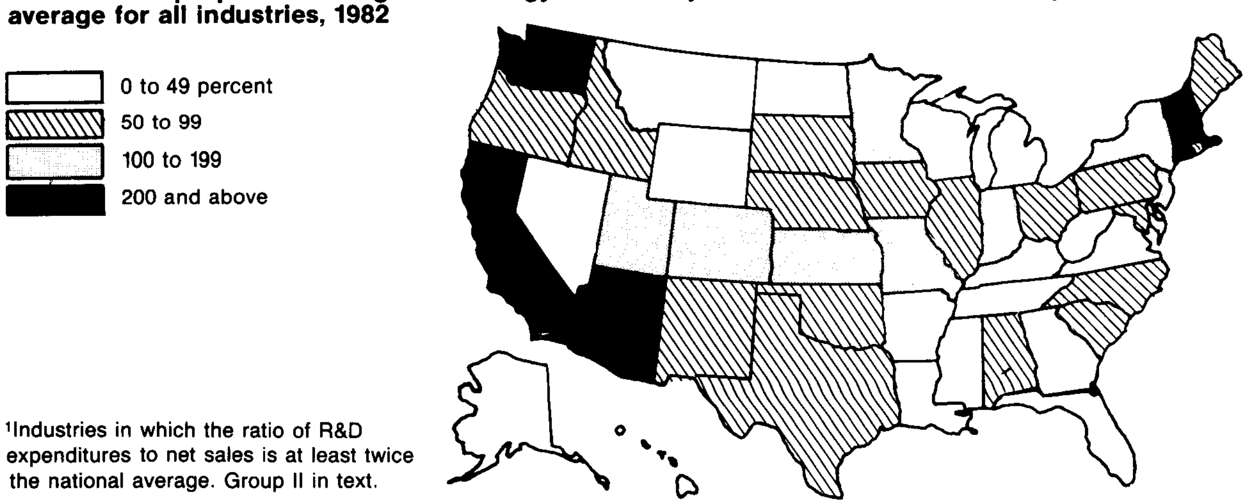
High technology employment is not expected to take up the slack in job generation caused by the long-term decline in heavy durable goods industries, including those we have defined as high tech. What is true for the Nation as a whole of course, does not hold for certain States and areas. (See charts 1 and 2.) High technology employment can have a

Chart 1. The proportion of high technology workers by State in 48 industries[1] compared with the average for all industries, 1982



[1] Industries in which high tech employment is at least 1.5 times the national average. Group I in text.

Chart 2. The proportion of high technology workers by State in six industries[1] compared with the average for all industries, 1982



[1] Industries in which the ratio of R&D expenditures to net sales is at least twice the national average. Group II in text.

Table 5. Metropolitan areas ranked by high technology employment levels and percentages of total nonagricultural employment in three States, September 1982

[In thousands]

State	Group I			Group II			Group III		
	SMSA[1]	Number of employees	Percent	SMSA[1]	Number of employees	Percent	SMSA[1]	Number of employees	Percent
California, total		1,523.3			616.3			930.0	
Top 5 areas, total		1,321.1			574.5			848.4	
Top 5 areas as percent of State's high tech employment		86.7			93.2			91.2	
	Los Angeles	606.3	17.2	Los Angeles	259.5	7.4	Los Angeles	365.0	10.4
	San Jose	261.3	37.5	San Jose	169.5	24.3	San Jose	227.7	32.7
	Anaheim	175.7	20.9	Anaheim	78.4	9.3	Anaheim	121.3	14.4
	San Francisco	173.0	11.1	San Diego	45.1	6.8	San Francisco	67.4	4.3
	San Diego	104.8	15.8	San Francisco	22.0	1.4	San Diego	67.0	10.1
Texas, total		1,016.8			154.4			362.3	
Top 5 areas, total		739.2			134.0			286.3	
Top 5 areas as percent of State's high tech employment		72.7			86.8			79.0	
	Houston	349.1	22.0	Dallas	102.0	6.6	Dallas	140.9	9.1
	Dallas	284.5	18.4	Houston	10.4	.7	Houston	86.9	5.5
	San Antonio	36.4	8.7	Austin	10.4	3.8	Beaumont	24.0	16.2
	Beaumont	35.3	23.8	San Antonio	7.1	1.7	Austin	21.6	8.1
	Austin	33.9	12.6	Lubbock	4.3	4.8	San Antonio	12.9	3.1
Michigan, total		623.4			28.8			118.4	
Top 5 areas, total		490.3			24.5			88.3	
Top 5 areas as percent of State's high tech employment		78.6			85.1			74.6	
	Detroit	325.5	21.0	Detroit	11.7	.8	Detroit	48.1	3.1
	Flint	59.2	33.9	Kalamazoo	7.9	7.5	Grand Rapids	15.8	6.0
	Ann Arbor	37.4	28.5	Muskegon	2.2	3.9	Kalamazoo	10.6	10.0
	Grand Rapids	34.9	13.3	Grand Rapids	1.4	.6	Ann Arbor	9.5	7.2
	Lansing	33.3	18.6	Benton Harbor	1.3	2.4	Muskegon	4.3	7.6

[1]Standard Metropolitan Statistical Area.

large impact on a local economy. Local success stories include California's Silicon Valley and the Route 128 area in Massachusetts and New Hampshire.[12] In a relatively short period, these areas have developed substantial industrial bases built on high technology industries.

We analyzed data on the distribution of high technology employment in three States—California, Michigan and Texas. The results are shown in table 5.[13]

Regardless of the definition used, we found most employment to be located in the largest metropolitan areas. The top five areas in each State accounted for between 72.7 and 93.2 percent of the high tech jobs, depending on the State and definition used. Nonagricultural employment in these areas ranged from 63.7 to 74.2 percent of all employment in each State. Thus, the distribution of high technology employment appears to be concentrated within the States.

In California, the Los Angeles area, with a large aerospace industry, shows the highest level of high technology employment by a large margin over San Jose. However, the San Jose area, which contains "Silicon Valley," has the highest proportion of high tech jobs in California, regardless of definition. In the San Jose area, from a quarter to more than one-third of the jobs are in high tech industries.

Texas ranked second, third, and fourth in the *number* of high technology jobs. Because of its size and large employment base, however, it ranked no higher than eighth in the *proportion* of workers in high tech jobs. When scrutinized at the metropolitan level, however, several Texas areas emerge as high technology centers.

Dallas provided over 100,000 high technology jobs, regardless of definition. The Houston area is also a major source of jobs, while Beaumont shows a large proportion of high tech jobs in groups I and III, primarily because of its chemical and petroleum refining industries.

Michigan has a high proportion of high technology jobs in group I, which includes auto manufacturing. (See table 6). With groups II and III, Michigan ranks 14th and 39th among all States. Detroit, under the group III definition, shows almost 50,000 high technology jobs, and the Kalamazoo area displays a smaller proportion of high tech workers (7.5 and 10.0 percent in groups II and III).

Outside of those two areas, high technology industry does not appear to be a major factor in the Michigan economy unless auto manufacturing remains in the high technology definition.

If we look at the nonmetropolitan proportion of high tech employment in the three States, we find that California has 1.6 percent in group I, .4 percent in group II, and .5 percent in group III; Texas, 10.4, 4.0, and 5.8; and Michigan, 9.5, 7.8, and 15.6.

Few counties outside metropolitan areas have many high tech jobs. (Hutchinson County in Texas is an exception, with more than 5,000 in group I, and almost 2,500 in group III.)

Employment by State

In 1982, the share of the Nation's high technology employment in the 10 States with the highest levels of high tech employment ranged from 57.4 to 66 percent among our three groups, while these States had only 54.1 percent of the total U.S. nonfarm employment. (See table 6.) Eight States—California, New York, Texas, Massachusetts, New Jersey, Florida, Illinois, and Pennsylvania, appear on all three lists. All were also among the 10 States with the most nonagricultural employment in 1982. Only two States not among the top 10 in employment appear on the three lists—Washington and Connecticut—largely because each had more than 10 percent of the national employment in aircraft and parts (SIC 372), which appears in all three high technology definitions.

California not only heads each list but does so by a large margin. New York's total nonagricultural employment was 74 percent of California's in 1982, but it had only half of California's high technology employment in group III, and about a third of its group II employment, illustrating the importance of definitions.

Has the concentration of high tech employment within the larger States increased over the last several years? The following shows the percentage of total U.S. high technology employment in the top 5 States under each definition for selected years from 1975 to 1982:

	1975	*1977*	*1979*	*1982*
Group I	38.4	37.8	38.3	37.4
Group II	46.7	47.1	47.6	47.5
Group III	41.6	40.9	40.4	40.7

The concentration of high technology employment in the largest States does not appear to be increasing, regardless of the definition used.

As we have seen, comparing a State's high technology employment to its total nonagricultural employment produces a much different picture than looking at absolute levels. Small States appear on these lists, as a broad spectrum of industries in large States tends to overshadow small groups of emerging industries. Only under the broadest definition—group I—do as many as 5 of the 10 States with the most nonfarm employment qualify. Under the most restrictive definition—group II—only two large States are included.

Table 6. Employment in three groups of high technology industries in 10 States with highest levels of high technology employment, annual averages,[1] 1982

[In thousands]

Group I		Group II		Group III	
Total, U.S.	13,038.3	Total, U.S.	2,633.7	Total, U.S.	5,943.4
Top 10 States	7,489.5	Top 10 States	1,737.4	Top 10 States	3,566.6
California	1,527.5	California	610.6	California	933.1
Texas	1,068.4	New York	205.3	New York	493.4
New York	924.0	Massachusetts	160.7	Texas	372.0
Ohio	683.0	Texas	157.6	New Jersey	316.8
Illinois	672.0	New Jersey	116.9	Massachusetts	305.5
Michigan	651.0	Florida	108.1	Pennsylvania	277.0
Pennsylvania	615.4	Connecticut	98.5	Illinois	261.5
New Jersey	521.7	Illinois	96.2	Ohio	247.8
Massachusetts	450.0	Pennsylvania	93.3	Connecticut	185.8
Florida	376.5	Washington	90.2	Florida	173.7

[1]Because fourth quarter 1982 data were not available at the time of publication, a 9-month average was used.

Table 7. High technology employment as a percent of total nonagricultural employment in top 10 States under three definitions, 1982 annual average[1]

Group I		Group II		Group III	
Total, U.S.	13.4	Total, U.S.	2.8	Total, U.S.	6.2
Delaware	24.0	New Hampshire	7.2	Delaware	16.2
New Hampshire	21.0	Vermont	7.0	Connecticut	13.0
Michigan	20.4	Connecticut	6.9	New Hampshire	12.5
Connecticut	20.3	Arizona	6.8	Vermont	11.7
Vermont	18.9	California	6.2	Massachussetts	11.7
Indiana	17.6	Massachussetts	6.1	New Jersey	10.3
Massachussetts	17.2	Washington	5.7	California	9.5
Texas	17.0	Kansas	4.7	Arizona	9.0
New Jersey	16.9	Utah	4.2	Washington	8.2
Kansas	16.5	Colorado	3.9	Kansas	7.8
Ohio	16.5				

[1]9 month average.

It is noteworthy that Massachusetts, despite its size, is on all three lists. (See table 7).

Turning again to group I, we find 46 States had 10 percent or more of their nonagricultural employment in high technology industries. However, in group II no State had more than 7.2 percent of high tech employment.

The performance of Delaware under the three definitions is quite interesting. It tops groups I and III with 24.0 and 16.2 percent of its nonfarm employment in high technology. In group II, however, Delaware places 42nd in the Nation, with only .8 percent. Groups I and III both include the entire chemical manufacturing industry (SIC 28). Group II only includes drug manufacturing (SIC 283). Because more than 10 percent of the total employment in Delaware is in chemical manufacturing (about 10 times the national proportion), any high technology definition which includes the entire chemical industry places Delaware at or near the top in the proportion of high tech employment.

A regional pacesetter

The relative importance of high technology among States, however, no matter how defined, shows that the New England States lead other regions in the proportion of high technology employment. The New England area has provided the ideal environment for these industries. Preeminent educational institutions provide the needed skilled workers. Also, for many decades the area has had a decaying industrial base. In 1947, Massachusett's leading nondurable manufacturing industries were textiles, apparel, and leather, with a total employment of almost 250,000 workers. In 1982, employment in those industries totaled slightly more than 75,000 workers. The departure of the textile and apparel industry to the South and overseas left behind an industrial infrastructure, coupled with an awareness of the need to attract and foster industrial development. New England States (with the exception of Massachusetts) also tend to be small, making, as noted, the impact of high technology employment more noticeable.[14]

Although for the Nation as a whole, high technology industries generated only between 4.7 and 15.3 percent of the new jobs in the United States during 1972–82, several

States showed greater growth. Even in narrowly defined group II, nine States saw high tech jobs account for 10 percent or more of the rise in their total employment between 1975 and 1982. In Massachusetts, growth exceeded 18 percent. (See table 8.) Maine, absent from the top 10 in percentage of high tech employment, appears to have experienced significant job generating effects from high tech expansion under the group II definition.

However, care must be used in analyzing the impact of high technology growth in a State. A State may register a large increase in high tech jobs in a generally expanding economy, or a modest gain in a stagnant economy. Examples of both situations appear in all three groups of high tech industries. Massachusetts, which tops groups II and III and ranks fourth in group I, is an example of the first situation. Massachusetts ranked 10th in total job creation between 1975 and 1982 and depending on definition, 3rd, 2nd, or 4th in high tech job generation. South Dakota, which ranks 1st, 8th, and 3rd in percentage growth of high tech jobs, added a total of only about 20,000 new jobs, one of the smallest increases in the country. However, a large proportion (10.0 to 49.1 percent—according to definition) were high tech, such as those within electrical and nonelectrical machinery manufacturing (SIC 35 and 36).

Table 8. High technology employment growth as a percentage of total nonagricultural employment growth in top ten States, 1975–82, under three definitions

Group I		Group II		Group III	
Total, U.S.	21.0	Total, U.S.	5.8	Total, U.S.	11.3
South Dakota	49.1	Massachussetts	18.3	Massachussetts	30.0
New Hampshire	43.1	New Hampshire	15.8	Vermont	26.9
Vermont	38.7	Vermont	11.5	South Dakota	25.1
Massachussetts	35.2	Arizona	10.6	New Hampshire	25.0
Nebraska	33.1	Maine	10.1	Connecticut	21.4
Rhode Island	32.6	California	10.0	Idaho	19.9
Idaho	32.4	Oregon	10.0	Maryland	19.9
Montana	31.5	South Dakota	10.0	District of Columbia	19.8
Delaware	30.7	Washington	10.0	Rhode Island	19.2
Colorado	30.3	Rhode Island	9.1	Oregon	18.0

IT SHOULD BE REITERATED that even when high tech is very broadly defined, as in group I, it has provided and is expected to provide a relatively small proportion of employment. Thus, for the foreseeable future the bulk of employment expansion will take place in non-high tech fields. □

——*FOOTNOTES*——

[1] Robert Vinson and Paul Harrington, *Defining High Technology Industries in Massachusetts* (Boston, Mass., Department of Manpower Development, September 1979.)

[2] *Ibid.*

[3] *Technology, Innovation, and Regional Economic Development* (Washington, U.S. Congress, Office of Technology Assessment, Sept. 9, 1982). This 14-page report describes a project to assess the implications of high technology to include factors which promote the development of high technology industries in States and localities.

[4] *An Assessment of U.S. Competitiveness in High Technology Industries* (Washington, U.S. Department of Commerce, International Trade Administration, February 1983), 68 pp. See, particularly, Appendix A, "Defining Technology Intensive Trade," pp. 33–37.

[5] Ibid. See also Michael Boretsky, "Concerns About the Present American Position in International Trade," *Technology and International Trade* (Washington, National Academy of Sciences, 1971), and "The Threat to U.S. High Technology Industries: Economic and National Security Implications," draft (Washington, U.S. Department of Commerce, International Trade Administration, March 1982).

[6] Ibid. See also Regina Kelly, "Research and Development in U.S. Trade in Manufactures," paper prepared for International Economics Course, George Washington University, 1974, and "The Impact of Technological Innovation on International Trade Patterns," *Staff Economic Report*, (Washington, U.S. Department of Commerce, Office of Economic Research, December 1977).

[7] Ibid. See also C. Michael Aho, and Howard F. Rosen, "Trends in Technology-Intensive Trade," *Economic Discussion Paper 9* (Washington, U.S. Department of Labor, Bureau of International Labor Affairs, October 1980).

[8] Ibid. See also Lester A. Davis, "Technology Intensity of U.S. Output and Trade," (Washington, U.S. Department of Commerce, International Trade Administration, July 1982.)

[9] Ann M. Lawson, "Technological Growth and High Technology in U.S. Industries" (Washington, U.S. Department of Commerce, Bureau of Industrial Economics, *Industrial Economics Review*, Spring 1982), p. 12.

[10] See Arthur J. Andreassen, Norman C. Saunders, and Betty W. Su, "The economic outlook for the 1990's: three scenarios for economic growth;" Valerie A. Personick, "The job outlook through 1995: industry output and employment projections," and Howard N Fullerton and John Tschetter, "The 1995 labor force: a second look," elsewhere in this issue.

[11] Some managerial jobs also involve the development and application of technology, and many of these jobs are filled by workers transferring from these "technology-oriented" occupations. Data are not available to identify this group.

[12] "America Rushes to High Technology for Growth," *Business Week*, March 28, 1983, p. 87.

[13] The industry employment statistics cited in this study are from two Bureau of Labor Statistics payroll employment programs. The industry classifications are taken from the 1972 Standard Industrial Classification Manual, Office of Management and Budget.

Employment estimates for the Nation were compiled from the Current Employment Statistics program. These data are produced from employer payroll records reported to the Bureau on a voluntary basis each month. Self-employed persons and others not on a regular civilian payroll are outside the scope of the survey.

State and county data were compiled from the ES-202 program, which collects information on the employment and wages of workers covered by unemployment insurance programs. Each quarter all covered employers submit mandatory reports of employment and wages to the appropriate State Employment Security Agency. These reports are edited and summarized by county, State, and detailed industry, and forwarded to the Bureau. Self-employed persons are not covered in this statistical program.

[14] For more on the factors which enabled New England to become a leading area in high technology, see Lynn E. Browne and John S. Hekman, "New England's Economy in the 80's," *New England Economic Review*, January/February 1981, pp. 5–16.