



COLORADO
INNOVATION
NETWORK

THE 2012 COLORADO INNOVATION INDEX

Reaching our Innovation Summit

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Development and
International
Trade



Talent

Ideas

Capital

Entrepreneurship

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John W. Hickenlooper
Governor

August 2012

Dear Friends,

As we conclude the first year of implementing the *Colorado Blueprint*, it is our pleasure to introduce you to the inaugural edition of the **2012 Colorado Innovation Index: *Reaching Our Innovation Summit***. To achieve our objective of Cultivating Innovation and Technology in the great state of Colorado, we created the Colorado Innovation Network (COIN) in November 2011 to connect and convene innovation leaders across Colorado's public, private, and academic sectors. As part of that commitment, COIN has created this report to take a comprehensive look at how Colorado is creating an environment in which innovation, entrepreneurship, and job creation can thrive.

Recognizing the need to identify metrics through which we can study innovation performance and activities in Colorado, COIN worked in partnership with a research team at Colorado State University (CSU) sponsored by Chief Innovation Officer and Dean of CSU's College of Business Ajay Menon and led by Dr. Stephan Weiler to build the first ever Colorado Innovation Index, a new information resource that provides analysis and insights on innovation activity in our state.

As with all of COIN's activities, this report is intended to act as a catalyst for businesses, entrepreneurs, and policy makers to ultimately stimulate economic growth, job creation, and business attraction and retention. We want to support innovative business activities and establish a reputation for Colorado as the most innovative state in the country.

Across the four components of innovation measured in this report, Colorado performs strongly in all categories—ideas, talent, capital, and entrepreneurship. Among Colorado's key assets are its high per capita rates of workers with science and technology degrees, relatively low living costs, high quality of life, and a desirable location in which to recruit and retain the most talented workers. Notably, these are some of the many reasons by which Colorado was recognized as a national leader in innovation through its selection by the United States Department of Commerce to become the site of a U.S. Patent and Trademark Office.

We hope that you find this study to be interesting and useful in recognizing the important role that innovation serves in Colorado's economic future and success. We invite you to read the Index, embrace Colorado's entrepreneurial spirit, and join our collaborative network in making Colorado the most innovative state in the nation.

Sincerely,

John Hickenlooper
Governor

Executive Summary

Cultivating innovation is the key to creating new jobs and growing a more competitive, dynamic and resilient economy in Colorado.



According to the U.S. Census Bureau, Colorado's population now tops five million. Coloradans are one of the nation's most educated populations, ranking second among the 50 states for percentage of residents with a bachelor's degree or higher, and Colorado is home to four major research universities. The state has strong and diverse industry clusters especially in the areas of aerospace, bioscience and medical devices, food and agriculture, energy and natural resources, information and technology. These factors make up Colorado's strong economic foundation.

Over the past year, Colorado's emerging innovation climate has been touted across the nation. The 2011 Kauffman Index of Entrepreneurial Activity listed Colorado as fifth for the highest rate of entrepreneurial activity in the United States, with 450 new business owners per 100,000 adults. Earlier this year, MoneyTree named Colorado the fourth leading destination for Early-Stage Venture Capital Investment, the U.S. Chamber listed Colorado number two for the 2012 top 10 states for entrepreneurship and innovation, and StartUpHire listed Colorado as first for growth in the startup job sector, as the state saw a 170 percent increase in startup jobs between 2010 and 2011. In addition, The Beacon Hill Institute issues an annual report on state competitiveness and Colorado has consistently ranked in the top ten, and was assigned the number three spot in 2011. In particular, Colorado's strength in technology, an innovation-dependent industry, was cited as a contributing factor to the strong ranking (Beacon Hill).

Cultivating innovation is the key to creating new jobs and growing a more competitive, dynamic and resilient economy in Colorado. The Colorado Innovation Network (COIN) is a primary catalyst to spur innovation and growth in Colorado by supporting business activities and establishing Colorado as the most innovative state in the country. This report, presented by COIN, is among the first steps taken towards this mission.

Colorado Innovation Index

The Colorado Innovation Index will become an annual report that measures Colorado's industry-driven and overall innovation progress to be released at COIN's Innovation Summit. This index will not only serve as a regular report, but also as a call-to-action that defines innovation issues and challenges facing the state, assesses Colorado's performance and provides recommendations for a future roadmap towards an increase in innovation for the state.

The focus of this inaugural report is on where Colorado stands in comparison to the nation as a whole and seven other benchmark states, with respect to one particular asset – innovation. The seven benchmark states used to compare Colorado with are Arizona, California, Massachusetts, New York, North Carolina, Texas and Utah. These benchmark states were chosen either because they are known as innovative hotbeds, such as North Carolina or California, or because, like Utah and Arizona, they are regional neighbors with close geographic and economic ties. This two-tiered approach to benchmarking

is important in that it compares Colorado against its regional peers, and also provides a point of reference against what it can aspire to be. The key metrics and graphs use the most up-to-date publicly available data, and when possible compare the current measure against an anchor year (usually 2000 unless otherwise noted). In that sense, the bar charts map the COIN metrics in three contrasting dimensions: relative to the United States, across the peer group states, and over time. Benchmarking the state measures to the U.S. also helps control for broader business cycles, including the intervening two recessions.

Defining Innovation

For the purposes of this report, innovation is defined as a *product, process or service that generates new value in the market*. Under this definition, innovation can take many forms. It may be something tangible, such as a tablet computer, intangible, such as a new way of isolating proteins for genetic research, or a hybrid of the two, such as a way of processing credit card payments with a new piece of hardware. Because innovation in this context can be somewhat ambiguous, it is not something that can be measured directly. Instead, this report analyzes the components of innovation that come together to create new innovations and link them to the marketplace.

Innovation, first and foremost, is born from a talented populace. These talented people provide a stream of great ideas, and help attract capital to bankroll the development of those ideas. Therefore innovation requires talent, ideas, and capital to generate innovation in its rawest form.

Raw innovation on its own, however, does not create new products. The innovators themselves may or may not possess the skills to bring their ideas to market, and so require businesses, and in particular entrepreneurs, to do so. Innovators rely on entrepreneurial small business leaders or managers in larger institutions for their knowledge of the marketplace, ability to shape innovations for that marketplace, and understanding of the necessary risk/reward trade-offs in order to bring innovation to

customers. The entrepreneur is thus in many ways the most critical element to realizing the potential of innovation, as they are the matchmakers who have the skills to identify, develop, refine, and market successful innovation.

This report uses these four components to benchmark the components of innovation in each of the benchmark states. **Talent, ideas, and capital** are used to represent the components necessary to produce raw innovation, and **entrepreneurship** is used to measure the refining and matching process. In breaking down innovation into these four components, this report strives to build a bigger picture of where each state stands in terms of its innovative potential. Each element on its own will not necessarily result in abundant innovation, but when combined as a whole becomes an innovative sum far greater than its constituent parts. Although the gathered metrics lay no claim to being exhaustive surveys of potential talent, ideas, capital, and entrepreneurship, the chosen indicators provide broadly comparable readings for the four components' status across states.

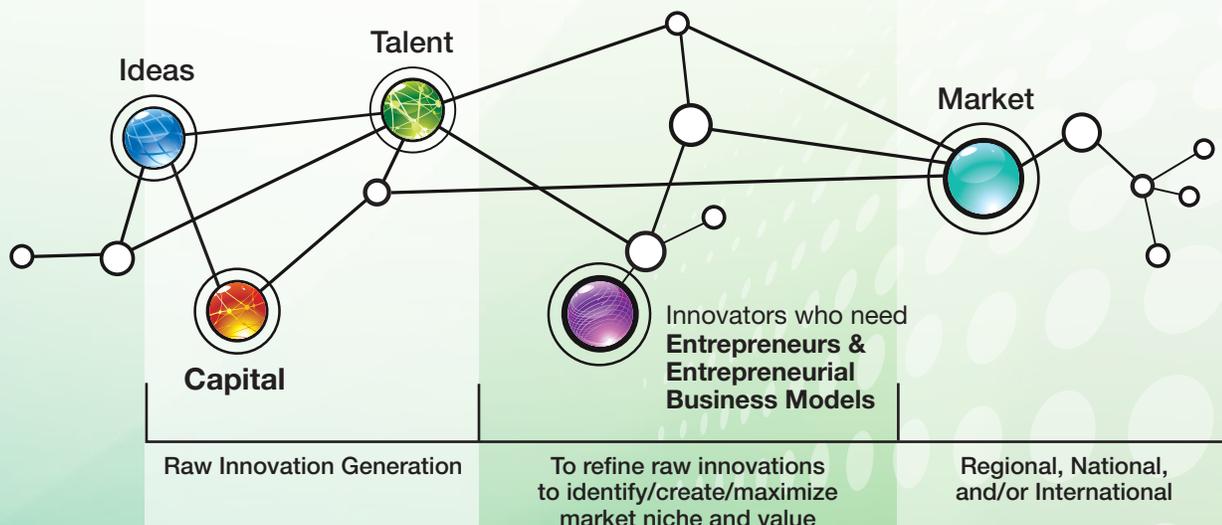
Colorado has substantial niche strengths within each of the benchmark components. The state has a significant talent pool, comprised of a well-educated workforce compared to its peers. These workers have demonstrated the ability to generate productive ideas, aided by the presence of Colorado's universities and national

research centers. Colorado also has access to capital alongside a business-friendly tax system intended to encourage companies to set up shop in the state. Overall, Colorado has demonstrated that it possesses many of the pieces required for assembling raw innovation, though there is also still significant room for growth among all the components.

Colorado also has strengths with respect to its entrepreneurial potential for identifying and maximizing the market value of these raw innovations. The state demonstrates an above average penchant for entrepreneurship, with a high prevalence of self-employment and a high small-business birth rate. While entrepreneurship is generally prevalent, the income-generating value-adding capabilities of these establishments are somewhat more uneven. Such returns to entrepreneurs vary regionally throughout the state, and small businesses have tended to be more successful than the self-employed in generating income returns to their workers. This "returns" terminology mirrors that of more traditional investments, as incomes from entrepreneurial innovations literally reflect the payoffs for maximizing such innovations' market value. Overall, Colorado has proven itself entrepreneurial in spirit, but still has room to develop in terms of its ability to truly maximize its innovative potential.

Defining and Tracking Innovation

Product, process, or service that generates new value in the marketplace

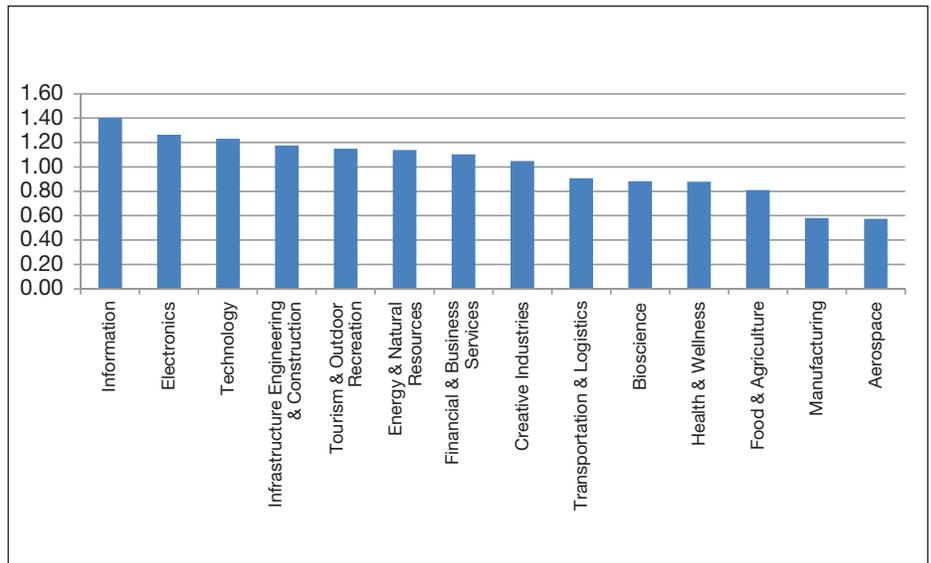


Economic Context

Colorado's Key Industries

Colorado's current and potential strengths are a result of its bottom-up economic development strategy, a perspective which itself was the genesis for the Colorado Innovation Network as part of the Colorado Office of Economic Development and International Trade's Colorado Blueprint. The Blueprint aims to create a more competitive state economy, which represents three-year strategic plans for Colorado's key industries, of which cultivating innovation is a core objective. The 14 key industry groups are in and of themselves a promising example of collaborative competition, where businesses that compete directly in the marketplace also understand the advantages of collaboration to maximize all firms' potential, which is especially crucial in today's globalized marketplace. There is an intrinsic relationship between even the largest, most established firms and the growth of small firms and their innovations, as the latter can nimbly find and bridge gaps that can strengthen an entire industry cluster.

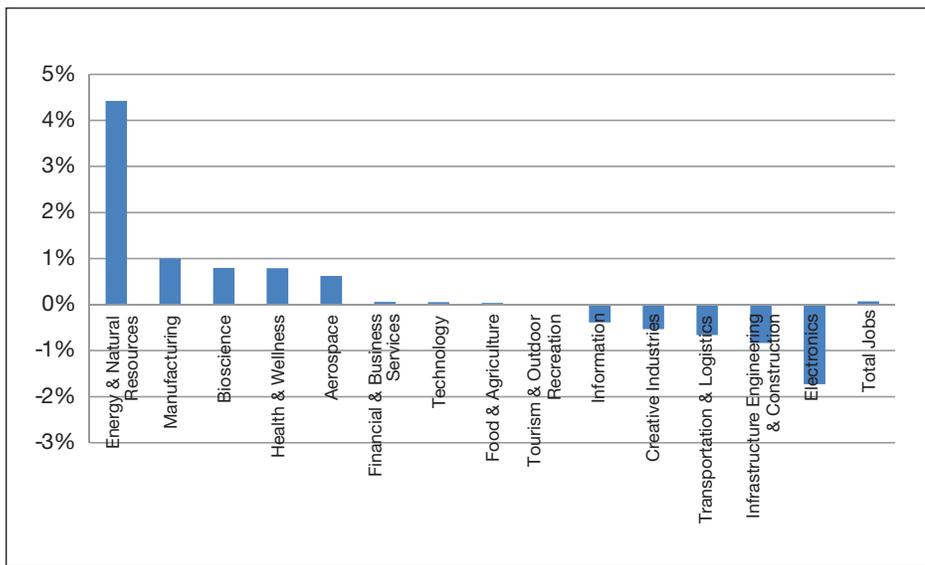
Industry organization within a region can itself have a considerable impact on the local economy. On the one hand, having a large concentration of certain industries can bring benefits. Firms within that industry can share labor and talent pools reducing hiring costs and allowing knowledge and learning to transfer between firms, often leading to new technological developments. Common goods and services providers to the industry can also congregate around the consolidated industry, further reducing costs to the firm through increased competition among providers. On the other hand, having a diverse mix of industries within a region is also important for sustained economic growth. This diversity adds to the robustness of the region in an industry downturn, as other industries may continue to grow. A diverse set of industries benefits innovation as knowledge is transferred between industries, often leading to productive new ideas benefitting regional growth.



Industry	AZ	CA	CO	MA	NY	NC	TX	UT
Manufacturing	0.59	0.73	0.58	0.77	0.65	1.45	0.84	1.08
Technology	0.99	1.15	1.23	1.21	1.22	0.88	0.99	1.06
Electronics	1.5	1.8	1.26	1.86	1.14	0.95	1.04	1.29
Energy & Natural Resources	0.55	0.66	1.14	0.58	0.64	0.78	2.08	1.14
Food & Agriculture	0.76	1.84	0.81	0.48	0.51	1.09	0.69	0.85
Bioscience	0.69	1.09	0.88	1.17	1.09	1.19	0.9	1.76
Aerospace	0.97	0.82	0.57	0.73	0.54	0.95	0.89	0.94
Information	0.75	0.97	1.4	1.04	1.32	1.1	0.98	0.97
Health & Wellness	0.91	0.85	0.88	1.17	1.4	1.02	0.97	0.92
Creative Industries	0.65	1.33	1.05	1.34	1.45	0.9	0.69	1.18
Tourism & Outdoor Recreation	1.14	1.07	1.15	0.88	1.07	0.91	0.94	1.05
Transportation & Logistics	0.92	0.97	0.91	0.81	1.07	0.97	1.09	1.11
Infrastructure Engineering & Construction	1.14	0.94	1.18	0.82	0.94	0.93	1.29	1.19
Financial & Business Services	1.11	0.95	1.1	1.26	1.5	0.88	0.99	1.06

Figure 1 - Key Industry Location Quotients (2011)

Location Quotient (LQ) is defined as the percentage of a region's total employment concentrated within a particular industry divided by that same industry's concentration percentage calculated at the national level. Total employment includes both private and public payroll jobs, but does not include proprietors.



Colorado’s 14 key industries are listed according to their relevant concentration in **Figure 1**; the Defense and Homeland Security industry is not shown in the following figures due to insufficient data. These concentrations are determined by using LQs, which tell us how concentrated an industry is within a particular region, relative to the national average. An LQ greater than one tells us that a given industry is more concentrated within that region than it is at the national level, while levels less than one imply a less concentrated industry. Colorado has a high LQ in multiple high technology industries including Information, Electronics, Technology, Infrastructure Engineering and Construction, and Energy and Natural Resources. As these high-tech types of industries tend to be reliant on innovation, the consolidation of these types of industries in Colorado demonstrates that there is already an innovative foundation in the state.

However, in order to remain competitive, the state’s ability to maintain and grow the key components of innovation is critical to maintaining the relatively high levels of employment in these sectors. This imperative is highlighted in **Figure 2**, which demonstrates that growth in many of these key industries has failed to keep pace with the nation’s growth in these industries over the last decade.

Industry	AZ	CA	CO	MA	NY	NC	TX	UT
Manufacturing	-0.24%	-0.77%	1.00%	-0.58%	0.02%	-2.03%	1.59%	2.44%
Technology	0.18%	-0.48%	0.05%	-0.43%	-0.26%	1.22%	1.14%	1.72%
Electronics	-0.30%	-0.49%	-1.73%	-1.24%	1.22%	-0.69%	-0.03%	2.92%
Energy & Natural Resources	0.71%	-0.84%	4.42%	-2.23%	-2.26%	-1.08%	2.92%	2.96%
Food & Agriculture	-0.23%	0.55%	0.04%	0.63%	-0.07%	-0.60%	-0.42%	1.92%
Bioscience	2.25%	0.29%	0.79%	-0.85%	-1.68%	0.43%	0.40%	2.13%
Aerospace	0.81%	-0.11%	0.62%	-0.32%	-0.72%	-2.22%	2.77%	1.59%
Information	-0.76%	-0.55%	-0.39%	-0.02%	0.61%	-0.19%	0.34%	2.61%
Health & Wellness	1.56%	-0.66%	0.79%	0.07%	-0.46%	0.55%	0.58%	1.27%
Creative Industries	0.98%	0.80%	-0.54%	0.12%	-0.08%	-0.46%	-0.02%	1.55%
Tourism & Outdoor Recreation	0.38%	-0.12%	-0.02%	-0.12%	0.12%	0.19%	0.98%	0.65%
Transportation & Logistics	0.47%	-0.05%	-0.66%	-1.03%	-0.71%	0.07%	1.20%	1.33%
Infrastructure Engineering & Construction	-1.39%	-0.54%	-0.83%	-0.25%	0.77%	-0.94%	1.49%	0.92%
Financial & Business Services	1.12%	-0.51%	0.06%	-0.60%	-0.80%	1.75%	1.73%	1.57%
Total Jobs	0.33%	-0.26%	0.07%	-0.26%	0.04%	-1.81%	1.11%	1.16%

Figure 2 - Annualized Growth Rate (2001-2011) (Relative to U.S.)

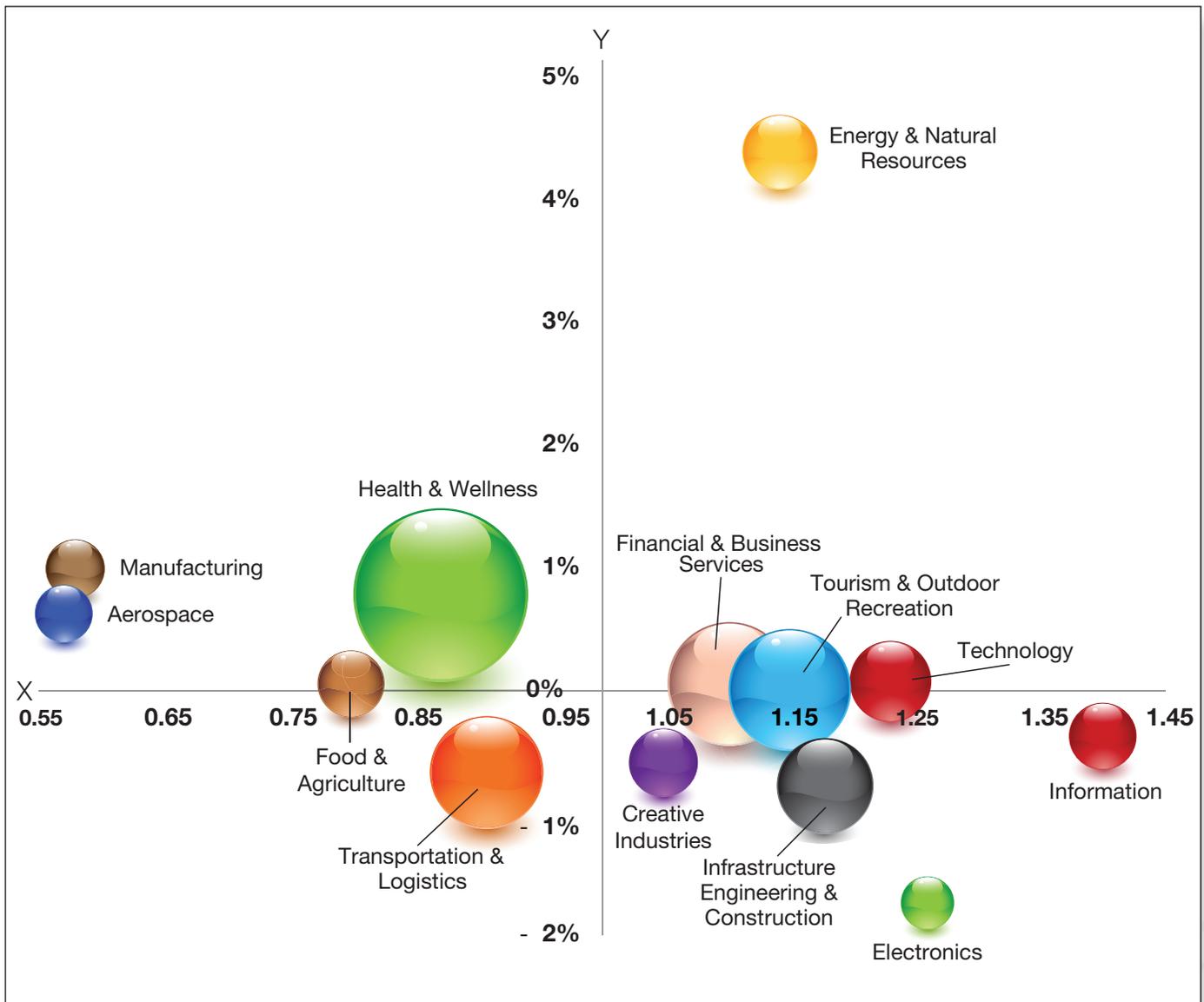


Figure 3 - Growth / Location Quotient Matrix

Growth/Location Quotient Matrix

The above graphic illustrates the previous information. On the X axis are the location quotients of each Key Industry; on the Y axis, the annualized growth rate from 2001-2011. The size of each bubble represents the relative size of each key industry's employment to Colorado's total economy.

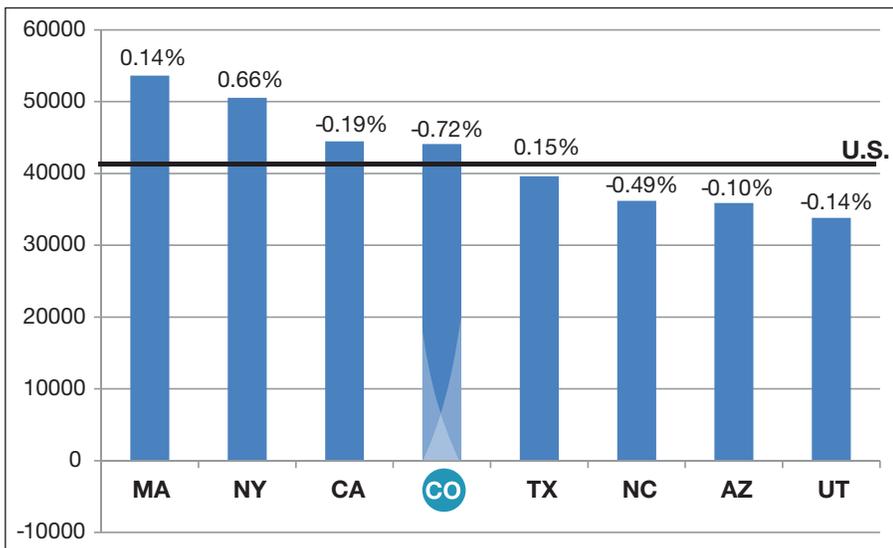
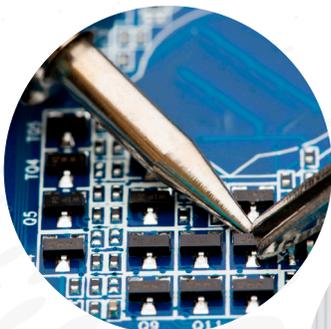


Figure 4 - Per-Capita Personal Income (2011) and Annualized Growth Rates (Relative to U.S.) (2001-2011)

Income

Personal income not only reflects the overall economic success of a region, it also highlights the ultimate effect of innovation factors on an economy. Personal income comes largely from workers' wages and owners' profits, which are themselves based on the market's valuation of the state's products and services as well as the workforce's productivity. Innovation has a direct effect on both. First, innovation yields superior products and services, such as the suddenly ubiquitous tablet computers, which the market values more highly than existing offerings. Second, innovation leads to improved processes which make workers more productive at generating these products and services. Gross Domestic Product (GDP) worker metrics offer a substantively identical picture. The income measure furthermore provides a tangible sense of the economic well-being of a region in that it gives an idea of what the average person earns, although is not adjusted for often substantial differences in the cost of living. **Figure 4** displays the level of Per-Capita Personal Income in 2011, as well as the difference in annualized growth rate in per capita income over the prior decade from the national average. As shown in **Figure 4**, Colorado is currently above the national average in per-capita income, performing relatively strongly among the peer group. Yet Colorado also has trailed the national average in per capita income growth over the last decade by the largest amount among the peer group.



Summary of Highlights:

The Four Components



Talent

- Colorado trails only Massachusetts for having the most workers with a bachelor's degree or higher in the nation, but has recently slipped significantly in educating its own homegrown talent.
- Colorado continues to exceed the national average for Science, Technology, Engineering, and Mathematics (STEM) degree attainment, though has been declining over the last decade.
- Colorado is an attractive place to move for all populations, especially the young and talented.



Ideas

- The non-profit and university sectors in Colorado contribute an above-average amount to expenditure in R&D, but overall R&D intensity lags the nation.
- Colorado is slightly ahead of the nation in terms of science and engineering academic R&D funding and article output.
- Colorado outperforms many benchmark states in patents, issuing over 450 patents per million residents in 2011, and will become one of four national satellite sites for the U.S. Patent Office.



of Innovation



Capital

- Colorado offers a high level of private capital funding in the form of venture capital investments (ranked third in the peer group), small business loans and access to bank branches (ranked second for both).
- Colorado receives a relatively large amount of public funding from Small Business Innovative Research and Small Business Technology Transfer Grants, while slightly below the national average in terms of National Institutes of Health funding.
- Colorado's tax favorableness is competitive, ranking higher than the majority of our benchmark states.



Entrepreneurship

- Colorado ranks above the national average in terms of breadth of entrepreneurship among both the self-employed and small businesses.
- While Colorado has a high prevalence of self-employment establishments, they are only average in terms of entrepreneurial returns.
- Colorado performs particularly well in terms of small business measures, scoring high relative to the nation and the peer group with respect to births and returns to labor, although net job creation has slowed significantly.





Talent

People are the basis for innovation in an economy. A vibrant, smart, educated, and highly talented workforce will generate great ideas. They also will attract the capital necessary to bring those ideas to market, and some will become entrepreneurs who take control of the innovation process themselves. Additionally, having a talented workforce benefits both those firms already existing in the state, as they have a larger pool of potential employees to draw from, and will help to attract outside businesses wanting to tap into that talent. Talent can either be generated internally through a strong education system or externally by drawing talent from other places. Colorado's education system and many amenities give it strengths at both creating and attracting talent. The U.S. Chamber of Commerce ranked Colorado as one of the top ten "talent pipeline" states measured by such criteria as education accessibility and attainment.

To illustrate and compare the concentration of talent in Colorado three metrics are considered: workforce, education, and migration flows. Colorado is already a leader in demonstrating the ability to attract talent, but has fallen behind at generating its own talent base.

Workforce

In today's world, educational attainment is more crucial than ever, as work has become increasingly complex. For a variety of reasons it is also now essential that workers obtain the skills necessary for the increasingly challenging work problems through post-secondary schooling. Therefore, the educational background of a workforce is indicative of the skills possessed in that workforce, specifically a state workforces' educational attainment level.

Colorado already has a talented workforce based on educational attainment measures. In 2011, Colorado was second in the peer group for the percentage of the workforce holding a bachelor's degree or greater, nearly 10 percent above the U.S. average (Figure 5) at 44 percent. An additional 14 percent of Colorado's workforce holds a graduate degree, ranking it third. However, even in Colorado, the proportion of workers with a bachelor's degree or higher is still less than half the population.

Highlights

- Colorado trails only Massachusetts for having the most workers with a bachelor's degree or higher in the nation, but has recently slipped significantly in educating its own homegrown talent.
- Colorado continues to exceed the national average for STEM degree attainment, though has been declining over the last decade.
- Colorado is an attractive place to move for all populations, especially the young and talented.

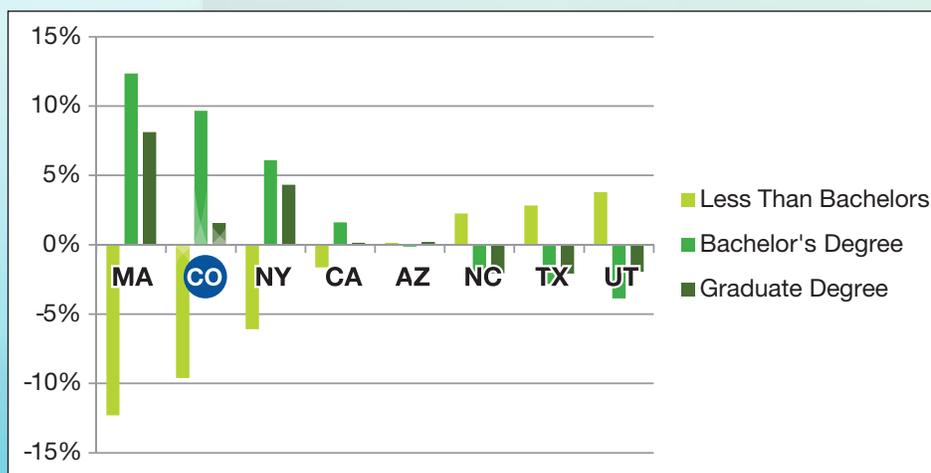


Figure 5 - Workforce by Education Attainment (2011) (Relative to U.S.)

Education

While the current education level of Colorado's workforce is important, the ability to generate new talent is equally important. To this effect, two measures are evaluated: first, the percentage of the college-aged population currently in school, and second, the percentage of degrees in technology-oriented fields.

Young Adults Pursuing Further Education

The first metric examines the percentage of college-aged students (specifically those aged 18-24) currently enrolled in school, which includes those people enrolled in colleges, universities, and professional schools, as those currently enrolled in school will comprise the talent workforce of the future.

Colorado has been trending in a negative direction in terms of post-secondary enrollment. While it led this category among this study's peers in 1991, a contributing reason to the current high level of educational attainment in the state, it now lags behind many of its peers and the U.S. average, as seen in **Figure 6**, with less than 35 percent of 18-24 year olds enrolled in school.

Degrees in Technology-Oriented Fields

Each state's share of degrees in Science, Technology, Engineering, and Mathematics (STEM) is considered further. STEM degrees are critical because today's world is increasingly reliant on technologically capable workers at the same time that education systems are having trouble supplying these workers at a fast enough rate to keep up with demand. While workers of many backgrounds contribute to innovation, the overall lack of STEM graduates makes the ability of schools to generate these graduates especially important.

While all of the peer states and the nation as a whole saw a decrease in STEM graduates, as seen in **Figure 7**, Colorado saw an especially large decline. In 2000-2001 almost 16 percent of degrees granted in Colorado were in STEM fields, whereas less than 12 percent were in 2008-2009. Colorado went from being a leader in this category to the middle of the pack among

its peers, though it still awards more STEM degrees than the national average.

According to the Denver Scholarship Foundation, Colorado will need to graduate more students in order to keep up with demand from employers. They project that 70 percent of jobs in Colorado will require a certificate or degree by the year 2020, while only 41 percent of Coloradans currently hold an associate's degree or higher (Complete College America). A significant factor is the low rates of young people pursuing and completing educational training beyond high school, especially among minority and lower-income groups.

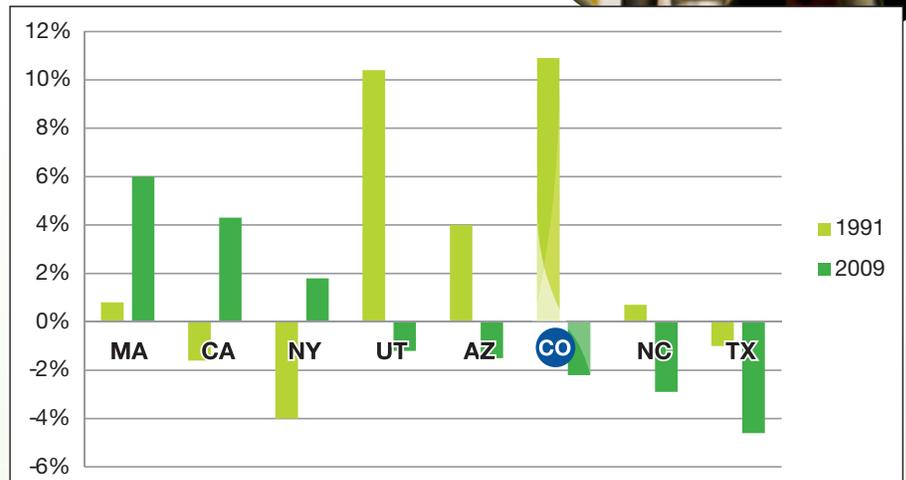


Figure 6 - Percentage of 18-24 year olds enrolled in school (Relative to U.S.)

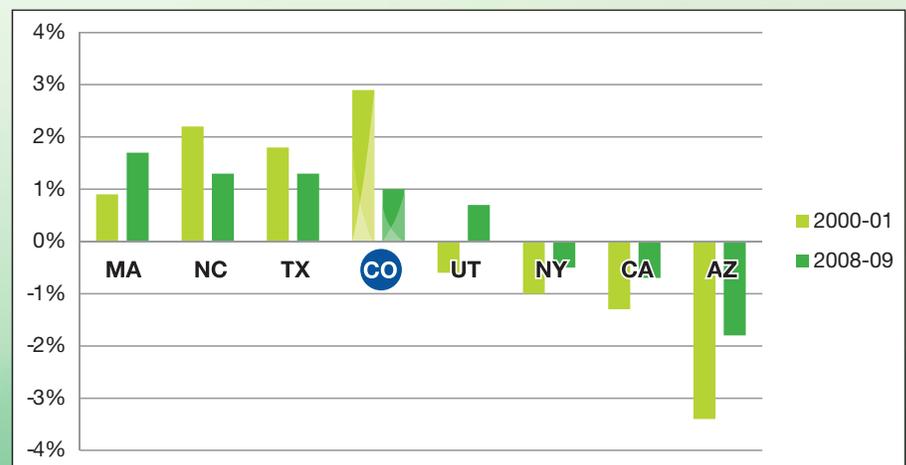


Figure 7 - Percentage of degrees granted in STEM fields (Relative to U.S.)

Migration Flows

In addition to homegrown talent, it is also important to be able to attract skilled labor from other places. While it is imperative to develop and have access to capable young talent, there is often no substitute for already-skilled, more experienced workers. The ability to attract already-skilled talent, then, is also critical to building an innovative workforce. Colorado, with its affordability relative to the coasts and many amenities, is particularly well-suited to attract talented workers.

Each state is evaluated in terms of the most recently available data on net migration of young single adults (ages 25 to 39) that are college-educated (**Figure 8**) to assess the flows of new talent, along with the net flow of migrants between the years 2000-2009 (**Figure 9**) to understand the more recent flow of the overall population moving into the states. In both metrics Colorado is shown to be an attractive place to move for all populations, especially talented young people. Colorado's continued ability to attract workers is critical to its future ability to fill talent gaps in its workforce.

The ability to attract talent and boast one of the most educated populations in the nation alongside the state's declining ability to graduate its own qualified workforce is widely known as the "Colorado Paradox." Graduating its own students will be a crucial factor for Colorado's economic future.

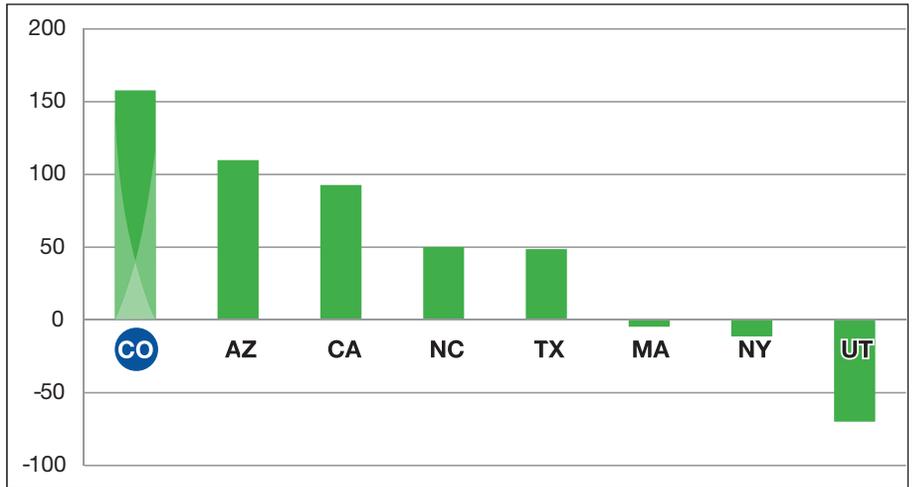


Figure 8 - Net Domestic Migration Rate of Single, College-Educated Population aged 25 to 39 (per 1000, 1995-2000)

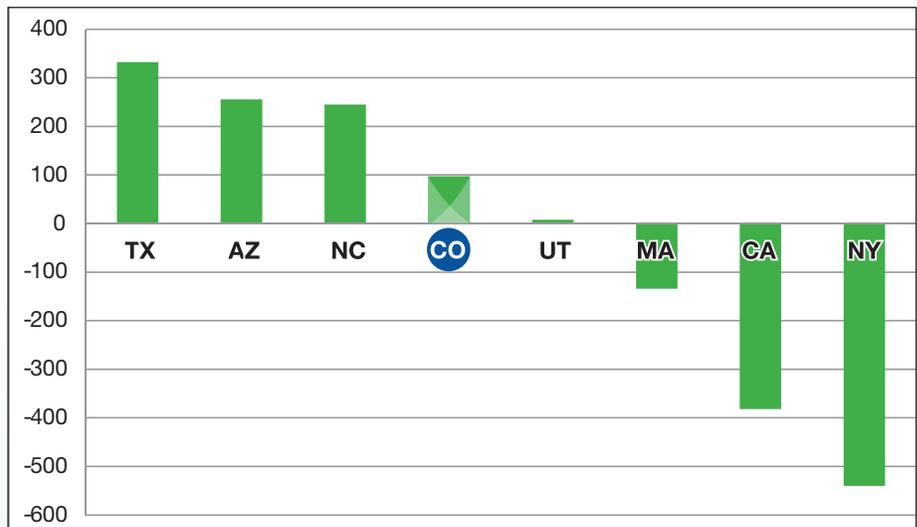


Figure 9 - Net Domestic Migration (in thousands) (1999-2009)

Ideas

While talent is important to innovation, it takes more than just talented people.

Those people must have productive ideas. Therefore, when measuring innovation it is important to get a sense of the types of ideas being created as well as the types of people available to generate those ideas. While the talent section explored the characteristics of the talent pool, this section explores factors which determine the flow of ideas generated within an economy. Three metrics are considered to provide an assessment of idea generation: research and development (R&D), academic R&D including article output within science and engineering fields, and patents.

Research and Development

Research and Development Intensity

Research and development (R&D) flows from a number of sources. Private nonprofits and universities fund research, deepening the publicly-accessible pool of available knowledge. The public sector is another source of R&D funding, by contributing its own research and funding to private and other public institutions. Both the federal and state governments provide R&D funding through organizations such as the national research laboratories, including the National Renewable Energy Lab (NREL) in Golden, Colorado, and the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, as well as providing research grants to private sector businesses, nonprofits, and universities.

Yet, while Colorado nonprofits and universities play a larger role in R&D than they do nationally, private business is still the predominant source of R&D funding in both the United States and Colorado (Figure 10). For many firms, developing new technologies and innovations are either a major part or the core of their business. For these types of firms, generating new ideas is critical to their ability to compete and succeed. In order to ensure that they stay on the cutting edge in product development, these types of firms invest heavily in research and development to create and improve products and processes on a continual basis. Since R&D is the mechanism by which many large firms generate the ideas critical to innovation, a way of benchmarking R&D is important.

R&D intensity is often the way firms are benchmarked against each other in terms of their R&D investment. This intensity is measured by R&D expenditures divided by revenue, representing how much of a company's income is reinvested back into developing new products. Similarly, this measure can be grossed up to an economy-wide scale by instead dividing overall R&D expenditure in the region by that region's income, represented by its GDP.

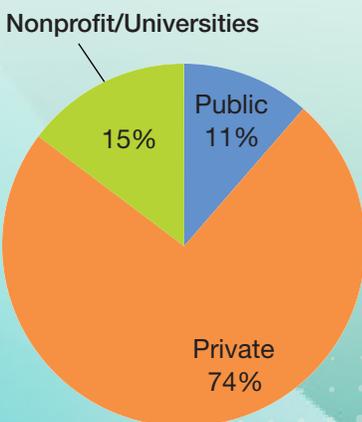
Colorado ranks low in its peer group, and is below the national average in terms of R&D intensity (Figure 11). Colorado reinvested just over two percent of its GDP back into R&D in 2008, noticeably below the U.S. rate.

Highlights

- The nonprofit and university sectors in Colorado contribute an above-average amount to expenditure in R&D, but overall R&D intensity lags the nation.
- Colorado is slightly ahead of the nation in terms of science and engineering academic R&D funding and article output.
- Colorado outperforms many benchmark states in patents, issuing over 450 patents per million residents in 2011, and will become one of four national satellite sites for the U.S. Patent Office.



U.S. Total



Colorado

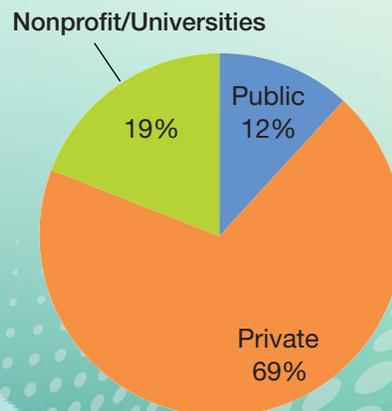


Figure 10 - Research and Development Expenditures by Sector (2008)

Academic R&D

Because colleges and universities are the place where most fundamental research occurs, they create the critical foundations for more specific research economy-wide. It is important to gauge the ability of those institutions to generate research not only because it benefits the economy as a whole, but also because of the benefits to the regions in which they reside. Academic research has direct economic effects when it draws money into a region through public, private, and nonprofit grant funding. There are also indirect effects resulting from knowledge spillovers. That is, when fundamental research is done at a college or university, it can be transmitted to regional businesses. This transmission occurs either through the relationships that people within that university have with local workers, be they casual or professional, or in that these institutions can act as a professional pipeline. In this context, university researchers may be hired by firms where they can apply the research they have already undertaken, or they may strike out on their own as entrepreneurs in hopes of realizing opportunity from the ideas they have created. The importance of this to the private sector has recently manifested itself in the large number of businesses that have set-up research centers near universities across the nation and developed collaborative research relationships with various departments and projects.

Academic R&D Funding

Academic R&D is benchmarked in two ways, focusing specifically on science and engineering output as a case study with particularly direct effects on broader industry innovations. The first is a measure of the ability of academic R&D to draw in research funding, and is measured using the total Academic R&D dollars dedicated to Science and Engineering research per million residents. Ample R&D funding is a strong benchmark both in that greater funding can support a larger amount of research but also as a signal in that the best and most productive researchers tend to attract the most funding.

Colorado ranks above the national average in terms of academic funding for Science & Engineering R&D near the middle of its peer group (**Figure 12**), at about \$200 per resident in 2009.

Academic Article Output

While R&D funding measures the ability to attract capital to fundamental research, it does not tell the whole story, as it does not describe the actual productivity of that research. While funding represents an input to research, it is also useful to look at academic research's most concrete form of output, namely peer-reviewed publications. These publications represent each discipline's best judgment on the contribution of a research idea to the knowledge frontier. Again leveraging science and engineering's particularly direct ties to innovation, the number of those disciplines' articles published per million residents is evaluated. As peer reviewed articles are one of the primary ways by which academic research is dispersed, this provides a proxy for the actual amount of knowledge being generated and disseminated by academic institutions.

Colorado is consistent with most of its peer group and somewhat above the national average in terms of academic output (**Figure 13**), publishing nearly 600 articles per million residents in 2009.

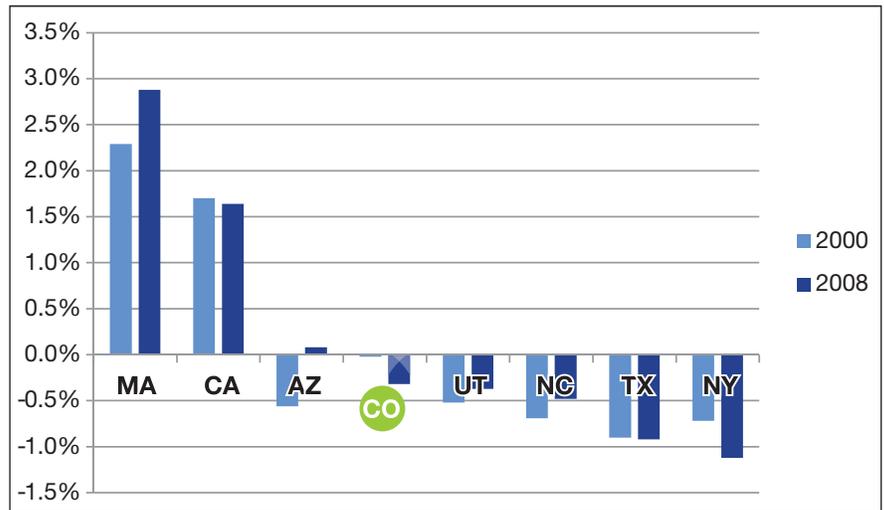


Figure 11 - Figure 10 - Research and Development as a Percentage of State GDP (Relative to U.S.)

Patenting

Patents are a direct expression of innovation as legal representations of innovative ideas, and thus a measurable indicator of raw innovation by businesses and individuals. Patents allow assignees to legally protect and profit from their innovative ideas. By granting this legal protection for the value a new idea may generate, patents give assignees an incentive to innovate; their existence is also a record of past innovation. While they are not an all-encompassing record, as many innovative companies may opt not to patent for a variety of reasons in certain industries, as a whole they can provide insight into



the innovative output of a region. For this reason, the patents issued per million residents benchmarks the productivity of idea generation.

While far trailing the two leading benchmark states, California and Massachusetts, Colorado still performed relatively well in terms of its ability to generate patents. Colorado ranked third overall among the peer group (Figure 14), generating over 450 patents per million residents in 2011. Notably, Colorado was recognized for its high performance in this area by being selected by the U.S. Department of Commerce to become one of four satellite locations for the U.S. Patent and Trademark Office in July 2012. U.S. Patent and Trademark Office officials indicated that Denver was chosen over other western cities due to its high per capita rates of people with science and technology degrees, relatively low living costs, high quality of life, and a desirable location in which to recruit and retain the most talented workers.

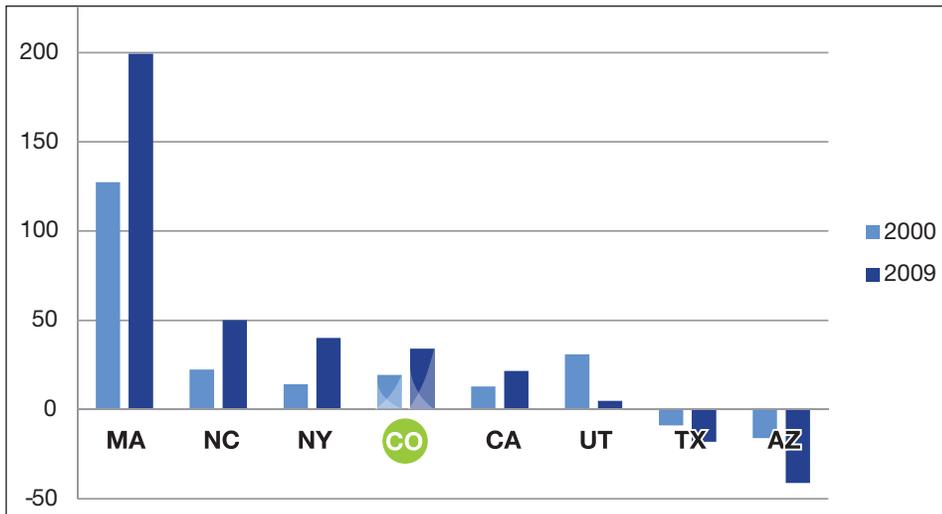


Figure 12 - Academic Science and Engineering R&D (\$ millions) per million residents (Relative to U.S.)

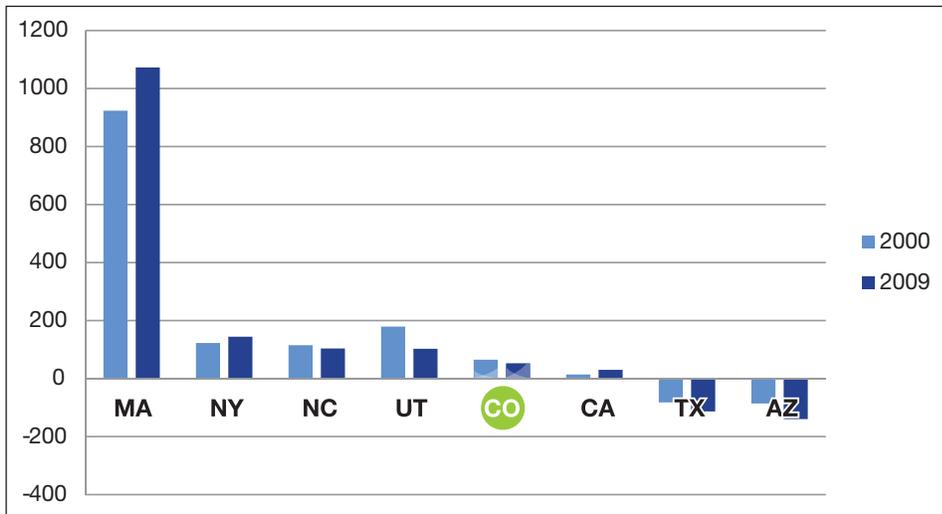


Figure 13 - Academic Science and Engineering Article Output per million residents (Relative to U.S.)

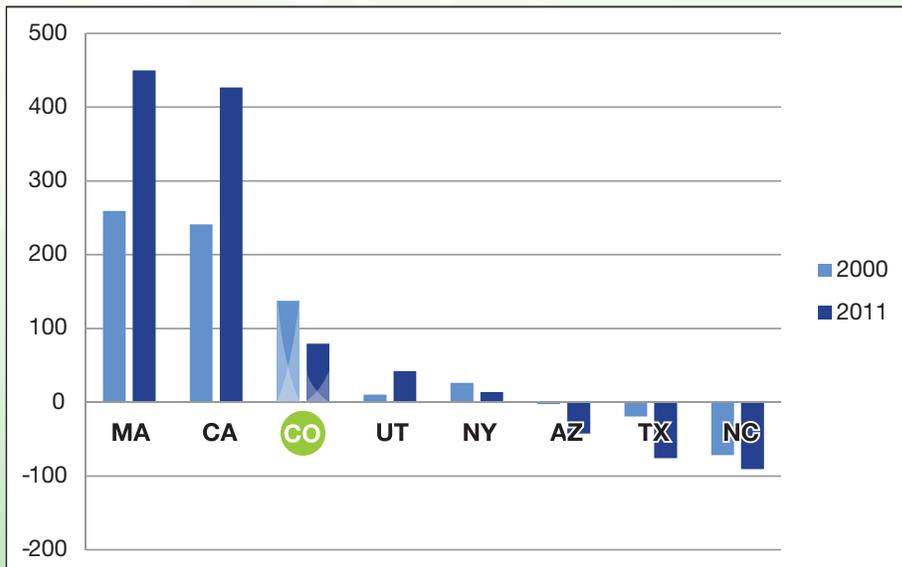


Figure 14 - U.S. Patent and Trademark Office Patents Issued per million residents (Relative to U.S.)





Capital

Whether it is the expense of purchasing or leasing manufacturing equipment, renting office space, hiring talented employees, or compensating the creator of those innovative ideas, creating good ideas takes money. Therefore, capital is important regionally because it helps preexisting innovators bring their ideas to fruition. Capital can also help attract innovative and talented people from other places, with these folks often bringing more capital with them as well. Capital is the backbone of R&D funding, a key benchmark in the previous section. The following section has three separate components: private capital, public capital, and tax favorableness. Although not exhaustive, the metrics are useful in providing a general picture of a state's capital resources.

Private Capital

Venture Capital

For entrepreneurs with new ideas, access to capital can be difficult. Banks may be unwilling to lend to new ventures, especially in products/services for which the bank and/or region have little experience. Loan risks are assessed based on track records, which are often precisely what innovative startups lack. Venture capital (VC) arrived as a way to better align the interests of both entrepreneurs and investors by giving small firms access to equity, rather than debt financing. By financing with equity, VC firms, unlike banks, can share in the upside as well as the downside of funding risky new businesses. Because of the way equity financing is structured, it can also be advantageous to the entrepreneur, as

they do not need to worry about frequent repayments, and can utilize all of their initial funding to continue to grow their enterprise.

To measure benchmark states in terms of VC funding, quarterly investment data available through the PricewaterhouseCoopers (PwC) MoneyTree Report is analyzed, released by PwC in conjunction with the National Venture Capital Association and Thomson Reuters.

While far behind Massachusetts and California, Colorado did well relative to the rest of the peer group (**Figure 15**), attracting a little more than \$120 in venture capital funding per person in 2011.

Highlights

- Colorado offers a high level of private capital funding in the form of venture capital investments (ranked third in the peer group), small business loans and access to bank branches (ranked second for both).
- Colorado receives a relatively large amount of public funding from Small Business Innovative Research and Small Business Technology Transfer Grants, while slightly below the national average in terms of National Institutes of Health funding.
- Colorado's tax favorableness is competitive, ranking higher than the majority of the benchmark states.

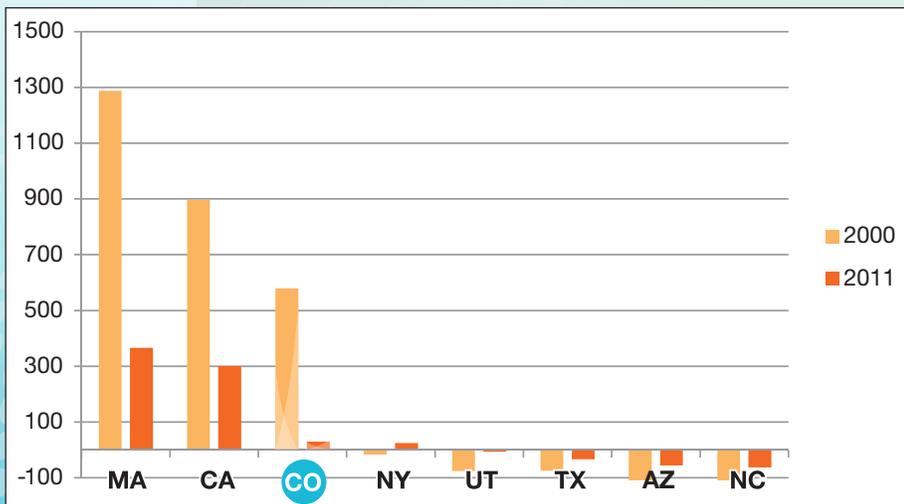


Figure 15 - Total Venture Capital Funding (\$ millions) per million residents (Relative to U.S.)



Small Business Loans

Traditional debt financing through small business loans are a more accessible and simpler approach for most entrepreneurs, especially those who operate more standardized businesses requiring more conventional operating credit lines. When banks are confident in a new business' ability to readily get on their feet, generate income, and eventually pay back their loan, they are more willing to lend. Regions which have a broader history of startups also allow banks to better assess the risk profiles of a given investment project.

One way to gauge the health of lending in a region is to look at the number and value of loans given to small businesses. Using Community Reinvestment Act Data available through the Small Business Administration, states are benchmarked according to both the number of small business loans made under \$100,000, and the value of those loans, normalized on a per-million resident basis. As seen in **Figures 16 and 17**, Colorado ranked high among both its peer group and relative to the national average in both of these metrics.

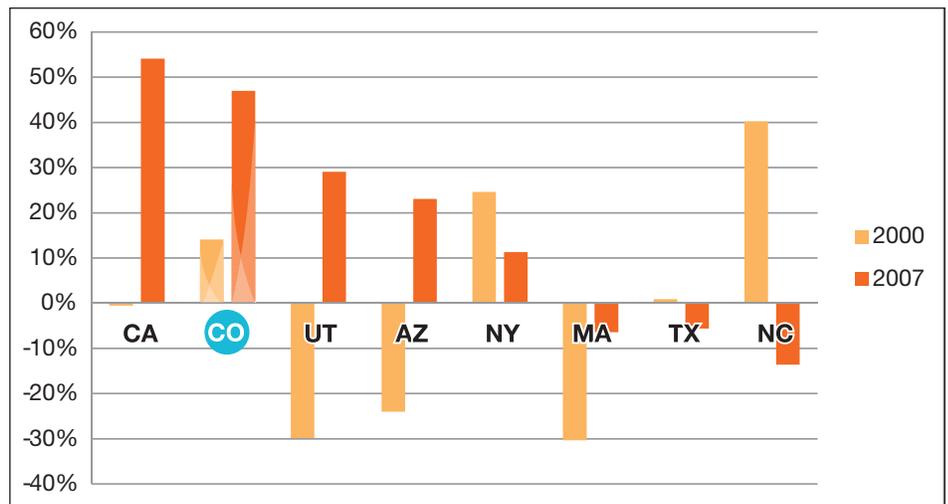


Figure 16 - Number of Business Loans under \$100,000 per million residents (Relative to U.S.)

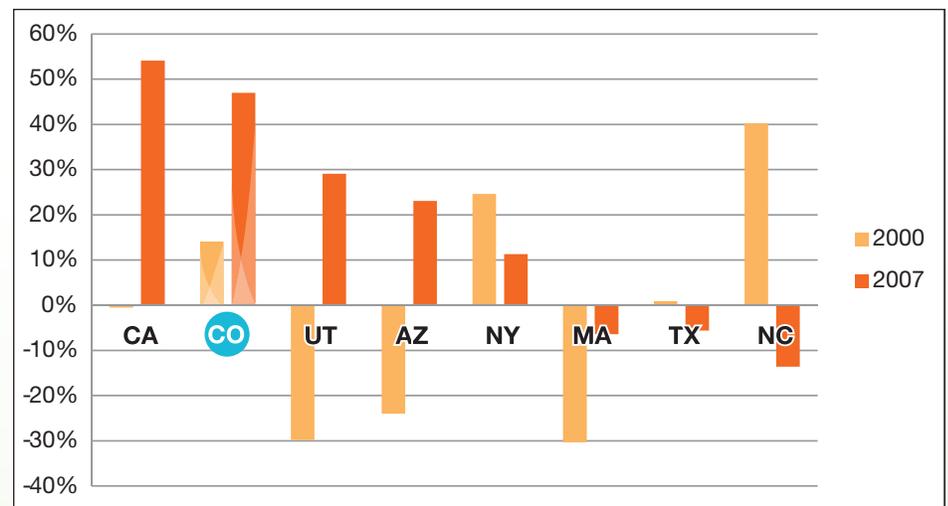


Figure 17 - Value of Business Loans under \$100,000 per million residents (Relative to U.S.)



Bank Branches

Because banking is primarily a relationship-based enterprise, accessibility of bank branches is also important to small business success. Banks are much more likely to lend if they have good information about the businesses to whom they are lending. Therefore, having a larger number of banks increases the probability that a business can find a regional bank that has the time, network, and information to more confidently provide ongoing loans to evolving small businesses.

The states are benchmarked using Small Business Administration data on the number of banks per state, which has been normalized per million residents. Colorado ranked toward the top of the peer group and slightly above the national average in this measure in 2008, as seen in **Figure 18**.

Public Capital

Public funding is another critical element to developing innovative research. Public funding is awarded to many different sectors, and is not exclusively tied to direct federal research, such as is done at NREL or NCAR. Public grants are also awarded to private businesses and nonprofits. Two categories of public funding for private research are reviewed here, one targeted at small business, the other at the medical sector.

Small Business Grants

Small Business Innovative Research (SBIR) grants encourage domestic small businesses to engage in federal based R&D, and are awarded through 11 participating government agencies. Small Business Technology Transfer (STTR) grants are similarly awarded through government agencies. However, these grants differ in that they require the recipient to collaborate with a research institution for the first two phases of the project, allowing technology and knowledge to be transferred both from the institution to the recipient and vice versa. Such collaborative transfers of technology are intended to spur innovation through knowledge sharing and communication.

Figure 19 shows the number and value of SBIR and STTR awards per million residents relative to the national average received by each of the benchmark states since 2009. Colorado comes in second for both award

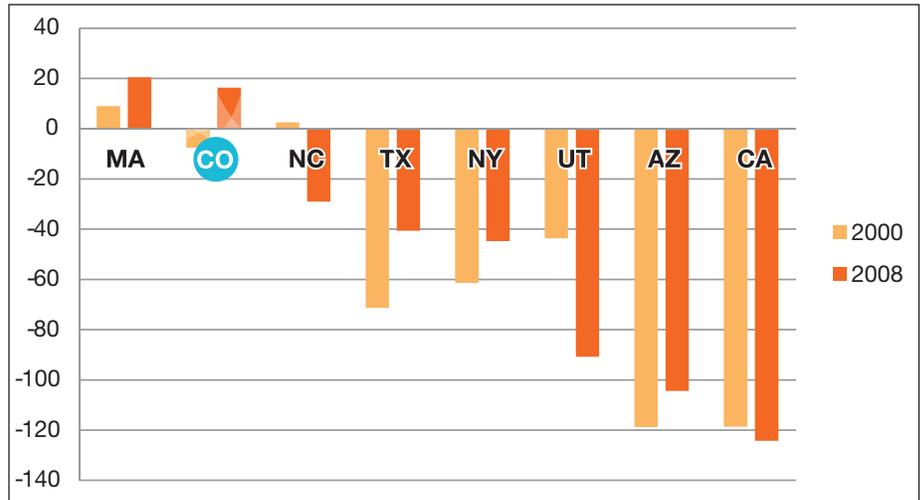


Figure 18 - Number of Bank Branches per million residents (Relative to U.S.)

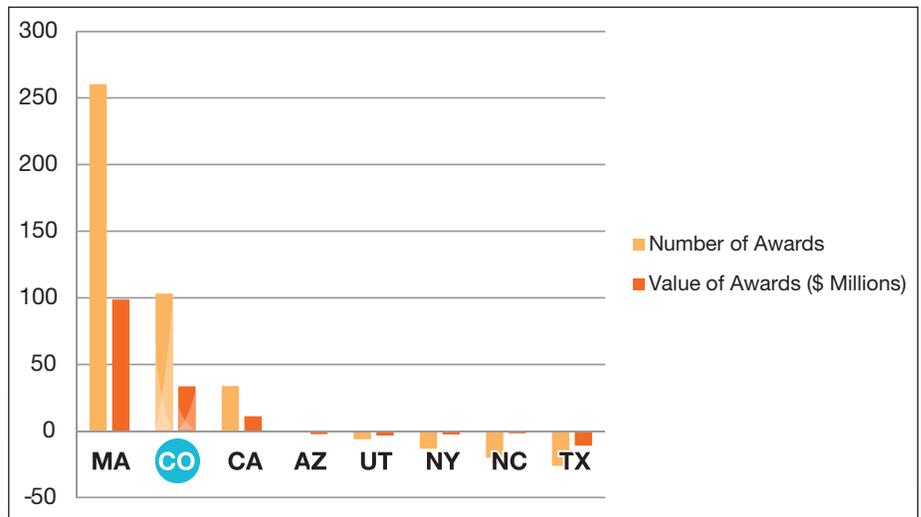


Figure 19 - SBIR/STTR Awards per million residents since 2009 (Relative to U.S.)



value per million residents and number of awards per million residents. These grant dollars are awarded to innovative companies that are at the cutting edge of technology and directly contribute to Colorado's innovative economy.

National Institutes of Health Funding

The National Institutes of Health (NIH) provide grants for companies and individuals engaging in medical research. This funding goes towards researching and developing cutting edge technological advances in the healthcare sector. As seen in **Figure 20**, Colorado ranks low among its peers and slightly below the national average in terms of 2011 NIH funding per million residents, likely related to the relatively few medical schools and research centers in the state.

Tax Favorableness

While not directly related to capital funding, the tax structure of a state can affect businesses' decision to locate there. States with low taxes will increase the bottom-line profitability of businesses, all else equal. Low tax rates also tend to go along with pro-business policies at the state level as a whole. Such policies may include R&D tax credits or preferential treatment of capital expenditure that in particular benefit certain types of innovative industries.

The Tax Foundation releases an annual report titled The State Business Tax Climate Index, which measures the favorableness of a state's tax system. The higher the score, the more favorable that state is for business with respect to taxes. The index is composed of five different tax components and 118 different variables. The breakdown of weighting for the components is as follows:

- 33.1% - Individual Income Tax
- 21.4% - Sales Tax
- 20.3% - Corporate Tax
- 14.% - Property Tax
- 11.1% - Unemployment Insurance Tax

In 2012, Colorado ranked 16th overall, placing it third among the benchmark states behind Texas and Utah, as seen in **Figure 21**.

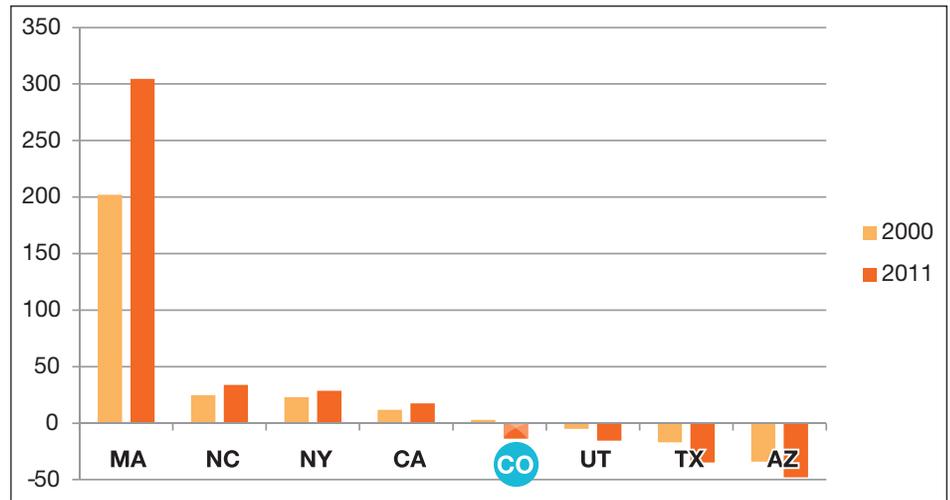


Figure 20 - NIH Funding (\$ millions) per million residents (Relative to U.S.)

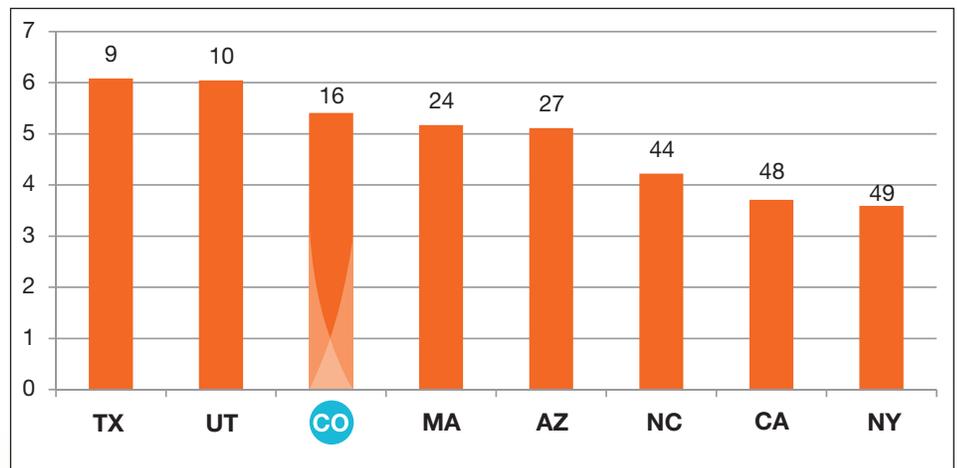


Figure 21 - State Business Tax Climate Index and Rank (2012)





Entrepreneurship

Talent, ideas, and capital are all fundamental to successful innovation. However, the process of bringing innovation to market is complex, and it is the role of entrepreneurial businesses and business models to coordinate this process. More specifically, this process involves many elements, including identifying the potential end market for the innovation and then refining the innovation, its production and its marketing to maximize the new market value that this innovation can generate. This process is even more complicated for a new innovation, in that it is by definition unexplored. In undertaking this process, the entrepreneur brings together and refines the raw innovation elements of talent, ideas and capital in order to bring that raw innovation to market. The income “returns” to entrepreneurial firms and their workers represent the payoffs for maximizing the potential market value of innovations.

Entrepreneurship exists in both established and new businesses. However, innovative entrepreneurial capacities can be more easily tracked in young firms, which are only born and grow if they successfully provide new value to a particular market. Such entrepreneurship can be measured in terms of both breadth and depth. In its initial self-employment phase, entrepreneurial breadth is a measure of the prevalence of these self-employed entrepreneurs in an economy, while depth is focused on the returns to these entrepreneurs. Yet such solo or partner entrepreneurs are not yet creating any jobs, except for their own. The second stage of entrepreneurship, where firms actually employ workers beyond the immediate owners, is thus defined as small business. The number of establishments and net jobs these small businesses generate, as well as the income generated by these workers, become the respective breadth and depth benchmarks for the economic development impact of the entrepreneurs’ second stage, namely that of employer firms. This distinction is important, for while one typically thinks of entrepreneurs in terms of the sole proprietor or partnership striking out to pursue a new idea, successful entrepreneurs will eventually hire their own employees, becoming small business owners themselves. Colorado consistently ranks above the national average in terms of breadth in entrepreneurship, as well as establishment births and returns to labor in small businesses. The strength of the Front Range, in particular, is highlighted in a 2005 U.S. Small Business Administration report, highlighting Fort Collins as the most innovative-entrepreneurial region, with Denver ranked sixth (SBA).

Self-Employment

When ideas are new, entrepreneurs generally do not have the means or access to capital necessary to hire employees. Therefore, entrepreneurial efforts usually begin as non-employer establishments, comprised either of a single “sole proprietor” or a partnership of a few entrepreneurs agreeing to share joint profits. This first stage benchmarks entrepreneurial activity in Colorado by examining both the prevalence and relative success of self-employment in the state. As might be expected for such “starter” firms, these non-employer firms represent the vast majority of business establishments across the country, but generate less than 4 percent of all business sales. Colorado ranks far above the national average in terms of entrepreneurial breadth

in the state, but slightly below the U.S. benchmark in terms of the returns to these entrepreneurs. County by county, however, there are large differences in the relative success of entrepreneurship, with high value-added firms clustered particularly around the Denver metropolitan area, with other entrepreneurial clusters scattered throughout the state.

Self-Employment Breadth

Entrepreneurial breadth in this initial self-employment phase measures the prevalence of self-employed workers in a given region, calculated by measuring the number of proprietors in a region and dividing by the total number of employed people. This measure is useful for

Highlights

- Colorado ranks above the national average in terms of breadth of entrepreneurship among both the self-employed and small businesses.
- While Colorado has a high prevalence of self-employment establishments, they are only average in terms of entrepreneurial returns.
- Colorado performs particularly well in terms of small business measures, scoring high relative to the nation and the peer group with respect to births and returns to labor; although net job creation has slowed significantly.

characterizing the willingness of people in a region to take the risks associated with becoming self-employed. Self-employment has also helped lead labor market recoveries from the two recessions since 2000, as willing entrepreneurial risk-takers forge out on their own before more risk-wary firms begin more significant payroll hiring.

While this measure can be a useful gauge of the entrepreneurial willingness of a region, it does not necessarily indicate the success of entrepreneurs, particularly with respect to innovation. In particular, rural areas are often characterized by a prevalence of self-employment breadth, as there may be few job opportunities outside of starting one’s own business. While such entrepreneurs

still must provide tangibly new value to the market to survive, the marketplace in question may be limited in size and/or scope.

Colorado is the leader among the focal states in terms of self-employment breadth. In 2010 Colorado led this metric with nearly 25 percent of employed Coloradans being self-employed, up from about 19 percent in 2000. This upward trajectory followed the national trend, as Colorado was about 3.9 percent above the national average in measuring self-employment breadth in 2000, and 3.8 percent above this average in 2010, as expressed in **Figure 22**.

Self-Employment Depth - Returns to the Entrepreneur

Self-employment depth measures the value-added of entrepreneurship, the returns to the entrepreneur, capturing the percentage of total sales kept by entrepreneurs as income. As noted previously, a person's income is itself directly determined by the market's value of the things they produce as well as their productivity, each of which is in turn directly influenced by innovation. This metric evaluates the efficiency of entrepreneurs in converting revenue into an income for themselves, as a proxy for the market's valuation of the innovative products, processes, and/or services that the entrepreneur uses and/or produces. Firms more dependent on the specific talents and ideas embodied in the entrepreneur's product will capture a greater portion of their revenue in the form of income, while more capital-oriented firms will spend a greater amount on equipment, rent, and other intermediate inputs. In 2009, Colorado was fourth in the tested peer group slightly below the national average (**Figure 23**), converting about 62 cents of every dollar into income returns to the entrepreneur.

Yet there is significant variation in terms of self-employment depth regionally across Colorado. Only seven counties throughout the state performed better than the national average in this statistic, as can be seen by the counties in purple found in **Figure 24**. Furthermore, many counties' entrepreneurial establishments did not reach even half of the average national returns to the entrepreneur in 2009, as denoted by the counties in yellow.

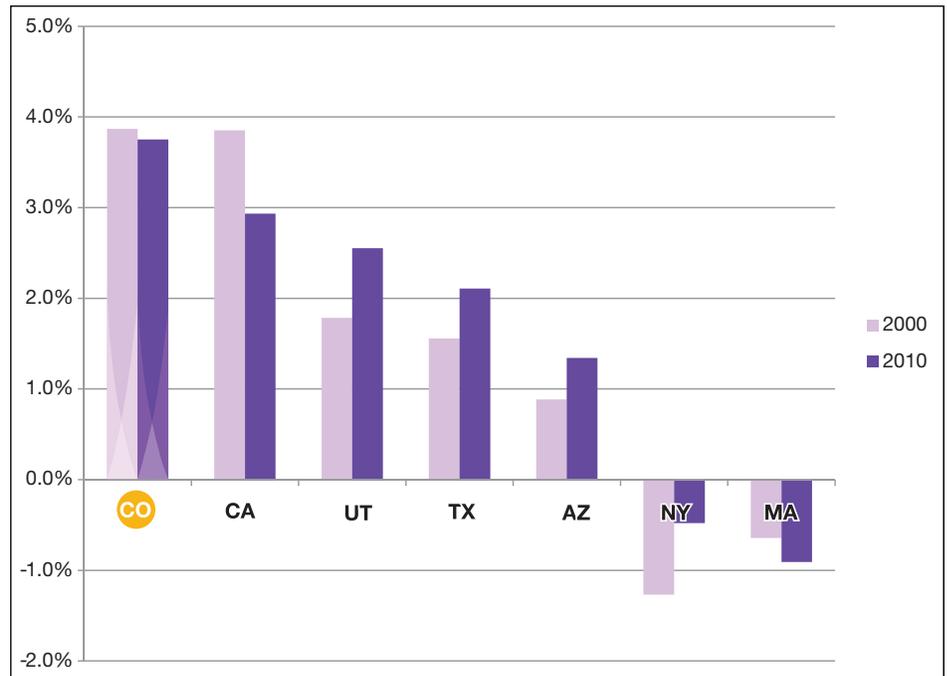


Figure 22 - Self-Employment Breadth (Self-employed workers/Total work force, relative to U.S.)



Figure 23 - Self-Employment Depth: Returns to the Entrepreneur (Relative to U.S.)

Small Business

While the previous two measures focused on the self-employed, small businesses who employ workers are perhaps an even more important marker of entrepreneurship. While many businesses start as sole proprietors, the most successful ones will tend to grow into small businesses, creating new jobs and incomes along the way. Small business entrepreneurship is an important job creator in the United States, as well as a vital vehicle for bringing innovation to market.

Breadth - Birth Rate

An economy full of ideas, talent, and capital will generate many new innovative products, and along with them the small businesses necessary to bring them to market. The birth rate measures the number of new employer establishments created each year as a percentage of existing establishments among various firm sizes. Economies with many new business births are representative of an entrepreneurial economy that provides a strong test bed for new innovations. In addition, having many new businesses increases the probability that highly successful ones will evolve from that broader seedbed.

Colorado has historically done better than its peers at creating new small business establishments. In 2010, Colorado was second among this group, generating 1.5 more small business establishments per hundred than the national average, as shown in Figure 25.

Breadth - Net Job Creation Rate

Successful entrepreneurship manifests itself in the form of growing small businesses, which are major job creators in the U.S. The small business net job creation rate looks at the net number of jobs created by small businesses consisting of less than 500 employees, comprised of jobs created by both new and existing small businesses minus those lost by closing and contracting firms. This rate reflects the relative strength of entrepreneurial innovations, as newly born businesses seek not only to survive but to thrive and expand based on their new market niches.

Colorado's small business net job creation has followed similar patterns to its Western

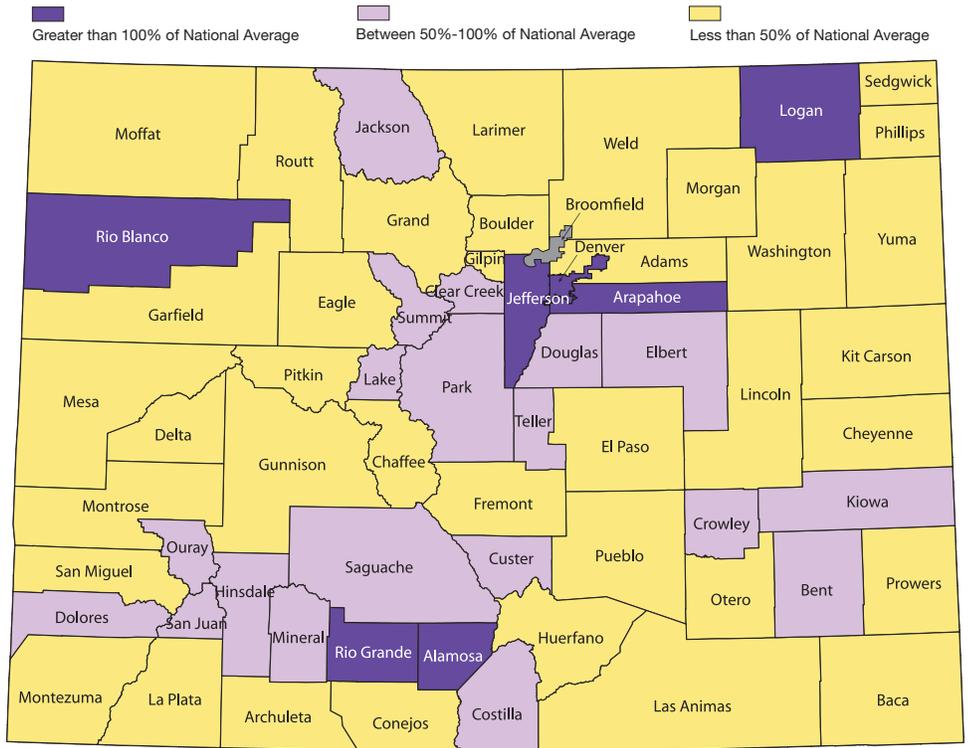


Figure 24 - Self-Employment Depth: Returns to the Entrepreneur (By Colorado Counties 2009)

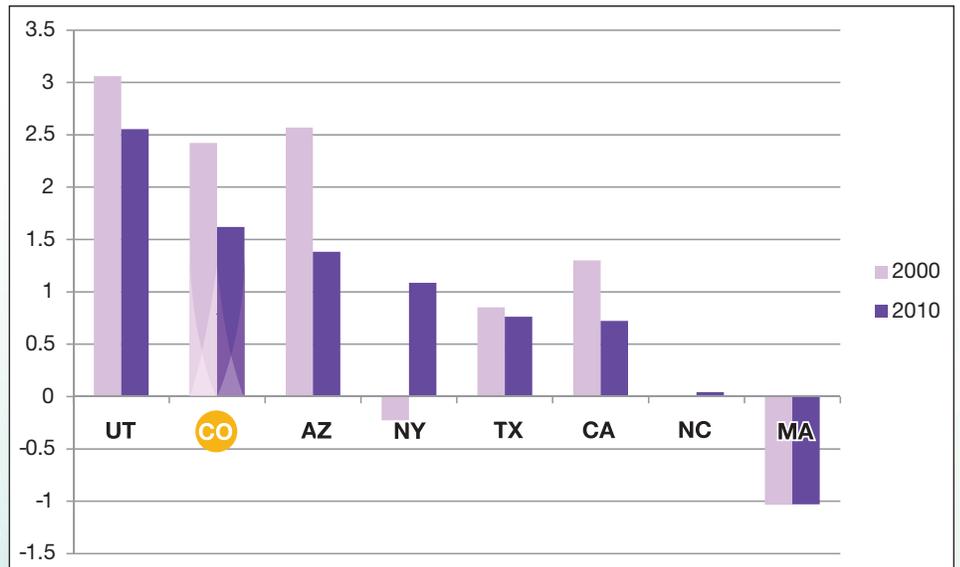


Figure 25 - Birth Rate of Establishments <500 Employees (Relative to U.S.)

peers. These states generally outperformed the national average in terms of net job creation in 2000, while 2010 saw all of these same states lagging. In 2010, Colorado lagged four of its peers, as well as the national average, in terms of net job creation. However, it performed better than its three other western peers - Arizona, California, and Utah - as can be seen in **Figure 26**.

Depth - Returns to Labor

In parallel with the focus on income-generating returns for entrepreneurial proprietors, the ability of small businesses to create new value also yields useful insights. The goal of this entire report has been to track innovation, which generates fresh market value to the economy through new products, processes, and services. That value should be most strongly expressed in the higher value of outputs generated by employed workers as well as their productivity, both of which are the bases for determining their incomes. Our final metric explores these incomes as a proportion of total business sales. This metric also allows insight on not only the returns from innovations, but also workforce investments in upgrading talents, skills and ideas. These returns are measured by taking the total payroll paid out by firms and dividing by the total receipts, effectively estimating the relative value of the workers' production in a firm, which itself is partially a product of innovations in the industry in which they work. Firms that have valuable employees working with valuable innovations are willing to pay their employees a higher proportion of firms' overall revenue, as they are crucial to the success of the business.

Among the peer group examined in this study, Colorado ranks third in terms of the return on labor, with 21 percent of receipts by businesses with less than 500 employees going to worker pay in 2007. This result suggests a high degree of ideas and talent encapsulated in Colorado's employee, with the state's returns to labor significantly higher than the national average, as seen in **Figure 27**.

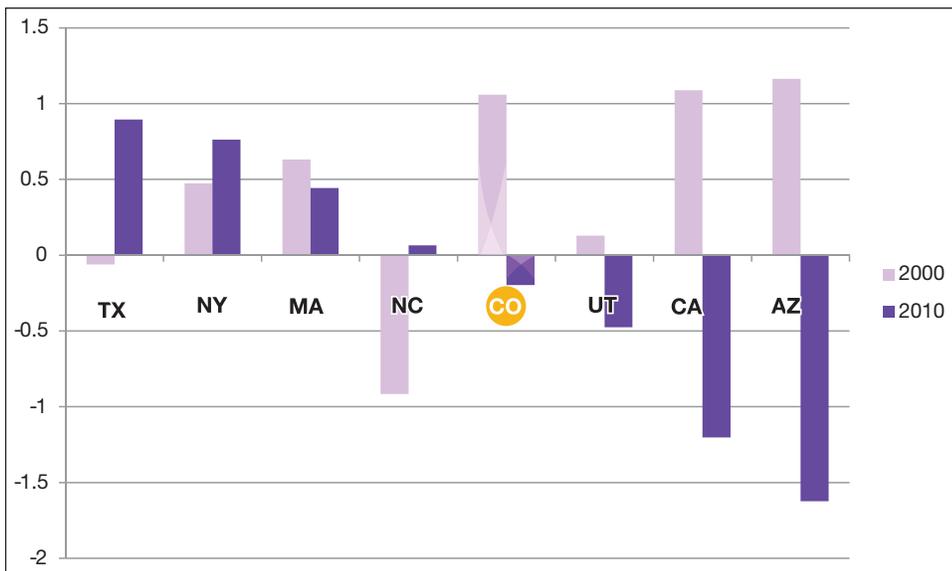


Figure 26 - Net Job Creation by Establishments of <500 Employees (Relative to U.S.)



Figure 27 - Returns to Labor (Relative to U.S.) 2007



Conclusion

Colorado possesses the ingredients – ideas, talent, capital – for formulating raw innovation, as well as the catalyst – an entrepreneurial business sector – for capitalizing on these bases. While our findings support other sources’ optimism in a number of key areas, especially with regard to the available talent pool and key entrepreneurship and small business metrics, there are also many opportunities for Colorado to develop.

The Colorado Innovation Network will continue to work to uncover solutions that will drive innovation further in the state.



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Figure 25: Derived using data from U.S. Census Bureau, Business Dynamics Statistics (BDS) Data Tables: Establishment Characteristics: Establishment Size. Retrieved from http://www.census.gov/ces/dataproducts/bds/data_estab.html

Figure 26: Derived using data from U.S. Census Bureau, Business Dynamics Statistics (BDS) Data Tables: Establishment Characteristics: Establishment Size. Retrieved from http://www.census.gov/ces/dataproducts/bds/data_estab.html

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To view background research for this publication, visit www.coloradoinnovationnetwork.com/innovation-index-background-research

What is the Colorado Innovation Network?

The Colorado Innovation Network (COIN) is a primary catalyst to spur innovation and growth in Colorado. Launched in November, 2011, by Colorado Governor John Hickenlooper, COIN's mission is to stimulate economic growth, create jobs, increase tax revenue and attract new businesses to the state of Colorado by supporting innovative business activities and establishing a reputation for Colorado as the most innovative state in the country.

COIN leverages and coordinates robust resources already present in the state, and adds momentum and visibility to existing work. Through COIN, leaders from industry, nonprofits, foundations, government and academia convene and commit to achieving the common goal of increased economic competitiveness. The alignment of these resources will act as a catalyst for businesses and entrepreneurs across the state.



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