DRIVERS FOR A SUCCESSFUL TECHNOLOGY-BASED ECONOMY: BENCHMARKING WASHINGTON'S PERFORMANCE

A Technology Alliance Report

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Technology Alliance

The Technology Alliance is a statewide, not-for-profit organization founded in 1996 to bring together leaders from Washington's diverse high-tech businesses, research institutions and the community dedicated to our state's long-term economic success. Through programs, events, research studies, and policy activities, the Technology Alliance works to achieve our vision of a vibrant technology-based economy benefiting all of Washington's citizens.

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A benchmarking advisory group consisting of chief executive officers of technology companies, senior staff from large research organizations and private companies, university professors, venture capitalists, and attorneys specializing in technology sector issues worked with the authors and Technology Alliance staff to produce this report. Advisory group members provided their expertise on one or more of the indicators of the study. The key questions and major indicators from the initial report in 2003 were carried over, though the findings for this report were examined by advisory group members for their significance and implications. In addition, the Technology Alliance board and executive committee reviewed the report at several stages. The many hours these individuals contributed to this report is gratefully acknowledged.

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Executive Summary

The technology-based industry in Washington state continues its important role in the growth and development of the state economy. The state's natural resource industries are no longer leaders of job growth; manufacturing job growth has been increasingly constrained by foreign competition; and, growth in international trade has been influenced by competition from other west coast ports. Technology industries, based on innovation in information technology, bio-science, nanotechnology, and other fields, generate new companies with products and services that are gaining domestic and foreign markets, generating many high-wage jobs, and creating significant wealth. These industries have a bright future in Washington if the appropriate conditions are created or improved.

Comparing Washington's Performance on Three Key Drivers for a Technology-Based Economy

Leaders in states and regions throughout this country recognize the immediate and long-term benefits of having a robust technology sector and the high-paying jobs that go with it. Many states and regions are competing aggressively to create an environment that attracts, nurtures, and keeps technology-based businesses and the people who establish and grow them. This report assesses how well Washington is doing crafting such an environment. Numerous studies have demonstrated that technology-based businesses do well in states with these characteristics:

- education systems that stress science and engineering at all levels, resulting in a strong and technologically sophisticated workforce;
- dynamic research programs yielding commercializable technology ideas; and,
- a history of entrepreneurial activity and the financial capacity to support technology startups.

This report provides benchmarks for Washington's performance relative to peer states on more than 40 indicators that fall under three key drivers—Education, Research Capacity, and Entrepreneurial Climate.

By comparing Washington to a set of peer states and to neighboring states on indicators in these three categories, readers can assess Washington's position and progress. Eight peer states (California, Colorado, Georgia, Massachusetts, Maryland, Michigan, Texas, and Virginia) were chosen based on analyses of high-tech industry concentration in all 50 states. None of these peer states has a mix and concentration of technology industries that is identical to Washington, but each has concentrations of technology-based businesses that are also important in the Washington economy. Indicators were chosen based on both their effectiveness in measuring an issue and on the availability of quality data that can be measured repeatedly so that trends in Washington's position among its peers can be detected. Members of the Technology Alliance executive committee and board participated in framing the issues and vetting potential indicators for the three key drivers. They include chief executive officers of technology companies, senior staff from large research organizations and private companies, university professors, venture capitalists, and attorneys specializing in technology sector issues.

Overall Impressions

Washington has one of the most technology-based economies of any state in the nation, enjoying considerable growth in the high-tech sector for the last several decades. It has seen the emergence of several leading technology companies, national recognition for its research and higher education institutions, and renown for its high quality of life. Notwithstanding recent history, data in this report find Washington state in a less than competitive position on some of the key drivers for a technology-based economy. If this state is to ensure its continued growth through innovation and entrepreneurship, it must address a number of areas in its K-12 and higher education systems, attract additional talent and funding to higher education research institutions, and build more support for new and emerging companies. Chief findings of this study are summarized below.

EDUCATION

K-12 Education

K-12 indicators include high school graduation rates, preparation for studying for higher-level math and science subjects, performance in advanced math and science, and per-student funding levels. With few exceptions, Washington typically falls in the middle or slightly below its eight peer states on these indicators, and on several indicators has trended downward. These rankings are a cause for concern, particularly for the long term. On some measures, such as preparation for further study in math and science, all states need to do better as the economy shifts in the direction of more advanced technology jobs. For example, while Washington is ranked sixth nationally in terms of our students' performance in math, we dropped to 17th in reading. But, only about one-third of our 8th graders scored at or above "proficient" on these tests, a disturbingly low percentage in Washington and nationally. Washington ranked 32nd in per pupil funding in 2003, a drop from 25th position in 1999. Focused strategic investments and communication efforts are needed to improve student achievement in Washington.

Higher Education

Higher education plays a critical role in a technology-based economy. It produces the skilled, well-educated graduates needed in the technology-based workforce. If these people are not produced in local educational institutions, employers must look to out-of-state or international sources for their workforce. Large employers are able to engage in this inter-regional or international search process much more easily than small companies. If Washington high school graduates do not have adequate access to higher education at the baccalaureate and graduate level, many will end up with lower earnings over their lifetimes.

Washington's performance in higher education needs improvement to lead the technology-based industries that are based in this state. The number of bachelor's degrees granted overall, particularly in science and engineering majors, is in the lowest third of the nation on a per capita basis; Washington's position has deteriorated on this indicator in recent years. Washington also ranks low in the production of Ph.D.'s in science and engineering on a per capita basis, with a production level that is several times lower than the top producing peer state. As a consequence, Washington technology companies have to turn to out-of-state sources to grow their workforce to a greater extent than they should have to, effectively shutting out Washington residents from many high-paying technology-based jobs because they lack access to baccalaureate and graduate degrees. This low level of baccalaureate and advanced degree production may also be contributing to the lack of local management to run high-tech companies in Washington.

RESEARCH CAPACITY

On a per capita basis, Washington is one of the leading research-oriented states. However, when looking across the categories of research and development activity, we find a highly uneven pattern of performance. On industry, federal, and non-profit research expenditures, Washington ranks among the highest in the nation, and generally above our peer states. However, Washington ranks poorly on the level of spending on academic research (21st in 2003, down from 20th in 1999), and performs dismally in non-federal government funding to academic institutions, ranking 48th nationally. This poor position on academic research is a byproduct of our relatively small higher education enterprise. The two research universities in Washington—University of Washington and Washington State University—actually compete very well, but cannot carry the state against states that have larger public university systems or the added benefit of private research universities. Research leads to innovations that are often patented. On this measure, Washington has improved, moving from 15th to 11th in patents granted annually on a per capita basis between 2001 and 2004. We have also improved our position on the relative number of National Academy of Science members, a measure of the prestige of senior scholars at higher education institutions. Overall, Washington's research capacity has improved and continues to be a large contributor to our state's high-tech economy.

ENTREPRENEURIAL CLIMATE

A mixed picture emerges on the entrepreneurial climate measures. The recent recession has clouded the data for many of these measures, and future benchmarking efforts may find a change in these measures. Washington ranked high on overall business establishment births in 2003. In contrast, high-tech establishment births were actually negative in 2002, reflecting the recent recession. This was also the case for many peer states. Washington is also among the highest ranking peer states in venture capital activity, and our position has improved, although this measure is dominated by California and Massachusetts. Compared to our peer states, we do not have a large number of Inc. 500 rapidly growing small companies, but our position on this measure has improved dramatically from 36th in 2000 to 17th in 2005. Our workforce ranks in the middle of the pack of our peer states in terms of college graduates as a share of the workforce, but we rank among the highest of the states (11th in 2004) on this measure. We are positioned even better in terms of the number of scientists and engineers as a share of our labor force, ranking 5th in 2003, up from 9th in 2001.

Introduction

This report assesses how well Washington is doing in creating an environment where technology-based businesses can flourish. It is an updated version of a similar assessment conducted three years ago (Sommers, 2003). Technology-based businesses do well in states with education systems that stress science and engineering at all levels, resulting in a strong and technologically sophisticated workforce; dynamic research programs yielding commercializable technology; and, a history of entrepreneurship and financial capacity to support technology start-ups. These three broad categories—Education, Research Capacity, and Entrepreneurial Climate—are the drivers of technology-based economic development.

Development of technology-based sectors of the economy is very important to Washington state. The state's natural resource industries are no longer leaders of job growth; manufacturing job growth has been increasingly constrained by foreign competition; and, growth in international trade has been influenced by competition from other west coast ports. Technology industries, based on innovation in information technology, bio-science, nanotechnology, and other fields, generate new companies with products and services that are gaining domestic and foreign markets, generating many high-wage jobs and creating significant wealth. These industries have a bright future in Washington if the appropriate conditions are created or maintained.

The Technology Alliance commissioned this updated benchmarking report to provide new data on Washington's performance in the three drivers and measure its progress against that of other states since the initial report was published in 2003. By comparing Washington's position to peer and neighbor states, as well as providing an assessment of Washington's position nationally, this report provides an objective basis for state policy discussions and for the Technology Alliance to develop its own organizational initiatives to foster the long-term vitality of technology industries. Some portions of this report have text that is very similar to the 2003 benchmarking report, and the overall report is intentionally organized in a manner very similar to the 2003 benchmarking report to allow comparisons of many benchmarks.

Members of the Technology Alliance executive committee and board participated in framing the issues and vetting potential indicators for each major driver category. They include chief executive officers of technology companies, senior staff from large research organizations and private companies, university professors, venture capitalists, and attorneys specializing in technology sector issues.

Methodology

This assessment is based on three key methodological principles:
- The method used to define technology-based industries.
- The definition of states considered to be peers against which to benchmark Washington's performance.
- The selection of indicators or metrics within the three major categories of drivers.

Defining Technology-Based Industries

There are many ways of defining "high-tech" or technology-based industries, and the Technology Alliance has reviewed these various approaches and has settled upon a method that is similar to that used by the U.S. Department of Labor Bureau of Labor Statistics (Beyers, Andreoli and Hyde, 2005). This method focuses on the occupational structure of employment in particular industries, using Washington state data, and identifies industries with relatively high proportions of employment in science, engineering, and computer-related occupations. In this analysis, industries with at least 10% of their labor force in these occupations were considered to be technology-based or high-tech.

Other definitions have arbitrarily considered particular industries to be high-tech, or have used R&D expenditures as a share of sales as the basis for defining high-tech. Patent rates have also been used as an indicator of high-tech activity. The Technology Alliance argues that industries with a relatively high concentration of employees in scientific, engineering, and computer related occupations are likely to be engaged in developing new technologies, leading to the development of new companies, products, and services. The definition used in this study has also been used by the Washington Technology Center in their *Index of Innovation and Technology* studies (Sommers and Cheatham, 2003). The data underlying the definition of technology-based industries used in this report were estimated by the State of Washington Employment Security Department, and are based on the 2002 North American Industry Classification System (NAICS) definitions.

Peer States

No other state in the United States has an industrial structure that is exactly the same as Washington state. However, some similarities in industrial structure are revealed by looking at the concentration of technology-based industries across the United States. In the 2003 benchmarking report, the Technology Alliance developed measures of the concentration of technology-based industries important in the Washington economy for all of the states. The measures of concentration used for this purpose are called "location quotients (LQ)," which are defined below. Peer states were selected after an analysis of these location quotients. Since the 2003 report, the values of location quotients for particular industries have changed somewhat in all states. However, the Technology Alliance chose to keep the same peer states after a lengthy evaluation of whether alternatives to the list used in the 2003 report were appropriate. One of the purposes of a study of this type is to report not only changes in Washington's rank on the various indicators, but also to identify trends in states considered to be our major competitors or peers.

In the 2003 report, the technology-based industries described in the appendix were grouped into four broad industry groups (aircraft, other manufacturing, computer and data processing, and other services), and location quotients for each of these industries (as well as for total technology-based employment) were reported for 17 states, based on Bureau of Labor Statistics employment data defined by the old Standard Industrial Classification (SIC) definitions of industries[1]. That analysis led to the identification of eight peer states, plus Oregon and Idaho as neighbor states. Since publication of the 2003 report, the U.S. has fundamentally changed the basis for defining industries, and in many cases the newer NAICS definitions are not comparable with the old SIC system. The Technology Alliance recognizes that this major change in industry definitions means that there is some degree of non-comparability between the current report and the 2003 report. However, it is possible to develop broadly similar definitions of technology-based industry, using the newer industry by occupation data established by NAICS.

Location quotients (LQs) are used by regional economists to identify the relative importance of an industry in a region compared to a benchmark region. In this case the benchmark is the nation as a whole. The measure is simple: the percentage of total employment in an industry in a region divided by the percentage of employment in the same industry nationally. If a region has a higher percentage of employment in an industry than the nation, then this index is above 1. And if it has a percentage lower than the national average, then the index is below 1. We have used the location quotient concept for many of the benchmarks contained in this report, as it provides a convenient way of comparing Washington with peer states, while controlling for differences in the absolute size of state economies and populations.

Table 1: Location Quotients (LQs) for Technology-Based Industry

State	National Rank 2003	LQ Total 2003	LQ Total 2000	LQ Aerospace 2003	LQ Other Mfg. 2003	LQ Computer Services 2003	LQ Other Services 2003
Massachusetts	1	1.39	1.35	0.49	1.33	1.97	1.35
Washington	2	1.32	1.15	6.35	0.69	1.95	1.26
Virginia	3	1.29	1.20	0.07	0.68	2.92	1.35
California	4	1.23	1.20	1.75	1.06	1.52	1.23
Colorado	5	1.22	1.24	1.24	0.67	1.85	1.37
Maryland	6	1.20	1.04	0.23	0.71	2.19	1.30
Texas	11	1.12	0.97	1.47	1.15	0.98	1.11
Michigan	12	1.06	1.39	0.29	1.09	0.71	1.14
Georgia	21	0.93	0.93	1.25	0.70	1.00	1.02
Idaho	17	0.98	0.91	0.02	1.43	0.38	0.91
Oregon	20	0.94	0.89	0.41	1.08	0.96	0.89

< Peer state ranking

Table 1 contains estimates of location quotients for peer states, neighbor states, and Washington state for the year 2003. The basis for this table is slightly different than the 2003 report, but it is generally comparable. The rank values for 2003 are based on the position of each state relative to the nation as a whole. The location quotients for all high-tech are presented for both

[1] California, Colorado, Georgia, Massachusetts, Maryland, Michigan, Texas, and Virginia were selected as peers. Arizona, Illinois, Minnesota, North Carolina, New York, and Pennsylvania were considered, but found to be sufficiently different in their technology-based industry structure to be rejected as peers (Sommers, 2003). Please refer to the 2003 Benchmarking study for reasoning as to the inclusion or exclusion of states.

2000 and 2003, showing how Washington state has considerably increased its location quotient value and moved ahead of Virginia, California, Colorado, and Michigan in the three-year period. It should be re-emphasized that the year 2000 data were based on a different source and classification scheme than used for the 2003 measures, so these changes in position may be related to differences in classification due to changes in the underlying data. The data reported here are similar to those reported in another Technology Alliance study (Beyers, Andreoli and Hyde, 2005).

Table 1 clearly illustrates how Washington's position is propelled by an extremely strong aerospace sector, anchored by the Boeing Company. No other state has a concentration of aerospace activity that even begins to approach that found in Washington state. It should be noted that Washington's LQ in this sector declined from 8.9 in 2000 to 6.4 in 2003, a reflection of large job losses in the aerospace industry during this time period. Washington's position in other manufacturing moved in the opposite direction, increasing from 0.53 to 0.69, indicating that we have deepened our employment concentration in other manufacturing components of technology-based industry. Washington has also improved its position in the other two industry components, computer services and other services. Washington has moved from a concentration about 150% of the national average in computer services to nearly double the national average in just three years, while increasing from an LQ roughly equal to the national average to more than 25% above it in other services. Across all segments of technology-based industry except aerospace, Washington has gained against the nation as a whole, and in aerospace we still have a commanding lead among peer states.

Drivers of Technology-Based Development

While other factors such as business climate, infrastructure, and quality of life are important to business success, the three factors that are the focus of this report are particularly important to technology-based companies. In order for a technology-based business to be successful, it must have a highly educated workforce. Strong science, mathematics, and engineering backgrounds are frequently required for staff in these companies. Additionally, a pool of commercializable technologies must exist, so the absolute magnitude of research and development activity in a state or metropolitan area is also very important. Finally, without a favorable entrepreneurial climate—including investors willing to support startup technology companies, and entrepreneurs and managers who know how to build them—the pool of ideas and educated workforce cannot be effectively melded to grow successful companies.

The 2003 Technology Alliance benchmarking study relied to a great extent upon measures developed by the Milken Institute and the Progressive Policy Institute, measures that sometimes use proprietary calculations or are not updated on a regular basis. Since 2000, the Technology Administration of the U.S. Department of Commerce has released four reports with many benchmark indicators included in this report. However, as of 2004, the Technology Administration has stopped producing this useful report. In producing the current Technology Alliance report, we have developed as many measures as possible from public data sources that are likely to be available in future years, so that updates of the data used to construct the indicators in this report can be repeated.

Indicator Methodology

This report provides a number of indicators, grouped into three major categories and measured in multiple ways. Both input and output indicators are provided for each category. Inputs of talent, ideas, and money feed the innovation process, while outputs include new company formation, employment growth, and patent activity. For each indicator, we have provided the most recent data available, as well as trends over the past decade if those data were available.

Several comparison points are possible for each indicator. Washington can be compared to the eight peer states, to its two neighboring states, or to all 50 states based on absolute magnitudes or per capita national rankings. In this report, we provide comparisons of Washington with the peer states and our neighboring states, and in most cases report the national leading state if it is not Washington, one of our peers, or a neighboring state. For a few indicators, however, only peer and neighboring state information, plus a national total, are provided due to data limitations. For most indicators, both absolute values (e.g. dollars spent on R&D) and proportional measures (e.g. R&D dollars per capita) are provided. In some cases, readers may wish to look at the absolute differences between Washington and other states, in other cases, it makes sense to put a medium-sized state such as Washington on a more equal footing with smaller or larger states by using a proportional measure. The order in which the states are listed in the tables indicates their ranking among the selected peer group.

Education

High-tech companies require a highly educated workforce. The growth of job openings for scientific and engineering positions continues at a significant pace, and the number of those positions that require an advanced degree is also increasing. Preparation for these careers begins at a very young age because fundamental skills and concepts must be learned early in order for a student to progress to more advanced thinking and skills development. Quality and rigor in elementary and secondary education is critical for students to perform well in post high school academic settings.

Receiving a high-quality education is even more important when national and international competitors are considered, especially in today's knowledge-based economy. If the education system in a state is not supporting the needs of the local economy, companies are forced to recruit workers from out-of-state and from abroad, thus denying in-state residents those high-wage career opportunities. Weak education systems also limit the growth of young and small high-tech companies. Whereas large companies can afford to recruit workers from around the globe, smaller companies typically must rely on local talent.

To prepare Washington's children to be the next generation of high-tech innovators and entrepreneurs, a productive and excellent education system must be in place now to ensure this future. The following indicators measure how well Washington is doing compared to its peer states on adding value to our high-tech economy by preparing and building the intellectual capital within our state—our children.

Two questions addressed in this section:
1. How well is Washington's K-12 system preparing our students for higher education?
2. How well is Washington's higher education system preparing our students for the technology-based economy?

K-12 Indicators

The major question addressed in this section is:
How well is Washington's K-12 system preparing our students for higher education?

Sub-questions addressed below include these:
1. How many students graduate from high school?
2. How many students are proficient in math and science?
3. How many students are preparing themselves for high-level math and science?
4. How much is being invested in the state's K-12 education system?
5. How do U.S. students compare with their international peers?

High school graduation

How many students graduate from high school?

In today's society and world economy, earning a high school diploma is an essential step for young people, and hopefully the first step toward higher education and life-long learning. Graduating from high school leads to much better life outcomes, such as decreased dependence on social support services, increased potential for earning higher wages, and greater chances for continuing education. However, simply earning a high school diploma or GED is not sufficient preparation for most high-tech jobs or jobs that pay a living wage. Today, graduation from high school should be viewed as simply a first step toward higher education, graduate school, and a life filled with learning.

The extent to which our public schools are succeeding at graduating students and preparing them for the workforce or higher education

Table 2: Public high school graduation rates in the United States

State	Percentage 2002	Rank 2002	Percentage 2000	Rank 2000
Michigan	78%	16	na	na
Maryland	77%	17	72%	26
Massachusetts	75%	21	73%	25
Virginia	74%	26	75%	18
Colorado	72%	29	69%	31
Washington	72%	31	68%	32
Texas	68%	36	67%	34
California	67%	38	66%	35
Georgia	56%	49	56%	49
Idaho	75%	23	79%	12
Oregon	71%	32	66%	36
New Jersey	89%	1	87%	1

< Peer state ranking

Source: Manhattan Institute for Policy Research is under great scrutiny today. According to the Manhattan Institute for Policy Research, the national high school graduation rate for all public school students remained relatively flat over the last decade: it was 72% in 1991, and 71% in 2002. In Washington, 72% of the students comprising the class of 2002 who started high school four years earlier received their diplomas. As shown in Table 2, this measure places Washington at 31st in the nation and sixth among peer states. It also means that while approximately 60,000 Washington high school students graduate in a given year, 24,000 of their peers do not graduate with them.

Proficiency in mathematics and science

How many students are proficient in math and science?

Proficiency measures for eighth grade students in reading, mathematics, science and other subject areas are available from the National Assessment of Educational Progress (NAEP), also known as the "Nation's Report Card." NAEP is the only nationally representative and continuing assessment of what U.S. students know and can do in various subject areas. Subject areas are assessed on a periodic schedule. According to the requirements of the No Child Left Behind Act of 2001, NAEP must administer reading and mathematics assessments for grades 4 and 8 every other year and, provided funds are available, may conduct assessments in additional subject areas such as writing, science, and economics. NAEP does not provide scores for individual students or schools, but instead compiles and reports results by state regarding subject-matter achievement, instructional experiences, and school environment for populations of students. Student achievement levels on NAEP exams are categorized as basic, proficient, and advanced.

In the subject areas that were assessed since the release of the 2003 study—reading, science, and mathematics—Washington's eighth grade students scored reasonably well relative to those in other states, but it is clear that all states need to significantly improve student achievement in these subjects. In reading (Table 3), Washington placed 17th nationally and third among its peers, but those respectable rankings were earned by just 34% of eighth grade students in the state scoring "at or above proficient." Similarly, on the science assessment (Table 4), 33% of Washington's eighth grade students scored at or above proficient, which was enough to rank the state 18th in the nation and fifth among peer states. In mathematics (Table 5), the performance of Washington's eighth grade students placed the state sixth nationally and second only to Massachusetts among the peers; however, this lofty position is based on just 36% of those students scoring at or above proficient.

Table 3: Percentage of 8th graders who scored "At or Above Proficient" in reading

< Peer state ranking

State	Percentage 2005	Rank 2005	Percentage 2003	Rank 2003
Massachusetts	44%	1	43%	1
Virginia	36%	10	36%	13
Washington	34%	17	33%	24
Colorado	32%	23	36%	12
Maryland	30%	28	31%	31
Michigan	28%	31	32%	27
Texas	26%	36	26%	40
Georgia	25%	40	26%	38
California	21%	46	22%	44
Oregon	33%	21	33%	23
Idaho	32%	22	32%	28

Source: U.S. Department of Education

Table 4: Percentage of 8th graders who scored "At or Above Proficient" in science

< Peer state ranking

State	Percentage 2005	Rank 2005	Percentage 2000	Rank 2000
Massachusetts	41%	5	39%	4
Colorado	35%	12	na	37
Michigan	35%	13	35%	8
Virginia	35%	14	29%	16
Washington	33%	18	na	37
Maryland	26%	27	27%	20
Georgia	25%	28	23%	28
Texas	23%	33	23%	25
California	18%	42	14%	35
Idaho	36%	10	37%	7
Oregon	32%	21	34%	13
North Dakota	43%	1	38%	6

Source: U.S. Department of Education

Table 5: Percentage of 8th graders who scored "At or Above Proficient" in mathematics

< Peer state ranking

State	Percentage 2005	Rank 2005	Percentage 2003	Rank 2003
Massachusetts	43%	1	38%	2
Washington	36%	6	32%	16
Virginia	33%	16	31%	20
Colorado	32%	18	34%	10
Texas	31%	22	25%	34
Maryland	30%	28	30%	26
Michigan	29%	30	28%	31
Georgia	23%	38	22%	39
California	22%	41	22%	38
Oregon	34%	15	32%	19
Idaho	30%	24	28%	29

Source: U.S. Department of Education

Preparation for studying high-level mathematics and science

How many students are preparing themselves for high-level math and science?

Success in college and the workplace requires critical thinking and problem solving skills. Expectations of high school graduates from future employers and from colleges and universities are greater than ever before, and research shows a strong correlation between taking advanced coursework in high school and achieving success in college and the workplace. In order to be properly prepared for the advanced mathematics and science courses required by university science and engineering programs, students must begin their preparation at an early age.

One useful indicator of where students are in their preparation is the percentage of students who report taking algebra—a gateway course to higher level mathematics—in eighth grade. The Council of Chief State School Officers (CCSSO) obtained data on course taking for eighth grade students from the National Assessment of Educational Progress (NAEP) mathematics assessment for 1996 and 2003. The percentage of eighth grade students taking Algebra 1 is a key indicator for several reasons. Many states and districts are moving toward an eighth grade curriculum with greater emphasis on algebra for all students. Additionally, higher level high school science and math courses often require algebra completion as a prerequisite (CCSSO, 2005). Algebra 1 enrollments in eighth grade indicate the proportion of students that enter high school more prepared to take higher level courses.

Table 6: Percentage of students who reported taking Algebra 1 in 8th grade

< Peer state ranking

State	Percentage 2003	Rank 2003	Percentage 1996	Rank 1996
California	46%	1	27%	15
Massachusetts	33%	3	41%	2
Maryland	32%	4	41%	3
Virginia	28%	14	29%	9
Colorado	27%	16	28%	11
Georgia	27%	17	29%	8
Texas	25%	22	25%	24
Michigan	21%	34	29%	10
Washington	20%	36	26%	21
Idaho	28%	10	na	43
Oregon	25%	24	28%	13

Source: Council of Chief State School Officers

In 2003, just 20% of Washington's eighth graders reported taking Algebra 1 (Table 6). This percentage is down from 26% reported in 1996. In fact, students in all of the peer states, except for one, reported taking Algebra 1 at lower percentages in 2003 than in 1996. This is a disturbing trend and reverses gains that were made during the 1990s to bolster student preparedness for higher level mathematics.

Advanced mathematics and science

The Advanced Placement program, commonly known as AP, offers high school students the opportunity to receive college credit for courses in various subject areas. The College Board develops and maintains the course offerings and coordinates the administration of annual AP examinations. AP exam scores are reported to colleges with a range of 1 (no recommendation) to 5 (extremely qualified). Each college determines the scores they will accept for credit, with most awarding credit to a student who scores at least 3 (qualified). AP courses are typically regarded as more rigorous, challenging and demanding than standard high school coursework. The advantage of taking AP courses is better preparation for higher education: students who succeed in AP courses and exams have studied a subject matter to a greater depth, learned and practiced important learning and studying skills, and are more confident in their ability to succeed in college (Bureau of Curriculum and Instruction, Connecticut State Department of Education, 2006). Students who take AP courses improve their chances of gaining acceptance into competitive colleges and expand their options to take upper level courses in their field of interest or complete their undergraduate degrees in less time, thus saving on college costs.

Table 7: Number of Advanced Placement exams per 1,000 11th and 12th grade students

< Peer state ranking

State	Number 2005	Rank 2005	Number 2004	Rank 2004	Number 2003	Rank 2003
Maryland	413	1	384	1	363	1
Virginia	397	2	367	2	359	2
California	329	6	310	6	316	6
Texas	310	8	290	9	281	9
Massachusetts	293	11	276	10	280	10
Colorado	274	12	254	13	237	13
Georgia	249	16	216	15	228	15
Washington	194	24	175	27	159	27
Michigan	166	31	157	26	159	26
Idaho	140	37	124	38	114	38
Oregon	134	39	114	41	102	41

Source: The College Board

In general, Washington's AP student participation and performance levels in 2005 place it in the middle of all states and among its peers. The number of AP exams taken per 1,000 11th and 12th grade students in Washington was 194, 24th in the nation and next to last among peer states, as shown in Table 7. Of concern is the fact that students in Maryland took more than double the number of exams (413) than Washington students, and students in Georgia, the closest peer state to Washington, took 28% more AP exams. Although the Office of Superintendent of Public Instruction notes the percentage increase in the number of AP exams taken in Washington over the past 10 years is the sixth highest growth rate in the nation, it is clear that the absolute number of Washington students preparing themselves to succeed in college must be dramatically improved for Washington to be competitive with top states (Office of the Superintendent of Public Instruction, 2005).

In terms of performance, the percentage of AP exams on which Washington students scored 3 or above was 61.9%, placing the state 27th nationally and fifth among peer states (Table 8). For Washington, and all of its peer states, this percentage rate has declined over the past several years. On the AP Calculus AB examination (Table 9), the percentage of Washington's students who scored 3 or above was 63.1%, ranking 18th in the nation and third among peers. Though the current rates of performance leave much room for improvement, students in Washington can succeed in AP coursework and there are encouraging examples of districts in which they do. In the Bellevue School District (which has 18.6% of its students eligible for free or reduced lunch meals), 277 students took the AP Calculus exam and 228 of them received a score of 3 or above, a pass rate of 82.3%. Bellevue, in fact, outperforms the top-ranked state in our peer group (Massachusetts) as well as the top performing state in the country (North Dakota). Under district leadership that has emphasized rigor and college preparation, Bellevue's students are demonstrating what Washington's students are capable of achievement in advanced courses.

Table 8: Percentage of Advanced Placement exams scored grade 3 or above

State	Percentage 2005	Rank 2005	Percentage 2003	Rank 2003
Massachusetts	72.0%	2	72.6%	2
Maryland	66.0%	13	67.7%	14
Michigan	65.4%	15	65.8%	18
Colorado	62.2%	26	64.1%	25
Washington	61.9%	27	63.0%	28
Virginia	61.7%	29	62.2%	31
California	57.8%	36	59.4%	35
Georgia	57.6%	37	58.5%	36
Texas	48.6%	44	51.9%	44
Oregon	63.6%	21	67.8%	13
Idaho	62.5%	25	64.5%	22
Connecticut	72.7%	1	73.3%	1

< Peer state ranking

Source: The College Board

Table 9: Percentage of students scoring 3 or above on Advanced Placement Calculus AB exam

State	Percentage 2005	Rank 2005	Percentage 2004	Rank 2004
Massachusetts	67.5%	5	66.9%	10
Maryland	67.1%	6	66.2%	13
Washington	63.1%	18	62.5%	21
Michigan	62.7%	19	63.6%	18
California	59.9%	21	60.4%	26
Colorado	55.9%	31	58.7%	31
Virginia	55.8%	32	57.2%	33
Georgia	54.6%	35	54.6%	38
Texas	45.0%	44	46.5%	43
Idaho	64.2%	11	69.9%	3
Oregon	59.4%	22	65.4%	15
North Dakota	78.7%	1	73.1%	1
Bellevue (WA) Public Schools	82.3%			

< Peer state ranking

Source: The College Board

Investments in K-12 education

How much is being invested in the state's K-12 education system?

Although money alone does not guarantee that schools produce graduates who are ready to enter the workplace or to succeed in college, funding for K-12 schools must be at an adequate level in order to meet basic operating and instructional requirements. Further, because science courses tend to be more expensive than other courses due to the cost of materials and equipment, the level of investment in schools provides some insight into their ability to train students for the future (Sommers, 2003). The same could be said about curriculum reform efforts, teacher training, and the redesign and creation of new, smaller schools.

Per-pupil expenditure from all public sources is a standard measure of the resources devoted to K-12 education. In 2003, per-pupil expenditures in Washington's elementary and secondary public schools was only 90% of the national average, 32nd nationally and second from last among the peer group (Table 10). While most of Washington's peers have either increased their per-pupil expenditures or kept spending stable from previous years, Washington's per-pupil spending declined by almost 4% between 1999 and 2003.

Expenditures per-pupil as a percentage of per capita personal income was also calculated (Table 11), as a measure of a state population's ability to pay for spending on K-12 education. Washington's income per capita is the 12th highest in the nation, but the state ranks 45th in expenditures per-pupil as a percentage of per capita personal income, at 21.8%. West Virginia, whose personal income per capita ranks near the bottom of all states at 48th, spends 33.9% of per capita personal income, the most per-pupil in the nation.

Table 10: Per-pupil expenditures for public K-12 education as a percentage of the national average

< Peer state ranking

State	Percentage 2003	National Rank 2003	Per-pupil expenditures 2003	Percentage 1999	National Rank 1999	Per-pupil expenditures 1999
Massachusetts	130.1%	4	$10,460	126.9%	6	$8,260
Maryland	113.8%	10	$9,153	112.6%	12	$7,326
Michigan	109.2%	14	$8,781	114.2%	11	$7,432
Virginia	97.3%	23	$7,822	97.6%	22	$6,350
Georgia	96.7%	24	$7,774	93.6%	26	$6,092
California	93.9%	26	$7,552	89.1%	32	$5,801
Colorado	91.8%	30	$7,384	91.0%	30	$5,923
Washington	90.2%	32	$7,252	93.9%	25	$6,110
Texas	88.8%	33	$7,136	87.4%	34	$5,685
Oregon	93.2%	28	$7,491	104.9%	15	$6,828
Idaho	75.6%	48	$6,081	77.8%	46	$5,066
New Jersey	156.3%	1	$12,568	155.9%	1	$10,145

Source: U.S. Department of Education

Table 11: Per-pupil expenditures for public K-12 education as a percentage of per capita personal income in 2003

< Peer state ranking

State	Per-pupil expenditures as a percentage of per capita personal income	National Rank Percentage of per capita personal income	Personal income per capita	National Rank Personal income per capita	Per-pupil expenditures
Michigan	28.2%	14	$31,191	19	$10,460
Georgia	27.0%	17	$28,767	33	$9,153
Massachusetts	26.5%	23	$39,522	3	$8,781
Texas	24.5%	32	$29,079	29	$7,822
Maryland	24.4%	33	$37,444	4	$7,774
Virgina	23.2%	40	$33,647	10	$7,552
California	22.6%	44	$33,421	11	$7,384
Washington	21.8%	45	$33,255	12	$7,252
Colorado	21.4%	47	$34,558	7	$7,136
Oregon	26.1%	25	$28,748	34	$7,491
Idaho	23.5%	38	$25,882	44	$6,081
West Virginia	33.9%	1	$24,557	48	$8,319

Source: U.S. Department of Education

International comparisons

How do U.S. students compare with their international peers?

The global marketplace presents challenges and realities that students in the U.S. must recognize and face head-on in order to succeed. The knowledge-based economy values workers for their education and training, and students who perform the best in mathematics and science will gain advantages in the global marketplace no matter their location. Using international comparisons can help to provide a picture of how well U.S. students are performing in relation to their peers in other countries. Since there are virtually no student achievement assessments common among different nations, comparing Washington state students with those from other nations is not possible. Assessments conducted internationally presented in this section of this report help to provide comparisons between the U.S. and other nations, recognizing that they are not specific to students in Washington. Readers can infer relative performance of Washington students on a number of the indicators presented in this section with those just presented that are based on the NAEP exams.

The Trends in International Mathematics and Science Study (TIMSS) conducted in 2003 is the third comparison of mathematics and science achievement carried out since 1995 by the International Association for the Evaluation of Educational Achievement (IEA), an international organization of national research institutions and governmental research agencies. TIMSS is closely linked to the curricula of the participating countries, providing an indication of the degree to which students have learned mathematics and science concepts in school. In 2003, 46 countries participated in TIMSS at either the fourth- or eighth-grade level, or both (Tables 12A-12D).

Table 12A: Average scale scores of 4th grade students on TIMSS mathematics exam

Country	2003	1995
Singapore	594	590
Hong Kong	575	557
Japan	565	567
Netherlands	540	549
Latvia	533	499
England	531	484
Hungary	529	521
United States	518	518
Cyprus	510	475
Australia	499	495
New Zealand	496	469
Scotland	490	493
Slovenia	479	462
Norway	451	476
Islamic Republic of Iran	389	387

Source: U.S. Department of Education

All participating countries were required to draw random, nationally representative samples of students and schools.

On the TIMSS mathematics exam, the average score of U.S. fourth-grade students exceeded the overall average score of their international peers. They outperformed their peers in 13 of the 24 other participating countries, and performed lower than their peers in 11 countries (Table 12A). In comparison to students from the 10 participating OECD-member countries, U.S. fourth-graders outperformed their peers in five of the OECD-member countries and were outperformed by five of them. The Organization for Economic Cooperation and Development is an intergovernmental

Table 12B: Average scale scores of 8th grade students on TIMSS mathematics exam

Country	2003	1999	1995
Singapore	605	604	609
Republic of Korea	589	587	581
Hong Kong	586	582	569
Chinese Taipei	585	585	na
Japan	570	579	581
Belgium-Flemish	537	558	550
Netherlands	536	540	529
Hungary	529	532	527
Malaysia	508	519	na
Russian Federation	508	526	524
Slovak Republic	508	534	534
Latvia	505	505	488
Australia	505	na	509
United States	504	502	492
Lithuania	502	482	472
Sweden	499	na	540
Scotland	498	na	493
Israel	496	466	na
New Zealand	494	491	501
Slovenia	493	na	494
Italy	484	479	na
Bulgaria	476	511	527
Romania	475	472	474
Norway	461	na	498
Republic of Moldova	460	469	na
Cyprus	459	476	468
Republic of Macedonia	435	447	na
Jordan	424	428	na
Islamic Republic of Iran	411	422	418
Indonesia	411	403	na
Tunisia	410	448	na
Chile	387	392	na
Philippines	378	345	na
South Africa	264	275	na

Source: U.S. Department of Education

organization of 30 industrialized countries committed to democracy and the market economy, countries which may be considered our most immediate competition in the global marketplace. U.S. eighth-graders also exceeded the international average in mathematics (Table 12B). However, they were outperformed by their peers in 14 countries, five of which were OECD members. U.S. students were outperformed by students from non-OECD member countries Singapore, Hong Kong, Chinese Taipei, Latvia, and Russian Federation at both the fourth- and eighth-grade level.

On the TIMSS science exam, U.S. fourth-grade students scored higher than their peers in 19 other countries and were outperformed by five countries (Table 12C), including one OECD-member country (Japan). U.S. eighth-graders scored higher than their peers in 36 of the participating countries and were outperformed by eight countries (Table 12D). However, four of those countries were OECD-members. Non-OECD member countries Singapore, Chinese Taipei, and Hong Kong outperformed their U.S. peers in science at both the fourth and eighth grade level (NCES, Highlights from the TIMSS 2003, 2004).

Table 12C: Average scale scores of 4th grade students on TIMSS science exam

Country	2003	1995
Singapore	565	523
Japan	543	553
Hong Kong	542	508
England	540	528
United States	536	542
Hungary	530	508
Latvia	530	486
Netherlands	525	530
New Zealand	523	505
Australia	521	521
Scotland	502	514
Slovenia	490	464
Cyprus	480	450
Norway	466	504
Islamic Republic of Iran	414	380

Source: U.S. Department of Education

Table 12D: Average scale scores of 8th grade students on TIMSS science exam

Country	2003	1999	1995
Singapore	578	568	580
Chinese Taipei	571	569	na
Republic of Korea	558	549	546
Hong Kong	556	530	510
Japan	552	550	554
Hungary	543	552	537
Netherlands	536	545	541
United States	527	515	513
Australia	527	na	514
Sweden	524	na	553
Slovenia	520	na	553
New Zealand	520	510	511
Lithuania	519	488	464
Slovak Republic	517	535	532
Belgium-Flemish	516	535	533
Russian Federation	514	529	523
Latvia	513	503	476
Scotland	512	na	501
Malaysia	510	492	na
Norway	494	na	514
Italy	491	493	na
Israel	488	468	na
Bulgaria	479	518	545
Jordan	475	450	na
Republic of Moldova	472	459	na
Romania	470	472	471
Islamic Republic of Iran	453	448	463
Republic of Macedonia	449	458	na
Cyprus	441	460	452
Indonesia	420	435	na
Chile	413	420	na
Tunisia	404	430	na
Philippines	377	345	na
South Africa	244	243	na

Source: U.S. Department of Education

In 1995, TIMSS conducted a study of the final year of secondary school which showed that the performance of U.S. high school seniors was among the lowest of their peers from 20 other countries assessed in both mathematics and science (Table 12E). TIMSS also reported that U.S. twelfth graders performed less well than they did at eighth grade, based on additional assessments. Additionally, the more advanced U.S. students, those taking courses in pre-calculus, calculus, and physics, performed at low levels when compared with similar students in other countries (U.S. Department of Education, 1998).

From TIMSS, we see that U.S. students in early school years have reasonable levels of achievement when compared with other countries, but then performance lags by eighth grade and worsens by twelfth grade. The results from TIMSS suggest that many U.S. students disengage from learning mathematics and science content and concepts as they progress through the U.S. education system. As the world becomes “flatter,” and as knowledge-based and high-tech jobs become more accessible worldwide, performance in mathematics and science will become a larger determinant of who will be prepared to pursue science and engineering occupations. TIMSS raises concerning questions regarding who is really receiving a “world class” education.

Table 12E: Average scale scores of 12th grade students on TIMSS mathematics and science exams (ranked by math)

Country	Math score	Rank by math	Science score	Rank by science
Netherlands	560	1	558	2
Sweden	552	2	559	1
Denmark	547	3	509	11
Switzerland	540	4	523	8
Iceland	534	5	549	3
Norway	528	6	544	4
France	523	7	487	13
New Zealand	522	9	529	6
Australia	522	8	527	7
Canada	519	10	532	5
Austria	518	11	520	9
Slovenia	512	12	517	10
Germany	495	13	497	12
Hungary	483	14	471	18
Italy	476	15	475	17
Russian Federation	471	16	481	15
Lithuania	469	17	461	19
Czech Republic	466	18	487	14
United States	461	19	480	16
Cyprus	446	20	448	20
South Africa	356	21	349	21

Source: U.S. Department of Education

Higher Education Indicators

The central question addressed in this section is:
How well is Washington's higher education system preparing our students for the technology-based economy?

Sub-questions addressed in this section include:
1. How many state residents earn a bachelor's degree?
2. How many higher-level degrees in science and engineering are conferred by state universities?

Number of bachelor's degrees granted

How many state residents earn a bachelor's degree?

High-tech companies often stress the importance of earning a baccalaureate degree to enter their workforce, which helps ensure that potential employees possess the skills and abilities needed to contribute and innovate. Thus, the percentage of the young adult population who hold a four-year degree is an important indicator of the elements needed to sustain and grow a high-tech economy. Without an adequate number of baccalaureate degrees granted to a state's young adult population, a state's high-tech companies will be forced to look out-of-state and internationally to fill positions, which are often the highest paying jobs in the workforce.

According to the NSF's Science and Engineering State Indicators 2006 report, from 2001 to 2003, all states in the peer group increased the number of bachelor's degrees granted as a percentage of their 18-24 year old population. In Washington, in-state institutions granted bachelor's degrees to 4.13% of traditional college age individuals, up from 4.03% in 2001, as shown in Table 13. However, despite this increase, Washington's national rank has continued to slip, going from 33rd in 1998 to 36th in 2003.

Table 13: Bachelor's degrees granted as a percentage of the 18-24 year old population

State	Percentage 2003	National Rank 2003	Bachelor's degrees 2003	18-24 year old population 2003	Percentage 2001	National Rank 2001	Bachelor's degrees 2001	18-24 year old population 2001
Massachusetts	7.47%	2	44,612	596,934	7.26%	3	42,731	588,812
Colorado	5.18%	20	23,559	454,558	4.88%	20	21,410	438,886
Michigan	5.02%	23	49,758	992,111	4.82%	22	46,115	956,545
Maryland	4.78%	26	24,277	507,475	4.71%	24	22,085	469,101
Virginia	4.71%	28	34,623	735,711	4.69%	26	32,822	700,552
Washington	4.13%	36	25,558	618,757	4.03%	35	23,441	581,680
California	3.66%	43	130,593	3,569,122	3.56%	42	123,382	3,467,051
Georgia	3.57%	45	31,703	889,685	3.37%	45	28,790	853,685
Texas	3.51%	46	82,507	2,351,723	3.37%	46	76,074	2,258,949
Oregon	4.33%	31	15,053	347,267	4.17%	31	13,887	333,057
Idaho	3.90%	40	5,974	153,101	3.20%	47	4,646	145,008
Rhode Island	8.22%	1	9,389	114,254	7.48%	2	8,283	110,760

< Peer state ranking

Source: National Science Foundation

Science and engineering baccalaureate degrees are of particular interest to high-tech companies. In 2003, Washington's colleges and universities granted bachelor's degrees in an engineering or natural sciences field to 0.68% of 18-24 year olds (Table 14). Among peer states Washington ranks seventh and ranks 37th nationally on this measure. Similar to total bachelor's degrees granted, Washington's national ranking in its ability to grant science and engineering bachelor's degrees has steadily declined, from 35th in 2001 to 37th in 2003.

As the section on Entrepreneurial Climate will later show, the number of positions in engineering and science fields is increasing, making the relatively low output of baccalaureates by Washington's colleges and universities a major concern. As high-tech companies look to expand their operations and number of employees, they will increasingly be forced to seek qualified individuals to fill their workforce from out-of-state and from abroad.

Table 14: Bachelor's degrees granted in natural sciences and engineering as a percentage of the 18-24 year old population

< Peer state ranking

State	Percentage 2003	National Rank 2003	NS&E Bachelor's degrees 2003	18-24 year old population 2003	Percentage 2001	National Rank 2001	NS&E Bachelor's degrees 2001	18-24 year old population 2001
Massachusetts	1.26%	4	7,500	596,934	1.22%	4	7,163	588,812
Colorado	1.09%	8	4,959	454,558	1.00%	10	4,403	438,886
Maryland	1.04%	10	5,278	507,475	0.87%	20	4,060	469,101
Michigan	0.94%	15	9,300	992,111	0.95%	14	9,086	956,545
Virginia	0.79%	25	5,846	735,711	0.86%	21	5,993	700,552
California	0.69%	36	24,610	3,569,122	0.65%	38	22,403	3,467,051
Washington	0.68%	37	4,231	618,757	0.67%	35	3,886	581,680
Georgia	0.68%	38	6,049	889,685	0.63%	42	5,351	853,685
Texas	0.55%	44	12,988	2,351,723	0.57%	46	12,941	2,258,949
Idaho	0.72%	30	1,104	153,101	0.63%	39	916	145,008
Oregon	0.72%	31	2,490	347,267	0.75%	30	2,503	333,057
Rhode Island	1.41%	1	1,615	114,254	1.12%	6	1,246	110,760

Source: National Science Foundation

Number of higher-level degrees granted

How many higher-level degrees in science and engineering are conferred by state universities?

Many high-tech companies, large and small, employ Ph.D.-level scientists and engineers. Many of them lead the research and development activities of large software companies, biotechnology laboratories, or small startup companies. In addition, Ph.D.-level scientists and engineers are needed as educators at colleges and universities to train students.

The Division of Science Resources Statistics at the NSF conducts a survey of the earned science and engineering doctorates in all 50 states. In 2004, Washington's universities awarded 477 doctorates, or 55.52 per 100,000 25-34 year olds (Table 15). That placed Washington seventh among its peer states and 28th nationally, which is an improvement in rank from the previous year. However, Massachusetts, with a population size similar to Washington's, produced over three times the number of doctorate degrees than Washington, and has done so since at least 1999. Washington's closest peer on this measure, Virginia, awarded 16% more doctorates per 100,000 in this age cohort.

Since the market for new Ph.D.s in science and engineering is both national and international, this measure is very significant. As doctorate holders decide where to work, their choices are often a reflection of a location's quality of life, continuing education opportunities, and economic vitality and growth. The production and presence of large numbers of science and engineering graduates enriches a state's workforce and catalyzes the transfer of current technical knowledge into the local economy (Technology Administration, 2004). The high rate of Ph.D. production in Massachusetts, Maryland, and Michigan, is an economic asset, and a source of competitive strength that Washington lacks.

Table 15: Science and engineering Ph.D.s awarded per 100,000 25-34 year olds

State	Number per 100,000 2004	National Rank 2004	Ph.D.s awarded 2004	25-34 year old population 2004	Number per 100,000 2003	National Rank 2003	Ph.D.s awarded 2003	25-34 year old population 2003
Massachusetts	168.22	1	1,481	880,404	153.39	1	1,363	888,560
Maryland	95.24	4	677	710,846	87.98	5	634	720,652
Michigan	77.51	10	1,012	1,305,648	72.66	15	954	1,312,899
California	66.62	16	3,499	5,252,511	64.28	21	3,405	5,296,858
Colorado	64.97	18	466	717,277	74.44	14	533	716,024
Virginia	64.53	19	655	1,015,092	60.96	24	620	1,017,047
Washington	55.52	28	477	859,190	51.62	31	441	854,311
Georgia	48.03	36	655	1,363,671	45.94	36	620	1,349,465
Texas	47.82	37	1,595	3,335,725	47.13	35	1,548	3,284,470
Oregon	54.15	30	274	505,997	51.14	32	256	500,562
Idaho	30.33	46	56	184,610	39.06	42	70	179,230

< Peer state ranking

Source: National Science Foundation, U.S. Census Bureau

Conclusions

Although Washington's K-12 students perform relatively well compared to peer states on NAEP exams, the levels of achievement in math and science must be raised significantly, with nearly two-thirds of students considered "below proficient" on the verge of entering high school. At the high school level, participation and achievement in a rigorous curriculum that includes advanced mathematics and science courses is imperative to compete with the top states. Elevated achievement in a more rigorous curriculum is also essential to keep the greatest number of pathways open for Washington's students in terms of higher education, apprenticeships, and career choices. Graduation requirements must be increased to raise achievement and preparation. Currently only two years of math are required for Washington's students to graduate from high school. That requirement must be changed to four years of math, including the completion of at least Algebra 2 before the end of high school. Currently, more than 50% of high school graduates who enter Washington's community and technical colleges directly after high school need to take remedial math before they can take math courses for credit (Washington State Board for Community and Technical Colleges, 2003). Four years of challenging mathematics, including Algebra 2, increases opportunities after high school. The science requirement must also be increased, from two years to three years, because without that necessary preparation, high school students are simply not ready to be successful at the next step, whether that is college, an apprenticeship program, or on-the-job training.

Washington's performance in higher education needs to be improved to sustain and bolster the high-tech economy in our state. Although the absolute number of bachelor's degrees granted by Washington's colleges and universities has increased, other states have also increased their output and surpassed Washington in national rank. Without increasing the number of bachelor's degrees granted, particularly in science and engineering fields, high-tech companies in our state will look to other states and nations to fill open positions.

Research Capacity

A number of the indicators presented in this section address inputs to the technology creation process, including funding for research and development (R&D) and assembling pools of researchers capable of leading R&D programs. Other indicators assess outputs, such as patenting by corporations, research institutions, and individuals.

The capacity to conduct leading-edge R&D is essential to compete in a rapidly evolving technology economy. Successful R&D programs are also important in that they attract talented scientists and researchers into an area. These individuals may make their careers in the laboratory, or they may emerge from the laboratory over time as leaders of new companies.

Research Capacity Indicators

The major question addressed in this section is:
Do our research institutions and the people who fuel them receive the support necessary to generate the ideas and innovations that are the foundation for a vibrant technology-based economy?

Several sub-questions are addressed in separate sections below:
1. How much do the federal and state governments, industry, and academic and private non-profit institutions spend on the performance of research and development in Washington state, and how do we compare to other states in research activity?
2. What is the level of innovation in Washington state, and how does it compare to that of other states?
3. Is Washington state attracting and keeping leading scientific and medical researchers and engineers?

Research and Development Funding

How much do the federal and state governments, industry, and academic and private non-profit institutions spend on the performance of research and development in Washington state, and how do we compare to other states in research activity?

Both public and private support for R&D are important indicators of the strength of the research sector in a state. University and non-profit researchers conduct basic research in many fields that yield potentially commercializable technologies. Private companies usually specialize in more applied development work, taking their own ideas or basic research through a further development process that results in a product or service that can be sold at a profit. While greater expenditures are required in the applied development process than in basic research, both components are essential for vibrant technology-based economic development.

Understanding the data on R&D requires an explanation of several terms. The National Science Foundation (NSF) is the primary source of data on R&D. NSF conducts surveys that are the basis for most statistics about R&D funding. NSF distinguishes between sources of funds for R&D, and performers who actually engage in R&D activity. Funders of R&D include various agencies of the federal government; non-federal governmental entities such as states, municipalities, counties, and special districts; private industry; and, non-profit organizations such as foundations and interest groups. The classes of research performers in the NSF data include federal government agencies, universities and colleges, private industry, and non-profit organizations.

Industry is both the largest source of R&D funds and the largest performer of R&D activity. Ideally, it would be useful to break down this indicator by sector, but the concentration of this activity in a few large firms in most industries and regions precludes disclosure by NSF of industry sources and industry performers. In this section we present data on R&D performers by broad category. Table 16 breaks down R&D activity into its academic, industry, university and college, federal agency, federally-funded research and development center, and non-profit constituents. Data are presented on absolute R&D expenditures, national rank with regard to absolute expenditures, R&D per capita, and rank per capita.

With regard to absolute dollars spent by academic institutions on R&D, Washington ranked 14th nationally, a position equal to our population rank, as reported in Table 16A. However, when academic R&D expenditures are converted to a per capita basis Washington's position deteriorates. Washington ranked 21st in academic R&D per capita in 2003, a drop from the 20th position in 1999. This relatively low standing comes as a surprise to some, given the fact that the University of Washington receives the highest level of federal grants and contracts of any public university in the United States. However, the overall size of the research-oriented higher education enterprise in Washington state is small relative to our population size, a fact also evident in data presented in the previous section on enrollment in higher education. Two of our

Table 16A: Academic expenditures on research & development

State	Per capita 2003	Rank per capita 2003	Total Academic expenditures ($1,000s) 2003	Rank total Academic expenditures 2003	Rank per capita 1999
Massachusetts	$283	1	$1,821,817	5	2
Maryland	$258	2	$1,423,186	7	1
Colorado	$153	18	$694,862	19	11
California	$151	19	$5,362,683	1	15
Washington	$142	21	$869,695	14	20
Michigan	$138	23	$1,388,284	9	28
Georgia	$135	24	$1,175,852	12	18
Texas	$125	27	$2,765,634	3	30
Virginia	$105	38	$773,200	16	36
Oregon	$123	29	$436,958	27	25
Idaho	$77	44	$105,039	47	43

< Peer state ranking

Source: National Science Foundation

Table 16B: Federal expenditures on research & development

State	Per capita 2003	Rank per capita 2003	Total Federal expenditures ($1,000s) 2003	Rank total Federal expenditures 2003	Rank per capita 1999
Maryland	$642	1	$3,538,000	1	1
Virginia	$293	2	$2,166,000	3	2
Massachusetts	$140	7	$899,000	5	17
California	$80	8	$2,834,000	2	13
Colorado	$77	9	$350,000	16	10
Georgia	$71	10	$614,000	9	18
Washington	$67	14	$412,000	15	21
Texas	$38	24	$830,000	6	24
Michigan	$24	35	$243,000	19	31
Oregon	$35	26	$124,000	29	26
Idaho	$20	39	$27,000	45	28

< Peer state ranking

Source: National Science Foundation

Table 16C: Industry expenditures on research & development

State	Per capita 2003	Rank per capita 2003	Total Industry expenditures ($1,000s) 2003	Rank total Industry expenditures 2003	Rank per capita 1999
Massachusetts	$1,724	1	$11,094,000	4	3
Michigan	$1,512	4	$15,241,000	2	1
Washington	$1,504	5	$9,222,000	6	4
California	$1,329	6	$47,142,000	1	7
Colorado	$779	12	$3,544,000	17	13
Maryland	$726	13	$3,998,000	15	28
Virginia	$562	19	$4,152,000	14	27
Texas	$500	23	$11,057,000	5	22
Georgia	$243	33	$2,108,000	22	30
Oregon	$835	11	$2,973,000	19	24
Idaho	$545	21	$745,000	34	9

< Peer state ranking

Source: National Science Foundation

peer states, Massachusetts and Maryland, are at the top of national rankings on per capita academic R&D, while our neighbors Idaho and Oregon are ranked well below Washington on this index. Colorado, California, Michigan, and Georgia are in a similar position as Washington in per capita rankings, while Texas and Virginia rank significantly lower than Washington. Simply put, Washington state relies almost exclusively on its two public research universities—University of Washington and Washington State University—to carry the state on this measure. Washington has no private research universities, and the bulk of the public university research is concentrated within those two main institutions.

Federal R&D activity in Washington state in 2003, reported in Table 16B, was about half the level of academic R&D. This activity is undertaken by a number of federal agencies, with the departments of Health and Human Services, Defense, Commerce, and Agriculture accounting for most of this spending. Washington's position on this measure improved from 21st in 1999 to 14th in 2003. Federal R&D activity is strongly concentrated in the states adjacent to the national capital (Maryland and Virginia), and also shows stronger concentrations than Washington in Massachusetts, California, Colorado, and Georgia. These states also improved their position on this measure since 1999.

Industry R&D as measured in absolute dollars accounts for the majority of R&D activity in Washington state and nationally. Industry was responsible for 80% of total R&D expenditures in Washington state in 2003. Washington maintained a strong national ranking on this measure, at 6th in absolute dollars spent, and 5th when measured on a per capita basis, as reported in Table 16C. Our position slipped slightly from the 4th position nationally in 1999, but only Massachusetts and Michigan had a higher per capita ranking on this measure among our peers. California ranked slightly below Washington on a per capita basis, although it accounted for the largest amount of industry spending when measured on an absolute basis. Other peer states and our neighbor states ranked well below Washington on a per capita basis on this measure. The per capita measures for Idaho and Oregon exhibit considerable change between 1999 and 2003, with Idaho falling in per capita rank while Oregon rose sharply.

NSF reports non-university non-profit research organizations as a separate category of research expenditure. In Washington, the largest organization of this type is the Fred Hutchinson Cancer Research Center. Nationally, outlays on this category of R&D are much smaller than industry, university and college, and federal R&D, accounting for 2% of overall R&D in 2003. However, Washington state occupies a strong position with regard to this type of R&D, as reported in Table 16D. Washington was ranked 5th nationally in spending by non-profits on a per capita basis, a drop from 4th position in 1999. Massachusetts and Maryland ranked above Washington on this measure, while our other peer states ranked below us on a per capita basis. Our neighbor states Oregon and Idaho also ranked well below Washington on this measure.

The last category of R&D expenditures funding reported by NSF is for research performed in federally funded research and development centers (FFRDCs). These include national laboratories, such as the Pacific Northwest National Laboratory managed by Battelle in Richland, Washington; Los Alamos National Laboratory in New Mexico; and, Oak Ridge National Laboratory in Tennessee. This category of spending is quite unevenly distributed among the states, as it depends upon the physical presence of such facilities. FFRDC research accounted for 5.9% of total R&D expenditures in Washington state in 2003, and 4.4% nationally. Washington state ranked first among its peers in 2003, as reported in Table 16E, and improved its position nationally from 7th to 4th on a per capita basis since 1999. New Mexico ranked first nationally on this measure in both 1999 and 2003. California, Massachusetts, Colorado, Maryland, and Virginia also ranked high on this measure, while Georgia and Michigan had none of this type of research and Texas had very little. Idaho's ranking on a per capita basis was higher than that of Washington due to activity at the Idaho National Laboratory, while Oregon had no research of this type.

Table 16D: Non-profit expenditures on research & development

State	Per capita 2003	Rank per capita 2003	Total Non-profit expenditures ($millions) 2003	Rank total Non-profit expenditures 2003	Rank per capita 1999
Massachusetts	$202	1	$1,301	1	1
Maryland	$54	4	$299	5	2
Washington	$47	5	$286	6	4
California	$26	9	$920	2	8
Virginia	$14	14	$107	11	16
Colorado	$13	16	$61	16	9
Texas	$5	29	$115	9	25
Georgia	$3	36	$25	24	35
Michigan	$1	49	$11	33	37
Oregon	$10	21	$37	19	17
Idaho	$1	46	$1.8	49	49

< Peer state ranking

Source: National Science Foundation

Table 16E: Federally funded research and development centers (FFRDCs) expenditures on research & development

State	Per capita 2003	Rank per capita 2003	Total FFRDC expenditures ($millions) 2003	Rank total FFRDC expenditures 2003	Rank per capita 1999
Washington	$111	4	$679	5	7
California	$96	5	$3,404	2	2
Massachusetts	$81	6	$523	6	3
Colorado	$80	7	$362	9	4
Maryland	$54	9	$296	11	15
Virginia	$52	10	$381	8	6
Texas	$1	18	$18	18	15
Georgia	0	19	0	19	15
Michigan	0	19	0	19	15
Idaho	$241	2	$330	10	15
Oregon	0	19	0	19	15
New Mexico	$2,048	1	$3,849	1	1

< Peer state ranking

Source: National Science Foundation
Note: states with zero (0) funding are all considered to have the same rank.

Another perspective on university and college research is gained by focusing on funding from government sources other than the federal government, as reported in Table 17. Non-federal government funding comes mostly from states and is often used as seed capital to jumpstart new research programs. If successful, new endeavors started with state funds are then able to compete for federal research funding or attract private investment. Washington ranks near the bottom of all the states in this type of funding, a significantly lower level of state support for our research sector than our peers and the rest of the nation. Washington's position has deteriorated from 46th in 1999 to 47th in 2003. The top ranked peer state, Texas, spends nearly five times as much, on a per capita basis, as Washington does on university and college R&D, while our neighboring states spend three or four times as much. In absolute dollars, Texas and California spend much larger sums than Washington on this type of research, creating competitive opportunities for leveraging research that are not captured by the per capita spending perspective.

Recent efforts in Washington to increase state funding for research resulted in creation of the Life Sciences Discovery Fund (LSDF). While we cannot predict the future impact of such funding relative to other states, it is instructive to calculate Washington's position in 2003 as if the $35 million per year from the LSDF had been available. When we add those dollars to the $20 million in state funds that were actually received that year, Washington jumps from 48th to 24th place, and would have ranked 6th rather than last among the peer states on a per capita basis.

Total R&D expenditures by research performers other than private industry are shown in Table 18. Industry R&D tends to be focused on development, while other performers tend to be more strongly focused on research. Table 18 provides a picture of the combined university, federal, non-profit, and FFRDC expenditures. Washington is positioned well on this measure on a per capita basis, due to our strength in non-profit and FFRDC research. California leads the nation on an absolute basis on this measure, while Washington comes in a little above its rank by population (14th). Peer states ranking above Washington on an absolute and per capita basis include Maryland, Massachusetts, and Virginia. Idaho has dramatically improved its position on this measure since 1999, probably due to increases in FFRDC funding. Washington's position on this measure has improved since 1999, although total spending in California is six times that in Washington and per capita spending in Maryland is three times that in Washington. Washington's position on this measure is pulled down by our relatively low level of university and college R&D.

Table 17: Non-federal government funding for university and college research & development

State	Per capita 2003	Rank per capita 2003	Total expenditures ($millions) 2003	Rank total expenditures 2003	Rank per capita 1999
Texas	15.33	6	339	1	18
Maryland	11.44	14	63	13	7
Virginia	10.42	16	77	11	20
Georgia	9.79	17	85	10	16
Michigan	9.33	21	94	8	29
California	7.98	27	283	2	32
Colorado	6.81	36	31	29	28
Massachusetts	6.68	37	43	21	35
Washington	3.26	47	20	33	46
Idaho	13.91	8	19	34	8
Oregon	10.68	15	38	26	15
Montana	23.98	1	22	31	5

< Peer state ranking

Source: National Science Foundation

Table 18: Total expenditures of non-industrial research performers on research & development

State	Per capita 2003	Rank per capita 2003	Total expenditures ($millions) 2003	Rank total expenditures 2003	Rank per capita 1999
Maryland	$1,119	2	$6,164	2	1
Massachusetts	$706	3	$4,544	4	3
Virginia	$464	5	$3,430	7	4
Washington	$366	7	$2,247	11	13
California	$353	8	$12,522	1	5
Colorado	$323	11	$1,468	18	9
Georgia	$209	23	$1,815	14	19
Texas	$169	33	$3,728	6	35
Michigan	$163	36	$1,643	15	34
Idaho	$340	10	$464	33	45
Oregon	$168	34	$599	29	32
New Mexico	$2,469	1	$4,628	3	2

< Peer state ranking

Source: National Science Foundation

Another measure of industry research activity, NSF Small Business Innovation Research (SBIR) awards, is presented in Table 19. The relatively small size of this program leads to fairly significant year-to-year changes in state totals, especially those states that receive relatively few of these awards. Thus, NSF has averaged their level over three-year time periods and has indexed them relative to Gross State Product (GSP). Washington does not fare as well on this index as for all industry R&D, and our position as well as that of each peer state has not changed much over the past decade. Oregon's position has deteriorated, while Idaho has moved up considerably.

Looking across the different classes of R&D performers, it is clear that industry is the largest performer of R&D, with expenditures accounting for 80% of total R&D expenditures in Washington. In Massachusetts, the leading state for total R&D expenditures per capita, industry accounts for 71% of the total. While industry is a relatively strong contributor to the total in Washington, non-federal government sources are very weak in this state. Despite the dominance of the University of Washington among public universities in accessing federal research dollars, overall academic research expenditures per capita in Washington are not at a high level compared to other states.

Table 19: NSF Small Business Innovation Research (SBIR) awards

State	SBIR Awards per $1M GSP 2001-03	Rank per $1M GSP 2001-03	Average SBIR Awards ($1,000s) 2001-03	Rank per $1M GSP 1997-99	Rank per $1M GSP 1992-94
Massachusetts	$721	1	$208,446	1	1
Colorado	$386	2	$70,313	3	4
Maryland	$370	5	$74,933	5	5
Virginia	$296	6	$85,948	6	8
California	$230	8	$314,505	7	9
Washington	$161	13	$37,722	14	12
Michigan	$84	26	$29,292	22	26
Texas	$70	32	$54,863	26	27
Georgia	$46	39	$14,228	33	35
Oregon	$144	16	$16,608	12	10
Idaho	$80	28	$3,074	41	38

< Peer state ranking

Source: National Science Foundation

Washington's Level of Innovation

What is the level of innovation in Washington, and how does it compare to that of other states?

R&D programs generate new technologies which may be turned into profitable business ventures. The first step on the way out of the laboratory is often filing a patent application to protect commercial interests in a commercializable technology. Thus, a good measure of the success of R&D programs is the number of patents granted. Admittedly, this is an imperfect measure since a patent is actually just a way to protect commercial rights, not a measure of technology development, per se. In some fields, such as software, copyrights may be used in addition to or in lieu of patents, and in other fields, companies are able to distinguish their product through marketing programs or to develop lower-cost production methods than their competitors. In these instances, companies may not feel a need to obtain patent protection. Also, some patents simply are more important than others, as they represent breakthrough inventions that will lead to a string of subsequent innovations. One measure that could signal the importance of a patent is the number of citations received, identified by state, type of institution, or type of company. However, there are so many variations in patenting behavior in different scientific fields that a valid comparison of patent citations by state would require taking a sample of patents in certain fields and comparing citations across states just for selected fields. It was not possible to develop this measure in this study.

Despite the abovementioned difficulties, which suggest that the number of patents filed is lower than the true number of significant inventions, patent counts are the best available measure of technological progress. Table 20 presents measures of the number of utility patents issued to patent-holders in Washington, the peer states and neighbor states in 2004. The absolute number of patents issued to California patent-holders was 8.8 times that issued to Washington patent-holders. Another perspective is gained by indexing the granting of patents to a per capita level, shown in Table 20, as patent rates per 100,000 in population for the year 2004. On this measure Washington ranks 11th, an improvement over 15th place in 1999, but is still well behind peer states Massachusetts, California, and Colorado. Oregon and Idaho exhibit much higher patent rates per capita than Washington, with Idaho leading the nation due to the presence of Micron and Hewlett-Packard. Massachusetts, the peer state with the highest patent rate, had 56% more patents per capita than Washington in 2004.

Table 20: Number of patents issued per 100,000 population

State	Patents per 100,000 population 2004	Rank 2004	Number 2004	Population	Rank 2001
Massachusetts	61	3	3,904	6,407,382	3
California	60	4	21,601	35,842,038	5
Colorado	50	8	2,289	4,601,821	10
Michigan	41	10	4,122	10,104,206	11
Washington	39	11	2,442	6,207,046	15
Texas	28	20	6,239	22,471,549	17
Maryland	26	22	1,436	5,561,332	22
Georgia	17	30	1,492	8,918,129	29
Virginia	16	31	1,181	7,481,332	32
Idaho	131	1	1,822	1,395,140	1
Oregon	55	6	1,967	3,591,363	12

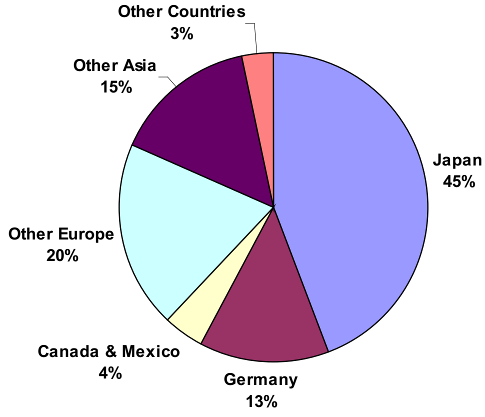
< Peer state ranking

Source: U.S. Patent and Trademark Office

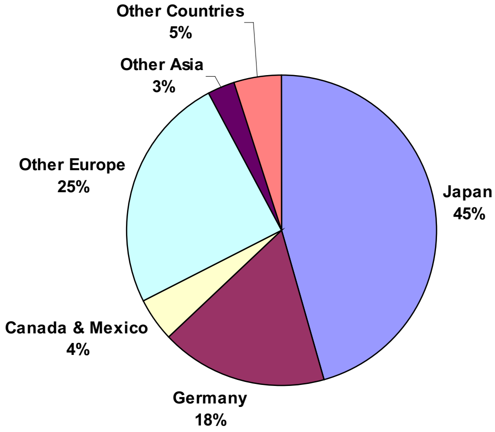
In this report, we find it instructive to additionally focus on the relative importance of international patent activity, in comparison to domestic patent activity. To place in context international awards of U.S. patents, of total patents issued (164,293) in 2004, 51.3% (84,271) went to U.S. patent recipients, and 48.7% (80,022) went to foreign recipients. Over the 1963-1983 time period, 31% of patents went to foreigners, so there has been a sharp increase in the share of U.S. patents going to foreign recipients over the last two decades.

Chart 1 shows the location of foreign patents in 2004. Other Asia, where Taiwan and South Korea dominate (they account for 82% of patents granted in that category), accounted for 15% of total foreign patents in 2004, up from just 3% in 1990. The number awarded to China (715) and India (363) is quite small, about 1% of total foreign patents issued in 2004. In 1990, foreign patent recipients accounted for 48% of the total issued, almost the same percentage as in 2004. However, the number of patents issued annually has continued to grow. Japan had the same share of the total issued to foreign patent holders – 45% – in 1990 and 2004. Germany and Other Europe fell between 1990 and 2004, while Other Asia increased dramatically.

Chart 1: Foreign recipients of U.S. patents



2004



1990

Source: U.S. Patent and Trademark Office

A longer term view of patents is presented in Table 21. This table reports cumulative patents issued between 1963 and 2004, as well as patents issued in the more recent 1983-2004 time period. This longer-term view shifts the perspective on patent activity significantly. Over the 1963-2004 time period, California had ten times the number of patents issued to businesses and individuals than patents awarded in Washington. On a per capita basis, Massachusetts, Michigan, California, Colorado, and Maryland all ranked above Washington. Idaho and Oregon also rank above Washington on this longer term measure (e.g. 1963-2004).

Looking at just the 1983-2004 time period a somewhat different situation emerges. Washington moves ahead of Maryland among our peers, and Idaho and Oregon also move up in the rankings. Considering just the last decade (last column in Table 21), we see more repositioning. Older industrial states such as Michigan and Delaware decline, while Idaho rises to the top, and Washington improves its position over its 1963-2004 and 1983-2004 rankings. Washington's peers have generally moved up over time (Virginia is an exception to this trend), probably reflecting the relatively recent growth of technology-based industry in these states and related increases in patent activity.

The level of innovation in Washington, as measured by patents, is not as high as might be expected given our rate of research activity. It may be that the type of industrial research in Washington (dominated by aerospace and computer services) does not lead to as high of patent rates as industrial research in a state such as Idaho, where technology-based manufacturing is led by computer equipment manufacturing. Additionally, the non-industry R&D in which Washington has a high national ranking may not be associated with strong rates of patent activity. However, the low rank of academically performed R&D (Table 16A) may be linked to Washington's low level of patent activity. This is a topic that needs additional research.

Table 21: Cumulative number of patents issued (indexed against population)

State	Patents 1963-2004 per 10,000 population	Rank Patents 1963-2004 per 10,000 population	Cumulative Patents 1963-2004	Patents 1983-2004 per 10,000 population	Rank Patents 1983-2004 per 10,000 population	Cumulative Patents 1983-2004	Patents 1995-2004 per 10,000 population	Rank Patents 1995-2004 per 10,000 population	Cumulative Patents 1995-2004
Massachusetts	146	4	93,288	83	4	53,300	53	3	32,517
Michigan	115	5	116,470	62	10	62,231	36	12	35,031
California	99	12	353,372	65	9	232,903	42	9	138,854
Colorado	74	18	34,009	54	11	24,856	42	10	16,941
Maryland	73	20	40,457	40	21	22,046	26	23	13,277
Washington	58	23	35,795	42	18	26,057	30	14	17,506
Texas	56	25	124,811	39	22	86,575	27	19	54,503
Virginia	41	29	30,486	24	30	17,828	15	31	10,199
Georgia	28	43	24,604	20	36	18,234	15	30	12,028
Idaho	109	7	15,213	99	2	13,816	96	1	11,998
Oregon	66	22	23,585	48	17	17,276	36	11	11,843
Delaware	212	1	17,571	99	1	8,222	51	4	3,866

< Peer state ranking

Source: U.S. Patent and Trademark Office

Leading Scientists and Researchers

Is Washington state attracting and keeping leading scientific and medical researchers and engineers?

In addition to investments in R&D activity and an active program of protecting ideas through patents and licensing programs, strong research capacity also depends upon the presence of a pool of talented researchers in science and engineering fields. There is no universally accepted, easily observable metric for this critical factor. However, two available measures do provide some perspective on the pool of such talent in Washington state and in peer states. One is focused on senior researchers, and the other on younger scientists, and they are complementary. Senior researchers help attract younger talent in all areas of R&D activity. Ideally it would be desirable to know the relationship between the presence of people of this type and the results of their efforts (output measures) such as patent activity generated by their work, journal articles published, grants received, etc. However, data are not available to trace such causal relationships.

To gauge the pool of senior talent, the most obvious indicator to use is number of members in the National Academies of Sciences or Engineering, or the Institute of Medicine. These three academies select the best scientists in the nation as members. They provide directories indicating by state the number of members residing in each state. In Table 22, we present current estimates of membership in these three academies. It should be noted that some of these people belong to more than one of the academies, such that adding up their membership can lead to some double-counting. Second, some of these people are retired and live in a different state than where they were employed at the time they were elected to membership, or they might live in a different state than where they work. Neither of these presents a severe problem, although they must be noted when drawing inferences from the results listed in Table 22. Overall, National Academies membership data provide a glimpse into which states boast accomplished science and engineering talent.

Table 22 shows the number of academy members per million state population, and the rank of Washington and its peer and neighbor states in 2006 and 2002. Washington moved up from 9th to 7th place nationally in the concentration of academy members. Washington ranks fourth among the peer states, a position that did not change from 2002 to 2006.

Table 22: National Academy Members

< Peer state ranking

State	Number per million population 2006	Rank per million population 2006	Total members 2006	National Academy of Sciences 2006	National Academy of Engineering 2006	Institute of Medicine 2006	State Population (1,000s)	Rank per million population 2002
Massachusetts	110.6	1	708	295	216	197	6,399	1
Maryland	53.4	2	299	94	66	139	5,600	3
California	39.8	4	1,437	605	553	279	36,132	4
Washington	26.2	7	165	63	59	43	6,288	9
Colorado	20.4	10	95	32	48	15	4,665	12
Virginia	16.4	14	124	18	70	36	7,567	17
Michigan	13.9	18	141	31	64	46	10,121	21
Texas	10.8	26	246	49	148	49	22,860	26
Georgia	8.4	30	76	10	35	31	9,073	30
Oregon	11.8	23	43	15	19	9	1,429	27
Idaho	4.9	35	7	1	6	0	3,641	37

Source: National Academy of Sciences, National Academy of Engineering, Institute of Medicine

The measure we used to gauge the pool of young science and engineering talent was the number of Sloan Foundation fellows selected by state each year. This fellowship is awarded to recent Ph.D.'s who have shown substantial progress in research since leaving graduate school and embarking on a research career. The program awards 116 fellowships annually to enhance the careers of the very best young faculty members in the United States and Canada in the following fields: chemistry, computational and evolutionary molecular biology, computer science, economics, mathematics, neuroscience, and physics. The Foundation's award-making process is validated by an interesting statistic: 26 of its prior awards went to young scientists who subsequently earned Nobel prizes. Thus, the number of Sloan fellowships awarded to scientists in each state provides a measure of the strength of the younger talent pool in science to complement the senior scientist measure discussed above.

Because the number of Sloan fellowships awarded is small, indexing them each year would be problematic due to shifting numbers of awards in particular states, as shown in Table 23. However, we can look at the cumulative number of awards for recent years and develop a measure of frequency of award, as is reported in the Total Number column of Table 23. In absolute numbers, California has garnered over ten-times as many of these awards as Washington, a differential far larger than one might expect based on the state's respective size. Table 23 clearly indicates that Massachusetts and California receive a disproportionate share of these awards, but Washington does quite well against the majority of peer states and is in a position similar to that related to National Academy membership.

A longer-run view of the award of Sloan Fellowships is presented in Chart 2, which reports the number of these awards by state from 1990 through 2006. This chart documents the fact that California and Massachusetts have been awarded a disproportionate share of these awards for a decade and a half, giving these states a long-term competitive advantage in the massing of talent necessary for the creation of the next waves of discoveries leading to competitive advantage in technology-based industries. There is a strong correlation between the states with high ranks in NAS membership and Sloan fellowships. The position of most of Washington's peer states and neighbor states is low on both Sloan Fellowships and NAS membership.

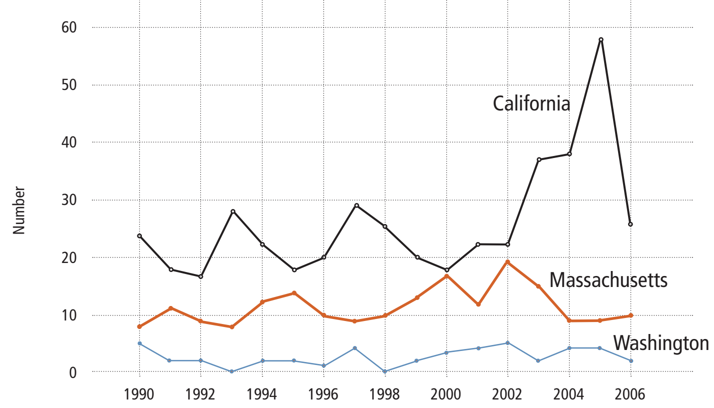
Table 23: Sloan Foundation fellowships by state

State	Per million population	Total number 2002-06	2006	2005	2004	2003	2002
Massachusetts	9.7	62	10	9	9	15	19
California	5.0	181	26	58	38	37	22
Maryland	3.2	18	4	4	6	1	3
Washington	2.7	17	2	4	4	2	5
Michigan	2.0	20	5	4	6	2	3
Colorado	1.3	6	1	2	1	0	2
Texas	1.2	27	6	5	4	6	6
Georgia	1.1	10	3	4	0	1	2
Virginia	0.5	4	0	0	1	2	1
Oregon	0.3	1	1	0	0	0	0
Idaho	0.0	0	0	0	0	0	0

< Peer state ranking

Source: Alfred P. Sloan Foundation

Chart 2: Sloan Foundation fellowships 1990-2006 (selected states)



Source: Alfred P. Sloan Foundation

Conclusion

Washington occupies the middle ground with respect to its peers in the strength of its research capacity. That said, these peer states (and our neighbors) have strong technology-based economies, and there is no reason to expect that Washington should not be in their league with regard to these indicators. We do relatively well overall in R&D activity, less well on innovation, and relatively well in concentration of highly regarded scientists and engineers. A critical area of weakness is in overall research activity in higher education, a problem that can only be remedied by expanding the level of research activity in Washington through a robust expansion of enrollments at the graduate and undergraduate level, as well as in related numbers of faculty needed in science and engineering at research institutions that would bring up our overall levels of academic grant and contract activity. One of our biggest weaknesses is in non-federal government support for college and university R&D. The state took a positive step toward addressing this shortcoming with the Life Sciences Discovery Fund; it remains to be seen once it is fully operational whether it allows us to keep pace with our peer states. Washington does well in the industrial area on R&D, even though this effort is strongly concentrated in a few industries. We should aim for diversification of industry R&D, and seek to grow our academic research enterprise, which would also grow our key indicators of highly regarded science and engineering staff and new researchers. Overall, since the last measurement of these indicators in 2003, Washington's research capacity has improved and continues to be a large contributor to our state's high-tech economy.

Entrepreneurial Climate

Entrepreneurs are critical to the technology development process. The number, size, and growth of startup companies are significant indicators of a healthy technology-based economy, along with the availability of funding and the technical workforce to support these young, innovative companies. Funding and workforce constitute the input measures in this section, while the data on startup companies measure output.

Data for some of the indicators used in the 2003 report are not available for this update. We have expanded information on other indicators relating to entrepreneurial climate that are likely to be replicable in future reports.

Entrepreneurial Climate Indicators

The major question asked in this section is:
Does the entrepreneurial climate in Washington support new company creation?

Sub-questions are addressed in separate sections below:
1. How many new companies, including high-tech companies, are starting in the state, and how does Washington compare to peer states?
2. Is funding and investment available to start and grow new companies, and how does this supply of capital compare to other states and regions?
3. Does Washington state have workers with the right talents and training to start and sustain technology-based businesses compared to peer states?
4. Does the environment in Washington state support sustained growth of startup businesses compared to peer states?

Creation of Technology-Based Companies

The first group of indicators in this section relates to the founding of new companies, a key aspect of technology-based economic development. Here, we seek to answer the question:

How many new companies, including high-tech companies, are starting in the state, and how does Washington compare to peer states?

Technology-based companies may be more likely to start up in states with a business culture that generally supports entrepreneurial activities. Table 24 shows the total number of establishment births per 100,000 state residents. Washington ranked second among peer states on this measure in 2003, about 20% below the leading peer state, Colorado, which ranked third in the nation. Idaho ranked higher than Washington, while Oregon's rate was just above that of Washington. The rest of the peer states ranked below Washington on this measure. Washington's national ranking fell two places, from 10th to 12th, from 2000 to 2003. Relative positions of states on this measure have not changed dramatically over the last decade. It is unclear how the recession of 2001-2003 may have altered these establishment birth rates.

Table 24: Number of establishment births per 100,000 residents

State	Number 2003	Rank 2003	Establishment births 2002-2003	Population 2003	Rank 2000
Colorado	367	3	16,693	4,550,688	1
Washington	292	12	17,886	6,131,445	10
Georgia	276	15	23,958	8,684,715	14
Massachusetts	263	20	16,906	6,433,422	18
California	258	22	91,419	35,484,450	21
Virginia	253	24	18,709	7,386,330	27
Texas	238	31	52,677	22,118,510	29
Maryland	236	34	12,979	5,508,909	34
Michigan	210	43	21,185	10,079,990	45
Idaho	339	5	4,627	1,366,332	7
Oregon	300	11	10,689	3,559,596	9
Wyoming	376	1	1,885	501,242	4

< Peer state ranking

Source: U.S. Census Bureau

Many young businesses fail shortly after their startup, and thus it is useful to have a measure of net business formation in addition to gross new startup rates. We hear anecdotally from many entrepreneurs that starting a successful technology-based company comes after an initial failure of a business model, from which the entrepreneur learns and develops a more robust model of business activity. Thus, the measure of overall business startups in Table 24 is not the best measure of entrepreneurship, particularly as these data are not limited to technology-based businesses. NSF has developed measures of the net versus gross rates of new technology-based business formations. Table 25 presents estimates of these data for 2002, and comparison to 1999. It should be noted that the year 2002 was part of the recent recession, and it should not come as a surprise to find that net formation rates of high-tech establishments in Washington and several other peer states were negative in that year.

Table 25: Net formation of high-tech establishments per 10,000 total business establishments

State	Net number 2002	Rank 2002	Net formation of high-tech establishments 2002	Total establishments 2002	Rank 1999
Virginia	14.2	7	257	180,501	10
Maryland	10.6	11	140	131,815	7
Texas	4.2	19	202	482,169	14
Colorado	2.9	23	41	142,247	4
Georgia	0.7	27	15	206,323	8
Washington	-4.0	40	-66	165,933	13
Michigan	-6.2	42	-147	237,616	39
California	-6.2	43	-508	820,997	12
Massachusetts	-20.9	48	-367	175,991	5
Idaho	16.0	5	62	38,842	20
Oregon	-1.2	34	-12	101,933	41
Utah	23.6	1	139	58,788	18

< Peer state ranking

Source: National Science Foundation

Another perspective on high-tech business formation is given in Table 26, which indicates the net high-tech business formations as a percentage of all business establishments. Table 25 showed that Washington had negative net high-tech business formation in 2002. The following measure is similar to that presented in Table 25, and we see that several of our peer states had strong downward movement on this measure into the recession, especially California, Michigan, and Massachusetts.

A perspective on the relative dependence of peer and neighbor states on high-technology businesses is provided in Table 27, which defines the percentage of all business establishments in high-tech industries in 2002. Washington does not have an especially strong position on this measure, which contrasts with the concentration of employment measured by location quotients. A likely explanation for this disparity is the presence in Washington of some very large establishments in sectors such as aerospace, which contribute strongly to a measure based on absolute employment, but pull down a measure such as that reported in Table 27. Washington outperforms neighboring states Oregon and Idaho on this measure. The highest ranking peer states have about one-third more high-tech establishments in their overall population of business establishments than Washington state.

Table 26: High-tech business formations as a percentage of all business establishments

State	Percentage 2002	Rank 2002	Rank 2000	Rank 1999
Virginia	0.14%	6	2	3
Maryland	0.11%	9	7	4
Texas	0.04%	19	38	18
Colorado	0.03%	21	5	7
Georgia	0.01%	27	21	9
Washington	-0.04%	40	24	21
Michigan	-0.06%	42	32	44
California	-0.06%	43	3	11
Massachusetts	-0.21%	48	11	15
Idaho	0.16%	5	10	28
Oregon	-0.01%	32	25	38
Utah	0.24%	1	4	10

< Peer state ranking

Source: National Science Foundation

Table 27: High-tech business establishments as a percentage of all business establishments

State	Percentage 2002	Rank 2002	Number of high-tech business establishments 2002	Rank 2000	Rank 1998
Colorado	8.72%	1	12,400	3	3
Virginia	8.38%	3	15,122	4	5
Maryland	8.35%	4	11,008	5	6
Massachusetts	8.34%	5	14,669	2	1
California	7.84%	6	64,348	7	7
Georgia	6.88%	14	14,188	13	13
Washington	6.41%	16	10,642	15	15
Texas	6.31%	18	30,421	17	16
Michigan	5.77%	20	13,721	20	20
Oregon	5.90%	19	6,009	19	19
Idaho	4.86%	31	1,889	33	40

< Peer state ranking

Source: National Science Foundation

Funding and Investment Availability

The next question addressed in this section is:

Is money available to start and grow new companies, and how does this supply of capital compare to other states and regions?

Venture capital is an essential ingredient in many high-tech startups. A company may be founded with the entrepreneur's personal resources, and some startups also secure early "angel" capital investments. Most high-tech companies with the goal of growing into substantial enterprises seek investments from venture capital funds to support expansion once the essential product viability and business model have been established. Thus, indicators of the extent of venture capital investment in a state are very important.

The leading data source on venture capital is the PriceWaterhouseCoopers MoneyTree® Report, which compiles data on current and historic levels of activity in venture capital. The 2003 benchmarking report used regional markets as the basis for reporting these data. For the current report we have elected to examine venture capital activity by state. The primary effect of this change in presentation concerns California, which not only gets the lion's share of venture capital, but is composed of three large markets that previously were reported separately (Silicon Valley, L.A./Orange County, and San Diego). Table 28 reports the distribution of investment percentages and the number of deals. California garnered almost half of the total U.S. venture capital investment in 2005, while Washington claimed just 3.5% of venture capital investment and 3.9% of venture capital deals. However, the 3.5% share of the national total was an improvement over 2002, when Washington had 2.7% of venture capital investments.

A longer-term perspective on venture capital investment is presented in Charts 3A and 3B. Chart 3A clearly shows the huge spike in venture capital investment in the year 2002. The scale of activity in California compared to most other states makes it almost impossible to view the activity in states other than Massachusetts, so another way of displaying these expenditures is reported in Chart 3B.

Table 28: Venture capital investments

< Peer state ranking

State	Investment amount ($ millions) 2005	Investment percentage of U.S. total 2005	Number of deals 2005	Deals percentage of U.S. total 2005	Investment percentage of U.S. total 2002
California	$10,427	48.1%	1,228	41.8%	44.7%
Massachusetts	$2,375	11.0%	339	11.5%	11.9%
Texas	$1,087	5.0%	163	5.5%	6.0%
Washington	$752	3.5%	116	3.9%	2.7%
Colorado	$615	2.8%	79	2.7%	2.6%
Maryland	$438	2.0%	99	3.4%	2.8%
Virginia	$408	1.9%	76	2.6%	2.1%
Georgia	$256	1.2%	60	2.0%	2.6%
Michigan	$85	0.4%	20	0.7%	0.5%
Oregon	$138	0.6%	28	1.0%	0.7%
Idaho	$8	0.0%	2	0.1%	0.1%

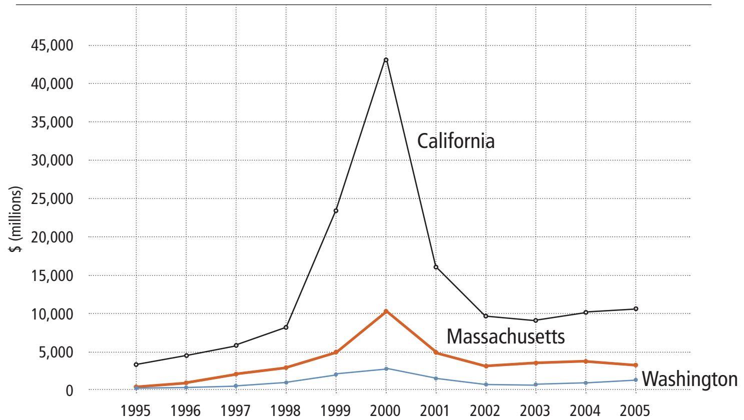
Source: PriceWaterhouseCoopers MoneyTree® Report

This figure converts the dollar scale to a semi-logarithmic form, which makes it much easier to track the trend for specific states. Washington was caught up in the burst of investment that peaked in 2000, and like the rest of the U.S. had a big decline in venture capital activity after that year. Since 2003, the level of venture capital activity has increased in Washington, and we have improved our position relative to several of our peers (notably Georgia, Colorado, and Virginia).

Chart 3C provides another longitudinal perspective, tracking the number of deals by state from 1995 through 2006. All states showed the same "spike" in deals in 2000 as observed for dollars of investment.

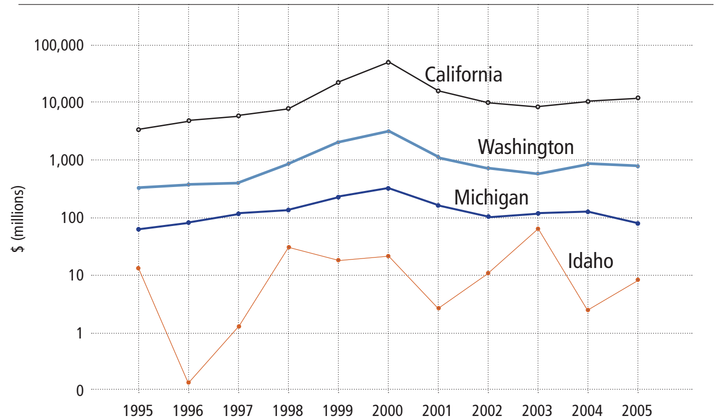
PriceWaterhouseCoopers MoneyTree® Report data series also reports venture capital activity by type of activity. Most segments have had a pattern similar to that reported in Table 28 and Charts 3A-3C. However, venture capital in biotech has exhibited a different pattern, and we present data here on trends in this segment of the venture

Chart 3A: Venture capital investments (selected states)



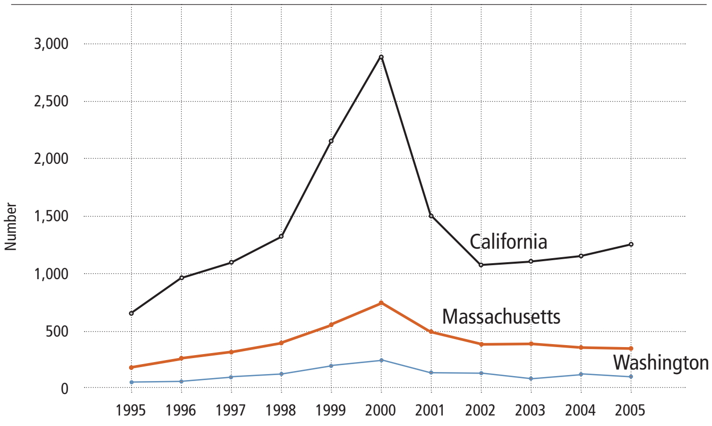
Source: PriceWaterhouseCoopers MoneyTree® Report

Chart 3B: Semi-logarithmic scale of level of venture capital investments (selected states)



Source: PriceWaterhouseCoopers MoneyTree® Report

Chart 3c: Number of venture capital deals (selected states)



Source: PriceWaterhouseCoopers MoneyTree® Report

capital industry. Table 29 shows that Washington ranks 4th among peer states, the same as for all venture capital. While our share of the national total is the same for biotech venture capital and all venture capital in 2005 at 3.5%, on the biotech measure our share has increased more rapidly, up from 1.3% in 2002.

Chart 4A reports trends in biotech venture capital over the 1995-2005 time period. This figure shows the clear dominance of California and Massachusetts on this measure, and the increasing trend for funding in this sector to be concentrated in California. Washington's position has recovered from the low in 2002, but has not been as strong in recent years as it was in 2000.

Chart 4B shows the trend for the number of deals in biotech venture capital. Here again we see that California has continued to increase its share of biotech deals, but it is clear that Washington has also seen a greater number in recent years. Maryland shows a strong upward trend in the last few years in the number of deals that is not reflected in the dollars invested in biotech in that state.

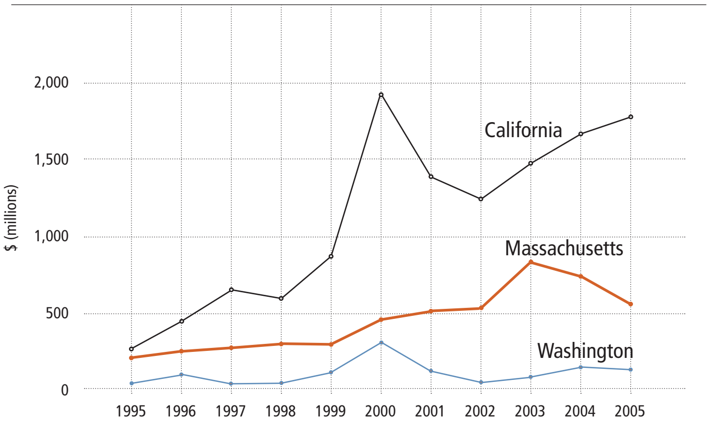
Table 29: Venture capital investments in biotech

State	Investment amount ($ millions) 2005	Investment percentage of U.S. total 2005	Number of deals 2005	Deals percentage of U.S. total 2005	Investment percentage of U.S. total 2002
California	$1,782	47.3%	126	34.9%	39.9%
Massachusetts	$547	14.5%	46	12.7%	17.2%
Maryland	$177	4.7%	33	9.1%	5.6%
Washington	$131	3.5%	14	3.9%	1.3%
Colorado	$98	2.6%	4	1.1%	1.9%
Texas	$56	1.5%	9	2.5%	1.5%
Georgia	$49	1.3%	7	1.9%	1.7%
Michigan	$31	0.8%	6	1.7%	0.6%
Virginia	$9	0.2%	4	1.1%	0.1%
Oregon	$14	0.4%	2	0.6%	0.0%
Idaho	$0	0.0%	0	0.0%	0.0%

< Peer state ranking

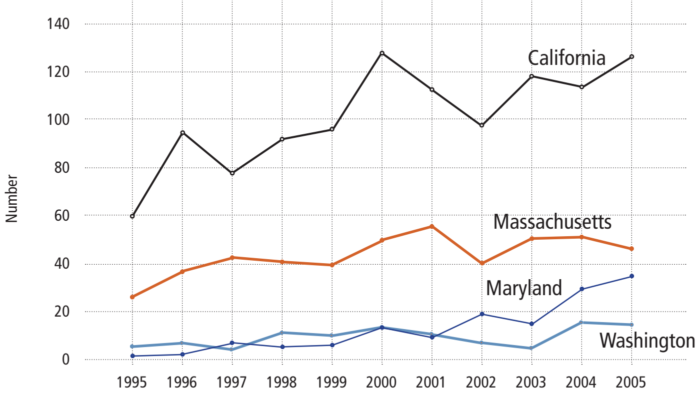
Source: PriceWaterhouseCoopers MoneyTree® Report

Chart 4a: Venture capital investments in biotech (selected states)



Source: PriceWaterhouseCoopers MoneyTree® Report

Chart 4b: Number of venture capital deals in biotech (selected states)



Source: PriceWaterhouseCoopers MoneyTree® Report

NSF has used the PriceWaterhouseCoopers MoneyTree® Report data to create some aggregate indicators of venture capital activity that are similar to other measures presented in this report. Table 30 presents absolute values of venture capital relative to gross state product in the year 2003. On this measure we see a somewhat different alignment of the peer states. Massachusetts comes off above its position as measured in absolute terms (Table 28), and California falls to second place. The data in Table 30 show a huge gap between three states, Massachusetts, California, and Colorado, and the rest of the peers on this measure. This table also shows that Maryland has catapulted into the top-ten ranked states overall since 1995. Washington's position has deteriorated slightly, but we still rank among the top states as recipients of venture capital when indexed against gross state product.

NSF also indexed the PriceWaterhouseCoopers MoneyTree® Report data on the number of deals against the number of high-tech establishments, as shown in Table 31. Washington ranked fourth nationally in 2002 in the number of deals per high-tech establishment, well above our position on the receipt of dollars. This suggests that the average deal in Washington state is smaller than the national average. Washington's position on this measure has not changed much since 1998. Among peer states, the biggest changes in the number of deals relative to the number of high-tech establishments were a big jump in Maryland and a clear downward trend in Colorado.

Table 30: Venture capital as a percentage of gross state product

< Peer state ranking

State	Percentage 2003	Rank 2003	Rank 2000	Rank 1995
Massachusetts	8.70%	1	1	2
California	5.73%	2	2	1
Colorado	3.33%	4	3	3
Maryland	1.66%	6	7	14
Washington	1.63%	7	6	4
Texas	1.42%	9	12	13
Virginia	1.24%	14	5	6
Georgia	0.97%	17	14	16
Michigan	0.26%	30	35	28
Idaho	1.29%	12	39	21
Oregon	0.83%	18	15	23

Source: National Science Foundation

Table 31: Venture capital deals as a percentage of high-tech establishments

< Peer state ranking

State	Percentage 2002	Rank 2002	Rank 2000	Rank 1998
Massachusetts	2.43%	1	1	1
California	1.64%	2	2	2
Washington	1.01%	4	3	5
Maryland	0.83%	5	10	16
Colorado	0.73%	8	5	3
Virginia	0.58%	12	6	11
Georgia	0.57%	13	9	13
Texas	0.54%	15	11	15
Michigan	0.21%	31	28	33
Oregon	0.43%	20	15	25
Idaho	0.11%	41	40	36

Source: National Science Foundation

Talented Workforce

A technically trained workforce is essential to the success of technology-based development, and therefore the next question addressed is:

Does Washington state have workers with the right talents and training to start and sustain technology-based businesses compared to peer states?

Table 32 shows the relative intensity of scientists and engineers in the workforce of each peer state. Washington does very well on this measure, and its position has improved relative to the U.S. as a whole. This table calculates rank position by the number of scientists and engineers per 100,000 persons in the workforce. Maryland and Massachusetts rank just above Washington, and well ahead of remaining states shown in Table 32. Washington's high ranking on this measure reflects the strong science and engineering workforce of two very large companies, Boeing and Microsoft. It would be interesting to compare states with such large Fortune 500-type companies removed from the data to see how strong smaller companies are in terms of science and engineering staff. Unfortunately, there is no statistical basis for making this comparison.

Table 32: Intensity of scientists and engineers per 100,000 workers

< Peer state ranking

State	Number 2003	Rank 2003	Number 1999	Rank 1999
Virginia	5,794	1	3,618	7
Massachusetts	5,744	2	4,681	1
Maryland	5,424	3	3,889	4
Colorado	5,339	4	4,408	2
Washington	5,133	5	3,465	9
California	4,168	9	3,127	10
Michigan	3,896	14	2,663	15
Texas	3,583	18	2,614	16
Georgia	3,487	20	2,194	30
Idaho	3,926	12	2,511	21
Oregon	3,598	17	2,613	17

Source: National Science Foundation

Drilling down by type of science and engineering worker provides additional insights. The next three tables are based on NSF data, and it should be noted that the definitions used by NSF vary from the definitions used for scientists and engineers counted in Table 32, such that the numbers in particular occupational categories per 100,000 worker do not add up to the values reported in Table 32.

Table 33 shows the number of engineers per 100,000 persons in the workforce. Washington ranks lower on this measure than on the overall science and engineering workforce, but still commands a very respectable position nationally and ranks much higher than our neighbor states, Idaho and Oregon.

Table 33: Number of engineers per 100,000 workers

< Peer state ranking

State	Number 2003	Rank 2003	Number 2001	Rank 2001
Massachusetts	1,537	1	1,174	2
Colorado	1,463	2	1,068	4
California	1,311	5	1,013	8
Virginia	1,276	6	1,104	3
Maryland	1,219	7	918	12
Washington	1,191	9	1,399	1
Michigan	1,173	10	949	11
Texas	1,057	15	961	10
Georgia	727	34	734	20
Oregon	855	26	597	30
Idaho	563	44	464	44

Source: National Science Foundation

The number of computer and information science experts per 100,000 workers is reported in Table 34. These individuals are important to software and internet-based companies, as well as to a wide variety of other companies with substantial information processing operations. This category of occupations has been expanding rapidly, spreading into many industries not generally considered to be technology-based. Washington continued to rank high nationally on this measure, with an increase of 11% growth in these occupations as a share of the workforce between 2001 and 2003. Top-ranked Virginia expanded this category of employment by 13%, and Maryland by 23%. Massachusetts, California, Georgia, Texas, and Michigan had modest rates of growth in the intensity of this occupational category in their labor force, while Colorado saw a decline.

Table 35 presents estimates of the number of life and physical scientists per 100,000 persons in the workforce. Life and physical scientists are critical to biotech, biomedical product, computer and instrument manufacturing, and other types of companies. On this measure Washington ranks quite well, moving up from 9th position in 2001 to 5th position nationally in 2003. Two peer states, Maryland and Massachusetts, ranked above Washington in both years. Washington has moved up strongly against California, which saw its ranking decline along with that of Virginia and Michigan. Among our neighboring states, Idaho showed improvement in its national ranking from 2001 to 2003.

Table 34: Number of computer and information science experts per 100,000 workers

< Peer state ranking

State	Number 2003	Rank 2003	Number 2001	Rank 2001
Virginia	3,939	1	3,490	1
Massachusetts	3,178	2	3,037	3
Maryland	3,175	3	2,575	4
Colorado	3,161	4	3,213	2
Washington	2,710	5	2,446	6
California	2,229	10	2,051	8
Georgia	2,104	12	1,884	15
Texas	1,935	15	1,880	13
Michigan	1,530	26	1,302	29
Oregon	1,847	18	1,620	20
Idaho	1,368	30	985	35

Source: National Science Foundation

Table 35: Number of life and physical scientists per 100,000 workers

< Peer state ranking

State	Number 2003	Rank 2003	Number 2001	Rank 2001
Maryland	651	2	338	7
Massachusetts	634	3	391	4
Washington	579	5	330	9
Colorado	504	8	267	14
Texas	416	16	202	25
California	397	18	249	16
Virginia	361	21	257	15
Georgia	276	35	126	44
Michigan	200	48	151	35
Idaho	549	7	301	10
Oregon	345	24	206	24
Alaska	918	1	685	1

Source: National Science Foundation

Another measure of talent in the workforce is the share of science and engineering workers who hold a doctorate. Table 36 presents data on this indicator. Washington again does relatively well, having improved its position from 12th in 1997 to 11th in 2003. Virginia catapulted from 14th to 6th place and Maryland moved up from 3rd to 1st, signaling the importance of job gains for people with doctorates in and around Washington, D.C. Most peer states and our neighboring states moved up on this measure between 1997 and 2003, but California and Colorado saw a slight erosion of their position. Nationally, the share of people with a doctorate in the employed workforce has continued to rise slowly.

A broader measure of the educational attainment level of the workforce is reported in Table 37. This table indicates state rankings based on the percentage of the workforce that holds a bachelor's degree. Washington, with just under 40%, exceeded the national average of 37.4% in 2004. This percentage rose relatively rapidly over the ten-year period: in 1994, 29.5% of the U.S. workforce held a bachelor's degree. Washington ranked 11th in the nation on this measure in 2004, the same position we held in 1994. Maryland and Virginia improved their rank between 1994 and 2004, reflecting the rapid growth in government and producer service jobs in the greater Washington, D.C. area requiring at least a bachelor's degree.

Table 36: Science and engineering doctorate holders as a percentage of the employed workforce

< Peer state ranking

State	Percentage 2003	Rank 2003	Percentage 1997	Rank 1997
Maryland	0.98%	1	0.78%	3
Massachusetts	0.90%	3	0.73%	4
Virginia	0.58%	6	0.45%	14
Colorado	0.52%	9	0.48%	8
California	0.51%	10	0.46%	10
Washington	0.51%	11	0.46%	12
Michigan	0.35%	25	0.31%	33
Texas	0.32%	29	0.30%	34
Georgia	0.29%	35	0.26%	40
Oregon	0.43%	16	0.36%	21
Idaho	0.38%	20	0.33%	26

Source: National Science Foundation

Table 37: Bachelor's degree holders as a percentage of the workforce

< Peer state ranking

State	Percentage 2004	Rank 2004	Percentage 1994	Rank 1994
Massachusetts	49.5%	1	40.3%	1
Maryland	46.0%	3	34.3%	7
Virginia	43.8%	5	32.9%	12
California	42.6%	7	34.4%	6
Colorado	42.6%	8	33.6%	9
Washington	39.7%	11	33.0%	11
Georgia	36.4%	19	31.8%	17
Michigan	33.3%	29	25.4%	33
Texas	31.6%	36	26.1%	31
Oregon	36.6%	18	31.8%	16
Idaho	30.3%	42	26.6%	30

Source: National Science Foundation

Sustaining Young Companies

Does the environment in Washington state support sustained growth of startup businesses compared to peer states?

Another way of addressing the question of the environment for sustaining startups is to look at the number of rapidly growing firms in each state, based on Inc. Magazine's "Inc. 500" list of the most rapidly growing firms in the country. Washington had 12 or fewer Inc. 500 companies in the three years shown in Table 38. This number is less than any of its peer states, but is similar to our neighbor state, Oregon. Using a measure of the number of Inc. 500 firms per 10,000 business establishments as a basis for ranking, we find Washington ranked 17th in 2005, a considerable improvement from 36th position in 2000.

Table 38: Number of Inc. 500 firms per 10,000 business establishments

< Peer state ranking

State	Number per 10,000 business estab. 2005	Rank 2005	Number of Inc. 500 firms 2005	Number per 10,000 business estab. 2000	Rank 2000	Number of Inc. 500 firms 2000
Virginia	1.9	1	35	1.8	1	31
Massachusetts	1.5	3	26	1.5	3	26
Maryland	1.4	4	19	0.9	7	12
Colorado	1.1	6	16	1.2	6	17
Georgia	1.0	9	21	1.3	5	26
California	0.9	10	77	0.9	10	69
Washington	0.7	17	12	0.4	36	7
Texas	0.7	20	32	0.8	12	39
Michigan	0.5	23	13	0.6	22	14
Idaho	0.8	15	3	0.3	42	1
Oregon	0.4	30	4	0.7	18	7

Source: Inc. Magazine

Conclusion

Washington's entrepreneurial climate presents a mixed picture, yet one that is fairly competitive when compared to its peer states. The 2002 recession has clouded the data for some of these measures, particularly in the creation of high-tech companies which showed negative figures. Future benchmarking studies may give clarity to these measures. The availability of funding to start and grow new companies in Washington remains a strength for the state and is improving, ranking it high among peer states. However, venture capital investment is dominated by California and Massachusetts, with nearly 60% of all investments in the U.S. occurring in those two states.

The number of technically trained individuals in Washington's workforce places the state in a solid position when compared with its peers and the rest of the nation. Although the number of engineers in Washington's workforce saw a sharp decline in 2003, the number of computer experts remained steady, and the state's overall intensity of scientists and engineers in the workforce pushed the state well into the top ten. In an area of accelerating importance and investment in many states, the number of life and physical scientists in Washington rose by 75% between 2001 and 2003, outpacing Massachusetts' increase of 62% but trailing Maryland's increase of 93%.

Finally, the high number of science and engineering doctorate holders and bachelor's degree holders in Washington's workforce will help contribute to the state's competitiveness in the future. However, five of Washington's eight peer states have larger numbers on both measures. When the workforce data are compared with the higher education graduation rates from the first section of this report, Washington is clearly importing much of its workforce for its high-tech industries. In general, large companies can afford to recruit new employees from the global marketplace, but smaller ones find this to be a far more challenging prospect. This may disadvantage small, startup companies, which may affect the level of venture capital investments in the state, though the current trend does not show this. A long-run solution to this problem is increased production of college-educated high-tech workers in Washington, which will require substantial expansion of the higher education system in this state.

Overall, the current entrepreneurial climate in Washington is in positive territory, with confidence from venture capitalists in our state's emerging high-tech businesses, and with leadership and contributions from our state's high-tech talent.

Study Conclusion

Washington has one of the most technology-based economies of any state in the nation, but inadequacies with some parts of its economic drivers and competition from other states present significant challenges for the future. Since the time of our initial benchmarking study in 2003, Washington is healthier on many indicators of a successful innovation economy, but still needs to improve.

Our entrepreneurial climate is fairly robust, with venture capital activity among the highest of the group of peer states below California and Massachusetts. The intensities of various types of engineers and scientists in Washington's workforce, who are the necessary talent to start and sustain high-tech businesses, put the state among the top ten in the nation. In research capacity, Washington is strong in R&D and has been very competitive at attracting research funds. R&D spending in industry, federal labs, and non-profit research organizations increased in Washington, and overall R&D expenditures (excluding industry) ranked the state 7th nationally and 4th among peer states, but state-funded college and university R&D remained near the bottom in the nation.

Low state investment in university and college R&D continues to be a concern, with the current level near the bottom of all states. Washington's production of future high-tech workers is also a concern. While the total number of bachelor's degrees, and science and engineering bachelor's degrees, conferred by Washington's higher education system increased, our rankings slipped and remained in the bottom third nationally on both measures. Although not presented in this report, state appropriations per student at Washington's higher education institutions remains significantly lower than at peer institutions in other states. Moreover, since science and engineering degrees are more expensive to produce, those programs at Washington's colleges and universities are at an even greater disadvantage relative to our peers. As the number of scientific and engineering jobs grow in Washington, the low production level by Washington's colleges and universities will force companies to fill their workforce from out-of-state sources.

Among the critical drivers of an innovation economy, Washington's performance in K-12 education is of greatest concern. With few exceptions, our numbers on K-12 education measures are in the middle or back of the pack. The high school graduation rate in Washington is only 72%, and the level of funding for K-12 education is 90% of the national average; both levels are too low to serve our state's residents and meet the demands of a technology-based economy. While the rankings of Washington's 8th graders in math and science proficiency may be encouraging, the rates of proficiency (in the 30% range) are disturbingly low. And the number of K-12 students preparing themselves for high-level math and science, taking more rigorous courses, and preparing for higher education, must all increase to put Washington in a more competitive position. The solid foundation that a good education provides to a student is the same foundation that a knowledge-based economy needs to grow, innovate, and prosper.

The drivers of the technology-based economy in Washington have improved over the past several years, and can continue to improve if a number of areas are addressed. With purposeful actions, strategic investments, and focused communications, a vibrant technology-based economy benefiting all of Washington's citizens is within reach.

Appendix: Alternative Definitions of Technology-Based Industry: A Sampling of Recent Studies

There is a continuous stream of research focusing on technology-based industries in the United States and in other developing and developed countries. As discussed in the Methodology section, the Technology Alliance has used an occupational classification of R&D related work as its basis for defining the scope of the industries included in this and three previous studies. In this section, we describe several other recent studies, to merely highlight the diversity of approaches to this general subject.

American Electronics Association

The American Electronics Association (AEA) produces national, state, and metropolitan area reports on industries it deems to be high-tech. The AEA has recently changed its definition of high-tech to be based on NAICS codes. The AEA's 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, 2003). Their definition includes computers and peripheral equipment, communications and consumer electronics, electronic components, semiconductors, defense electronics, measuring and control instruments, electromedical equipment, photonics, communications services, software publishers, computer systems design and related services, internet services, engineering services, R&D testing laboratories, and computer training. Using this definition, AEA 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. They also issue on-line press releases that highlight activity levels in each state (American Electronics Association, 2003). The AEA's scope of high-technology industry is narrower than this study, amounting to about 50% of the number of jobs encompassed in the Technology Alliance definition.

Bureau of Labor Statistics and Employment Security Department

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, has embraced a definition very similar to that used in the three previous Technology Alliance economic impact studies and in this study. He writes, "For this analysis, industries are considered high-tech if employment in both research an 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 three prior TA studies), as well as in a number of other recent and older studies, including many reviewed in the earlier TA studies. The Washington State Employment Security Department has embraced the BLS definitions, and has provided a very useful overview of employment in these industries in Washington as well as geographic patterns of employment and trends in earnings (Dillingham, 2000).

Office of Technology Policy

The Office of Technology Policy (a U.S. Department of Commerce agency), has 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, but this series has been discontinued. The 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 in the 2004 report. 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 2002 NAICS codes. The industry list used by the Office of Technology Policy is similar, but not identical, to the classification used in this study.

Milken Institute

The Milken Institute produces 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, Koepp, et. al., 2004). The Milken Institute publishes periodically a state index of science and technology, which is based on 75 different measures. These measures span R&D inputs, risk capital and infrastructure, human capital investment, technology and science workforce, and technology concentration. The latter includes measures similar to those included in the Office of Technology Policy, although the latest edition of the Milken science and technology indicators imply use of SIC codes rather than NAICS codes. Milken does not specifically identify the industries included in their high-technology industry list. Washington ranked 7th on the technology and science workforce indicator, and 13th on the technology concentration index in 2004. 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 State Index of Innovation and Technology 2003

This report was published by the Washington Technology Center. The authors of this report, Dr. Lee Cheatham and Dr. Paul Sommers, used a complex methodology for identifying sectors to be included. They started with sectors having at least 7% of occupations in a list of "technology occupations" selected by the authors, and presumably measured using the industry-x-occupation matrices generated by the Washington State Employment Security Department. Using this first pass, "Each of these potential technology SIC sectors was then examined for the individual companies included. This company-by-company scan allowed pruning of the list for those segments that had a high percentage of technology occupations but really represented delivery of routine services based on a technology" (Cheatham & Sommers, p. 27). Clearly, the judgment of the authors played a considerable role in this definitional process. This exercise was conducted at a four-digit level of SIC code detail. The employment in the establishments included in that study is 79% of the estimated technology-based employment reported in the current TA study. Having defined the industries in the set included in the study, the authors then developed a series of indicators documenting innovation capacity, new business startups, business closings, patent generation, and R&D expenditures. The results show the strong position of Washington versus other states on a variety of measures, including innovative capacity, employment growth rates, financial capacity, human potential, economic competitiveness, and quality of life. The 2005 WTC Index used the Technology Alliance definition of 10% or more employment in R&D occupations.

Drivers For A Successful Technology-Based Economy: Benchmarking Washington's Performance

This report was prepared by Dr. Paul Sommers for the Technology Alliance and published in May 2003 (Sommers, 2003). In this analysis, Sommers used the same definition of high-tech as used in the Washington State Index of Innovation and Technology. Using this definition, sets of industry groups were defined (all high-tech, aircraft, other manufacturing, computer and data processing, and other services), and location quotients were calculated for these industry groups. State values for the location quotients were analyzed, and a set of states was selected as peers due to their concentrations of high-tech industry. Idaho and Oregon were also included in this analysis, to provide comparative measures for our neighboring states. Using these states as the basis for comparison, indicators were developed for three broad categories of benchmarks: education, research capacity, and entrepreneurial climate. This analysis is based on a somewhat extended definition of high-tech industry than used in the prior Technology Alliance economic impact studies. The 2006 benchmarking study uses the same definition as this study.

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The Technology Alliance is a statewide, not-for-profit organization founded in 1996 to bring together leaders from Washington's diverse high-tech businesses, research institutions and the community dedicated to our state's long-term economic success. Through programs, events, research studies, and policy activities, the Technology Alliance works to achieve our vision of a vibrant technology-based economy benefiting all of Washington's citizens.

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