Milken Institute

State Technology and Science Index

Enduring Lessons for the Intangible Economy

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The Milken Institute is an independent economic think tank whose mission is to improve the lives and economic conditions of diverse populations in the U.S. and around the world by helping business and public policy leaders identify and implement innovative ideas for creating broad-based prosperity. We put research to work with the goal of revatalizing regions and finding new ways to generate capital for people with original ideas.

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Executive Summary

The late-2000 bursting of the dot-com, technology and telecom bubbles, and the subsequent collateral damage as it rippled through many regions and states, caused some to question the efficacy of economic development based upon technology and science. Many point to the experience of Silicon Valley and other previously high-flying tech centers such as Denver, Seattle and Dallas. After exceptional technology-fueled economic growth in the second half of the 1990s, Silicon Valley has shed nearly 20 percent of its employment base. Silicon Valley's and other tech centers' recent experience illustrates the unique characteristics of this business cycle—the associated volatility of being at the leading edge of innovation, and the lack of immunity, even for the technology capital of the world, from herd mentality and group think.

In the Institute's first report of California's position in technology and science, based upon our *State Technology and Science Index*, we stressed the need for states to recognize the new realities of the intangible economy. In the intervening time, however, the nuances of those realities have themselves taken on new meanings. This mandate remains unchanged as states' economic future is wedded to their technology prowess.

The engines that propel state and regional economies forward today differ dramatically from the engines of the past. The old engines of economic success were the accumulation of physical assets, proximity to waterways, railways, raw materials and the manufacturing infrastructure that developed around them such as cheap labor.

The new engine of regional economic prosperity is based upon how successful a given location is in attracting and expanding technology and science assets and leveraging them for economic development. State and regional economic performance is determined by how effectively it uses its comparative advantages to create and expand knowledge assets and convert them into economic value. States succeeding in technology-based growth will push income per capita higher, especially relative to those states that falter. Most of the critical elements for success are intangible.

As pointed out in the 2002 Index, the notion of a New Economy has often been mischaracterized and even more often misunderstood. What economists really have been describing with growing frequency in recent years is the movement from a tangible-asset to an intangible-asset-based economy. The economy is not itself new, but the relative importance of economic assets has been fundamentally transformed. In an intangible economy, concepts such as patents, copyrights, customer relationships, brand value, unique institutional designs, the value of future products and services, and their structural capital (corporate culture, systems, and processes) become ever more important to firms. Most of the value of the intangible economy is anchored to a firm's stock of human capital and to the locations in which they reside.

In order to provide a benchmark assessment for states, and provide a means to monitor progress, we have utilized our **State Technology and Science Index**. This index encapsulates a comprehensive inventory of technology and science assets that can be leveraged to promote economic development. The State Technology and Science Index is composed of five equally-weighted major composites—Research & Development Inputs, Risk Capital and Infrastructure, Human Capital Investment, Technology and Science Workforce, and Technology Concentration and Dynamism.

There are 75 individual indicators that comprise the five major composites and are listed in the appendix. To achieve a score of 100 on any of the major composites, a state would have to rank 1st in each of the indicator components. Second place was assigned a score of 98; a 3rd-place ranking gave a state a score of 96 and so forth until the 50th-place ranking was assigned a score of 2. The individual category scores were averaged for the composites to which they were assigned and the five composite were then averaged for the overall score. Each indicator was benchmarked to a relevant measure such as population, Gross State Product or number of establishments. This adjusts for the absolute size of a state's economy.

State Technology and Science Index and Findings

National State Technology & Science Index
Overall Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Massachusetts	MA	1	1	0	84.35
California	CA	2	3	1	78.86
Colorado	CO	3	2	-1	78.77
Maryland	MD	4	4	0	78.19
Virginia	VA	5	5	0	72.27
Washington	WA	6	6	0	69.87
New Jersey	NJ	7	7	0	69.03
Minnesota	MN	8	10	2	67.49
Utah	UT	9	9	0	66.49
Connecticut	CT	10	8	-2	66.26
Rhode Island	RI	11	21	10	64.01
New Hampshire	NH	12	13	1	63.43
Delaware	DE	13	11	-2	62.51
New Mexico	NM	14	20	6	61.75
New York	NY	15	12	-3	60.66
Pennslyvania	PA	16	16	0	60.36
Arizona	AZ	17	18	1	58.47
Georgia	GA	18	15	-3	58.10
Oregon	OR	19	23	4	57.76
North Carolina	NC	20	17	-3	57.28
Illinios	IL	21	19	-2	56.59
Vermont	VT	22	31	9	56.00
Texas	TX	23	14	-9	54.91
Ohio	OH	24	27	3	54.18
Michigan	MI	25	24	-1	54.01

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Kansas	KS	26	22	-4	53.12
Wisconsin	WI	27	25	-2	51.76
Nebraska	NE	28	32	4	50.91
Indiana	IN	29	30	1	50.73
Idaho	ID	30	26	-4	49.03
Missouri	MO	31	28	-3	48.11
Florida	FL	32	29	-3	44.47
Maine	ME	33	36	3	43.47
Tennessee	TN	34	40	6	42.77
Oklahoma	OK	35	37	2	42.65
Alabama	AL	36	33	-3	42.36
Iowa	IA	37	35	-2	41.90
Montana	MT	38	34	-4	40.65
Hawaii	HI	39	43	4	40.05
Alaska	AK	40	39	-1	39.91
Wyoming	WY	41	38	-3	38.72
Louisiana	LA	42	44	2	36.66
Nevada	NV	43	42	-1	36.09
South Carolina	SC	44	41	-3	35.94
North Dakota	ND	45	45	0	34.55
West Virginia	WV	46	48	2	33.65
South Dakota	SD	47	47	0	33.31
Kentucky	KY	48	46	-2	32.61
Arkansas	AR	49	50	1	29.53
Mississippi	MS	50	49	-1	27.48
State Average					**52.64**

The State Technology and Science Index encapsulates a state's comprehensive inventory of technology and science assets that can be leveraged to promote economic development. Its research and development capabilities can be commercialized for future regional and state technology growth. A state's entrepreneurial capacity and risk capital infrastructure comprise the fuel that determines the success rate of converting research into commercially viable technology services and products. Human capital is the most important intangible asset of a regional or state economy.

The intensity of a state's technology and science workforce indicates whether that state has sufficient depth of high-end technical talent on the ground. Technology concentration and dynamism can be viewed as a measure of technology outcomes. Measuring technology growth points to policymakers' and other stakeholders' effectiveness in transforming regional assets into regional prosperity.

Massachusetts holds a dominant 1st-place position in the 2004 State Technology and Science Index with an overall score of 84.4. Massachusetts was 1st in three of the five components and its lowest position was 3rd. California's overall score of 78.9 ranks the state 2nd in the nation, about 5.5 index points behind 1st-place Massachusetts. Colorado—a mere 0.09 index points behind California—was 3rd, with the highest score in Human Capital Investment in the country. Maryland was a very close 4th overall and challenged Massachusetts for the top position in Technology and Science Workforce component. Virginia (72.3 score) was 5th overall and 1st in Technology Concentration and Dynamism. Washington (69.9 score) was 6th, New Jersey (69.0 score) 7th, Minnesota (67.5 score) 8th, Utah (66.5 score) 9th, and Connecticut 10th, with an overall score of 66.3.

Massachusetts' score in Research & Development (92.2) placed it almost 12 index points above 2nd-place California. This was the highest score on any of the five components and the largest gap between 1st and 2nd place. Massachusetts is also1st in the nation for total funds in industrial scientific R&D and in venture capital dedicated to biotechnology and the medical device industry. Massachusetts retains its 2002 position, 1st overall. California's ranking represents an improvement over the 2002 Index where it placed 3rd. Given the state's virtual tie with Colorado and 1st place Massachusetts' continued sizable lead, however, despite California's top-tier ranking, there is ample room for improvement. On the other hand, the diversity of California's technology clusters gives it a unique position among states.

Colorado's position is a strong one and it ranked 1st in one of the five components while 2nd-place California did not hold any number one placements. Colorado's lowest position on any of the components was 5th. Taking a mid-course correction, Colorado's Governor Owens signed legislation ending the certified capital corporations (CAPCOs) because of poor investment returns and redirected $50 million to a new Colorado Venture Capital Authority to provide capital to businesses throughout the state. Maryland held its 4th-place position of 2002. Maryland's most poignant strengths are in the life sciences and communications technology, two sectors with extremely bright long-term prospects, and where it has some of the best and deepest talent in the nation. Maryland's lowest position was 6th and all of its other Composite Index scores are in the top five. Unless there is a serious deterioration in performance, these input measures are likely to help raise Maryland's concentration and dynamism performance. A recent set of recommendations provided by Governor Erlich's Commission on Development of Advanced Technology Business is one of the most forward looking roadmaps for technology-based economic development.

Virginia's high score (90.4) in Technology Concentration & Dynamism placed it more than four index points above the 2nd-place state, Colorado. This indicates great potential for the future. Virginia and Colorado, which in a relatively short time have developed vibrant and expanding high-tech economies, offer more attractive cost structures than states such as Massachusetts and California, and are closing the gap. Now occupying the top two positions in the Technology Concentration & Dynamism Compound Index, Virginia and Colorado could easily pull farther ahead of the more mature high-tech economies of 3rd-place Massachusetts and 4th-place California in this category, and boost their overall position in the future.

Massachusetts does not appear to be taking its position for granted. Governor Romney proposed some major technology-based economic development investments last September, but vetoed some of the measures that the legislature passed. The Governor cited budget concerns. When the legislature reconvened in its 2004 session, it overrode $67 million in funding that had been vetoed. The initiatives range from regional Centers of Excellence to funding targeted investment in emerging technologies.

California's public policy appears to be moving in the opposite direction, calling into question whether it will retain its position in the future. One of the budget proposals calls for cutting incoming college freshman enrollment in the fall by over 7,000 in University of California and Cal State systems in response to the state's fiscal crisis. California may lose many students to other states and some that stay won't enter science and engineering programs that might have enrolled.

Washington recorded a top 10 position in four of the five composite indices and was 13th on the remaining one. It was first in the nation in business starts for the latest year available. Washington's 6th–place position in 2004 ties its 2002 performance. Governor Locke has proposed a new tax incentive program for R&D and jobs in rural areas of Washington, in the hopes of enhancing Washington's position. New Jersey remained 7th in 2004, principally due to its high position in the areas of technology and science workforce, and technology concentration and dynamism. Among technology and science occupations, New Jersey scores in the top five in Computer & I.S. Experts and Life & Physical Scientists, reflecting its strength in pharmaceuticals and telecommunications. Governor McGreevey is attempting to extend New Jersey's strong position in life sciences by proposing that the state fund controversial stem cell research and requesting a 50 percent increase in New Jersey's technology tax credit transfer program.

Minnesota improved two positions relative to the 2002 index, moving up to 8th-place. Minnesota improved its ranking in four out of the five components and recorded the largest gain in Research & Development. Governor Pawlenty has proposed a bonding bill to the legislature that would forge a new research partnership between the Mayo Clinic and the University of Minnesota in the biosciences area. His aim is to increase the effectiveness of research in the state. Utah retained its 9th–place position overall and its best placement was in technology concentration and dynamism, where it captured the highest number of Inc. 500 companies per 10,000 business establishments. Utah is taking action to foster its position in the future. Legislators recently passed a constitutional amendment, which if approved by voters, would permit universities to take ownership in private business in exchange for intellectual property. Connecticut scored best in human capital investment.

Mississippi is 50th on the 2004 overall index with a score of 27.5, a reduction in one position from 2002. Mississippi was last in the technology concentration and dynamism component, with recent growth performance its weakest area, representing the wrong direction in momentum. Mississippi might want to pay attention to the McCoy Working Group's recommendations which strongly suggest that the state must quickly commit substantial resources to higher education if it wants to make the state relevant in the intangible economy. Arkansas moved up to 49th overall, but had its best scores in recent growth. Kentucky slipped two notches to 48th in 2004 with its biggest regression in risk capital and entrepreneurial infrastructure.

South Dakota is 47th in 2004, and while it didn't slip relative to 2002, its recent growth performance deteriorated. Governor Rounds' 2010 Initiative seems to be a step in the right direction. Among other things, it calls for a loan program for entrepreneurs and start-up companies that do business in their home state. West Virginia inched up two positions in 2004 to 46th with a big improvement in measures of risk capital and entrepreneurial infrastructure. North Dakota remained at 45th in the 2004 index. South Carolina fell three positions to 44th with slippage in four out of the five components. South Carolina just unveiled a $500 million technology-based economic development package that targets life sciences, commits state funds to venture capital and facility and infrastructure improvements at the state's three research universities. It may be behind other states in making these investments, but at least corrective actions are under way. Nevada was 43rd in 2004, followed by 42nd-place Louisiana, which improved by two positions relative to 2002. Wyoming rounds out the bottom 10 with a score of 38.7.

Rhode Island holds the distinction of recording the most improvement. Rhode Island rose from 21st in 2002 to 11th in 2004, almost cracking the top 10. Rhode Island jumped 24 places in risk capital and entrepreneurial infrastructure with the biggest gain in IPO proceeds. Additionally, Rhode Island had a sizable increase in technology and science workforce. The state seems committed to seeding investments in its future as Governor Carcieri unveiled a fiscal year 2005 budget calling for some aggressive technology-based economic development initiatives. Just behind Rhode Island in the most improved category was Vermont, which rose 9 positions in the 2004 Index to 22nd. Vermont improved in all five components, but experienced its best performance in risk capital and entrepreneurial infrastructure. Vermont had a dramatic increase in industrial R&D as well.

New Mexico and Tennessee both improved by six positions in 2004. New Mexico rose to 14th in 2004. New Mexico's best performance was in measures of growth in venture capital funding. Tennessee, at 34th, moved up due to better human capital scores and venture capital. Hawaii, Nebraska and Oregon each improved by four positions in 2004. The inclusion of R&D in agricultural sciences and Hawaii's better score in industry R&D advanced that state. Nebraska benefited by the inclusion of R&D in agricultural sciences as well, but witnessed solid improvement in several areas. Oregon saw notable gains in research and development and in human capital investment.

The Eastern United States continues its dominance of the overall Index, with 1st-ranked Massachusetts, 4th-ranked Maryland, 5th-ranked Virginia, 7th-ranked New Jersey, and 10th -ranked Connecticut constituting half of the top 10 category. The West's 2nd-ranked California, 3rd-ranked Colorado, 6th-ranked Washington, and 9th-ranked Utah virtually round out the top 10, making the upper tier of the Index basically a bicoastal cohort. Only Minnesota, as it did in the 2002 Index year, managed a place in the top 10, giving at least one position among the top 10 to a region beyond the East Coast or American West.

On the opposite end of the ranking spectrum, the Deep South has the unenviable position of dominating the bottom 10 with 42nd-ranked Louisiana, 44th-ranked South Carolina, 49th-ranked Arkansas, and 50th-ranked Mississippi. The less populous states of the West (41st-place Wyoming, 43rd-ranked Nevada), Midwest (45th-ranked North Dakota, 47th-ranked South Dakota), and Northern-most areas of the South (46th-ranked West Virginia, 48th-ranked Kentucky) round out the bottom-tier.

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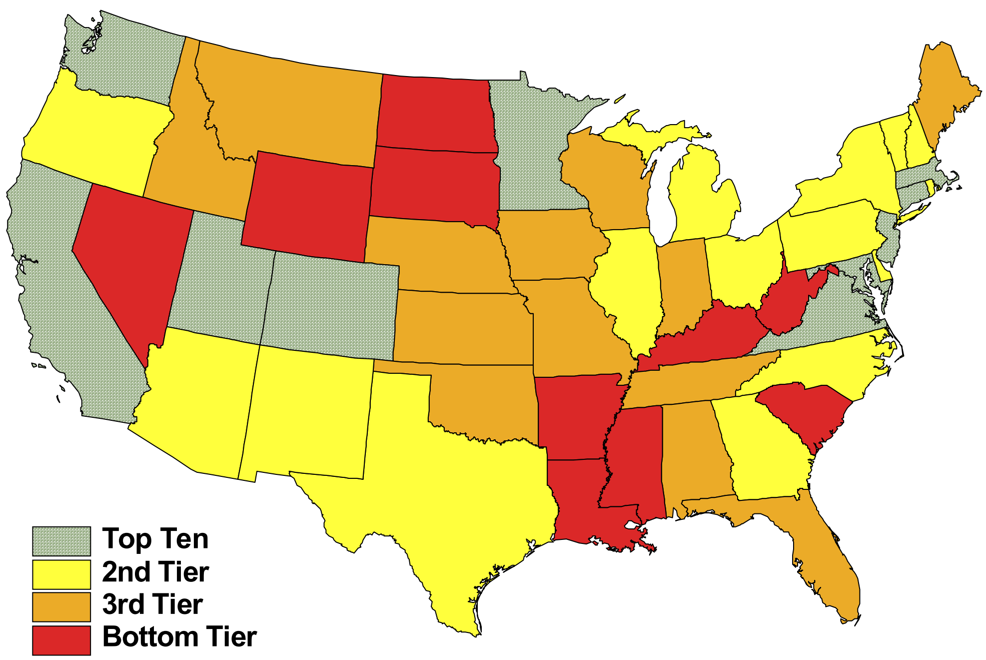
2004



Statistical Relationships

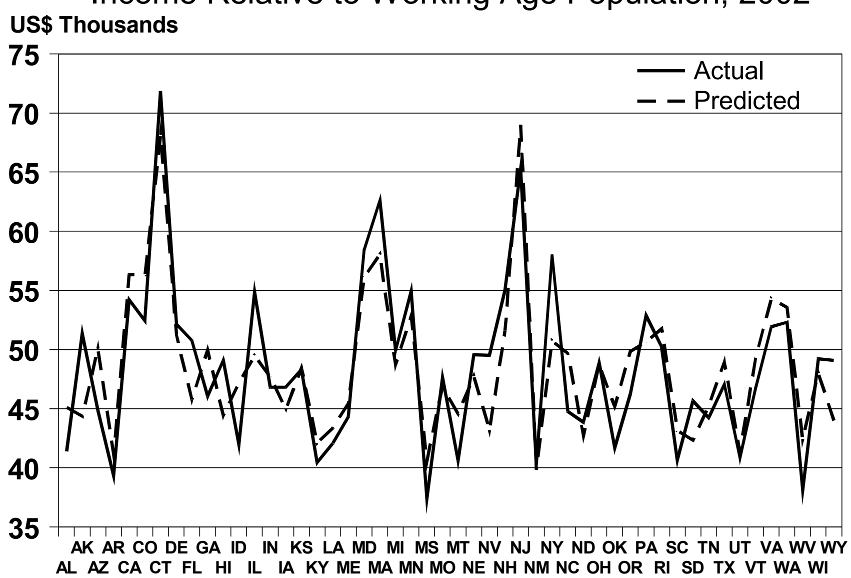
Having provided theoretical arguments for the validity of the State Technology and Science Index in measuring the current infrastructure and prospects for success in an intangible-based economy, it is critical to examine whether it means anything in a statistical sense. To test the relationships, we utilized regression analysis and various econometric techniques. Regression analysis looks at how changes in a dependent variable can be explained by movements in several independent variables. It tests the relative importance of each independent variable in explaining movements in the dependent variable and the overall explanatory power of the relationship.

One of the many tests we performed was to measure how much of the Technology Concentration and Dynamism composite could be explained in a statistical sense across states on the basis of movement in the other four composites. As was stated earlier, the Technology Concentration and Dynamism component can be considered an outcomes measure.

This equation was able to explain nearly 84 percent of the variation of the Technology Concentration and Dynamism across states—a very strong statistical relationship. All four independent variables were highly significant, but the Risk Capital and Entrepreneurial Infrastructure composite was the most important single variable in explaining technology outcomes across states.

Per Capita Income & Tech and Science Index

Income Relative to Working Age Population, 2002



Source: Milken Institute

Another way to test the statistical relevance of our State Technology and Science Index is to look at its relationship to per capita income across states. We examined a number of specifications. The dependent variable—the one whose changes we are trying to explain—was the working age per capita income of states for 2002. Based upon changes in the State Technology and Science Index, we were able to explain more than 75 percent of the variations in per capita income of the working age population across states. The accompanying chart displays this relationship of the actual values versus those predicted from the equation. This relationship is so strong that it would be expected not to be the true statistical relationship in only one out of approximately one million times (F-test was 48.3).

By examining the time series properties of the relationships we can better understand the lags in changes in the variables with measures of outcomes. The results indicate that for states with the lowest per capita income, the highest rates of return to investment appear to be in improvements in broad measures of human capital, such as percent of the adult population with a bachelor's degree or greater. Improvements in a state's K-12 system first starts impacting the SAT and ACT scores, leading to higher college enrollment rates, and ultimately, more bachelor's degree holders. At the other end of the scale, there is a long time lag between improvements in the research and development infrastructure and technology outcomes, but they are highly significant. Enhancing the entrepreneurial skills and venture capital networks of a state will garner enormous returns. Nurturing the process and a long-term commitment, accomplish this.

Conclusions

Current budgetary problems and challenges in state capitals across the nation are engendering new, often unprecedented, thinking about state policy. Economically leading states such as Massachusetts and California are no more protected than those that are poor performers. All corners of the nation's knowledge economy landscape are facing heightened demands to go beyond the status quo. We at the Milken Institute believe that our Index provides a valuable framework of measures to guide state policy makers and the public on the realities of their performance in the knowledge-based economy of today.

Just as a high ranking should not be interpreted to mean that a state should be complacent about its competitive position, a lower ranking similarly should not be taken to mean that a state is consigned to a fate of underperformance. Virginia, though not part of the Deep South, is geographically a southern state. Its rise to high-tech economic dynamism over recent years can offer lessons for states that aspire to a more prosperous future in the intangible economy. California itself had an economy dominated by natural resources and agriculture as recently as the middle of the 20th century; its high-tech industrial base, compared to the more mature high-tech economies of East Coast, is a relatively recent phenomenon. Moreover, new state policies that may come from recently launched initiatives such as Accelerate Arkansas and Louisiana's TechSouth IT Summit, hold out the potential for substantial improvement among underperforming states and regions.

Introduction – The Intangible Economy in Flux

In the Institute's release of its first *State Technology and Science Index* in 2002, we stressed the need for states to recognize the new realities of the intangible economy. This mandate remains unchanged. In the intervening time, however, the nuances of those realities have themselves taken on new meanings.

Across the nation, states are facing radically altered conditions for their funding sources and spending priorities. Ohio Governor Taft, for example, has been moving aggressively on his Third Frontier Project. The Third Frontier Project is a $1.6 billion plan to create high-paying jobs for Ohioans. Last summer new components were approved by the state legislature to foster technology-based economic development and growth. Ohio General Assembly Am. Sub. House Bill 1 creates incentives to invest in Ohio firms as they attempt to commercialize research coming out of private, public and university labs. It established the Research and Development Investment Fund, created the Ohio Research Commercialization Grant Program and expanded the Technology Investment Tax Credit Program.[1] Nevertheless, the Governor did suffer a setback in November when voters rejected his $500 million tech bond efforts by rejecting Issue One, a constitutional amendment that would have authorized the state to issue bonds over 10 years to fund technology-based economic development. It was a narrow defeat—51 percent to 49 percent—that might have passed had proponents effectively answered opponents' claims that it was corporate welfare. Undaunted, Governor Taft is requesting to redirect additional dollars to continue his aggressive investment plan.

Not to be outdone by Ohio, Michigan Governor Granholm has undertaken a number of research commercialization and venture capital access initiatives to foster tech growth in her state. One of the most far reaching efforts is in the area of higher education. Governor Granholm stated in her January, 27 2004 State of the State Address, "And because engineers and technology workers are so important to the Michigan workforce, beginning in the next academic year we will make zero percent loans available to students in our public universities who pursue engineering and technology degrees. They'll keep that zero percent rate as long as they continue to study and work in Michigan." This is an innovative public policy initiative that should deliver future returns to the state.

In Alabama after only four months in office, Governor Bob Riley, a conservative renown for his anti-tax principles felt compelled to propose raising taxes by $1.2 billion a year. Not only was this the first time in Governor Riley's political career that he had ever supported a tax increase, he was, moreover, proposing the single biggest tax increase in Alabama's history—a drastic measure aimed at relieving the state's most dire fiscal situation since the Great Depression. Dubbed "Laying the Foundation for Greatness," the governor's proposal was designed to solve more than the state's fiscal deficit. It was, rather, designed to help eradicate a deficit in human capital as well by using tax dollars to boost the state's number of skilled workers and consequentially its economic performance. With a rationale grounded in the sort of comparative rankings on which the Institute's Index is based, the governor appealed to voters with the question: "Do you still want to be 49^{th} and 50^{th} in everything we do?"[2] In the end the Alabama electorate rejected the governor's plan, but that hardly diminishes (and in fact underscores) the significance of the boldness of his proposal.

Throughout the U.S., state policy makers and the public are—in their varying ways—dealing with the changed dynamics brought on by tough times in an increasingly knowledge-based economy. Unorthodox measures are becoming less exceptional. The impetus to initiate radical change is hardly limited to economically underperforming states like Alabama. Only one month after voters defeated Governor Riley's proposal, voters in California took the unprecedented step of recalling a sitting California head of government. As his replacement, they elected a complete newcomer to political office, Arnold Schwarzenegger. Prior to his ascent to leadership of the state, Governor Schwarzenegger's civic activities focused on enhancing educational programs and improving California's business competitiveness. He and his administration have continued to emphasize both in their policy formulations. An example of a novel blending of these policy priorities comes from the recommendation by members of the state executive on how to address budgetary shortfalls in California's public school system Their solution? Empower individual campuses to compete *à la* the principles of free market for students. The idea is to redefine the role of principals from that of administrator to that of "entrepreneur."[3]

New challenges are engendering new, often unprecedented, thinking about state policy. Economically leading states are no more protected than those that are poor performers. All corners of the nation's knowledge economy landscape are facing heightened demands to go beyond the status quo. We at the Milken Institute believe that our Index provides a valuable framework of measures to guide policy makers and the public on the realities of state performance in the knowledge-based economy of today.

As pointed out in the 2002 Index, the notion of a New Economy has often been mischaracterized and even more often misunderstood. What economists have really been describing with growing frequency in recent years is the movement from a tangible-asset to an intangible-asset-based economy. The economy is not itself new, but the relative importance of economic assets has been fundamentally transformed. In an intangible economy, concepts such as patents, copyrights, customer relationships, brand value, unique institutional designs, the value of future products and services and their structural capital (corporate culture, systems, and processes) become ever more important to firms. Most of the value of the intangible economy is anchored to a firm's stock of human capital and to the locations in which they reside.

The intangible economy is based upon more than high-technology industries alone, although they are essential for sustained economic success. Places that can attract, grow and retain firms and industries proficient at deploying information technology, in addition to producing it, will be at a competitive advantage. Most firms know that investing heavily in information and communication technologies can accelerate product development cycles, if properly designed and deployed.

These technologies are moving us from a vertically oriented, command-and-control hierarchy to one that is horizontal, based on entrepreneurial, organized, dynamic networks with collaboration as its centerpiece. Because speed is vital, structures that impede rapid decision-making are rendered obsolete.

This underpins why we have created the Milken Institute's State Technology and Science Index. It provides states with a benchmark by which to monitor progress; its distinct, but interrelated measures and indicators encapsulate a comprehensive inventory of the technology and science assets that are a hallmark of intangible economies. Specifically, the Index is composed of five major, equally-weighted composites—Research & Development Inputs, Risk Capital and Infrastructure, Human Capital Investment, Technology and Science Workforce, and Technology Concentration and Dynamism. These five composites are comprised of 75 individual components. Each of the components is measured on a relative basis to a relevant indicator (population, Gross State Product, number of establishments, etc.) The data is collected from a number of governmental agencies, foundations, and private sources, then compiled, calibrated and analyzed by the Milken Institute.

Intangible economics are driven by the ability of locations to attract and expand science and technology assets and leverage them for economic development. State and regional economic performance is determined by how effectively its comparative advantages are used to create and expand knowledge assets and convert them into economic value. If you can use recreational amenities such as a beach, snow-capped mountains or an innovative culture to retain or draw these assets, you are ahead in the technology-based economic-development game. And states succeeding in technology-based growth will push income per capita higher, especially relative to those states that falter.

Science, technology and knowledge-driven innovation are critical to job and wealth creation in these new dimensions of economic reality. The degree to which a state's knowledge assets are harnessed and converted into successful innovations, products and services, determine its economic future. The research, development and innovation assets, the risk-capital and entrepreneurial infrastructure, human capital capacity, the technology and science workforce, and ultimately, the technology concentration and dynamism, are the measures for states and regions in an intangible economy.

One thing intangible economies are not, however, is infallible. As with any sector, over investing, misallocating resources, building excess capacity, and making poor strategic decisions will not be sustained in the end. The technology sector's recessionary trough that followed in the swell of the dotcom bubble reminds us of this persistent fact of economic existence. Yet by the same measure, a periodic downturn in the technology sector by no means implies that the sector has declined in economic significance. Indeed, the way in which the fortunes of national and state economies have become more tightly bound to the variances in the tech sector underscore the rising importance of such intangible, knowledge-based sectors. The Institute pointed out as much in its 1999 study, *America's High-Tech Economy: Growth, Development and Risks for Metropolitan Areas*, in which we stressed the generally positive facets of technology-based growth, but also warned of the downsides:

> *On balance, the benefits to the economy from technology far exceed the less-noticed negative aspects of technology-driven economic development. However, there are risks emanating from the technology industry's inherit volatility, its growing importance in the overall economy, and the closer relationship between it and the business cycle of the U.S. economy. ...A synchronous shock spread across a number of related technology industries, such as computers and semiconductors, in combination with some other inauspicious development could cause a recession in the entire economy.*[6]

A noticeable development that has occurred in the nearly five years since the release of *America's High-Tech Economy* is the widening use of global outsourcing in the nation's manufacturing and service activities. What once involved the relocation of more basic work tasks to countries like China and India has since emerged as a trend in transferring a broad spectrum of job functions. White collar positions in high-tech, previously thought to be shielded from this evolutionary process, are now also being impacted. The debate about what policy makers should do in response is being hotly contested and will likely remain so for the foreseeable future. For as long as this trend continues, however, the imperative for states to develop further unique intellectual assets and means to facilitate entrepreneurial activity in the science and technology sectors will grow ever stronger.

Outline of the Index

Much of the following analysis is based upon comparing and contrasting leading states to those lagging in concentrations of technology, science and related economic assets. The companion report on California, *California's Position in Technology and Science: A Comparative Benchmarking Assessment*, offers a brief description of each indicator, explains why these indicators are important, and gives a summary of California's position relative to other top states. Even with the focus on top performers, however, all states can benefit from the information generated by the Index. For those states not specifically mentioned in the text, indicator data on all states is available for downloading from the Institute's web site at www.milkeninstitute.org.

With this Index, we look at the ecosystem of economic development and sustainability. It is important to constantly innovate, start and grow firms to augment the diversity of the economic ecosystem because many big firms will likely stagnate or even disappear. Greater economic diversity lessens the chances of the entire ecosystem collapsing when several dominant species (firms) become extinct.

We start with the research and development capabilities that can be commercialized for future state and regional technology growth. A state's entrepreneurial capacity and risk capital infrastructure are the ingredients that determine the success rate of converting research into commercially viable technology services and products. Human capital is the most important intangible asset of a regional or state economy. The intensity of the technology and science workforce indicates whether states have sufficient depth of high-end technical talent on the ground. Technology concentration and dynamism can be viewed as a measure of technology outcomes. By measuring technology growth we are able to assess the effectiveness of policymakers and other stakeholders in transforming regional assets into regional prosperity.

Research and Development Assets

Background and Relevance

The new raw materials of technology-based economic development are the research, development and innovation capacities of places. The research and development infrastructure of a state is critical to building new industry clusters from breakthrough technologies or sustaining the vibrancy of existing industry clusters. A new cluster can be formed by importing firms that have commercialized technology elsewhere, but those regions in which basic research and development activities take place have distinct advantages in building a cluster that "sticks."[7]

Ongoing support and high quality of research and development puts the United States in a unique position as it progresses through the early years of the 21st century. U.S. research and development expenditures exceed the combined total of the remaining G-7 countries (Japan, Germany, France, United Kingdom, Canada and Italy). More importantly, however, the U.S. excels in converting its research prowess into economic value by high commercialization success.[8]

The United States' R&D stature relies on the depth and breadth of its regional innovation infrastructure. Knowledge and discovery derived from basic research can be applied to innovation and converted into economic value more effectively at the location of its development. Regional innovation capacity stems from the strength of the region's basic innovation infrastructure, specific conditions supporting innovation in a cluster, and degrees of interaction between the two.[9]

Private research laboratories, federal research laboratories, and university-based research and development, are important drivers of economic development, if properly channeled and harnessed. Research and development investments and policies are an integral component of economic development in successful regions and states. All economic development activities benefit from well-designed and executed programs to expand the research and development assets.[10] Investments in R&D strengthen the research competencies in a region and attract further investments by the private and public sectors in a process of dynamic feedback loops.

Long-run economic growth is highly dependent on funding and performing R&D activities. Harvard University competitiveness guru, Michael Porter, stated it bluntly: "in the long run, the eroding base for innovation is the real challenge and the abiding constraint on our standard of living.[11]"

The biggest category of R&D expenditures is industry-performed research and development. Industry funds and conducts more R&D than all other sectors combined. Industry R&D expenditures rose briskly in the second half of the 1990s and reached 70 percent of all U.S.-funded R&D in 2000.[12] In the manufacturing sector, funding growth was attributable to large increases in electronic and communications equipment, pharmaceuticals and biotechnology. Other key developments were the rapid gains in non-manufacturing R&D. In 1982, the nonmanufacturing sector accounted for less than 5 percent of industry R&D, but reached 36 percent by 2000. The largest shares were in professional, scientific, and technical services and the broad information category.

Places with firms reinvesting their profits into their innovation pipeline will likely have long lives and be an engine of development. The value of industry R&D can be hidden in the incremental innovation of its products and services, but entirely new technologies can be spawned as well. Returns to industry R&D activities are more short-term focused.[13] Despite the critically acclaimed success of university-based R&D centers such as Silicon Valley and Raleigh-Durham, our research shows that location-based industry R&D deserves more credit than it is afforded for sustained job and wealth creation, although the two are clearly interrelated.

Technology firms are continually monitoring the globe for attractive locations for their R&D activities. Corporate R&D is a global endeavor. Missing an important emerging R&D region, may mean sacrificing market opportunity or losing competitive advantage to a global rival.[14] For example, the fastest growing segment of U.S. industrial R&D expenditures is foreign-based multinational corporations. Foreign multinationals have also attempted to gain access to U.S.-based R&D through mergers and acquisitions with innovative firms. Foreign M&A activity is a strategy being deployed to gain quick access to emerging technologies. This is an excellent indication that the U.S. is perceived to be an innovation hotbed, but also suggests that our innovation capacities may be transferred to other nations. The transfer occurs not only from foreign acquirers of U.S. R&D assets either. The direction of global outsourcing trends in recent years demonstrates that for all the strengths the U.S. has in R&D, U.S. companies will not hesitate to place crucial research functions in other nations that offer sufficiently attractive attributes.

Another key development in private-sector innovation is the shift to aspiring new firms as a source for R&D. Corporate research laboratories are accounting for a smaller share of industry R&D.[15] Federal programs such as the Small Business Innovation Program (SBIR) attempt to support private-sector R&D through a set-aside program earmarked for promising technology at small firms not yet demonstrated to be commercially viable. These new firms have difficulty accessing the capital that they need to demonstrate commercial potential. SBIR is the federal government's effort to fill this void. For a firm to qualify for an SBIR award it must meet four criteria: it must be a for-profit entity; American-owned and independently operated; employ the principal researcher, and have no more than 500 employees.

Federally funded R&D can be an important economic development asset. Through its seemingly unintended regional development policies over the past 50 years, the federal government has reinforced and enhanced the position of well-known technology clusters. These regions were often sited for strategic national security and political reasons. By placing defense-related federal research facilities in such places as Silicon Valley where advanced semiconductors were designed and produced, the federal government helped them prosper.[16] The locations in which these labs spin out technology have likewise benefited.

Federal support of R&D has diminished as a share of total R&D funding. Federal R&D funding was heavily defense-related during the Cold War years. The federal share of total R&D peaked in the early 1960s at 65 percent and began a gradual descent, falling below 50 percent for the first time in 1979. Today, the federal share is just above one-quarter total R&D funding. After adjusting for inflation, absolute federal funding of R&D fell in the second half of the 1980s and has remained flat since.

There have been some significant changes in the distribution of federal R&D funds across research areas over the past decade. Federal funds have been shifted toward life sciences and away from the physical sciences and engineering. Basic and applied federal funding of life sciences rose from 40 to 45 percent of the total in the 1990s, while physical sciences and engineering fell from 38 to 32 percent.[17] Supporters of government funding of life sciences are pleased, but many scientific groups are concerned about the potential long-term impacts of the shift. These shifts have important implications for states and regions attempting to attract more federal R&D funding.

Expenditures for university-based research and development may be funded by the federal, state and local government, industry, nonprofits, or the universities directly. University research tends to be oriented toward basic research that addresses long-term, fundamental knowledge and scientific discovery. The nation’s universities and colleges account for approximately half of basic research. Universities receive over 60 percent of their total R&D funding from the federal government. The bulk of the funding is going into life sciences as evidenced by the dramatic increase in university patenting in this promising field.

The economic value of university research accrues over many years. However, university facilities, research staff, and knowledge contribute to the research base and have a short-term payoff too: they attract new business.[18] States with successful research universities have played an important role in attracting research-oriented companies. Increasingly, universities are conducting more applied research for the benefit of specific corporate sponsors. Joint industry/academic research collaboration supports industry research objectives by granting them access to cutting-edge innovation and establishes a network for hiring top graduates.

A region’s R&D assets are important, but the degree of interaction with other elements of the economic environment determines whether commercially viable outcomes result. Location-based technological change depends upon user-producer relationships (interfirm, interindustry and consumer-producer); science-production relations; interfirm relations in dynamic clusters; and firm-government-university relations. It is increasingly important that these relationships are nonhierarchical, and based on substance-dependent communication and action processes.[19]

Collaboration in research and development among corporate labs, corporate supplier networks, universities and government labs, is evolving into a new distributed, external platform system for innovation.[20] Relationships between industry and universities have grown more extensive over the past two decades as federal sources of R&D funding are increasingly tied to attracting private sector investments.

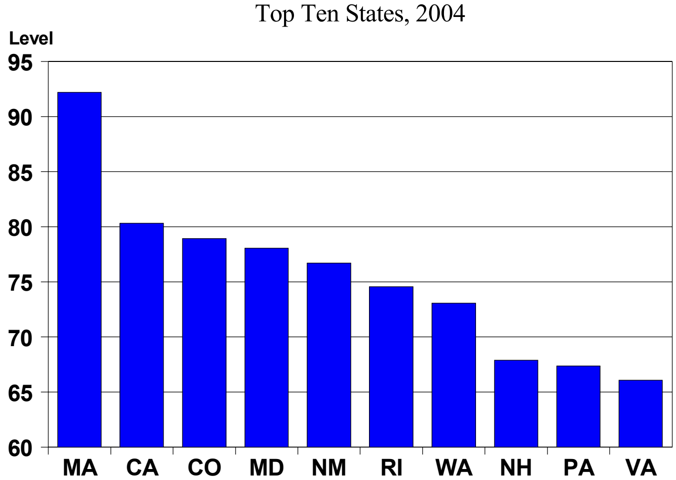
As an example, The Small Business Technology Transfer (STTR) program seeks to increase the participation of small businesses in federal R&D and to increase private sector commercialization of technology from federal sources. Many newly chartered firms play an increasingly instrumental role in today's rapid commercialization of technology innovations. Unencumbered by other core technology assets, small firms can bring new products and services to market quickly. The unique feature of the STTR program is its requirement that the small-business applicant organization formally collaborate with a research institution in phase I and phase II.

Technology transfer policies must be part of research facility charters. To fully leverage new technologies for commercial success, applied research programs need to be established between the government and university labs with the private sector. The culture at many university and government research facilities must also emphasize commercial applications, beyond research for the sake of scientific discovery.[21] Patent activity at universities has accelerated in both quantity and quality over the last five years. In 2002, 13 of the top 25 universities witnessed a 50 percent or greater increase in the number of patents issued since 1997, six of which have seen increases of 100 percent or more. The Association of University Technology Managers' annual licensing survey shows that total university income from patents increased from $700 million in 1997 to $1.1 billion in 2002. States in which scientists and other researchers are encouraged and given support to license their research to the private sector, become part-time consultants to private firms, and move to the private sector themselves to develop commercial applications, will reap the economic rewards.

State Findings

Massachusetts scores as the top R&D state on a relative size basis in our Research and Development Composite Index for 2004. The state's number one ranking is unchanged from the 2002 Index and the composite score that gave it this standing has likewise remained statistically unchanged from its exceptionally high level of 92.2. To earn a perfect index score of 100, a state would have to place 1st in each of the R&D Composites' 18 components. Massachusetts' score thus approximates a perfect competitive ranking. California improved its score from 77.9 in the 2002 Index to 80.3 in 2004. This increase has consequently improved the state's standing, moving it from a 4th-ranked position to 2nd. Colorado's 2nd -place score of 79.9 in the 2002 Index dipped slightly to 78.9 and the state now ranks 3rd. The remaining seven of the top 10 states in the 2004 Index are Maryland 4th (up from 5th), New Mexico 5th (up from 6th), Rhode Island 6th (down from 3rd), Washington 7th (up from 9th) and a strong 5.2 index points above 8th-place New Hampshire (up from 10th), Pennsylvania 9th (up from 13th) and 10th-place Virginia (up from 12th).

Research & Development Inputs Component
Top Ten States, 2004

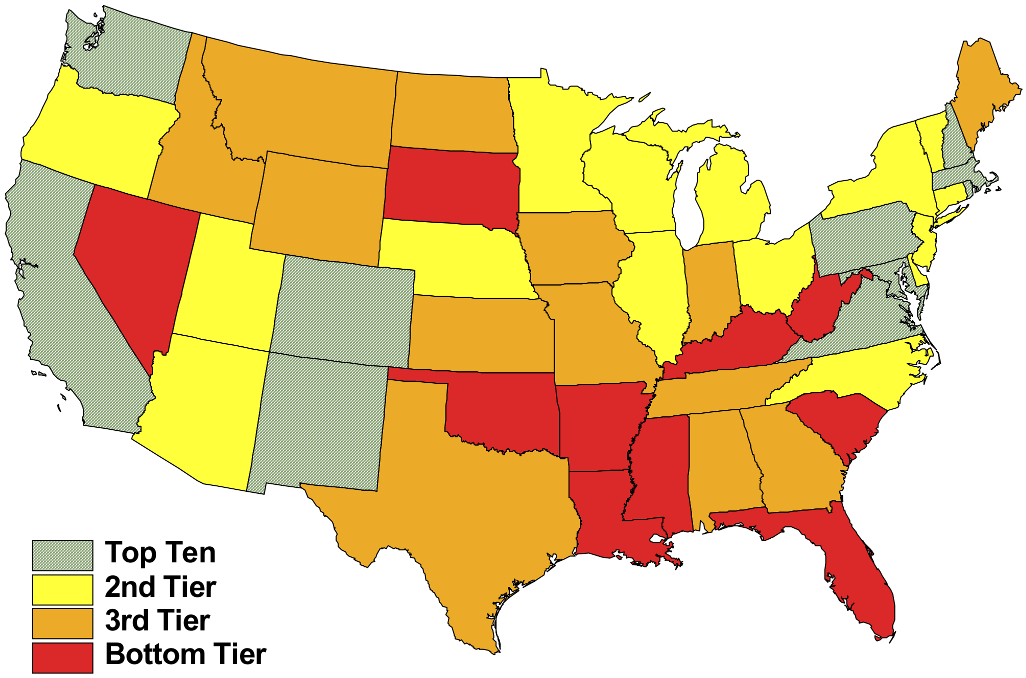


Source: Milken Institute

The accompanying table depicts the Research & Development Composite 2004 rank, its 2002 rank and its average score for all 50 states. The 2004 Index adds two indicators that were not part of the 2002 Index: per capita R&D Expenditures on Agricultural Sciences and per capita R&D Expenditures on Biomedical Sciences. The additions reflect the growing importance of life science research to the economy. R&D spending is classified as coming from three general sources: the federal government, private industry, and academia. The Index's Federal R&D expenditure measure captures the sum of all basic and applied research in projects that are federally supported and includes work pertaining to national defense, health, space research and technology, energy, and general science. The Industry R&D measure sums all the money spent by corporations on basic and applied research, including those amounts spent by corporations on federally funded R&D centers. Industry R&D receives great weight in the composite index because of its large share of overall R&D. All research, basic and applied, performed by colleges and universities is funded by a combination of federal, industry and academic sources.

The National Science Foundation is an independent agency of the United States government that funds research and education in science and engineering through grants, contracts and cooperative agreements. Research and development expenditures on engineering dollars per capita is the statewide amount of funds spent at doctorate-granting institutions on various basic and applied engineering programs. Other important funding categories include physical sciences, environmental sciences, math, and computer and life sciences.

Research and Development Inputs Component
2004



In short, the STTR awards are federally funded research awards granted to small businesses and nonprofit research institutes. SBIR awards fund the often costly startup and development stages as well as encourage the commercialization of the research findings. The funding rate of competitive National Science Foundation (NSF) project proposals for basic research are crucial for generating momentum at the formative stages of R&D in universities.

In 2004, as in the 2002 index, Massachusetts recorded a remarkable performance. Massachusetts was in the top five in 16 out of 18 categories. California scored relatively well in the individual indicators. For 2004, the state placed in the top half of the nation in all but two of the 18 measures. Colorado was 1st in National Science Foundation Funding and 2nd in SBIR awards. Colorado's overall position slipped somewhat due to a decline in ranking from 9th in academic R&D in 2002 to 16th in 2004, and to a slight drop in industry R&D. Maryland owes its lofty ranking to its 1st-place position in federal and academic R&D, particularly in engineering, life science and biomedical fields. Maryland is taking further steps to enhance its position by a series of technology-based initiatives, including a permanent State Chief Technology Officer. With its national labs, New Mexico is 2nd in federal R&D and academic R&D in engineering.

Rhode Island scores high in R&D expenditures on environmental sciences and math and computer science and the funding rate on NSF proposals. Washington scores high (3^{rd}) in industry R&D and (2^{nd}) on the funding rate for NSF proposals. New Hampshire climbed to 4^{th} in the country on overall academic R&D based upon its jump in engineering R&D. Pennsylvania's highest rank was in engineering R&D at 8^{th}, but it saw improvement in several categories from 2002. Virginia is in the top 5 on federal R&D and NSF funding.

Arkansas has the dubious distinction of ranking 50^{th} in 2004 in the Research & Development Composite Index with an average score of 16.4. South Dakota is 49^{th}, sliding from 47^{th} in 2002. South Dakota was last in academic R&D. West Virginia was 48^{th}, falling two slots from 2002. West Virginia was next to last in academic R&D and last in National Science Foundation Research funding. Louisiana, at 47^{th} , improved by one position from 2002. Louisiana's position in academic R&D increased as well. Nevada was 46^{th}, representing a decline of two positions from 2002. Kentucky was 45^{th}, but was up four positions relative to 2002. Kentucky recorded a sizable increase in NSF funding. Oklahoma's score of 27.5 placed it 44^{th}. Mississippi placed 43^{rd} in 2004, up one placement from 2002. South Carolina scored 34.5 placing it 42^{nd}. Rounding out the bottom 10 at 41^{st} was Florida, which slipped by two positions from 2002.

Nebraska recorded the biggest improvement in 2004, increasing its ranking by 15 places. The addition of R&D expenditures on agricultural sciences (3^{rd} ranking) and biomedical sciences (15^{th} ranking) to the composite index improved its position. Vermont witnessed the second-largest gain in 2004, moving up by 11 places. A dramatic increase in its industry R&D score was largely responsible. Hawaii had the next largest improvement moving up nine places to 28^{th} in 2004. The inclusion of R&D in agricultural sciences and Hawaii's better score in industry R&D moved it up. Oregon and Minnesota both improved five places. Oregon rose to 16^{th} in 2004 with a notable improvement in federal R&D and the inclusion of R&D in agricultural sciences. Minnesota increased to 19^{th} in 2004 with big gains in federal R&D and industry R&D.

Risk Capital and Entrepreneurial Assets

Background and Relevance

Entrepreneurial capacity and behavior are prime drivers of economic growth and job creation in the new intangible-based economics of place. Entrepreneurs see the economic potential of new technologies and apply them to business concept innovations. Business-management author Gary Hamel describes business concept innovation as "the capacity to imagine dramatically different business concepts or dramatically new ways of differentiating existing business concepts.[23]"

In eras of rapid technology change, entrepreneurial skills have a unique role to play because new enterprises, having no history and no personal stakes, are better positioned to harness new forms of technology. The message is this: to be a successful state or region over the long haul calls for capable entrepreneurs and the risk capital infrastructure to support them. Perhaps more importantly, public policy officials must understand the role of entrepreneurial activities and serve as a catalyst in building the social network infrastructure to nurture success.

The focus on the role of individual entrepreneurs in local and national economic development has waxed and waned in the history of economic thought.[24] Adam Smith bestowed high importance on business owners and managers in promoting an efficient market-based economy. Much of our current understanding of industrial clusters, and what causes their formation and sustainability, dates back to Alfred Marshall.[25] Yet Marshall didn't see the entrepreneur as essential to his industrial districts, nor did he explicitly incorporate them into his neoclassical synthesis. He saw innovation stemming from 'organization' knowledge that was seemingly in the air, showing that he was aware of entrepreneurial activities, but relegated them to a secondary role.

Joseph Schumpeter provided much of the modern thinking on the role of the entrepreneur in new firm formation dynamics. Writing in the 1930s, Schumpeter conferred a central role in the theory of economic development and capitalism itself on entrepreneurs.[26] He saw innovation as the force behind capitalism, and entrepreneurs driving innovation by efficiently combining factors of production. Entrepreneurs unleash waves of creative destruction. Schumpeter attributed the success of regional business systems to organizational entities with differentiated practices based upon "experience and teamwork."

The ability to garner the required resources and overcome all impediments by seizing new business opportunities defines entrepreneurship. Entrepreneurs see stable careers as unfulfilling and embark on the financial uncertainty of creating something from their passion-held ideas. Entrepreneurs are essential to a thriving economy because new ideas are best-implemented in new firms. Existing businesses often fear "cannibalizing" their current sales and hesitate to introduce new products.[27] Old, big and bureaucratic firms often do not even recognize the value of their own discoveries and how they could be applied. American technology innovation is full of examples of entrepreneurs adopting new technologies developed at established firms.

When Steve Jobs visited Xerox's PARC facility and witnessed an early prototype of the graphic user interface (GUI), Xerox did not see how the technology could be applied. Later, Jobs founded Apple Computer, which used the GUI for its Macintosh personal computer. Similarly, Sun Microsystems, an outside start-up, created the computer workstation market even though IBM held the patents to the technology. The world's leading pharmaceutical firms played virtually no role in the burgeoning field of biotechnology. Big Pharma was forced to acquire biotechnology firms because they didn't pursue research in this area and develop their own expertise. Nevertheless, they knew of the scientific breakthroughs in the field of microbiology and the commercial promise it offered.

Inventions advance the store of human knowledge, but do not affect the local economic system until they are implemented as an innovation. Risk capital by itself will not turn new ideas into commercially viable products; that is the role of entrepreneurs. Innovation and economic impact occur when an entrepreneur garners the financing, creates a business model, and transfers the invention into the private sector.[28] Even MIT economist and best-selling author Lester Thurow, altered his formerly pessimistic view on the relative decline of U.S. industry. Thurow now believes that "entrepreneurs are central to the process of creative destruction, since they are the individuals who bring the new technologies and the new concepts into active commercial use. They are the change agents of capitalism."[29]

Job creation statistics display the importance of entrepreneurship to the U.S. economy. In the second half of the 1990s, businesses with fewer than 100 employees created 75 percent of all new jobs in the United States. Moreover, 15 percent of the fastest growing new firms accounted for more than 90 percent of net new job creation. Furthermore, 16 percent of all U.S. businesses have been in existence less than one year.[30] Contrast this performance with Fortune 500 firms: since 1980 they shed more than 5 million jobs while 38 million new jobs were created in the United States.

The explosion in the availability of capital to individual entrepreneurs has supported new firm formation and economic growth. In the old financial order, only organizations and individuals with money were given access to borrowed funds for investment purposes. Consequently, riskier, more innovative entrepreneurs faced great difficulty in obtaining early-stage funding.[31] The increased availability of risk capital to technology start-ups is particularly powerful because their product or service is unproven and the market potential is difficult to ascertain. Most traditional banks do not want to accept intellectual property as collateral for a loan, although some have established venture capital divisions to enter this expanding capital market.

Efficient capital markets promote economic development and facilitate wealth creation by channeling investments into productive enterprises. Broader access to capital and a wider distribution across the population improve ownership patterns that diffuse its benefits and boost economic growth[32]. Broadly diversified financial systems result in efficient capital allocation to alternative investment opportunities. This process is highlighted by the increasing shift to market-based financing, especially to an early-stage business investment market, and away from the traditional intermediated-finance model.

Many of these new firms require large amounts of external financing for an extended period before they can tap traditional debt or equity markets. Private equity from pools of individual investors (angels) or highly specialized venture capital (VC) firms attempt to fill this void.

Angel investors are groups of loosely organized individuals who pool financial resources to provide start-up or early-stage funds to firms. After either exhausting their own financial resources or those from friends and family, entrepreneurs turn to angel investors. Angel investors fill smaller financing needs than traditional venture capitalists provide. VC funds may prove incompatible with new firms for a number of reasons: the limited size of early-round investments, modest future anticipated needs, or a higher risk profile associated with limited information on market potential for their product.

When an angel-backed firm's financing needs expand beyond the capacity of the angel market, they approach venture capital firms. Contrary to public perception, VC firms rarely invest in start-up firms, although some VC funds have been established solely to provide seed financing. The majority of their investments are follow-on funding and they place them in business sectors where rapid growth is expected. Venture capitalists look for high rates of return over a five-year period with an exit strategy of cashing out after a firm becomes publicly traded through an initial public offering or a merger or acquisition by an established firm.[33]

Venture capital has a history of funding new technologies. These are the most risky investments, but can offer high returns. Venture capitalists backed fledgling semiconductor firms, then personal computers, followed by the disk drive industry, biotechnology in the early 1990s (before the market crash in 1992) software in the mid-1990s, and dot-coms at the end of the decade. Intel, Microsoft, Apple Computer, Cisco, Genentech and Amazon were all venture-backed firms.

Venture capitalists often place high importance on the passion of the entrepreneur and the talent of the senior management staff. The product or service is central to the issue of whether to fund a firm, but VCs see passion and talent as critical determinants, as well. They evaluate such factors as market potential, ability to establish branding, and whether their space is defensible against imitators. Venture firms are able to take substantial risks because of the large upside of a small number of their investments. The net returns of VC funds are accumulated from a small minority of investments with the bulk of the returns coming from 10 percent of the firms.[34]

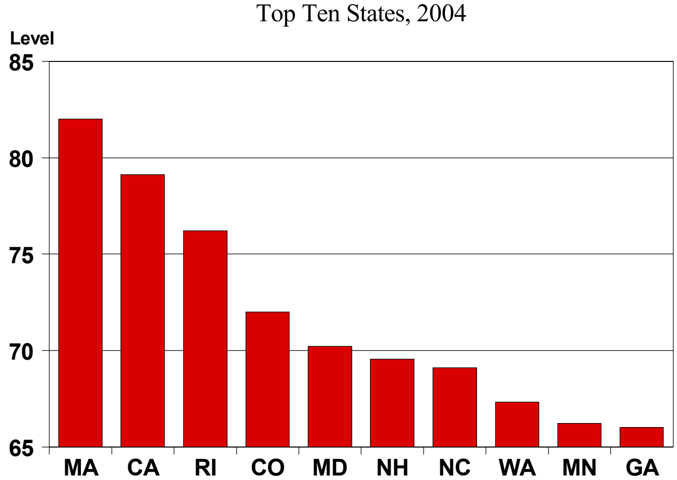
Venture capital placement is an important later-stage measure of commercialization activity for new technologies and business concept innovations. Venture capital funding represents a small share of the overall capital markets, but its true value cannot be measured in dollars. VCs assist in business plan development, become board members, lend management skills, suggest strategic partnerships and alliances, assist in expansion plans, and bring in key talent where needed. Venture capital activity is an excellent way to assess whether financiers have confidence in the new ideas and entrepreneurial infrastructure of a region.

A new conceptual framework for state and regional economic growth must be built that explicitly recognizes the role of entrepreneurship in the intangible-based economics of place. First, it is important to recognize that entrepreneurial activity is molded by a consistent set of factors. This entrepreneurial framework includes training and support from the private and public sectors and the availability of early-stage financing. Then, the intensity of entrepreneurial activity is a function of the extent to which individuals recognize the entrepreneurial opportunities and possess the capacity—motivation and skills—to exploit them.[35] The interaction between recognition of opportunities and the capacity to pursue them will increase the level of start-ups efforts, new firm birth and job formation.

State Findings

Massachusetts was 1st in our 2004 Risk Capital & Infrastructure Component score at 82.0, a distinction it held in 2002. Massachusetts is a highly technologically intensive state. California's risk capital score was 79.1, placing it 2nd in the nation in 2004 and consistent with its 2002 position. Following Massachusetts and California, the remaining top 10 states in the nation are Rhode Island (which scored 76.2) and jumped from 27th in 2002, Colorado (72.0), Maryland (70.2), New Hampshire (69.6), North Carolina (69.1), Washington (67.3), Minnesota (66.2), and Georgia (66.0).

Risk Capital & Infrastructure Component
Top Ten States, 2004



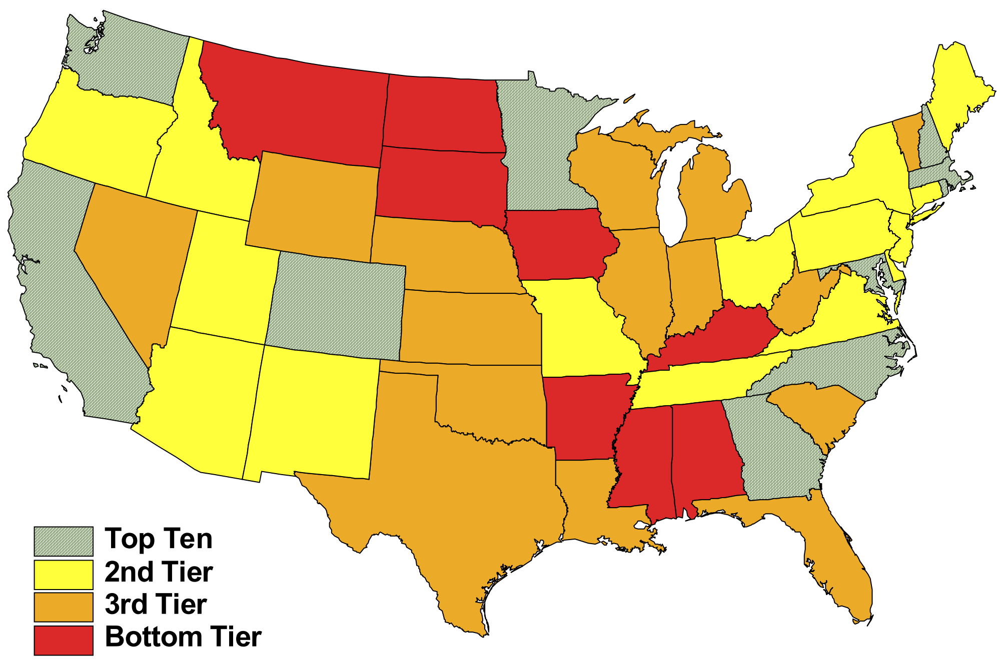
Source: Milken Institute

The Index's Risk Capital and Entrepreneurial Infrastructure Composite measure is composed of nine individual components, each benchmarked to a relevant indicator. Each of the nine indicators included in the composite, along with California's score and ranking, are displayed in the accompanying chart. The Risk Capital and Infrastructure (RCI) component aims to measure each state's entrepreneurial culture through the analysis of risk capital vehicles such as venture capital investment and IPO activity. The component further seeks to gauge the effects of such vehicles in terms of business creation and patents activity.

The RCI composite index is calculated by totaling the state ranks of each RCI indicator and dividing it by the total number of indicators. Several indicators on venture capital are included in order to capture its relative size and those states that are witnessing rapid gains. A high growth rate in venture capital placements indicates that a state is witnessing early success in building technology-based firms for future economic development and job creation and closing the gap with more advanced states. Growth in total venture capital funding and in the number of companies receiving VC investment captures this element.

We include the number of companies receiving venture capital investment per 10,000 firms and VC investment as a percentage of Gross State Product (GSP) to measure the flow and strength of each state's venture capital activity relative to its total economy. Venture capital's share of a state's economy is important because of the strong relationship between those states that have higher venture capital investment activity and entrepreneurial success, job creation, wealth creation and higher standards of living.

Risk Capital & Infrastructure Component
2004



The Small Business Investment Company (SBIC) program is geared towards business incubator-type establishments that award small businesses services ranging from various forms of financial capital to management consulting. SBICs are able to provide these services because they are leveraged by the Small Business Association (SBA). SBIC establishments behave in a manner similar to that of venture capitalists—their goal is to identify profit potential in unleveraged small businesses and fund it in hopes of high returns on investment. Business incubators aim to provide up-and-coming small businesses with guidance and various resources such as physical facilities, office equipment, business assistance services, and management consulting in order to enable economic growth and development during the critical formative stages.

Patents are granted by the Patent and Trademark Office (PTO), a division of the United States Department of Commerce. Innovation and scientific advancement is protected through patents by prohibiting others to make, use, or sell the invention. On a state-to-state basis, the greater the number of patents per 100,000 people, the more inventive, innovative and scientifically curious, are its agencies and institutions.

Business formation is important to a state's local economy because it is an indicator of entrepreneurship, innovative spirit and optimistic expectations. An Initial Public Offering (IPO) occurs when a company decides to sell shares of its common stock to the general public. Companies that go public are typically those that have established a proven track record by means of revenues or sales history.

Although not dominating the Risk Capital and Entrepreneurial Infrastructure component as much as in the Research and Development Input component, Massachusetts' performance is nevertheless very strong coming in nearly 3 index points ahead of 2nd-place California. Massachusetts was in the top five in six out of nine categories and was 1st in both companies receiving venture capital (VC) investment per 10,000 business establishments and VC investment relative to GSP. Massachusetts isn't taking its number-one position for granted. The legislature recently passed funding of a wide range of tech-based initiatives including increased seed capital pools and support in acquiring equipment and research facilities.

California is just behind Massachusetts in both of these important categories and slightly ahead of Massachusetts in SBIC funds dispersed. The University of California system was tops in patents granted to universities. Rhode Island's performance was exceptional; it improved its score in eight out of the nine components. Colorado was 1st in SBIC funds, 2nd in business starts and in the top five in four components. Maryland was in the top 10 in four of the components and scored highest in VC investment relative to GSP.

New Hampshire broke into the top 10 by improvements in companies receiving VC investment, growth in companies receiving VC investment and moved up to 3rd in VC investment as a percent of GSP. Another new entrant into the top 10 was North Carolina with improvement in all but two components. North Carolina's highest score was 5th in growth of companies receiving VC investment. North Carolina has ambitious plans to create and attract biotech start-up companies. To support this effort, it has plans for a $75 million One North Carolina Fund and establishing a general fund for faculty start-up packages. Nationwide, VC investment in life sciences rose to $4.89 billion in 2003 and is the highest proportion directed to the area in 12 years.[36] Washington retained its position at 8th, mostly attributable to its 1st–place ranking in business starts. Minnesota was in the top 10 in three components and Georgia was in top half in all but two components.

North Dakota retained the 50th position in 2004, ranking in the bottom five in six out of the nine categories and scoring 16.2 overall. Mississippi slid to 49th in 2004, down six positions from 2002. Kentucky is 48th and fell from 45th in 2002. Kentucky's highest score was in growth in companies receiving VC investment at 30th. Alaska scored 47th and dropped from its 2002 position in the composite. Montana dropped into the bottom

10 at 46th. Iowa is 45th and only made it out of the bottom 10 on three components. Next, Alabama at 44th, dropped into the bottom 10. Hawaii scored 33.8, placing it 43rd. Hawaii was in the bottom half of the distribution in six of the components. Ranking 42nd, Arkansas improved five positions relative to 2002. At 41st, South Dakota witnessed an improvement compared to 2002.

Rhode Island recorded the biggest improvement relative to its 2002 ranking by leaping 24 places. Rhode Island's biggest jump was in IPO proceeds. Governor Carcieri unveiled plans for a new tax incentive program aimed at attracting entrepreneurs, displaying his commitment to further gains. West Virginia saw the second-largest gain by moving up 18 positions to 30th overall. West Virginia was 1st in growth in number of companies receiving VC investment and 2nd in total VC investment growth. Overall, West Virginia improved its ranking in eight out of the nine categories. Vermont rose in the rankings by 15 positions with broad overall improvement. Tennessee improved by 13 positions, moving up to 23rd. Tennessee's venture capital scores increased. Ohio and New Mexico both rose by 12 positions. Ohio witnessed strong gains in its venture capital rankings.

Human Capital Capacity

Background and Relevance

Knowledge and the innovation capacities of human capital are at the core of the new intangible-based economics of place. In the old tangible-based economy, human capital was not seen as a reservoir of talent exploitable for economic development. In contrast, today a state or region's most important source of competitive advantage is the knowledge embedded in its people (intellectual capital). In contrast to the past, where firms and industry agglomerations attracted people, the intangible-based economy's dynamic is that concentrations of talent are attracting firms. Michael Milken was among the first to recognize these changing dynamics when he stated, "Today, with the emergence of the information age, the strength of a country is based on knowledge. National greatness will arise not from our natural resources or our factories, but from our people—people with new ideas and skills."[37]

Labor was seen as an expense that must be minimized to achieve superior financial performance in the past. Labor was a rented, hired and fired factor of production that warranted little investment. Even today, the balance sheets of most corporations are mired in our industrial past because labor is only discerned as an expense item. Human capital, or the value of the intellectual assets of U.S. companies, has been estimated to represent between 70 to 75 percent of their total asset value by University of Chicago Nobel laureate Gary Becker. Many technology firms have market capitalization 10 to 20 times the value of their physical assets.

In the new intangible economics of place, the knowledge, skills, experience and innovation potential of talented individuals have greater value than the capital equipment or even capital itself. A successful enterprise accesses, creates and utilizes knowledge to sustain competitive advantage. It provides the required training, information technology, direction and proper motivational system to ensure that its employees build new knowledge and value. Places with firms that understand and live by these dynamics are well-positioned to exploit human capital for economic development. Federal Reserve Chairman Alan Greenspan summarized this new reality very succinctly when he stated that "virtually unimaginable a half-century ago was the extent to which concepts and ideas would substitute for physical resources and human brawn in the production of goods and services.[38]"

Perhaps Jane Jacobs conveys the message on the importance of human capital most poignantly. She draws parallels between the vibrant and flexible processes of nature in order to build better models for economic planning. She culls examples from chaos theory to cell biology, to ecology and evolution. "Beginning with the very start of a settlement and continuing for as long as the place maintains an economy, human effort is combined with imports. …And the most important ingredient qualitatively—although not always quantitatively—is human capital. That means skills, information, and experience—cultivated human potentialities—resulting from investments made by the public, by parents, by employers, and by individuals themselves."[40]

Talent is so vital to regional prosperity because we have entered a knowledge-based economy. This change is so fundamental that it conflicts with basic economic concepts such as scarcity that have been taught to students for generations. Intellectual capital can be a bountiful resource that does not adhere to the law of diminishing returns. Knowledge resides with an individual or group and is not an easily manipulated asset.[41] Knowledge grows when collaboration and sharing with others occurs; it is not depleted because even if it is transferred, the original owner still possesses it. Innovation, or the flow of new knowledge, thrives in an environment of collaboration, but dies in an environment based solely on competition.

Little research has been conducted on how people choose where to locate, though economists and others have lavished a deal of attention on how firms choose to do so. In the past, people tended to follows jobs to places, but today economic and lifestyle considerations are both important. Richard Florida of Carnegie Mellon has studied this phenomenon and developed his "creative capital theory" in an attempt to explain it. In his book, *The Rise of the Creative Class,* he states:

> Essentially my theory says that regional economic growth is driven by the location choices of creative people—the holders of creative capital—who prefer places that are diverse, tolerant and open to new ideas. (1) It identifies a type of human capital, creative people, as being key to economic growth; and (2) it identifies the underlying factors that shape the location decisions of people, instead of merely saying that regions are blessed with certain endowments of them.[43]

In other words, geography matters more than ever because skilled technical and creative people determine firm and regional success, and firms must consider where high-end human capital chooses to locate.[44] Skilled professionals—especially science and technical talent—increasingly determine the future economic prosperity of states and regions.

There are two basic forms of knowledge that contribute to economic value and growth: "theoretical" and "tacit" knowledge. Theoretical knowledge is acquired through traditional formalized primary, secondary and tertiary educational systems. This knowledge can be scientific, technical or liberal-arts based. Knowledge work is often unstructured and tends to be iterative, relying on both deductive and inductive reasoning. Formalized education provides a framework to allow effective learning and research activities that create new, formalized knowledge.

Tacit knowledge can best be described as informal or how-to knowledge. Tacit knowledge is created within teams that innovate inside a firm. Firms create value through development of knowledge management strategies that foster sharing knowledge throughout an organization. In the past, knowledge was typically acquired and resident within separate individuals or groups. This knowledge is embedded in the systems, processes, methodologies, and technologies resident within organizations—residing in people's thinking and experiences.[45] There is evidence that knowledge spillovers are typically based upon tacit knowledge. Innovative activity has a high propensity to cluster spatially in industries where tacit knowledge plays a critical role because it is primarily transferred through informal networks, typically demanding direct and repeated contact and dialogue.

Many human capital skills have been transferred from knowledge created long ago. What is unique today is the high value associated with recently acquired knowledge and skills. Knowledge workers who possess the most current skills are witnessing dramatically higher earning power than ones with older skills. For example, computer programmers with knowledge of the latest programming languages earn more than twice as much as those with knowledge in older languages.

Knowledge is now being incorporated as a distinct factor in growth theory. A diverse set of theoretical and empirical work has emerged as endogenous, or new, growth theory. This body of work differentiates itself from traditional growth theory by emphasizing that economic growth is an outcome of a dynamic economic system. Endogenous growth theory postulates several channels through which technology, human capital and the creation of new ideas enable a virtual circle and feedback to economic growth.

New growth theory shows that knowledge has a separate and distinct impact on promoting economic growth. New growth theory is generally associated with University of Chicago economist Paul Romer. Romer perhaps best captures what is at the core of this theory stating, "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."[46]

Several studies have found that people are more productive when they work around others individuals with a strong investment in human capital. Our own work and others find strong statistical relationships between the depth of human capital and urban and regional growth.[47] For example, differences in per capita income among states are most closely associated with the percent of the adult population that has at least a bachelor's degree.[48] Individual human capital is more productive in the presence of high collective human capital.[49]

In a pioneering study, Glaeser discovered that the need to access common pools of talent was becoming stronger in determining why firms tend to cluster together in regional complexes than on the basis of access to suppliers and customers.[50] Regional migration patterns of knowledge workers are another way to test the sustainability of regional economic growth differentials. Analysis supports the pattern that knowledge workers are attracted to regions with higher returns to knowledge.

As with private firms, states and regions must access, create and utilize knowledge to sustain competitive advantage in the intangible economy. Talented individuals are highly mobile and can reward regions that attract them and punish those that lose them. Regions must utilize the knowledge assets in their possession such as universities, research centers, and most importantly, the talent that they create or attract to fuel economic growth.

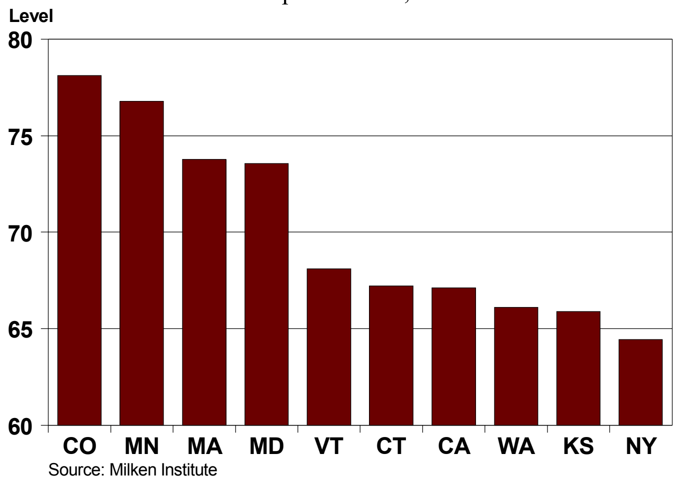
State Findings

Colorado's overall score on the Human Capital Investment Composite Index (HCI) is 78.1, ranking the state 1st in the nation. This marks an increase from the state's 2nd place performance on the 2002 index. Minnesota, which scored 76.8, was 2nd. Massachusetts was 3rd (73.8) and the remainder of the top 10 are Maryland (73.6), Vermont (68.1), Connecticut (67.2), California (67.1), Washington (66.1), Kansas (65.9) and New York (64.4). In general, there is less dispersion from the mean in the HCI than in either of the previous two composites.

There are 20 individual indicators included in this composite. The HCI aims to measure stock of human capital and rate of investment (flow) between states by gauging the concentration and momentum of various science and engineering fields. It is calculated by totaling the state ranks of each indicator and dividing it by the number of indicators.

Bachelor's degrees are important to a state because it gives an indication of both the level of educational attainment and the type of skills that are demanded by the state's firms. The total number and percentage of the population with advanced degrees or higher are important to a state because large concentrations of people with advanced degrees are a good indicator of a state labor pool's sophistication and level of skill development. Another measure included is the concentration of Ph.D. degree holders. States with high levels of Ph.D. degree holders are safely assumed to have quality research and development centers and a solid advanced education system.

Human Capital Investment Component
Top Ten States, 2004



Large concentrations of doctoral scientists are important to a state because it's an indication of work being performed in various research and development projects. Regions with clusters in biotechnology, communications technologies and medical research are expected to have large concentrations of doctoral scientists to fuel innovation. An engineer's main professional purpose is simply to innovate and enable performance. States that recognize and meet the need for state-sponsored programs in their university systems will position themselves to attract and develop engineering talent.

Many important human capital flow measures are included. The presence and constant flow of graduate students in science and engineering are important to a state because it serves as a means to enhance the future of the science and engineering community in a particular state. The flow of scientists and engineers into the workforce and academia is conducive to developing new technologies.

Post-doctorate work is important both to holders of PhDs and institutions alike because it allows degree-holders to further their knowledge in their field of intellectual interest. The share of bachelor degrees granted in science or engineering fields is important because it demonstrates where professional interests lie among the college student population. Measuring the number of recent degrees granted in science or engineering, be it bachelor's, master's, or PhD degrees, allows stakeholders and policy makers to assess momentum and popularity, and guide future efforts to attract students.

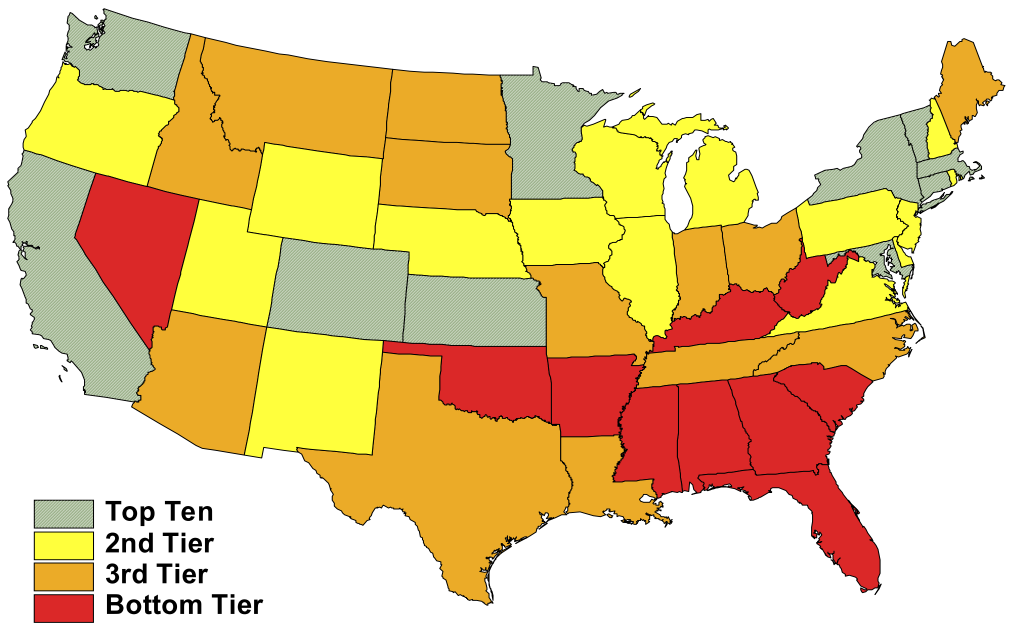
States that are better able to utilize creative budget finance become more attractive competitors for graduate-level talent by offering favorable supplemental aid packages to attract students to their institutions of higher learning. State appropriations for higher education are important because they show how much money is being allocated by the state to run its junior college and university systems. Increases in state appropriations for higher education give analysts insight into shifts in state spending patterns, and whether they are making wise investments in their future labor force.

Verbal Scholastic Aptitude Test (SAT) scores are important to state education analysts because they allow them to measure the verbal competence of high school students on a time series and cross sectional basis. Average Math SAT scores are important to a state's secondary education because they are evidence of the strength and effectiveness of its mathematics and critical thinking curriculum. American College Testing Assessment (ACT) scores, like SAT scores, provide colleges and universities with a means of measuring students' aptitude as well as an instrument to predict academic performance during the student's first year in college.

Home computers allow children and adults alike to become technically proficient as well as to take advantage of knowledge and resources that would otherwise be difficult to attain. Access to the Internet gives people access to resources, both commercial and educational, for which they would otherwise have to travel long distances.

Colorado moved to 2nd in the nation in 2004 in the category ranking percent of the population age 25 and above holding a bachelor's or higher degree, up from 4th on the 2002 index. Colorado was in the top 10 in 15 out of the 20 indicators and in the top five on seven indicators. Perhaps most impressive, Colorado was 2nd in recent degrees in science or engineering as a percent of the civilian workforce. Minnesota improved its score relative to 2002 and moved up three positions. Minnesota stands out among the Midwestern states as a top performer. Minnesota does not dominant any of the 20 indicators, but is in the top half of the country in all but one indicator. Massachusetts fell from its 2002 1st -place position, dropping two slots in 2004. Nevertheless, Massachusetts holds a unique position being 1st in both advanced degrees or greater, and in PhD degrees as a percent of the over-25 population. Maryland was just behind Massachusetts and was 1st in percent of population age 25 and over holding a bachelor's or higher degree. Vermont was in the top 10 in the population age 25 and over with a bachelor's, advanced degree and PhD degree.

Human Capital & Investment Component
2004



Connecticut scores well on most indicators, but stands out by its 2nd position in advanced degrees. California ranks 5th in PhDs relative to the adult population and in doctoral engineers per 100,000 people. Many of these PhDs are held by those born abroad. Washington scores best in categories analyzing recent degree holders in science or engineering. Kansas improved its ranking in several indicators. New York is new to the top 10—attributable to gains in indicators of recent graduates in science and engineering.

West Virginia ranks 50th in the HCI component in 2004, slipping seven places from 2002. West Virginia is last in bachelor's degree or higher and in PhDs as a percent of the population age 25 or higher. West Virginia's score was 22.1. West Virginia's best rank was 15th in recent master's degree in science or engineering. Nevada was 49th in 2004 as its gaming and hospitality industry attracts many immigrants with low educational attainment. South Carolina ranked 48th with it worst performance in SAT and ACT scores. Mississippi was 47th and was consistently in the bottom-tier on measure of the stock of human capital such as the percent of the population age 25 and above with a bachelor's degree. Arkansas stayed in the bottom-tier at 46th. Kentucky recorded the 45th position, but improved relative to 2002 in the percent of the population age 25 or above with a bachelor's degree. Florida improved one position in 2004 to 44th. Florida scores better on measures on the stock of human capital versus internal flows. This reflects Florida's ability to recruit talent from outside the state. Georgia ranked 43rd in 2004, down two places from 2002. Alabama was 42nd and Oklahoma scored 38.2, placing it 41st place.

Alaska and Tennessee tied for the biggest improvement in the rankings relative to 2002, climbing eight positions in 2004. Alaska's percent of the population age 25 or over with a bachelor's degree or greater rose to just slightly below the U.S. average. Tennessee witnessed a notable increase in PhD degree-holders. Kansas leapt to 9th in 2004, up six positions from 2002. Kansas saw a large improvement in bachelor's degree or greater as a percent of the age 25 and over population. Maine rose six positions in 2004 with a big jump in PhD degree holders. Hawaii, Louisiana and Wisconsin each improved five positions. Wisconsin improved in the percent of households with Internet access. Louisiana climbed in state appropriations for higher education as did Hawaii.

Technology and Science Workforce

Background and Relevance

Research and development are the raw materials of innovation that the technical and scientific workforce converts into commercially viable products and services. The most economically successful places are those with businesses whose innovation processes are organized in a collaborative framework with research, design and production engaging in dynamic, interactive learning processes.[52] More effective research and design occurs where it is located near production operations. The technical and scientific workforce of a region propels its technological sophistication, innovation and economic growth, not only for technology firms, but for all firms where innovation is a key competitive advantage.

Regions with a high concentration of skilled technical and science workers have another advantage—industry clustering pools workers, creating a labor force with industry-specific skills.[53] As design engineers, programmers, biologists and the like migrate from other regions to a geographic cluster or remain in a cluster after graduating from local institutions, they reinforce the initial advantages that a region has, stimulating further localized growth. In this way, a region gains the most fundamental source of its competitive advantage—highly mobile, geographically discriminating labor assets.

In a local high-velocity labor market, scientific and technical workers benefit from the opportunity to move from one employer to another. Firms also benefit when there is local technical talent that possesses the industry-specific skills they require, reducing the firms' searching costs. The ease with which locations can assemble, circulate and reassemble teams of highly skilled workers both helps foster new firm formation and sustain mature technology firms.[54]

Technology spillovers can result from a local high-velocity labor market. New process and product innovations within a cluster can be shared through informal relationships. As labor moves between firms, labor-market network relationships evolve by ex-colleagues remaining in informal contact with one another.[55] This tacit knowledge sharing among technicians and scientists gives their host regions distinct advantages by communicating the latest noncodified advances in their fields. Technology or knowledge-sharing might be perceived by some member firms as a negative externality at times, but usually generates a comparative advantage that helps keep the cluster's members ahead of other competing geographic clusters. California's Silicon Valley provides perhaps the best example of knowledge-sharing in a high-velocity labor market.

Business management guru Gary Hamel notes that most firms would be sent into cardiac arrest by the high employee turnover in Silicon Valley, yet, that is probably one of its greatest strengths. Hamel states that "every Silicon Valley CEO knows that if you don't give your people truly exhilarating work … they'll start turning in their badges.[58]" Turnover in Silicon Valley is 20 to 25 percent per year during its periodic high-tech industry growth spurts. The best and brightest tend to move the most. Skilled technicians and scientists change employers with less hesitancy than most people change positions within a firm. Technical workers in Silicon Valley are in constant pursuit of the next killer opportunity.

Skilled technical workers possess the keys to the creation of economic value. Despite this recognition, firms have difficulty defining what is unique about knowledge and technical workers, and how to describe them. Science and technical workers do not just access knowledge and apply it to firm-specific objectives. Rather, more importantly, they harness new information to generate new knowledge, bringing both inductive and deductive analytic skills to complex problems and creating new concepts and processes. New knowledge generation can take the form of incremental innovation as well as radical innovation that propels a business into new endeavors.

Science and technology work is based upon complexity and uncertainty—demanding a high degree of independent judgment. The complexity of work can be seen as one dimension and thought of as a continuum, with routine work at one end, and knowledge work at the other. Complex work involves unstructured problems with varying degrees of detail, extended time horizons, imprecise information inputs and diffuse scope. Routine work is characterized by structured problems defined by its accuracy of detail, short time horizons, information with clear formats and narrow scope.[59] The second dimension is whether these technicians operate in a collaborative, team environment or as independent operators. A high level of interdependence is characterized by cross-functional and/or team-based organization, while low interdependence involves a single function or single actor.

When most people think of a technical or knowledge worker, they envision an individual specialist who is immersed in a particular field of knowledge. These types of knowledge workers apply and build upon their specialized knowledge through their work. An electrical engineer is an excellent example of just such a knowledge worker. When these individual operators interact with others, it is typically within a community of colleagues. With similar specialized training, they develop both common terms of reference and their own common language filled with jargon that others do not understand.

These scientists, engineers and other skilled technicians (S&E) are the new workforce elites. They are individuals either educated in the sciences and engineering fields or people who were not educated in these fields, but hold occupations in these categories.

S&E workers comprise less than 5 percent of the workforce, but contribute far more to regional vitality than these figures may indicate.[60]

In 1999, there were approximately 13 million S&E staff (including all who were trained in these fields or employed in these occupations) residing in the United States.[61] It is common for these workers to report that research and development is a major focus of their employment. Narrowly defined S&E jobs totaled 3.7 million in 2000, an increase of 159 percent between 1980 and 2000. This increase was an annual gain of 5 percent, versus 1.1 percent for all job categories in the United States over that time period. The most rapid growth was witnessed in mathematics and computer sciences, where employment rose from 177,000 in 1980 to 1.3 million in 2000—a remarkable increase of 623 percent.

Engineers represent the largest category of S&E workers. Engineers comprise 39 percent (1.38 million) of all S&E workers. Computers scientists and mathematicians, however, are rapidly closing the gap and account for 33 percent (1.17 million) of S&E positions. Physical scientists account for about 9 percent of all S&E occupations. Bachelor's degrees were the highest degree obtained by 56 percent of workers employed in S&E jobs; another 29 percent list a master's degree and 14 percent reported a doctorate.

In 1999, the latest year available, the median annual salary of employed bachelor's degree holders in S&E occupations was $59,000; master's degree holders earned $64,000, and Ph.D.-degree recipients earned a median salary of $68,000. Computer scientists and mathematicians with bachelor's degrees reported higher salaries than master's or doctorate holders in those fields. This partially indicates that more recently acquired knowledge in programming languages has higher value in the marketplace, but also reflects that more computer scientists employed in the private sector hold bachelor's degrees, while doctorate-degree holders tend to work for universities and research centers.

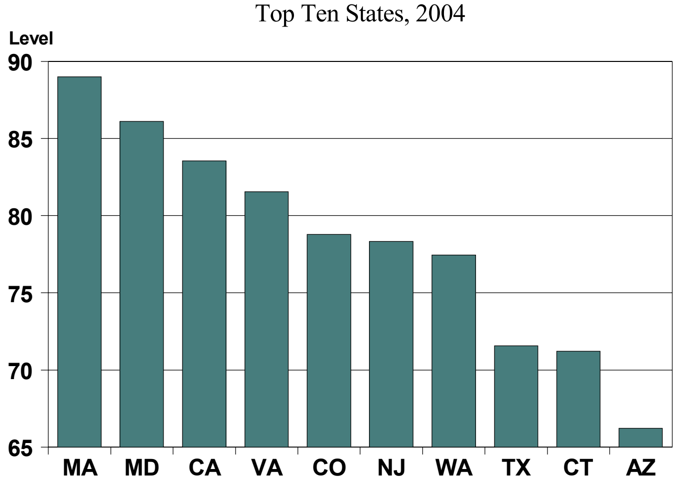
Looking ahead, the demand for S&E workers is expected to be very strong. Over the next decade, employment in S&E occupations is projected to increase more than three times faster than total employment.[62] This translates into the need for an additional 2.2 million S&E workers. The United States has experienced a rapid increase in the immigration of foreign-born scientists and engineers. The knowledge of scientists and engineers can be transferred across borders more easily than other skills because it is more codified. For example, 27 percent of doctorate-holders in S&E in the United States are foreign born. Among recent-degree recipients, the percentages are even higher.

Technology-based economic development is largely dependent upon the supply of scientific and engineering talent required to staff rapidly growing technology firms and their larger cousins.[63] Innovation and the scientific and technical skill base of a region are best combined for maximum performance. For state and local economic development, the message is this: the quality of scientists, engineers, physicists, system engineers and other creative technical workers that states train and retain, and attract from other locations, will profoundly impact a region's future technology industry development.[64]

State Findings

In the composite measure of its Technology and Science Workforce, Massachusetts records its third 1st-place finish among the first four composite measures with a score of 89.0—a remarkable score that demonstrates the breadth of technical talent in the state. Massachusetts even improved upon its lofty 3rd position in 2002. Maryland's score of 86.1 placed it 2nd. California scores high (83.6), ranking 3rd in the nation in Technology and Science Workforce. A positive performance, to be sure, but also one that represents a decline from the 2002 Index. The remainder of the top 10 include Virginia (81.6), Colorado (78.8), New Jersey (78.3), Washington (77.4), Texas (71.6) and Arizona (66.2). The top 10 states in the overall Index are those that are widely recognized for their high-tech economic dynamism: A tech workforce tends to gather intensity in states that offer both the relevant job opportunities and a vibrant, growth-oriented business environment.

Technology & Science Workforce Component
Top Ten States, 2004



Source: Milken Institute

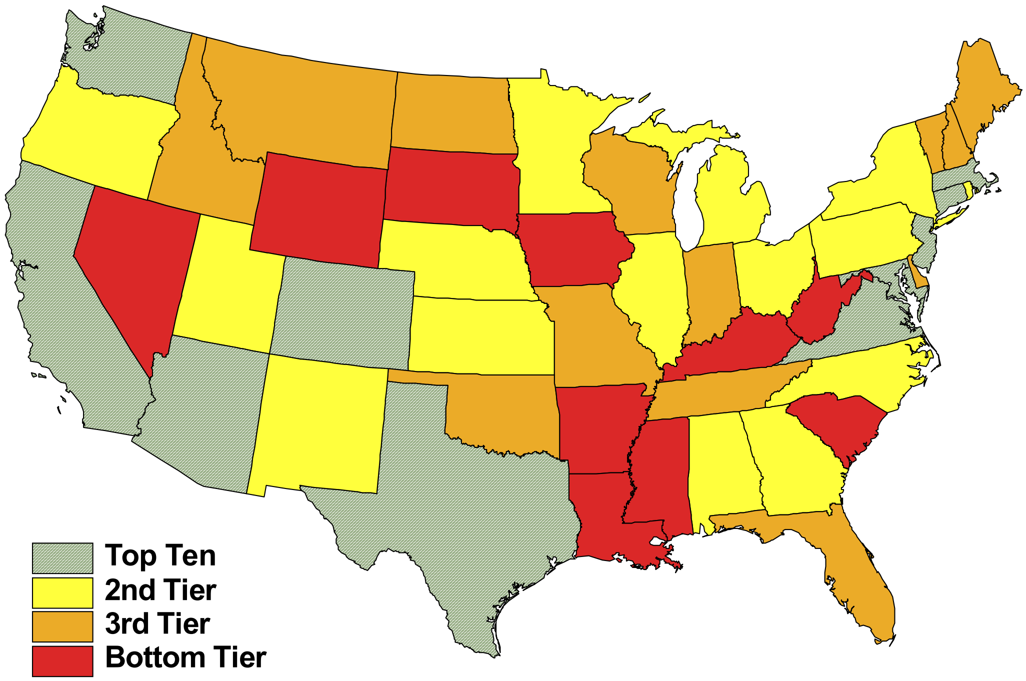
There are 18 indicators included in this composite. The Technology and Science Workforce composite attempts to measure what research and innovative capacity is resident in a state, not what may be promised in the future. The intensity of the technology and science workforce is an excellent measure of the sophistication and technology competency of human capital in a state's economy.

The Intensity of Computer and Information Science (I.S.) Experts indicator is calculated by averaging the intensity scores of six different types of Computer and Information Science-related occupations—Computer and Information Scientists, Computer Programmers, Software Engineers, Computer Support Specialists, Systems Analysts, and Database and Network Administrators. Intensity is defined as the percent share of employment in a particular industry or occupation as it relates to total state employment. Computer and Information Science experts are important to a state's vitality because I.S. is considered to be a high value-added occupation, and a sign of a technologically dynamic and entrepreneurial region.

The Intensity of Life and Physical Scientists indicator is calculated by averaging the intensity scores of six different types of Life and Physical Science-related occupations—Agricultural and Food Scientists, Biochemists and Biophysicists, Microbiologists, Medical Scientists, Physicists, and Miscellaneous Life and Physical Sciences. These types of scientists are important to a region's scientific community because they help support and promote entrepreneurial activities. Regions benefit from a thriving Life & Physical science industry because these scientists make enormous contributions to building up the region's reputation as a high technology, high value-added center.

The Intensity of Engineers indicator is calculated by averaging the intensity scores of six different types of engineering-related occupations—Electronics Engineers, Electrical Engineers, Computer Hardware Engineers, Biomedical Engineers, Architectural Engineers, and Other Engineers. Engineers are important to a region because they are the traditional creators and innovators of multiple technologies and processes. An abundance of high-skilled engineers leads to increased research and development funding and opportunities both from within and outside the region.

Technology & Science Workforce Component
2004



Massachusetts' score was nearly 3 index points higher than 2nd-place Maryland. Massachusetts is in the top 10 in all six of the Computer & I.S. Experts occupations and was 1st in intensity of Software Engineers. Massachusetts was 3rd in intensity of Life & Physical Scientists. Massachusetts was strongest in intensity of Engineers with a 1st-place performance. Within the engineering category, Massachusetts nearly doubled the intensity of biomedical engineers of the 2nd-place state. Maryland scores 1st in intensity of Life & Physical Scientists, especially so in Microbiologists where it more than doubled Massachusetts' intensity. Although California demonstrates strength in its intensity of computer and I.S. experts, its intensity of life and physical scientists and engineers measurements are even stronger. With 124 life and physical scientists for every 100,000 members of the working population, the state ranks 2nd in the nation. Home to 653 engineers per 100,000 members of its state workforce, California ranks 3rd in the nation

Virginia, only 2 index points behind California overall, is 1st with a score of 96.0 in intensity of Computer & I.S. Experts. This position partially reflects the pervasiveness of federal government contract work. Colorado is 2nd in intensity of Engineers and 3rd in Computer & I.S. Experts. New Jersey isn't among the leaders in any single occupation category, but is in the top five in Computer & I.S. Experts and Life & Physical Scientists. Reflecting the presence of Microsoft and a cluster of software firms in the Seattle area, Washington is 4th in intensity of Software Engineers. Based upon its computer and semiconductor clusters, Texas is 5th in intensity of Engineers. Connecticut scores highest at 83.7 in Computer and I.S. experts. Arizona recorded it strongest position in intensity of Engineers.

With a score of 28.1, Nevada is 50th in the Technology and Science Workforce composite. Nevada's highest position was 45th in Computer and & I.S. Experts. Nevada was only in the top half of states in two of the 18 occupational categories. Arkansas, 49th, recorded its highest position in Life & Physical Scientists. Louisiana's 48th position in 2004 was an improvement from 50th in 2002. Louisiana's overall ranking is harmed by its dismal performance in Computer & I.S. Experts. Mississippi suffers from a lack of engineering and computer and I.S. talent and ranks 47th overall. Kentucky, 46th, is next to last in intensity of Life & Physical Scientists. Wyoming has the distinction of being last in intensity of Computer & I.S. experts and 45th overall in 2004. At 44th, West Virginia scores near the state average on Life & Physical Scientists, but falters in the other categories. South Carolina slipped into the bottom 10 in 2004 at 43rd, a fall of five places from its 2002 position. South Dakota, 42nd, edged down two positions from 2002. With a score of 42.4, Iowa plunged to 41st in 2004, down from 34th in 2002. Iowa witnessed a major deterioration in intensity of Software Engineers.

Rhode Island recorded the best improvement in the Technology and Science Workforce composite from 2002, climbing by 11 positions to 21st in 2004. This was the second composite in which Rhode Island had the biggest gain. Rhode Island moved up in Computer & Information Scientists and Computer Support Specialists. North Dakota rose by nine positions in 2004 and was 1st in intensity of Agricultural & Food Scientists. Indiana improved its position to 31st in 2004, up six from 2002. Indiana gained in its placement in intensity of Life and Physical Scientists. Vermont edged up five positions to 36th in 2004 with a big jump in Software Engineers. Kansas, New Mexico and Ohio all improved by four positions in 2004.

Technology Concentration and Dynamism

Background and Relevance

Where clusters of existing technologies expand and emerging science-based technologies form, are critical factors in shaping the economic winners and losers of the first half of the 21st century. Because knowledge is generated, transmitted, and shared more efficiently in close proximity, economic activity based on new knowledge has a high propensity to cluster within a geographic area.[65] As economic activity is increasingly based more on intangible assets, those states with vibrant technology clusters will experience superior economic growth. In other words, if you are a state with several leading clusters, your state will have more innovations, less of which will escape to other regions, or at least, they will do so at a slower rate.

The keys to regional and state viability now are linked to their ability to establish local technology clusters that are networked with the global business community. The paradox of the global-based economy is that the enduring competitive advantages lie in location-specific competencies—knowledge, workforce skills, customer and supplier relationships, entrepreneurial infrastructure, management practices, the motivations, and quality-of-place attributes that allow firms to thrive. In essence, thinking locally to succeed globally.[66]

Industry clusters and their associated support infrastructure are a region's best defense against being arbitraged in a global cost-minimization game, especially in those based upon technology agglomerations. Firms, and the clusters to which they belong, can mitigate input-cost disadvantages through global sourcing. Location sustainability is contingent upon making more productive use of inputs, based largely on innovation competencies. Clusters linked to the outside world offer their regions access to the best practices and latest industry developments.[67] Regions will excel to the extent that the firms and talent in them can innovate successfully by being there, rather than somewhere else.

To create international comparative advantage in an information-age economy, clustering innovative activity is imperative. The spatial dimensions of economic activity are becoming an interesting field of inquiry—space is central to understanding how an economy works.[68] Since the late 1980s, there has been renewed interest in "economic geography" mainly because of new statistical tools. If we really lived in a world of constant returns, we would not see the high level of specialized economic activity within regions that we do. This clustering results from businesses and workers seeking geographic proximity with others engaged in related activities. Increasing returns lead to competitive advantages, as in, the more that is produced, the cheaper it is to make. Such externalities, or what an economist might call agglomeration effects, typically arise from three primary sources: labor-force pooling, supplier networks and technology spillovers.

How do we describe clusters? A common misperception of clusters is that they are based upon a single industry. One single industry might be the core of a cluster, but without its partners, it may not endure for long. Industry clusters are geographic concentrations of sometimes competing, sometimes collaborating firms, and their related supplier-network.[69] They are agglomerations of inter-related industries that foster wealth creation in a region, principally through the export of goods and services beyond its borders.

Clusters depict regional economic relationships—local industry drivers and regional dynamics—more richly and aptly than do standard industrial methods. An industry cluster differs from the traditional definition of an industry group. It represents an entire value chain of a broadly defined industry sector from suppliers to end products, including its related suppliers and specialized infrastructure. A cluster of interdependent linked firms and institutions represents a collaborative organization form that offers its members advantages in efficiency, effectiveness and flexibility.[71]

Supplier networks are instrumental to the success of clusters and fostering sustained agglomeration processes. Clusters are inter-connected by the flow of goods and services. This flow is stronger than the one linking them to the rest of the local economy. Cluster members usually include governmental and other nongovernmental entities such as public/private partnerships, trade associations, universities, think tanks and vocational training programs. These institutions provide specialized skill training, education, research, and technical support. Cluster members include both high and low-value activities.[72]

The key to regional technology sustainability is based upon the diversity of its ecosystem. Locally based innovative technology firms that evolve into dominant players are necessary, but not sufficient for sustaining the system. These newly dominant firms assist regions in developing technology management capabilities that can be leveraged to quicken the pace of innovation for new entrants. Newly formed entrepreneurial firms can tap into the technology management capabilities resident in the region to rapidly exploit emerging technology market opportunities. Many high-tech regions have developed capabilities for rapid design changes at dominant firms, and more importantly, integrating new regional knowledge into new firm births.

The process of commercializing emerging technologies requires the ability to manage uncertainty and complexity as many will be highly disruptive in nature, potentially threatening key regional incumbents. The failures of established incumbents are well cataloged and commercialization models have explicitly incorporated the principle that attackers from the outside are generally required when an emerging technology threatens the existing regime.[73] The issues that can leave incumbents ill-prepared stem from the technological doubts, vague market signals, and nascent competitive structures that differentiate emerging from established technologies. To cope and triumph requires innovative managerial competencies and new cross-functional skills.[74]

Sustaining a technology-based ecosystem in a particular region requires more than technology capabilities. Social capabilities are required to promote the ecosystem as well. Discussing leading technology clusters, co-author, Rob Koepp points out in his book,[75] *Clusters of Creativity*, "The progress of these clusters can only be understood if one gets behind how they and the enterprises that populate them have been managed, specifically in regards to how management practices facilitate a cluster's lifeblood of innovation and entrepreneurship—two pillars of economic behavior that are universal to all forms of economic existence, not just the particular sectors of advanced technology with which the Siliconia are so readily associated."

Diversity of technology-based clusters is important for regional success as well. A strong agglomeration in one to two technology industries such as telecommunications services or communications networking equipment can be an economic engine during a boom, but a liability during a bust, as many places have discovered.[76] Technology diversity can also act as a virtual unplanned innovation engine. Serendipitous confluences from seemingly unrelated technology fields can create a critical advantage for the host region. Ronald Kostoff, in a broad survey of regional innovation processes, found that "an advanced pool of knowledge must be developed in many fields before synthesis leading to innovation can occur.[77] Additionally, technology advances are likely to be from cross-disciplinary capabilities. For example, the leading centers of biotechnology may well be those with the proper mix of bioinformatics, mathematics and microbiology.

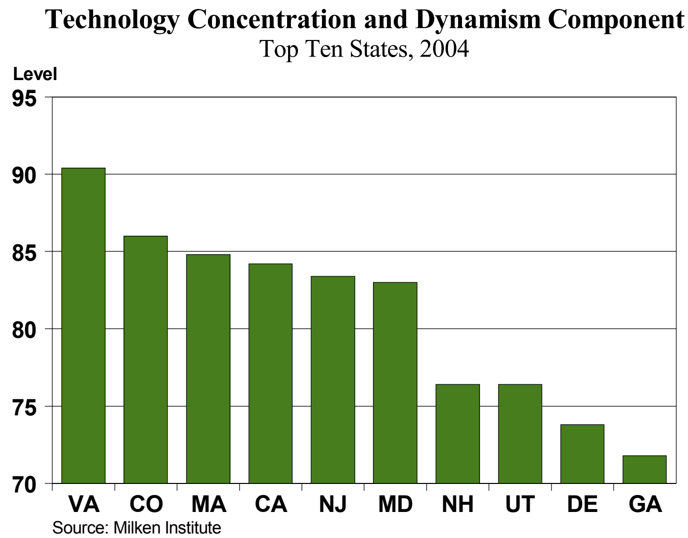
Jacobs' observations on dynamic externalities for all types of industries in a particular location appear to be prescient for technology firms.[78] She maintained that these dynamic externalities form based upon communications about production possibilities among firms in different industries, as opposed to the specialization or concentration of the same industry. Diversity speeds up the technological adoption process in a collective cumulative process. Vinod Sutaria expands on this in his book, *The Dynamics of New Firm Formation*[79] where he states, "Dynamic externalities, through their unpredictable and creative nature, pose a serious threat to the static assumptions of neoclassical theory. The existence of dynamic externalities is expected to stimulate the formation of new firms. There is a clear link between them."

Technology-based clusters are determining which places are succeeding or falling behind. Without growth in high-tech industries, states risk not participating in the intangible-based economy. It is imperative for state and local development officials and business leaders to promote high-tech expansion and cluster formation, or they risk substandard economic growth in the future. Although high-tech is not the only development strategy to pursue, it is a key distinguishing feature of regional vitality in the 21st century.

State Findings

Virginia holds the 1st position in the Technology Concentration & Dynamism Component in 2004, a lofty position that it held in 2002. Virginia's 90.4 score places it more than 4 index points above the 2nd-place state, Colorado. Colorado's 86.0 score is solid and shows that despite the current technology difficulties, the state is well positioned for the future. Massachusetts' 3rd-place score of 84.8 is not very far below Colorado's. California ranks 4th in the nation in its high-technology concentration and dynamism. The other top 10 states in the U.S. for this component are (in descending order) New Jersey (83.4), Maryland (83.0), New Hampshire (76.4), Utah (76.4), Delaware (73.8) and Georgia (71.8).

There are 10 indicators included in the composite. In many respects, this index can be viewed as a measurement of technology outcomes. This composite index aims to measure the degree to which each individual state's economy is fueled by the technology sector. In essence, the composite illustrates the effectiveness of each state's entrepreneurial, governmental and policy-formulating success, or lack thereof. Measuring high technology employment, payroll activity, net business formations and growth displays the successes or failures of regional efforts. Technology concentration and dynamism should be viewed as an indicator of technology outcomes.



Having a high percentage of high-technology businesses is important to a regional economy because it suggests that there is a large quantity of establishments whose model is centered on high value-added, dynamic products and services. States with large shares of high technology employment are expected to have high payrolls as high-tech jobs warrant above-average salaries. Furthermore, it is an important inducement for technology firms based elsewhere to establish operations in the state and retain existing firms contemplating expansion. Drawing comparisons between employment and establishments in the high-tech sector to salaries being paid to high-tech workers allow analysts to determine the quality of jobs being created in the sector and in the economy as a whole.

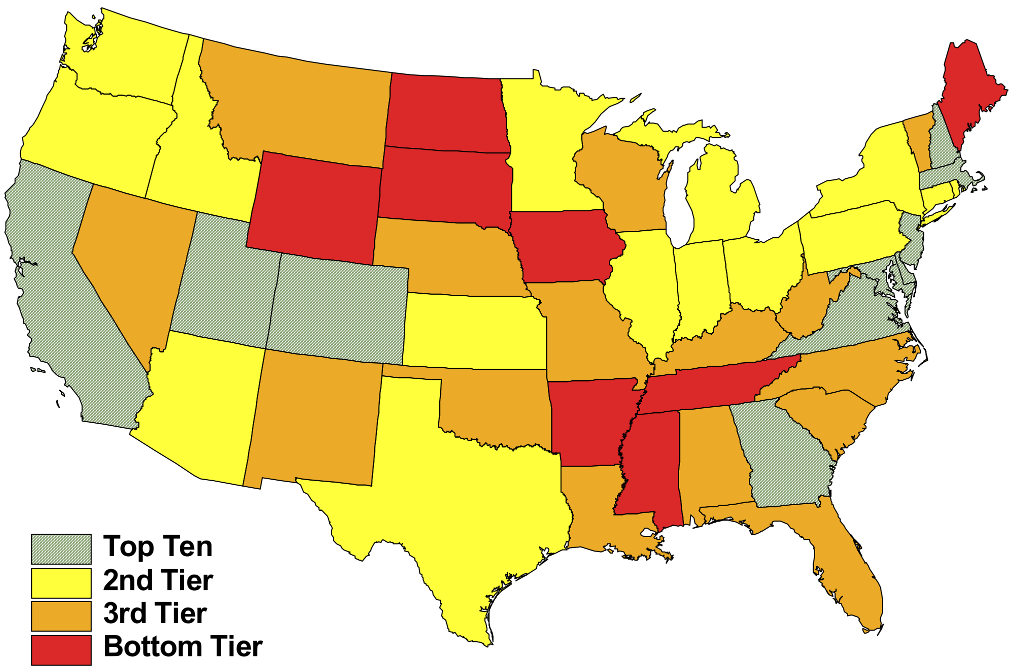
Concentration of high technology industries is important to a state's economy because it provides a way to measure the impact of a given industry on the state's economic performance. High location quotients allow analysts to safely assume significant impact on a state's high technology sector from positive as well as negative shocks.

Business births are important to a state because healthy gains in businesses are signs of economic stability, prosperity and optimism. Business births in the high technology sector are particularly important because prosperity at the regional level during the last three decades has been linked to high technology expansion. Net high technology business establishment formation is important in analyzing a state's economy. Net high-tech establishment formation allows analysts and policy makers to gauge the supplier network and the state of a regional economy.

The number of Technology Fast 500 Companies in a state assesses its high-technology sector success. Since technology has been a primary driver of economic growth, an indicator that gauges the number of technology companies in terms of growth and expansion is crucial when assessing a state's technology sector. The presence of Fast 500 companies in any given state is important because it shows where the fastest growing privately held companies are located.

Examining where technology is prevalent is not the same as examining where technology is growing. Average yearly growth in high tech aims to capture where technology has grown fastest during the past five years regardless of industry base. Determining the number of industries that are growing faster than the U.S. on average is important when performing cross-state analysis because it allows analysts to see what industries within the high technology sector are more successful in different parts of the country than in others.

Technology Concentration and Dynamism Component
2004



Virginia rose to be among the technology elites over the past decade. To demonstrate its strong position, Virginia was among the top five in seven out of the 10 indications in the Technology Concentration & Dynamism Component. With 25.6 percent of its state payroll in high-tech industries, it is 1st in the nation. Colorado maintained its 2nd position by its consistent above-national-average performance. Colorado, with 8.1 percent of its establishments in high-tech industries, scores ahead of California. Massachusetts dominates the indicators of technology concentration, but witnessed slower growth than most other top-tier states, which kept it out of the top position overall. 7.3 percent of all California businesses operate as high-technology enterprises. This represents an improvement over the state's performance in the 2002 Index where 7.1 percent of

California businesses registered as high-tech. New Jersey retains its 5th position in 2004, matching its 2002 performance. New Jersey holds the distinction of having the highest percentage (8.4) of establishments in high-tech NAICs codes.

Maryland scores in the top 10 in the nation in eight out of the 10 indicators. Maryland's highest position, 2nd, was in the number of high-tech industries growing faster than the U.S. New Hampshire improved its position from 2002 by moving up three slots to 7th. Nevertheless, there is a wide gap of 6.6 index points between New Hampshire and 6th-place Maryland. New Hampshire's biggest improvement was in the number of Inc. 500 companies per 10,000 business establishments. Utah, essentially tied with New Hampshire, captures the highest number of Inc. 500 companies per 10,000 business establishments. Delaware scores in the upper part of the second-tier on most indicators, but breaks into the top five on net high-tech establishments per 10,000 business establishments and high-tech industries' average yearly growth. Georgia's position is attributable to its high scores in recent indicators of growth.

Mississippi is last (50th) among states on technology concentration and dynamism recording a score of 19.4. It slipped one position from 2002. Most discouraging for Mississippi's future position is that its best scores were in measures of technology concentration, while its performance in growth measures was at or near the bottom. South Dakota, falling six positions from 2002, finds itself 49th in the nation. Similar to Mississippi, South Dakota witnessed poor performance in recent technology growth measures. North Dakota was 48th just 1.1 index points ahead of its Southern neighbor. Hawaii moved to 47th in 2004, up three positions from 2002. Recent performance measures, such as its 24th-place rank in net formation of high-tech establishments per 10,000 business establishments, assisted it relative to 2002. Wyoming fell seven positions in 2004, placing it 46th.

Maine, 45th, scores above average in only one indicator—net formation of high-tech establishments per 10,000 business establishments. Arkansas' 44th position is a slight improvement from 2002, but ranked 12th in high-tech industries' average annual growth. Alaska is positioned 43rd and moved up slightly due to strong growth in high-tech relative to the national average over the last five years. Tennessee's position deteriorated by two positions relative to where it was in 2002, coming in at 42nd overall in 2004. Rounding out the bottom 10 was Iowa which scored 34.4 in 2004.

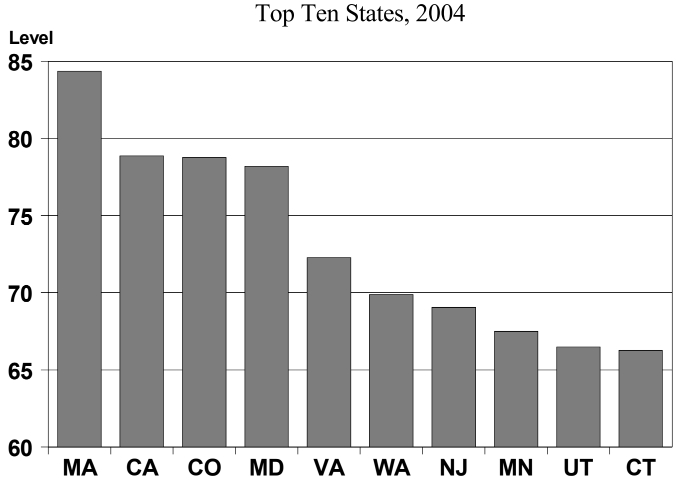
Nebraska and Oregon each improved by nine positions in 2004. Nebraska moved up to 38th by consistent improvement in recent performance such as number of Inc. 500 companies per 10,000 business establishments. Oregon, at 18th, jumped substantially in the Inc. 500 category as well, but saw steady increases across most indicators. Indiana enhanced its standing by six, moving up to 19th. Indiana scored big improvements in both percent of employment and percent of payrolls in high-tech NAICs codes. Rhode Island was among the best improving states by rising five positions in 2004 to 21st. Rhode Island showed strong gains in several growth indicators. Four states rose 4 positions in 2004, Alabama, Ohio, Pennsylvania and West Virginia.

State Technology and Science Index and Findings

The State Technology and Science Index encapsulates a state's comprehensive inventory of technology and science assets that can be leveraged to promote economic development. Its research and development capabilities can be commercialized for future regional and state technology growth. A state's entrepreneurial capacity and risk capital infrastructure is the fuel that determines the success rate of converting research into commercially viable technology services and products. Human capital is the most important intangible asset of a regional or state economy.

The intensity of the technology and science workforce indicates whether states have sufficient depth of high-end technical talent on the ground. Technology concentration and dynamism can be viewed as a measure of technology outcomes. Measuring technology growth, points to the effectiveness of policymakers and other stakeholders in transforming regional assets into regional prosperity.

State Technology & Science Index
Top Ten States, 2004



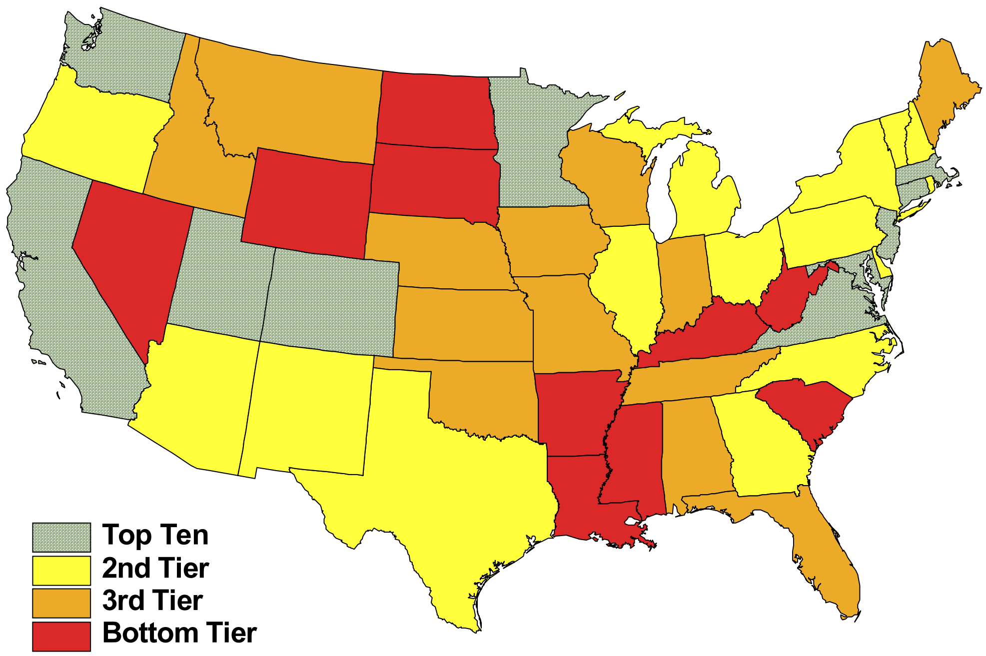
Source: Milken Institute

Massachusetts holds a dominant 1st-place position in the 2004 State Technology and Science Index with an overall score of 84.4. Massachusetts was 1st in three of the five components and its lowest position was 3rd. California's overall score of 78.9 ranks the state 2nd in the nation, about 5.5 index points behind 1st-place Massachusetts. Colorado (a mere 0.09 index points behind California), was 3rd with the highest score in Human Capital Investment in the country. Maryland was a very close 4th overall and challenged Massachusetts for the top position in Technology and Science Workforce component. Virginia (72.3 score) was 5th overall and 1st in Technology Concentration and Dynamism. Washington (69.9 score) was 6th, New Jersey (69.0 score) 7th, Minnesota (67.5 score) 8th, Utah (66.5 score) 9th, and Connecticut 10th with an overall score of 66.3.

Massachusetts' score in Research & Development (92.2) placed it almost 12 index points above 2nd-place California. This was the highest score on any of the five components and the largest gap between 1st and 2nd place. Massachusetts is also first in the nation for total funds in industrial scientific R&D and in venture capital dedicated to biotechnology and the medical device industry. Massachusetts retains its 2002 position, 1st overall. California's ranking represents an improvement over the 2002 Index where it placed 3rd. Given the state's virtual tie with Colorado and 1st-place Massachusetts' continued sizable lead, however, despite California's top-tier ranking, there is ample room for improvement. On the other hand, the diversity of California's technology clusters gives it a unique position among states.

Colorado's position is a strong one and it ranked 1st in one of the five components while 2nd-place California didn't hold any number one placements. Colorado's lowest position on any of the components was 5th. Taking a mid-course correction, Governor Owens signed legislation ending the certified capital corporations (CAPCOs) because of poor investment returns and redirected $50 million to a new Colorado Venture Capital Authority to provide capital to businesses throughout the state. Maryland held its 4th-place position from 2002. Maryland's most poignant strengths are in the life sciences and communications technology, two sectors with extremely bright long-term prospects, and where it has some of the best and deepest talent in the nation. Maryland is another state that is likely to build upon its intangible economic asset base in coming years. Although the state's worst showing in the compound indexes was in fact for the outcomes measure of Technology Concentration & Dynamism, "worst" here is a relative term, as it still placed 6th. All of its other Composite Index scores are in the top five. Unless there is a serious deterioration in performance, these input measures are likely to help bring up Maryland's concentration and dynamism performance. A recent set of recommendations provided by Governor Erlich's Commission on Development of Advanced Technology Business is one of the most forward looking roadmaps for technology-based economic development. At 4th-place in the overall Index, it borders 5th-place Virginia.

State Technology & Science Index
2004



Virginia's high score (90.4) in Technology Concentration & Dynamism placed it more than 4 index points above the 2nd-place state, Colorado. This indicates great potential for the future. Virginia and Colorado, which in a relatively short time have developed vibrant and expanding high-tech economies, offer more attractive cost structures than states such as Massachusetts and California and are closing the gap. Now occupying the top two positions in the Technology Concentration & Dynamism Compound Index, Virginia and Colorado could easily pull farther ahead of more mature high-tech economies of 3rd-place) Massachusetts and 4th-place California in this category and boost their overall positions in the future.

Massachusetts' doesn't appear to be taking its position for granted. Governor Romney proposed some major technology-based economic development investments last September, but vetoed some of the measures that the legislature passed. The Governor cited budget concerns. When the legislature reconvened in its 2004 session, it overrode $67 million in funding that had been vetoed. The initiatives range from regional Centers of Excellence to funding targeted investment in emerging technologies. The legislation even set aside $15 million for creation of the John Adams Institute to promote "the development, growth, attraction and retention of technology-intensive and innovation-driven clusters of organizations…"[80]

California's public policy appears to be moving in the opposite direction, calling into question whether it will retain its position in the future. One of the budget proposals calls for cutting incoming college freshman enrollment in the fall by over 7,000 in University of California and Cal State systems in response to the state's fiscal crisis. California may lose many students to other states and some that stay won't enter science and engineering programs that might have enrolled.

Washington recorded a top 10 position in four of the five composite indices and was 13th on the other one. It was 1st in the nation in business starts for the latest year available. Washington's 6th position in 2004 ties its 2002 performance. Governor Locke has proposed a new tax incentive program for R&D and jobs in rural areas of Washington, in the hopes of enhancing Washington's position. New Jersey remained 7th in 2004, principally due to its high position in the technology and science workforce and technology concentration and dynamism. Among technology and science occupations, New Jersey scores in the top five in Computer & I.S. Experts and Life & Physical Scientists, reflecting its strength in pharmaceuticals and telecommunications. Governor McGreevey is attempting to extend New Jersey's strong position in life sciences by proposing that the state fund controversial stem cell research, recognizing that there could be high returns to the state's economy. The Governor also requested a 50 percent increase in New Jersey's technology tax credit transfer program. This program is the most aggressive in the country in allowing biotech or technology businesses to sell their unused net-operating loss carry forwards and unused R&D tax-credit carry forwards.[81]

Minnesota improved two positions relative to the 2002 index, moving up to 8th. Minnesota improved its ranking in four out of the five components and recorded the largest gain in Research & Development. Governor Pawlenty has proposed a bonding bill to the legislature that would forge a new research partnership between the Mayo Clinic and the University of Minnesota in the biosciences area.[82] His aim is to increase the effectiveness of research in the state. Utah retained its 9th position overall and its best placement was in technology concentration and dynamism where it captured the highest number of Inc. 500 companies per 10,000 business establishments. Utah is taking action to foster its position in the future. Legislators recently passed a constitutional amendment, which, if approved by voters, would permit universities to take ownership in private business in exchange for intellectual property.[83] Connecticut scored best in human capital investment.

Mississippi is 50th on the 2004 overall Index with a score of 27.5, a reduction in one position from 2002. Mississippi was last in the technology concentration and dynamism component with recent growth performance its weakest area, representing the wrong direction in momentum. Mississippi might want to pay attention to the McCoy Working Group's recommendations which strongly suggest that the state must quickly commit substantial resources to higher education if it wants to make the state relevant in the intangible economy. Arkansas moved up to 49th overall, but had its best scores in recent growth. Kentucky slipped two notches to 48th in 2004 with its biggest regression in risk capital and entrepreneurial infrastructure.

South Dakota is 47th in 2004, and while it didn't slip relative to 2002, its recent growth performance deteriorated. Governor Rounds 2010 Initiative seems to be a step in the right direction. Among other things, it calls for a loan program for entrepreneurs and start-up companies that do business in their home state.[84] West Virginia inched up two positions in 2004 to 46th with a big improvement in measures of risk capital and entrepreneurial infrastructure. North Dakota remained at 45th in the 2004 index. South Carolina fell three positions to 44th with a slippage in four out of the five components. South Carolina just unveiled a $500 million technology-based economic development package that targets life sciences, commits state funds to venture capital, and facility and infrastructure improvements at the state's three research universities.[85] It may be behind other states in making these investments, but at least corrective actions are under way. Nevada was 43rd in 2004, followed by 42nd-place Louisiana which improved by two positions relative to 2002. Wyoming rounds out the bottom 10 with a score of 38.7.

Rhode Island holds the distinction of recording the most improvement. Rhode Island rose from 21st in 2002 to 11th in 2004, almost cracking the top 10. Rhode Island jumped 24 places in risk capital and entrepreneurial infrastructure with the biggest gain in IPO proceeds. Additionally, Rhode Island had a sizable increase in technology and science workforce. The state seems committed to seeding investments in its future as Governor Carcieri unveiled a fiscal year 2005 budget calling for some aggressive technology-based economic development initiatives. Just behind Rhode Island in the most improved category was Vermont which rose nine positions in the 2004 Index to 22nd. Vermont improved in all five components, but witnessed the best performance in risk capital and entrepreneurial infrastructure. Vermont had a dramatic increase in industrial R&D as well.

New Mexico and Tennessee both improved by six positions in 2004. New Mexico rose to 14th in 2004. New Mexico's best performance was in measures of growth in venture capital funding. Tennessee, at 34th, moved up due to better human capital scores and venture capital. Hawaii, Nebraska and Oregon each improved by four positions in 2004. The inclusion of R&D in agricultural sciences and Hawaii's better score in industry R&D moved it up. Nebraska benefited by the inclusion of R&D in agricultural sciences as well, but witnessed solid improvement in several areas. Oregon saw notable gains in research and development and in human capital investment.

The Eastern United States continues its dominance of the overall Index, with 1st-ranked Massachusetts, 4th-ranked Maryland, 5th-ranked Virginia, 7th-ranked New Jersey, and 10th-ranked Connecticut constituting half of the top 10 category. The West's 2nd-ranked California, 3rd-ranked Colorado, 6th-ranked Washington, and 9th-ranked Utah virtually round out the top 10, making the upper tier of the Index basically a bicoastal cohort. Only Minnesota, as it did in the 2002 Index year, managed a place in the top 10, giving at least one position among the top 10 to a region beyond the East Coast or American West.

On the opposite end of the ranking spectrum, the Deep South has the unenviable position of dominating the bottom 10 with 42nd-ranked Louisiana, 44th-ranked South Carolina, 49th-ranked Arkansas, and 50th-ranked Mississippi. The less populous states of the West

(41st-place Wyoming, 43rd-ranked Nevada), Midwest (45th-ranked North Dakota, 47th-ranked South Dakota), and Northern-most areas of the South (46th-ranked West Virginia, 48th-ranked Kentucky) round out the bottom-tier of states.

Just as a high ranking should not be interpreted to mean that a state should be complacent about its competitive position, a lower ranking similarly should not be taken to mean that a state is consigned to a fate of underperformance. Virginia, though not part of the Deep South, is geographically a southern state. Its rise to high-tech economic dynamism over recent years can offer lessons for states that aspire to a more prosperous future in the intangible economy. California itself had an economy dominated by natural resources and agriculture as recently as the middle of the 20th century; its high-tech industrial base, compared to the more mature high-tech economies of East Coast, is a relatively recent phenomenon. Moreover, new state policies that may come from recently launched initiatives such as Accelerate Arkansas and Louisiana's TechSouth IT Summit, hold out the potential for substantial improvement among underperforming states and regions.

Statistical Relationships

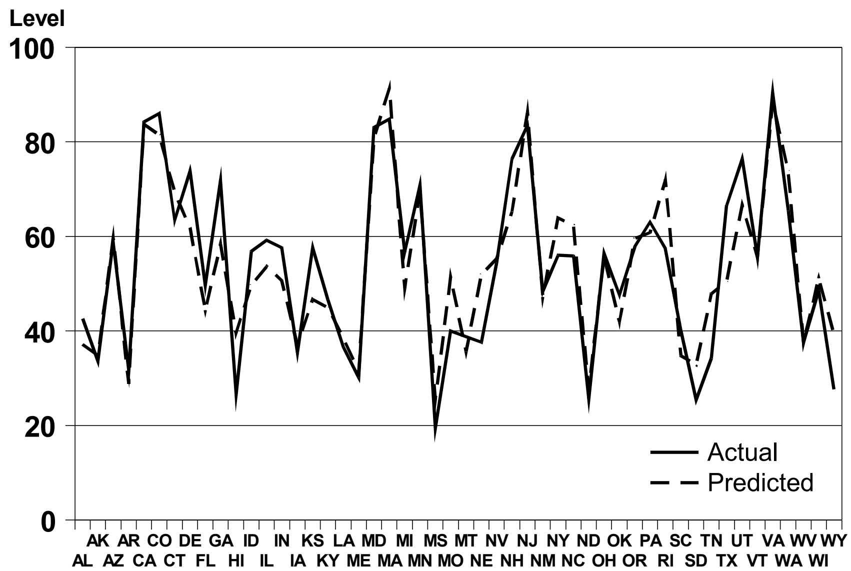
Having provided theoretical arguments for the validity of the State Technology and Science Index in measuring the current infrastructure and prospects for success in the intangible-based economy, it is critical to examine whether it means anything in a statistical sense. There are numerous statistical tests that could be deployed to analyze these relationships. We will be refining them to expand the richness of our understanding them relationships, but we have focused on several encouraging approaches. To test the relationships, we utilized regression analysis and various econometric techniques. Regression analysis looks at how changes in a dependent variable can be explained by movements in several independent variables. It tests the relative importance of each independent variable in explaining movements in the dependent variable and the overall explanatory power of the relationship.

One of the many tests we performed was to measure how much of the Technology Concentration and Dynamism composite could be explained in a statistical sense across states on the basis of movement in the other four composites. As was stated earlier, the Technology Concentration and Dynamism component can be considered an outcomes measure. There is a high degree of correlation between the four composites that were introduced as independent variables that present difficulties in isolating the separate impacts of each. Initial tests showed the presence of multicollinearity among the variables. We used a form of ridge regression that satisfactorily separated the relative affects of the four variables.

This equation was able to explain nearly 84 percent of the variation of the Technology Concentration and Dynamism across states—a very strong statistical relationship. The accompanying chart displays this relationship of the actual values versus those predicted from the equation. All four independent variables were highly significant, but the Risk Capital and Entrepreneurial Infrastructure composite was the most important single variable in explaining technology outcomes across states. Human capital is critical, but without strong entrepreneurial skills and risk capital, it isn't fully leveraged for maximum technology performance. On the other hand, without high-end technical talent, entrepreneurial skills don't matter much. The Risk Capital and Entrepreneurial Infrastructure composite is highly significant in determining technology outcomes at the upper end of the distribution. In other words, Massachusetts' and California's strong positions in technology outcomes are largely explained by their unique ecosystems of entrepreneurial and private-equity financing. The relationship with respect to this variable is nonlinear.

Tech Outcomes vs. Other Components

Score 0 - 100

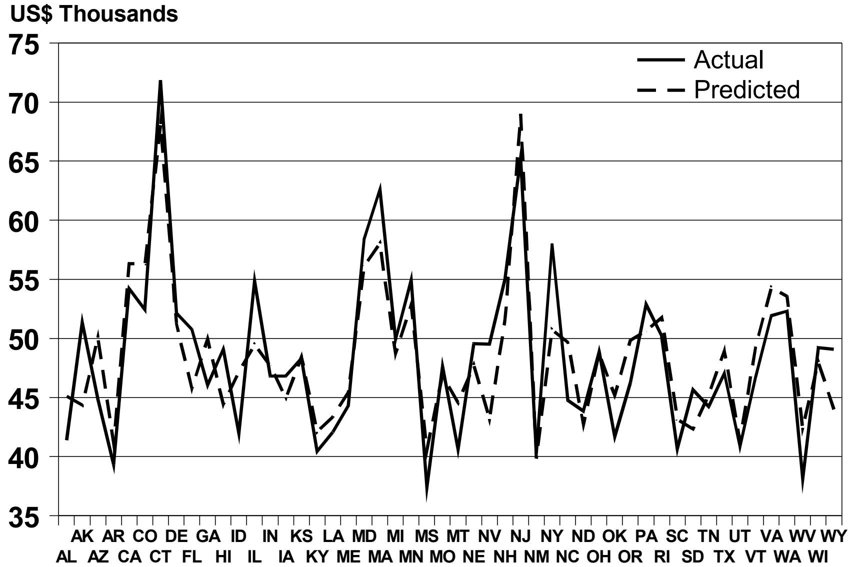


Source: Milken Institute

Another way to test the statistical relevance of our State Technology and Science Index is to look at its relationship to per capita income across states. We examined a number of specifications. The dependent variable—the one whose changes we are trying to explain—was the working age per capita income of states for 2002. This adjusts for the differences in population age distributions across states. For example, Utah's high birth rate has produced a larger proportion of young dependents than any other state; therefore, its per capita income would be lower.

Per Capita Income & Tech and Science Index

Income Relative to Working Age Population, 2002



Source: Milken Institute

Based upon changes in the State Technology and Science Index, we were able to explain more than 75 percent of the variations in per capita income of the working age population across states. This includes correcting for the impact of the high concentration workers in the financial services living in New York, Connecticut and New Jersey. This relationship is so strong that it would be expected not to be the true statistical relationship in only one out of approximately one million times (F-test was 48.3).

In separate regressions introducing the five composites that comprise the overall State Technology and Science Index, the Human Capital Investment Composite was the single most important variable. This seems reasonable since it includes broader measures of human capital that are important to any industry, such as the percent of the population with bachelor's and masters' degrees. On the other hand, in one functional form, raising the percent of the population with a PhD by 0.1 percentage point was associated with an increase in per capita income of almost $1,300, while a similar increase in bachelors' degree returned less than $140 per capita.

We began examining the time series properties of the relationships to better establish the lags in changes in the variables with measures of outcomes. The results indicate that for states with the lowest per capita income, the highest rates of return to investment appear to be in improvements in broad measures of human capital, such as percent of the adult population with a bachelor's degree or greater. Improvements in a state's K-12 system first starts impacting the SAT and ACT scores, leading to higher college enrollment rates, and ultimately, more bachelor's degree holders. At the other end of the scale, there is a long time lag between improvements in the research and development infrastructure and technology outcomes, but they are highly significant. At the very high end of the distribution, there are enormous returns to enhancing the entrepreneurial skills and venture capital networks in states. To accomplish this requires nurturing the process and a long-term commitment.

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Appendix

National State Technology & Science Index
Overall Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Massachusetts	MA	1	1	0	84.35
California	CA	2	3	1	78.86
Colorado	CO	3	2	-1	78.77
Maryland	MD	4	4	0	78.19
Virginia	VA	5	5	0	72.27
Washington	WA	6	6	0	69.87
New Jersey	NJ	7	7	0	69.03
Minnesota	MN	8	10	2	67.49
Utah	UT	9	9	0	66.49
Connecticut	CT	10	8	-2	66.26
Rhode Island	RI	11	21	10	64.01
New Hampshire	NH	12	13	1	63.43
Delaware	DE	13	11	-2	62.51
New Mexico	NM	14	20	6	61.75
New York	NY	15	12	-3	60.66
Pennslyvania	PA	16	16	0	60.36
Arizona	AZ	17	18	1	58.47
Georgia	GA	18	15	-3	58.10
Oregon	OR	19	23	4	57.76
North Carolina	NC	20	17	-3	57.28
Illinois	IL	21	19	-2	56.59
Vermont	VT	22	31	9	56.00
Texas	TX	23	14	-9	54.91
Ohio	OH	24	27	3	54.18
Michigan	MI	25	24	-1	54.01
Kansas	KS	26	22	-4	53.12
Wisconsin	WI	27	25	-2	51.76
Nebraska	NE	28	32	4	50.91
Indiana	IN	29	30	1	50.73
Idaho	ID	30	26	-4	49.03
Missouri	MO	31	28	-3	48.11
Florida	FL	32	29	-3	44.47
Maine	ME	33	36	3	43.47
Tennessee	TN	34	40	6	42.77
Oklahoma	OK	35	37	2	42.65
Alabama	AL	36	33	-3	42.36
Iowa	IA	37	35	-2	41.90
Montana	MT	38	34	-4	40.65
Hawaii	HI	39	43	4	40.05
Alaska	AK	40	39	-1	39.91
Wyoming	WY	41	38	-3	38.72
Louisiana	LA	42	44	2	36.66
Nevada	NV	43	42	-1	36.09
South Carolina	SC	44	41	-3	35.94
North Dakota	ND	45	45	0	34.55
West Virginia	WV	46	48	2	33.65
South Dakota	SD	47	47	0	33.31
Kentucky	KY	48	46	-2	32.61
Arkansas	AR	49	50	1	29.53
Mississippi	MS	50	49	-1	27.48
State Average					**52.64**

Research and Development Inputs
Composite Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Massachusetts	MA	1	1	0	92.18
California	CA	2	4	2	80.32
Colorado	CO	3	2	-1	78.94
Maryland	MD	4	5	1	78.07
New Mexico	NM	5	6	1	76.71
Rhode Island	RI	6	3	-3	74.55
Washington	WA	7	9	2	73.06
New Hampshire	NH	8	10	2	67.88
Pennsylvania	PA	9	13	4	67.36
Virginia	VA	10	12	2	66.08
Utah	UT	11	8	-3	65.37
Arizona	AZ	12	16	4	65.13
Connecticut	CT	13	11	-2	65.01
Delaware	DE	14	7	-7	63.21
Michigan	MI	15	18	3	60.35
Oregon	OR	16	21	5	60.11
New York	NY	17	14	-3	59.96
New Jersey	NJ	18	15	-3	59.43
Minnesota	MN	19	24	5	58.99
Vermont	VT	20	31	11	57.83
Illinois	IL	21	19	-2	57.20
North Carolina	NC	22	17	-5	54.96
Nebraska	NE	23	38	15	54.07
Wisconsin	WI	24	27	3	53.76
Ohio	OH	25	22	-3	53.04
Georgia	GA	26	25	-1	52.14
Alaska	AK	27	20	-7	50.07
Hawaii	HI	28	37	9	49.54
Alabama	AL	29	26	-3	49.08
Montana	MT	30	23	-7	48.77
Idaho	ID	31	34	3	48.13
Texas	TX	32	28	-4	45.28
Indiana	IN	33	29	-4	44.71
Missouri	MO	34	36	2	43.01
Kansas	KS	35	35	0	42.58
Iowa	IA	36	32	-4	42.33
Maine	ME	37	41	4	40.28
Tennessee	TN	38	30	-8	38.76
Wyoming	WY	39	33	-6	38.67
North Dakota	ND	40	40	0	36.48
Florida	FL	41	39	-2	35.18
South Carolina	SC	42	43	1	34.46
Mississippi	MS	43	42	-1	32.00
Oklahoma	OK	44	45	1	27.52
Kentucky	KY	45	49	4	25.24
Nevada	NV	46	44	-2	24.85
Louisiana	LA	47	48	1	22.81
West Virginia	WV	48	46	-2	22.77
South Dakota	SD	49	47	-2	21.03
Arkansas	AR	50	50	0	16.37
State Average					**51.51**

Risk Capital and Infrastructure Composite Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Massachusetts	MA	1	1	0	82.00
California	CA	2	2	0	79.11
Rhode Island	RI	3	27	24	76.22
Colorado	CO	4	4	0	72.00
Maryland	MD	5	9	4	70.22
New Hampshire	NH	6	14	8	69.56
North Carolina	NC	7	13	6	69.11
Washington	WA	8	8	0	67.33
Minnesota	MN	9	11	2	66.22
Georgia	GA	10	7	-3	66.00
Utah	UT	11	12	1	64.67
Connecticut	CT	12	6	-6	64.44
New York	NY	13	3	-10	62.44
Delaware	DE	14	18	4	61.78
Virginia	VA	15	10	-5	60.89
New Jersey	NJ	16	5	-11	60.67
Oregon	OR	17	16	-1	59.33
Arizona	AZ	18	21	3	58.89
New Mexico	NM	19	31	12	58.67
Ohio	OH	20	32	12	58.22
Pennslyvania	PA	21	19	-2	58.00
Maine	ME	22	25	3	57.78
Tennessee	TN	23	36	13	55.56
Idaho	ID	24	17	-7	54.67
Missouri	MO	25	30	5	54.67
Indiana	IN	26	34	8	54.44
Vermont	VT	27	42	15	53.33
Florida	FL	28	23	-5	50.44
Texas	TX	29	15	-14	50.44
West Virginia	WV	30	48	18	49.78
Oklahoma	OK	31	39	8	48.00
Wisconsin	WI	32	20	-12	47.56
Louisiana	LA	33	37	4	47.33
Illinois	IL	34	22	-12	46.44
Nebraska	NE	35	35	0	46.44
Nevada	NV	36	26	-10	45.33
Michigan	MI	37	33	-4	38.89
Wyoming	WY	38	46	8	38.89
South Carolina	SC	39	28	-11	37.56
Kansas	KS	40	24	-16	36.22
South Dakota	SD	41	49	8	35.33
Arkansas	AR	42	47	5	34.67
Hawaii	HI	43	40	-3	33.78
Alabama	AL	44	29	-15	30.22
Iowa	IA	45	41	-4	28.67
Montana	MT	46	38	-8	27.56
Alaska	AK	47	44	-3	24.67
Kentucky	KY	48	45	-3	23.78
Mississippi	MS	49	43	-6	22.22
North Dakota	ND	50	50	0	16.22
State Average					**51.53**

Human Capital Investment
Composite Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Colorado	CO	1	2	1	78.11
Minnesota	MN	2	5	3	76.78
Massachusetts	MA	3	1	-2	73.78
Maryland	MD	4	3	-1	73.56
Vermont	VT	5	9	4	68.11
Connecticut	CT	6	6	0	67.22
California	CA	7	4	-3	67.11
Washington	WA	8	8	0	66.11
Kansas	KS	9	15	6	65.89
New York	NY	10	13	3	64.44
Utah	UT	11	10	-1	63.89
New Jersey	NJ	12	16	4	63.33
Delaware	DE	13	7	-6	62.78
Virginia	VA	14	13	-1	62.44
New Mexico	NM	15	11	-4	62.11
Iowa	IA	16	19	3	60.67
Illinois	IL	17	12	-5	59.56
Wisconsin	WI	18	23	5	58.89
Michigan	MI	19	17	-2	58.78
Oregon	OR	20	27	7	57.67
New Hampshire	NH	21	25	4	55.67
Rhode Island	RI	22	22	0	54.89
Wyoming	WY	23	18	-5	52.67
Pennsylvania	PA	24	21	-3	52.11
Nebraska	NE	25	20	-5	51.00
Missouri	MO	26	24	-2	50.11
North Dakota	ND	27	28	1	49.22
Ohio	OH	28	31	3	48.89
Hawaii	HI	29	34	5	47.78
Indiana	IN	30	32	2	47.44
Alaska	AK	31	39	8	47.22
Maine	ME	32	38	6	44.56
North Carolina	NC	33	25	-8	44.44
Montana	MT	34	30	-4	44.00
Arizona	AZ	35	29	-6	43.33
South Dakota	SD	36	37	1	42.78
Louisiana	LA	37	42	5	41.56
Texas	TX	38	36	-2	40.67
Idaho	ID	39	33	-6	40.11
Tennessee	TN	40	48	8	38.56
Oklahoma	OK	41	35	-6	38.22
Alabama	AL	42	40	-2	36.44
Georgia	GA	43	41	-2	35.11
Florida	FL	44	45	1	34.89
Kentucky	KY	45	44	-1	32.22
Arkansas	AR	46	49	3	30.89
Mississippi	MS	47	46	-1	28.56
South Carolina	SC	48	47	-1	28.11
Nevada	NV	49	50	1	27.78
West Virginia	WV	50	43	-7	22.11
State Average					**51.25**

Technology and Science Workforce
Composite Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Massachusetts	MA	1	3	2	89.00
Maryland	MD	2	1	-1	86.11
California	CA	3	2	-1	83.56
Virginia	VA	4	4	0	81.56
Colorado	CO	5	5	0	78.78
New Jersey	NJ	6	8	2	78.33
Washington	WA	7	6	-1	77.44
Texas	TX	8	7	-1	71.56
Connecticut	CT	9	9	0	71.22
Arizona	AZ	10	10	0	66.22
Georgia	GA	11	12	1	65.44
Nebraska	NE	12	14	2	65.44
Minnesota	MN	13	11	-2	64.67
Kansas	KS	14	18	4	63.33
New Mexico	NM	15	19	4	62.89
North Carolina	NC	16	13	-3	62.11
Utah	UT	17	20	3	62.11
Pennsylvania	PA	18	15	-3	61.33
Illinois	IL	19	22	3	60.56
New York	NY	20	16	-4	60.44
Rhode Island	RI	21	32	11	57.00
Michigan	MI	22	23	1	55.44
Ohio	OH	23	27	4	54.33
Oregon	OR	24	24	0	53.89
Alabama	AL	25	28	3	53.44
Missouri	MO	26	25	-1	52.78
Florida	FL	27	21	-6	52.22
Oklahoma	OK	28	30	2	51.89
Delaware	DE	29	31	2	51.00
Wisconsin	WI	30	17	-13	50.00
Indiana	IN	31	37	6	49.44
New Hampshire	NH	32	26	-6	47.67
Tennessee	TN	33	29	-4	46.78
Idaho	ID	34	36	2	45.44
North Dakota	ND	35	44	9	45.22
Vermont	VT	36	41	5	45.11
Maine	ME	37	35	-2	44.56
Montana	MT	38	33	-5	44.11
Alaska	AK	39	39	0	44.00
Hawaii	HI	40	42	2	42.56
Iowa	IA	41	34	-7	42.44
South Dakota	SD	42	40	-2	42.00
South Carolina	SC	43	38	-5	39.56
West Virginia	WV	44	43	-1	36.00
Wyoming	WY	45	45	0	35.78
Kentucky	KY	46	47	1	35.22
Mississippi	MS	47	46	-1	35.22
Louisiana	LA	48	50	2	35.00
Arkansas	AR	49	49	0	34.11
Nevada	NV	50	48	-2	28.11
State Average					**55.25**

Technology Concentration
Composite Index, 2004

State		Rank (2004)	Rank (2002)	Rank Change	Score (2004)
Virginia	VA	1	1	0	90.40
Colorado	CO	2	2	0	86.00
Massachusetts	MA	3	4	1	84.80
California	CA	4	3	-1	84.20
New Jersey	NJ	5	5	0	83.40
Maryland	MD	6	6	0	83.00
New Hampshire	NH	7	10	3	76.40
Utah	UT	8	7	-1	76.40
Delaware	DE	9	8	-1	73.80
Georgia	GA	10	12	2	71.80
Minnesota	MN	11	13	2	70.80
Texas	TX	12	11	-1	66.60
Washington	WA	13	9	-4	65.40
Connecticut	CT	14	14	0	63.40
Pennslyvania	PA	15	19	4	63.00
Illinois	IL	16	18	2	59.20
Arizona	AZ	17	16	-1	58.80
Oregon	OR	18	27	9	57.80
Indiana	IN	19	25	6	57.60
Kansas	KS	20	15	-5	57.60
Rhode Island	RI	21	26	5	57.40
Idaho	ID	22	17	-5	56.80
Michigan	MI	23	21	-2	56.60
Ohio	OH	24	28	4	56.40
New York	NY	25	22	-3	56.00
North Carolina	NC	26	20	-6	55.80
Vermont	VT	27	29	2	55.60
Nevada	NV	28	23	-5	54.40
Florida	FL	29	24	-5	49.60
Wisconsin	WI	30	30	0	48.60
New Mexico	NM	31	33	2	48.40
Oklahoma	OK	32	32	0	47.60
Kentucky	KY	33	31	-2	46.60
Alabama	AL	34	38	4	42.60
Missouri	MO	35	36	1	40.00
South Carolina	SC	36	34	-2	40.00
Montana	MT	37	37	0	38.80
Nebraska	NE	38	47	9	37.60
West Virginia	WV	39	42	3	37.60
Louisiana	LA	40	35	-5	36.60
Iowa	IA	41	41	0	35.40
Tennessee	TN	42	40	-2	34.20
Alaska	AK	43	44	1	33.60
Arkansas	AR	44	45	1	31.60
Maine	ME	45	46	1	30.20
Wyoming	WY	46	39	-7	27.60
Hawaii	HI	47	50	3	26.60
North Dakota	ND	48	48	0	25.60
South Dakota	SD	49	43	-6	25.40
Mississippi	MS	50	49	-1	19.40
State Average					**53.66**

Appendix

Data Source

R&D Inputs	
Federal R&D	NSF, Federally Funded R&D
Industry R &D	NSF, R&D in Industry
Academic R&D	NSF, Academic R&D Expenditure
National Science Foundation Funding, Percent	NSF, EPSCoR
National Science Foundation Research Funding , Percent	NSF, EPSCoR
R&D Expenditures on Engineering	NSF, Academic R&D Expenditure
R&D Expenditures on Phys Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Environ Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Math & Comp Sci	NSF, Academic R&D Expenditure
R&D Expenditures on Life Sciences	NSF, Academic R&D Expenditure
R&D Expenditures on Agricultural Sciences	NSF, Web Caspar
R&D Expenditures on Biomedical Sciences	NSF, Web Caspar
Average Annual # of STTR Awards	SBA; OTP
STTR Awards (Award Dollars)	SBA; OTP
SBIR Awards	SBA; OTP
SBIR Awards per 10,000 Business Establishments (Phase I)	NSF, EPSCoR
SBIR Awards per 10,000 Business Establishments (Phase II)	NSF, EPSCoR
Competitive NSF Proposals Funding Rate	NSF, EPSCoR
Risk Capital & Infrastructure	
Total Venture Capital Investment Growth	Ventureeconomics.com
# of Companies Receiving VC Investment	Ventureeconomics.com
Companies Receiving VC Investment	Ventureeconomics.com
Venture Capital Investment	Ventureeconomics.com
Average Annual SBIC Funds Disbursed	SBA; OTP
Number of Business Incubators	NBIA; OTP
Patents Issued	US PTO; Milken Institute
Number of Business Starts	SBA; Office of Advocacy
IPO Proceeds	Security Data Corporation; Milken Institute
Human Capital Investment	
Bachelor's Degree or Greater	US Census Bureau
Advanced Degree or Greater	US Census Bureau, DSS
PhD Degrees	US Census Bureau, DSS
Number of Students in Science & Engineering	NSF, EPSCoR
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
State Appropriations for Higher Education (percent Change)	NSF, EPSCoR
Number of Doctoral Scientists	NSF, State Science & Engineering Profile
Number of Doctoral Engineers	NSF, State Science & Engineering Profile

Number of Science & Engineering PhDs Awarded	NSF, State Science & Engineering Profile
# of Science & Engineering Post doctorates Awarded	NSF, Web Caspar
% of Bachelor's Degrees Granted in Sci & Eng	NCES; OTP
Recent Bachelor's Degrees in Sci or Eng	NSF; OTP
Recent Master's Degrees in Sci or Eng	NSF; OTP
Recent PhDs in Sci or Eng	NSF; OTP
Households With Computers	US DOC; OTP
Households With Internet Access	US DOC; OTP
Technology & Science Workforce	
Intensity of Computer & Information Scientists	BLS, DOL; Milken Institute
Intensity of Computer Programmers	BLS, DOL; Milken Institute
Intensity of Software Engineers, Systems Software	BLS, DOL; Milken Institute
Intensity of Computer Support Specialists	BLS, DOL; Milken Institute
Intensity of Computer Systems Analysts	BLS, DOL; Milken Institute
Intensity of Database & Network Administrators	BLS, DOL; Milken Institute
Intensity of Agricultural & Food Scientists	BLS, DOL; Milken Institute
Intensity of Biochemists and Biophysicists	BLS, DOL; Milken Institute
Intensity of Microbiologists	BLS, DOL; Milken Institute
Intensity of Medical Scientists	BLS, DOL; Milken Institute
Intensity of Physicists	BLS, DOL; Milken Institute
Intensity of Other Life, Phys Occupations	BLS, DOL; Milken Institute
Intensity of Electronics Engineers	BLS, DOL; Milken Institute
Intensity of Electrical Engineers	BLS, DOL; Milken Institute
Intensity of Computer Hardware Engineers	BLS, DOL; Milken Institute
Intensity of Biomedical Engineers	BLS, DOL; Milken Institute
Intensity of Agricultural Engineers	BLS, DOL; Milken Institute
Intensity of Other Engineers	BLS, DOL; Milken Institute
Technology Concentration	
Percent of Establishments in High-Tech SIC Codes	US Census Bureau; OTP
Percent of Employment in High-Tech SIC Codes	US Census Bureau; OTP
Percent of Payroll in High-Tech SIC Codes	US Census Bureau; OTP
Percent of Establishment Births in High-Tech SIC Codes	US Census Bureau; OTP
Net Formation of High-Tech Establishments	US Census Bureau; OTP
Number of Technology Fast 500 Companies	US Census Bureau; OTP
High-Tech industries (Average Yearly Growth)	Economy.com; Milken Institute
Number of High-Tech Industries Growing Faster than U.S.	Economy.com; Milken Institute
Number of High-Tech Industries With LQs Higher Than 1.0	Economy.com; Milken Institute
Number of Inc. 500 Companies	Inc. Magazine; OTP

* **Abbreviations**

BLS: Bureau of Labor Statistics	NSF: National Science Foundation
DOL: Department of Labor	OTP: Office of Technology Policy
EPSCoR: Experimental Program to Stimulate Competitive Research	SBA: Small Business Administration
NBIA: National Business Incubation Association	US DOC: US Department of Commerce
NCES: National Center for Education Statistics	US PTO: US Patent and Trademark Office

About the Authors

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