Carnegie Mellon
Policy • Management • Information Technology Heinz School
Center for Economic Development

Carnegie Mellon University
Center for Economic Development
UTDC Suite 208
4516 Henry Street
Pittsburgh, PA 15213

Phone: 412.268.9880
Fax: 412.268.9828
Email: ced-info@andrew.cmu.edu
www.smartpolicy.org

Smart Policy for Innovative Regions

Technology Industries and Occupations for NAICS Industry Data

By
Jerry Paytas, Ph.D.
Interim Director, Center for Economic Development

Dan Berglund
President & CEO, State Science and Technology Institute

State Science & Technology Institute
5015 Pine Creek Drive
Westerville, OH 43081
Phone: (614) 901-1690
Fax: (614) 901-1696
Email: ssti@ssti.org
www.ssti.org

February 2004

Introduction

The effort to operationalize the concept of "technology industry" has created a variety of approaches that have produced mixed results. Most classifications of technology industries rely on industry-level data that obscure the broad range of activities and technological sophistication that characterizes the actual firms within them (Markusen, Hall and Glassmeier 1986; Thompson 1988). However, the availability and comparability of data often make these definitions the only practical solution. The most common indicators are measures of the relative expenditures on R&D and the proportion of the workforce in science and technology occupations (Malecki 1991).

There were numerous definitions of technology industries under the Standard Industry Classification System (SIC). Although the SIC system has been replaced, the definition of technology industries has not been translated into the North American Industry Classification Systems (NIACS). Updating this definition is not as simple as using the crosswalks provided for SIC-NAICS conversion. One of the principal problems with the SIC-based technology definition was that the boundaries it drew created discrepancies regarding what it included and what it excluded. Using the conversion tables will only extend the legacy of old deficiencies into the new system.

A universal definition of technology industries is not likely to be useful to everyone. In recognition of these diverse needs, this report presents two basic alternatives that provide a choice between a focus on technology-based employment or the generation of technological innovation, as well as options for a broad or narrow definition of technology industries.

Whether technology is defined by innovation or human capital, the definition is only useful if it translates into industry classifications. The underlying data should also be reliable and comprehensively cover all industries. Unfortunately many good definitions are limited by incomplete data. The National Science Foundation's Survey of Industrial Research and Development provides statistics on R&D expenditures by industry and the employment of scientists and engineers. These statistics could be used to assess the innovativeness of different industries, but the survey does not consistently report the data for all industry levels but varies reporting at the two, three and four digit NAICS codes.

A more comprehensive source is the U.S. Bureau of Labor Statistics' Occupational Employment Statistics (OES), which report employment by occupation at consistent levels of industry aggregation. Chapple et al (2004) identified a set of occupations using the 1998 OES that are science and engineering intensive and identified the 3 digit SIC industries whose share of employment in those occupations exceed three times the national average.

Recently, the Bureau of Labor Statistics updated the OES series for 2002 with crosswalks to the NAICS industry employment at both the four and five digit level of detail. This finally enables a translation of the technology definition to the new NAICS system. The Carnegie Mellon University Center for Economic Development (CED) translated the occupations identified by Chapple et al (2004) into the NAICS four and six digit codes to provide a more refined definition of technology industries that can be used with the new industry data reported by the BLS and other sources. Following the methodology of Chapple et al (2004), industries are identified as technology if their employment of these occupations exceeds three times the national average of 3.33%, or 9.98%.[1] This provides our list of Technology Employers, which provides a robust and broad definition for the NAICS statistics (Table 1: Technology Employers).

There is great interest in other methods of defining technology industries. Other industries may not employ large number of technology-related occupations, but they are generators of technology. The definition of Technology Generators uses the industry data from the NSF's Survey of Industrial Research and Development. In order to compensate for the variations in coverage, the data is used only for industries reported at the three or four digit NAICS codes. The list of nondisclosed industries is contained in Appendix 1. Industries that are only reported at the two digit NAICS level are not included. Industries are identified as Primary Technology Generators (Table 2) if they exceed the U.S. average for both research and development expenditures per employee ($11,297.00) and for the proportion of full-time-equivalent R&D scientists and engineers in the industry workforce (5.9%). Industries that meet only one of these criteria are identified as Secondary Technology Generators (Table 3). While this data is less reliable, it does provide an alternative view of technology and one that will be used regardless of the data issues. By including it here with these caveats and by providing a comparison to the occupational definition, we hope to at least make it possible to compare and contrast the definitions.

Data

The data files can be accessed at www.smartpolicy.org.

[1] S&T occupations comprise 3% of the total workforce, but the average proportion for all industries is 3.3%. This higher standard is used because it excludes several borderline industries.

Table 1: Technology Employers

NAICS 4	NAICS 6	NAICS Industry
2111	211100	Oil and Gas Extraction
2111	211111	Crude Petroleum and Natural Gas Extraction
3251	325100	Basic Chemical Manufacturing
3251	325110	Petrochemical Manufacturing
3251	325120	Industrial Gas Manufacturing
3251	325131	Inorganic Dye and Pigment Manufacturing
3251	325182	Carbon Black Manufacturing
3251	325188	All Other Basic Inorganic Chemical Manufacturing
3251	325192	Cyclic Crude and Intermediate Manufacturing
3251	325199	All Other Basic Organic Chemical Manufacturing
3254	325400	Pharmaceutical and Medicine Manufacturing
3254	325411	Medicinal and Botanical Manufacturing
3254	325412	Pharmaceutical Preparation Manufacturing
3254	325413	In-Vitro Diagnostic Substance Manufacturing
3254	325414	Biological Product (except Diagnostic) Manufacturing
3332	333200	Industrial Machinery Manufacturing
3332	333210	Sawmill and Woodworking Machinery Manufacturing
3332	333220	Plastics and Rubber Industry Machinery Manufacturing
3332	333292	Textile Machinery Manufacturing
3332	333293	Printing Machinery and Equipment Manufacturing
3332	333294	Food Product Machinery Manufacturing
3332	333295	Semiconductor Machinery Manufacturing
3332	333298	All Other Industrial Machinery Manufacturing
3333	333300	Commercial and Service Industry Machinery Manufacturing
3333	333313	Office Machinery Manufacturing
3333	333314	Optical Instrument and Lens Manufacturing
3333	333315	Photographic and Photocopying Equipment Manufacturing
3333	333319	Other Commercial and Service Industry Machinery Manufacturing
3341	334100	Computer and Peripheral Equipment Manufacturing
3341	334111	Electronic Computer Manufacturing
3341	334113	Computer Terminal Manufacturing
3341	334119	Other Computer Peripheral Equipment Manufacturing
3342	334200	Communications Equipment Manufacturing
3342	334210	Telephone Apparatus Manufacturing
3342	334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
3342	334290	Other Communications Equipment Manufacturing
3343	334300	Audio and Video Equipment Manufacturing
3343	334310	Audio and Video Equipment Manufacturing
3344	334400	Semiconductor and Other Electronic Component Manufacturing
3344	334412	Bare Printed Circuit Board Manufacturing
3344	334413	Semiconductor and Related Device Manufacturing
3344	334414	Electronic Capacitor Manufacturing
3344	334415	Electronic Resistor Manufacturing
3344	334417	Electronic Connector Manufacturing
3344	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing

NAICS 4	NAICS 6	NAICS Industry
3344	334419	Other Electronic Component Manufacturing
3345	334500	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
3345	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
3345	334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
3345	334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use
3345	334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
3345	334514	Totalizing Fluid Meter and Counting Device Manufacturing
3345	334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals
3345	334516	Analytical Laboratory Instrument Manufacturing
3345	334517	Irradiation Apparatus Manufacturing
3345	334519	Other Measuring and Controlling Device Manufacturing
3364	336400	Aerospace Product and Parts Manufacturing
3364	336411	Aircraft Manufacturing
3364	336412	Aircraft Engine and Engine Parts Manufacturing
3364	336413	Other Aircraft Part and Auxiliary Equipment Manufacturing
3364	336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
4234	423400	Professional and Commercial Equipment and Supplies Merchant Wholesalers
5112	511200	Software Publishers
5112	511210	Software Publishers
5161	516100	Internet Publishing and Broadcasting
5179	517900	Other Telecommunications
5181	518100	Internet Service Providers and Web Search Portals
5181	518111	Internet Service Providers
5182	518200	Data Processing, Hosting, and Related Services
5413	541300	Architectural, Engineering, and Related Services
5413	541310	Architectural Services
5413	541330	Engineering Services
5413	541370	Surveying and Mapping (except Geophysical) Services
5413	541380	Testing Laboratories
5415	541500	Computer Systems Design and Related Services
5415	541511	Custom Computer Programming Services
5415	541512	Computer Systems Design Services
5416	541600	Management, Scientific, and Technical Consulting Services
5417	541700	Scientific Research and Development Services
5417	541710	Research and Development in the Physical, Engineering, and Life Sciences
5417	541720	Research and Development in the Social Sciences and Humanities

Table 2: Primary Technology Generators

NAICS 4	NAICS 6	NAICS Industry
3251	325100	Basic Chemical Manufacturing
3251	325110	Petrochemical Manufacturing
3251	325120	Industrial Gas Manufacturing
3251	325131	Inorganic Dye and Pigment Manufacturing
3251	325182	Carbon Black Manufacturing
3251	325188	All Other Basic Inorganic Chemical Manufacturing
3251	325192	Cyclic Crude and Intermediate Manufacturing
3251	325199	All Other Basic Organic Chemical Manufacturing
3252	325211	Plastics Material and Resin Manufacturing
3252	325212	Synthetic Rubber Manufacturing
3341	334100	Computer and Peripheral Equipment Manufacturing
3341	334111	Electronic Computer Manufacturing
3341	334113	Computer Terminal Manufacturing
3341	334119	Other Computer Peripheral Equipment Manufacturing
3342	334200	Communications Equipment Manufacturing
3342	334210	Telephone Apparatus Manufacturing
3342	334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
3342	334290	Other Communications Equipment Manufacturing
3344	334400	Semiconductor and Other Electronic Component Manufacturing
3344	334412	Bare Printed Circuit Board Manufacturing
3344	334413	Semiconductor and Related Device Manufacturing
3344	334414	Electronic Capacitor Manufacturing
3344	334415	Electronic Resistor Manufacturing
3344	334417	Electronic Connector Manufacturing
3344	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
3344	334419	Other Electronic Component Manufacturing
3345	334500	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
3345	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
3345	334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
3345	334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use
3345	334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
3345	334514	Totalizing Fluid Meter and Counting Device Manufacturing
3345	334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals
3345	334516	Analytical Laboratory Instrument Manufacturing
3345	334517	Irradiation Apparatus Manufacturing
3345	334519	Other Measuring and Controlling Device Manufacturing
5112	511200	Software Publishers
5112	511210	Software Publishers
5413	541300	Architectural, Engineering, and Related Services
5413	541310	Architectural Services
5413	541330	Engineering Services
5413	541370	Surveying and Mapping (except Geophysical) Services
5413	541380	Testing Laboratories

NAICS 4	NAICS 6	NAICS Industry
5415	541500	Computer Systems Design and Related Services
5415	541511	Custom Computer Programming Services
5415	541512	Computer Systems Design Services
5417	541700	Scientific Research and Development Services
5417	541710	Research and Development in the Physical, Engineering, and Life Sciences
5417	541720	Research and Development in the Social Sciences and Humanities

Table 3: Secondary Technology Generators

NAICS 4	NAICS 6	NAICS Industry
3254	325400	Pharmaceutical and Medicine Manufacturing
3254	325411	Medicinal and Botanical Manufacturing
3254	325412	Pharmaceutical Preparation Manufacturing
3254	325413	In-Vitro Diagnostic Substance Manufacturing
3254	325414	Biological Product (except Diagnostic) Manufacturing
3361	336111	Automobile Manufacturing
3361	336112	Light Truck and Utility Vehicle Manufacturing
3361	336120	Heavy Duty Truck Manufacturing
3362	336211	Motor Vehicle Body Manufacturing
3362	336212	Truck Trailer Manufacturing
3362	336214	Travel Trailer and Camper Manufacturing
3363	336312	Gasoline Engine and Engine Parts Manufacturing
3363	336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing
3363	336340	Motor Vehicle Brake System Manufacturing
3363	336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
3363	336399	All Other Motor Vehicle Parts Manufacturing
3364	336400	Aerospace Product and Parts Manufacturing
3364	336411	Aircraft Manufacturing
3364	336412	Aircraft Engine and Engine Parts Manufacturing
3364	336413	Other Aircraft Part and Auxiliary Equipment Manufacturing
3364	336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing

Appendix 1

Table 4: Industries with R&D data not disclosed or collected

Industry Description	NAICS	Code
Food	311	(D)
Textiles, apparel, and leather	313-16	(D)
Paper, printing and support activities	322, 323	(D)
Petroleum and coal products	324	(D)
Pharmaceuticals and medicines	3254	(D)
Other chemicals	325 (minus 3251-52, 3254)	(D)
Plastics and rubber products	326	(D)
Electrical equipment, appliances, and components	335	(D)
Motor vehicles, trailers, and parts	3361-63	(D)
Other transportation equipment	336 (minus 3361-64)	(D)
Medical equipment and supplies	3391	(D)
Other miscellaneous manufacturing	339 (minus 3391)	(D)
Other manufacturing	31-33 (minus 311-16, 321-27, 331-37, 339)	(N)
Utilities	22	(D)
Construction	23	(D)
Transportation and warehousing	48, 49	(D)
Radio and television broadcasting	5131	(D)
Telecommunications	5133	(D)

(D) = Data withheld to protect operations of individual companies
(N) = Data not collected

References

Chapple et al. 2004. Gauging Metropolitan "High-Tech" and "I-Tech" Activity, *Economic Development Quarterly*, Vol. 18, No. 1 (February): 10-29.

Malecki, Edward. 1991. *Technology and Economic Development*. New York: John Wiley and Sons.

Markusen, Ann, Peter Hall and Amy Glassmeier. 1986. *High Tech America*. Boston: Allen and Unwin.

National Science Foundation. 2000. *Survey of Industrial Research and Development, 2000*. Tables e-1 and e-6. Retrieved from http://www.nsf.gov/sbe/srs/nsf03318/htmstart.htm

Thompson, C. 1988. Some problems with R&D/SE&T based definitions of high technology industry. *Area* 20: 265-77

U.S. Bureau of Labor Statistics. 2004. *2002 Occupational Employment and Wage Estimates: 2002 National 4-digit NAICS Industry-Specific estimates*. Retrieved from http://www.bls.gov/oes/oes_dl.htm#2002

CED Staff

The Carnegie Mellon Center for Economic Development (CED) was established in 1987 as an applied research center bringing academic resources to bear on key issues in regional economic development.

Strategic guidance for innovative organizations and regions

Dr. Jerry Paytas, Interim Director
412.268.9856,
paytas@andrew.cmu.edu

Robert Gradeck, Policy Analyst
412.268.9849,
rgradeck@andrew.cmu.edu

Lena Andrews, Policy Analyst
412.268.9810,
landrews@andrew.cmu.edu

Dr. Donald F. Smith, Jr., Chairman
412.683-2265,
ds2i@andrew.cmu.edu

Center for Economic Development

Carnegie Mellon Center for Economic Development
UTDC Suite 208
4516 Henry Street
Pittsburgh, PA 15213

Phone: 412.268.9880
Fax: 412.268.9828
Email: ced-info@andrew.cmu.edu

www.smartpolicy.org

SSTI is the most comprehensive resource available for those involved in technology-based economic development.

Since its inception in 1996, SSTI has developed a nationwide network of practitioners and policymakers dedicated to improving the economy through science and technology. This network has resulted in unique access to information. SSTI uses this access to assist states and communities as they build tech-based economies, conduct research on best practices and trends in tech-based economic development, and encourage cooperation among and between state and federal programs.

State Science & Technology Institute
5015 Pine Creek Drive
Westerville, OH 43081
Phone: (614) 901-1690
Fax: (614) 901-1696
Email: ssti@ssti.org

www.ssti.org