

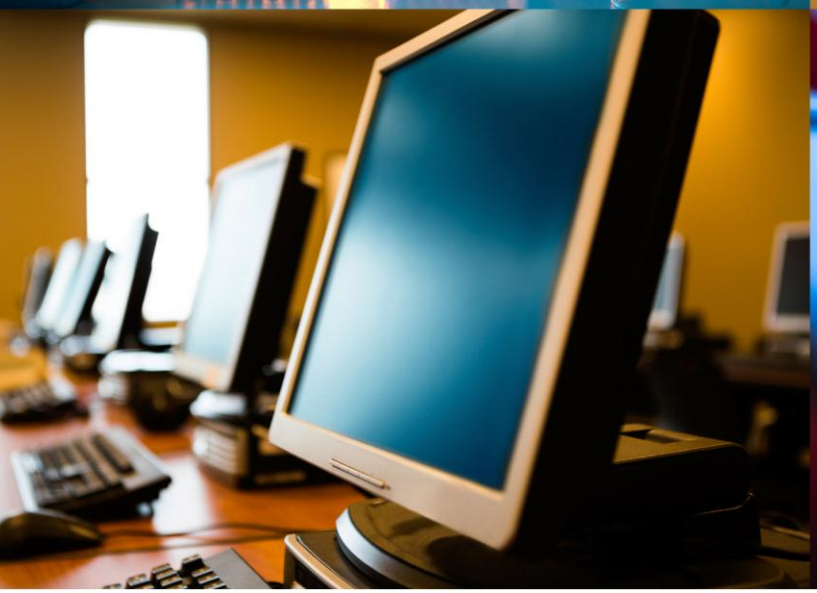


The Economic Impact of Technology-Based Industries in Washington State

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Technology Alliance

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Executive Summary

Technology-based industries continue to be at the forefront of the development of the Washington economy. They account for the largest share of employment, business activity, and labor income of any major sector in the state's economic base. Other key industries include natural resource-based sectors such as agriculture and food products, forest products, and services including tourism and transportation.

This study defines technology-based businesses as those with a strong proportion of their labor force in research and development (R&D) related occupations. This definition is consistent with recent analyses by the U.S. Bureau of Labor Statistics of measures of "high-tech" industries. In this study, the industries considered to be technology-based or "high-tech" have, with limited exceptions, at least 16.2% of their employment in R&D related occupations, equivalent to twice the state average for all industries. In Washington State in 2010, technology-based industries had an average of 42% of their employment in these occupations. In other industries just 3% of employment was in these occupations.

Data benchmarked against the first half of 2011 from the Washington State Employment Security Department (ESD) and for 2010 from the Nonemployers Series reported by the U.S. Census Bureau were used to estimate employment in industries included in this study. Based on our analysis, technology-based industries employed 434,343 people in Washington State last year (this includes estimates of university and federal research employees, and self-employed people not covered by the ESD). Through multiplier effects, a total of 1.44 million jobs in Washington State were created due to technology-based industries, which is 45% of total employment in Washington State (ESD covered employment plus proprietors). Similar percentages of overall Washington State business activity (sales, labor income, and tax revenues) are associated with the industries included in this study.

Economic impacts of industries included in this study are relatively high due to the wages paid in these industries. Technology-based industries support an average of 3.32 jobs for each direct job, compared to 2.33 jobs in other industries in the Washington economy. Labor income (wages and salaries, supplements to wage and salaries, and proprietors' income) in technology industries averaged $94,531 in 2011, a figure 90% above the average of $49,680 for other industries in the Washington State economy. Technology-based businesses contribute strongly to Washington's export base, as 76% of their sales are out-of-state compared to 27% for other industries.

There has been rapid growth in technology-based industries compared to overall economic activity. Employment has expanded from 96,000 covered private sector jobs in 1974 to 384,434 private sector jobs in 2011, an increase of 300%. This compares to a statewide increase in covered employment of 206% over the same time period. In 2011 there were 12,384 public sector and federal research related jobs in Washington State, and 37,525 self-employed people in technology-based industries, bringing total technology-based employment to 434,343. Covered employment in technology-based

industries has grown from 6.7% to 13.6% of the state total over the 1974-2011 time period, indicating that technology-based companies and institutions have made a growing contribution to the economic base of the state.

The concentration of technology-based industries in Washington State is well above the national average. Based on 2009 data, the latest year for which data are available to make national comparisons with the definitions of technology-based industry used in this study, Washington employment in these industries is 47% above the national average. Our aerospace and software/computer services sectors are the primary contributors to this high index.

If we exclude aerospace – historically our largest technology-based industry and still our largest employer – Washington's concentration of technology-based industry is 31% above the national average, up from 20% in 2009. Washington's non-aerospace technology-based industries have grown in recent years at a faster pace than those of the nation as a whole. Waste remediation activity in Washington State has a concentration 86% above the national average, largely due to activities at Hanford, while research and development has a concentration 28% above the national average. The overall concentration of technology based industries in Washington State increased somewhat from the previous Technology Alliance economic impact study released in 2010, from 37% to 47% above the national average.

Research and development expenditures in Washington State, an important indicator of technology-based activity, are more important than in the United States as a whole. R&D activity in Washington State as a share of Gross State Product in 2008 was 5.0%, compared with the national average of 2.8%. R&D in our business and non-profit sectors is particularly strong, while our level of university and college research is similar to the national average. Business accounts for the largest share of R&D dollars in Washington State (83% in 2008). Washington's concentration of total R&D expenditures places us 5th in the U.S. in terms of dollars received, and 6th when the size of R&D expenditures is indexed by Gross State Product. Washington's indexed concentration of business R&D ranks us 3rd in the nation, while for federally funded research and development centers and "other non-profits" we rank 4th. For comparison, Washington is the 13th most populous state in the nation.

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Acknowledgements

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I. Introduction

This report is the seventh estimate of the magnitude of employment, business activity, and income related to a major segment of the Washington State economy—our technology-based industries—commissioned by the Technology Alliance. A relatively high level of employment in research-related computing, scientific, and engineering occupations has been the basis for defining the industries included in these studies. While primarily in the private sector, some important segments of technology-based industries are public employers. All segments generate a significant fraction of their business volume out-of-state, thereby contributing to the state's export base.

As a group these industries have been growing rapidly, expanding their contribution to the state economy over the past several decades. They are expected to continue this growth trajectory, and they will likely be an even more important component of the state economy in coming years. The latest industry employment projections from the Washington State Employment Security Department (ESD) project 26% growth in the technology-based industries included in this report between 2010 and 2020, compared to 14% for other industries in the state economy (these estimates exclude state and federal research activity) (ESD 2012).

This report documents the growth and development of technology-based industries in the Washington economy up to the year 2011, as well as their impact on the aggregate state economy in the year 2011. Similar studies were released by the Technology Alliance in 1997, 1998, 2001, 2005, 2008, and 2010, benchmarked to 1995, 1997, 2000, 2003, 2007 and 2009 data, respectively (Beyers and Lindahl 1997; Beyers and Nelson 1998; Beyers and Lindahl 2001; Beyers, Andreoli and Hyde 2005, Beyers 2008, Beyers 2010).

Each of these reports started by defining the industries included in them. This is not an easy task, for terms such as "technology industry," "high technology," and "advanced technology" are frequently used by scholars, the media, political figures, and others to refer to this rapidly changing part of our economy. Some of these industries manufacture products, while others are engaged in research that may or may not lead to the production of a product. Some are engaged primarily in long-term research or render services with an ongoing, strong technology factor in their production. It is not easy to define clearly all of the industries that should be considered for inclusion in a study of this type. Section II of this report describes how technology-based industries were defined in this study.

After defining the economic activities covered in this report, and reviewing the importance of research and development activity in the Washington economy, Section III traces the historical development of these industries in Washington State and how their concentration within the state compares to the rest of the nation. As this section documents in detail, the growth of employment in technology-based industries has been steadily shifting, albeit gradually, from a heavy concentration in aerospace and other manufacturing industries to most employment being in service industries. This section

also presents information on the geographic distribution of technology-based industries among counties in Washington State, and on the size distribution of technology-based establishments in Washington State compared to the U.S. as a whole.

Section IV analyzes the impact of these industries on the Washington State economy. Through the use of the Washington State input-output model, direct, indirect, and induced employment; output (sales); income; and tax revenues generated by technology-based industries are presented. These impacts are then compared to the entire state economy. Approximately 45% of total employment (covered and self-employed) in Washington State can be attributed to technology-based industries in the year 2011. Section V provides some concluding comments, including a brief overview of the history of the economic impact of technology-based industries in Washington State, as documented in previous Technology Alliance studies.

This report has six appendices. Appendix I contains a review of alternative definitions of technology-based industries used in recent studies in the United States. Appendix II provides technical notes about the input-output model used to calculate economic impacts. Appendix III contains detailed location quotients for technology-based industries in Washington State in 2009. Appendix IV documents the growth of detailed technology-based industries in Washington State from 1974 to 2002, as measured by the Standard Industrial Classification (SIC) definition of industries. Appendix V presents estimates of detailed employment levels in Washington State from 1998 through 2011, as measured by the North American Industry Classification System (NAICS). Appendix VI presents estimates of technology-based employment in Washington by county in 2011.

II. Defining Technology-Based Industry and Measuring the Importance of R&D Activity in Washington State

Advanced economies continue to evolve in their economic structure. Through the "Great Recession" we saw nationally faltering output in many technology-based sectors as well as the economy as a whole. As the economy has recovered this evolution in economic structure has continued. This report focuses on how the technology-based sectors contribute to the Washington economy, and reports longitudinal information on how employment in these sectors has changed over time. We know that there has been a shift economy-wide in the composition of what is produced and particularly explosive growth in service-based activities and business activity related to the Internet. The methods by which these goods and services are produced are continually evolving, and there have been changes in the use of labor and capital in the production process.

Each of these dimensions—the mix of industries, the method of production, and the intensity of use of the factors of production—have undergone revolutions in regions such as Washington State, as well as in national economies and globally. As these changes have occurred, industries that are growing and deemed "high technology" have often been singled out as dynamic agents in the process of development in regional

economies (Atkinson and Andes 2010; DeVol, Klowden and Yeo 2010). There are numerous challenges involved in defining these industries. Factors considered in alternative definitions of technology-based industries include: the nature of the products or services they produce; characteristics of the production process; the structure of the labor force; the ratio of R&D spending as a fraction of sales revenues; and the length of product life-cycles.

Defining Technology-Based Industry

When the Technology Alliance undertook the first study of the economic impact of technology-based industries, a large amount of time was spent deciding upon how to define the industries covered by the study. The first two reports included an appendix that reviewed historically important studies focused on methodology for defining technology-based industries. This appendix is not included in this impact analysis. Those interested in these matters can either contact the Technology Alliance or the author to obtain a copy of the earlier studies that include these appendices. Appendix I in the current study describes briefly definitions used in several recent studies of high-technology industries, to give a flavor of the variety of definitions that have been used in recent years.

The definition of "high-tech" has been made more difficult in a world in which information technologies and other advanced technologies influence the way that business is done in every industry. Doctors and loggers use similar computer technologies as computer software makers and manufacturers of semiconductor chips to operate their businesses. So, there can be no question but that the nature of production has been altered by modern technologies across the economy, including the public sector.

The definition of technology-based industries in Washington State used occupational categories considered as R&D intensive by the National Science Foundation (NSF 2012). Table 1 lists examples of these occupational classifications. There were 95 occupations considered to be R&D related in the ESD's industry-x-occupation matrix used to define the industries included in this study. These are computer, engineering, and scientific occupations.

While it is the case that all industries in the Washington economy now rely on information technologies and other indicators of technology-intensive industry to a greater or lesser extent, there are significant variations in their commitment to staff who try to cause change in the products and services that they provide through their research and development efforts. This study focuses on industries that have this commitment, and after considerable deliberation and evaluation of approaches taken in studies in other regions, a definition of at least 16.2% employment in R&D intensive occupations, or twice the state average for all industries, was established. With limited exceptions, the industries included in this study meet the 16.2% threshold.

Early Technology Alliance economic impact studies used a threshold of 10% employment in R&D occupations, a figure consistent with that suggested by the Bureau of Labor Statistics as an indicator of high-technology industry (Hecker 1999). The first

three studies examined industries defined by Standard Industrial Classification (SIC) categories. Since 2005 the Technology Alliance studies have used a spreadsheet obtained from ESD that provides estimates of employment by industry and occupation using the North American Industry Classification System (NAICS) to determine which industries meet the R&D employment threshold to qualify as technology-based.

Table 1 Selected Examples of R&D Intensive Occupations

Standard Occupational Category (SOC)	Occupational Description	% of Total
15-1031	Computer Software Engineers, Applications	11.7%
15-1032	Computer Software Engineers, Systems Software	6.6%
15-2031	Operations Research Analysts	0.5%
15-2041	Statisticians	0.2%
17-1011	Architects, Except Landscape and Naval	1.3%
17-2011	Aerospace Engineers	2.7%
17-2051	Civil Engineers	5.2%
17-2141	Mechanical Engineers	2.5%
17-3023	Electrical and Electronic Engineering Technicians	1.1%
17-3029	Engineering Technicians, Except Drafters, All Other	1.5%
19-1023	Zoologists and Wildlife Biologists	0.8%
19-1042	Medical Scientists, Except Epidemiologists	2.0%
19-2031	Chemists	0.8%
19-2041	Environmental Scientists and Specialists, Including Health	1.7%
19-3021	Market Research Analysts	3.7%
19-3051	Urban and Regional Planners	1.2%
19-4021	Biological Technicians	1.6%
	Other R&D Intensive Occupations	54.7%

The data in these spreadsheets have reported significant increases in total employment in R&D intensive occupations, leading to the decision in recent studies to increase the percentage of employment in R&D intensive occupations used to define technology-based industries from 10% to twice the state average for all industries. It should be noted that the Bureau of Labor Statistics has also observed these same trends in occupational structure, and the role they play in developing their current definitions of technology-based industry (Hecker 2005).

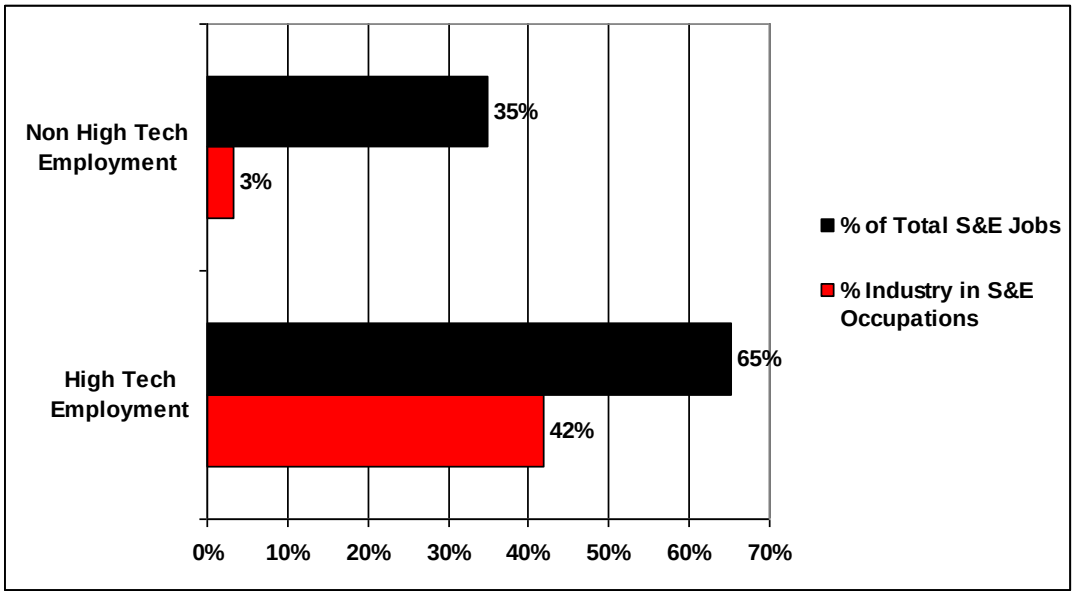
The ESD matrix of employment and occupations used in this study defines industries through the use of the 2007 NAICS codes; these codes are slightly different than the original set of NAICS codes first utilized by the federal government in 1997, and modified in 2002 and 2007. These redefinitions of the NAICS codes have presented difficulties in the consistent estimation of employment by industry over time as reported in Section III of this report. In a few cases the 2002 NAICS codes separated activities (such as Internet service providers) that were aggregated with broader categories in the 1997 NAICS, and then these categories were recombined with the 2007 NAICS

redefinitions. However, the changes in the NAICS codes are a minor issue compared to the more general matter of drawing comparisons between the NAICS scheme and the SIC codes used in the earlier Technology Alliance studies, as discussed in Section III.

Shares of employment were calculated for each industry included in the 2010 industry-x-occupation matrix for engineering, scientific and computer related occupations (codes beginning with SOC 15, 17, and 19). These calculations found that 8.1% of total employment in Washington State was estimated to be in these occupations in the year 2010; hence, double this percentage (16.2%) was used as the primary basis for defining technology-based industry in the current study.

The industries that are included in this study after this process of evaluation are listed in Table 2, along with the corresponding percentage of R&D employment. Figure 1 indicates that the majority (65%) of science, computer, and engineering workers are employed in technology-based industries. However, 35% are employed in other industries, the majority in computer-related occupations. Technology-based industries have an average of 42% of their workforce in computer, science, and engineering occupations, compared to 3% in other industries in the Washington economy in 2010.

Figure 1 Computer, Science, and Engineering Jobs in Technology-Based and Other Industries in Washington State, 2010



Two industries included in Table 2 have less than 16.2% R&D-related employment: electronic shopping and mail-order houses, and waste treatment and disposal. These sectors were included after careful examination of their occupational structure. Electronic shopping and mail-order houses have a very high level of computer-related employment, but relatively small shares of employment in engineering and scientific occupations. Waste treatment and disposal have relatively high levels of engineering and scientific occupations, but a relatively small share of employment in computer-related occupations.

Table 2 R&D Employment Concentrations in Washington's Technology-Based Industries

NAICS	Industrial Description	% R&D
	Technology Intensive: R&D Occupations Over 30%	
5413	Architectural and Engineering Services	70.1%
5415	Computer Systems Design and Related Services	66.3%
5112	Software Publishers	64.8%
5417	Scientific Research and Development Services	60.5%
3364	Aerospace Manufacturing	35.7%
5191	Other Information Services	35.5%
5416	Management and Technical Consulting Services	34.8%
518	ISP and Data Processing	33.0%
	University and Federal Research	(Not covered in ESD data base: see text)
	Other Technology Industries: R&D Occupations 11.8% - 30%	
334	Computer and Electronic Manufacturing	29.4%
324	Petroleum and Coal Products	27.9%
3361	Motor Vehicle Manufacturing	26.7%
517	Telecommunications	24.2%
335	Electrical Equipment Manufacturing	23.4%
3336	Turbine and Power Transmission Equipment Manufacturing	23.3%
4234	Commercial Equipment Merchant Wholesalers	22.0%
5511	Management of Companies and Enterprises	19.5%
5629	Remediation and Other Waste Services	17.9%
3335	Metalworking Machinery Manufacturing	17.8%
3332	Industrial Machinery Manufacturing	16.6%
325	Chemicals Manufacturing	16.2%
5622	Waste Treatment and Disposal	13.9%
4541	Electronic Shopping and Mail-Order Houses	11.8%
	All Technology-Based Industries	**41.9%**

Two industrial classifications included in the ESD employment-x-occupation matrix had a high concentration of employees in research-related occupations, but were excluded from this study. They were the federal government and state government other, with 21.2% and 16.5% employment in research-related occupations. These two industrial classifications had a large level of employment (67,743 and 62,473, respectively). However, we could not determine what categories of government activity were included in these two industrial classifications, and we have included some activity in government in this study. In future studies of this type, it would be useful if the ESD could categorize the agency structure of these two sectors, to isolate where these research-related employees are concentrated.

University and Federal Research

Two categories included in Table 2, university research and federal research organizations, were not defined for inclusion in this study through the use of the industry-x-occupation matrix. University research employment includes research-related workers at the University of Washington and Washington State University. The federal research organizations include National Oceanic and Atmospheric Administration (NOAA) agencies in Washington State (except the National Weather Service) and the Naval Undersea Warfare Center at Keyport. Their occupational mix is strongly skewed towards a research and development dominated labor force. In contrast to the measurement of employment for other sectors covered in this study, university research employment measures include only research-related employment. Thus, the teaching, service and extension, housing, fellowship/traineeship, and hospital employment at the two research universities were excluded from this study.

Life Sciences

Life sciences (including biotechnology and medical devices) are not identified separately in the NAICS codes shown in Table 2. Most biotechnology and medical device employment is encompassed within three NAICS codes included in this study: chemicals manufacturing (NAICS 325), computer and electronic product manufacturing (NAICS 334), and scientific research and development services (NAICS 5417). A portion of medical devices is included in NAICS 3391, an industry that did not meet the criteria for inclusion in this study. The Washington Research Council estimates that 10,038 people were employed in biotechnology and medical devices in Washington State in 2010[1]. Its report shows 2,085 people employed in drug and pharmaceuticals manufacture (NAICS 3254), and 7,953 employed in medical devices and equipment (NAICS 3345 and 3391). The council estimates 3,730 people are employed in biotech research, which is about 18% of total employment in scientific research and development services (including self-employed).

Measuring the Importance of R&D Activity in the Washington Economy

The industries defined in Table 2 with high proportions of their labor force in research and development intensive occupations are also likely to devote relatively high proportions of their expenditures on R&D activities. Data from the National Science Foundation (NSF) are reported annually on a wide range of indicators of scientific and engineering effort at the national and state level. Before turning to an historical and comparative account of the importance of employment in technology-based industries in Washington, the state's position with regard to these measures is reviewed. Table 3 details Washington's position on a variety of measures of R&D funds using NSF data. The latest data are for the year 2008, while the primary benchmark for this study is 2011. Two rank measures are provided: (1) total dollars spent, and (2) ranks based on indexed estimates of spending relative to state GSP. Washington's overall position is 5th nationally based on total spending and 6th nationally when viewed from an indexed perspective.

[1] This figure is based on "Trends in Washington's Life Sciences Industry 2007-2011" by the Washington Research Council, released in November 2011.

Table 3 Washington State Distribution of R&D Funds, 2008

Performer and Sources of Funds	$ Millions	2008 Rank $ Used	2008 Rank Indexed	2000 Rank $ Used	1993 Rank $ Used
United States Sources: Total Used	$16,696	5	6	8	11
A. Federal Government: Total Used (1)	$258	18	24	14	21
B. Business: Total Used (2)	$13,876	5	3	7	9
Federal Sources	$717	14	13	D	8
Business Sources (3)	$13,159	5	2	D	10
C. Universities and Colleges: Total Used(4)	$1,058	14	34	14	14
Federal Sources	$721	14	25	11	10
Non-federal Government Sources	$61	17	32	35	32
University & College Sources	$156	22	40	22	NA
Business Sources	$81	13	11	11	14
Non-Profit Sources	$39	25	38	27	NA
D. Non-Profits: Total Used (5)	$1,504	4	4	4	5
Non-profit FFRDC	$1,137	4	4	4	NA
Other Non-profits	$367	4	6	7	NA
E. State Internal (6)	NA	NA		NA	NA

Notes:
(1) Total funds used by the federal government from federal sources.
(2) The category previously labeled "Industry" is now called "Business" by NSF. Business totals include R&D performed by industry-administered federally funded research and development centers.
(3) Business R&D support to business performers includes all non-federal sources of funds.
(4) For universities and colleges, funds are for doctorate-granting institutions only.
(5) For the non-profit sector, funds distributed by state and region include only federal obligations to organizations in this sector, including associated federally funded research and development centers (such as the Battelle Memorial Institute). Estimated non-federal support to the non-profit sector is excluded from these state data.
(6) Internal performers include state agency and department employees, and services performed by others in support of an internal R&D project. These data are reported every other year and were not available for 2008.
NA – Data not available for this year; NSF measures these data biennially. Source: National Science Foundation

Washington's comparative position has improved since the last study, which used data for 2007. NSF data show on a variety of key indicators that Washington is in a strong position with regard to R&D activities. In 2008, NSF estimated Washington-based entities used $16.7 billion in R&D funds, which was 4.96% of our gross state product (GSP); nationally, R&D was 2.82% of Gross Domestic Product (GDP). This placed us 5th among the states based on total spending, well above our position as the 13th most populous state in the country (Census 2011). This relative concentration of expenditures on R&D activities is mirrored in the next section of this report, which demonstrates that the employment concentration in technology-based industries in Washington is also well above the national average. In 2008 the concentration of doctoral scientists and engineers employed in Washington State exceeded the national average[2].

[2] This conclusion is based location quotients calculated from data in NSF Science and Engineering Profiles by State (last updated November 2011), for employed S&E doctorate holders by state for the year 2008, and Census Bureau estimates of population and labor force by state.

Business dominated Washington R&D expenditures in 2008, as it did nationally (72% of national R&D was performed by business, while in Washington State 83% of R&D funds were used in business sectors). Washington's position is 5th nationally in business R&D dollars expended, and 3rd when indexed to GSP. In Washington, business R&D expenditures were likely dominated by funds spent by The Boeing Company on the development of new product lines, such as the new 787 airplane, and by the Microsoft Corporation[3]. Federal R&D activity in Washington is largely at the Keyport Naval Undersea Warfare Center and at NOAA.

University and college funds accrue primarily to the University of Washington and Washington State University. University and college research spending yielded a ranking (14th) that is closer to our population rank (13th) than is the case for other R&D performers in Washington (all of which are well above average). However, when indexed, Washington's university and college funding position falls considerably, to 34th in the nation, largely due to relatively weak non-federal government (e.g. state government) and university and college funding sources (such as endowments). While Washington ranks 14th nationally in the receipt of federal research funds, our position falls to 25th once expenditures have been indexed. This relatively weak position has been associated with our relatively small enrollment of higher education students and related research faculty in science and engineering (Beyers and Chee 2006).

Notable in Table 3 is the receipt of funds by non-profits, as defined by NSF, which in Washington State is dominated by funding to the Fred Hutchinson Cancer Research Center in the other non-profits sector, and by the Battelle Memorial Institute (Pacific Northwest National Laboratory) in the non-profit FFRDC sector. Washington's ranking as the 4th highest recipient of research funds by non-profit FFRDC's and the other non-profit sector highlights the importance of these organizations to the state's R&D activities.

Although it is not possible to classify expenditures of R&D funds by NAICS code, it is certain that almost all of these funds were received by industries covered in this study. Again, the impacts considered in this analysis are based on all of the business activity in the industries which have high levels of R&D employment, not only the impact of activities directly associated with R&D expenditure.[4] It should be noted that Washington's position on a number of the indicators reported in Table 3 has improved, as our ranking has moved up for most measures from the spending ranks calculated in the first Technology Alliance economic impact study.

[3] Unfortunately, NSF does not disaggregate business R&D activity by industry due to disclosure laws.

[4] The one exception to this principle is for university research, where the impacts are confined to the impact of research-related activities, and excludes other bases for the economic impact of universities.

III. Trends in Washington State Technology-Based Industry Employment and Comparison with Other States

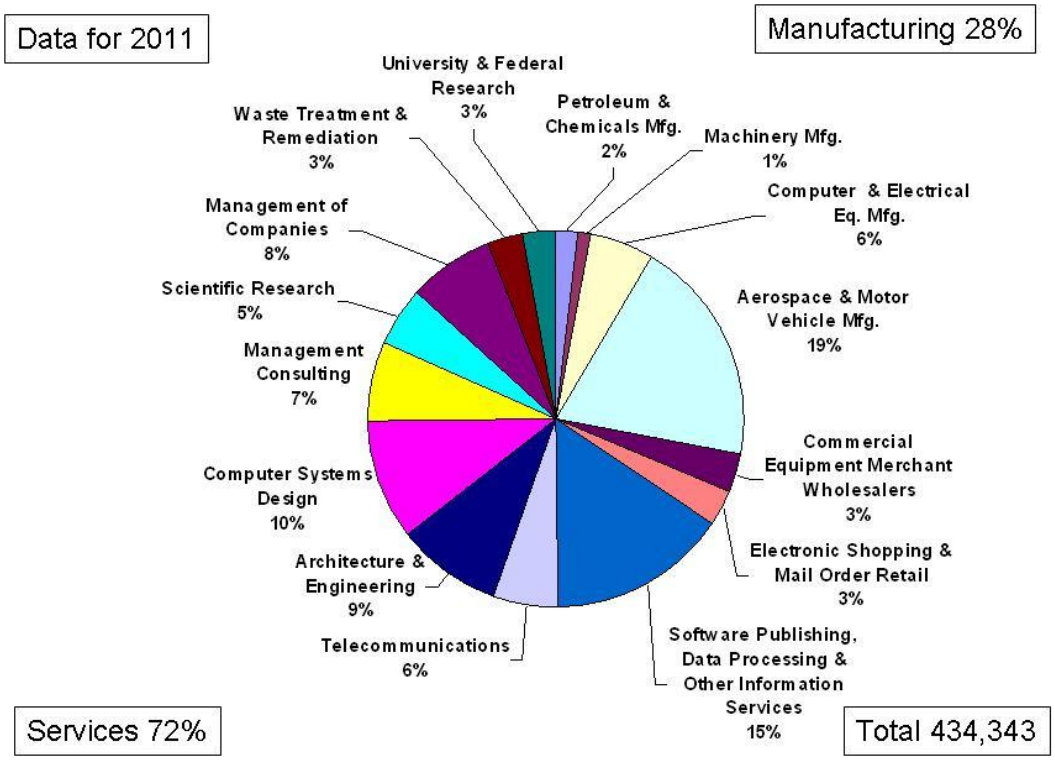
Current Employment

In 2011, technology-based industries employed 434,343 people in Washington State, 13.4% of the state's total covered employment and nonemployer base of 3.2 million. As Table 4 reports, and Figure 2 illustrates, manufacturing industries accounted for 28% of total technology-based jobs, with aerospace and motor vehicle manufacturing being the largest single category (19% of the total). The remaining 37,191 manufacturing jobs are divided between machinery, computer, and electrical equipment manufacturing (28,791 jobs) and petroleum refining and chemicals (8,400 jobs).

Table 4 Employment in Technology-Based Industries, 2011

Industry	Covered Employment	Non-employer	Total
Petroleum & Chemicals Manufacturing	8,194	206	8,400
Machinery Manufacturing	4,771	0	4,771
Computer & Electrical Equipment Manufacturing	23,755	265	24,020
Aerospace & Motor Vehicle Manufacturing	85,011	0	85,011
Commercial Equipment Merchant Wholesalers	13,397	214	13,611
Electronic Shopping & Mail Order Retail	11,154	2,329	13,483
Software Publishing, Data Processing & Other Information Services	62,529	3,755	66,284
Telecommunications	24,389	463	24,852
Architecture & Engineering	34,431	5,318	39,749
Computer Systems Design	35,751	8,279	44,030
Management & Technical Consulting	14,905	15,857	30,762
Scientific Research	20,027	839	20,866
Management of Companies	32,743	0	32,743
Waste Treatment & Remediation	13,377	0	13,377
University & Federal Research	12,384	0	12,384
Total	**396,818**	**37,525**	**434,343**

Figure 2 Washington State Employment in Technology-Based Industries



The bulk of technology-based employment in Washington State is found in a variety of non-manufacturing industries. This category includes sectors that provide services—for example, architecture and engineering—and industries that produce intellectual property-based goods, software being a prominent example. The information sector (composed of software publishers, data processing, telecommunications, other information services, and computer systems design) accounts for 31% of total technology-based employment. Producer services includes architecture and engineering, scientific research and development, management and technical consulting, management of companies and enterprises, and waste treatment and remediation. Together, these industries account for 32% of total technology-based employment.

The balance of technology-based jobs is found in commercial equipment merchant wholesaling, electronic shopping and mail-order houses, and university and federal research activities, each of which accounts for another 3% of technology-based employment.

Employment Trends

In the first four Technology Alliance economic impact studies, we were able to construct detailed information on employment by broad lines of technology-based industry (excluding university and federal research) back to 1974. This time series was based on the SIC classification system. With the shift to the NAICS classification system

there are two important changes that make it impossible to present a harmonious estimate of employment trends from 1974 to 2011. First, some of the sectors considered technology-based under the SIC system of classification were divided up into new categories in which at even the finest level of detail the SIC classification system was not commensurable with the NAICS system (the dispersal of SIC 737 computer services into parts of the NAICS information industry, and into part of computer systems design and related services, illustrates this issue). Second, the NAICS system recognized new industries that had no antecedent in the SIC system, but meet the current test of having a high concentration of scientific, engineering, and computer-related occupations. Management of companies and enterprises is a good example of this second issue.

There is a third issue that arises in making such comparisons: the changing occupational employment mix in particular industries. Whereas some industries were excluded from earlier definitions of technology-based industry, the evolution of their occupational mix has led to their inclusion under the current definition. Petroleum refining is an example of this—it did not qualify for inclusion in the 2008 study, but it is included in the current study. Even under the SIC system there were discontinuities in classification, such as the movement of much of Hanford from chemicals (plutonium) manufacturing to services in 1991.

There are no perfect solutions to these statistical issues. The easiest solution is to include in this section both the historical data in the SIC format, to provide information on the evolution of technology-based industries (Table 5), as well as the data in the NAICS format (Table 6). Table 6 presents data for the years in which NAICS data are available, and while the totals do not add up perfectly to the values in Table 5, they allow us to have some evidence regarding the recent evolution of technology-based employment in the industries included in the current study.

Figure 3 presents estimates of private sector covered employment in technology-based industries from 1974 through 2011. This figure shows estimated aerospace employment, software and other computer services employment, and other technology-based employment. The figure illustrates the significant growth of non-aerospace technology-based employment in Washington. It uses the SIC industry definitions up to 2002, and uses the NAICS definitions for the years 2007, 2009, and 2011.

The growth of private sector employment in Washington's technology-based industries defined on an SIC basis was steady in the aggregate, increasing from 95,910 in 1974 to 259,648 in 2002, or 171%, as described numerically in Table 5 and in more detail in Appendix IV. This compares to total wage and salary employment growth in the Washington State economy during the same period of 92%. In 1974, technology-based industries accounted for 6.7% of state employment; by 2002 this had increased to 11.3%. The inclusion of aerospace, which has demonstrated a high degree of cyclicality over the 1974 to 2002 period, masks a tremendous amount of growth in many of the non-aerospace sectors.

Biotechnology/biomedical manufacturing, an industry that was practically non-existent decades ago, had the highest percentage growth of any sector, expanding over twelve-fold between 1974 and 2002. Software and other computer services also expanded twelve-fold over the 1974-2002 time period. Aerospace has become steadily less important as a share of technology-based employment: in 1974 (as shown in Figure 3) almost 55% of private-sector technology-based employment was in this sector; by 2002 its share had fallen to 23%.

It is also important to note the structural transformations that have occurred within the software and computer services industry. At the end of the 1970s, software and other computer services employment was dominated by data processing services undertaken on mainframe computers. The adoption of minicomputers and personal computers led to a significant decline in employment in data processing, evident in the large drop in employment in this industry between 1980 and 1982. Simultaneously, software and computer programming activity for personal computers started to become more and more important in Washington State, and the industry began to expand again and is now dominated by software production. This history demonstrates that cyclical changes in technology-based employment are not confined to aerospace in Washington State.

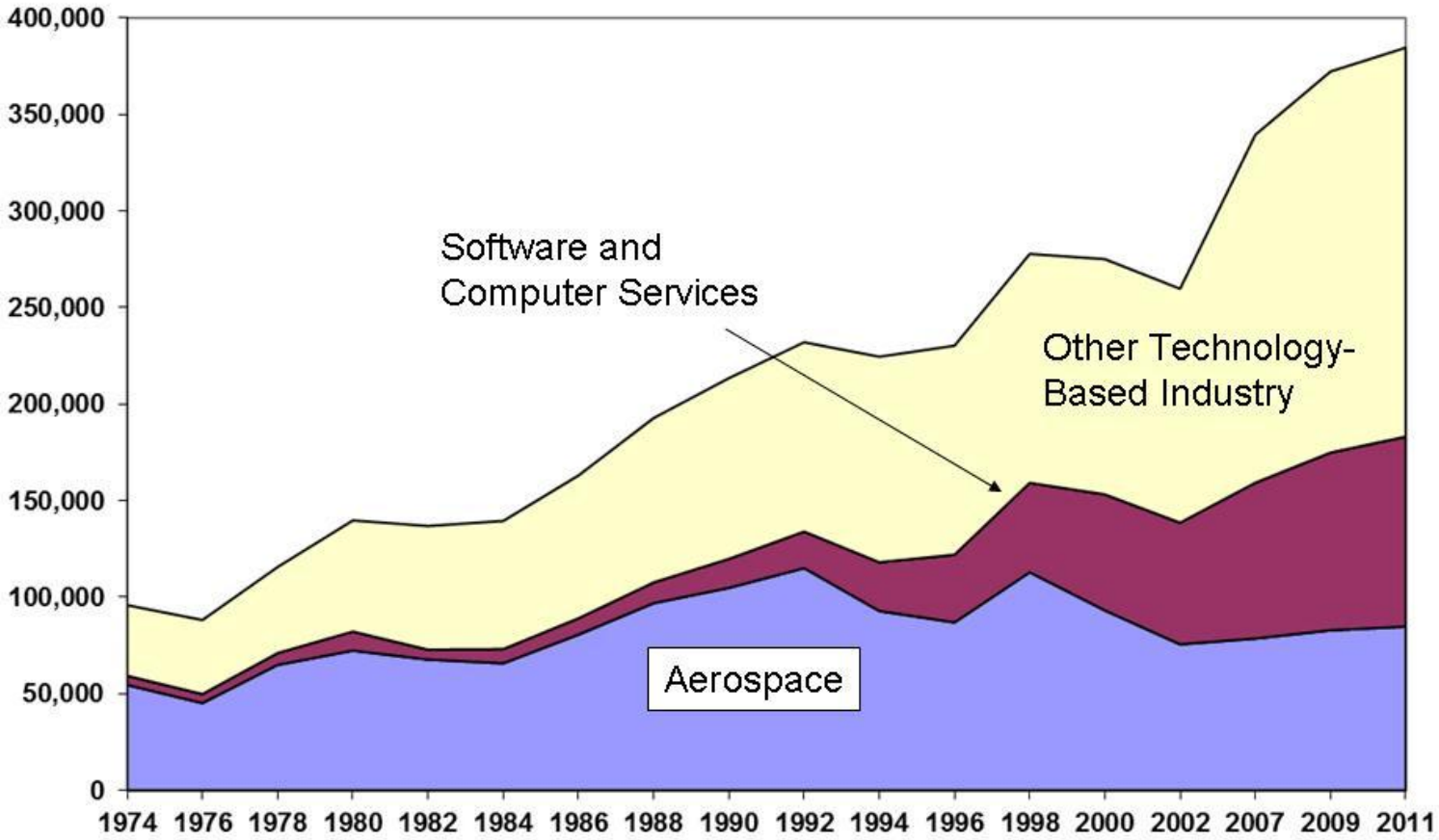
Table 5 Employment History for Washington State Technology-Based Industries, 1974-2002 (private-sector covered employment; SIC-based definitions)

	% Chg 74-02	2002	2000	1998	1996	1994	1992	1990	1988	1986	1984	1982	1980	1978	1976	1974
Manufacturing Industries																
Aerospace	**37%**	75,667	93,221	112,962	87,024	92,911	115,126	104,860	96,963	80,675	65,824	67,794	72,406	65,014	45,257	54,646
Computers and Electronics	**296%**	19,389	23,642	23,776	21,128	17,808	15,361	15,800	15,275	15,675	17,050	14,518	11,211	7,559	5,030	4,899
Motor Vehicles and Machinery	**16%**	11,885	15,685	15,199	15,711	15,500	12,275	13,471	12,554	8,040	7,745	12,068	10,384	9,643	8,747	10,208
Specialized Instruments and Devices	**228%**	7,388	8,324	8,573	7,927	7,144	8,023	9,099	8,447	7,258	6,691	4,922	4,295	1,996	2,338	2,254
Chemical Production and Petroleum Products	**-26%**	5,369	5,792	5,679	5,849	5,894	6,202	14,386	13,473	12,870	11,914	10,696	10,128	9,390	6,978	7,277
Biotechnology/Biomedical Manufacturing	**1,266%**	8,375	7,990	7,665	6,944	6,892	6,004	4,787	4,002	2,797	1,237	1,191	755	465	505	613
Service Industries																
Engineering, Research, and Consulting Services	**506%**	68,637	60,327	57,580	50,617	47,606	50,135	36,012	31,308	27,276	21,698	20,614	20,738	15,504	14,747	11,311
Software and Other Computer Services	**1,239%**	62,938	60,009	46,254	34,983	25,194	18,851	14,990	10,737	8,453	7,350	5,089	9,854	6,109	4,627	4,702
Total	**171%**	259,648	274,989	277,688	230,183	224,490	231,977	213,405	192,759	163,044	139,509	136,892	139,771	115,680	88,229	95,910

Sources: U.S. Census Bureau County Business Patterns, Washington State Employment Security Department

Notes: Excludes university and federal research employment. A portion of the engineering, research, and consulting sector is related to biotechnology. Historical data on the level of biotechnology research employment are not available.

Figure 3 Growth of Employment in Technology-Based Industries in Washington State, 1974-2011 (covered employment, excluding government and university research activities)



Source: U.S. Census Bureau County Business Patterns, Washington State Employment Security Department

Other sectors with high growth rates in Table 5 include engineering, research, and consulting services (506%), reflecting the rapid growth of other types of business services in the state and U.S. economy (as well as a reclassification of activities at the Hanford site, discussed below), computers and electronics manufacturing (296%), and specialized instruments and devices (228%). Motor vehicles and machinery, a sector which many might not consider high technology but exceeded the 10% threshold of employment in R&D occupations under the SIC definitions used in the early Technology Alliance economic impact reports, showed very modest growth at 16%.

A Note on Hanford

The 26% decline in employment within chemical production and petroleum refining in Table 5 reflects the reclassification of activities from plutonium production to environmental remediation at the Hanford site. From the Second World War until 1989, the Hanford works was a major contributor to national defense weapons production, through the manufacture of plutonium. Over this long span of time, the federal government instituted a management structure for the Hanford nuclear facility that employed a contractor to operate the plutonium production process. This industrial activity was classified in SIC 281, industrial inorganic chemicals. In addition to nuclear materials production activity, research emerged as an important component of the Tri-Cities economy, led by the research activities of the Battelle Memorial Institute. Battelle managed (and still manages) the Pacific Northwest National Laboratory and also operates a separate research program affiliated with Battelle's larger mission as a research enterprise.

With the end of plutonium manufacture and the shift of the federal effort at Hanford towards environmental cleanup, the classification of employees who were considered part of the inorganic industrial chemicals manufacturing industry were shifted to research and testing (SIC 873). This change of classification was undertaken by ESD in 1991. In our historical employment series for SIC 281 and 873, the impact of this change of classification is evident. In the ongoing cleanup efforts at Hanford in recent years, most employment has been reclassified again, and is now in waste management and waste remediation (NAICS categories 5622 and 5629). These industries are included in the current study.[5]

Recent Employment Trends

Table 6 presents estimates of employment for the 1998-2011 time period by NAICS definitions used in this study. More detail on the history of employment by NAICS codes is found in Appendix V. NAICS codes were changed in 2002 and 2007, rendering some sectors non-comparable (NC) due to these definitional changes. This table documents the rapid growth of employment in software publishers and computer

[5]Department of Energy employment in the Hanford region is currently less than 500 (http://www.hanford.gov/page.cfm/HanfordOverview, accessed May 19, 2012). ESD reports 579 people employed by the federal government in the administration of air and water resources and waste management in Washington State in the 2nd quarter of 2011. It also reports 815 federal employees in Benton County in 2011, many of whom are likely Department of Energy employees. This federal employment is not included in this study.

systems design, scientific research and development, waste management, and electronic shopping and mail order houses. The aerospace employment cycle is evident in this table as well, with a large drop in aerospace employment between 1998 and 2005, and a rebound after 2005. The employment history in business services is affected by the data reported for management of companies, which shows a large drop in levels between 2000 and 2002. A similar drop is recorded in computer manufacturing. These changes

Table 6 Employment Trends for NAICS Technology-Based Industries

	% Change 1998-2011	2011	2009	2007	2005	2002	2000	1998
Manufacturing								
Petroleum Products	16.3%	2,370	2,606	2,444	2,314	2,726	2,030	2,037
Chemicals	9.5%	5,824	5,796	5,919	5,202	5,798	4,842	5,320
Machinery	-0.6%	4,771	5,256	5,752	5,042	3,890	4,870	4,798
Computers	-59.2%	19,477	21,539	22,576	22,003	25,948	45,554	47,720
Electrical Equipment	15.9%	4,278	4,213	4,286	4,206	3,782	3,500	3,691
Aerospace	-24.9%	84,831	82,932	78,667	65,096	75,667	93,221	112,962
Motor Vehicles	-87.1%	180	894	700	1,400	700	700	1,400
Services								
Commercial Equipment Merchant Wholesalers	NC	13,397	14,195	14,277	13,774	14,399	NC	NC
Electronic Shopping & Mail Order Houses	135.6%	11,154	89,06	10,833	9614	9586	6613	4734
Software Publishers, Data Processing, and Computer Systems Design	206.3%	91,286	87,425	79,643	65,445	60,488	54,486	29,803
Telecommunications	-19.2%	24,389	25,741	26,140	25,717	30,988	32,975	30,200
Other Information Services	NC	6,994	4,515	2,954	2,278	NC	NC	NC
Management of Companies & Enterprises, Architecture & Engineering, and Management & Technical Consulting	-10.1%	82,079	82,273	80,282	74,183	68,126	88,347	91,273
Scientific Research & Development	111.1%	20,027	19,117	18,765	18,090	16,354	10,936	9,489
Waste Treatment and Remediation	87.4%	13,377	11,958	11,539	11,646	9,539	8,695	7,140
Total		**384,434**	**377,366**	**364,777**	**326,010**	**NC**	**NC**	**NC**
Estimate for 1998 through 2002			*At Least:*			*327,991*	*356,769*	*350,567*

Sources: U.S. Census Bureau County Business Patterns, Washington State Employment Security Department
Notes: Excludes university and federal research employment and self-employment. A portion of the scientific research and development sector is related to biotechnology. In 2010 this segment included approximately 3,730. The Washington Research Council estimates that there are another 6,850 research related life sciences jobs outside biotech (Washington Research Council 2011). Historical data on the level of life sciences research employment are not available. NC=not comparable

may be related to reclassifications of establishments as a result of changes in NAICS classification principles. Changes in NAICS codes in 2002 and 2007 have affected the definitions of industries included in the various Technology Alliance economic impact studies, leading to some discontinuities in employment statistics in cases where these redefinitions have made it impossible to classify industries in a harmonized manner.

Concentration of Technology-Based Industries in Washington State

Washington State's concentration of technology-based employment has increased significantly over the past several decades. In 1985, our relative share of private sector technology industries was 10% above the national average; by 1997, this share had increased to 42% above the national average (Beyers and Lindahl 1997; Beyers and Nelson 1998; Beyers and Lindahl 2001). In the wake of the downturns in aerospace employment after 1998, and impacts on technology-based industry of the business cycle in 2001-2002 and the dot-com bust, the concentration of technology based employment declined somewhat in Washington. In 2009, the latest year for which national data by state were available, Washington's concentration of technology-based industries was 47% above the national average.

Table 7 identifies "location quotients" for each of the NAICS technology-based sectors. The location quotient is a simple measure of the relative concentration of a particular industry in a certain region compared to the concentration of that industry for the nation as a whole. A value less than 1.0 indicates that an industry is underrepresented in a state or region, a value over 1.0 indicates a higher level of concentration than the nation, and a value around 1.0 indicates that the concentration of an industry within the state or region is similar to that within the national economy[6]. Table 7 uses two measures of employment: U.S. County Business Patterns, and the U.S. Census Bureau Nonemployer Statistics. The nonemployer data are derived from tax returns filed with the Internal Revenue Service by self-employed persons, in which they self-identify the industry from which they are receiving self-employment income.

The 2010 data for technology-based self-employment indicate that their number was 9.4% of the numbers of people reported in County Business Patterns; this compares to 12.3% economy-wide on this same measure. Thus, technology-based industries have a lower share of self-employed workers than in the economy as a whole. The number of self-employed persons in the United States has gradually increased in recent years; their inclusion in the statistical basis for calculating location quotients does not change significantly Washington's overall concentration, but it does provide a broader basis for calculating these indices, and the Washington input-output models used for economic impacts includes self-employment in measures of labor income and employment.

[6] U.S. Census Bureau data are used in this section of the report, rather than Washington State Employment Security Department data, because the calculations in this section of the report must be compared to other states in the United States.

Table 7 Location Quotients in Washington Private Sector Technology-Based Industries, 2009

Industry	County Business Patterns	Self-Employed	Combined
Petroleum Products	0.693	0.432	0.676
Chemicals	0.346	1.020	0.360
Machinery	0.712	1.020	0.727
Computers	0.938	1.457	0.958
Electrical Equipment	0.338	0.967	0.353
Aerospace & Motor Vehicles	5.409	1.074	5.483
Commercial Equipment Merchant Wholesalers	1.079	1.110	1.097
Electronic Shopping & Mail Order Houses	0.903	1.565	1.018
Software Publishers & Computer Systems Design	2.801	2.550	2.250
Telecommunications	1.230	0.802	1.238
Data Processing & Other Information Services	1.353	1.175	1.328
Business Services	1.241	2.383	1.343
Scientific R&D	1.263	1.314	1.280
Waste Treatment and Remediation	1.898	0.622	1.860
All Technology-Based Industry	**1.410**	**2.059**	**1.465**

The strongest concentration of technology-based industry in Washington State is in aerospace and motor vehicle manufacturing, with a location quotient of 5.48. No other sector included in this study approaches this dominance. Software publishers and computer systems design have a concentration 2.25 times the national average, while waste management has a concentration twice the national average. Commercial equipment merchant wholesalers, telecommunications, data processing and other information services, business services[7], and scientific R&D are all above the national average in concentration. Appendix III presents location quotients for more detailed industries than those contained in Table 7, and these data make it clear that Washington's position is due to aerospace in which our location quotient is 7.2, while in motor vehicles our location quotient is only 0.1.

Figures 4 through 6 depict the concentration of technology-based industries in Washington State, compared to other states. These figures also show specific location quotients for Technology Alliance peer states, along with location quotient values for some other states with high location quotients that are not peer states (in red type).

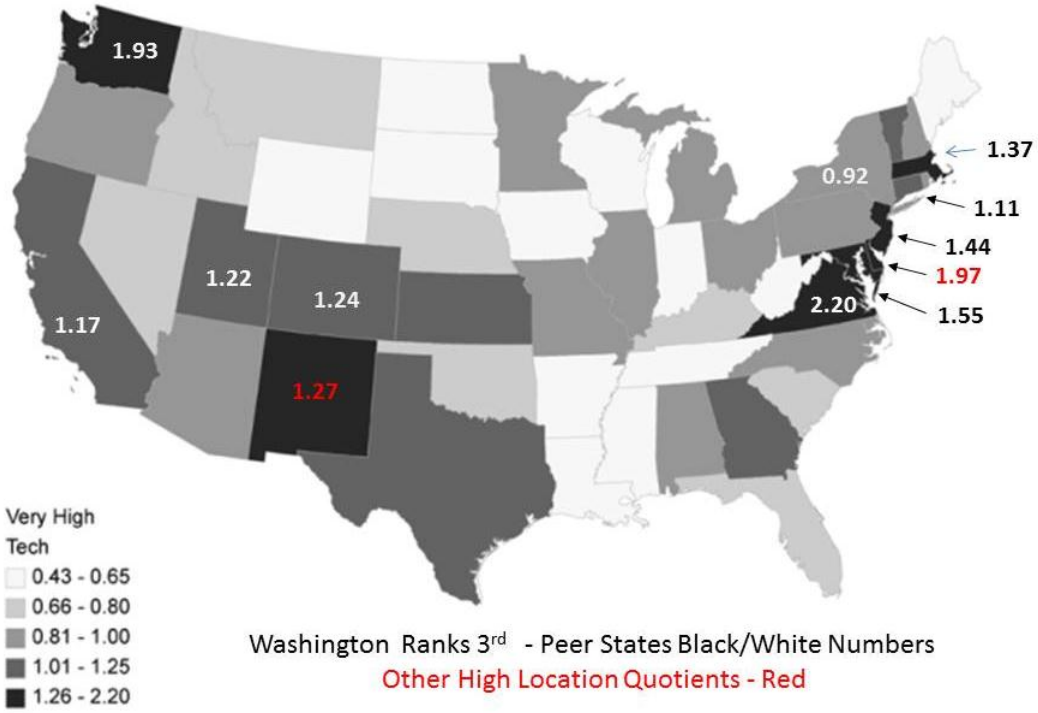
The location quotient for all technology-based employment in 2009 placed Washington 2nd in its relative concentration of technology-based industries (1.465) surpassed only by Virginia (1.468). Virginia has strong concentrations in architectural and engineering, computer systems design, scientific research and development, and management and technical consulting services.

[7] Including Management of Companies, Architecture and Engineering Services, and Management and Technical Consulting Services

New Jersey has strong concentrations in chemicals, commercial equipment merchant wholesalers, telecommunications, management of companies, computer systems design, management and technical consulting, and scientific research and development. Massachusetts is heavily concentrated in computer and electronics manufacturing, software, and scientific research and development. California has multiple concentrations of technology-based industries, including computers and electronics, software, commercial equipment merchant wholesalers, other information services, and scientific research and development. Colorado has a high concentration in telecommunications, commercial equipment merchant wholesalers, data processing, architecture and engineering, and computer systems design.

Maryland has high concentrations in architecture and engineering, computer systems design, scientific research and development services, and management and technical consulting services. Utah has concentrations in computer manufacturing, aerospace, electronic shopping, software, management and technical consulting, and data processing. Connecticut has strong concentrations in machinery, electrical equipment, and aerospace manufacturing, and other information services. New York has a strong concentration of employment in other information services.

Figure 4 Location Quotients for Technology-Based Employment in the U.S. (industries as defined in Table 2, excluding university and federal research)



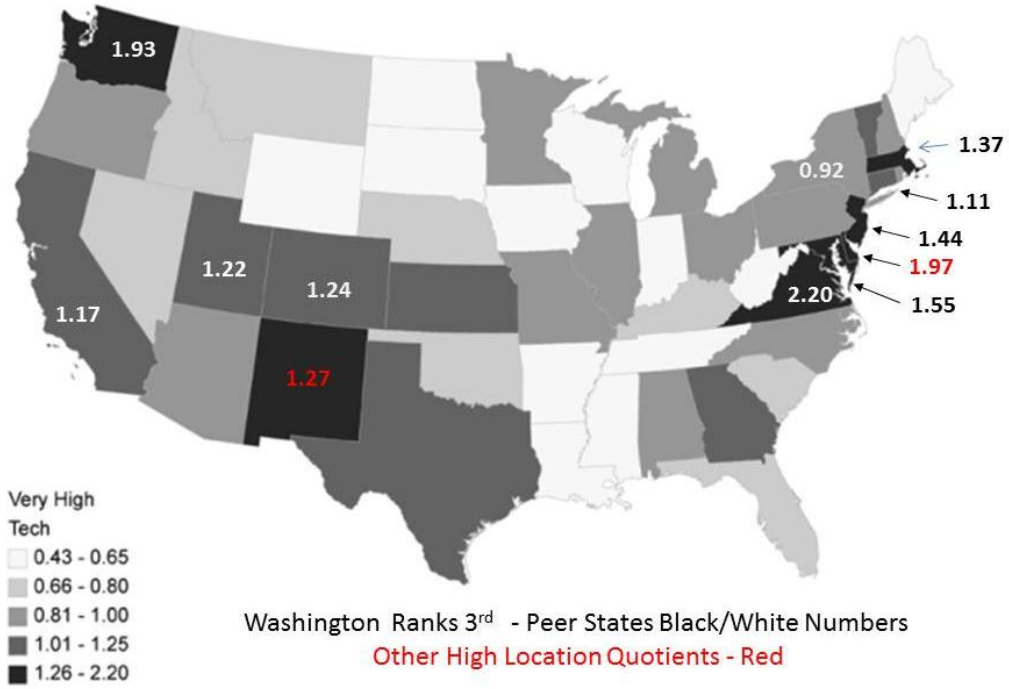
In the 1997 Technology Alliance economic impact study, Washington ranked 6th in the U.S. in its location quotient for technology-based industries, based on data for the year 1993. In the 1998 study we were propelled to the top of the nation in our concentration of these industries, a ranking based on data for 1995. Washington retained

this position in the 2001 study, using national data for 1997. In the 2005 study, our position slipped to 3rd and then, in the 2008 study we ranked 4th, fueled primarily by employment losses in the aerospace sector. In the 2010 study we also ranked 4th.

It is not possible to tease apart precisely the relative contributions to Washington's shifting position in these location quotients in industry detail due to the shift from the SIC to the NAICS classification schemes, and changes in the definition of technology-based industry in these studies. However, with the growing importance of services in the definition of technology-based industry, it is clear that states such as Virginia, Maryland, Connecticut, and New Jersey are strong competitors with their proximity to the nation's capital and our leading financial center, New York City. Washington's position is strongly impacted by our very strong concentration in software publishing—our location quotient is 6.25, more than double that of the closest other state (Massachusetts, with a value of 2.76).

Figure 5 identifies concentrations in "technology-intensive" industries, or those with greater than 30% of employment in R&D occupations (see Table 3 for a list of these sectors). The inclusion of aerospace and software publishers in this category (26% of employment in R&D occupations within Washington State are in these two sectors), is responsible for our very high concentration (1.93)—the third highest index in the nation after Virginia (2.20) and Delaware (1.97).

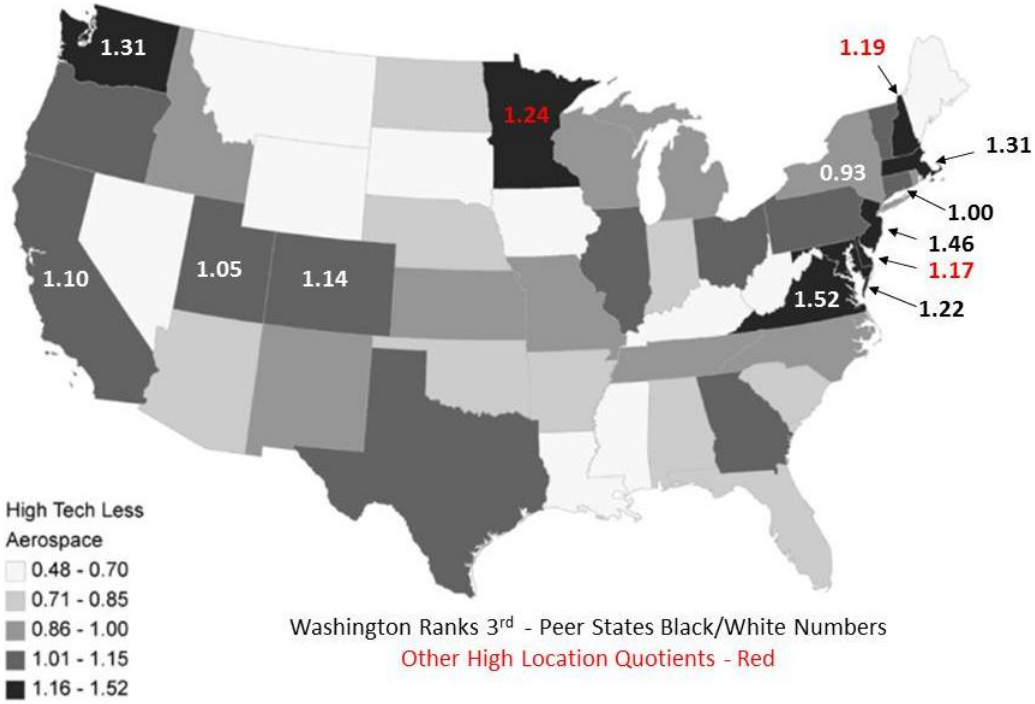
Figure 5 Location Quotients for Technology-Intensive Employment (greater than 30% employment in R&D occupations)



The strong contribution of aerospace to the high location quotients for Washington State depicted in Figures 4 and 5 is more sharply evident when the sector is excluded from the calculation, as shown in Figure 6. Without aerospace Washington's technology-based industry location quotient falls to 1.31. In part, this is a reflection of the state's low concentration in machinery, chemicals and petroleum, and selected trade and business services.

While Washington State enjoys an almost unsurpassed dominance in its concentration of aerospace employment (only Kansas has a higher location quotient than Washington), the state is currently not a national center of non-aerospace technology-based manufacturing. The industries that pull us up to the national average are computers and electronics, software, research, and waste management. States that have the highest location quotients in Figure 6 (Virginia and New Jersey) have strong concentrations in a variety of technology-based services, but not in software.

Figure 6 Location Quotients for Non-Aerospace Technology-Based Employment



Size Distribution of Technology-Based Establishments

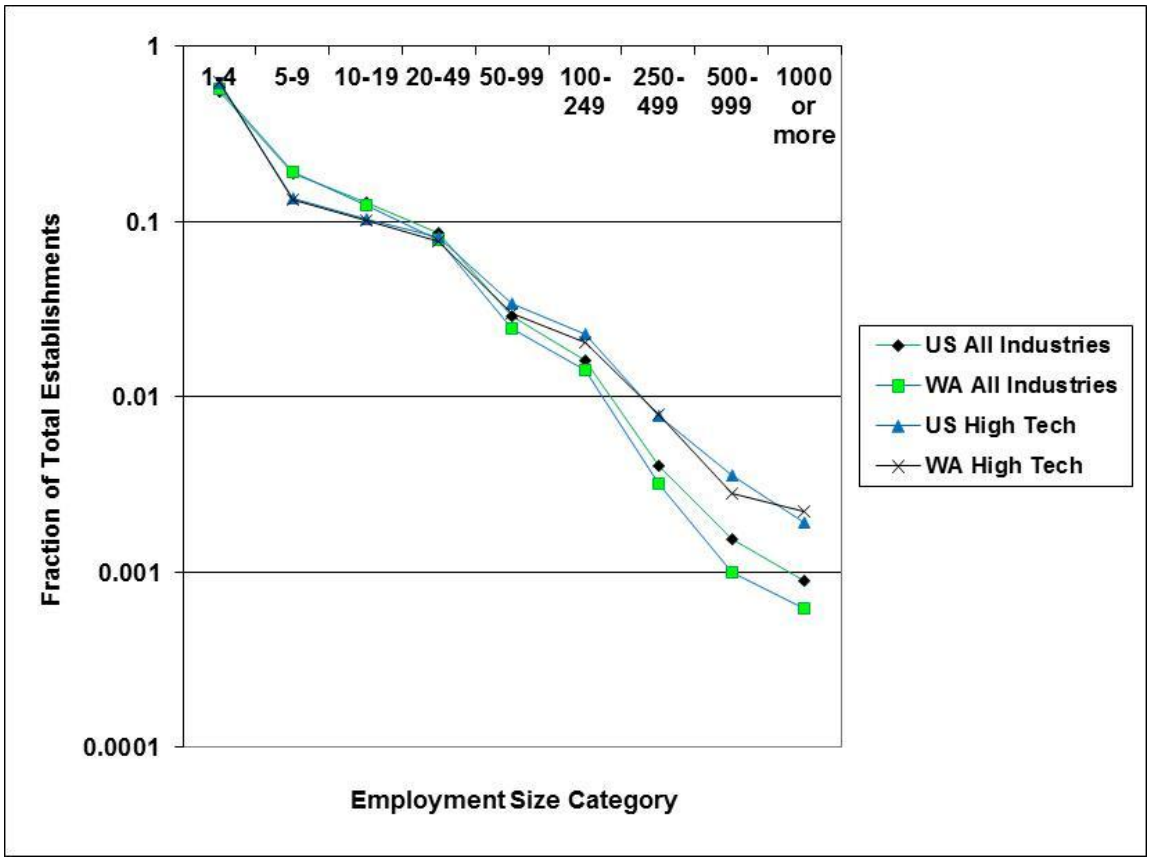
County Business Patterns (CBP) provides establishment counts by size category, while the Nonemployer Series provides estimates of proprietorships. These data are presented in Table 7, and in Figures 7, 8 and 9. These data indicate that 15,437 technology-based establishments in Washington State employed a total of 394,352 people in 2009. with an average of 26 employees per establishment[8]. The Nonemployer Series

[8] The year and data base for County Business Patterns differs from the Employment Security Department covered employment series, used as the benchmark for this study. Therefore, the totals are not the same, but they are quite similar.

for 2009 contains an additional 37,014 individuals, most of whom are reported in services, with 43% of the total reported in NAICS 5416, consulting services.

Figure 7 is presented in a semi-logarithmic format, and includes the size distribution of technology-based establishments in Washington State and the United States, as well as the distribution for employment in all industries. This figure clearly indicates (1) a similar size distribution for technology-based establishments in Washington State and in the United States, and (2) the fact that Washington and U.S. technology-based industries have a "tail" of larger establishments (over 100 employees). Figure 8 shows the estimated total employment by size category, using the estimated size per establishment reported in Table 8[9]. Figure 8 reports that almost half of employment in Washington technology-based industries are in establishments with 500 or more employees. In contrast, Figure 9 indicates the very skewed distribution of establishment size, with 99.5% of the total establishments employing fewer than 500 people, and 86% employing fewer than 20 people.

Figure 7 Size Distribution of Technology-Based Establishments, 2009 (excludes self-employed and university and federal research)



[9] The estimated size for the category over 1,000 employees was calculated by subtracting total employment in the smaller size categories from the total employment, and calculating the average employment for the remaining employees.

Table 8 Size Distribution of Technology-Based Establishments in Washington State

NAICS Code	Industry Code Description	Total Establishments	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1,000 or more	Non-Employer
324	Petroleum and Coal Products Manufacturing	28	9	4	3	5	1	2	3	1	0	14
325	Chemicals Manufacturing	238	89	60	29	36	11	11	0	2	0	192
3332	Industrial Machinery Manufacturing	91	31	13	18	13	8	5	3	0	0	54
3335	Metalworking Machinery Manufacturing	62	28	9	6	12	2	3	2	0	0	36
3336	Turbine & Power Transmission Manufacturing	9	4	1	1	2	0	1	0	0	0	5
334	Computer and Electronic Product Manufacturing	331	129	46	40	54	25	20	6	9	2	248
335	Electrical Equipment, Appliance and Component Manufacturing	106	42	18	8	23	9	6	0	0	0	117
3361	Motor Vehicle Manufacturing	8	2	4	0	1	0	1	0	0	0	4
3364	Aerospace Product and Parts Manufacturing	118	37	8	21	13	8	14	10	2	5	52
4234	Professional & Commercial Equipment and Supplies Merchant Wholesalers	798	421	131	115	81	21	17	8	2	2	214
4541	Electronic Shopping and Mail-Order Houses	618	424	94	52	24	14	8	1	1	0	2,328
5112	Software Publishers	337	131	50	48	49	23	20	9	2	5	742
517	Telecommunications	1,114	550	189	176	100	41	26	22	6	4	463
518	ISP and Data Processing	339	151	48	51	48	22	13	4	1	1	810
5191	Other Information Services	230	130	27	27	22	7	10	7	0	0	1,339
5413	Architecture, Engineering, and Related Services	3,137	1,914	496	359	237	78	43	8	1	1	5,318
5415	Computer Systems Design and Related Services	2,872	2,083	319	230	150	52	26	6	4	2	8,279
5416	Management, Scientific, and Technical Consulting Services	3,243	2,737	240	137	84	31	11	2	1	0	15,857
5417	Scientific Research and Development Services	466	249	62	56	47	20	22	8	0	2	839
55	Management of Companies and Enterprises	1,005	370	173	142	151	76	51	24	10	8	0
5622	Waste Treatment and Disposal	42	15	9	7	4	6	0	0	0	1	15
5629	Remediation and Other Waste Management Services	245	123	52	33	28	3	4	0	1	1	88
	Total # Establishments	**15,437**	**9,669**	**2,053**	**1,559**	**1,184**	**458**	**314**	**123**	**43**	**34**	**37,014**
	Average Size (# Employees)	**25.55**	**2**	**7**	**13**	**35**	**70**	**140**	**350**	**700**	**4,405**	
	Total Employment	**394,352**	**19,338**	**14,371**	**20,267**	**41,440**	**32,060**	**43,960**	**43,050**	**30,100**	**149,766**	

Source: U.S. Census Bureau County Business Patterns and Nonemployer Statistics

Figure 8 Share of Total Employment by Size Category

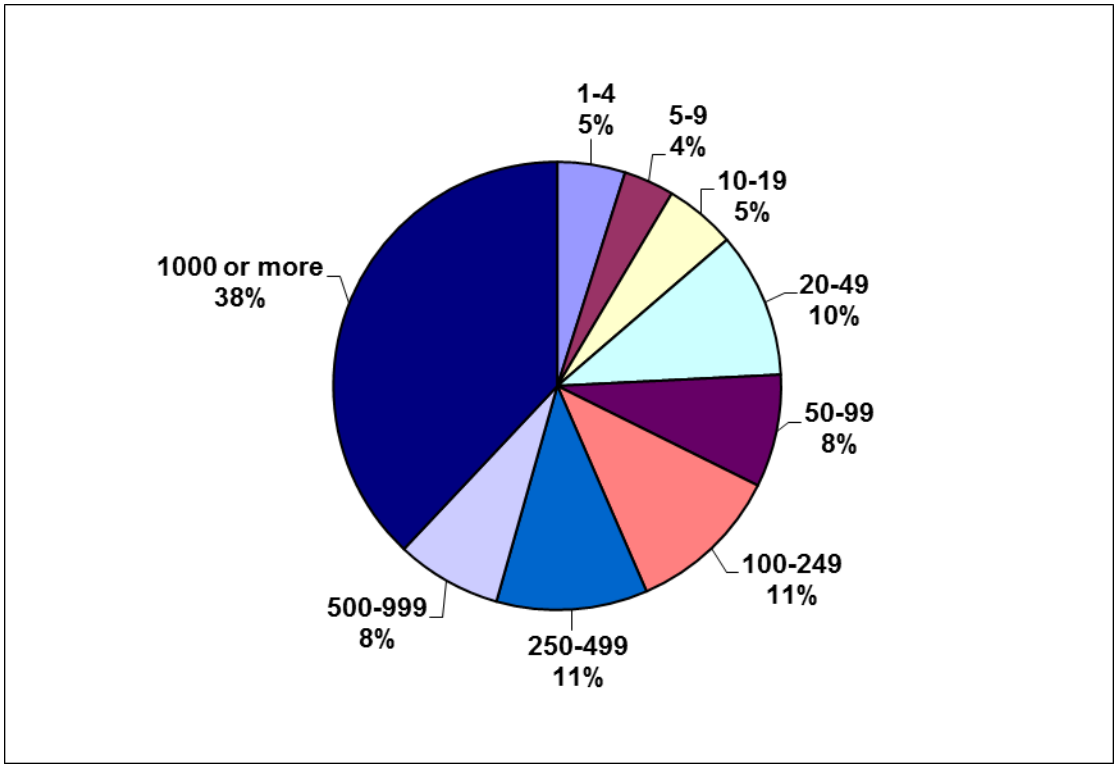
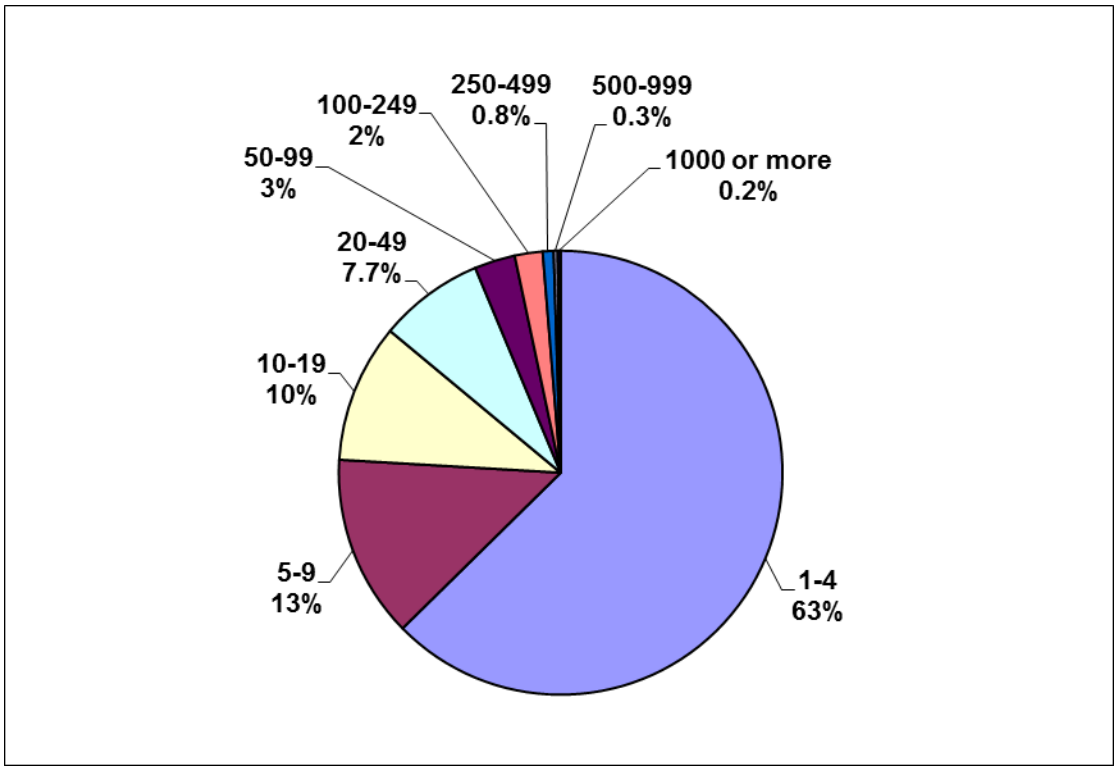


Figure 9 Share of Total Number of Establishments by Size Category



University and Federal Research

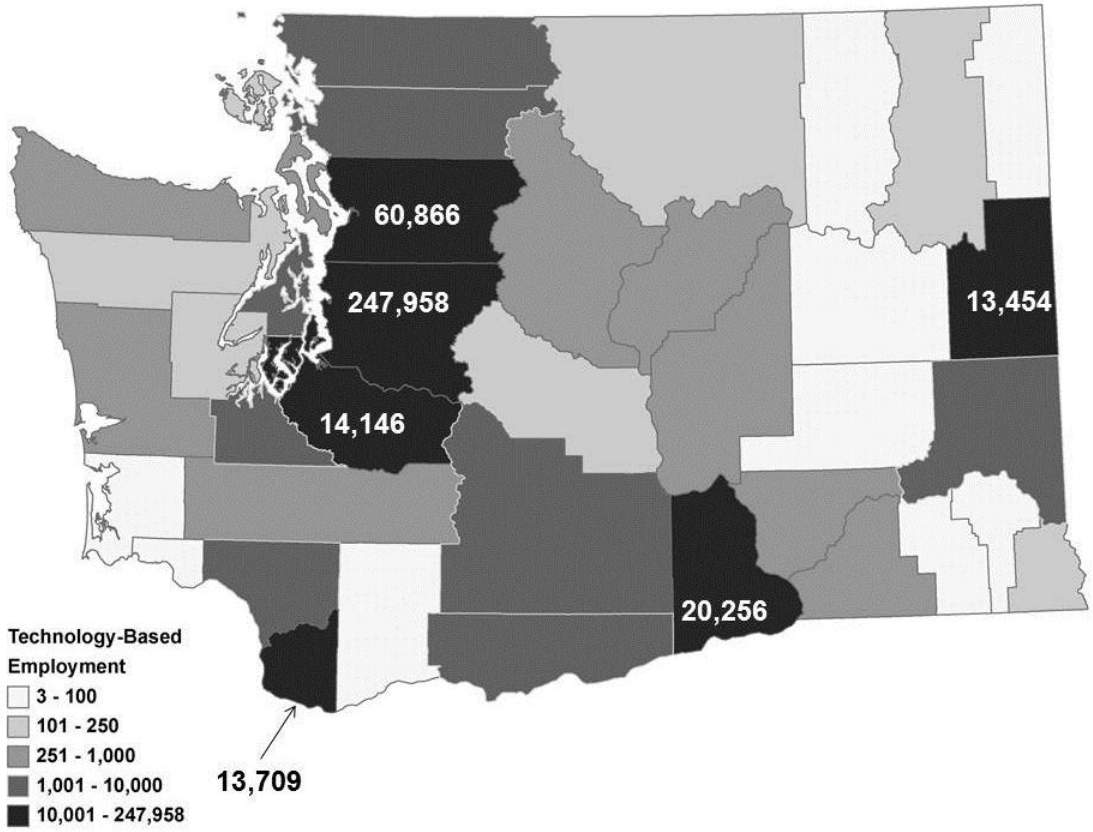
The historical trends described in this section, and the maps showing the concentration of technology-based employment, exclude employment in university and federal research organizations due to a lack of historical information on these entities. The University of Washington and Washington State University provided special tabulations of their research-related expenditures and employment for the year 1997, including direct outlays associated with research grants and contracts and associated indirect costs. It was assumed that these cost distributions have not changed for the purposes of this study.

It is estimated that 12,384 people were employed at university and federal research establishments in 2011, as measured on an FTE basis. At the UW, grant and contract activity has expanded significantly over time, rising from $179 million in 1975 to $673 million in 2011 (as measured in constant 1982-1984 dollars). Grant and contract expenditures at the UW were $1.287 billion in fiscal year 2011, of which $825 million was for research (UW 2011). The balance of these grant and contract funds were obligated for training, fellowships, and other activities (including institutes and conferences, and are not included in this study). The UW is currently the 2nd largest university recipient of federal research funding in the U.S. and the largest recipient among public institutions.

Distribution of Technology-Based Jobs in Washington State

While employment in technology-based industries is concentrated strongly in the Seattle-Everett metropolitan area (where aerospace and technology-based service employment is primarily located), there are firms located in every county in the state. Figure 10 shows the distribution of employment in 2011. Outside of King and Snohomish counties, there are also relatively large numbers of employees in Benton (20,256), Clark (13,709), Pierce (14,146), and Spokane (13,454) counties. Fourteen counties have at least 1,000 persons employed in technology-based industries. Appendix VI contains estimates of technology-based employment for all 39 counties in Washington State.

Figure 10 Technology-Based Employment by County



Source: U.S. Census Bureau Nonemployer Statistics, Washington State Employment Security Department

Summary

Washington's technology-based industries have grown substantially in the past three decades, such that in the aggregate they now represent over 13% of total employment (including university and federal employment at Keyport and NOAA). While aerospace and computer services continue to play a dominant role and are the primary reason that Washington has one of the highest concentrations of technology-based industries, other sectors have emerged that contribute to further diversification of the state's economy. As the next section describes in detail, these industries now represent a substantial component of Washington State's economic base.

IV. Economic Impact Analysis

While technology-based industries employ more than 434,000 people in Washington, there are broader impacts on our economy beyond direct employment. These larger "multiplier" effects occur as a result of businesses within these industries selling their goods and services outside the state, making intermediate purchases within the state, and providing payments to employees in the form of wages and other labor income, a large portion of which is spent on other goods and services within the state economy.

To calculate these larger impacts, an input-output model was used, which provides a detailed representation of economic linkages within a regional or national economy. We have used the Washington State input-output model to calculate the impacts of technology-based industries on the Washington economy for the year 2011 (Beyers and Lin 2008). Before describing results from this analysis, a brief discussion of the input-output methodology is presented. A technical appendix on modeling is included as Appendix II.

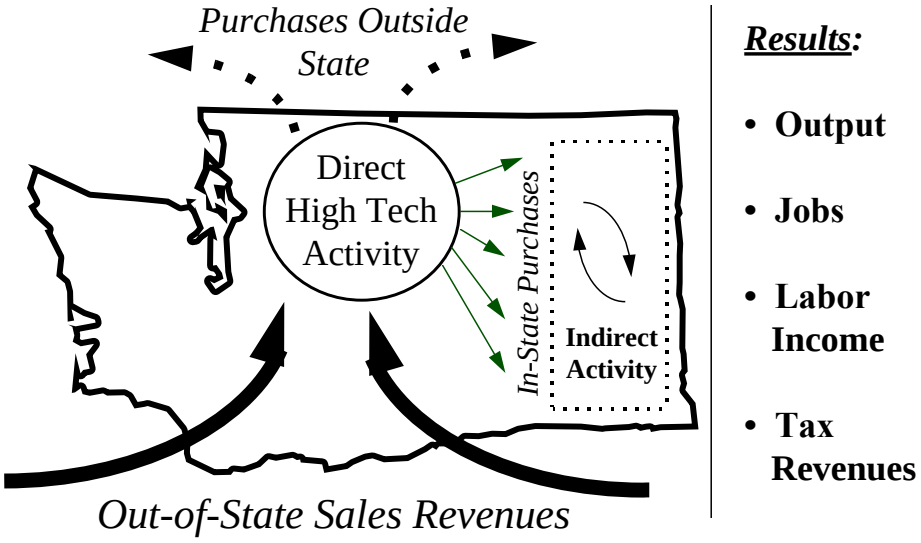
The Washington State Input-Output Model

Washington State has invested in the construction of seven regional input-output models beginning in 1963, with the latest model released for the year 2002. A new model is being constructed benchmarked against the year 2007; it was not completed before publication of this report. These models describe where Washington industries sell their products and where they purchase the inputs needed to make their products. The structural relationships contained in these models are used to estimate the indirect impacts associated with industrial production. The models are divided into "sectors," which have distinctive patterns of inputs, or purchases of goods and/or services regionally. These distinctive purchasing patterns lead to varying multipliers. The widespread application of regional input-output models to impact analyses stems from their ability to pinpoint these differing levels and patterns of impact by industry.

Figure 11 is a schematic that describes the general structure of a regional input-output model. Demands for the products or services of individual industries lead to the direct purchase of inputs to make products and services. These direct purchases are made from suppliers located inside Washington State but are also procured in non-Washington markets. For example, Boeing imports all of the jet engines assembled into aircraft from elsewhere in the United States or abroad, but they also purchase some services and manufactured goods in Washington State and make large payments to their labor force.

Within the regional economy, the purchases of goods, services, and payments to the labor force have "ripple effects." For businesses, these ripple effects begin when they procure inputs to produce the products or services they sell to a client. "Second-round" and "third-round" effects take place as other industries are drawn into the production process indirectly to produce output ultimately delivered to the business. Similarly, labor force earnings are spent on consumption of goods and services, such as food, housing, cars, clothing, etc. These expenditures also have ripple effects, which are captured in regional input-output models.

Figure 11 Schematic of the Washington State Input-Output Model



Through the use of a generalized form of the direct structural relationships found in a regional input-output model, it is possible to trace out the summarized impact of the demand from any given industry on all industries. These impacts are measured as (1) the level of business activity (or output) generated in all industries, (2) the number of jobs created in all industries, (3) the level of labor income earned in all industries, and (4) selected tax revenues. Separate measures of impact were calculated for each of the NAICS codes shown in Appendix V, and aggregated to the industrial groupings used in Table 11. Details of this computational process are discussed in Appendix II.

Impact Results

Results from the impact analysis are presented first in the aggregate and then with more detail related to particular segments of technology-based industries in Washington State. Table 9 presents direct and aggregate impact results. Some 434,343 jobs, $230 billion in sales, $770 million in taxes, and $41 billion in labor income were directly attributable to technology-based industries in Washington State in 2011.[10] These values increase significantly once the indirect effects are added from the input-output model calculations. Direct and indirect employment impacts total 1,441,721 jobs; overall impacts equal $369.5 billion in sales, with $85.6 billion in labor income. The aggregate level of state sales and use, business and occupation (B&O), and local sales and use taxes are estimated to be $6.1 billion.[11] Later in this section, we will disaggregate these large impacts into the contributions of individual sectors.

[10] Direct tax impacts are estimated business and occupation tax collections.

[11] Total tax impacts are much higher than direct tax impacts, as they include sales taxes generated from the spending of labor income, as well as direct and indirectly generated business and occupation tax revenues.

Table 9 also presents estimates of multipliers: the multiplier represents simply the relationship between the direct effects and the sum of the direct and indirect impacts. To interpret these multipliers, we can say, for instance, that for every technology-based job in Washington State, there are a total of 3.32 jobs created in the state economy.

Table 9 Direct and Total Impacts of Washington's Technology-Based Industries

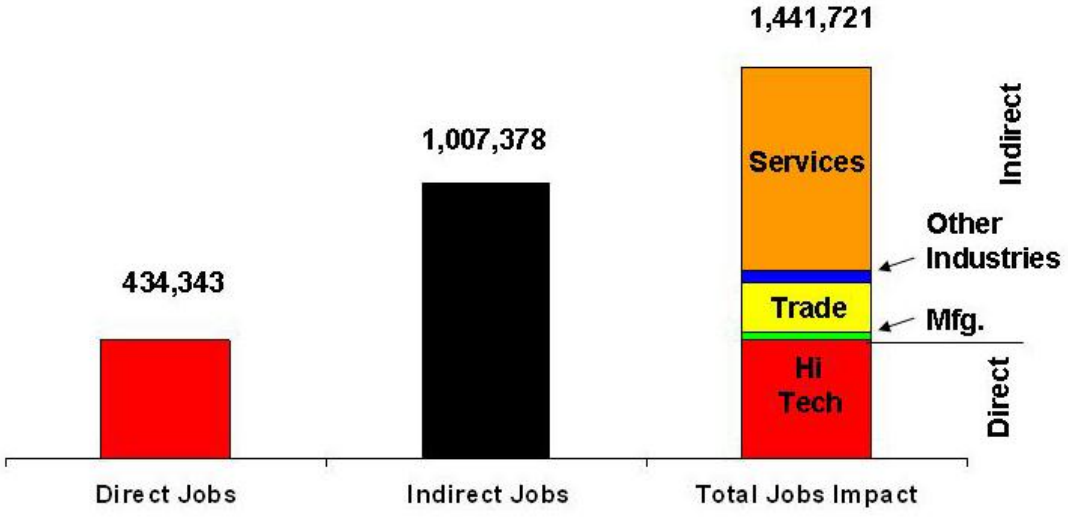
$ in Millions		**% Change from 2010 Study in Nominal $**[12]
Direct Impacts		
Sales	$230,960	73.7%
Employment	434,343	13.8%
Labor Income	$41,059	-2.3%
Taxes	$770	-8.1%
Total Cumulative Impacts		
Sales	$369,543	55.0%
Employment	1,441,721	19.3%
Labor Income	$85,775	11.8%
Taxes	$6,132	15.1%
Multipliers		
Sales	1.60	
Employment	3.32	
Labor Income	2.09	

The input-output model provides estimates of output, income, and employment impacts in each industry in the economy due to the demands related to each individual technology-based industry. The impacts in Table 9 could be presented at this level of detail, but a simpler view of these impacts is presented in Figure 12, which shows the total direct and indirect employment effects.

Of the 1,007,378 indirect and induced jobs created in the Washington economy, some 33,719 of these are in manufacturing, with the balance spread across a wide variety of services and other industries. These impacts reflect the strong leveraging impact of labor income earned by workers in technology-based industries, income that is well above the state average per worker as will be documented shortly. The expenditure of this labor income robustly stimulates the trade, services,[13] and other industry[14] sectors in the input-output model.

[12] The current study includes self-employed persons in the direct impacts; previous Technology Alliance economic impact studies have not included these employees.
[13] Services includes transportation and warehousing; information; finance, insurance, and real estate; professional services; educational services; health services; arts, recreation and accommodation services; food services and drinking places; and other services.
[14] The other industry group includes: agriculture, agricultural services, forestry, fishing, logging, mining, utilities, and construction.

Figure 12 Total Direct and Indirect Employment Impacts



Industries have varying impacts on regional economies, as measured by business activity, employment, and income through input-output models. The magnitude of these impacts is a function of their connectivity to these economies. The industries included in this study have major differences in their impacts, as documented in Table 10. Table 10 presents the total employment impact multiplier and labor income per job by industry, and identifies industry variations in the proportion of purchases made in Washington State and the share of out-of-state sales. This table also compares technology-based industry impacts to the average for all other industries in the Washington economy. Variations in labor income levels per job and in-state purchases each influence multiplier levels, contributing to the multiplier effect of these sectors on the Washington economy.

Table 10 Key Indicators for Technology-Based Industries

	Employment Multiplier	Labor Income Per Job	% In State Purchases	% Out of State Sales
Manufacturing				
Aerospace & Motor Vehicles	2.86	$96,755	6.9%	97.4%
Machinery, Computers & Electronics, and Electrical Equipment	3.81	$57,010	19.9%	86.3%
Chemicals & Petroleum Products	4.87	$78,518	16.9%	49.0%
Services				
Software Publishers, Data Processing, Other Information Services, and Computer Systems Design	4.47	$123,780	20.8%	79.3%
Telecommunications	4.72	$98,565	37.0%	8.3%
Commercial Equipment Merchant Wholesalers	2.77	$92,165	17.3%	40.4%
Electronic Shopping & Mail Order Houses	2.47	$78,459	20.1%	15.1%
Scientific Research & Development	2.69	$96,207	18.2%	67.9%
Architecture & Engineering, Management Consulting, and Management of Companies & Enterprises	2.39	$75,432	23.6%	60.5%
Waste Treatment and Remediation	2.78	$76,998	31.6%	85.0%
University & Federal Research	2.04	$68,459	19.4%	95.0%
All Technology-Based Industries	**3.32**	**$94,531**	**16.6%**	**75.5%**
Other Washington Industries	*2.33*	*$49,829*	*27.1%*	*27.4%*

Table 11 presents summary impacts of technology-based business activity by sectoral group. This table is followed by a brief discussion of the impacts of each sector. Total impacts are as reported in Table 9.

Table 11 Summary Impacts by Sector

	Sales ($ Millions)	Employment (# of Jobs)	Labor Income ($ Millions)	Taxes ($ millions)
Manufacturing				
Aerospace & Motor Vehicles	$104,296.5	243,000	$15,350.7	$1,089.9
Machinery, Computers & Electronics, and Electrical Equipment	$24,793.8	109,669	$6,405.0	$409.3
Chemicals & Petroleum Products	$39,254.0	40,908	$2,217.2	$288.9
Services				
Software Publishers, Data Processing, Other Information Services, and Computer Systems Design	$103,442.3	492,807	$30,096.0	$2060.4
Telecommunications	$27,817.8	117,281	$6,505.8	$552.6
Commercial Equipment Merchant Wholesalers	$6,796.7	37,640	$2,304.5	$141.7
Electronic Shopping & Mail Order Houses	$5,329.2	33,268	$1,911.9	$119.1
Scientific Research & Development	$8,542.5	56,097	$3,492.3	$229.6
Architecture & Engineering, Management Consulting, and Management of Companies & Enterprises	$38,786.1	246,616	$13,899.0	$991.6
Waste Treatment and Remediation	$6,313.2	37,178	$2,065.2	$144.2
University & Federal Research	$4,170.9	27,258	$1,526.8	$104.5
All Technology-Based Industries	**$369,542.9**	**1,441,721**	**$85,774.6**	**$6,132.0**

Manufacturing

Aerospace & Motor Vehicles

The aerospace and motor vehicles sector generated 243,000 jobs in the Washington economy in 2011, 7.5% of total state employment. Most of the impact of this sector comes from the aerospace sector which employed 84,831 people in 2011, while motor vehicles had only 180 employees. As Table 10 indicates, the aerospace and motor vehicles sector is strongly focused on markets outside Washington State. The aerospace component of this sector has a history of fluctuation, as the demand for commercial aircraft has boomed or collapsed. The year 2011 corresponded to an expanding phase in the aerospace cycle, with the sector gaining 6,164 jobs in Washington State between 2007 and 2011. However, 2011 employment fell short of the 1998 peak level of employment by 28,000 jobs.

While the aerospace and motor vehicles sector accounted for 19% of direct technology-based jobs in 2011, it accounted for a somewhat smaller share (17%) of total job impacts. Although labor income per worker is high in this sector, it has weak backward linkages to other industries in the state economy when compared to other technology-based industries. The result is a lower multiplier than found in a number of other technology-based sectors, but a level still above the state average (Pascall, Pederson et al. 1989).

Machinery, Computer & Electronics, and Electrical Equipment

The machinery, computer and electronics, and electrical equipment manufacturing sector is quite diversified. The machinery component is composed of manufacturers of industrial; metal working; and engine, turbine & power transmission machinery. The sector also includes computer and peripheral equipment; communications equipment; audio and video equipment; semiconductors and other electronic components; navigational, measuring, electromedical and control instruments; reproducing magnetic and optical media; electric lighting equipment; household appliances; electric equipment; and other electrical equipment and components. These industries collectively employed nearly 29,000 people and supported almost 110,000 total jobs in 2011. The computer and electronics component experienced significant job growth over the 1974-2002 time period (296%), as indicated in Table 5 and Appendix IV, although it experienced a 12% decrease in employment between 2007 and 2011.

This sector is strongly tied to non-Washington markets, exporting 86% of its product. Its jobs multiplier of 3.81 is above than the average for all technology-based industries. This sector accounted for 6.6% of technology-based jobs in 2011, and 7.6% of all jobs created statewide by technology-based industries.

Chemicals & Petroleum Products

The chemicals manufacturing industry includes firms engaged in organic and inorganic chemicals manufacturing; plastics materials manufacturing; pesticide and fertilizer manufacturing; biomedical products manufacturing; and paints, adhesives, cleaning, and other chemical products manufacturing. Nearly 6,000 people worked in this industry in 2011, with another 2,400 employed in petroleum products. Together, these industries supported almost 41,000 jobs in the Washington economy.

The chemicals manufacturing sector has exhibited considerable employment change over time; Table 5 shows a large drop in employment between 1990 and 1992. This was largely due to a reclassification of people who were employed in plutonium production at Hanford into research and testing services (note the large increase in employment in this sector in Appendix IV between 1990 and 1992). Table 6 reports NAICS-based chemicals and petroleum refining employment has grown slightly since 1998.

This sector has slightly lower wages than all technology-based sectors (see Table 10), but it has a relatively high employment multiplier due to structural relations in this sector captured in the Washington input-output model. The petroleum products industry sells about 45% of its output out-of-state, while the chemicals industry is more strongly focused on markets outside Washington State, selling 83% of its output in external markets. This sector was responsible for only 1.9% of the technology-based jobs in Washington State, but supported 2.8% of the total jobs related to technology-based industries.

Services

Software Publishers, Data Processing, Other Information Services, and Computer Systems Design & Related Services

This sector comprises establishments primarily engaged in computer software publishing or publishing and reproduction, and establishments primarily engaged in providing infrastructure for hosting or data processing services. These establishments may provide specialized hosting activities, such as web hosting, streaming services or application hosting; provide application service provisioning; or may provide general time-share mainframe facilities to clients. Data processing establishments provide complete processing and specialized reports from data supplied by clients or provide automated data processing and data entry services. It also includes establishments providing custom computer programming services, computer integrated systems design, computer facilities management, and other computer related services. Other information services is dominated by employment in internet publishing and broadcasting, but also includes news syndicates, libraries, and other information services.

This sector directly employed 110,317 people, with a relatively high job multiplier of 4.47. It supported almost 493,000 jobs in the Washington economy in 2011, or 15.2% of total state employment. The high multiplier is related to the high labor income per worker in this sector, estimated to be $123,780, more than two and one-half times the state average labor income per job. This sector accounted for 25.4% of technology-based jobs, and through its relatively high multiplier, it was responsible for 34.2% of total jobs created by technology-based industries in Washington. This sector has very strong out-of-state sales (79%), and makes in-state purchases at a slightly higher level than all technology-based industries.

Reclassifications from the old SIC code to NAICS and redefinitions of NAICS codes make it difficult to estimate growth of this sector using consistent definitions. However, Table 5 reports growth under the SIC definition of 1239% from 1974 to 2002, while Table 6 reports more than a tripling of employment in software publishers and computer system design from 1998 to 2011.

Commercial Equipment Merchant Wholesalers

This industry includes establishments wholesaling photographic equipment and supplies; office equipment; computer and computer peripheral equipment; software; medical, dental and hospital equipment; ophthalmic goods; and other commercial and professional equipment and supplies. This industry was not included in the first three Technology Alliance economic impact studies. Redefinitions of the classification of wholesaling in the 2002 revisions of the NAICS codes led to the inclusion of this sector because of its relatively high concentration of computer-related occupations. The NAICS definition for this industry does not mesh well with SIC-based definitions, so it is not possible to develop historical estimates of employment in this industry prior to 1998.

This industry employed over 13,000 people and supported nearly 38,000 jobs in the Washington economy in 2011. The sector has high earnings per worker, and a degree

of export-market orientation similar to all Washington industries. This sector accounted for 3.1% of technology-based jobs in Washington State, and was responsible for 2.6% of total jobs created due to technology-based industries.

Electronic Shopping & Mail Order Houses

This industry comprises establishments primarily engaged in retailing all types of merchandise using non-store means, including electronic media such as interactive television or the Internet. This industry employed 11,154 people in 2011, or 3.1% of technology-based employment in Washington. It supported 33,268 total jobs, which is 2.3% of the jobs supported by technology-based industry in the state. This industry has grown rapidly, increasing state employment by 136% from 1998 to 2011.

The Washington State input-output table does not provide an estimate of markets for sub-categories within retailing; it reports exports of 15% in the retail sector, the figure reported in Table 10. It is quite likely that the level of out-of-state sales for the electronic shopping and mail-order industry is well above this figure, but there are no survey data available to document the level of out-of-state sales. The largest employer in this industry is Amazon.com, headquartered in Washington State, which also has fulfillment centers located around the United States and in foreign countries. Amazon's global sales cannot be attributed to its headquarters activity; it is unknown what the percentage of sales filled by this company's Washington establishments are shipped to customers located in the state. It is also unknown what percentage of overall Amazon and other electronic shopping and mail order house employment is classified in this industry, as opposed to NAICS 55, management of companies and enterprises.

Telecommunications

The telecommunications industry is composed of establishments providing wired, wireless, and satellite telecommunications; telecommunications resellers; and other telecommunications services. Changes in NAICS code definitions made in 2007 have altered where some telecommunications activities are classified. Due to these reclassifications there is a lack of historical data for this industry. The current industry had 24,852 employees in 2011, which was 5.7% of all technology-based employment in Washington State. This industry has a relatively high jobs multiplier, supporting 117,281 jobs or 8.1% of all jobs in the Washington economy supported by technology-based industry.

The Washington input-output table reports a low level of out-of-state sales for this industry, only 8.3%, making this sector the most strongly linked to the Washington economy of any technology-based industry. The industry's level of in-state purchases was higher than that of other technology-based industries. Labor income per worker is slightly above the technology-based industry average.

Architecture & Engineering, Management Consulting, and Management of Companies & Enterprises

This sector includes establishments engaged in architecture, engineering, and related services; management, scientific, and technical consulting services providers; and establishments providing management of companies and enterprises, including

headquarters services. Over 76,000 people were employed in these industries in2011, and the sector supported almost 247,000 jobs in the Washington economy. Earnings in this sector are below the average for all technology-based industries, but well above the statewide average[15]. This sector accounted for 23.8% of all technology-based jobs in Washington State, and it supported 17.1% of the total jobs created by technology-based industries.

This sector is not comparable to definitions based on the SIC system, but some components of it were included in earlier Technology Alliance studies. Table 5 indicates that engineering, research, and consulting services had strong growth in Washington State between 1974 and 2002, while Appendix IV indicates that architectural and engineering services and management and public relations services have also had strong growth over this time period. In the SIC classification scheme, headquarters were treated as "administrative and auxiliary" establishments, and were reported as a component of two-digit industry statistics. The NAICS system reclassified these entities into NAICS code 55. This category is now called management of companies and enterprises. Research and testing services were included in this industry grouping in early Technology Alliance studies, but in studies since 2005 this activity is classified as scientific research and development services.

Market data for this sector show that about 61% of sales are made out-of-state. Appendix V reports a sharp drop in employment in management of companies and enterprises (NAICS 55) between 2000 and 2002. This is likely related to reclassifications of establishments in the wake of the 2002 NAICS redefinitions. Unfortunately, there are no statistical reports available that document these reclassifications.

Scientific Research & Development

This industry is composed of scientific research and development services establishments, including establishments engaged in physical, engineering, and biological research, as well as those engaged in social science and humanities research. Over 20,000 people worked in this industry statewide in the year 2011, and it supported a total of over 56,000 jobs. Earnings are similar to the average for technology based industries. This industry accounted for 4.8% of technology-based industry employment, and was the source of 3.9% of the jobs supported in the Washington economy by technology-based industries.

Appendix IV reports the SIC-based system of measurement of research and testing services employment, which is not quite the same as the definition used in this study. This data series shows that this sector has had strong growth over the 1974-2002 time period. In 1992 the large jump in employment in this sector was due to the reclassification of a large number of Hanford-related workers from chemicals. In about 1995 many of these people were again reclassified into waste treatment and waste

[15] The architecture and engineering, and management consulting employment in this sector is large, and the earnings per self-employed person ($41,600) are well below those who are employed on a wage and salary basis ($74,655).

remediation. Thus, the trend of employment shown in Appendix IV is not based on an entirely consistent definition of this sector in the SIC classification framework.

Table 6 reports more than a doubling of employment in this industry since 1998, when the NAICS definition measurement was first reported. This industry has about 68% of its revenues from outside of the state; this is likely a conservative estimate, as a substantial fraction of the activity in this sector takes federal account at the Pacific Northwest National Laboratory. Unfortunately, the Washington input-output model, which was used to develop this estimate of out-of-state sales, does not provide detail on markets for these sub-sectors.

Waste Treatment & Disposal and Waste Remediation

This sector is composed of remediation and other waste management services; it does not include establishments engaged in waste collection. The majority of employment in this sector is related to Hanford cleanup activities. Historically, Hanford activities were largely classified in chemicals manufacturing, when plutonium production was taking place there. When this activity ceased in the 1980's, employment at Hanford was initially reclassified into the research sector (SIC 873), and much of this activity was later reclassified into waste treatment & disposal and waste remediation (these are NAICS definitions).

In 2011, this sector employed 13,337 people, and supported 37,178 jobs in the Washington economy. It accounted for about 3.1% of direct technology-based jobs, and for about 2.6% of total job impacts. This sector has 85% of its revenue from out-of-state sources.

University & Federal Research

This sector is composed of research activity at the University of Washington and Washington State University, and research and development being undertaken by NOAA and at the Keyport Naval Undersea Warfare Center. No historical data are available for this sector. The definition of this sector differs from the first three Technology Alliance studies, which included other components of research activity along with university and federal research. In the 2005, 2008, and 2010 studies, these other research activities are considered to be a separate sub-sector, as discussed above.

The wage level is lower than other technology-based industries, creating low multipliers. This is due to the inclusion of university research in this sector, in which a large number of graduate students are paid a relatively modest level of income compared to research staff and faculty. About 3% of the jobs in technology-based industries are in this sector, and they support around 2.0% of total jobs related to technology-based industry. Almost all of the income to this sector is derived from out-of-state sources, primarily from the federal government. Federal stimulus money to the University of Washington component of this sector was about 10% of total grant and contact awards in FY 2010.

V. Conclusions

This study describes the growing importance of technology-based industries in the Washington economy. In 2011 these industries employed 434,343 people, and supported a total of 1,441,721 jobs in the state economy. Technology-based industries were responsible for 45% of Washington's 3.2 million wage and salary and self-employed jobs in 2011. The share of Washington employment accounted for by private sector technology-based industries has risen from 6.7% to 13.6% from 1974 through 2011, a trend that suggests that the total impact of technology-based employment on the state economy has expanded significantly over the past three decades.

Tax revenues from the state business and occupation (B&O) tax due to technology-based industries (inclusive of indirect effects) were estimated to be $1.82 billion in 2011. (Local B&O tax collections were not estimated in this study.) Sales and use tax revenues to the State of Washington due to technology-based industries (inclusive of indirect effects) were estimated to be $2.8 billion; an additional $1.079 billion in local sales and use taxes were generated to local governments, for a total tax impact of $6.13 billion.

Technology-based industries directly and indirectly generated a total of $86 billion in labor income in 2011, which is 41% of total labor income earned in Washington that year. Thus, from the multiple perspectives of job creation, tax revenues, and labor income, technology-based industries account for about 40%-45% of total activity in the state economy[16].

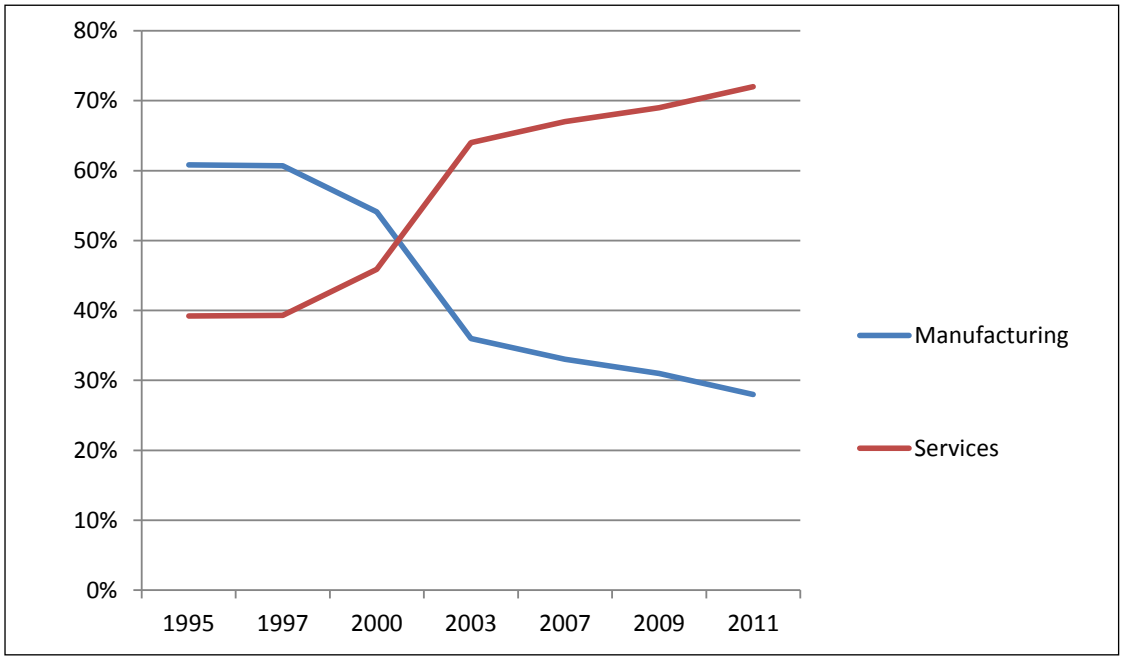
From a national perspective, Washington State is a center of technology-based employment and R&D activity. The concentration of employment in these sectors in Washington places us 2nd in the nation, and we also ranked 6th in R&D funding indexed against Gross State Product. Washington has increased its concentration of technology-based industries over time, from 10% above the national average in 1985 to 47% above it in 2011.

The change in the definition of technology-based industries due to the shift from the SIC system to NAICS makes it difficult to estimate growth rates for many Washington technology-based industries compared to the nation as a whole over the long run. Statistics for the SIC-based system presented in this report indicate strong growth rates in some sectors (such as computers and electronics and software and other computer services), and the increase in the relative concentration of technology-based industries in Washington State is indicative of a stronger overall expansion of employment in these sectors than in the national economy.

[16] A direct measure of their contribution to gross state product was not undertaken in this study, primarily because the output of these sectors enters export markets, while gross state product is predominantly composed of sales to regional components of final demand (consumption, investment, and state and local government outlays).

As technology-based employment has grown in Washington State, it has also become more diversified. In 1974, 57% of technology-based employment was in aerospace; by 2011 this share had fallen to 19%. Given the fluctuations in employment in the aerospace sector, this percentage could move up again, or it could continue to decline. However, a number of other technology-based sectors have recently experienced rapid growth, including software and internet publishers; computer systems design; scientific research and development; architectural and engineering services; and management and technical consulting services. Growth in these services industries should help the Washington economy continue the long-term diversification of its technology-based employment. Figure 13 documents the changing shares of manufacturing and services employment across the seven studies of technology-based industry conducted by the author for the Technology Alliance.

Figure 13 Shares of Technology-Based Employment in Manufacturing and Services



Technology-based industry jobs are high-wage, full-time types of work. In 2011 the average level of labor income per job in technology-based industry in Washington State was $94,531, which is 90% above the average level of labor income per worker in other industries in Washington State. This high wage level is prevalent in all technology-based industries, and it leads to relatively high impact levels related to the expenditure of this income.

Technology-based industries are also strongly focused on external markets, selling 76% of their output to clients located out-of-state. This level of export sales is much higher than other industries in the Washington economy (27%), making these industries key and growing contributors to the state's economic base. They also provide a stimulus to industries within the state economy through their purchases of goods and services needed to produce their output. The linkage pattern of these industries creates

higher than average multipliers, leading to relatively high levels of impact per dollar of business activity or per directly-created job.

This study documents the fact that private sector for-profit technology-based industries and related private non-profit and public sector research organizations have significant economic impacts on the Washington economy. There are other measures of impact that could also be constructed to describe the contribution of these industries, including the investment in productive capital needed to support their production process. The research and development intensity of these sectors also has a long-term impact on new business formation, as new businesses spin out of existing firms and research organizations. In industries such as biotechnology, this process has important impacts as firms move from the research to the commercialization phase of the production process. University research also results in new business formation that has lasting economic impacts on the state economy. Again, this study has not quantified these effects and is therefore a conservative view of the larger impacts of technology-based activities in the state economy.

While this study is based on a widely accepted definition of technology-based industry, it is clear that there are other industries and categories of economic activity that are changing the economic landscape which have their roots in or make heavy use of advanced information technologies. The demise of many early dot-com businesses is a good example of many business concepts built around information technologies. While some of these enterprises were premised on business models that have not survived, the expansion of electronic commerce is real and now the subject of measurement by the U.S. Census Bureau.

The use of the Internet for business-to-business sales and purchases is burgeoning, and the application of information technologies in a wide array of industries has now been recognized as fueling an increase in the productivity of American industry (Atkinson and Andes 2010). The federal statistical agencies have identified key information technology-producing and information technology-using sectors that have contributed very strongly to the recent growth in gross domestic product and employment. These include many of the technology-based industries covered by this study, but also include a number of other sectors such as motion pictures, health care, and producer services—sectors seen as vital to the so-called New Economy. Other studies of technology-based industry in the Washington State economy could consider embracing the activities included in the federal "Digital Economy" studies, recognizing that these studies have a different basis than used in this study for defining the economic activities that are central to the New Economy perspective (Economics Statistics Administration 2003).

In summary, technology-based industries constitute a growing, vibrant, innovative sector in the Washington economy. They provide good jobs for Washington residents and contribute an increasing share of our economic base. If the trends of recent years are any indicator, these industries will play an even more important role in our economy in coming decades.

Appendix I. Alternative Definitions of Technology-Based Industries: A Sampling of Recent Studies

A continuous stream of research focuses on technology-based industries in the United States and in other developing and developed countries. As discussed in Section II, the Technology Alliance has used an occupational definition of R&D related work as its basis for defining the scope of the industries included in this and the previous Technology Alliance economic impact studies. In this appendix several recent studies are discussed, to highlight the diversity of approaches to defining technology-based or high tech indusry.

TechAmerica

TechAmerica was formed by the merger of the AeA, ITAA, GEIA, and CSIS, which they argue is "the largest and strongest voice and resource for technology in the United States." TechAmerica is continuing to produce documents that were previously produced by the American Electronics Association (AEA), at the national, state, and metropolitan area on industries it deems to be high-tech (TechAmerica 2012). AEA changed its definition of high-tech to be based on NAICS codes, and these codes are being used by TechAmerica. The TechAmerica and AEA website states: "The U.S. government has replaced its system for classifying industries. This will have significant consequences on the data AEA produces for high-tech employment and wages, particularly for Cyberstates" (American Electronics Association 2008). Their definition includes computers and peripheral equipment, communications and consumer electronics, electronic components, semiconductors, defense electronics, measuring and control instruments, electromedical equipment, photonics, telecommunications services, internet services, software publishers, computer systems design and related services, internet services, engineering services, R&D testing laboratories, and computer training. Using this definition, TechAmerica publishes documents such as Cyberstates, which provides a state-by-state national assessment of measures such as employment, earnings, exports, R&D, and venture capital investment (TechAmerica 2012). They also issue on-line press releases that highlight activity levels in each state, provide estimates of high-tech in 60 major metropolitan areas (cybercities), and are producing measures of high-tech international trade for the states. The TechAmerica scope of high-technology industry is narrower than this study, amounting to less than 50% of the number of jobs encompassed in the Technology Alliance definition.

Bureau of Labor Statistics

The Bureau of Labor Statistics reviewed the definition of high-technology employment in a paper published in 1999. Hecker (1999) revisited the widely cited 1983 evaluation of these definitions by BLS and, using the considerable resources at the disposal of the federal statistical agencies, embraced a definition very similar to that used in the Technology Alliance economic impact studies. He writes, "For this analysis, industries are considered high tech if employment in both research and development and in all technology-oriented occupations accounted for a proportion of employment that was at least twice the average for all industries in the Occupational Employment Statistics survey " (Hecker 1999). The paper includes a useful comparison of the

industries included in this definition (they are the ones used in the first three TA studies), as well as in a number of other recent and older studies, including many reviewed in the earlier TA studies. Hecker recently revisited the definition of high-tech, given the shift in measurement to the NAICS system (Hecker 2005). His NAICS definitions are very similar to those used in this study.

National Science Foundation

The National Science Foundation (NSF) presents annually Science and Technology Indicators (SEI), a diverse set of measures related to NSF's mission. NSF states: "SEI is first and foremost a volume of record comprising the major high-quality quantitative data on the U.S. and international science and engineering enterprise." (NSF 2012). SEI has seven chapters, among which is a set of state indicators. Relevant to this Technology Alliance Economic Impact Study are data on the science and engineering labor force, research and development spending, and the state indicators. These data were used in this study to document the level of doctoral employment in Washington industries compared to the U.S. as a whole. NSF also uses the same definition of occupations as used in the current study to define technology-based industry.

Office of Technology Policy

The Office of Technology Policy (a former U.S. Department of Commerce agency) published a set of indicators of state performance in science and technology using measures of funding, human resources, capital investment and business assistance, the technology intensity of the business base, and outcome measures (Office of Technology Policy 2004). Four editions of this set of indicators were published. These reports included a set of measures related to high-technology industry, including the percentage of establishments, employment, and payroll in high-tech NAICS codes; the share of establishment births in high-tech; and the net level of high-tech business formation per 10,000 establishments. Washington ranked 1st in the share of payroll in high-tech NAICS codes, 5th in the share of employment in high-tech NAICS codes, and 15th in the percentage of establishments in high-tech NAICS codes. The Office of Technology Policy defined high-technology industry by reclassifying the 1999 definition of high-technology developed by the BLS into concordant NAICS codes (Hecker 1999). Thus, the Office of Technology Policy did not use newer the industry-x-occupation data in developing their NAICS classification of high-tech industries. Their system is also based on the 1997 NAICS codes, while the current Technology Alliance study has used the 2007 NAICS codes. The industry list used by the Office of Technology Policy is similar, but not identical, to the classification used in this study. This office was abolished in 2007.

Milken Institute

The Milken Institute has produced a variety of reports that have a high-tech component to them. This organization positions itself as "….an independent economic think tank whose mission is to improve the lives and economic conditions of diverse populations in the U.S. and around the world by helping business and public policy leaders identify and implement innovative ideas for creating broad-based prosperity." (DeVol, Klowden, and Yeo 2011) The Milken Institute publishes periodically a state

index of science and technology, which was based on 79 different measures in the 2011 edition, which is benchmarked against the year 2010. These measures span R&D inputs, risk capital and entrepreneurial infrastructure, human capital capacity, technology and science workforce, and technology concentration and dynamism. The latter includes measures similar to those included by the Office of Technology Policy. Milken does not specifically identify the industries included in their technology concentration and dynamism indicator. Washington ranked 4th on the technology and science workforce indicator, and 3rd on the technology concentration and dynamism index in 2010. These rankings are composites of individual values within these categories, so they are not directly comparable to the Office of Technology Policy measures (even if it were clear what industries Milken included in its analyses). Washington's overall rank is 6th in the 2011 edition of the State Technology and Science Index, down from 5th in 2008.

The 2010 State New Economy Index

This latest version by Atkinson and Andes has been published by the Information Technology and Innovation Foundation and the Kauffman Foundation (Atkinson and Andes 2010). They developed a set of indicators for the states, and then focus on economic development strategies for the new economy. High-tech industry is defined as by the AEA, plus the addition of biomedical sectors based on work of the BLS (Atkinson and Andes 2010). Washington State ranked 2nd in 2010 in this analysis, up from 4th in Washington's position in the 1999, 2002, and 2007 State New Economy Index measures. This analysis used 26 measures in the 2010 analysis, many of which are similar those used in the Milken Institute analysis.

Index of the Massachusetts Innovation Economy

This document is not a study of technology-based industry as such, but it has many parallel considerations to information reported in this document, and in the State New Economy and Milken Reports. A set of peer states are selected—Washington is not one of them—and a set of indicators of performance of Massachusetts versus these peers is presented (Massachusetts Technology Collaborative & John Adams Innovation Institute 2011). Industry clusters are defined, although it is not clear how, and these include aspects of technology-based industries as defined in this report, but also other industries. The report has 25 indicators of performance, including some identical to those used in this study (such as R&D indexed to a per capita or per $ of GDP). The report is suggestive of directions for policy, but does not directly articulate recommendations. As indicated earlier in this report, Massachusetts is very strong in research-related measures, due to the very strong research-oriented higher education system in that state. It is less clear from this report how well Massachusetts fares on technology-based industry measures used in this report.

Appendix II. Technical Notes on the Input-Output Model

The impact estimates developed in this study stem from the utilization of an "input-output model." Models of this type are based on static, cross-sectional measures of trade relationships in regional or national economies. They document how industries procure their inputs and where they sell their outputs. Pioneered by Wassily Leontief, who won the Nobel Prize in Economic Science for his insights into the development of input-output models at the national level, these models have become "workhorses" in regional economic impact analysis in recent decades.

Washington State is fortunate to have a rich legacy of research developing input-output models. Early work was led by Philip J. Bourque and Charles M. Tiebout. Input-output models have now been estimated in Washington State for the years 1963, 1967, 1972, 1982, 1987, 1997 and 2002. No other state in the U.S. has this rich historical legacy of survey-based or quasi-survey based regional input-output models. The current economic impact study is based on work completed in 2007-2008 by a team of Washington State government staff and William B. Beyers (Beyers and Lin 2008).

Input-output models decompose regional economies into "sectors"–groups of industries with a common industrial structure. At the heart of these models are "Leontief production functions," which are distributions of the cost of producing the output of sectors. Leontief augmented the national accounts schema developed by Kuznets (also a Nobel laureate in economics) to take into account the significant levels of intermediate transactions that occur in economic systems in the process of transforming raw materials and services into "finished products" or "final products." Sales distributions among intermediate and final sources of demand are used as the accounting bases for the development of the core innovation of Leontief: that these relationships can be used to link levels of final demand to total industrial output by way of a system of "multipliers" that are linked through the channels of purchase in every industry to the production of output for final demand.

This system of relationships is based on accounting identities for sales. Mathematically, the system may be represented as follows. For each industry we have two balance equations:

(1) $X_i = x_{i,1} + x_{i,2} + ... + x_{i,n} + Y_i$

(2) $X_j = x_{1,j} + x_{2,j} + ... + x_{n,j} + V_j + M_j$

where: X_i =total sales in industry i,
X_j = total purchases in industry j
$x_{i,j}$ = intermediate sales from industry i to industry j
Y_i = final sales in industry i
M_j = imports to sector j
V_j = value added in sector j.

For any given sector, there is equality in total sales and total purchases:

(3) $X_i = X_j$ when i=j.

This system of transactions is generalized through the articulation of Leontief production functions, which are constructed around the columns of the regional input-output model. They are defined in the following manner.

Let us define a regional purchase coefficient:

$$r_{i,j} = x_{i,j}/X_j.$$

Rearranging,

$$x_{i,j} = r_{i,j}X_j$$

Substituting this relationship into equation (1) we have:

(4) $$X_i = r_{i,1}X_1 + r_{i,2}X_2 + ... + r_{i,n}X_n + Y_i$$

Each sector in the regional model has this equation structure, and since the values of X_i equal X_j when i=j, it is possible to set this system of equations into matrix notation as:

(5) $$X = RX + Y$$

This system of equations can then be manipulated to derive a relationship between final demand (Y) and total output (X). The resulting formulation is:

(6) $$X = (I-R)^{-1}Y$$

where the $(I-R)^{-1}$ matrix captures the direct and indirect impacts of linkages in the input-output model system. The input-output model utilized in the modeling for this research project was developed by a committee led by Dr. William Beyers and Dr. Ta-Win Lin, and was published in 2008 by the Washington State Office of Financial Management. The model has 50 sectors.

A major issue that surrounds the estimation of the $(I-R)^{-1}$ matrix is the level of "closure" with regard to regional final demand components, which are personal consumption expenditures, state and local government outlays, and capital investment. It is common practice to include the impacts of labor income and the disposition of this income in the form of personal consumption expenditures in the multiplier structure of regional input-output models. The additional leveraging impact of these outlays is referred to as "induced" effects in the literature on models of this type. It is less common to include state and local government expenditures in the induced effects impacts, but it can be argued that demands on state and local governments are proportional to the general level of business activity and related demographics. In contrast, investment is

classically argued to be responsive to more exogenous forces, and is not a simple function of local business volume. In the model that we developed for this impact study we have included personal consumption expenditures as a part of the induced-demand linkages system. We have considered Washington personal consumption expenditures to be a function of labor income. The resultant Leontief inverse matrix is available from the Office of Financial Management in either the "simple" or the "complex" impact analysis spreadsheet.

Appendix III. Location Quotients for Technology-Based Industries in Washington State, 2009

NAICS	Description	County Business Patterns	Nonemployer Statistics	Combined
324	Petroleum and Coal Products Manufacturing	0.693	0.432	0.676
325	Chemical Manufacturing	0.346	1.02	0.360
3332	Industrial Machinery Manufacturing	1.301	2.12	1.327
3335	Metalworking Machinery Manufacturing	0.690	1.12	0.704
3336	Turbine & Power Transmission Manufacturing	0.096	0.16	0.098
334	Computer and Electronic Product Manufacturing	0.938	1.457	0.958
335	Electrical Equipment, Appliance and Component Manufacturing	0.338	0.967	0.353
3361	Motor Vehicle Manufacturing	0.064	0.072	0.065
3364	Aerospace Product and Parts Manufacturing	7.200	0.460	7.200
4234	Professional & Commercial Equipment and Supplies Merchant Wholesalers	1.079	1.11	1.097
4541	Electronic Shopping and Mail Order Houses	0.903	1.565	1.018
5112	Software Publishers	6.526	1.396	6.255
517	Telecommunications	1.230	0.802	1.238
518	ISP and Data Processing	1.121	1.049	1.122
5191	Other Information Services	1.998	1.267	1.775
5413	Architecture, Engineering, and Related Services	1.313	2.383	1.403
5415	Computer Systems Design and Related Services	1.015	2.754	1.189
5416	Management, Scientific, and Technical Consulting Services	0.789	2.382	1.200
5417	Scientific Research and Development Services	1.263	1.314	1.280
55	Management of Companies and Enterprises	1.343	*	1.343
5622	Waste Treatment and Disposal	1.711	0.569	1.708
5629	Remediation and Other Waste Management Services	1.974	0.489	1.974
	All Technology-Based Industries	**1.41**	**2.059**	**1.465**

* By definition, there is no self-employment in NAICS 55.

Appendix IV. Growth of Employment in Technology-Based Industries in Washington State, 1974-2002 (excluding government and university research), SIC Definition

SIC	Description	2002	2000	1997	1995	1992	1990	1988	1986	1984	1982	1980	1978	1976	1974
28	Chemicals except SIC 283 (drugs)	3,174	3,994	3,939	3,946	4,443	12,789	11,962	11,225	10,307	9,028	8,594	7,846	5,457	5,760
283	Drugs	2,410	2,101	1,940	1,585	853	500	442	320	317	454	165	205	213	264
291	Petroleum Products	2,195	1,798	1,740	1,903	1,759	1,597	1,511	1,645	1,607	1,668	1,534	1,544	1,521	1,517
348	Ordnance	69	111	206	2,186	3,308	3,532	3,234	23	75	3,043	350	400	400	427
351	Engines and Turbines	100	147	144	25	75	85	131	90	111	250	57	52	30	35
353	Construction and Related Machinery	3,187	3,978	3,468	2,933	2,479	3,103	2,997	2,771	2,562	3,256	3,389	2,906	2,494	3,302
355	Special Industry Machinery	3,180	3,969	4,088	4,296	2,930	3,300	2,798	2,426	2,217	3,251	3,748	3,331	2,913	3,431
356	General Industry Machinery	1,242	1,518	1,349	1,168	983	951	824	649	697	578	545	475	507	562
357	Computer and Office Equipment	5,657	6,730	7,576	7,407	3,903	4,247	5,715	5,400	6,124	4,012	3,000	1,933	1,372	1,081
361	Electric Distribution Equipment	184	275	263	250	202	208	180	300	341	382	325	415	465	386
362	Electrical Industrial Apparatus	2,014	2,027	1,573	1,400	878	1,015	830	670	608	1,000	1,237	474	240	240
365	Household Audio & Visual Equipment	1,269	1,613	1,503	1,457	911	829	763	301	258	310	370	354	250	95
366	Communications Equipment	2,518	3,587	3,137	2,981	1,801	1,759	1,694	892	2,604	3,138	4,148	1,910	1,700	2,300
367	Electronic Components	7,323	9,071	9,375	7,261	6,508	6,662	5,302	7,012	6,065	4,595	1,194	1,613	377	386
369	Miscellaneous Electrical Equipment & Supplies	424	341	349	372	1,158	1,080	791	1,100	1,050	1,081	937	860	626	411
371	Motor Vehicles and Equipment	4,107	5,963	5,944	5,103	2,500	2,500	2,570	2,081	2,083	1,690	2,295	2,479	2,403	2,451
372&376	Aerospace	75,667	93,221	112,962	87,024	115,126	104,860	96,963	80,675	65,824	67,794	72,406	65,014	45,257	54,646
381&382	Search/Navigation Equipment & Measuring Devices	7,229	8,182	8,301	7,713	7,797	8,922	8,250	7,101	6,471	4,642	3,690	1,935	2,287	2,214
384	Medical Instruments & Supplies	5,965	5,889	5,725	5,359	5,151	4,287	3,560	2,477	920	737	590	260	292	349
386	Photographic Equipment	159	143	272	214	226	177	197	157	220	280	605	61	51	40
737	Computer Services	62,938	60,009	46,254	34,983	18,851	14,990	10,737	8,453	7,350	5,089	9,854	6,109	4,627	4,702
871	Engineering Services	27,678	24,617	24,646	23,092	19,032	17,418	14,177	14,147	11,673	11,984	12,107	8,571	8,034	6,772
873	Research & Testing Services*	26,237	22,611	21,329	17,847	21,293	9,872	9,029	6,175	4,785	4,644	4,827	3,747	3,216	2,612
874	Management & Public Relations	14,722	13,099	11,605	9,678	9,810	8,722	8,102	6,954	5,240	3,986	3,804	3,186	3,497	1,927
	Total	**259,648**	**274,989**	**277,688**	**230,183**	**231,977**	**213,405**	**192,759**	**163,044**	**139,509**	**136,892**	**139,771**	**115,680**	**88,229**	**95,910**

*Note: Includes an estimated 6,495 employees at Hanford in 2002 classified by ESD in sanitary services (NAICS 562910, Remediation Services).

Sources: Washington State Employment Security Department; U.S. Census Bureau County Business Patterns; The Boeing Company; estimates by author

Appendix V. Growth of Employment in Technology Based Industries in Washington State, 1998-2011 (excluding government and university research), NAICS Definition

NAICS	Industry	% Change 1998-2011	2011	2009	2007	2005	2002	2000	1998
	Manufacturing								
324	Petroleum Products	16.3%	2,370	2,606	2,444	2,314	2,726	2,030	2,037
325	Chemicals	9.5%	5,824	5,796	5,919	5,202	5,798	4,842	5,320
3332	Industrial Machinery	-7.1%	2,677	3,024	3,342	2,873	2,493	2,880	2,883
3335	Metalworking Machinery	2.3%	1,816	2,028	2,270	1,928	1,205	1,850	1,775
3336	Engine, Turbine & Power Transmission Machinery	98.6%	278	204	140	241	192	140	140
334	Computers	-59.2%	19,477	21,539	22,576	22,003	25,948	45,554	47,720
335	Electrical Equipment	15.9%	4,278	4,213	4,286	4,206	3,782	3,500	3,691
3364	Aerospace	-24.9%	84,831	82,932	78,667	65,096	75,667	93,221	112,962
3361	Motor Vehicles	-87.1%	180	894	700	1400	700	700	1,400
	Services								
4234	Commercial Equipment Merchant Wholesalers	NC	13,397	14,195	14,277	13,774	14,399	NC	NC
4541	Electronic Shopping and Mail Order Houses	135.6%	11,154	8,906	10,833	9,614	9,586	6,613	4,734
5112	Software Publishers	319.3%	51,197	51,468	47,240	41,122	35,782	27,022	12,209
517	Telecommunications	-19.2%	24,389	25,741	26,140	25,717	30,988	32,975	30,200
5182	Data Processing and Related Services	96.0%	4,338	4,030	4,005	2,816	1,885	2,767	2,213
5191	Other Information Services	NC	6,994	4,515	2,954	2,278	NC	NC	NC
5413	Architecture and Engineering Services	20.5%	34,431	35,771	34,367	31,000	29,701	28,888	28,564
5415	Computer Systems Design	132.4%	35,751	31,927	28,398	21,507	22,821	24,697	15,381
5416	Management and Technical Consulting Services	63.9%	14,905	12,942	11,436	9,870	8,239	11,685	9,093
5417	Scientific R&D Services	111.1%	20,027	19,117	18,765	18,090	16,354	10,936	9,489
551	Management of Companies and Enterprises	-38.9%	32,743	33,560	34,479	33,313	30,186	47,774	53,616
5622	Waste Treatment and Disposal	111.6%	3,787	3,293	3,220	3,728	1,899	2,101	1,790
5629	Remediation and Other Waste Services	79.3%	9,590	8,665	8,319	7,918	7,640	6,594	5,350
	Total	**NC**	**384,434**	**377,366**	**361,823**	**323,732**	**327,991**	**NC**	**NC**
	At Least	*9.7%*						*356,769*	*350,567*

NC=not comparable

Appendix VI. Washington Technology-Based Employment by County

Alphabetical	
Adams	60
Asotin	103
Benton	20,256
Chelan	740
Clallam	488
Clark	13,709
Columbia	10
Cowlitz	1,537
Douglas	407
Ferry	37
Franklin	515
Garfield	3
Grant	693
Grays Harbor	508
Island	697
Jefferson	206
King	247,958
Kitsap	5,525
Kittitas	234
Klickitat	1,141
Lewis	527
Lincoln	25
Mason	237
Okanogan	214
Pacific	95
Pend Oreille	57
Pierce	14,146
San Juan	164
Skagit	2,551
Skamania	56
Snohomish	60,866
Spokane	13,454
Stevens	206
Thurston	4,046
Wahkiakum	24
Walla Walla	832
Whatcom	6,076
Whitman	3,499
Yakima	2,404

By # of Jobs	
King	247,958
Snohomish	60,866
Benton	20,256
Pierce	14,146
Clark	13,709
Spokane	13,454
Whatcom	6,076
Kitsap	5,525
Thurston	4,046
Whitman	3,499
Skagit	2,551
Yakima	2,404
Cowlitz	1,537
Klickitat	1,141
Walla Walla	832
Chelan	740
Island	697
Grant	693
Lewis	527
Franklin	515
Grays Harbor	508
Clallam	488
Douglas	407
Mason	237
Kittitas	234
Okanogan	214
Jefferson	206
Stevens	206
San Juan	164
Asotin	103
Pacific	95
Adams	60
Pend Oreille	57
Skamania	56
Ferry	37
Lincoln	25
Wahkiakum	24
Columbia	10
Garfield	3

Source: U.S. Census Bureau Nonemployer Statistics, Washington State Employment Security Department

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