

Ohio's Technology Sector

- Ohio's high-technology cluster includes over 23,600 private sector establishments employing 453,000 people, based on data and criteria from the U.S. Bureau of Labor Statistics.
- This cluster of goods-producing and service-providing industry groups saw a net increase of over 1,000 establishments from 2001 to 2006, but experienced a net loss of about 27,700 jobs, a 5.8 percent decline.
- Two groups were notable exceptions to the overall jobs trend: managing of companies and enterprises gained almost 21,400, and R & D services gained almost 3,000.

Corporate R&D Expenditures

- Ohio's private-sector spent \$5.9 billion on R&D in 2005 - about 1.3 percent of the state's gross domestic product.
- 2,032 companies in Ohio performed industrial R&D activities. Ohio ranks 4th in the number of such companies and 10th in funds spent, according to the latest available data.
- Almost 77 percent of industry-performed R&D in Ohio is conducted by manufacturing companies.
- Ohio's concentration in manufacturing R&D is focused on products from basic chemicals, petroleum, coal, rubber, plastics, and non-metallic minerals, as well as paper and printing, primary and fabricated metals, electrical and transportation equipment (particularly aerospace and motor vehicles), appliances, and machinery.
- Outside of manufacturing, corporate R&D in Ohio focuses on construction, transportation and warehousing, and companies specializing in scientific R&D.

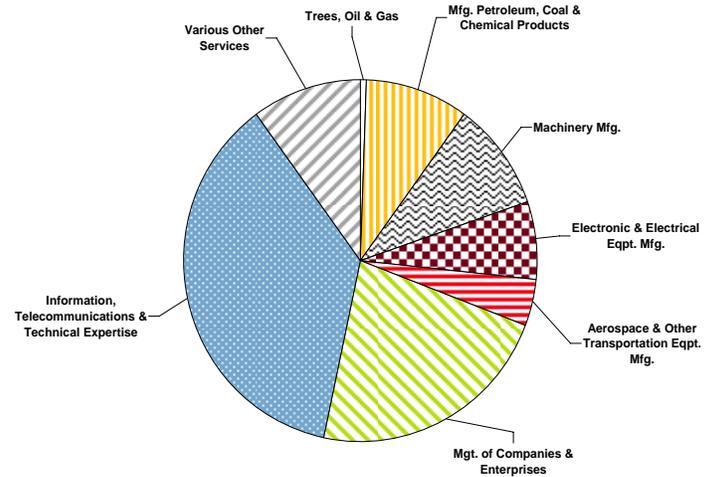
Academic R&D Expenditures

- R&D expenditures at Ohio's colleges and universities totaled \$1.53 billion in FY 2005. Ohio ranked 9th— just below North Carolina and just above Michigan.
- Academic research, unlike industrial research, has experienced strong growth recently. From 2000 to 2005, expenditures increased 66.7 percent in Ohio and 52.1 percent for the nation.
- In 2005, 61 percent of all academic R&D expenditures were directed to life sciences; 21 percent supported engineering; the national percentages were 60 and 15, respectively.
- Ohio State, the University of Cincinnati, and Case Western Reserve accounted for 79.6 percent of the \$1.53 billion total.

Venture Capital

- There were 49 venture capital deals involving 43 Ohio companies during 2007, according to the MoneyTree Survey; these 49 deals totaled \$170 million.
- While the number of companies and their deals are fairly typical of recent years, the total amount invested is below average.

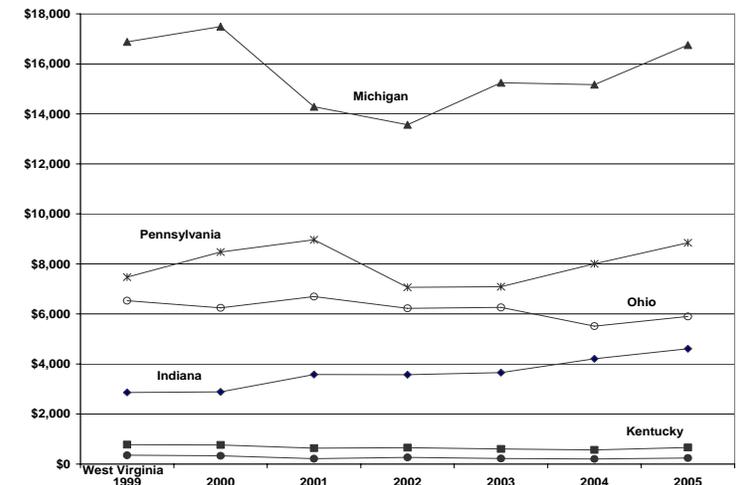
High-Technology Employment



Source: U.S. Bureau of Labor Statistics

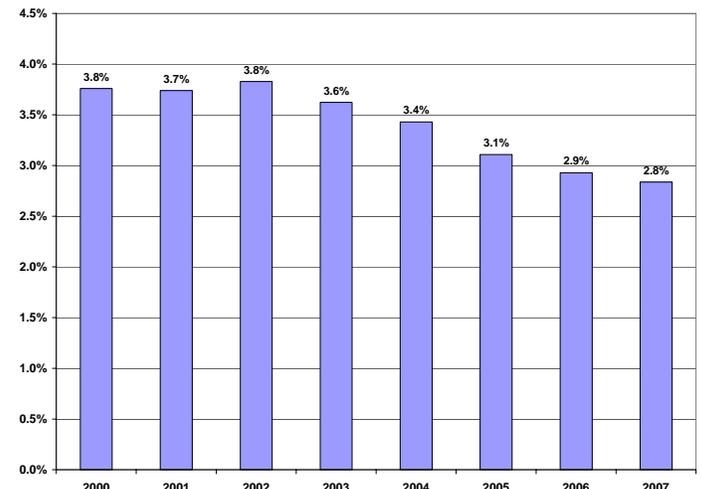
Corporate R&D Trends

(in millions of current dollars)



Source: National Science Foundation

Ohio's Share of U.S. Utility Patents



Source: U.S. Patent and Trademark Office

Patents and Technology Platforms

Ohio ranked 12th among the 50 states and the District of Columbia in 2007 with a total of 2,255 inventor patents (a.k.a. utility patents). This is the smallest number of such patents since 1988. The 2,255 patents were 2.8 percent of the total for the year.

Battelle recently analyzed Ohio patents assigned to academic institutions, independent inventors, and private companies as part of an effort to identify key technology platforms. According to Battelle, technology platforms serve as a bridge between a region's research core competencies and their application to commercial products. (*Positioning the State of Ohio for Economic Growth: Strategically Aligning Ohio's Research and Technology Portfolio*, June 2006.) A synopsis of selected platforms follows.

Advanced Materials

Research in advanced materials is leading to next-generation machines, improvements in product performance, and waste-free products. Applications range from combat armor and ceramic engine parts to prosthetic devices.

Academically, Ohio's strength in this field comes mainly from research conducted at The Ohio State University (OSU), Case Western Reserve (CWRU), the University of Cincinnati (UC), and the University of Dayton (UD).

Nationally, UD and OSU ranked second and third in total materials research in FY 2002. OSU partners with the Edison Welding Institute and houses the Fontana Corrosion Center. UD has the Center for Material Diagnostics.

Ohio's private-sector spent \$430 million in R&D related to advanced materials. Battelle identified 1,082 Ohio patents pertaining to advanced materials approved from 1999 through 2004. Patent leaders include Procter & Gamble, General Electric, and Lubrizol.

Electronics

Ohio leads the nation in the production of electrical equipment and appliances (NAICS 335) on the strength of manufacturers such as GE Lighting, Whirlpool, Rockwell Automation, Royal/Hoover, LSI Industries, and Holophane.

The Battelle report notes that electronics hardware and systems are at the heart of advanced instruments and machinery for power generation, transportation, and defense.

Gauging the state's investment in electronics R&D is somewhat difficult since much of the research is categorized under related industries; e.g., Delphi's research in electronic systems might be classified under motor vehicles.

Battelle identified 2,278 patents in the electronics cluster. Leading patent technologies include measuring and testing, heating, and switches.

Academic centers include OSU's Electroscience Laboratory and the NSF Industry-University Center for Intelligent Maintenance Systems at the University of Cincinnati.

Engineered Components and Industrial Machinery

Industrial machines—such as motors, pumps, valves, and

the components used to make manufacturing machinery—are the building blocks of industrial production systems.

The Battelle study found \$391 million in R&D efforts and 1,050 patents—in areas such as liquid purification, fluid handling, plastic shaping, pumps, valves and engines. Patent leaders include Dana, Parker Hannifin, and General Electric.

Engines, Turbines, and Power Generation Equipment

Ohio has a combination of strong engineering programs and research centers coupled with a unique industry base—the state is a leader in the production of motor vehicle engines, turbines, and power generation equipment.

Battelle's patent clustering analysis identified 336 patents with concentrations in power plants, internal combustion engines, fuel and related compositions, and pumps.

Academically, CWRU, UD, UC, and OSU have long-term partnerships with NASA Glenn, Wright-Patterson and/or GE Aircraft Engine.

Vehicle Systems

Ohio ranks second in the production of motor vehicles and vehicle parts.

In 2003, the state's transportation industry spent \$877 million at R&D centers operated by companies such as Honda, Delphi, and Dana. In addition, much of the industrial research conducted in Ohio in fields such as electronics, polymers, materials, and engines is related to the development of vehicle systems.

Academic research centers include the Transportation Research Center of Ohio, which develops national safety standards, UC's Center for Intelligent Maintenance Systems, and OSU's Center for Automotive Research.

Polymers

Ohio leads the nation in the production of rubber and plastics (NAICS 326) and ranks first in R&D expenditures.

Battelle identified 1,082 polymer patents—606 were in the synthetic resins or natural rubbers class. Goodyear, PPG Industries, and Ashland Chemical were among the patent leaders.

Academically, the University of Akron ranks second nationally and Case Western Reserve ranks sixth for their polymer programs.

Experimental Therapeutics and Diagnostics

According to Battelle, Ohio's strength in the biological sciences has led to a concentration in the fields of cancer and cardiovascular research and treatment, genomics, genetics, and neurology.

Academically, OSU has strengths in cancer genetics and pharmacy sciences, while the Cleveland Clinic and Case Western Reserve have overlapping strengths in cancer and

cardiovascular work. The Genome Research Institute in Cincinnati focuses on research in cancer and metabolic disorders.

Ohio's pharmaceutical industry employs 5,000 workers and is growing. The worldwide pharmaceutical market is projected to grow to \$3 trillion by 2020—a state capturing only a fraction of a percent of such a huge market would still see major economic gains, according to Battelle.

R&D Institution: Battelle Memorial Institute

Battelle Memorial Institute is headquartered in Columbus and employs a staff of 2,700 workers in the Columbus area.

Battelle is the world's largest non-profit independent research and development organization with 20,000 employees in more than 120 locations worldwide, including five national laboratories Battelle manages or co-manages for the U.S. Department of Energy.

Battelle conducts \$3.7 billion in R&D annually through contract research, laboratory management, and technology commercialization. Battelle provides innovative solutions to some of the world's most important problems including global climate change, sustainable energy technologies, high performance materials, next generation healthcare diagnostics and therapeutics, and advanced security solutions for people, infrastructure, and the nation.

Battelle and the national laboratories it manages or co-manages for the U.S. Department of Energy won 13 of the R&D 100 Awards for FY 2007.

R&D Institution: NASA Glenn Research Center

NASA Glenn is located adjacent to Cleveland Hopkins International Airport and employs more than 1,600 civil servant workers and 1,400 contract workers—over half are scientists or engineers.

NASA Glenn's impact on the state's economy exceeds \$1.2 billion and supports 10,000 jobs, according to Cleveland State University's most recent economic impact study.

Glenn leads NASA's research in the microgravity disciplines of fluid physics, combustion science, and the field of microgravity acceleration measurement.

Glenn also leads NASA research and development in aeropropulsion and has started work on a NASA research effort to convert such natural energy sources as coal, natural gas, biomass, and shale oil into a cleaner and more economical alternative to traditional commercial jet fuel.

In June 2006, NASA announced that Glenn Research Center will manage work on the service module for the new Orion spacecraft. This work will secure the Center's future in the near term and signals a shift in priorities from aeronautical research to space exploration.

NASA plans to use Orion to replace the aging shuttle fleet for missions to the International Space Station. It will take astronauts to the moon by 2020 and play a role in getting them to Mars. Its first flight with an astronaut crew is scheduled for September 2015.

R&D Institution: Wright-Patterson Air Force Base

Wright-Patterson Air Force Base is the foremost research and development center of the United States Air Force—the source for nearly every major innovation in U.S. military aviation and a major catalyst for high-tech growth in the Dayton region.

The Air Force Research Laboratory (AFRL) at Wright-Patterson is responsible for many of the century's most dramatic innovations in avionics and composites and a prominent source of technology transfer from military to civilian commercial use.

Wright-Patterson employs 18,250 civilian (10,350) and military personnel (7,900). At 8,145 acres, the Air Base is considered the largest employer at a single site in the state.

The Third Frontier Project

The Third Frontier Project was initiated in February 2002. This project is the state's largest-ever commitment to expanding the state of Ohio's high-tech research capabilities and promoting innovation and company formation that will create high-paying jobs for generations to come. The 10-year, \$1.6 billion initiative is designed to:

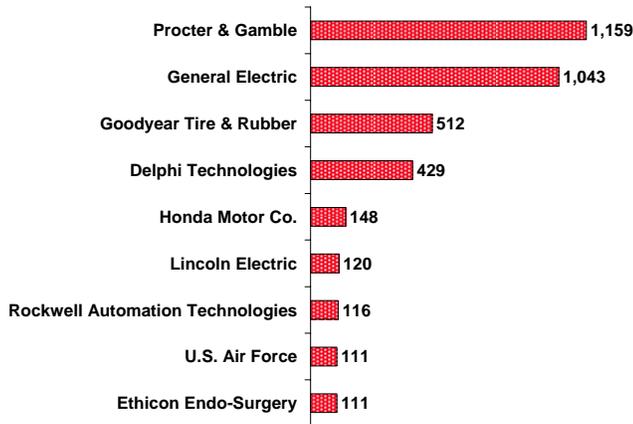
- Build world-class research capacity
- Support early stage capital formation and the development of new products
- Finance advanced manufacturing technologies to help existing industries become more productive

Through the Third Frontier Project, additional federal and private-sector support could boost the total investment to more than \$6 billion.

Edison Technology Centers

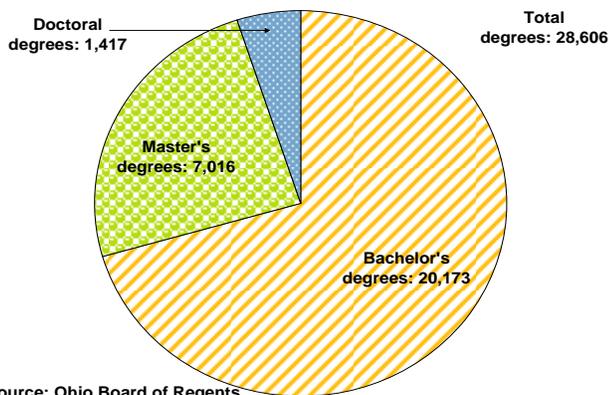
The Edison Technology Centers located around the state link industry with academia and government in partnerships to strengthen industrial competitiveness through technological innovation. They are: the Akron Industrial Incubator, the Innovation Center in Athens, Biostart and the Hamilton County Business Center in Cincinnati, Jumpstart and Venture Development MAGNET in Cleveland, Incubation Services TechColumbus, the Entrepreneurs Center in Dayton, Great Lakes Innovation and Development Enterprise in Elyria, the Braintree Center for Business Innovation in Mansfield, the Regional Growth Partnership in Toledo, and the Youngstown Business Incubator.

Ohio Patent Leaders, 2002 - 2006



Source: U.S. Patent & Trademark Office

Engineering Degrees, 2002 - 2006



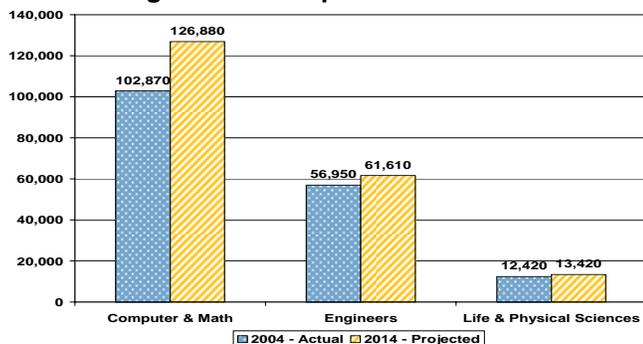
Source: Ohio Board of Regents

Occupation by Type of Employer (in thousands)

	Computer & Math	Architecture & Engineering	Life, Physical & Social Science
Total	108.1	101.6	43.8
Private company	82.3	86.0	24.7
Private non-profit	7.4	1.3	6.1
Self-employed	5.3	4.2	3.1
Government	13.1	10.0	9.9

Source: 2006 American Community Survey

Selected High Tech Occupations: 2004 and 2014



Source: ODJFS, Labor Market Information

Human Capital

Corporate Researchers

- Ohio's private for-profit companies employ 193,000 science, math, and engineering professionals. (See the middle-left table.)
- R&D activity in Ohio during 2005 was funded by \$5.9 billion. 92.3 percent of those expenditures were made by private sector organizations.
- Ohio was credited with 14,350 utility patents from 2002 through 2006. More than one-fourth was assigned to Ohio's top nine patenting companies. (See the upper-left chart.)
- Beginning in 2001, ODOD identified 140 significant new or expanded projects involving research and development activity; \$1 billion of investments were planned and over 7,000 new jobs anticipated when the projects are completed.

Entrepreneurs

- Over 12,500 self-employed science, computer, math, architectural and engineering professionals live in Ohio.
- Over 1,900 patents were granted to individual inventors in Ohio during the 2002-2006 period.
- Small businesses in Ohio received 1,563 SBIR awards worth \$423.7 million during FY1997-FY2004, ranking the state 8th and 7th, respectively.
- Ohio's Technology Investment Tax Credit, since its inception in 1996, has provided incentives for investment in 380 small Ohio technology startups.

Universities and Degrees

- There were 19 universities with graduate-level science and/or engineering programs in Ohio during 2006.
- In 2006, 12,908 students were enrolled in graduate-level science programs in Ohio; 3,402 of them were here on temporary visas. An additional 5,253 were enrolled in graduate-level engineering programs, with 2,597 of them here on temporary visas.
- In 2006, Ohio's colleges and universities awarded 4,236 bachelors, 1,494 masters, and 350 doctoral degrees in engineering fields; the summary number of 6,080 is an 18 percent increase from 2001.

Science, Engineering, Math, and Computers

- There were over 172,000 Ohioans working in computer, math, engineering, and physical and life science occupations in 2004. Their numbers are projected to increase 17.2 percent to almost 202,000 in 2014.
- Among specific occupations, Ohio also has relatively high concentrations of chemical, industrial, material and mechanical engineers, as well as chemists and material scientists.

High-Technology Industry Groups

An industry group is defined as "high-tech" if the percentage of selected occupations - computer or mathematical scientists, drafters, engineering or mapping technicians, physical and life scientists, or physical, life, and social science technicians, and managers of such - is at least twice the national average of 4.9%. In level 3 groups, such occupations comprise 9.8% to 14.7% of all jobs. In level 2 groups, they range from 14.8% to 24.6% of the jobs, and in level 1 they are at least 24.7% of all jobs.

Table: High-Technology Establishments and Employment in Ohio

NAICS Code	Industry Group Title	Establishments				Employment			
		2001	2006	Changes Number Pct.	2001	2006	Changes Number Pct.		
	Total	285,601	290,716	5,115 1.8%	5,435,231	5,314,572	-120,659 -2.2%		
	Summary of All High Technology Industries	22,599	23,642	1,043 4.6%	479,749	452,002	-27,747 -5.8%		
	Level 1 Summary	10,739	10,835	96 0.9%	178,967	160,331	-18,636 -10.4%		
3254	Pharmaceutical & Medicine Mfg.	54	48	-6 -11.1%	4,381	5,332	951 21.7%		
3341	Computer & Peripheral Eqpt. Mfg.	53	32	-21 -39.6%	3,709	1,899	-1,810 -48.8%		
3342	Communications Eqpt. Mfg.	72	66	-6 -8.3%	8,755	3,926	-4,829 -55.2%		
3344	Semiconductor & Other Electronic Component Mfg.	184	167	-17 -9.2%	10,581	6,586	-3,995 -37.8%		
3345	Navigational/Measuring/Electromedical/Control Instrmnts. Mfg.	303	268	-35 -11.6%	13,894	9,534	-4,360 -31.4%		
3364	Aerospace Product & Parts Mfg.	116	116	0 0.0%	16,946	15,817	-1,129 -6.7%		
5112	Software Publishers	196	311	115 58.7%	3,645	3,541	-104 -2.9%		
5161	Internet Publishing & Broadcasting	77	78	1 1.3%	3,554	3,563	9 0.3%		
5179	Other Telecommunications	23	16	-7 -30.4%	533	148	-385 -72.2%		
5181	Internet Service Providers & Web Search Portals	403	398	-5 -1.2%	6,253	4,252	-2,001 -32.0%		
5182	Data Processing, Hosting & Related Services	311	299	-12 -3.9%	5,678	4,682	-996 -17.5%		
5413	Architectural, Engineering & Related Services	3,714	3,615	-99 -2.7%	43,318	41,740	-1,578 -3.6%		
5415	Computer Systems Design & Related Services	4,667	4,801	134 2.9%	45,623	44,232	-1,391 -3.0%		
5417	Scientific Research & Development Services	566	620	54 9.5%	12,097	15,079	2,982 24.7%		
	Level 2 Summary	7,566	8,174	608 8.0%	110,514	97,873	-12,641 -11.4%		
2111	Oil & Gas Extraction	191	176	-15 -7.9%	2,630	2,386	-244 -9.3%		
2211	Electric Power Generation, Transmission & Distribution	369	308	-61 -16.5%	19,298	16,056	-3,242 -16.8%		
3251	Basic Chemical Mfg.	169	175	6 3.6%	11,774	10,348	-1,426 -12.1%		
3252	Resin, Synthetic Rubber & Fibers & Filaments Mfg.	97	104	7 7.2%	5,544	5,819	275 5.0%		
3332	Industrial Machinery Mfg.	322	297	-25 -7.8%	10,814	9,798	-1,016 -9.4%		
3333	Commercial & Service Industry Machinery Mfg.	127	110	-17 -13.4%	7,573	3,751	-3,822 -50.5%		
3343	Audio & Video Eqpt. Mfg.	12	9	-3 -25.0%	203	106	-97 -47.8%		
3346	Mfg. & Reproducing Magnetic & Optical Media	37	22	-15 -40.5%	850	234	-616 -72.5%		
4234	Professional & Commercial Eqpt. & Supplies Merchant Whlsr.	2,118	2,142	24 1.1%	27,924	24,954	-2,970 -10.6%		
5416	Management, Scientific & Technical Consulting Services	4,124	4,831	707 17.1%	23,904	24,421	517 2.2%		
	Level 3 Summary	4,294	4,633	339 7.9%	190,268	193,798	3,530 1.9%		
3241	Petroleum & Coal Products Mfg.	157	137	-20 -12.7%	5,025	4,552	-473 -9.4%		
3253	Pesticide, Fertilizer & Other Agricultural Chemical Mfg.	31	31	0 0.0%	2,431	2,062	-369 -15.2%		
3255	Paint, Coating & Adhesive Mfg.	144	130	-14 -9.7%	8,255	7,843	-412 -5.0%		
3259	Other Chemical Product & Preparation Mfg.	189	188	-1 -0.5%	8,733	6,621	-2,112 -24.2%		
3336	Engine, Turbine & Power Transmission Eqpt. Mfg.	91	77	-14 -15.4%	5,076	5,297	221 4.4%		
3339	Other General Purpose Machinery Mfg.	529	465	-64 -12.1%	29,534	25,898	-3,636 -12.3%		
3353	Electrical Eqpt. Mfg.	200	193	-7 -3.5%	11,690	9,379	-2,311 -19.8%		
3369	Other Transportation Eqpt. Mfg.	35	40	5 14.3%	2,045	2,145	100 4.9%		
4861	Pipeline Transportation of Crude Oil	9	8	-1 -11.1%	305	377	72 23.6%		
4862	Pipeline Transportation of Natural Gas	37	40	3 8.1%	525	370	-155 -29.5%		
4869	Other Pipeline Transportation	23	29	6 26.1%	183	235	52 28.4%		
5171	Wired Telecommunications Carriers	752	762	10 1.3%	22,482	14,760	-7,722 -34.3%		
5172	Wireless Telecommunications Carriers (exc. Satellite)	219	326	107 48.9%	4,641	4,317	-324 -7.0%		
5173	Telecommunications Resellers	211	158	-53 -25.1%	3,382	2,266	-1,116 -33.0%		
5174	Satellite Telecommunications	26	20	-6 -23.1%	61	51	-10 -16.4%		
5232	Securities & Commodity Exchanges	7	4	-3 -42.9%	34	3	-31 -91.2%		
5511	Management of Companies & Enterprises	1,087	1,485	398 36.6%	80,476	101,868	21,392 26.6%		
5612	Facilities Support Services	55	65	10 18.2%	1,954	2,585	631 32.3%		
8112	Electronic & Precision Eqpt. Repair & Maintenance	492	475	-17 -3.5%	3,436	3,169	-267 -7.8%		

Note: Several groups defined as high-tech are not shown because data for 2001 were suppressed, and their inclusion would have biased the summary figures and associated changes. The groups are Timber Tract Operations (NAICS 1131), Forest Nurseries & Gathering Forest Products (1132) - both level 2, and Monetary Authorities/Central Bank (5211) - level 3. In 2006, the first two groups had less than 10 employees, and the third had around 1,000.

Sources: Hecker, Daniel E., "High-technology employment: a NAICS update," *Monthly Labor Review* 128: 7, July, 2005, pp. 57-72, also available at <http://www.bls.gov/opus/mlr/2005/07/art6full.pdf>. U.S. Bureau of Labor Statistics, *Employment and Wages Annual Averages, 2001 & 2006*. Washington, D.C.: U.S. Government Printing Office, Tables 5 & 10. The 2006 data are also available at <http://www.bls.gov/cew/cewbultn06.htm>.