2016

STATE TECHNOLOGY AND SCIENCE INDEX

Sustaining America's Innovation Economy

Ross DeVol, Joe Lee, and Minoli Ratnatunga

MILKEN INSTITUTE
CENTER FOR JOBS AND HUMAN CAPITAL

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ON THE WEB

Data for each state and indicator can be found on our interactive website, at **www.statetechandscience.org**.

ACKNOWLEDGMENTS

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ABOUT THE MILKEN INSTITUTE

The Milken Institute is a nonprofit, nonpartisan think tank determined to increase global prosperity by advancing collaborative solutions that widen access to capital, create jobs, and improve health. We do this through independent, data-driven research, action-oriented meetings and meaningful policy initiatives.

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EXECUTIVE SUMMARY

As the Great Recession recedes in our rearview mirrors, it is becoming ever more apparent that innovative activities are determining an increasing proportion of the long-term economic growth of cities, metropolitan areas, regions, states, and even nations. Look no further than the Milken Institute's "Best-Performing Cities 2015" report for evidence that 13 of the top 25 metropolitan areas were technology centers. Among the leaders were San Jose, Seattle, Denver, Austin, and Raleigh—all with important high-technology clusters. Or look to California, where, despite a reputation for high taxes and regulatory hurdles, technology and innovation have fueled stellar economic performance since 2010.

The State Technology and Science Index (STSI) endeavors to benchmark states on their science and technology capabilities and broader commercialization ecosystems that contribute to company growth, high-value-added job creation, and overall economic growth. We view the STSI as a measure of a state's innovation pipeline. The index isn't intended to be a measure of immediate economic impact, but rather to demonstrate that the return on science and technology assets will accrue in future years. Along with deep human capital, individuals who recognize entrepreneurial opportunity and have the knowledge and skills to develop it are among the strongest assets a geographical area can have in today's innovation-based economy.

The STSI's 107 individual indicators are sorted into five composites: Research and Development Inputs, Risk Capital and Entrepreneurial Infrastructure, Human Capital Investment, Technology and Science Workforce, and Technology Concentration and Dynamism, illustrated by the icons below. The STSI overall scores are displayed in Table ES1 on the following page.

RESEARCH AND DEVELOPMENT INPUTS

RISK CAPITAL AND ENTREPRENEURIAL INFRASTRUCTURE

HUMAN CAPITAL INVESTMENT

TECHNOLOGY AND SCIENCE WORKFORCE

TECHNOLOGY CONCENTRATION AND DYNAMISM

TABLE ES1 **State Technology and Science Index:** 2016 rankings

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
Massachusetts	1	1	0	83.67
Colorado	2	4	2	80.40
Maryland	3	2	-1	80.31
California	4	3	-1	75.94
Washington	5	6	1	71.84
Connecticut	6	9	3	71.05
Minnesota	7	12	5	69.58
Utah	8	5	-3	69.14
Virginia	9	7	-2	65.88
Delaware	10	10	0	65.38
New Hampshire	11	8	-3	65.32
North Carolina	12	15	3	62.64
Oregon	13	17	4	62.33
Pennsylvania	14	14	0	61.54
Rhode Island	15	13	-2	59.84
Illinois	16	21	5	59.51
New Jersey	17	16	-1	59.40
Michigan	18	22	4	58.75
Texas	19	20	1	58.66
New York	20	11	-9	57.55
New Mexico	21	24	3	55.19
Wisconsin	22	25	3	55.06
Arizona	23	19	-4	54.88
Georgia	24	23	-1	53.53
Nebraska	25	30	5	53.53
Vermont	26	18	-8	52.58
Ohio	27	26	-1	52.32
Missouri	28	34	6	50.60
North Dakota	29	29	0	49.73
Indiana	30	27	-3	49.23
Kansas	31	28	-3	48.44
Idaho	32	33	1	46.30
Alaska	33	38	5	44.86
Montana	34	39	5	43.73
Iowa	35	31	-4	43.52
Wyoming	36	46	10	43.02
Alabama	37	32	-5	42.67
South Dakota	38	42	4	41.55
Hawaii	39	35	-4	40.35
Tennessee	40	36	-4	40.22
Florida	41	37	-4	38.82
Maine	42	41	-1	38.39
South Carolina	43	40	-3	35.84
Oklahoma	44	43	-1	34.62
Nevada	45	50	5	32.76
Louisiana	46	48	2	31.40
Kentucky	47	44	-3	30.53
Mississippi	48	49	1	29.84
Arkansas	49	45	-4	27.95
West Virginia	50	47	-3	25.84

Findings

- **Massachusetts** remained in first place with a score of 83.7, retaining the position it has held since the inaugural STSI was released in 2002. Massachusetts also stayed at the head of the pack in the Research and Development Inputs composite. However, the Bay State slipped somewhat in the Human Capital Investment and Technology and Science Workforce measures. Fortunately, its extensive university and private-sector research assets are breeding grounds for innovation.

- **Colorado** moved up to second place from fourth, with a score of 80.4. The Centennial State jumped from sixth to first in Human Capital Investment as it began to reap dividends from investments in its 14 public universities and 17 private four-year universities. A major commitment to clean tech is attracting substantial venture capital investments.

- **Maryland** slipped to third this year after a second-place finish in 2014. However, it was just 0.1 point behind Colorado. Moreover, Maryland was first in both Technology and Science Workforce and in Technology Concentration and Dynamism. With outstanding research universities such as Johns Hopkins and federal research centers such as the National Institutes of Health, Maryland has the requisite endowments for success.

- **California** came in fourth, a one-place dip from 2014. Its biggest decline was in Technology and Science Workforce, where it fell from fourth to seventh. That decline is largely a result of a more inclusive definition of technology and science occupations than in past years. California has the highest concentration in occupations requiring advanced degrees; however, broadening the occupation definitions to include those requiring vocational and technical training has allowed other states to move up. In its favor, California has an unrivaled ecosystem for research commercialization.

- **Washington** climbed one place to fifth in the 2016 STSI. Although it fell from second to eighth in Technology Concentration and Dynamism—dropping out of the top five for the first time—growth in the demand for cloud computing and e-commerce services support its impressive concentration of payroll and employment in high-tech industries, the highest of any state.

- Rounding out the top 10 are **Connecticut** (sixth); **Minnesota** (seventh and in the top 10 for the first time since 2004, thanks to world-class medical research and devices sectors); **Utah** (eighth); **Virginia** (ninth); and **Delaware** (10th).

- **Wyoming**, the most improved state, climbed 10 places, to 36th. The state had broad gains but benefited most from the broader definition of occupations in the Technology and Science Workforce category, which included its talent in mining engineering. **Missouri** rose six spots, to 28th; this is primarily attributable to a 24-place leap in Risk Capital and Entrepreneurial Infrastructure.

- There is some encouragement in the fact that the gap between the top and bottom scores on several 2016 STSI composites is narrower than in the previous four editions.

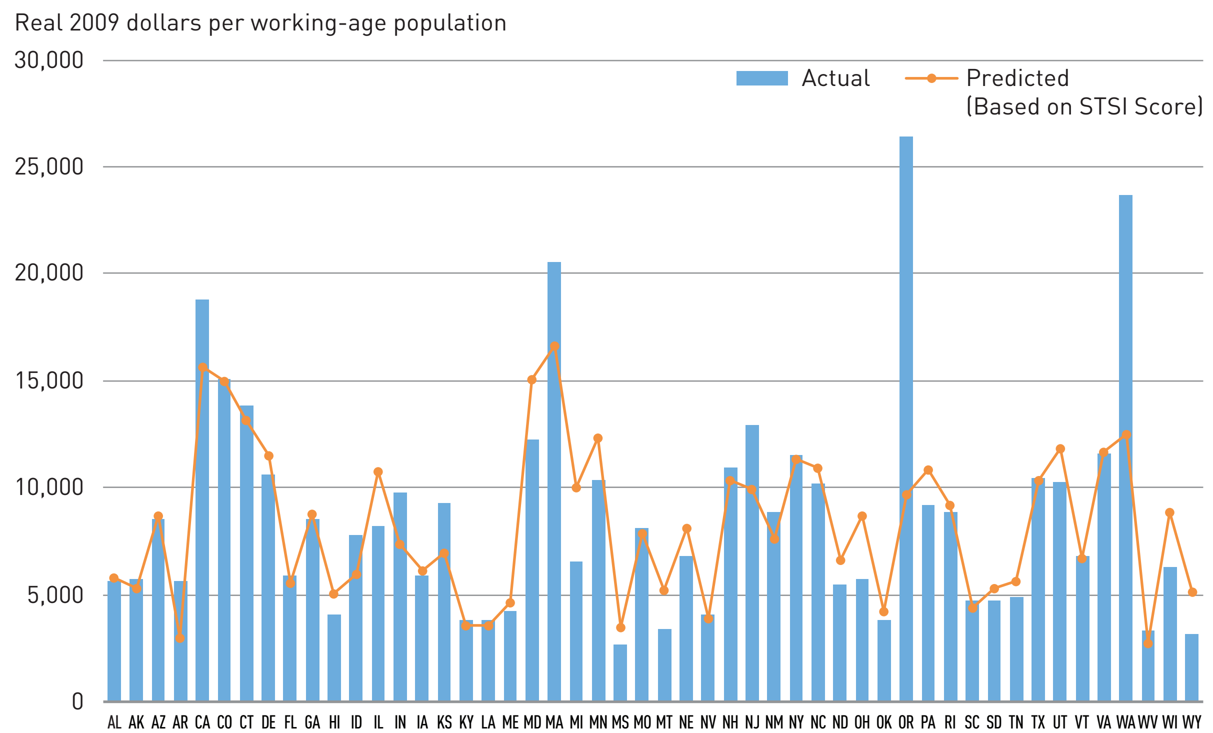
STSI and Economic Performance

The efficacy of the State Technology and Science Index in explaining variations in economic performance is strong and robust. We performed several regression analyses of the various relationships between the STSI and real high-tech GDP per capita and overall real GDP per capita of the working-age population. This adjusts for differences in population structure across states. States with higher birthrates, such as Utah, have high levels of young dependents.

The results demonstrate that STSI scores explain 75 percent of the variation in real high-tech GDP per capita of the working-age population across states. Figure ES1 graphically displays this relationship. It shows the actual 2014 values of real high-tech GDP per capita of the working-age population relative to those explained (predicted) by the association with the STSI. As shown in Figure ES1, Oregon and Washington have the largest unexplained variance. This is caused by the high concentration and large value of output per employee in the electronic components industry in Oregon (Intel) and in software employment in Washington (Microsoft). If we were to adjust for both, the overall explanatory power approaches 90 percent.

The findings show that for each 10 percent increase in the STSI score, real high-tech GDP per capita of the working-age population rises by 14.6 percent. An alternative interpretation is that at the mean STSI score, a 10-point increase translates into a 28.1 percent rise in real high-tech GDP of the working-age population. Additionally, a separate investigation found that 62 percent of the variation in real GDP per capita of the working-age population is reflected in movements in a state's STSI score. It's hard to imagine anything else with a higher return on investment.

FIGURE ES-1 **Real high-tech GDP per working-age population, 2014**



Sources: Moody's Analytics, Milken Institute calcuation.

States Where Investment Lags

The states with the weakest innovation assets and ecosystems for starting and growing innovative firms face a bleak future unless changes are made. West Virginia, Arkansas, Mississippi, Kentucky, and Louisiana make up the bottom five in this year's STSI. They are the least knowledge-intensive and their residents exhibit weak entrepreneurial skills. All of them have undertaken efforts to change their position in technology and science but have had limited success.

West Virginia had the biggest drop in STSI scores from 2002 to 2016, falling 4.3 points. Combined with a decline in coal production, the state's economic performance is in serious jeopardy. Although its decline was smaller, Kentucky, another coal state, faces similar challenges. Louisiana slipped as well. The good news is that Arkansas rose 5.2 points. Based on our statistical model, Arkansas' real high-tech GDP per capita of the working-age population is 6.3 percent higher than it would have been if its STSI scores had remained at 2002 levels. Mississippi has witnessed a small gain since 2002.

A renewed commitment to making investments in research, entrepreneurship, and human capital are necessary. We hope that the STSI aids in focusing the attention of these states and others on the need to invest and improve their current and future residents' economic fortunes.

1. INTRODUCTION

The Milken Institute's State Technology and Science Index looks at each state's technology and science capabilities and their impact on regional economic growth. It provides a method for comparing states' performance and aims to help them see the trends that will affect their economies in the future.

Improved performance by a number of lagging states narrowed the gap in scores separating the top and bottom performers on a number of the composite indices. The difference in highest and lowest scores on the Risk Capital and Entrepreneurial Infrastructure composite index, Human Capital Investment composite index, and Technology Concentration and Dynamism composite index all narrowed compared with the previous four editions.

The 2016 Technology and Science Workforce composite index was updated to include more occupations. Previously, this composite index focused primarily on occupations that typically require an advanced degree, but it now includes more occupations that require associate degrees and vocational training. As skilled engagement in the technology and science fields encompasses more occupations, the definition of this workforce must adapt if it is to capture the employees needed to staff a vibrant science- and technology-fueled economy.

The data for this release come from the recovery after the Great Recession. This marks the first State Technology and Science Index to evaluate which states were able to meaningfully advance or create a high-tech sector during the recovery and harness the powerful growth the sector has experienced in recent years. We can see confirmation that the high-tech sector has expanded its geographical footprint beyond its traditional hubs.

How a state fares in the index does not directly correlate to current economic performance and overall job creation, but it does clearly indicate whether the state is likely to create high-paying and future-proof positions.

2. OVERALL FINDINGS

Outline of the Index

The State Technology and Science Index provides a benchmark for states to assess their science and technology capabilities as well as the broader ecosystem that contributes to job and wealth creation. The index computes and measures 107 individual indicators relative to population, gross state product (GSP), number of establishments, percent change, and other factors. Data sources include government agencies, foundations, and private sources. For each individual indicator, the states are ranked in descending order, with the top state being assigned a score of 100, the runner-up a score of 98, and the 50th state a score of 2. The indicators are then combined to create rankings in the following five composites:

RESEARCH AND DEVELOPMENT INPUTS: We examine a state's R&D capacity to see if it has facilities that can attract funding and create innovations that can be commercialized. The category includes measures such as industrial, academic, and federal R&D; Small Business Innovation Research awards; and the Small Business Technology Transfer program, among others.

RISK CAPITAL AND ENTREPRENEURIAL INFRASTRUCTURE: The entrepreneurial capacity and risk capital infrastructure of states are the ingredients that determine the success rate of converting research into commercially viable technology services and products. We include several measures of venture capital activity as well as entrepreneurial pursuits, including patenting activity, business formations, and initial public offerings.

HUMAN CAPITAL INVESTMENT: Human capital is the most important intangible asset of a regional or state economy. We look at indicators that suggest the skill levels of the current and future workforce. Examples include the number of bachelor's, master's, and doctorate degrees relative to a state's population, and measures specific to science, engineering, and technology degrees.

TECHNOLOGY AND SCIENCE WORKFORCE: The intensity of the technology and science workforce indicates whether states have sufficient depth of high-end technical talent. Intensity is derived from the share of employment in a particular field relative to total state employment. We look at 47 occupation categories in three main areas: computer and information sciences, life and physical sciences, and engineering.

TECHNOLOGY CONCENTRATION AND DYNAMISM: By measuring technology growth, we are able to assess how effective policymakers and other stakeholders have been at transforming regional assets into regional prosperity. This includes measures such as the percent of establishments, employment, and payrolls that are in high-tech categories. It also measures growth in a number of technology categories.

At the Top

Massachusetts ranks No. 1 on the 2016 State Technology and Science Index, a position it has held consistently since STSI's inception. The state's score of 83.67 reflects a decrease of 2.92 points from 2014 and is its lowest score since 2010. Massachusetts remained at the top of the Research and Development Inputs composite index. The state's drop to No. 2 in the Technology and Science Workforce index marks the first time since 2002 that Massachusetts has not been first. Massachusetts also fell to second in the Human Capital Investment index and the Risk Capital and Entrepreneurial Infrastructure index and dipped one spot on the Technology Concentration and Dynamism index, to land at No. 5.

Massachusetts, known for its super cluster of educational institutions, had a 10-point drop in its Human Capital Investment score. This stems from lower SAT scores and lower state funding of student aid, which potentially limited access to higher education. Greater access to technology in other states also cut into Massachusetts' lead. Despite its high concentration of higher-education institutions, Massachusetts had an unusually low number of PhDs awarded in the science, engineering, and health fields in the 2016 index, and it ranked in the bottom half of states on this measure.

Going from No. 1 to No. 2 on the Technology and Science Workforce index should not detract from Massachusetts' progress in this area—its score increased by 8.27 points since 2014. This year, the index has been updated to better capture the technological and scientific workforce of a state, and the greatest changes are in the indicators for the composite indices representing the occupations in science and engineering. While other states with strong concentrations in occupations that required advanced degrees lost more ground as a result of these changes, the fact that Massachusetts dropped only one place demonstrates that it has a diverse high-tech workforce.

With its permanent research and development tax credit, Massachusetts offers manufacturers and research firms an incentive to locate long-term investments in the commonwealth.[1] Supplemental incentives target specific sectors, such as the life sciences, to spur development and create jobs. The Innovation Institute at the Massachusetts Technology Collaborative launched a program in 2012 to support the development of a big-data industry cluster and make the commonwealth a global destination for students, investors, and companies interested in big data.

Colorado climbed to No. 2 from No. 4 on the index, with a score of 80.4. The state retained its third-place ranking in the Research and Development Inputs index and moved up from seventh to third in the Risk Capital and Entrepreneurial Infrastructure index, equaling its highest-ever placement, on the 2008 index. The state provides incentives to support specific industries, including clean tech, helping it attract the fourth-highest amount of venture capital in this area in 2016. In the Human Capital Investment index, one of the most stable indices, Colorado made an impressive jump from sixth to first. In this index, Colorado ranks among the top 10 in 13 of the 21 indicators, with five of those being in the top five. Colorado's three-spot leap to third in the Technology and Science Workforce index was driven by a strong showing in the physical and life sciences sub-index and the engineering sub-index. High concentrations in these occupations provide the workforce for Colorado's innovative companies, such as those in the aerospace industry.

Colorado's overall score is 80.4, slightly more than three points below Massachusetts' and marginally lower than Colorado's previous peak, in 2002. One of the new aspects of this index is that high performance on many of the more stable measures has become concentrated in a few states, and these states often reap the benefits of growth in the more fluid indicators. This is best exemplified in the Human Capital Investment index, where Colorado scored equally well on both types of indicators. Colorado's strong performance in the Human Capital Investment index is fueled by major gains in the percent change in state appropriations for higher education and in recent BAs, MAs, and PhDs in science and engineering. With 14 public and 17 private four-year universities, Colorado is training a highly skilled workforce that makes it an attractive location for tech companies.

Maryland fell to third overall this year, scoring 80.31, more than three points behind Massachusetts but only barely lagging Colorado. Like other states at the top, Maryland's score dropped in 2016, falling one point from 2014. It retained its second-place ranking in the Research and Development Inputs index. In the Risk Capital and Entrepreneurial Infrastructure index, it dipped three spots, from fifth to eighth. It saw a two-place drop on the Human Capital Investment index, to fourth, but it took the top spot on both the Technology and Science Workforce index and the Technology Concentration and Dynamism index, climbing from second and third places, respectively.

Maryland has long been a source of innovation but, like its peers, faces ever-increasing competition for talent and funding. Leading the pack on both the technology and science workforce and the concentration of the high-tech sector gives Maryland an advantage in transforming these resources into innovation by strengthening research and development and improving access to funding. In order to maintain a strong workforce and leverage the agglomeration effects of its high-tech sector, a solid foundation is needed to support it. However, repetition of Maryland's drop in the Human Capital Investment rank could undermine the state's ability to maintain a highly skilled workforce in the long run.

With seven science and technology business parks in the state, Maryland aims to facilitate partnerships between research institutions and the private sector. Home to leading universities such as Johns Hopkins and federal research institutions and agencies such as the Federal Drug Administration, Maryland is leveraging its institutional assets and its proximity to Washington, D.C., to attract investment. Through vocational training programs such as P-TECH (Pathways in Technology Early College High Schools), recently introduced in the Baltimore City Public Schools, Maryland is also attempting to broaden access to employment opportunities in STEM-related fields.

California dropped one rank, from No. 3 to No. 4, down less than one point from 2014 with a score of 75.94. The Golden State rose six places on the Human Capital Investment index, to 11th, and reclaimed first place on the Risk Capital and Entrepreneurial Infrastructure index. It jumped to second from fifth in the Technology Concentration and Dynamism index, buoyed by a strong concentration of technology employment, firms, and sectors in the state. California held steady at fifth place on the Research and Development Inputs index, but moved from fourth to seventh in the newly expanded Technology and Science Workforce index. Much of that drop is attributable to the more inclusive definition of the technology and science occupations applied this year; California continues to have high concentrations in the occupations that require advanced degrees, which previously represented a larger share of this measure.

California has been among the top five on our State Technology and Science Index since 2002. The jump in the Human Capital Investment index is a positive sign that the state can not only attract talent but create it locally as well. Thanks to newer high-tech hubs along the coast supplementing the Bay Area super cluster, California performs well in the two most volatile indices: Risk Capital and Entrepreneurial Infrastructure and Technology Concentration and Dynamism, which contain more indicators likely to fluctuate from year to year than the other three composite indices. The effect of these indices performing well, combined with stable high scores on less dynamic measures, earns California a place in the top five year after year. The variety of drivers of the state's innovative economy—technology in Silicon Valley, highly skilled talent in the San Francisco Bay Area, entertainment in the Los Angeles area, and biotech in San Diego—have helped it outperform many of its peers. Indeed, the fact that so many of its metro economies are thriving—San Jose and San Francisco took the top two spots on the Milken Institute's 2015 Best-Performing Cities index—demonstrates the benefits that can accrue to a well-developed innovation ecosystem.

Washington climbed one place, to fifth, this year with a score of 71.84, its lowest since 2010. On the Human Capital Investment index, the state rose to 16th from 19th with a score of 59.43, its highest since 2008. Washington dropped six places, from second to eighth, in the Technology Concentration and Dynamism index, falling out of the top five for the first time. Just edged out of fourth place by Minnesota, Washington dropped two spots, to fifth, on the Technology and Science Workforce index, marking the first time since 2012 that the state ranked outside the top three. Washington retained seventh place in the Research and Development Inputs index, and 15th place in the Risk Capital and Entrepreneurial Infrastructure index. Growth in demand for cloud computing and e-commerce services supports its concentration of payroll and employment in high-tech industries, the highest of any state in the country. The expanding tech employment in e-commerce and cloud computing may help mitigate the braking effect of changes in the aerospace and defense sectors in future years, especially as a scaling back of operations at Boeing affects employment at the firm and in its supply chain.

Connecticut moved up three places, from ninth to sixth, with a score of 71.05. This marks the highest rank Connecticut has achieved over the seven releases of the State Technology and Science Index. The state moved up two spots in the Research and Development Inputs index, from 10th to eighth. In the Risk Capital and Entrepreneurial Infrastructure index, it gained three places, moving to 11th, and retained third place in the Human Capital Investment index. The state climbed six places, from 16th to 10th, in the Technology and Science Workforce index.

Connecticut showed major improvement in the Technology Concentration and Dynamism index, going from 21st to 10th. This dramatic rise marks one of the larger overall changes on this index. While modest increases were seen in the Research and Development Inputs index and Human Capital Investment index, these two indices have a much heavier focus on stock measures, and Connecticut's aerospace and defense sectors help anchor the state's performance in these areas. The major changes for Connecticut came from the Risk Capital and Entrepreneurial Infrastructure and the Technology Concentration and Dynamism indices, which are much more fluid, and can be attributed to the continuing development of the high-tech sector.

Minnesota entered the top 10 for the first time since 2004, reaching No. 7 with a score of 69.58. The state's No. 4 ranking on the Technology and Science Workforce index contributed to this ascent, as the state improved upon its seventh-place rank in 2014. It rose from 24th to 19th in the Research and Development Inputs index and climbed five spots, to 15th from 20th, in the Technology Concentration and Dynamism index, aided by developments in the health technology sector. However, Minnesota lost five places, going from 11th to 16th, in the Risk Capital and Entrepreneurial Infrastructure index and dropped from fourth to fifth in the Human Capital Investment index.

Minnesota has developed a long-term foundation for innovation. The jump in its Research and Development Inputs and Technology Concentration and Dynamism rankings are evidence of how the state is fast becoming a Midwestern leader in the tech world. This return to the top 10 comes at a time when the national tech sector is facing headwinds in drawing and keeping talent, creating space for newer tech hubs to draw business to utilize talent. Minnesota has grown a high-tech sector that can compete with better-known tech hubs such as Utah. A focus on technology transfer from the University of Minnesota Venture Center has helped add to the creation of companies and contributed to the state's rise in Technology Concentration and Dynamism.[2]

Utah moved from fifth to eighth, the largest decline among the top 10, and scored 69.14. The state lost six places in the Research and Development Inputs index, going from eighth to 14th. Performance on the Risk Capital and Entrepreneurial Infrastructure index improved, moving the state from 10th to sixth. Computer and software design companies in tech hubs like Provo-Orem, home to Brigham Young University, have attracted investment and contributed to this rise. Utah rose two places, to sixth, in the Technology and Science Workforce index by providing the labor pool necessary to fill industry demand for high-skill occupations. The state dropped six places, to 11th, in the Human Capital Investment index, but its largest and most notable decline was in the Technology Concentration and Dynamism index, where it fell from the top spot to 13th.

Utah's dramatic decline in Technology Concentration and Dynamism is largely attributable to drops in the indicators that measure growth over time. After very strong performances in previous years, Utah has been unable to maintain the blistering pace, and some other states are now experiencing faster growth. Utah has remained a key destination for business investment, ranking third for venture capital investment as a percentage of GSP, and this investment is fueling growth for example, in the medical device manufacturing sector in Salt Lake City.

Virginia dropped two spots, to ninth, on our 2016 index, its lowest-ever ranking. Apart from the Human Capital Investment index, where it climbed one spot, to seventh, it lost ground against other states on all the composite indices. In Technology and Science Workforce, where it has typically performed very well, Virginia dropped three places, to eighth. The commonwealth continues to have the highest concentration of workers in computer and mathematical occupations in the country, engaged in high-tech and research work at world-class companies and institutions in the northern Virginia technology corridor. In Technology Concentration and Dynamism, another traditional area of strength, Virginia dropped one place, to seventh. More significant shifts were experienced in the Research and Development Inputs and the Risk Capital and Entrepreneurial Infrastructure indices. On the former, Virginia plummeted eight spots, to 20th; on the latter, a 12-place drop left it at No. 25.

Delaware held steady at 10th place this year with a score of 65.38. On the Research and Development Inputs index, it retained sixth place. Delaware had a 10-spot drop in the Risk Capital and Entrepreneurial Infrastructure index, falling to 29th. A one-place improvement in the Human Capital Investment index kept the state in the top 10, at No. 9. In the Technology and Science Workforce index, it ranked 12th, one place lower than in 2014. A one-place improvement from 2014 in the Technology Concentration and Dynamism index put Delaware at No. 12 there as well. The state's competitive business climate, with low corporate taxes, makes it an attractive incorporation location for firms, contributing to the dynamism of the broader state economy.

Though it held on to roughly the same ranks on the majority of the indices, Delaware saw major losses in the Risk Capital and Entrepreneurial Infrastructure index this year. The indicators dragging it down were number of incubators, IPO proceeds, SBIC funds disbursed, and venture capital investment in clean tech.

Biggest Gainers

Wyoming had the biggest improvement, moving up 10 places, from 46th to 36th. This marks the first time Wyoming has been out of the bottom 10 since 2002, and it posted its highest score to date, at 43.02. The state saw a huge increase in its rank on the Technology Concentration and Dynamism index, up 17 places, from 48th to 31st. The indicators driving this change were net formation of high-tech businesses, number of companies in the Technology Fast 500, average yearly growth of high-tech industries, and high-tech industries growing faster than the U.S. average. The use of Wyoming Business Council incentives to lure high-tech companies to the state has yielded significant growth from a low base, contributing to the improved performance. Wyoming climbed 10 places in the Human Capital Investment index, from 32nd to 22nd. It saw a major increase in the Technology and Science Workforce index, from 46th to 15th, a 31-place rise. Wyoming is one of the states that benefited most from changes in the definition of this index, thanks to its strong concentration in mining-related engineers. On the Risk Capital and Entrepreneurial Infrastructure index, it ranked 47th, down one place from 2014. However, the state was last on the Research and Development Inputs index, dropping eight spots from 2014.

Missouri climbed six places, to 28th, the second-largest improvement on the 2016 index. The biggest contributor to this rise was its leap of 24 places, to seventh, on the Risk Capital and Entrepreneurial Infrastructure index. Strong performance on the number of business incubators, business starts, and companies (deals) receiving venture capital combined to lift Missouri on this sub-index, and it speaks to the improving business climate in the state. Improvements on the Research and Development Inputs index (up seven spots) and the Technology Concentration and Dynamism index (up nine) also boosted the state's overall standing.

Struggling States

New York and **Vermont** both experienced large declines in rank from 2014 to 2016. New York dropped nine places this year, with three of the major composites dragging the state down. The first was an eight-place decline on the Human Capital Investment index, which moved New York out of the top 10 (from seventh to 15th). The second was a 10-place decline on the Technology and Science Workforce index, from 26th to 36th—partly an artifact of the more inclusive definition used for that index this year. Third, in Technology Concentration and Dynamism it lost 12 places, going from 12th to 24th. Vermont dropped to 26th from 18th on the overall index from 2014 to 2016. It lost four places on the Human Capital Investment index, landing at 13th. It fell seven places on the Technology and Science Workforce index, ending up at 38th. The largest loss was on the Technology Concentration and Dynamism index, which saw a drop of 15 places, from 15th to 30th.

FIGURE 1 **How does your state stack up?** State Technology and Science Index 2016

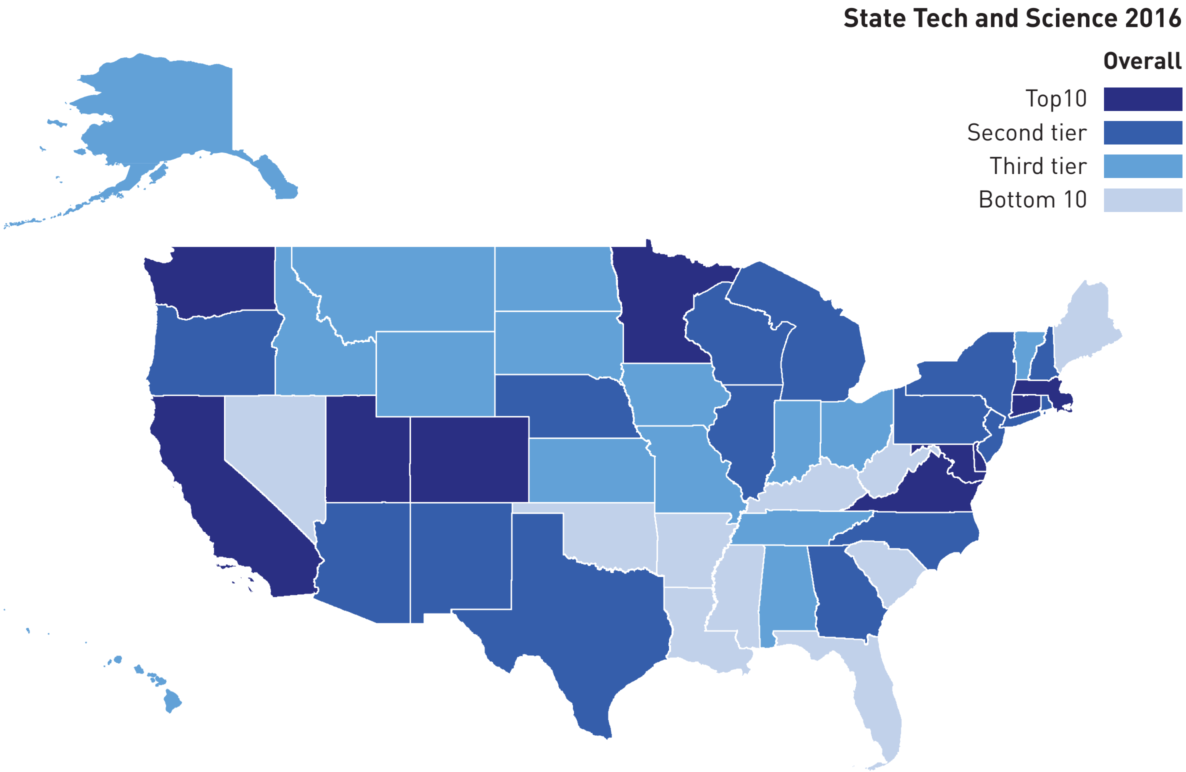
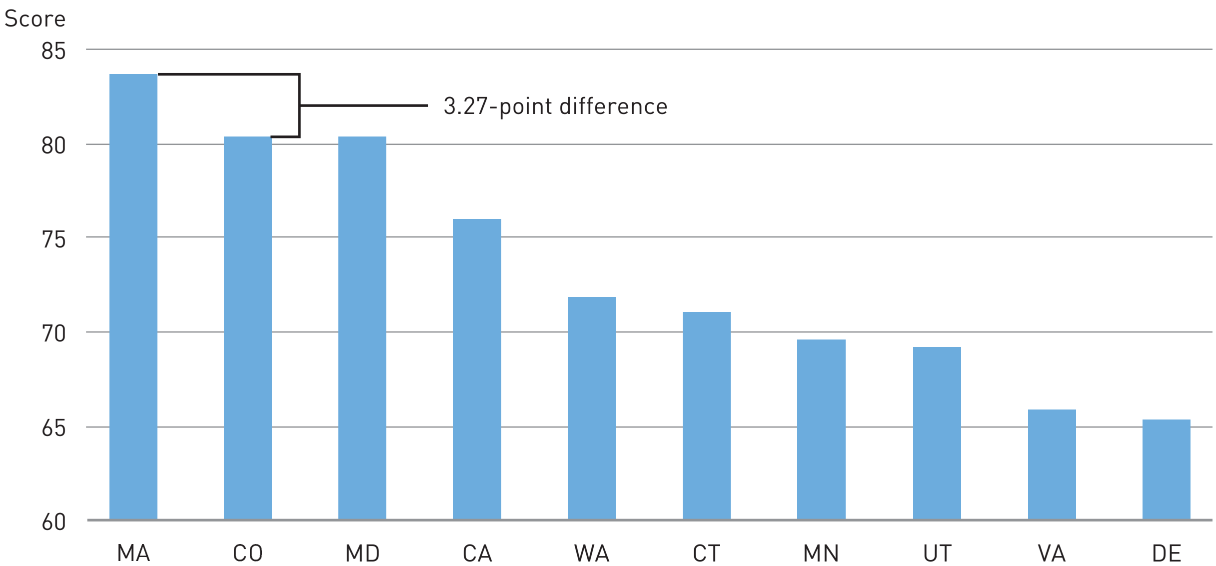


FIGURE 2 **State Technology and Science Index 2016:** Top 10 states



Source: Milken Institute.

TABLE 1	**State Technology and Science Index:** 2016 rankings

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Georgia	24	23	-1	53.53
Nebraska	25	30	5	53.53

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
Vermont	26	18	-8	52.58
Ohio	27	26	-1	52.32
Missouri	28	34	6	50.60
North Dakota	29	29	0	49.73
Indiana	30	27	-3	49.23
Kansas	31	28	-3	48.44
Idaho	32	33	1	46.30
Alaska	33	38	5	44.86
Montana	34	39	5	43.73
Iowa	35	31	-4	43.52
Wyoming	36	46	10	43.02
Alabama	37	32	-5	42.67
South Dakota	38	42	4	41.55
Hawaii	39	35	-4	40.35
Tennessee	40	36	-4	40.22
Florida	41	37	-4	38.82
Maine	42	41	-1	38.39
South Carolina	43	40	-3	35.84
Oklahoma	44	43	-1	34.62
Nevada	45	50	5	32.76
Louisiana	46	48	2	31.40
Kentucky	47	44	-3	30.53
Mississippi	48	49	1	29.84
Arkansas	49	45	-4	27.95
West Virginia	50	47	-3	25.84

3. RESEARCH AND DEVELOPMENT INPUTS

Background and Relevance

The Research and Development Inputs composite index measures the research capacity or ability to create new knowledge that has potential commercial applicability. The more extensive the research infrastructure of a state, the greater the opportunities for innovative outcomes and superior value-added economic performance. Much of this research may not have an immediate economic impact, but the returns will accrue in future years.

Innovative activities are determining an increasing proportion of long-term economic growth among advanced economies, as well as the vitality of their regions. Even among emerging economies, innovative capacity is playing an ever-greater role in explaining economic growth patterns, as low-cost labor diminishes in importance when nations rise along the development continuum. Innovation is an endogenous factor in the modern, dynamic economic system. Innovation can be viewed as the capital stock of accumulated knowledge resulting from research and development investments made over time with a depreciation rate applied based upon how long ago the investment occurred.

For innovation to occur, research and development must be accompanied by an efficient system for bringing ideas to market and creating high-paying jobs.

Sustaining these activities at an elevated rate requires a robust innovation infrastructure encompassing an effective national, state, and local policy framework that continuously nurtures R&D. Companies and entrepreneurs can execute long-term, research-intensive investments with greater confidence and reduced risk. Continuous and committed research and development is necessary to create transformational or incremental innovation, although it inescapably includes risk for industries, firms, and entrepreneurs.[3] Atkinson and co-authors present a persuasive argument for R&D in the growth process, contending that "R&D is the fundamental driver of innovation, and in developed, knowledge-based economies, innovation powers long-run economic growth."[4]

The spatial concentration of innovation activity provides the key framework for understanding regional or state success. Clusters are spatial concentrations of often competing, sometimes collaborating firms and their related supplier networks, including a variety of supporting institutions such as venture capital finance. A state may have one or two dominant innovation-based clusters or more distributed activity. Innovative clusters form and expand largely because new knowledge (fueled by R&D) tends to be generated, conveyed, and collected more efficiently in dense concentrations.[5] Many clusters have anchor firms that represent a disproportionate share of the research capacity of their respective industries and seed the geography through talent transmission and opportunities for former employees to in turn launch startups.[6]

The federal government, universities, and private industry are the three main sources of funding for R&D. Federal funding is primarily directed at basic scientific research that doesn't have an immediate commercial application. However, this basic research has been an important contributor to the applied research and development efforts of the private sector. In 2014, the federal government funded 24.7 percent of total U.S. R&D.

Universities are crucial assets in promoting technology-based and other high-value-added economic development. Research universities will play an even more vital role in the future. Leveraging research by converting it to a private-sector application, along with developing the talent that industry requires, are twin pillars for promoting success in high-value-added economic development. Research productivity and creation of human capital are the output of good universities fulfilling their mission. Universities are performing substantially more applied research at the behest of corporate sponsors, but the primary source of funding is basic research from federal grants.

Industry invests the most in research and development, accounting for 62.3 percent of the total in 2013 (the latest year for which data are available). Collaboration among corporate labs, university researchers, and their supplier networks (many of them small firms) is evolving to form a new distributed network platform system for innovation.[7] The U.S. is well known for its cutting-edge large corporations that perform extensive research and smaller R&D-intensive firms that transform discovery into a new vaccine, drug, software application, cloud storage, or communication chip.

Some clusters were seeded by attracting firms that have achieved commercialization success in another geography, but states with indigenous R&D have clear advantages in developing innovative clusters that don't fall apart over the long haul.[8] The scope of local innovation is dependent on the degree of a state's innovation competencies, along with the unique cluster attributes that strengthen it and the degree of interactions among the members.[9]

Composite Index Components

In general, R&D funds come from three sources: the federal government, private industry, and academia. We rank each state on 18 R&D indicators that fall under the following categories:

Federal R&D expenditures: This captures investments in all basic and applied research in such areas as national defense, health, space research and technology, energy, and general science.

Industry R&D expenditures: This is the total that corporations spent on basic and applied research, including funds spent at federally funded R&D centers. Industry R&D receives greater weight in the composite index because of its large share of overall R&D.

Academic R&D expenditures: This is the total spent on R&D by a state's colleges and universities. All research, basic and applied, performed by colleges and universities is funded by a combination of federal, industry, and academic sources, but more than 60 percent of R&D funding at universities originates from the federal government.

National Science Foundation (NSF) funding: The National Science Foundation, an independent federal agency, funds research and education in science and engineering through grants, contracts, and cooperative agreements. Its R&D expenditures on engineering are a key source of funding at doctorate-granting institutions, but we also include indicators that track NSF support of the physical sciences, environmental sciences, math, computer sciences, and life sciences. Finally, the funding rates of competitive NSF project proposals for basic research are also used to judge the success and research capabilities of a region.

Small Business Technology Transfer (STTR) awards: These federally funded research grants go to innovative small businesses and nonprofit research institutes to support technology commercialization efforts.

Small Business Innovation Research program (SBIR): This program funds the often costly startup and development stages and encourages commercialization of research findings. To be eligible, firms must be for-profit, American-owned, and independently operated, and employ a principal researcher and fewer than 500 workers.

State Rankings

The top five performers on the Research and Development Inputs composite index this year are unchanged from our 2014 report. The most volatile indicators are the R&D field specific indicators: engineering, environmental science, mathematics and computer science, agriculture, and biomedical research spending. Federal R&D funding and the two phases of SBIR funding also create fluctuations within this composite index.

AT THE TOP

Massachusetts retained the No. 1 spot on the Research and Development Inputs composite index. The commonwealth ranked in the top 10 for 15 of the 18 indicators that make up this index, with 13 placing in the top three. Massachusetts continues to be a hub of innovation, with a strong foundation of research and development funding likely to continue for some time. Massachusetts came in at No. 1 in average STTR dollars awarded and in private industry R&D expenditures. One of the state's programs that attracts STTR funding is the Small Business Matching Grant Program, which matches every dollar awarded through STTR and SBIR up to $500,000.[10, 11] With a score of 98.72, Massachusetts clearly outpaces its peers; there is a 14-point difference between first and second place.

Maryland held on to the No. 2 spot on this year's Research and Development Inputs index, scoring 84.42. It is the top performer on six of the indicators that make up this index: federal R&D spending per capita, academic R&D spending per capita, engineering R&D, math and computer science R&D, physical science R&D, and life science R&D. It also placed in the top 10 for another seven of the indicators. For the 36th year in a row, Johns Hopkins obtained the most federal R&D funding of all universities for fiscal year 2014, at $2.24 billion. The National Institute of Standards and Technology runs its cybersecurity research office out of Rockville, and this, combined with Maryland's cybersecurity tax credit and the fact that it is home to NSA headquarters, should allow for continuing concentration of cybersecurity experts in the state.[12, 13]

Colorado is again No. 3 in this index, scoring 82.62, less than two points behind Maryland. It ranks No. 1 in both NSF funding and NSF research funding, and is in the top five in five other indicators. Colorado received 326 NSF awards, ranging from a $3.6 million grant to increase enrollment in STEM programs to the AirWaterGas Sustainability Research Network for their research into groundwater contamination from oil and gas wells.[14, 15, 16]

New Hampshire held firm at No. 4, just over half a point behind Colorado with a score of 82.06. In addition to claiming the top spot in number of SBIR awards per 100,000 people, New Hampshire has eight indicators in the top 10 for this composite index. The state has recognized the importance of R&D to its economy through two recent legislative actions designed to foster such activity. The first, in 2013, doubled the tax credit, and the second, in 2015, made renewal of the credit permanent.[17]

California kept its spot at No. 5, scoring 79.57, almost 20 points behind the top performer on this composite index. The Golden State claimed five top 10 spots for the component indicators, including two first-place rankings: SBIR Phase I and Phase II awards per 10,000 businesses. California's R&D landscape includes groups such as Alphabet's X and Intel Labs. Organizations including Cal-BRAIN have awarded 18 grants for neurotechnology research to various California-based research institutions.[18]

Delaware, Washington, Connecticut, Pennsylvania, and **Rhode Island** round out the top 10 on this composite index this year. Delaware finds itself in the company of others that have established reputations as developing tech hubs. Amid a much stronger emphasis on science than on technology, the state's success is noteworthy. Companies like DuPont and AstraZeneca provide solid foundations for R&D opportunities.[19]

AT THE BOTTOM

Louisiana, Arkansas, and **Wyoming** make up the bottom three, each scoring less than 25 on the composite index this year. None of them has broken out of the bottom 10 in the last five releases. Wyoming had a massive drop in the amount of R&D funding in engineering, reflecting the contraction of the state's oil industry, which had been driving demand for advancement in engineering.

BIGGEST GAINERS

Missouri, Nevada, and **Arizona** made the biggest upward moves this year. **Missouri** and **Arizona** are home to emerging-technology and science hubs that drove the index. This reflects the increasing competition in the tech field, which is drawing jobs away from traditional hubs. **Nevada** has seen the rise of renewable-energy companies centered around solar. It also has seen the importance of supporting further diversification of its economy and in 2015 reestablished the Governor's Office of Science, Innovation, and Technology.[20]

FIGURE 3 **2016 Research and Development Inputs composite index map**

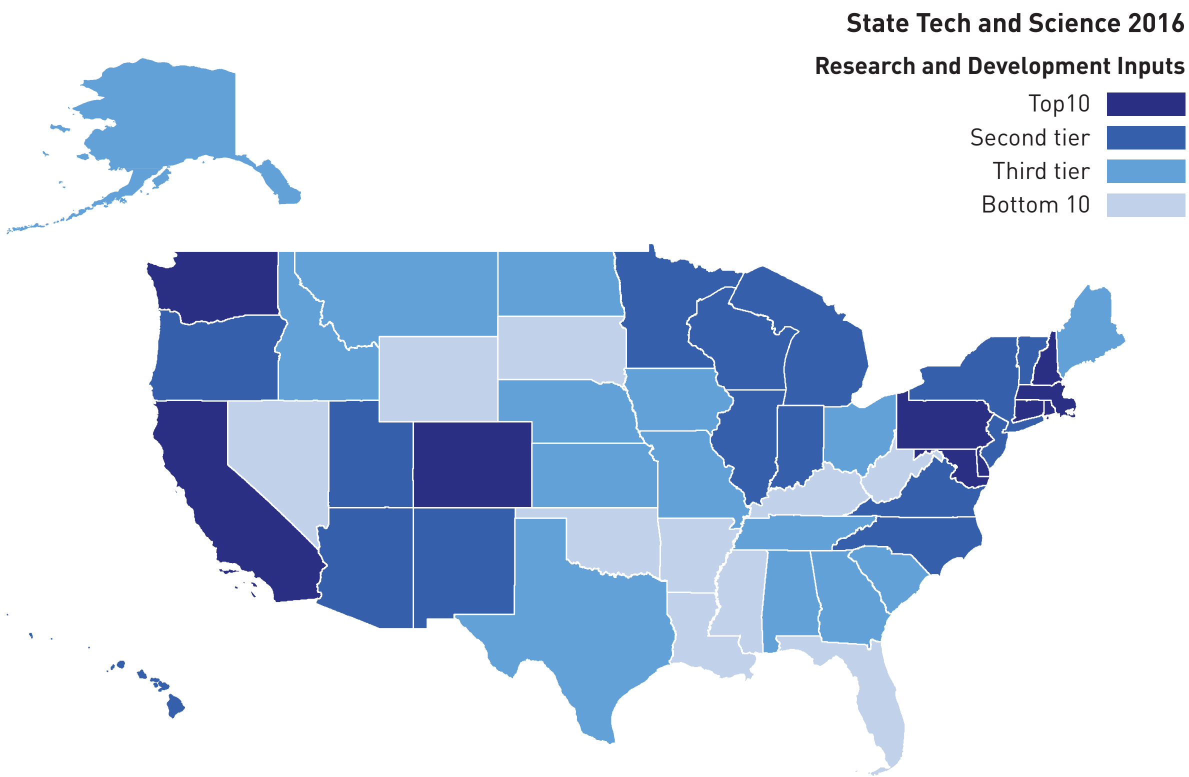
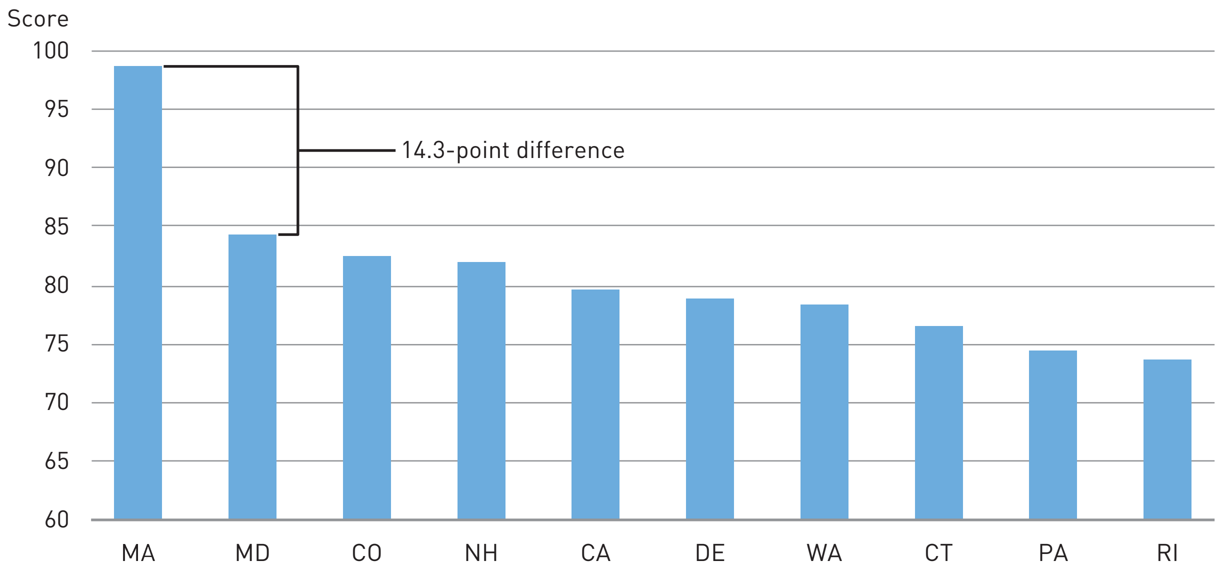


FIGURE 4 **2016 Research and Development Inputs composite index:** Top 10 states



Source: Milken Institute.

TABLE 2 **2016 Research and Development Inputs composite index:** State rankings

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
Massachusetts	1	1	0	98.72
Maryland	2	2	0	84.42
Colorado	3	3	0	82.62
New Hampshire	4	4	0	82.06
California	5	5	0	79.57
Delaware	6	6	0	78.90
Washington	7	7	0	78.25
Connecticut	8	10	2	76.46
Pennsylvania	9	11	2	74.42
Rhode Island	10	9	-1	73.65
Arizona	11	17	6	71.91
Oregon	12	13	1	69.10
Michigan	13	14	1	68.83
Utah	14	8	-6	67.74
Illinois	15	16	1	67.68
New Mexico	16	15	-1	67.60
New Jersey	17	21	4	67.53
Wisconsin	18	20	2	66.68
Minnesota	19	24	5	65.13
Virginia	20	12	-8	63.17
New York	21	18	-3	62.80
North Carolina	22	19	-3	62.62
Indiana	23	26	3	61.20
Vermont	24	27	3	58.29
Hawaii	25	23	-2	57.16
Ohio	26	25	-1	56.70
Montana	27	29	2	53.44
Alabama	28	22	-6	53.05
Idaho	29	30	1	52.63
Georgia	30	31	1	50.02
Iowa	31	28	-3	49.33
Texas	32	32	0	47.61
North Dakota	33	34	1	46.69
Kansas	34	36	2	46.40
Nebraska	35	35	0	44.48
Tennessee	36	37	1	44.19
Missouri	37	44	7	43.85
Maine	38	38	0	38.61
Alaska	39	33	-6	36.92
South Carolina	40	43	3	34.88
Nevada	41	48	7	33.86
South Dakota	42	39	-3	33.38
Florida	43	40	-3	29.93
Mississippi	44	45	1	29.08
Oklahoma	45	47	2	25.58
Kentucky	46	41	-5	23.68
West Virginia	47	46	-1	23.60
Louisiana	48	50	2	22.09
Arkansas	49	49	0	21.88
Wyoming	50	42	-8	20.15

4. RISK CAPITAL AND ENTREPRENEURIAL INFRASTRUCTURE

Background and Relevance

The Risk Capital and Entrepreneurial Infrastructure composite index measures the environment for entrepreneurial success, including access to risk capital. Entrepreneurship and the early-stage financing that supports the process of company formation and growth are crucial to a state's ability to maintain economic growth at a pace that fosters job creation for its citizens.[21]

Over the past few years, states and places that spawn new firms that achieve middle-market status explain much of the divergence in economic performance.[22] Individuals who recognize entrepreneurial opportunity—and have the knowledge and skills to develop it—are one of the strongest assets a geography can have in today's innovation-based economy.

Many existing firms will stagnate or disappear as technological change in the broader economy or in their industry disrupts their business models. Some large firms maintain substantial R&D budgets that yield innovations, but they become risk-averse and don't invest in new innovative ventures that might compete with existing product lines. A type of knowledge filter impedes these firms from recognizing the value of their newer intellectual property.[23]

The impact of entrepreneurship on economic growth, and on job creation in particular, is not immediate. Entrepreneurship researchers have found that the most important growth effects of startup firms can take up to 10 years to occur.[24] This is a reason why many state and local economic development agencies still focus their efforts on recruiting existing firms looking to relocate or expand operations: The results have a more immediate impact and can be readily tallied in terms of jobs and wages associated with them.

It is important to recognize that entrepreneurial activity is molded by a consistent set of factors. This framework includes training and support from the private and public sectors and access to early-stage risk capital.[25] The interaction between recognition of entrepreneurial opportunities and the capacity to pursue them will increase the level of startup activity, new-firm formation, and job creation, especially in high-tech industries.

A critical advantage for the most dynamic, innovation-driven, high-tech clusters has been the emergence of so-called serial entrepreneurs. These are individuals who exit the more established firms they helped launch in order to develop the next new idea into a startup. They recirculate money and entrepreneurial expertise back into the cluster, giving it an edge.

Entrepreneurial capabilities are essential to maintaining an ecosystem of innovation in a cluster. In an era of rapid technological change, entrepreneurs play a vital role because the new enterprises they form aren't encumbered by past institutional or personal biases. They are better positioned to envision ways to combine existing technologies with new discoveries and bring new products and services to the marketplace. Once initiated, the startup and spinoff process creates a virtuous, self-reinforcing progression by which a cluster innovation ecosystem nurtures and aids additional entrepreneurial efforts.

The second component of entrepreneurial success includes early-stage financing such as venture capital and crowdfunding, which fuel startup activity. Venture capitalists provide not mere money, but smart money. In other words, they have expertise in management, product development, and marketing, and also provide partnering opportunities. Studying trends in venture capital placements provides an important indication of where emerging-technology firms are seen to possess strong intellectual capital and rising entrepreneurial capabilities.

Enhanced capital availability to innovative entrepreneurs has aided new-firm formation and economic growth in many locations. This improved access to risk capital is vital to technology startups because the service or product is largely unproven and market potential is difficult to ascertain with any confidence. Many startups that evolve from research backgrounds require substantial sums of external financing to fully develop their ideas into successful products and services.

This is where private equity fills in, whether through loosely organized individual investors, such as angel investors; venture capital (VC) firms; or crowd-based funding that pools investments from multiple sources. The crowdfunding model has become more important in states without a strong VC platform. Venture capital investment typically follows the highest-quality deals. If capital invested in an area's firms fails to provide the anticipated returns, the money will likely move elsewhere. Consequently, venture capital investments tend to be highly associated with the level of innovation (patents per capita) resident in a state or region and the concentration of high-tech industries.[26]

Composite Index Components

To measure each state's entrepreneurial culture, the Risk Capital and Entrepreneurial Infrastructure composite index looks at 12 indicators in categories involving venture capital investment, initial public offerings, business creation, and patent activity:

Flow and strength of venture capital investment: To assess a region's potential for tech-based enterprises, we look at indicators such as growth in total venture capital funding, number of companies (deals) receiving VC investment per 10,000 firms, and VC investment as a percentage of gross state product.

Small Business Investment Company (SBIC) funds: The SBIC program, administered by the Small Business Administration, is geared toward incubator-type establishments that support small businesses, with services ranging from financial capital to management consulting. Like venture capitalists, the SBIC identifies profit potential in unleveraged small businesses and funds them in hopes of high returns on investment.

Business incubators and accelerators: These aim to provide up-and-coming small businesses with guidance and resources such as physical facilities, office equipment, business assistance services, and management consulting.

Patents: The greater the number of patents per 100,000 people in a state, the more inventive and scientifically curious the agencies and institutions in that state are. The numbers also indicate the likelihood of commercialization, because the cost and time required to register and protect an idea are significant.

Business formation: Business starts and initial public stock offerings are indicators of entrepreneurship and optimism. Companies that go public typically have a proven track record in terms of revenues or sales history.

Clean-tech/green-tech, nanotechnology, and biotechnology investments: Nanotechnology, clean-tech, and biotech are regarded as the forefront of technological innovation. Investments in these areas represent a cutting-edge mentality and serve as a measure of a state's willingness to take risks.

State Rankings

The Risk Capital and Entrepreneurial Infrastructure composite index is built on indicators that fluctuate year over year, and depend on a state's ability to attract investment and create new business through innovation. The most stable indicators in this index are SBIC funding, incubators/accelerators, and patents.

AT THE TOP

California reclaimed first place on the Risk Capital and Entrepreneurial Infrastructure index for the first time since 2008. Scoring 79 this year, it outperformed the second-place state by one-third of a point. California ranked in the top 10 for seven of the 12 indicators that make up this index. It ranked first in three of them—Venture Capital Investment as a Percent of GSP, Number of Companies (Deals) Receiving VC per 10,000 Firms, and Patents per 100,000 People—all relating to the vibrant entrepreneurial environment in the Golden State. One of California's main strengths is commercialization of university research. In 2014, the California Institute of Technology was able to collect $31.4 million from its patents. Stanford's functional antibodies patent generated some $550 million before the patent expired.[27]

Massachusetts fell one spot this year to place second, scoring 78.67. The drop of just under three points cost the state its place at the top of the index, which it had held since 2010, when it displaced California. This year, Massachusetts scored in the top 10 in six of the 12 indicators. Its performance on Venture Capital Investment as a Percent of GSP, VC in Nanotech, and Patents Issued ranked second in the nation. The drop in Massachusetts' composite score for this index can be attributed in part to a lack of new-business creation, and a related drop in new businesses securing funding. The level of funding and innovation in the state is strong, but a lack of activity, notably in biotech, indicates that other states are absorbing more of the growth. Massachusetts has seen large-scale VC investment into clean technology generate $2.8 billion from the state's water industry.[28]

Colorado moved up to third place from seventh in 2014. Its score of 72.91 puts it 5.76 points behind Massachusetts. In 2014, the gap between first and fifth place was more than 12 points, demonstrating the increasing competitiveness of this composite index. Colorado ranks in the top 10 for five of the 12 indicators in this composite, with two of them in the top five. Business starts and VC in clean tech made the largest contribution to Colorado's score, followed by venture capital as a percent of GSP, number of patents issued, and IPO earnings as a share of GSP. These five indicators are all directly linked to a strong startup culture and present a solid foundation for future growth. The National Renewable Energy Laboratory has partnerships with the University of Colorado, Boulder and Colorado State University, along with the private sector. This program, part of the Department of Energy, works to promote R&D, commercialization, and implementation of clean technologies.[29]

New York held on to fourth place, scoring 72.17. Financing was a key strength in the state, with three related indicators— Number of Companies (Deals) Receiving VC per 10,000 Firms, VC Investment as Percent of GSP, and IPO Proceeds as Percent of GSP—earning top five spots for New York. The state has grown its own tech sector, dubbed Silicon Alley. In 2015, Etsy.com became the largest New York-based exit, with a valuation of $1.8 billion.[30]

North Carolina broke into the top 10 for the first time since 2010, placing fifth with a score of 71.45. The state has four indicators in the top 10, with the Number of Companies (Deals) Receiving VC, SBIC Funds Disbursed, incubators and accelerators in the state, and VC in clean tech contribute most to their score. These indicators show funding sources are available in the state along with a pathway allowing ideas to commercialize. North Carolina in 2014 saw investments in tech companies raise more money than life sciences, raising $277 million and $255 million respectively, pointing to a diversifying high-tech sector.[31]

Utah, Missouri, Maryland, Georgia and **Oregon** round out the Top 10 for this composite index. **Utah** has been closing in on $1 billion of venture capital investment and as a result of this, the state also supports the tech sector with the Utah Capital Investment fund run out of the governor's office.[32, 33] **Missouri** breaks into the Top 10 for the first time, showing that the high-tech sector is expanding outside of the traditional states. With top five performance in both the number of business incubators per 10,000 establishments and business starts per 100,000 people, the state is experiencing substantial entrepreneurial activity. **Maryland** fell three places to eight, but it had five indicators in the top 10, all of which represent funding sources. IPO proceeds is Maryland's highest-ranking indicator, showing that companies are able to survive beyond initial phases. **Georgia** entered the top 10 for this composite index for the first time since 2008, advancing 17 places from last year. **Oregon** also broke into the top 10. The state gained a total of 14 ranks over the 2014 release. Companies such as Onboard Dynamics, Valliscor, and eChemion have taken part in the state's Regional Accelerator and Innovation Network program, seeking to take advantage of Oregon State University's growing R&D footprint.[34]

AT THE BOTTOM

West Virginia, Mississippi, and **Hawaii** make up the bottom of the Risk Capital and Entrepreneurial Infrastructure composite index, in descending order. Hawaii dropped 11 places in the rankings, and Mississippi and West Virginia dropped five and two ranks, respectively. Hawaii ranks No. 1 for number of incubators and accelerators but lacks general sources of funding to commercialize ideas. To that end, the Hawaii Strategic Development Corporation launched a startup investment capital program to work on bringing funds to the state.[35] All of these states have struggled to make it out of the bottom 10 in the last two STSI releases.

BIGGEST GAINERS

Missouri and Georgia rose 24 and 17 places, respectively, on this composite index. Companies in **Georgia** are attracting funding; the state ranked in the top 10 for overall growth in SBIC funding and IPO proceeds. Georgia's strengths are in Venture Capital funding both in general but also in clean tech. **Missouri** is home to three of the five largest venture capital firms in the Midwest: Missouri Technology Corp., BioGenerator, and Cultivation Capital.[36]

FIGURE 5 2016 Risk Capital and Entrepreneurial Infrastructure composite index map

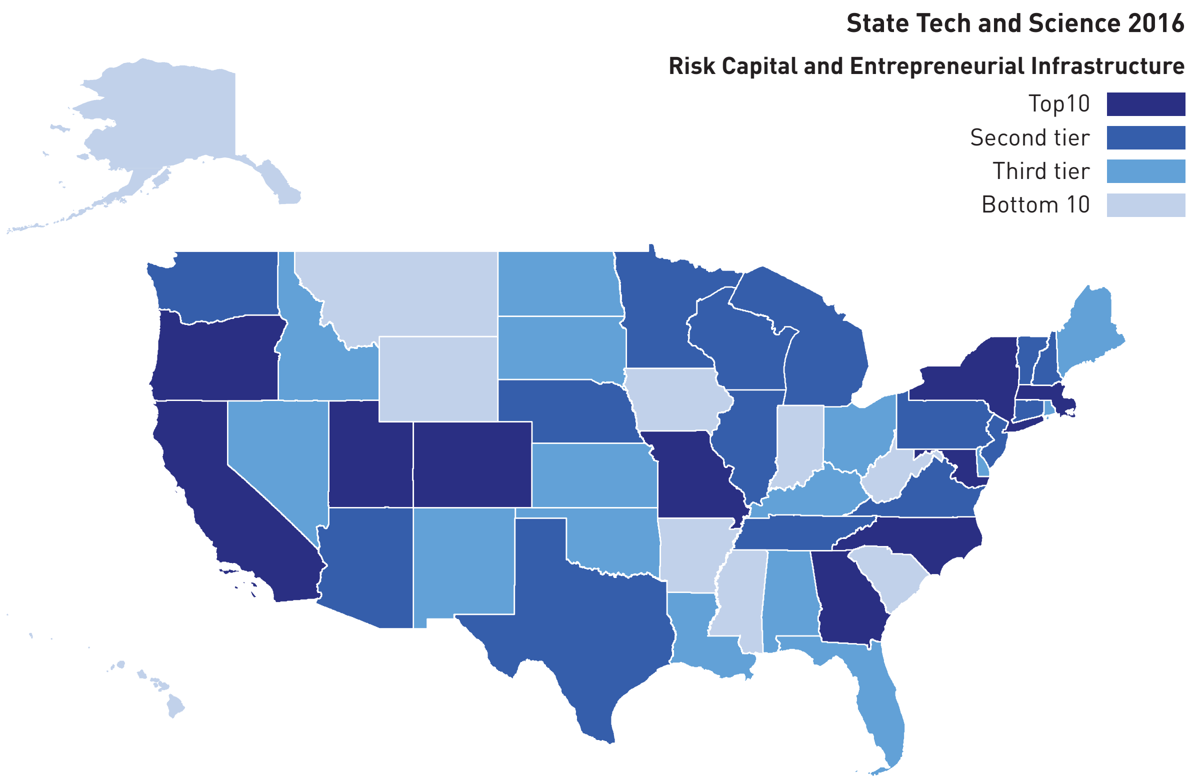
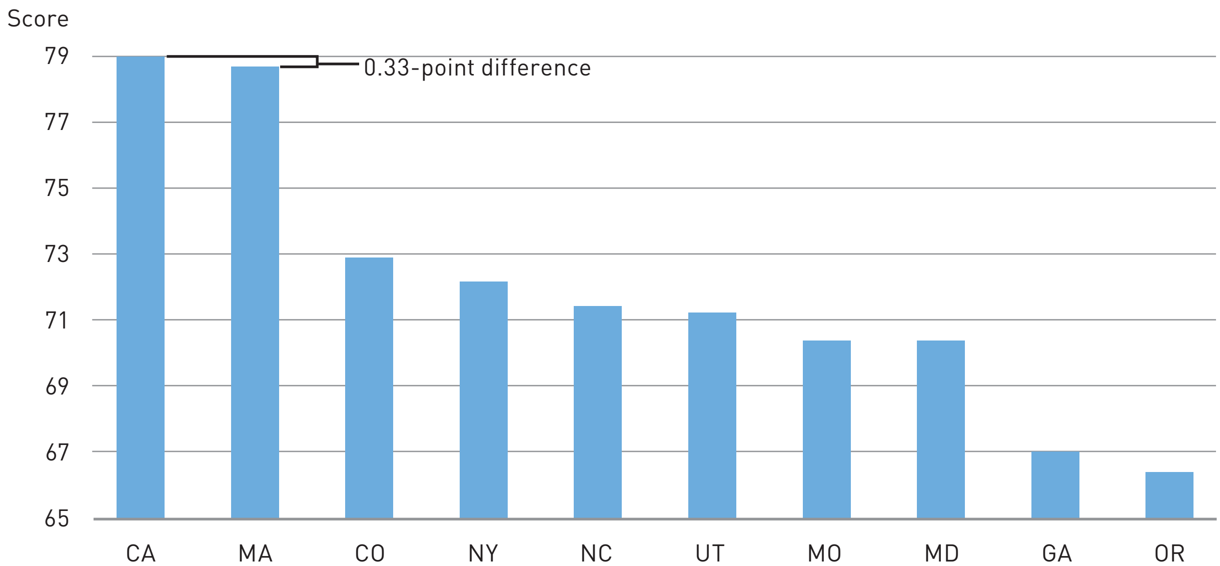


FIGURE 6 **Risk Capital and Entrepreneurial Infrastructure composite index:** Top 10 states



Source: Milken Institute.

TABLE 3 **Risk Capital and Entrepreneurial Infrastructure composite index:** State rankings

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
California	1	2	1	79.00
Massachusetts	2	1	-1	78.67
Colorado	3	7	4	72.91
New York	4	3	-1	72.17
North Carolina	5	12	7	71.45
Utah	6	10	4	71.27
Missouri	7	31	24	70.40
Maryland	8	5	-3	70.36
Georgia	9	26	17	67.00
Oregon	10	24	14	66.36
Connecticut	11	14	3	66.18
Texas	12	4	-8	66.00
Vermont	13	18	5	65.45
New Hampshire	14	9	-5	64.50
Washington	15	15	0	64.18
Minnesota	16	11	-5	62.73
Illinois	17	23	6	61.64
Arizona	18	17	-1	61.17
Nebraska	19	33	14	58.60
Wisconsin	20	36	16	58.00
New Jersey	21	7	-14	57.80
Tennessee	22	27	5	57.27
Michigan	23	25	2	56.36
Pennsylvania	24	6	-18	55.83
Virginia	25	13	-12	55.00
Florida	26	21	-5	54.18
Idaho	27	40	13	53.40
Rhode Island	28	22	-6	53.33
Delaware	29	19	-10	52.80
Kansas	30	34	4	51.82
Maine	31	41	10	50.73
New Mexico	32	30	-2	48.36
Ohio	33	20	-13	48.00
South Dakota	34	47	13	47.33
Oklahoma	35	35	0	46.73
Louisiana	36	32	-4	44.55
Nevada	37	29	-8	43.82
Alabama	38	45	7	43.45
Kentucky	39	43	4	43.40
North Dakota	40	16	-24	43.33
Arkansas	41	38	-3	43.00
South Carolina	42	28	-14	42.40
Indiana	43	42	-1	42.00
Alaska	44	49	5	41.33
Montana	45	50	5	39.82
Iowa	46	37	-9	39.40
Wyoming	47	48	1	36.33
West Virginia	48	46	-2	34.00
Mississippi	49	44	-5	32.86
Hawaii	50	39	-11	27.50

5. HUMAN CAPITAL INVESTMENT

Background and Relevance

It is essential for states and any regional economy to invest in human capital so they can gain sustainable competitive advantages in today's globally interconnected economy. Consequently, universities, community colleges, and accredited technical and vocational training facilities are key to regional economic growth and prosperity.[37]

This view—that the accumulation of skills over many years builds the stock of human capital, forms the source of innovative capacities, and drives the trajectory of state and local economic performance—is behind a perceived economic shift to a knowledge-based economy. Today, workforce talent determines economic prosperity, displacing physical capital and land as the most important factors.

Human capital depth and diversity are considered crucial ingredients in a region's economic performance. Many researchers have studied the benefits of investing in education.[38] Using macroeconomic evidence, Robert Lucas[39] and Paul Romer[40] demonstrated how "human capital accumulation," or new education and training, benefit the overall economy. Romer argued that "what is important for growth is integration not into an economy with a large number of people, but rather one with a large amount of human capital."[41] At the microeconomic level, the Mincerian wage model[42] quantifies how much an individual's pay increases with an additional year of schooling—probably as a result of increased productivity.

Concentrating human capital in a small geographic area helps create more rapid and higher-value-added regional economic growth.[43] The Milken Institute has provided research demonstrating the value of investment in human capital.[44] The returns on investing in additional schooling for regional economies are very high for postsecondary education. Adding one year of schooling to the average educational attainment for current workers with at least a high school education is accompanied by a gain in real GDP per capita of 17.4 percent and a rise in real wages per worker of 17.8 percent. However, one incremental year of education for workers with just nine or 10 years of schooling has minimal effect on real GDP per capita and real wages per worker.

Pools of skilled labor have important spillover effects. They attract business investment and create more demand for professional and other business services, so they stimulate local job creation and salary growth across the broader economy. As Enrico Moretti observed in his 2012 book, *The New Geography of Jobs*:

"Cities with a high percentage of skilled workers offer high wages not just because they have many college-educated residents and these residents earn high wages. This would be interesting but hardly surprising. But something deeper is going on. A worker's education has an effect not just on his own salary but on the entire community around him. The presence of many college-educated residents changes the local economy in profound ways, affecting the less skilled. This results in high wages not just for skilled workers but for most workers."

Investments in human capital have been found to provide higher returns to firms, not just individuals. Firms that attract and invest more in human capital demonstrate better performance in such areas as sales growth, market share, profitability, market capitalization, capital investment, and productivity. This relationship is evident in the performance of many Silicon Valley-based firms, such as Google and Apple, whose competitiveness strategy is largely based on a human capital strategy.

This productivity observation spills over from the firm to where they are physically located. Human capital is a central determinant of the level of productivity and its rate of growth.[45] These knowledge interactions in local and state economies are clearly correlated with innovation measures such as patents. There is substantial variation in rate of technological change between geographies. Many former manufacturing hubs are coming to recognize that human capital investment must be a key component of their transformation and recovery. College graduates might be the most important ingredient to Rust Belt turnarounds.[46]

Composite Index Components

The Human Capital Investment composite index contains 21 indicators in the following categories, measuring educational attainment and state funding for schools as a way of determining a region's commitment to an educated workforce:

The prevalence of various degrees: We look at almost a dozen indicators involving bachelor's, master's, and doctoral degrees, focusing particularly on the fields of science and engineering. These indicators suggest the labor pool's interests, its level of sophistication and skill development, and the availability of quality R&D centers and institutions of higher education. They also give clues as to the local job base and the area's ability to attract grants and other research funding.

State spending: We look at state spending on student aid and appropriations for higher education and the change in appropriations, which indicate a region's commitment to producing an educated workforce and the future quality of the labor force.

Home computer penetration and Internet access: These illustrate the extent to which the population is technically proficient. Computer ownership coupled with Internet access allows access to resources, both commercial and educational, for which residents might otherwise have to travel long distances.

Test scores: This includes the Scholastic Aptitude Test (SAT) and American College Testing Assessment (ACT) scores of high school students on a time-series and cross-sectional basis. Average math scores in particular measure the strength and effectiveness of secondary schools' math and critical-thinking curricula.

State Rankings

Human Capital Investment forecasts a state's ability to perform well in technology and science fields in the future. A highly skilled and technologically advanced workforce is a necessity for all successful economies. The sources of movement in this index show that states that have had fewer people with access to computers and broadband Internet have made significant improvements on this measure. The other sources of movement in this index include SAT scores and the number of recent graduates in science, engineering, and health.

AT THE TOP

Colorado took the top spot on this composite index, moving up from sixth in 2014. With a score of 75.14, it only just pulled ahead of Massachusetts. Colorado saw increases almost across the board, but with a particularly marked increase in the number of recent science and engineering graduates at the Ph.D. level (a 14-spot jump.) The state has a very highly educated population, ranking second in share of population with at least a bachelor's degree, and in the top 10 for a range of indicators relating to advanced degrees. Unsurprisingly, the state also ranks in the top three in share of households with a computer. Colorado's 14 public and 17 private four-year universities, along with its high-tech industries, help train and attract this educated workforce. While the change in state appropriations was an asset this year, its growth is off a low base of per-capita spending on higher education. Efforts to address this are underway; in 2014, the Colorado Commission on Higher Education was tasked with establishing a new funding formula for higher education to go into effect in fiscal year 2016, and despite budget constraints the state was able to increase funding to higher education slightly in the most recent budget.

Massachusetts dropped from No. 1 to No. 2, marking the first time the state, with its super cluster of educational institutions, has not held the top spot on this composite index. Some contributing factors to the decline were verbal SAT scores; percent change in state appropriations for higher-education funding; and number of science, health, and engineering PhDs awarded. The first dropped from the middle of the pack to the worst in the nation, while the latter two indicators went from ranking in the top 10 to the mid-30s. Given Massachusetts' world-class cluster of research universities, it is likely that it will return to its previously strong performance on doctorates awarded in science, health, and engineering.

Connecticut maintained its position at No. 3, although its score fell by two points. While five of the indicators were in the top five and overall performance was good, low SAT scores could be a source of concern if they persist. The state's educated population, ranking fourth in share with at least a bachelor's degree, has supported advanced manufacturing in the aerospace and submarine manufacturing sectors, among others.

Maryland came in at No. 4 this year, down two spots. The state's score fell by more than eight points, to 70.76. Although the state scores very well in almost all the higher-education indicators, its Verbal and Math SAT scores are in the bottom 10 in the nation. Number of households with computers and access to broadband Internet has also been a headwind for Maryland, as other states have improved greatly in this arena.

Minnesota, North Dakota, Virginia, Rhode Island, Delaware, and **New Hampshire** round out the top 10, with New Hampshire making the cut for the first time. North Dakota and Rhode Island improved their standing by six and five places, respectively. These states all have heavy representation in either the STEM or health fields, and have done well in the rankings.

AT THE BOTTOM

South Carolina, Arkansas, and **Nevada** remained in the bottom five of the Human Capital Investment composite index. Nevada retained its long-standing rank of 50th. These three states have never moved out of the bottom five, although their scores have improved. Only Nevada is stagnating, with an aggregate score under 30.

BIGGEST GAINERS

New Mexico (which rose from 25th place to 14th), **Wyoming** (32nd to 22nd), and **Hawaii** (39th to 31st) saw the biggest jumps in the Human Capital Investment index. New Mexico scored well in state appropriations for higher education and, thanks in part to top research institutions like Los Alamos National Laboratory, it also scored well in share of population with PhDs, as well as doctoral scientists and engineers per 100,000 people. Wyoming now has the highest per-capita state appropriations for higher education in the nation, an area where Hawaii also does well.

FIGURE 7 **2016 Human Capital Investment composite index map**

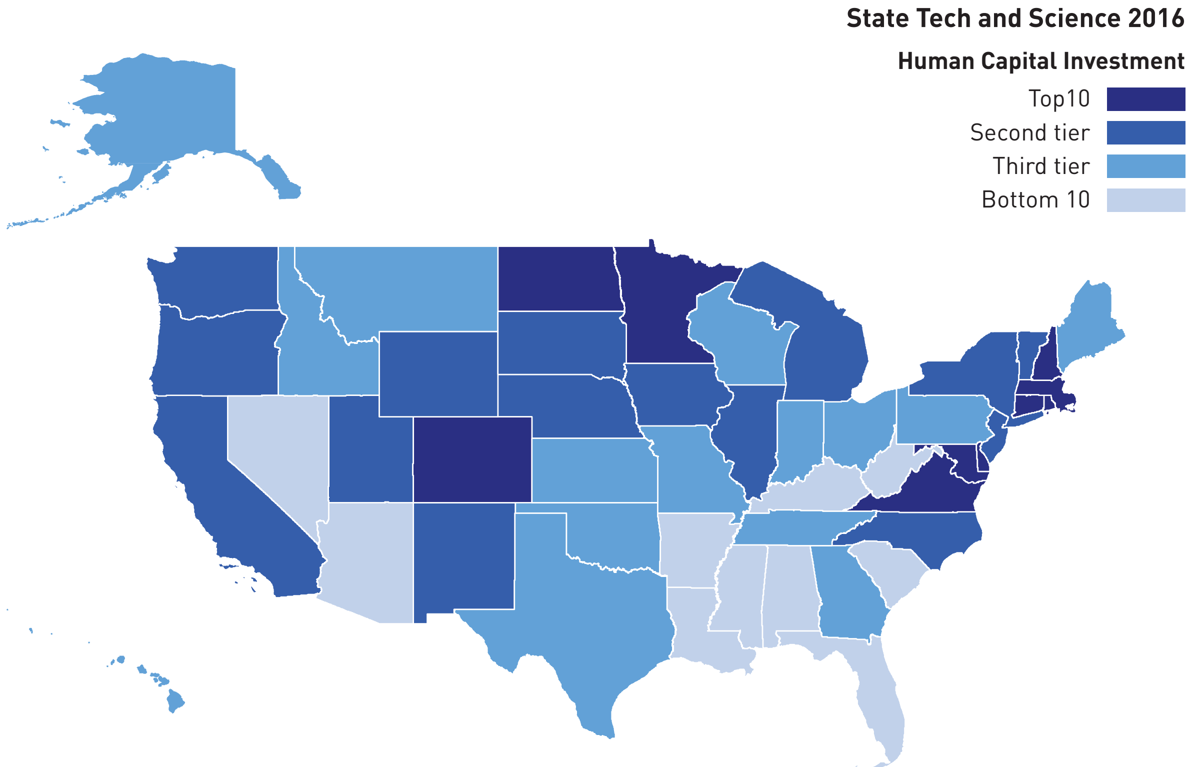
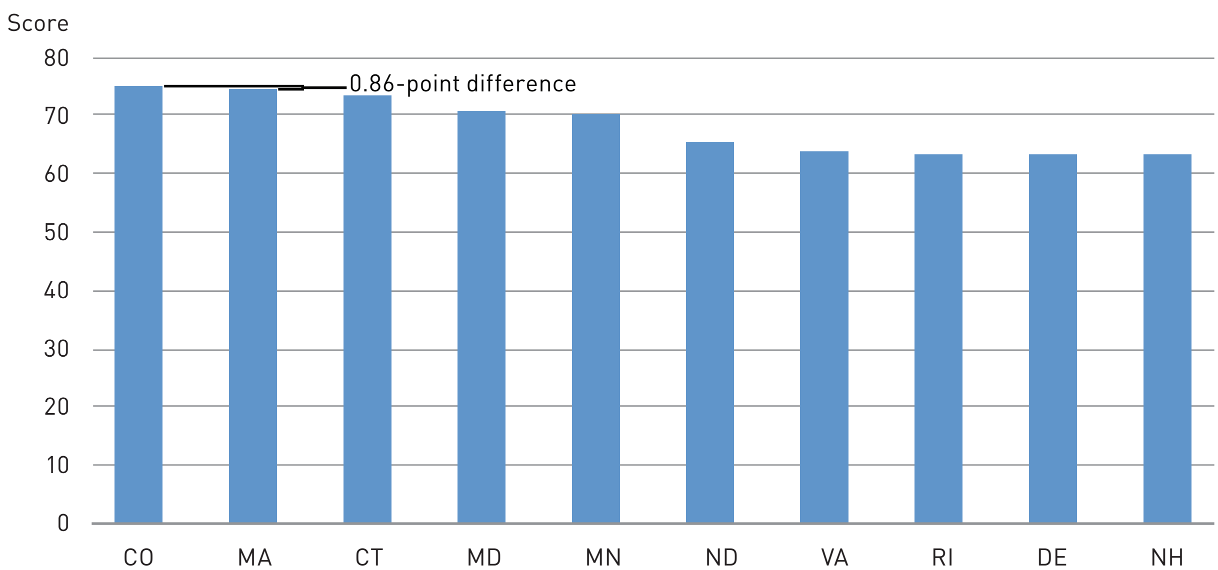


FIGURE 8 **2016 Human Capital Investment composite index:** Top 10 states



Source: Milken Institute.

TABLE 4 **2016 Human Capital Investment composite index:** State rankings

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
Colorado	1	6	5	75.14
Massachusetts	2	1	-1	74.29
Connecticut	3	3	0	73.71
Maryland	4	2	-2	70.76
Minnesota	5	4	-1	70.48
North Dakota	6	12	6	65.50
Virginia	7	8	1	64.10
Rhode Island	8	13	5	63.52
Delaware	9	10	1	63.43
New Hampshire	10	14	4	63.14
California	11	17	6	62.48
Utah	11	5	-6	62.48
Vermont	13	9	-4	60.95
New Mexico	14	25	11	60.86
New York	15	7	-8	60.76
Washington	16	19	3	59.43
Oregon	17	22	5	58.86
Iowa	18	18	0	58.19
Nebraska	19	15	-4	57.90
Illinois	20	11	-9	56.67
New Jersey	21	21	0	56.10
Wyoming	22	32	10	55.50
Michigan	23	20	-3	53.90
North Carolina	24	28	4	53.14
South Dakota	25	30	5	52.60
Wisconsin	26	23	-3	52.19
Pennsylvania	27	16	-11	51.90
Indiana	28	26	-2	50.95
Kansas	29	24	-5	50.86
Montana	30	35	5	50.29
Hawaii	31	39	8	46.19
Ohio	32	31	-1	46.00
Missouri	33	27	-6	45.43
Maine	34	40	6	44.19
Texas	35	41	6	43.24
Georgia	36	33	-3	42.19
Alaska	37	37	0	40.95
Oklahoma	38	42	4	39.90
Idaho	39	44	5	38.38
Tennessee	40	34	-6	36.95
Arizona	41	29	-12	36.19
Alabama	42	36	-6	35.52
Louisiana	43	46	3	35.05
Kentucky	44	45	1	33.81
West Virginia	45	38	-7	32.48
Florida	46	43	-3	31.52
Mississippi	47	48	1	31.05
South Carolina	48	47	-1	30.38
Arkansas	49	48	-1	30.00
Nevada	50	50	0	26.76

6. TECHNOLOGY AND SCIENCE WORKFORCE

Background and Relevance

Research can be performed and converted into a commercial venture only with the contributions of scientific and technical talent. Despite representing less than 5 percent of all private-sector jobs, these technology and science workers are crucial components of a state or local economy's ability to innovate and create high-value-added jobs.[47] The top states have leading clusters with innovation systems operating in a collaborative environment, with research, design, and production interacting in a dynamic learning process.[48]

In many cases, these tech and science workers become the entrepreneurs that seed the development and continuation of a cluster. The technical and scientific workforce of a region embodies the technological erudition, creative capacity, and economic growth potential not just of technology firms, but of all companies where innovation is a core element. Engineers, biochemists, and software developers with advanced degrees usually generate the innovative spark.[49]

However, skilled technicians with less than a bachelor's degree are also key to the applied research process. They assist in the development of prototype machinery and products and they install, maintain, and enhance the functionality of the inventions created and patented by researchers.[50] Herein lies an opportunity: Employers in key industries from aerospace to precision machine tools report that it is increasingly difficult to find qualified candidates to fill vacancies calling for science, technology, engineering, and mathematics (STEM) backgrounds below the bachelor's level because the workers with the skills and aptitudes necessary are in short supply.[51] The U.S. produces far too few STEM workers with associate degrees or certification credentials. These workers command much higher wages than those with general associate degrees.

Clusters that have a dense concentration of STEM workers have an additional advantage: pooling workers and creating a labor force with essential industry-specific skills.[52] Companies embedding themselves within technology clusters benefit from positive externalities such as knowledge spillovers and agglomeration effects. Additionally, labor productivity tends to be higher in locations densely populated with technology and science workers. One important study concluded that doubling employment concentration boosted productivity by nearly 6 percent.[53]

As biomedical engineers, microbiologists, biochemists, systems analysts, big-data scientists, applications programmers, and their occupational cousins migrate to a geographic cluster or remain in a cluster after graduating from local institutions, they reinforce the region's initial advantages, stimulating further localized growth. In this way, a cluster gains the most fundamental source of its competitive advantage: highly mobile, geographically discriminating labor assets.

In a high-velocity labor market within a cluster, STEM workers benefit from the opportunity to shift from one employer to another. Firms also gain the competitive advantage of lower recruitment costs when there is extensive local technical talent that possesses the industry-distinctive skills they require. The ease with which locations can assemble, distribute, and reassemble teams of skilled technology and science workers assists in promoting the birth of new firms and sustains mature ones.[54]

A local high-velocity labor market can spur technology spillovers. The latest technological advances contained in a cluster are communicated through informal relationships maintained by ex-colleagues in a labor-market network. This tacit knowledge interchange among scientists and technicians provides host clusters with key advantages by amplifying transmissions on the latest non-codified knowledge in their fields or industries.

California's Silicon Valley is an example of a flexible, knowledge-sharing, high-tech cluster. Workers move from company to company and maintain informal contact with former colleagues. This leads to informal labor-market networks[55] that can be a source of knowledge accumulation and transfer, boosting the overall knowledge capacity of the region.

Composite Index Components

The Technology and Science Workforce composite index reveals the research and innovative capacity in specific fields of high-tech employment. The occupations chosen as indicators—in the broad fields of computer and information science, life and physical science, and engineering—are considered the foundations of a high-tech economy, so the 47 occupations collectively also convey the entrepreneurial activity present in each region. We look at their "intensity," or prevalence, relative to total state employment:

Intensity of computer and information science experts: This group contains the intensity scores of Computer and Information Research Scientists, Computer Systems Analysts, Information Security Analysts, Computer Programmers, Software Developers - Applications, Software Developers - Systems Software, Web Developers, Database Administrators, Network and Computer Systems Administrators, Computer Network Architects, Computer User Support Specialists, Computer Network Support Specialists, Computer Occupations - All Other, Operations Research Analysts and Statisticians. These categories represent high value-added occupations and are a necessity in most technology or science firms.

Intensity of engineers: This looks at the intensity of agricultural and food scientists, Aerospace Engineers, Biomedical Engineers, Chemical Engineers, Civil Engineers, Computer Hardware Engineers, Environmental Engineers, Industrial Engineers, Materials Engineers, Mechanical Engineers, Mining and Geological Engineers, including Mining Safety Engineers, Nuclear Engineers, Petroleum Engineers and Engineers - All Other. These occupations are important to the scientific community because they support and promote entrepreneurial activities.

Intensity of life and physical scientists: This calculates the prevalence of Soil and Plant Scientists, Biochemists and Biophysicists, Microbiologists, Zoologists and Wildlife Biologists, Biological Scientists - All Other, Medical Scientists, Except Epidemiologists, Life Scientists - All Other, Physicists, Atmospheric and Space Scientists, Chemists, Materials Scientists, Environmental Scientists and Specialists, Including Health, Geoscientists, Except Hydrologists and Geographers, Physical Scientists - All Other, Agricultural and Food Science Technicians, Biological Technicians, Chemical Technicians and Nuclear Technicians. These professionals drive vitality because they design and construct everything from the largest of bridges to the tiniest, most intricate medical devices.

State Rankings

The definitional change from 2014 to 2016 gives states with large engineering and science workforces more opportunity to influence the 2016 rankings.

A more inclusive definition of the Technology and Science Workforce

This year we have updated the definition of the Technology and Science Workforce to be more inclusive of the occupations contributing to the high-tech sector. In 2014, index was made up of 18 standard occupational classification codes that were based on the previous system of occupation (OCC) codes and focused primarily on occupations that required advanced degrees. Progress in the high-tech sector over the last 12 years has made an update to this index necessary. The purpose of this update is to give a more accurate representation of the workforce needed for a vibrant technology and science economy.

Each of the three sub-indices was expanded. The computer and information science occupations sub-index captures employment in SOC codes in the 15-0000 range, and we have added nine new SOCs. The engineering occupations sub-index encompasses employment in the 17-0000 range of SOC codes, and eight new SOCs were added to this sub-index. The largest changes were made to the life and physical science occupations sub-index, which includes codes from the 19-0000 range of SOC codes. Employment from 12 new SOC codes was added to this sub-index.

These 29 additions represent a shift in the makeup of this index. We have made these changes to include more of the overall workforce rather than focus only on jobs that had the highest skill requirements in the high-tech sector. This expanded definition yields a more accurate representation of a state's ability to support the labor demands of science and technology firms. Although less concentrated in occupations that require advanced degrees, the occupations included are still highly skilled.

AT THE TOP

Maryland tops this year's Technology and Science Workforce composite index, up one spot. The state ranks first in concentration of life and physical scientists and second in concentration of computer and mathematical occupations as a share of the workforce. Maryland is 14th in concentration of engineers. With an overall score of 96, Maryland shows that its labor market includes a wide range of high-tech occupations, but its life sciences cluster is a crucial strength. With research institutions such as Johns Hopkins University and the University of Maryland, the large presence of federal agencies, including the Food and Drug Administration and the National Institutes of Health, and major private-sector activities in biotech and life sciences, Maryland is a leader in the discovery and development of bioscience and has attracted and developed the workforce to power this activity.

Massachusetts fell to second place in the index, yielding the top spot it had held since 2002. With a score of 95.33, the state is less than one point behind Maryland. Like Maryland, it has a high concentration of computer and mathematical occupations, ranking fourth, and of life and physical science occupations, ranking third. The Massachusetts engineering workforce is less concentrated, earning it 15th place on that sub-component index. The state's biotechnology cluster is well established and includes a thriving network of companies, universities, hospitals, and industry organizations. Massachusetts has made investments in maintaining and growing the cluster through 10 incentives created as part of the 10-year Life Sciences Initiative in 2008. With the nation's highest concentration of medical scientists, biomedical engineers, and biomedical technicians, Massachusetts' workforce has developed to fill the jobs created.

Colorado made it into the top five, climbing three places, to third. Its score of 92.67 captures how Colorado has been able to keep up with the demands of an ever more connected and tech-saturated nation. Ranking at No. 1 in concentration of engineers, it also placed fifth in concentration of computer and mathematical occupations and sixth in concentration of life and physical scientists. One employer of Colorado's technical workforce is the aerospace and defense industry, with space exploration-related research and development occurring at companies and institutions such as Lockheed[56] and Raytheon.[57]

Minnesota scored 88, a 17-point improvement that lifted the state three places, to No. 4. The 2016 index marks Minnesota's first appearance in the top five. The state ranks third in concentration of computer and mathematical operations occupations, 13th in concentration of engineers, and 11th in concentration of life and physical scientists. With a growing health technology sector, attracting new workers with the right skills to keep pace with the needs of the industry is proving challenging.[58]

Washington, Utah, California, Virginia, Alaska, and **Connecticut** round out the top 10 for this composite index. Washington fell to No. 5, losing two places. Utah gained two places, landing at No. 6. California dropped out of the top five, moving from No. 4 to No. 7. Virginia dropped from fifth to eighth. Alaska made a giant leap, from 28th to ninth, making it one the biggest gainers in this year's index. Connecticut entered the top 10 for the first time since 2008, gaining six places. The top 10 states are spread across all regions of the U.S., emphasizing the continuing geographic expansion of the U.S. high-tech sector.

AT THE BOTTOM

Mississippi, Arkansas, and **Nevada** rank 48th, 49th, and 50th, respectively. None of these states have ever been out the bottom 10 on this composite index. Mississippi lost four places, Arkansas lost six, and Nevada lost one. These three score poorly across the sub-composites, with only one indicator in the top half for each—a reflection of the dearth of high-tech or research-oriented industrial activity in these states. However, new investments such as the Tesla Gigafactory—a large-scale battery manufacturing facility in Nevada—may be reflected on future indices.

BIGGEST GAINERS

North Dakota, Wyoming, and **Alaska** saw the largest improvement in their ranks. These states benefited most from the expansion of the definition of science and technology occupations because of their large energy sectors and their high concentration of engineers engaged in mining and other natural resource extraction. North Dakota gained 34 places, from 47th to 13th, an especially strong performance attributable to shale-oil-related activity, though this may not be sustained as exploration stalls in the face of lower oil prices. North Dakota ranks fifth in concentration of engineers in its workforce, 15th in concentration of life and physical scientists, and 35th in concentration of computer and mathematics occupations. Wyoming rose from 46th to 15th place, a gain of 31 places. It ranks 15th in the life and physical scientist composite and 13th in concentration of engineers, but only 46th in concentration of computer and math occupations. Alaska moved into the top 10 from 28th, ending up at No. 9, an increase of 19 places.

FIGURE 9 **2016 Technology and Science Workforce composite index map**

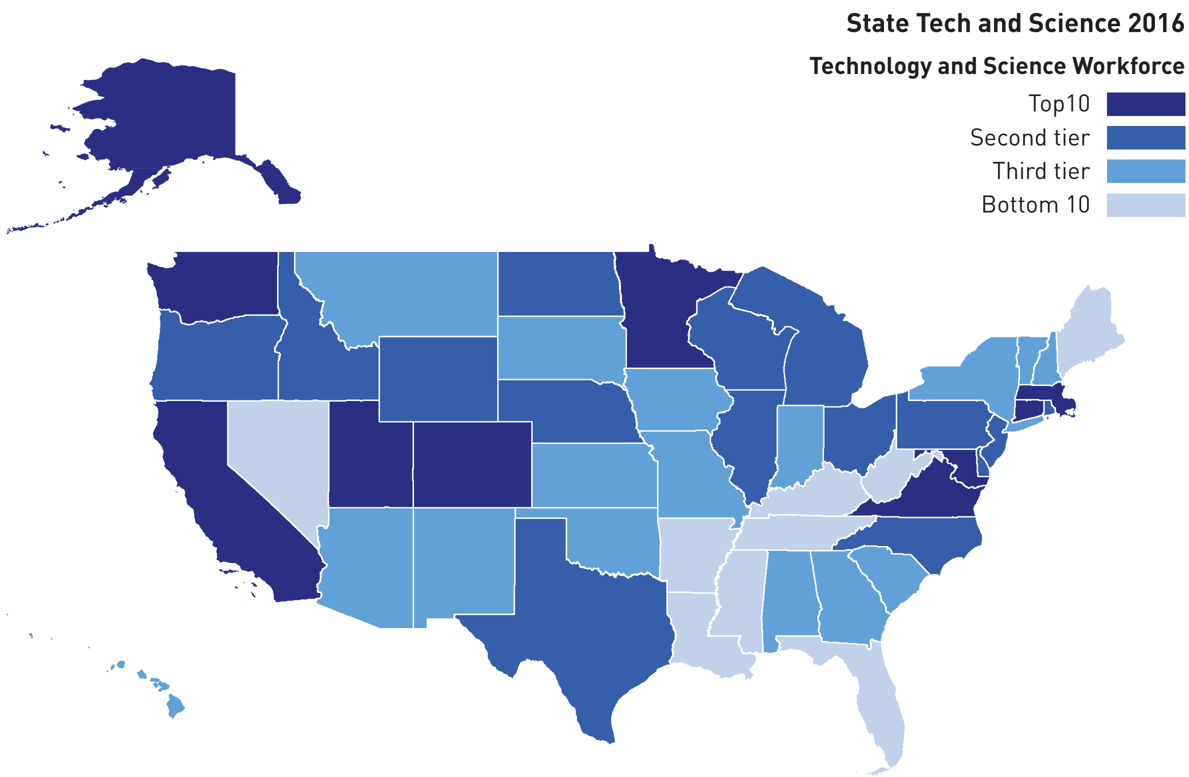
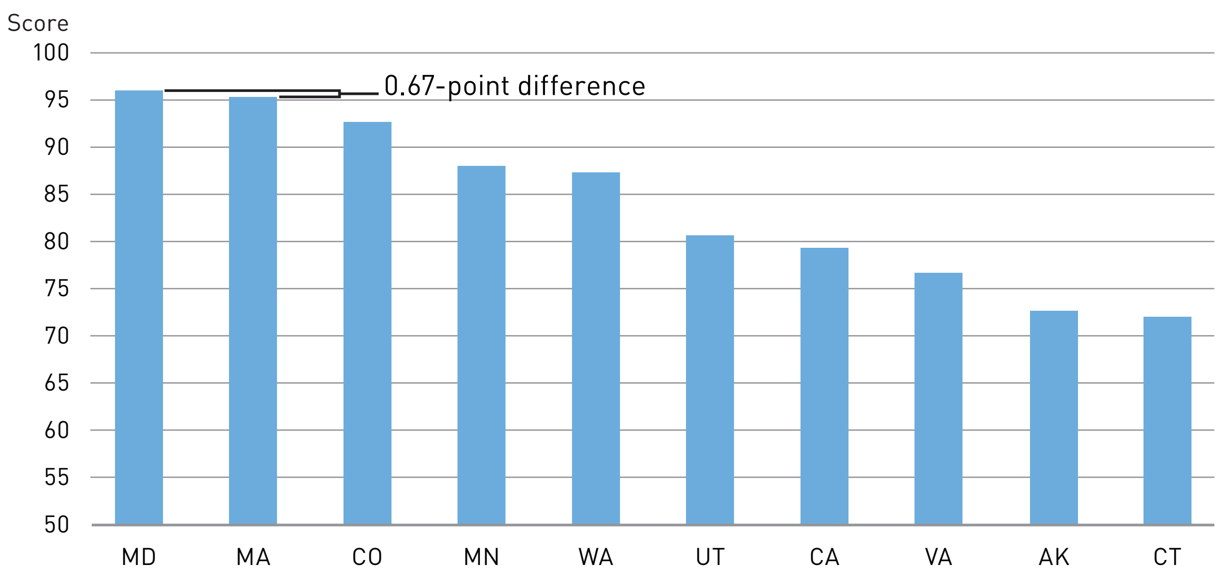


FIGURE 10 **2016 Technology and Science Workforce composite index:** Top 10 states



Source: Milken Institute.

TABLE 5 **2016 Technology and Science Workforce composite index:** State rankings

STATE	2016	2014	RANK CHANGE 2014-16	SCORE
Maryland	1	2	1	96.00
Massachusetts	2	1	-1	95.33
Colorado	3	6	3	92.67
Minnesota	4	7	3	88.00
Washington	5	3	-2	87.33
Utah	6	8	2	80.67
California	7	4	-3	79.33
Virginia	8	5	-3	76.67
Alaska	9	28	19	72.67
Connecticut	10	16	6	72.00
Nebraska	11	29	18	68.00
Delaware	12	11	-1	67.33
North Dakota	13	47	34	64.67
Pennsylvania	14	12	-2	62.67
Texas	15	10	-5	62.00
Wyoming	15	46	31	62.00
Wisconsin	17	17	0	61.33
Ohio	18	30	12	59.33
New Jersey	19	20	1	57.33
Oregon	19	33	14	57.33
North Carolina	21	19	-2	54.67
Rhode Island	21	9	-12	54.67
Michigan	23	24	1	53.33
Illinois	24	27	3	52.00
Idaho	25	23	-2	50.67
New Hampshire	26	13	-13	50.00
Arizona	27	14	-13	47.33
Indiana	28	32	4	46.67
Montana	29	36	7	46.00
South Dakota	29	37	8	46.00
New Mexico	31	18	-13	45.33
Kansas	32	21	-11	43.33
Missouri	33	25	-8	42.67
Alabama	34	22	-12	42.00
Georgia	35	15	-20	40.67
New York	36	26	-10	38.67
Iowa	37	35	-2	34.67
Vermont	38	31	-7	34.00
South Carolina	39	41	2	31.33
Hawaii	40	40	0	30.67
Oklahoma	40	39	-1	30.67
Tennessee	42	34	-8	27.33
Maine	43	42	-1	26.00
Florida	44	38	-6	20.67
Kentucky	45	45	0	16.67
Louisiana	45	50	5	16.67
West Virginia	45	48	3	16.67
Mississippi	48	44	-4	16.00
Arkansas	49	43	-6	14.67
Nevada	50	49	-1	11.33

7. TECHNOLOGY CONCENTRATION AND DYNAMISM

Background and Relevance

The evidence continues to mount that high-tech industries are crucial to maintaining state and local economic vitality. Look no further than the Milken Institute's 2015 Best-Performing Cities index, where 13 of the top 25 metropolitan areas of the country were technology centers such as San Jose, Seattle, Austin, and Raleigh.[59] It therefore isn't surprising that states with strong high-tech clusters are performing better than those without them. In the Technology Concentration and Dynamism composite index, we apply several metrics that attempt to measure the intensity and expansion of high-tech businesses by state.

Given that the intangible-based economy is driven by the ability of states and local economies to give birth to entrepreneurial-driven innovative firms, grow them, and ultimately transform them into large, multinational anchor firms, it is essential to monitor such activity. The inclusion of these smaller, high-growth firms may help accelerate the velocity of innovation and provide avenues for new entrants to the networks. This results in a flexible and sustainable configuration that continues to produce innovation and create new market opportunities.

The relevance of clusters can be illustrated in other ways. For example, DeVol and Milken Institute colleagues utilized a production function approach for U.S. metropolitan areas linking overall economic output (real GDP) per capita to patents per capita, controlling for other factors such as human capital. Innovation activity (patents) was found to be highly important in determining the variance of per-capita output.[60] Similar evidence is available at the state level.

This provides additional support for there being not just a link between innovative inputs and outputs, but locally derived innovation being captured in the clusters where it was created and translated into greater economic value for its inhabitants. These industry clusters must be able to leverage local competencies such as customer and supplier relationships, entrepreneurial infrastructure, management practices, motivation, and quality-of-place attributes that allow firms to thrive.[61]

A diverse base of industries aids technology clusters in being able to sustain themselves when industries and firms are subject to disruptive events. Clusters composed of a few technology industries are vulnerable to becoming a disadvantage during a recession.[62] Furthermore, diversity functions as a catalyst of innovation in the cluster, producing a competitive advantage for the region. Diversity also enables the rapid transmission of technologies in a collective, cumulative fashion.[63] According to Kostoff, "an advanced pool of knowledge must be developed in many fields before synthesis leading to innovation can occur."[64]

Diversity supports cross-industry collaborations, which have been a central characteristic of emerging and top-performing interdisciplinary industries. In this way, state and local economies have the ability to regenerate themselves through innovation management.[65]

Composite Index Components

After states pull in financing from public and private sources, invest in human capital, and amass a skilled workforce, what results do they produce? In essence, this composite reveals each state's entrepreneurial, governmental, and policymaking success (or failure) based on high-tech employment, payroll activity, net business formations, and growth:

High-tech employment: High-tech businesses are vital to a region's economic growth, especially given that jobs in this sector typically command above-average salaries. Drawing comparisons between employment and establishments in the high-tech sector with salaries being paid to high-tech workers allows analysts to determine the quality of jobs being created in the sector and in the economy as a whole. We look at the percent of high-tech businesses, employment, and payroll in each state.

High-tech business births: New companies are a sign of economic stability and optimism—and business births in the technology sector are particularly important because regional prosperity during the past three decades has been linked to high-tech expansion. This indicator looks at net formation of high-tech business establishments and percent of business births in the tech sector.

High-performing tech companies: The number of companies named in Deloitte's Technology Fast 500—an index that identifies the fastest-growing private tech companies—reflects the growth and expansion of the high-tech sector. We also look at the Inc. 500 rankings for a general snapshot of all companies. Taken together, they measure how well tech firms are performing against a wider field.

Growth in tech-sector industries: To see which industries in the high-tech sector are more successful in various regions, we look at the average yearly growth in high-tech industries to capture where technology has grown fastest in the past five years, the number of industries that are growing faster than the U.S. average, and high-tech industries with a location quotient (LQ) higher than 1.0, which indicates how prevalent those industries are in a region.

State Rankings

This index is split between indicators that measure quantities and flows. The movement in this index comes from growth and development of the high-tech sector.

AT THE TOP

Maryland moved up two places to take the top spot on this index. With strong showings in many of the indices both this year and in the past, Maryland is becoming an essential part of the nation's high-tech industry. With a strong showing in stock measures and a decent showing in growth measures, the state appears to be in a transition to a more established tech hub. MedStar Health, the university health-care systems, Northrop Grumman, and Lockheed Martin are all major employers in the state. The state's ability to provide the science, engineering, and tech sectors with resources is necessary to provide long-term stable economic conditions.[66]

California just missed the top spot this year, scoring 79.33, less than a point behind Maryland. California's mature tech hub in Silicon Valley is joined by the development of newer centers of activity. This diversification can be seen in the state's strength in the growth measures as well as the stock measures. California claimed the No. 1 spots for formation of high-tech companies and for total companies on the Fast 500 list. Silicon Valley and San Diego represent the cutting edge in science and technology. Innovations in the tech sector have revealed Los Angeles to be an emerging-tech center, with companies such as Snapchat and TrueCar located in Silicon Beach.

Colorado returned to the top five, moving up five places to land at No. 3. Scoring 78.67, the state improved upon its performance on our 2014 index. With slight improvements in the stock measures that make up this this index but a lack of improvement on the growth measures, Colorado has been transitioning from the fast-paced growth of a newer tech hub to more established patterns of tech hubs like California. Colorado has made its mark in the startup scene with names like Zayo, Webroot, Level3 and SolidFire. These home grown companies represent cybersecurity, cloud computing, and the ever changing B2B space.[67, 68]

Texas ranks No. 4, reaching the top five for the first time. Texas gained five spots from 2014, scoring 74.44. In 2016, high scores on net formation of high-tech businesses (second), number of companies on the Inc. 500 list (fifth), and the number of high-tech Industries with LQs higher than 1.0 (sixth) all contributed to Texas' improved ranking. The state continues to make its mark on the tech world with longtime resident companies such as Texas Instruments and Dell. Austin is seeing a strong startup community with names like RetailMeNot, Rackspace and uShip.com. Texas has changed the national tech landscape.[69, 70]

Massachusetts, North Carolina, Virginia, Washington, Georgia, Connecticut, and **New Hampshire** round out the top 10, with Connecticut and New Hampshire tied for 10th place. Massachusetts and North Carolina are also tied for fifth place. Washington dropped from second to eighth this year. Georgia and Connecticut both broke into the top 10 for the first time on this composite. Washington state has become the cloud computing capital. With Amazon and Microsoft dominating the tech landscape, firms like Valve, Zillow, T-Mobile, and Tableau represent responses to the changes in the tech world.

AT THE BOTTOM

North Dakota, South Dakota, and **West Virginia** are in the bottom three spots. **South Dakota** moved up two places, but it remains near the bottom, tied with North Dakota for 48th place. West Virginia dropped 13 spots, while **North Dakota** fell 15. The one bright spot for **South Dakota** is its 11th-place showing in growth in high-tech employment above the U.S. national average, though this growth is off a small base. The massive drop in oil prices has hurt North Dakota's engineering and science sectors, but there are bright spots in the energy sector. For example, the Sunflower Wind Project has found contractors for construction of the wind farm.[71]

BIGGEST GAINERS

Wyoming, Nevada, and **Michigan** improved the most in the rankings from 2014 to 2016. Wyoming made the largest gain, moving up 17 places to No. 31. It scored high in five-year annual growth and industries employment growth faster than the U.S. average, ranking seventh and first, respectively. Nevada ranks third in industries employment growth faster than the U.S. average. Michigan's strong indicators include an eighth-place finish in net formation of high-tech establishments and ninth in high-tech industries with employment growing faster than the U.S. average. Michigan has a highly skilled workforce and this talent is beginning to be utilized. Companies such as Accio Energy, Duo Security, and Sakti3 are all working on technologies that have reshaped the high-tech landscape.[72]

FIGURE 11 2016 Technology Concentration and Dynamism composite index map

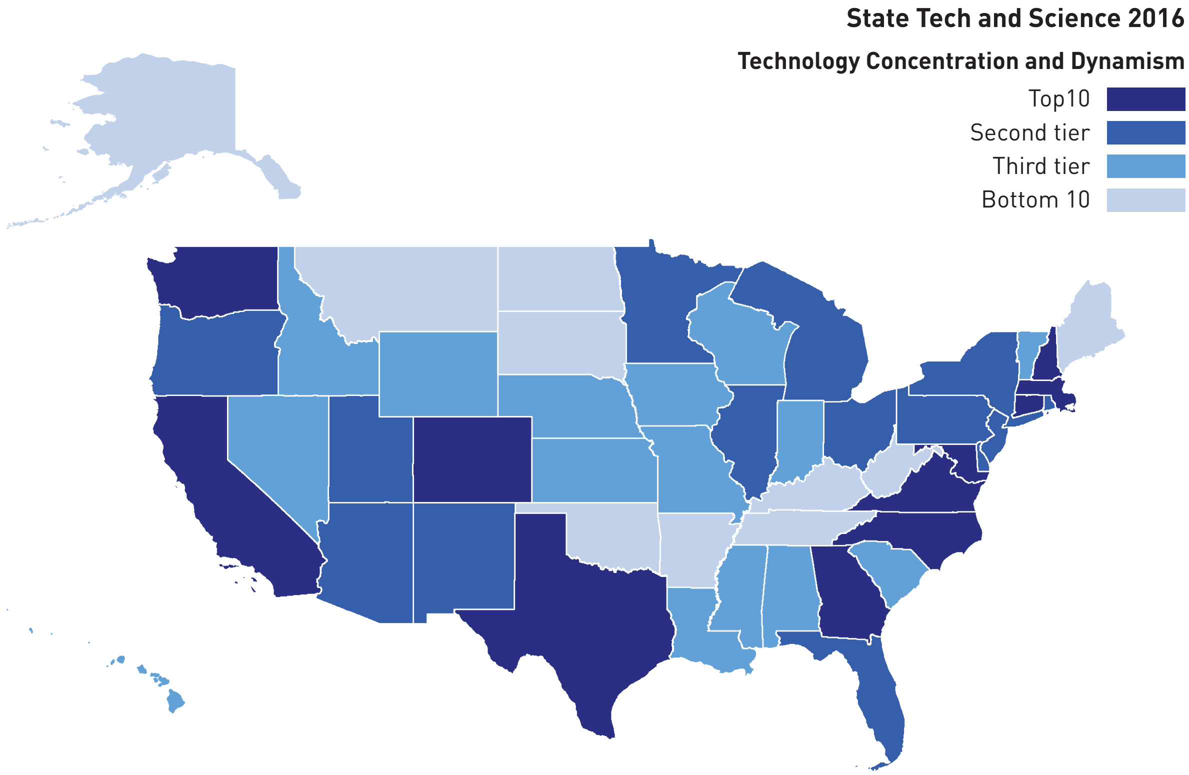
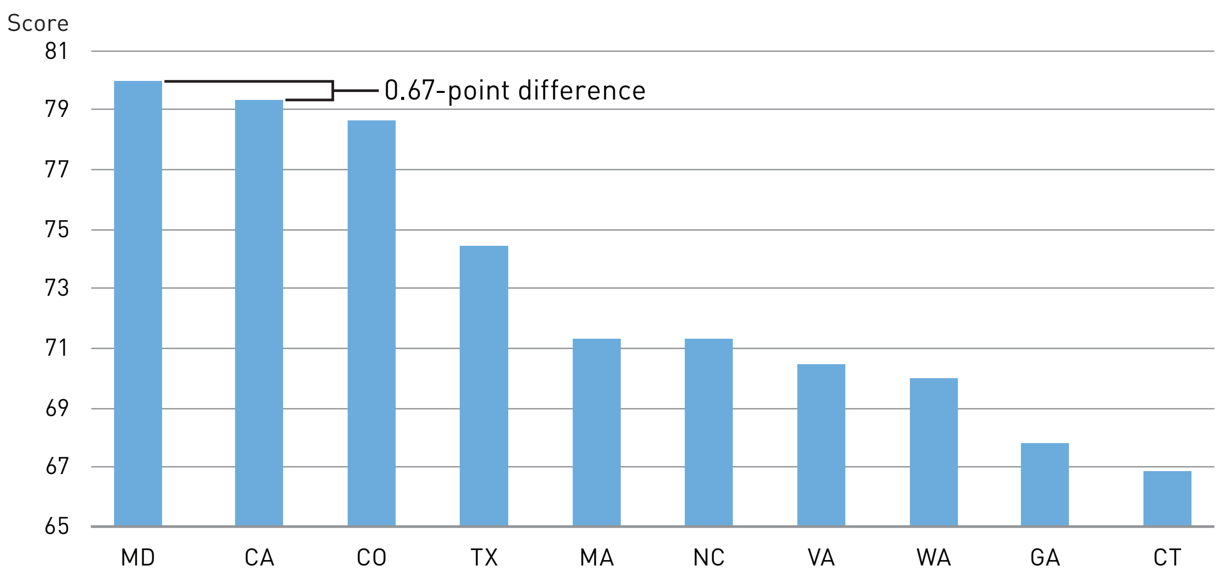


FIGURE 12 **2016 Technology Concentration and Dynamism composite index:** Top 10 states



Source: Milken Institute.

TABLE 6 **2016 Technology Concentration and Dynamism:** State rankings

STATE	2016	2014	RANK CHANGE 2014 -16	SCORE
Maryland	1	3	2	80.00
California	2	5	3	79.33
Colorado	3	8	5	78.67
Texas	4	9	5	74.44
Massachusetts	5	4	-1	71.33
North Carolina	5	7	2	71.33
Virginia	7	6	-1	70.44
Washington	8	2	-6	70.00
Georgia	9	11	2	67.78
Connecticut	10	21	11	66.89
New Hampshire	10	17	7	66.89
Delaware	12	13	1	64.44
Utah	13	1	-12	63.56
Pennsylvania	14	26	12	62.89
Minnesota	15	20	5	61.56
Michigan	16	30	14	61.33
Oregon	17	10	-7	60.00
Illinois	18	23	5	59.56
New Jersey	19	14	-5	58.22
Arizona	20	16	-4	57.78
Florida	20	26	6	57.78
Rhode Island	22	18	-4	54.00
New Mexico	23	31	8	53.78
New York	24	12	-12	53.33
Ohio	25	32	7	51.56
Missouri	26	35	9	50.67
Kansas	27	28	1	49.78
Nevada	28	43	15	48.00
Indiana	29	24	-5	45.33
Vermont	30	15	-15	44.22
Wyoming	31	48	17	41.11
Hawaii	32	36	4	40.22
Mississippi	32	44	12	40.22
South Carolina	32	29	-3	40.22
Alabama	35	39	4	39.33
Louisiana	36	40	4	38.67
Nebraska	36	38	2	38.67
Wisconsin	38	25	-13	37.11
Idaho	39	34	-5	36.44
Iowa	40	42	2	36.00
Tennessee	41	45	4	35.33
Kentucky	42	46	4	35.11
Alaska	43	22	-21	32.44
Maine	43	47	4	32.44
Arkansas	45	40	-5	30.22
Oklahoma	45	49	4	30.22
Montana	47	19	-28	29.11
North Dakota	48	33	-15	28.44
South Dakota	48	50	2	28.44
West Virginia	50	37	-13	22.44

8. APPENDIX: LIST OF COMPONENTS IN EACH COMPOSITE INDEX

RESEARCH AND DEVELOPMENT INPUTS	
Federal R&D Dollars per Capita	National Science Foundation (NSF)
Industry R&D Dollars per Capita	NSF
Academic R&D Dollars per Capita	NSF, Academic R&D Expenditure
National Science Foundation Funding	NSF, Experimental Program to Stimulate Competitive Research
National Science Foundation Research Funding	NSF, Experimental Program to Stimulate Competitive Research
R&D Expenditures on Engineering	NSF, Academic R&D Expenditure
R&D Expenditures on Physical Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Environmental Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Math and Computer Science	NSF, Academic R&D Expenditure
R&D Expenditures on Life Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Agricultural Sciences	NSF, WebCASPAR
R&D Expenditures on Biomedical Sciences	NSF, WebCASPAR
STTR Awards per 10,000 Businesses	Small Business Administration, U.S. Census Bureau
STTR Award Dollars	Small Business Administration
SBIR Awards per 100,000 People	Small Business Administration
SBIR Awards per 10,000 Businesses (Phase I)	NSF, Experimental Program to Stimulate Competitive Research (EPSCoR)
SBIR Awards per 10,000 Businesses (Phase II)	NSF, EPSCoR
Competitive NSF Proposal Funding Rate	NSF, EPSCoR
RISK CAPITAL AND ENTREPRENEURIAL INFRASTRUCTURE	
Total Venture Capital Investment Growth	PricewaterhouseCoopers/National Venture Capital Association MoneyTree Report, Thomson Financial
Number of Companies (Deals) Receiving VC per 10,000 Firms	PricewaterhouseCoopers/National Venture Capital Association MoneyTree Report, Thomson Financial
Growth in Number of Companies (Deals) Receiving VC	PricewaterhouseCoopers/National Venture Capital Association MoneyTree Report, Thomson Financial
Venture Capital Investment as Percent of GSP	PricewaterhouseCoopers/National Venture Capital Association MoneyTree Report, Thomson Financial
SBIC Funds Disbursed per $1,000 of GSP	Small Business Administration
Business Incubators per 10,000 Establishments	National Business Incubation Association, U.S. Census Bureau
Patents Issued per 100,000 People	U.S. Patent and Trademark Office
Business Starts per 100,000 People	U.S. Census Bureau
IPO Proceeds as Percent of GSP	Securities Data Corporation, Thomson Financial
VC Investment in Nanotechnology as Percent of GSP	Thomson Financial
VC Investment in Clean Technology as Percent of GSP	Thomson Financial
Sum of Equity Invested in Green Tech per $100,000 GSP	Thomson Financial
HUMAN CAPITAL INVESTMENT	
Percentage of Population with Bachelor's Degrees or Higher	U.S. Department of Education
Percentage of Population with Advanced Degrees	U.S. Department of Education
Percentage of Population with PhDs	U.S. Department of Education
Graduate Students in Science and Engineering	NSF, EPSCoR

Per Capita State Spending on Student Aid	NSF, EPSCoR
Average Verbal SAT Scores	NSF, EPSCoR
Average Math SAT Scores	NSF, EPSCoR
Average ACT Scores	NSF, EPSCoR
State Appropriations for Higher Education (per Capita)	NSF, EPSCoR
Percent Change in State Appropriations for Higher Education	NSF, EPSCoR
Doctoral Scientists per 100,000 People	NSF, Division of Science Resources Studies
Doctoral Engineers per 100,000 People	NSF, Division of Science Resources Studies
Science and Engineering PhDs Awarded	NSF, Division of Science Resources Studies
Science and Engineering Postdoctorates Awarded	NSF, Division of Science Resources Studies
Percentage of Bachelor's Degrees in Science and Engineering	National Center for Education Statistics, U.S. Department of Education
Recent Bachelor's Degree in Science and Engineering	NSF, Division of Science Resources Studies
Recent Master's Degree in Science and Engineering	NSF, Division of Science Resources Studies
Recent PhD Degree in Science and Engineering	NSF, Division of Science Resources Studies
Recent Degrees in Science and Engineering	NSF, Division of Science Resources Studies
Percentage of Households With Computers	U.S. Department of Commerce
Percentage of Households With Internet Access	U.S. Department of Commerce
TECHNOLOGY AND SCIENCE WORKFORCE	
Intensity of Computer and Information Research Scientists	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Systems Analysts	Bureau of Labor Statistics, Milken Institute
Intensity of Information Security Analysts	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Programmers	Bureau of Labor Statistics, Milken Institute
Intensity of Software Developers, Applications	Bureau of Labor Statistics, Milken Institute
Intensity of Software Developers, Systems Software	Bureau of Labor Statistics, Milken Institute
Intensity of Web Developers	Bureau of Labor Statistics, Milken Institute
Intensity of Database Administrators	Bureau of Labor Statistics, Milken Institute
Intensity of Network and Computer Systems Administrators	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Network Architects	Bureau of Labor Statistics, Milken Institute
Intensity of Computer User Support Specialists	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Network Support Specialists	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Occupations, All Other	Bureau of Labor Statistics, Milken Institute
Intensity of Operations Research Analysts	Bureau of Labor Statistics, Milken Institute
Intensity of Statisticians	Bureau of Labor Statistics, Milken Institute
Intensity of Aerospace Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Biomedical Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Chemical Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Civil Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Computer Hardware Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Environmental Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Industrial Engineers	Bureau of Labor Statistics, Milken Institute

Intensity of Materials Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Mechanical Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Mining and Geological Engineers, Including Mining Safety Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Nuclear Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Petroleum Engineers	Bureau of Labor Statistics, Milken Institute
Intensity of Engineers, All Other	Bureau of Labor Statistics, Milken Institute
Intensity of Soil and Plant Scientists	Bureau of Labor Statistics, Milken Institute
Intensity of Biochemists and Biophysicists	Bureau of Labor Statistics, Milken Institute
Intensity of Microbiologists	Bureau of Labor Statistics, Milken Institute
Intensity of Zoologists and Wildlife Biologists	Bureau of Labor Statistics, Milken Institute
Intensity of Biological Scientists, All Other	Bureau of Labor Statistics, Milken Institute
Intensity of Medical Scientists, Except Epidemiologists	Bureau of Labor Statistics, Milken Institute
Intensity of Life Scientists, All Other	Bureau of Labor Statistics, Milken Institute
Intensity of Physicists	Bureau of Labor Statistics, Milken Institute
Intensity of Atmospheric and Space Scientists	Bureau of Labor Statistics, Milken Institute
Intensity of Chemists	Bureau of Labor Statistics, Milken Institute
Intensity of Materials Scientists	Bureau of Labor Statistics, Milken Institute
Intensity of Environmental Scientists and Specialists, Including Health	Bureau of Labor Statistics, Milken Institute
Intensity of Geoscientists, Except Hydrologists and Geographers	Bureau of Labor Statistics, Milken Institute
Intensity of Physical Scientists, All Other	Bureau of Labor Statistics, Milken Institute
Intensity of Agricultural and Food Science Technicians	Bureau of Labor Statistics, Milken Institute
Intensity of Biological Technicians	Bureau of Labor Statistics, Milken Institute
Intensity of Chemical Technicians	Bureau of Labor Statistics, Milken Institute
Intensity of Nuclear Technicians	Bureau of Labor Statistics, Milken Institute
TECHNOLOGY CONCENTRATION AND DYNAMISM	
Percent of Businesses in High-Tech NAICS Codes	Bureau of Labor Statistics, Milken Institute, U.S. Census Bureau
Percent of Employment in High-Tech NAICS Codes	Bureau of Labor Statistics, Milken Institute, U.S. Census Bureau
Percent of Payroll in High-Tech NAICS Codes	Milken Institute, U.S. Census Bureau
Net Formation of High-Tech Establishments	U.S. Census Bureau
Number of Technology Fast 500 Companies	Deloitte & Touche; U.S. Census Bureau
Average Yearly Growth of High-Tech Industries	Moody's Economy.com; Milken Institute
High-Tech Industries with Employment Growing Faster Than U.S. Average	Moody's Economy.com; Milken Institute
High-Tech Industries With LQs Higher Than 1.0	Moody's Economy.com; Milken Institute
Number of Inc. 500 Companies	Inc. Magazine, U.S. Census Bureau

* All population statistics are from the U.S. Census Bureau. All Gross State Product figures are from the U.S. Department of Commerce.

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