December 2015

California's Innovation-Based Economy: Policies to Maintain and Enhance It

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MILKEN INSTITUTE

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Center for Jobs and Human Capital and California Center

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ACKNOWLEDGMENTS

The authors would like to thank their colleagues and former colleagues for their help. In particular, Michael Lin for his support preparing graphs, Priscilla Hamilton for her help with the analysis, and Armen Bedroussian for his assistance with the analytical framework. Our editor, Michael White, took great care to improve the clarity of the sometimes dense prose. We appreciate his insights and commitment to enhancing the quality of the final product. In addition, the authors would like to thank the many California stakeholders and policy-makers who offered their insight and encouragement to this endeavor.

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Table of Contents

EXECUTIVE SUMMARY 1

1. INTRODUCTION 9

2. ROLE OF INNOVATION IN ECONOMIC GROWTH 11

3. CALIFORNIA'S INNOVATION ECONOMY 21

4. CALIFORNIA'S PRIVATE-SECTOR R&D 33

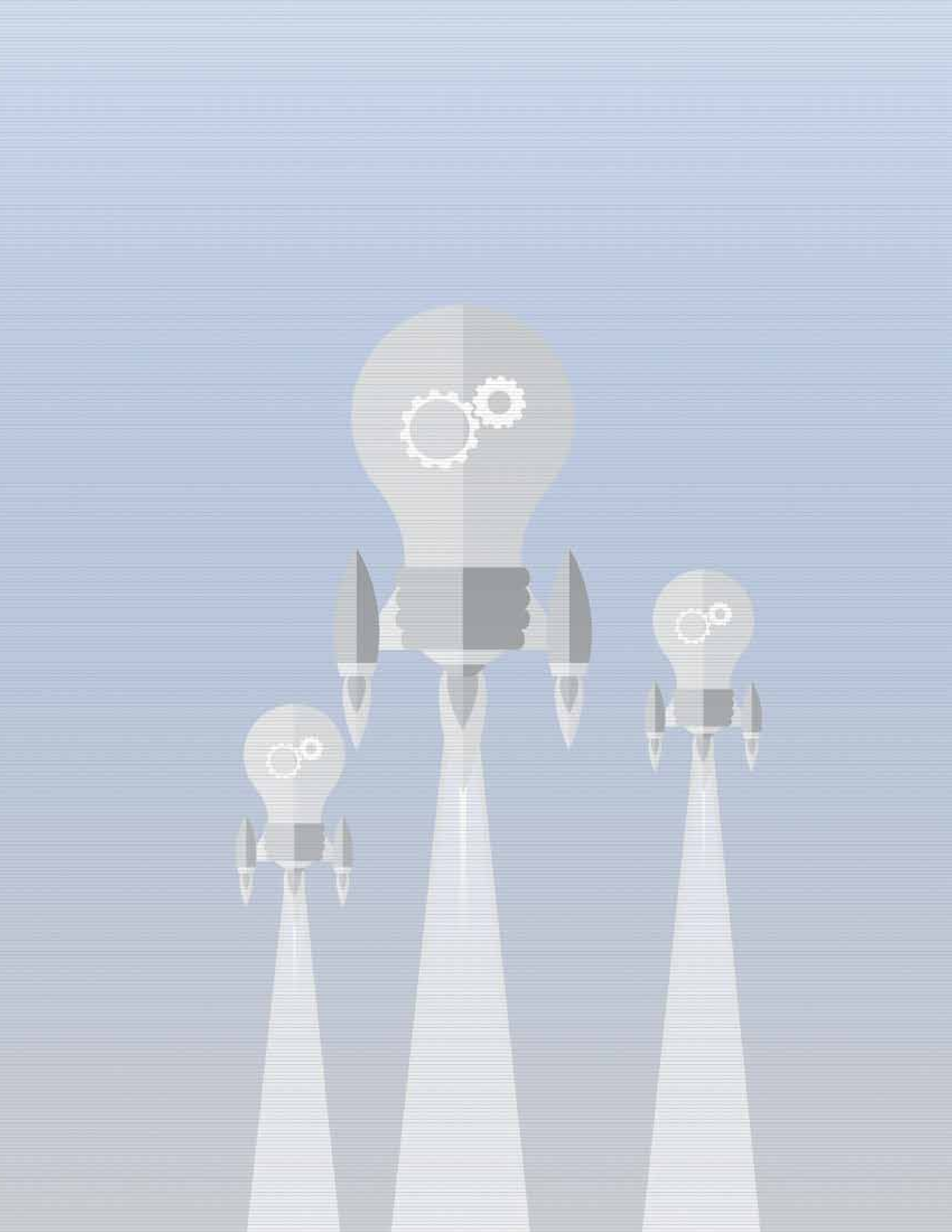
5. ENCOURAGING R&D SPENDING IN CALIFORNIA: SELECTED POLICY ALTERNATIVES 45

6. CONCLUSION 57

APPENDIXES 59

ENDNOTES 67

ABOUT THE AUTHORS 72



Executive Summary

Innovation is critical to the creation of high-quality, high-wage, sustainable jobs and economic growth, which, in turn, support a rising tax base in California and around the world. California's policymakers can't afford complacency in evaluating the dynamism of its innovation economy or in reviewing policies needed to buttress it. To maintain its leadership in innovation, California must provide a competitive business environment in which prospective and existing companies can conduct research.

In the global race for innovation, California enjoys advantages that other states and nations envy. These include leadership in diverse technology and knowledge-based industries, strong research institutions that provide unrivaled human capital and valuable intellectual property, an entrepreneurial culture aided by a deep pool of immigrant entrepreneurs, and the early-stage risk capital to bring innovations to market.

However, California also suffers from the widely held perception that it is inhospitable to businesses in terms of tax policy, regulatory regime, and other costs of doing business. This perception, along with competing incentives offered by other states and nations, means that California cannot rest if it wants to maintain its innovation supremacy and minimize the number of businesses choosing to locate or expand research operations elsewhere.

California must view itself as both part of a national system of innovation and a separate, distinct collection of regional innovation ecosystems. The state is dependent on federal policies that affect the location decisions of firms and entrepreneurs engaging in innovative activities. For example, U.S. national corporate tax rates, depreciation schedules, and research and development (R&D) tax credits, among others, influence these location choices.

However, policies at both the federal and state level are used to determine where R&D investments will be made, and thus where successful innovations occur and spur economic growth. A firm looking at placing innovative assets or expanding current operations in California examines the combined national and state-specific policies. While California can't directly affect innovation policies at the national level, it can reduce the cost of capital and make itself more attractive through the use of aggressive state R&D tax credits or by funding research at its universities.

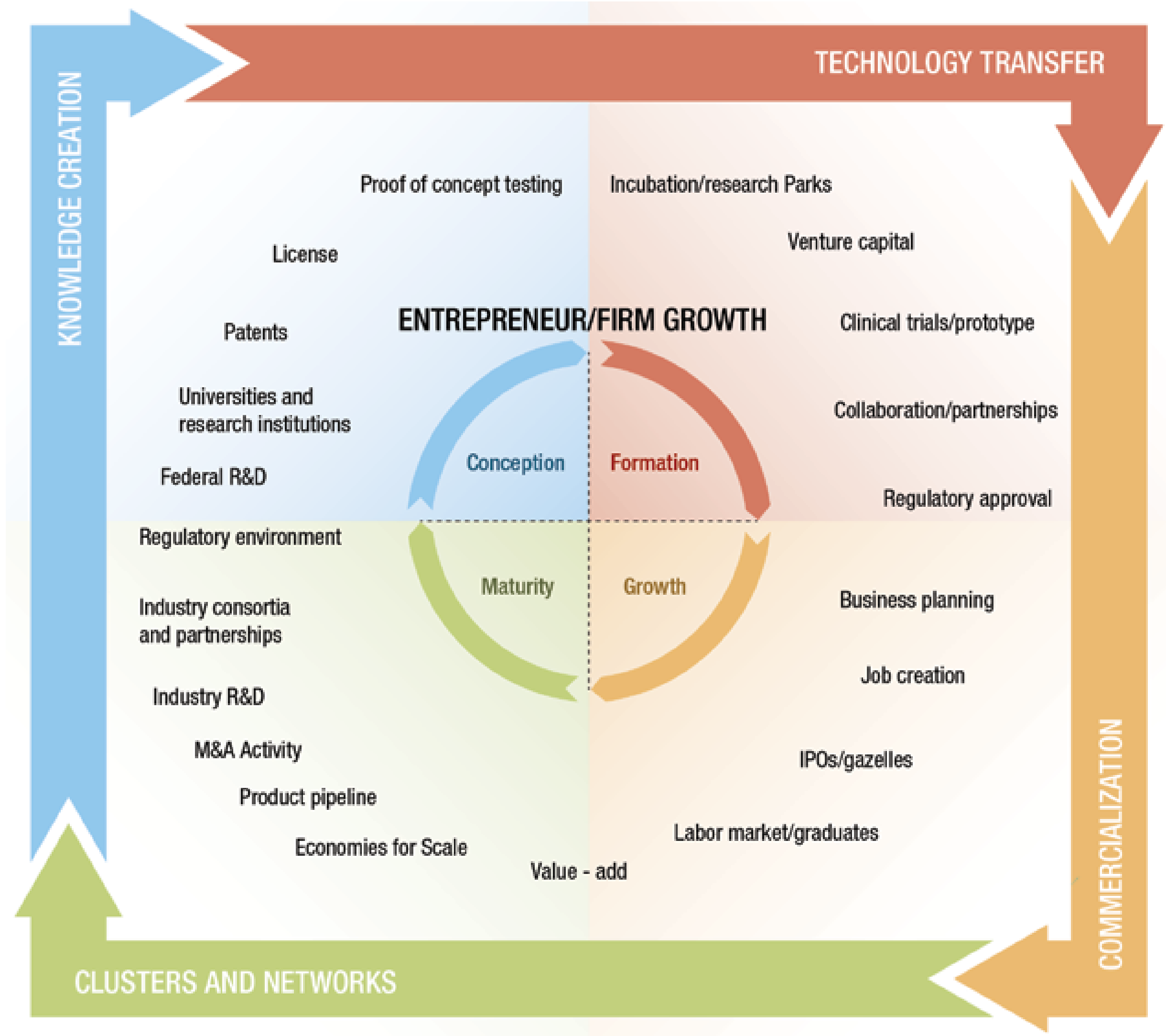
Innovation-Fueled Growth

Economists for centuries have debated the factors that determine long-term growth. However, in recent decades there has been a growing recognition of the crucial role innovation plays in advanced economies. New Growth Theory emphasizes that economic growth is an endogenous outcome of a dynamic economic system. Innovation is a vital endogenous factor in the long-run growth process. Innovation is largely the result of cumulative R&D investments, or the capital stock of knowledge.

A key challenge with industry-funded R&D is that firms will invest less than is socially optimal because of knowledge spillovers. The private rate of return for the innovating firm is less than the economywide benefits because other firms expropriate value. However, tax credits can reduce the costs of R&D and induce more investment. Extensive empirical research over the past two decades demonstrates a strong relationship between R&D tax credits and R&D activities.

The spatial clustering of innovation activity, especially in technology industries, is largely determining the economic prowess of nations. Clusters are spatial concentrations of often competing, sometimes collaborating firms and their related supplier networks, including a variety of supporting institutions such as venture capital finance. Innovative clusters form and expand largely because new knowledge tends to be generated, conveyed, and collected more efficiently in close proximity. Most such clusters have large anchor firms that account for much of the research capacity of their respective industries and seed the cluster through technical and managerial talent transfer and opportunities for former employees to engage as entrepreneurs through startup activities.

FIGURE ES1 Regional innovation life cycle



Sources: New Economy Strategies and Milken Institute.

Some member firms might perceive the sharing of technology or knowledge as a negative externality at times, but sharing usually engenders a comparative advantage that sharpens the entire cluster's edge over competing geographies. California's Silicon Valley is an excellent example of knowledge sharing in a high-velocity labor market.

California's Innovation Economy

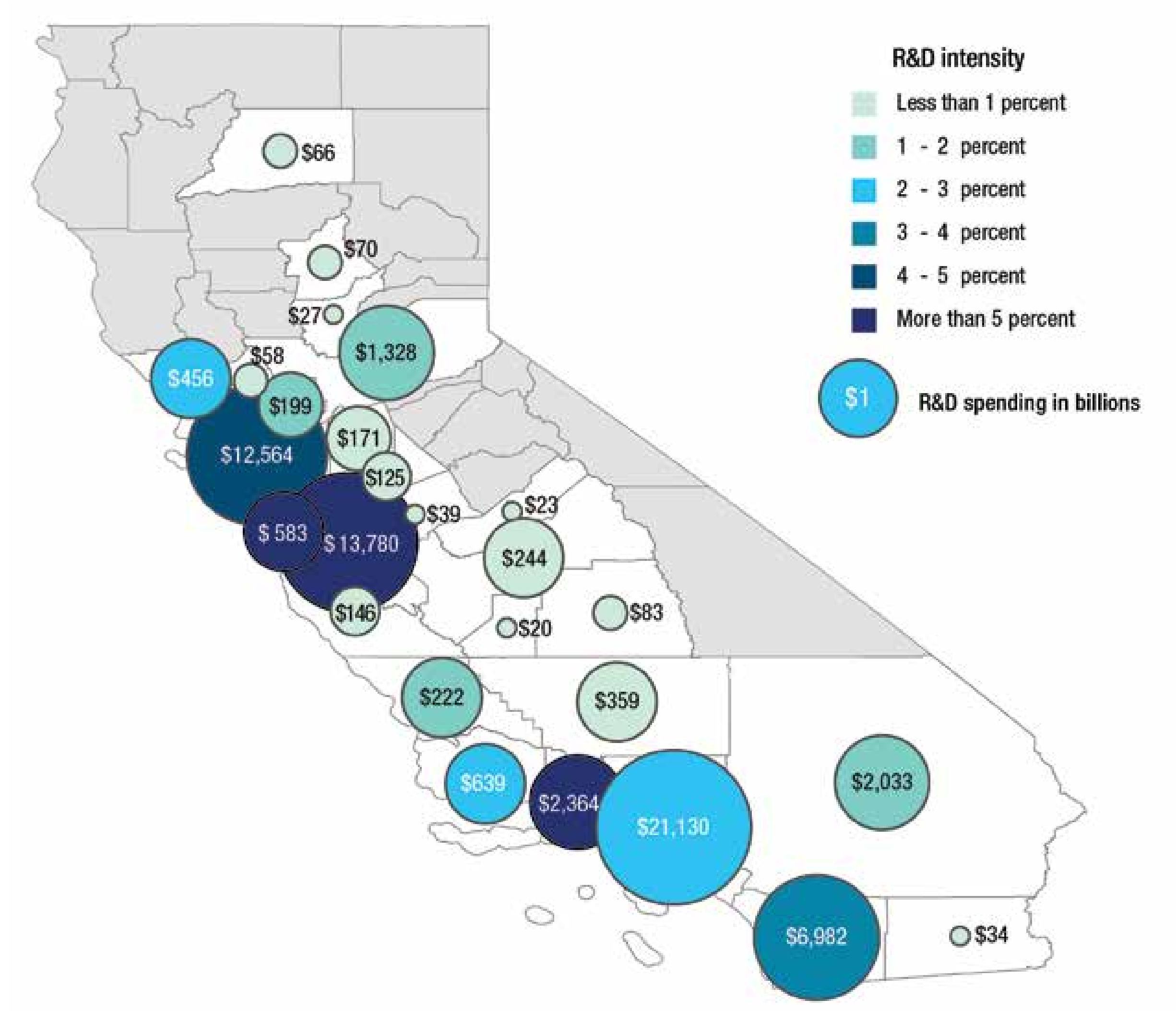
One of California's greatest assets is the diversity of its high-tech industries. A key measure of a state's or region's high-tech diversity is the number of industries in which it has a higher proportion of employment than the national average. California leads the nation in that measure, exceeding the U.S. average in 17 out of a possible 19 high-tech industries. The two states that tied for second place, Massachusetts and Utah, are above the average in 14 tech sectors.

California is also the leading state for industry R&D spending, with $76.9 billion in 2013. However, it's only logical that California would be first given that it has the largest economy and population. When you look at California's R&D adjusted for population, it ranks third. Federal funding of R&D is an area of strength for California. The state consistently places in the top 10 on a per capita basis. Most prominently, California leads the nation in patents issued per 100,000 people, at 104.8. This compares with the national average of 35.8.

The map below (Figure ES2) illustrates the geographic diversity of private-sector R&D in California. Compiling data from various public and private sources, we developed a unique set of measures for R&D activity level. (For more information, please see full report.) Using sources of R&D by industry sector in California, we calculate the R&D per employee and tie it to firm location by North American Industry Classification System (NAICS) code. We map firms engaged in R&D activity by industry to their spatial locations. This database enables the estimation of R&D for specific Assembly or congressional districts.

Santa Clara County has the highest level of private-sector R&D spending compared with other California counties, despite its small size. Santa Clara is a technology hub (the heart of Silicon Valley), and the high levels of R&D in the county emphasize its importance to businesses that want to remain competitive in their fast-moving industry. The San Francisco Bay Area has a plethora of tech talent, the Los Angeles area has both entertainment and technology, and San Diego has an emphasis in biotechnology. There are pockets of innovative activity in the Central Valley and in Riverside-San Bernardino as well. These growing industries, in the right environment, could help drive California's economic future with sustainable growth.

FIGURE ES2 R&D spending and intensity in California metropolitan statistical areas



Source: Milken Institute.

Providing private risk capital to California's stellar group of entrepreneurs is a crucial source of strength for the state's economy. At $28.1 billion in 2014, California had the largest amount of venture capital placement in the country. Another area of strength for California's innovation economy is the depth and breadth of its science, technology, engineering, and mathematics (STEM) talent. California has nine fields where its intensity ranks among the top seven states. California has regional innovation advantages as well. It has six metropolitan areas that rank among the top 20 technology centers in the U.S. and Canada.

Challenges

Yet California faces challenges in maintaining its innovation advantage, related to a few key research areas, human capital capacity, as well as ongoing cost and regulatory concerns. For example, California ranks 17th in per capita academic R&D. Other states are targeting academic funding as a means of boosting long-term economic performance. California's universities should be acquiring more funding from industry sources. Of particular concern, California is ranked 11th in R&D spending on the biomedical sciences at universities. Furthermore, while the Golden State still ranks high among U.S. states on per capita industry R&D, its research prowess is declining relative to several leading nations.

In the Milken Institute's 2014 State Technology and Science Index, California ranked 17th in the human capital composite, down from fourth in the inaugural reading in 2002—the largest decline of any state. This indicator attempts to measure stocks and flows of various science and engineering fields and broader degrees granted. California ranked 41st in recent degrees in science and engineering per 1,000 civilian workers in the 2014 index, a fall from 15th in 2002. California is not creating enough of its own STEM talent.

Because of California's poor position in comparisons of business climate, the state is ever more dependent on its innovation capacity. The ALEC-Laffer State Economic Competitiveness Index ranks California 37th on Economic Performance and 44th on Economic Outlook measures. California was last in four categories: top marginal personal income tax rate, personal income tax progressivity, average workers' compensation costs, and measures of labor laws. California ranks 40th on top marginal corporate income tax rate. On the Tax Foundation's State Business Tax Climate Index, it ranks 48th. On the Council on State Taxation's "The Best and Worst of State Tax Administration" scorecard, California receives a grade of D-, tying Louisiana for the lowest scoring.

Another frequently referenced comparison index is the State Competitiveness Report, published by the Beacon Hill Institute. Here California ranks 26th. On Forbes' "Best States for Business" list, California is 37th. Similarly, on CNBC's "America's Top States for Business," it ranks 27th. On Moody's Analytics State Cost of Doing Business Index, California is 40th.

Encouraging R&D Investment in California: Policy Alternatives

California's research credit, currently at 15 percent of qualifying supplemental research activity conducted within the state, in combination with the federal credit, forms a crucial part of the tax environment that businesses evaluate in choosing whether to site new research activity in California or another innovation hub. It serves as one of the most direct policy levers the Legislature can use to affect the level of R&D conducted in the state.

Policy Option One: Introduce Tradable Credits

California's research credits can be carried forward for use in future years if firms do not have sufficient tax liability in the year in which the credit was earned. This benefits firms with cyclical earnings that engage in R&D which may have losses in a particular year by allowing the credits to be stored for future use. However, many R&D intensive startup firms don't have earnings to use the credits against. It may be many years before they can hope to use these credits, diminishing the credits' worth and suppressing investment in current research activities.

Some states have established tradable credits. Under this system, firms that don't use their allotted credits may transfer them to another corporate taxpayer with enough tax liability. Such a policy change in California would need to be implemented in a way that encourages future R&D investments without rewarding past behavior. Making credits tradable in a retroactive manner could be characterized as a windfall for corporations without increasing research conducted in California in the future. That budgetary impact could be limited by making only newly generated credits tradable or permitting only businesses below a certain size to sell their credits.

Policy Option Two: Refund Credits for Small Businesses

Small businesses create a disproportionate share of net new jobs and can be sources of innovation and entrepreneurship. Some states have created programs that specifically encourage research activity at small firms. Since 2013 in Maryland, small businesses with assets of less than $5 million can receive a refund for any awarded research and development credits that exceed their income tax liabilities. This benefits startup companies conducting research with long development cycles by providing an incentive that lowers their costs before they are generating profits.

California could introduce a program that refunds a fixed percentage of unused research credits to qualifying small businesses. To limit the direct fiscal impact in California, total credits refunded through this program could be capped each fiscal year. To assess what the potential impact in California of a refundable credit targeted at small businesses would be, and to set an appropriate cap, it would be necessary to know what share of total unused research credits are earned by small businesses each year. In 2012, 25 percent of total assessed corporate income taxes were paid by companies with state net income taxable in California of less than $5 million, but this share doesn't necessarily align with the generation of research credits carried forward.

Policy Option Three: Increase the R&D Tax Credit for Qualifying Institutions Funding University Research

Under a California law implemented in 2000, firms funding basic research conducted in the state by qualifying institutions can receive a tax credit, equal to 24 percent of this spending above a base amount. In addition to universities, qualifying institutions include scientific research organizations and grant organizations. Basic research, which may take longer to bear fruit commercially than research conducted in-house by the private sector, is also vital to building California's knowledge base and innovative capacity.

Increasing the percent of incremental basic research spending that private companies can claim as a credit would further decrease the marginal cost of funding this work at universities and other qualifying institutions. One proposal introduced in recent years would raise the credit from 24 percent to 40 percent over five years. By increasing private-sector involvement in the process of choosing which research to fund, the state ensures that more projects viewed as having market value are pursued and that private funds are leveraged.

Policy Option Four: Double the R&D Tax Credit for Firms

The California Assembly has considered several bills in recent years to expand the state's research tax credit, with the aim of cementing the state as a prime location for investment in research and development. A more generous research tax credit would send a very visible signal that California values this type of activity and its contributions to the state's economy.

Silicon Valley is the benchmark for regions around the world trying to develop a technology cluster. Yet California's regulatory and business climate often makes the cost of operating in the state higher than elsewhere, acting as a disincentive for new investment. While research tax credits are only one of many factors a company considers when comparing potential locations, the combination of the federal and state credits for incremental research spending can represent a meaningful reduction in capital costs for a company.

Modeling the Impact

We chose to perform a detailed evaluation of the doubling of the research tax credit over five years, from 15 percent to 30 percent, to give a sense of the economic effects that might result from a major change of this type. Since the revenue impact had been estimated by the California Franchise Tax Board (FTB) for Assembly Bill 653 in the 2013-14 legislative session, we could build on its assessment of the static impact of the change on state corporate income tax revenue in our analysis. Using a dynamic economic model and based on previous work, we looked at the potential impact of the lower cost of doing research at private companies and the additional research activity that would result from the higher credit.

To model the impact of a change in the California research credit to 30 percent from 15 percent over five years, we combined a structural model adapted from the Milken Institute's "Jobs for America" report and the dynamic Regional Economic Models Inc. (REMI) model for California. Using historical trends in both private-sector research spending from the National Science Foundation and in utilization of the California research credit over time, we made adjustments from a baseline level of research spending in the state under different conditions, drawing on projections from the FTB. We provided lower and upper bounds for the likely impact of this policy change, because it is difficult to quantify with a high degree of precision.

Doubling the state research tax credit is a significant change in policy that would make doing research in the state more attractive for existing, new, and expanding large and small businesses. The modeling estimates that 10 years after the policy is implemented (Year 10), $700 million in additional research credits would stimulate approximately $4.5 billion to $6.8 billion in additional research and development activity in California, a multiplier of between 6.4 and 9.7. Our model predicts $7.7 billion to $10.5 billion in additional gross domestic product in California in Year 10 compared with no change in the credit. This translates into $3.2 billion to $3.8 billion in economic ripple effects from the additional research spending.

FIGURE ES3 Incremental economic impacts by Year 10

Increasing California R&D research credit to 30 percent from 15 percent over five years

	Low estimate	High estimate
Research spending (millions of fixed 2009 dollars)	4,513	6,769
GDP (millions of fixed 2009 dollars)	7,720	10,539
Employment (jobs)	60,215	83,979
Personal income (millions of fixed 2009 dollars)	7,330	10,212

Source: Milken Institute.

Research involves high-skill occupations offering high wages for employees with a range of qualifications. An increase in research activity would help create new employment opportunities. In our model assessment, we estimate that by Year 10 approximately 60,000 to 84,000 more jobs in California over a baseline where no change is made to the research credit. This is equivalent to a "cost" in forgone corporate tax revenue of $8,300 to $11,600 per new job created. Personal income earned by California residents would increase by $7.3 billion to $10.2 billion by Year 10. While this works out to approximately $121,000 per added job in Year 10, the new income would not necessarily accrue only to new employees and could represent increases in wages for existing employees.

The industry distribution of impacts is concentrated in those sectors that invest heavily in research and development. Professional, scientific, and technical services receive the largest boost, rising between $2.8 billion and $3.9 billion in Year 10. This is where biotechnology and much of the pre-market pharmaceutical research is captured. Computer and electronic product manufacturing records gains in output by capturing more R&D spending. Another industry benefiting from the expanded R&D credit is telecommunications. Through the indirect and induced impacts of greater R&D, sectors such as real estate, construction, retail trade, and wholesale trade are among the largest beneficiaries.

Conclusion

While officials can't alter California's high cost of doing business and onerous regulatory regime in the immediate future, other actions are possible. California has a history of incorrectly assuming—during periods of technology-based expansion similar to what the state is experiencing today—that its innovation-economy architecture is solid. For example, during the second half of the 1990s, as the dot-com boom was underway and tax receipts from capital gains and stock options were surging, California policymakers didn't fully comprehend the boom's ephemeral underpinnings. Again, just before the Great Recession, when tax receipts boomed again, the technology sector seemed poised to continue its advance.

California should take bold steps to maintain and enhance its capacity for innovation and the conversion of it into commercial applications, thereby allowing firms to create high-quality jobs in the state and benefiting from the large multiplier effect associated with them. While it's true that California has long been a high-tax, high-cost place to do business, the imperative for innovation in the state can't be overstated.

The Legislature must consider additional policies that will provide fertile ground for existing and prospective businesses and universities to conduct research. We believe that the policy prescriptions outlined in this report are an excellent place to start. Some might consider policies such as doubling the R&D tax credit as an unfair tax giveaway. If so, we submit that such an inducement is well worth the cost. The additional research and high-paying jobs that firms and entrepreneurs create would boost economic performance in the Golden State.

1. Introduction

California has a unique position among the world's innovation-driven economies. The Golden State has the key ingredients and a recipe for success. It has the technology industry base, talent, universities, entrepreneurs, and risk capital necessary to fuel economic growth. Innovation outcome success is closely tied to research and development activities and the ability to bring them to the marketplace through existing firms or newly formed enterprises.

Perhaps the greatest comparative advantage for California is its compendium of regional innovation ecosystems. These distinct clusters have the unique absorptive capacity to use their research activity as the basis for new companies that create thousands of high-wage jobs with remarkable efficiency. This is illustrated by the dominant position Silicon Valley holds as the world's leading innovation and commercialization hub. The spatial assets of California, however, extend well beyond Silicon Valley throughout the rest of the San Francisco Bay Area to Los Angeles, Orange and San Diego counties, along with other important areas.

Currently California's economy is advancing at a faster rate than the rest of the country. Much of this stems from its dominant position in the social networking and applications industries; the recovery in the global information and communications technology sector, where the state maintains a unique concentration of clusters; and the depth of California's economic collapse during the recent financial crisis and the inevitable resurgence.

As of this writing, California's economy is the seventh-largest in the world. However, from a longer-term perspective, although the state retains many competitive advantages, some indicators suggest its innovative capacity is declining, or will unless preventive steps are taken. For example, California ranked 17th in the human capital component of the Milken Institute's 2014 State Technology and Science Index and ranked slightly above average in its success at receiving National Science Foundation research funding.[1]

In this study, we describe the critical role innovation plays in economic growth around the world. The processes of information exchange along the innovation spectrum are delineated. We trace the evolutionary nature of innovation in California and demonstrate the extent to which research and development drives the economic performance of the state. We highlight several metrics that are crucial to understanding California's future position in the innovation-driven economy. Innovation should be seen as a factor of production that determines the productivity and economic wealth and health of California, especially since the state can no longer compete on a low-cost, low-wage formula.

Further, to better understand the impacts at the regional level, we map the locations of firms that heavily invest in R&D around the state. Utilizing data acquired from various public and private sources, we create a unique set of measures of R&D activity on a regional level. Using sources of R&D by industry sector in California, we calculate the R&D per employee and tie it to firm location by North American Industry Classification System (NAICS) code. We map firms engaged in R&D activity by industry to spatial location.

We explore four policy alternatives to encourage more R&D investment in the state, such as making the research tax credit tradable and refunding credits for small businesses. Using a detailed econometric input-output model, we highlight the likely economic impact of one such policy change: doubling California's existing R&D tax credit to 30 percent from 15 percent by annual 3 percent increments over five years. This would encourage companies to increase investment funding in the state, including many headquartered abroad, thereby promoting more R&D activity and, subsequently, spurring innovation that can help promote business formation and create jobs.

Additionally, doubling the state R&D tax credit would likely incentivize companies that wouldn't otherwise conduct their R&D activities in the state to reconsider, while capitalizing on the state's rich innovation assets and high-skilled labor capacity. This analysis provides estimates of the incremental R&D investment, the jobs and wages associated with it, capital expenditures on plant and equipment, export activity, and overall gains in real gross domestic product (GDP), while recognizing the costs to the state budget.

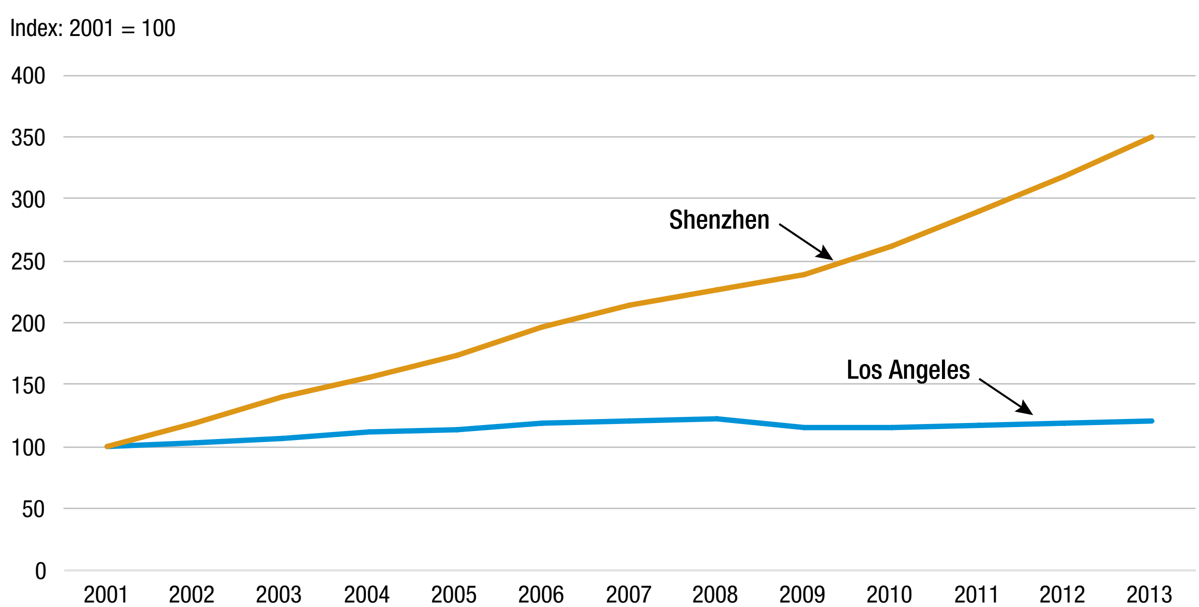
2. Role of Innovation in Economic Growth

Innovation is crucial to the economic well-being of nations, regions, firms, and individuals in the 21st century.[2] Innovative outcomes—job creation and high-paying jobs—are highly dependent on research and development activities and an efficient system for bringing them to market.

California has been a leader among U.S. states in developing policies to encourage research and spur innovations. While it competes for innovative activities with other states, it also must evaluate its position versus other countries and their climates for innovation. Advanced and emerging nations see innovation as critical to their international competitiveness. Whether it is the UK, Japan, or China, these nations are formulating and reevaluating policies to improve their prospects in the competition for innovation. National policies have been necessary, but local innovation-based actions also have been instrumental in determining success.

California's regions must look to innovative districts such as Shenzhen, China, to understand their relative position. As Shenzhen's economy grew exponentially over the past several decades, officials recognized that their model based on low-cost labor wasn't sustainable. They began devising a set of policy prescriptions to move up the value chain. Higher-value-added—and innovation-based—industries such as telecommunications, finance, and biopharmaceuticals were targeted and have been fueling recent growth. An example of Shenzhen's indigenous innovation success is Huawei, the world's largest telecommunications networking, equipment, and services provider. Nearly half of Huawei's employees engage in research and development at multiple R&D centers.[3]

FIGURE 1 Real GDP growth: Los Angeles vs. Shenzhen: 2001-2013



Sources: Bureau of Economic Analysis, 2014 Shenzhen Statistical Yearbook, World Bank.

In the U.S., Pennsylvania has implemented forward-thinking, innovation-economy public policy to boost its competitive position. The state made its R&D tax credit tradable for firms below a revenue threshold. Its Act 46 of 2003 allowed R&D tax credit recipients to apply to the Department of Community and Economic Development (DCED) to sell or assign their R&D tax credits to other firms. This is important because many early-stage innovative firms cannot use the credits because they aren't yet generating income. Further, the state subsequently increased the rate for small businesses. The Pennsylvania R&D tax credit originally generated a tentative credit at the rate of 10 percent. However, Act 116 of 2006 increased the rate at which the tentative R&D tax credit is calculated, to 20 percent for small businesses only, beginning with the credit awarded in December 2006.[4] This further incentivizes early-stage research at small firms.

2.1 Evolution of Innovation Growth Theory

Economists have altered their thinking away from the view that land, labor, and capital determine the long-term economic growth potential of a nation. Joseph Schumpeter was among the first to do so. His evolved model of a modern economy grew out of industrial organization theory, which portrayed innovation as an important component of industrial competition. The Schumpeterian model describes a "perennial gale of creative destruction,"[5] because the innovations determining growth are creating new technologies and processes but consequently render the results of previous innovations obsolete and, thereby, destroy them. The Schumpeterian model attributes a crucial role to the exit and entry of firms and the workers they employ. Further, it is consistent with recent empirical findings that labor and product mobility are critical components for growth-aiding properties at the technological frontier.[6]

An aggregate or economywide production function has been used for many decades to evaluate the productivity of various factor inputs such as capital, labor, and R&D expenditures (a measure of innovation). Many researchers contributed to the literature in this area, but Robert Solow was the primary catalyst in the advancement of growth theory, winning a Nobel Prize for his efforts. His pioneering research in the development of the neoclassical growth model laid the foundation for modern growth theory.[7] His theoretical framework, which decomposed contributions to output from capital and labor on the basis of a constant-returns-to-scale production function, helped establish a temporary consensus in the 1970s on growth theory.

Solow's findings suggested that only a small portion of economic growth could be attributed to labor and that capital formation was responsible for approximately one-third of growth. This left a large residual (unexplained portion) that is assigned to technological progress. In Solow's model, technological progress was determined exogenously (outside the system), and dubbed the "Solow residual." This was essentially a measure of the importance of innovation in the growth process.

Building on the shoulders of predecessors, subsequent generations of economists have advanced the idea of the critical nature of innovation in propelling economic growth.[8] Conflicting with classical economic theories that espoused the importance of labor and capital in production, many developing countries with ample supplies of workers and improving access to capital failed to achieve the growth rates predicted by these models. In reaction, a diverse set of theoretical and empirical work began to emerge in the late 1980s as endogenous, or new, growth theory. This body of work differentiates itself from the neoclassical model by emphasizing that economic growth is an endogenous outcome of a dynamic economic system, not the work of some supernatural force emanating from outside.

New Growth Theory was formulated to illuminate the processes behind long-term growth in light of these changing dynamics, addressing what Castells argued was the inadequacy of traditional economic thinking to explain some of the patterns observed by the postindustrial economy.[9] Under New Growth Theory, greater investments in innovation represent a vital endogenous factor in economic activity.[10] Innovation is a central component of modern thinking on long-term growth in advanced economies. Today, this channel has become more prominent and is a major area of empirical examination of sustainable economic growth models. Nations and regions must foster innovation-dependent production to create broad-based, sustainable economic prosperity.

2.2 Research and Development Underpinnings

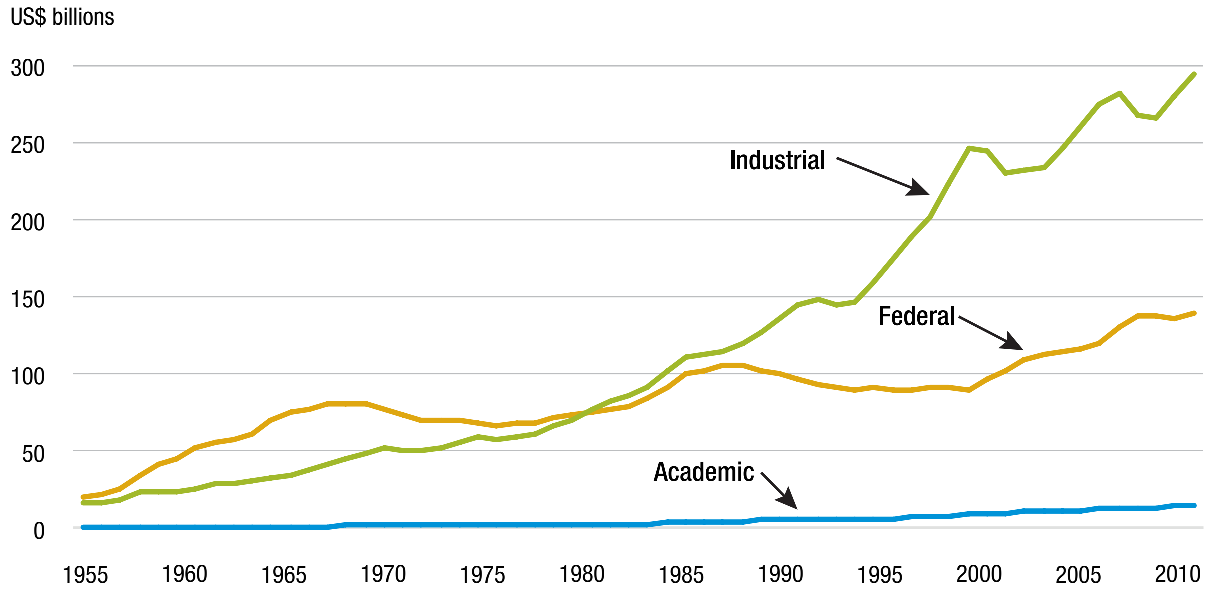
Sustainable growth depends on creating a constructive policy environment that can spur continuous innovation, along with other factors.[11] Bell articulated that innovation was largely composed of cumulative R&D investments, or the capital stock of knowledge.[12] The Organization for Economic Cooperation and Development (OECD) explains these pursuits as those that create knowledge or develop new applications of knowledge.[13] At a national and local level, investments in R&D are seeds that sprout into innovations that are converted into economic growth opportunities.[14]

Regardless of one's definition of innovation, its role in driving sustainable economic growth based on rising productivity is essential to understanding how a modern economy operates. As OECD Secretary-General Angel Gurría said at the announcement of the OECD's Innovation Strategy report, "Countries need to harness innovation and entrepreneurship to boost growth and employment, for innovation is the key to a sustainable rise in living standards."[15]

Given the essential role of innovation, then, one of the fundamental underpinnings for higher economic growth is the level of investment in and effectiveness of ongoing R&D activity. Sustaining this activity at an elevated rate requires a robust innovation infrastructure incorporating an effective national and regional policy framework that continuously nurtures R&D. With the infrastructure and policy framework in place, companies and entrepreneurs can implement long-term projects with greater confidence and reduced risk. The time-consuming process of research and development is necessary to spur true innovation, even though it inevitably involves risk for industries, firms, and entrepreneurs.

Atkinson and colleagues make a compelling case for the role of R&D in the growth process, arguing that "R&D is the fundamental driver of innovation, and in developed, knowledge-based economies, innovation powers long-run economic growth."[16] The three primary sources of funding for R&D are the federal government, universities, and private industry. Federal funding of R&D is primarily directed at basic scientific research that doesn't have an immediate commercial application. However, this basic research has been an important contributor to the applied research and development efforts of the private sector. The federal government's share of total R&D has declined in the aftermath of the Cold War. Additionally, the share of federal funding directed to the physical sciences and engineering has fallen.

FIGURE 2 Sources of R&D funding: Federal, industrial, and academic



Sources: National Science Foundation, American Association for the Advancement of Science.

Increasingly, universities are performing applied research for corporate sponsors, but they still conduct basic research funded by federal grants. Industry invests the most in research and development—more, in fact, than all other sectors combined. Collaboration among corporate labs, university researchers, and their supplier networks (many of them small firms) is evolving to form a new distributed network platform system for innovation.[17]

A key challenge with industry-funded R&D is that firms will invest less than a socially optimal amount because of knowledge spillovers. The private rate of return for the innovating firm is less than the economywide benefits, as other firms expropriate value.[18] There is overwhelming empirical evidence demonstrating that the broader rate of return to society is at least double the estimated returns to the innovating firm.[19] Countries' and regions' economic fortunes are harmed by suboptimal private-sector investment in R&D.

The risk of spillover and the potential for lower returns for the companies that actually perform the research point to the need for incentives that offset these obstacles. Research and development processes are major investments, and firms need to project long-term returns to justify them. Multiple risks are present in R&D and involve either high rates of failure or an extended period until an adequate return on investment is achieved. Empirical work demonstrates that lucrative reward systems and well-articulated regulatory structures can elevate the level of R&D spending.

Tax credits encourage more investment by reducing the costs of conducting R&D. Firms are more confident about accepting these risks when R&D incentives and direct higher funding into innovation are available.[20] Aggregating these incremental investments across the macro economy, we find that the creation of desirable R&D credits can generate broad and sustainable long-term economic growth.

This position has been corroborated by extensive empirical research over the last two decades.[21] It is not only common to see countries introducing tax incentives to encourage ongoing investments in R&D, in part to minimize market failures, but substantial evidence also indicates a strong relationship between R&D tax credits and R&D activities.[22] Incorporating elements in Romer's endogenous growth model, Russo estimated and compared the impact of several types of investment tax credits. He demonstrated that investment tax credits for R&D engendered the largest response in R&D spending relative to other types of incentives. Based on this extensive work, it emphasizes the role R&D tax credits can play in initiating and maintaining sustainable growth.

Harvard University competiveness guru Michael Porter makes an emphatic case for why R&D activities and innovation are critical: "In the long run, the eroding base for innovation is the real challenge and the abiding constraint on our standard of living."[23]

2.3 Regional Clusters of Innovation

Coincident with the newfound interest in better understanding innovation's role in an economy, which led to New Growth Theory, the late 1980s also witnessed resurgence in interest in theoretical and empirical research on the spatial dimensions of economic activity. These two fields were linked as economists and economic geographers recognized that innovative activities were becoming more clustered. Further, some proposed that national prowess in innovation was increasingly being determined by subnational, localized nodes of expertise. Here as well, Porter played an important bridge role. He hypothesized that the degree of spatial clustering of industries and, by extension, innovative capacities within a nation largely explained its international competiveness.[24]

Macroeconomic theory and application suggest that economic activities take place on a homogeneous, continuous geographic plane that is evenly distributed.[25] Actual experience is quite different: Economic activity in the U.S., China, and around the world is becoming more clustered in metropolitan areas.[26] Economic geography, or the spatial dimension of production, has been reborn.

Many prominent economists played a role in this renewal of interest in spatial economics. However, Nobel laureate Paul Krugman devoted over a decade of research to "new economic geography" and deserves credit for the popularization of it as a field of scientific inquiry. Krugman sought to explain the clustering phenomenon on the basis of increasing returns and positive externalities.[27] His analysis was based on the observation that clustering was the outcome of the process of economic agents seeking proximity with others engaged in a similar or related activity. Higher marginal returns are created for economic players when they are closely entwined and networked. He summarized that these clustering economies resulted from localized, external effects attributable to three main sources: labor-force pooling, supplier networks, and knowledge spillovers from innovative activities.

2.4 Empirical Evidence

A rich body of empirical literature has arisen investigating the degree to which innovative activities are clustered together geographically and the explanatory power that can be attributed to the major factors that make firms in these clusters are more innovative than firms engaged in similar activities in another area. There are many issues that aren't completely resolved in the relationship between clusters and innovative activities, but overall the evidence is compelling.

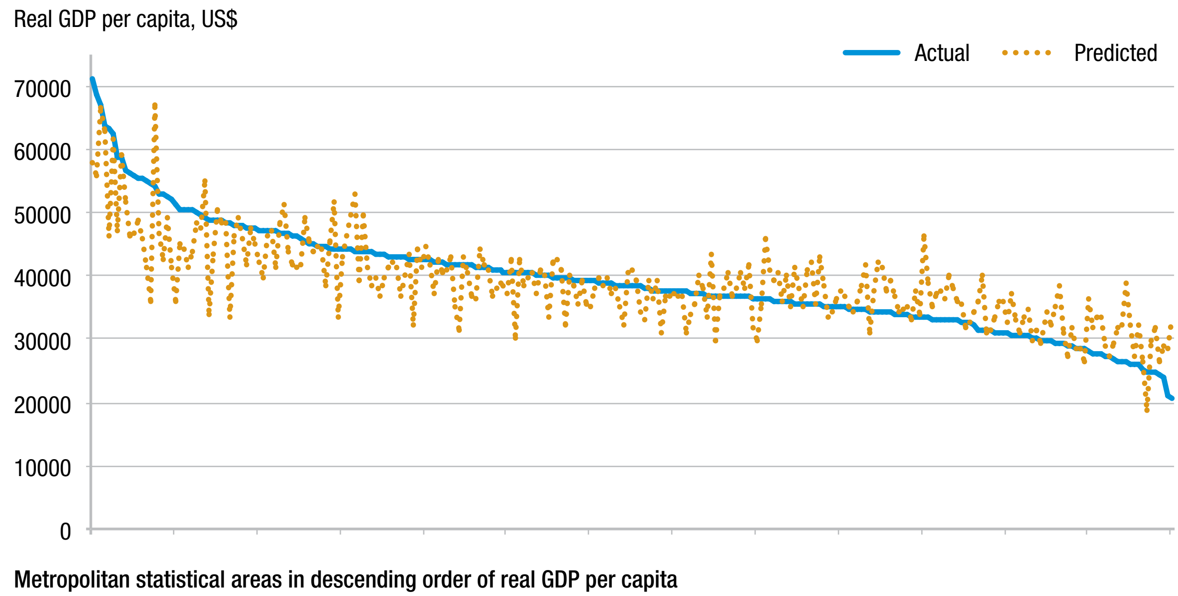
While it is beyond the scope of this paper to provide a thorough review of the empirical literature on clusters and the causal factors for their formation and growth, it is useful to provide a brief synopsis on key findings as they relate to innovative activities. This is crucial for appreciating how California can maintain its competitive advantage in generating and capturing the economic value of innovation.

A key area of inquiry has been how and to what extent firms and other players in innovation-based clusters benefit from these knowledge spillovers. Typically, an econometric knowledge-production function is estimated using regional (subnational) data utilizing measures of innovation outcome (patents) and innovation input (R&D expenditures). A strong statistical relationship has been found between these variables, leading to the conclusion that knowledge externalities exist as local firms overwhelmingly benefit from research activities generated in the local geography.

Jaffe's seminal paper on this subject was published in 1989[28] and spurred a plethora of research and attendant findings. His original paper focused on university-based research, but he subsequently extended it to industrial R&D. Substantial empirical evidence from Europe and the U.S. demonstrates that the production of innovative products and services has a high propensity to cluster in locations where the innovation inputs (R&D) are heavily concentrated.[29] Further, these newly created innovations spill over in the cluster where they emerged, and involve a substantial lag before diffusing to other locations.[30]

Additionally, the degree of spatial concentration varies by industry based on the stage of its industry life cycle and the importance of tacit, non-codified knowledge.[31] Moreover, in some industries, such as semiconductors, the density of clustering appears to be contingent upon the degree to which several large anchor firms have developed the majority of the innovations. In a more recent study, DeVol and colleagues utilized an alternative production function approach estimated for U.S. metropolitan areas linking overall economic output (real GDP) per capita to patents per capita, controlling for other factors such as human capital. They found innovation activity (patents) to be highly important in determining the variance of per capita output.[32] This provides additional support for there being not just a link between innovative inputs and outputs, but locally derived innovation being captured in the region where it was created and being translated into greater economic value for its inhabitants.

FIGURE 3 Real GDP per capita of U.S. metros, 2010 (actual vs. predicted)



Source: Milken Institute (2013), "A Matter of Degrees: The Effect of Educational Attainment on Regional Economic Prosperity."

Another focus of inquiry in the empirical literature has been the degree to which firms located in dense clusters are more innovative than the average firm in their industry. This econometric research explains firms' innovation rates dependent upon the strength of the cluster they are embedded in. Investigators use company data on innovations (usually patents), employment, and other financial measures and link them with regionwide measures on the different dimensions of industrial cluster strength and overall cluster attributes. Essentially, this body of work measures the role of scale effects that arise with firms that are immersed in a highly agglomerated landscape. The empirical results from these investigations provide robust support that firms embedded in clusters that are strong in their primary industry also develop a disproportionate share of innovations and witness growth exceeding that of firms located in smaller agglomerations.[33]

2.5 How Innovation-Based Clusters Operate

Innovation-based clusters are spatial concentrations of often competing, sometimes collaborating firms and their related supplier network, including a variety of supporting institutions. Innovative clusters form and expand largely because new knowledge tends to be generated, conveyed, and collected more efficiently in close proximity. Most have large, significant anchor firms that account for much of the research capacity of their respective industries and seed the cluster through technical and managerial talent transfer and opportunities for former employees to engage as entrepreneurs through startup activities.

This supplier network includes research universities and government labs that commercialize research in the form of spinout firms and through licensing to established firms within the cluster.[34] Universities not only create new knowledge, but disseminate it in the form of their graduates. Cluster members include governmental and nongovernmental agencies such as trade associations, think tanks, and vocational training programs. Cluster members also include early-stage finance such as venture capital or crowd-funding, which fuel startup activity. Venture capitalists provide not mere money, but smart money. In other words, they have expertise in management, product development, and marketing, and also provide partnering opportunities.

The local research and development environment and culture are essential to assembling new industry clusters from transformative technologies or sustaining the vitality of existing industry clusters. It is possible to seed a new cluster by attracting firms that have achieved commercialization success in another geography, but those regions with indigenous R&D have clear advantages in developing clusters that hang together over the long haul.[35] Local innovation scope is contingent upon the extent of a region's innovation competencies, along with the unique cluster attributes that augment innovation and the extent of the dynamic interactions among them.[36] Positive feedback loops are generated by greater investments in R&D as they improve research capacities and entice additional funding by both the private and public sectors.

The formation of new firms is vital because they diversify the regional ecosystem and replace large firms that don't survive. While dominant (anchor) firms provide the core research and development infrastructure of a cluster, they can miss an emerging technology that might cannibalize existing lines of business. However, startup firms can access the technology management capabilities that are resident in a cluster's established firms and exploit emerging technology breakthroughs much more efficiently than startups in a region without these anchor firms. Because extensive specialized support services (accounting, advertising, legal, etc.) developed around these anchor firms, the costs are lower for startups in these dense clusters.[37]

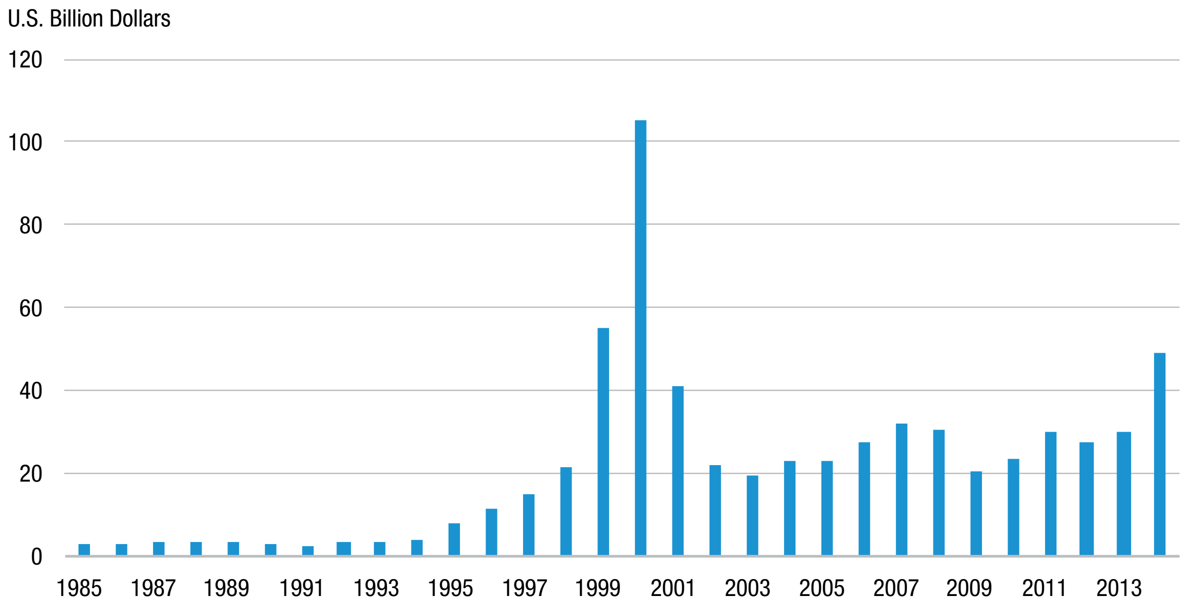
Entrepreneurial capabilities are essential to maintaining an ecosystem of innovation in a cluster. In an era of rapid technological change, entrepreneurs play a vital role because the new enterprises they form aren't encumbered by past institutional or personal biases. They are better positioned to envision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

To stick together over the long term, an innovation-based cluster needs capable entrepreneurs and the early-stage risk capital to support the conversion of research into commercially viable technology products and services developed at new firms. A conceptual framework for regional economic growth and cluster sustainability must be erected that explicitly recognizes the role of entrepreneurship.

The boost in capital availability to innovative entrepreneurs has aided new-firm formation and economic growth in many clusters. This improved access to risk capital is extremely vital to technology startups because the service or product is largely unproven and market potential is difficult to estimate with any precision. Many firms established from research backgrounds require substantial sums of external financing to fully develop their ideas into successful businesses. This is where private equity fills the void, whether through loosely organized individual investors, such as angel investors, or crowd-based funding or venture capital firms that pool investments from multiple sources.

Venture capital investment, based on observations of players in the field, follows the highest-quality deals. If capital invested in a cluster's firms fails to produce the expected returns, the money will likely move elsewhere. Consequently, venture capital investments tend to be highly associated with the level of innovation (patents per capita) resident in a cluster and the concentration of high-tech industries.[38]

FIGURE 4 National venture capital placements (1985-2014)



Source: 2015 NVCA Yearbook.

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 access to early-stage risk capital. Then, the intensity of entrepreneurial activity is a function of the extent to which individuals recognize the entrepreneurial opportunities and possess the aptitude, inspiration, and talent to exploit them.[39] The interaction between recognition of entrepreneurial opportunities and the capacity to pursue them will increase the level of startup activity, new-firm formation, and job creation, especially in high-tech industries. A critical advantage for the most dynamic, innovation-driven, high-tech clusters has been the emergence of the so-called serial entrepreneurs. These are individuals who cash out of the more established firms they helped launch to develop the next new idea into a startup. They recirculate money and entrepreneurial expertise back into the cluster, giving it an edge over others.

Scientific and technical talent is essential for discovering and converting innovations into viable products and services. The leading clusters are those with innovation systems operating in a collaborative environment with research, design, and production interacting in a dynamic learning process.[40] The technical and scientific workforce of a cluster creates its technological sophistication, innovation, and economic growth—not only for technology firms, but for all firms where innovation is an essential component.

Clusters with a dense concentration of science, technology, engineering, and mathematics (STEM) workers have an additional advantage: pooling workers and creating a labor force with essential industry-specific skills.[41] Companies embedding themselves within technology clusters benefit in terms of positive knowledge spillovers as well as agglomeration effects. Additionally, labor productivity tends to be higher in these locations densely populated with human capital. One important study concluded that doubling employment concentration boosted productivity by nearly 6 percent.[42]

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

In a cluster-based, high-velocity labor market, STEM workers benefit from the opportunity to shift 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' search costs. The ease with which locations can assemble, circulate, and reassemble teams of highly skilled workers helps to foster new company formation and sustains mature technology firms.[43]

A local high-velocity labor market can spur technology spillovers. Research advances within a cluster can be transmitted through informal relationships maintained by ex-colleagues in a labor market network. This tacit knowledge interchange among scientists and technicians provides host clusters with key advantages by amplifying communications on the latest non-codified knowledge in their fields.

Some member firms might perceive the sharing of technology or knowledge as a negative externality at times, but usually it engenders a comparative advantage that sharpens the entire cluster's edge over competing geographies. California's Silicon Valley is an excellent example of knowledge sharing in a high-velocity labor market.

3. California's Innovation Economy

3.1 History

California's rise to the leading edge of technological innovation has been powered by an extraordinary combination of scientific excellence, research and development assets, human capital, an entrepreneurial culture, and financial resources. Some trace the origins of an entrepreneurial culture to the Gold Rush days, when risk takers from across the country and around the world descended on Northern California.[44] The hydraulic mining technology developed during the Gold Rush has been cited by some as the first indigenous technology innovation.[45]

Defense, aerospace, computing, and early-stage electronics were among the sectors that sparked California's growing influence in technology. Many of these industries evolved from scientific discoveries funded by the U.S. government at federal labs and at California's private and public universities. For example, by investing in defense-related federal research facilities in Silicon Valley, where advanced semiconductors were designed and produced, the government helped manufacturers expand key knowledge and gain critical mass.

In more recent decades, this expansion has been fueled by a vast reallocation of resources from traditional manufacturing and agriculture to science- and technology-oriented industries such as biotechnology, medical instruments, semiconductors, and computer science. Daniel Coit Gilman, one of the early presidents of the University of California, seemed to appreciate the role of science in propelling California's economy. "Science is the mother of California," he said in remarks about finding ways to offset the state's "peculiar geographic position."[46] He might have added into the mix its entrepreneurial climate and the willingness to accept risk to develop a commercial application. In any event, Gilman understood California's unique advantage: the ability to commercialize scientific discoveries.

One of California's greatest assets is the diversity of it high-tech industries. This reduces the odds of the state suffering a major long-term economic retrenchment if one or two leading technology industries contracts. Additionally, technology diversity can act as a virtual unplanned innovation engine. Serendipitous confluences from seemingly unrelated technology fields can create a critical advantage for the host region. One researcher, 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."[47] Additionally, technology advances are likely to emerge from cross-disciplinary capabilities. Jane Jacobs' observations on dynamic externalities for all types of industries in a particular location appear to have been prescient for technology firms, and especially applicable in California.[48] She maintained that these dynamic externalities form as a result of 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. This process appears to have played a role in keeping California at the forefront of transformative changes in technology.

3.2 California's Current Position

3.2.1 Strengths

California's most impressive attribute is the diversity of its technology sector. A key measure of high-tech diversity is the number of industries in which it has a higher proportion of employment than the national average. The table below measures the number of high-tech industries with a location quotient (LQ) higher than 1.0 (which relates to how many high-tech industries in a state have employment location quotients exceeding the national average). For example, the LQ of 3.6 in Semiconductor and other electronic component manufacturing indicates that this industry is more than three times as important to California as it is to the nation overall. California ranks first in this measure of technology diversity, recording a concentration above the national average in an impressive 17 of the 19 high-tech industries. Massachusetts and Utah tied for second in this measure with above-average concentrations in 14 high-tech sectors. Additionally, California performs well (2nd) in such indicators as percent of payroll in high-tech NAICS codes, at 18 percent, just behind Washington. It ranks seventh or higher in percent of employment in high-tech NAICS codes, percent of establishment births in high-tech, number of Inc. 500 companies, and number of Technology Fast 500 companies.[49]

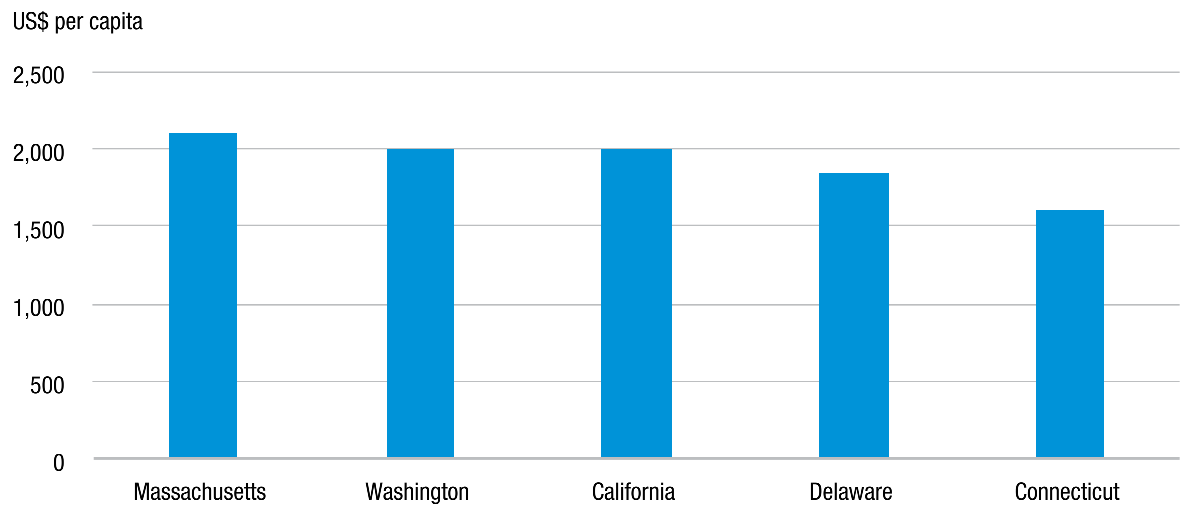
TABLE 1 2014 California location quotients (LQs) for high-tech industries

NAICS code	NAICS title	2014 location quotient (LQ)
3254	Pharmaceutical and medicine manufacturing	1.51
3333	Commercial and service industry machinery manufacturing	1.23
3341	Computer and peripheral equipment manufacturing	3.58
3342	Communications equipment manufacturing	2.22
3343	Audio and video equipment manufacturing	2.67
3344	Semiconductor and other electronic component manufacturing	2.10
3345	Navigational/measuring /medical/control instruments manufacturing	1.72
3346	Manufacturing and reproducing magnetic and optical media	2.82
3364	Aerospace products and parts manufacturing	1.30
3391	Medical equipment and supplies manufacturing	1.58
5112	Software publishers	1.58
5121	Motion picture and video industries	3.43
517	Telecommunications	0.92
518	Internet service providers, web search portals, and data-processing services	0.81
5191	Other information services	2.87
5413	Architectural, engineering, and related services	1.11
5415	Computer systems design and related services	1.32
5417	Scientific R&D services	1.81
6215	Medical and diagnostic laboratories	1.17

Source: Milken Institute.

Two of the pillars of California's innovation economy are research and development investment of firms and universities in the state. California is the leading state for industry R&D, with $76.9 billion spent in 2013. However, because California has the nation's largest economy and population, it makes sense that it would be first. When you look at California's R&D adjusted for population, it ranks third, behind first-place Massachusetts and Washington (Figure 5). Given that these states have much smaller economies, California's position should be viewed as very strong. California has several leading research universities, but academic R&D spending per capita in 2012 is barely above the national average and ranks the state 17th. California's strong absorptive capacity makes it very efficient at commercializing university research, but academic funding isn't as high as might be perceived. Federal funding of R&D is an area of strength for California. The state consistently places in the top 10 on a per capita basis.

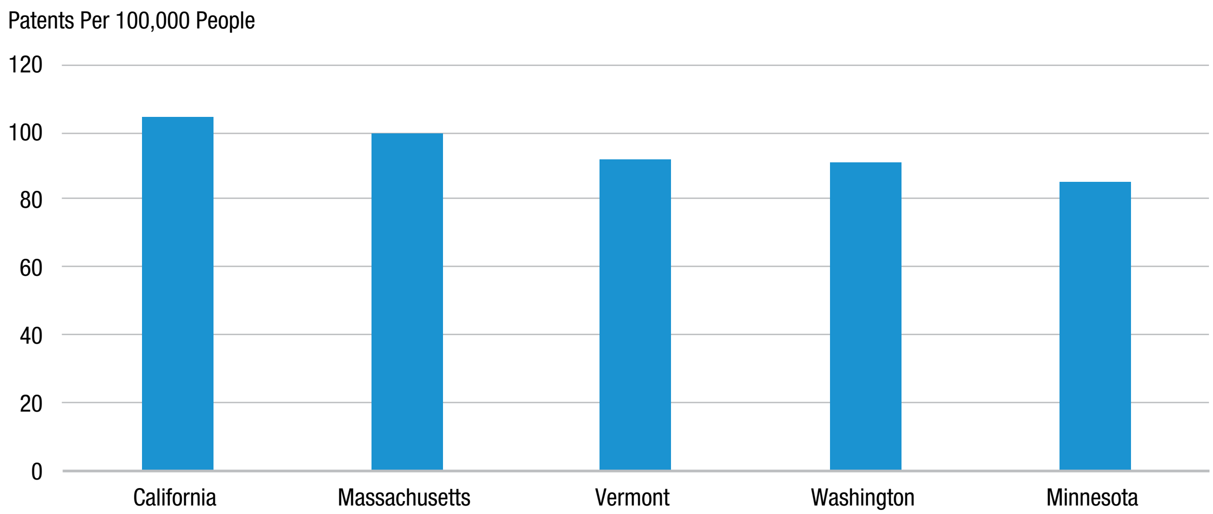
FIGURE 5 Industry R&D per capita for top five U.S. states (2013)



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

In other measures of innovation capacity, California performs solidly. For example, in 2014 it led the nation in patents issued per 100,000 people, at 104.8 (Figure 6). This compares with the national average of 35.8. This is an important metric because it reflects the quality of research performed by providing a strong indication of value of the intellectual property in terms of perceived commercial applicability.

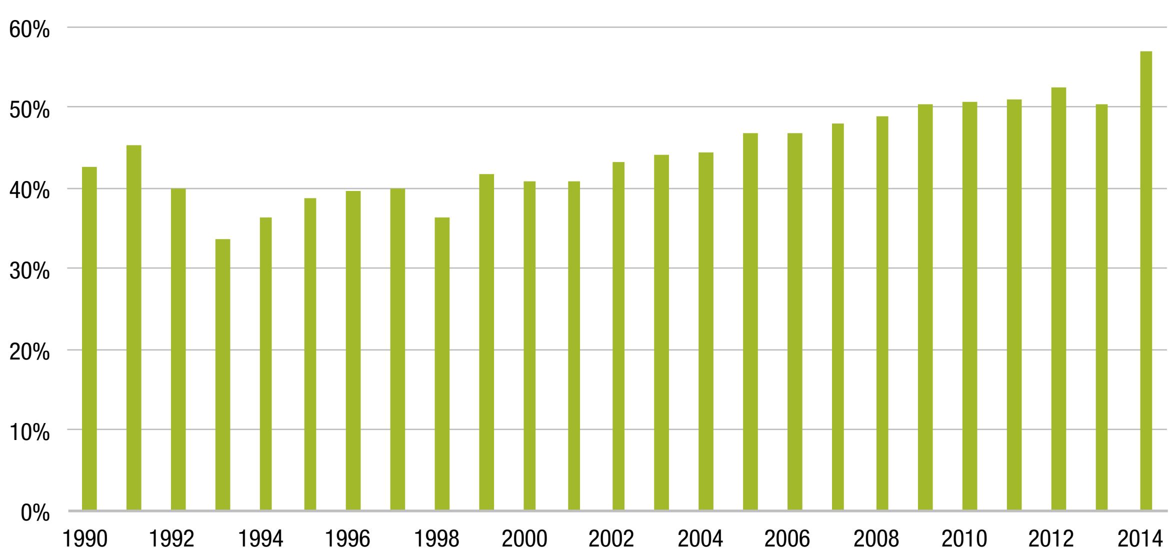
FIGURE 6 Patents per capita for top five U.S. states (2014)



Sources: U.S. Patent and Trademark Office, U.S. Census Bureau.

Small Business Technology Transfer (STTRs) awards illustrate the collaboration between small businesses or nonprofit research institutions and federally funded R&D. A key feature is the requirement for small businesses in the program to collaborate with a research institute. California consistently places in the top 10 in STTR awards relative to the number of business establishments. Another important metric is Small Business Innovation Research (SBIR) awards. These awards are granted by the 10 largest federal government departments and agencies. A key criterion for granting these awards to small businesses is the perceived commercial potential of their research. SBIR provides financial support for startup and development phases. California was seventh on awards granted per 100,000 population in 2012.

FIGURE 7 California share of national venture capital placements



Source: 2015 NVCA Yearbook.

The provision of private risk capital to California's stellar group of entrepreneurs is a crucial source of strength for the state's economy. California had the highest value in venture capital placements in the country in 2014, at $28.1 billion. This represents 57 percent of all venture capital placements in the U.S. Even when you adjust venture capital investment relative to GDP, California is just behind Massachusetts but more than double the figure for any other state. Entrepreneurship is a key advantage for California. Net business starts per 100,000 population are a good measure of Californians' proclivity to start new companies and of the success they achieve in the marketplace. Although this measure has substantial year-to-year volatility, California tends to score well. Based on information for 2012, California ranked sixth in this indicator.

Initial public offerings (IPOs) are a valuable measure of a state's ability to grow companies to the point of becoming a public corporation issuing common shares. By tapping public markets, firms can raise capital to meet their goals and enable private investors to cash out on their investments. California ranked first in IPO proceeds in 2013. Even after adjusting for IPO proceeds relative to GSP, it ranked a strong fifth among states.

Another area of strength for California's innovation economy is the depth and breadth of its STEM talent. An investigation of the state's STEM workforce by occupational categories reveals the extent of this advantage. Table 2 shows California's ranking among states for 10 critical STEM occupational categories based on intensity. It is calculated by each field's share of total employment. California doesn't have any first-place scores, but it has nine fields where its intensity is among the top seven. California's best position was second in the concentration of electronics engineers, where it is behind just Rhode Island. In four STEM occupational categories—biomedical engineers, computer hardware engineers, medical scientists, and microbiologists—California ranks third. The state ranks fourth in intensity of software engineers, systems software and seventh in computer and information science experts. California is sixth in intensity for both physicists and biochemists and biophysicists.

TABLE 2 California technology and science workforce rankings

Technology and science workforce indicators	2014 Score	2014 Rank
Biomedical engineers	96	3
Computer hardware engineers	96	3
Electrical engineers	76	13
Electronics engineers	98	2
Physicists	90	6
Medical scientists	96	3
Microbiologists	96	3
Biochemists and biophysicists	90	6
Software engineers, systems software	94	4
Computer and information science experts	92	7

Source: Milken Institute (2014) State Tech and Science Index.
Note: Highest possible score is 100.

California has another source of innovation diversity: It has six metropolitan areas that rank among the top 20 in the U.S. and Canada in high-tech importance as measured by concentration of employment and wages within a metropolitan economy and as a share of total national activity in high-tech industries. We call this metric a "tech pole" ranking (see Table 3).

TABLE 3 California tech pole rankings

MSA	Milken Institute tech pole ranking
San Jose-Sunnyvale-Santa Clara	1
Los Angeles-Long Beach-Glendale	5
San Diego-Carlsbad-San Marcos	7
Anaheim-Santa Ana-Irvine	8
San Francisco-San Mateo-Redwood City	10
Oakland-Fremont-Hayward	16
Oxnard-Thousand Oaks-Ventura	51
Sacramento-Arden-Arcade-Roseville	54
Riverside-San Bernardino-Ontario	81

Source: Milken Institute.

Silicon Valley (San Jose-Sunnyvale-Santa Clara metro area) is the most prominent high-tech cluster in North America—most likely in the world—and tops the tech pole index. Economic growth over the past three years is attributable to a “tech boom.” Silicon Valley’s unrivaled ecosystem of collaborating agents has a unique ability to spawn new firms that can create entirely new industries, while sustaining high-tech anchor firms that remain the dominant innovators in theirs. Its unsurpassed absorptive capacity[50] allows it to capture new internally generated knowledge, slowing the inevitable spillover to other regions, and convert it to viable firms better than any other area.

Silicon Valley firms see research and development as part of their genetic code and innovation at the core of their business mission. Stanford University provides cutting-edge research and transfers it, along with top-notch graduates, to the private sector to fuel regional growth. Its alumni and former students are among the most prominent entrepreneurs in the region, founding many of the leading firms. The University of California, Berkeley, and other local institutions (California State University, San Jose and the University of Santa Clara) also provide high-value human capital. Equally important, the area attracts highly skilled technical talent from around the nation and world. Immigrant entrepreneurs, mostly from Asia, start many of the region’s firms. These immigrants help in another way: Their high level of educational attainment assists in propelling the overall statistics for the region—21 percent of the population aged 25 and over has advanced degrees, double the national average.[51] Most of these are in STEM-related fields.

The San Jose metro area’s technology diversity is demonstrated by its ranking first or second in seven (out of a possible 19) individual tech pole indexes by industry. It places among the top 10 in 12 individual categories, and it has an employment concentration above the North American average in an impressive 16 fields. Overall, its high-tech employment concentration is 4.5 times the metro average for North America. San Jose was more than twice as important in the North American context as second-place Seattle-Bellevue-Everett, in Washington state.

San Jose was first in the tech pole rankings in computer and peripheral equipment manufacturing, accounting for 17.0 percent of employment and 28.4 percent of wages for that industry in North America. Apple, Hewlett-Packard, and Oracle’s computers and systems division (formerly Sun Microsystems) are the anchor companies in this field. The metro holds a similarly dominant position in semiconductor and other electronic component manufacturing, as Intel, Advanced Micro Devices, LSI, and many other leading firms are based there. Home to the prominent search engines Google and Yahoo, it's also the leader in data processing, hosting, and related services. Silicon Valley holds a dominant position in social media with Facebook and LinkedIn, and it remains an important center of influence in communications equipment, with Cisco and other firms.

Los Angeles-Long Beach-Glendale is fifth on the tech pole index, attributable to its still vast aerospace footprint, the technology-intensive segment of the motion picture industry, and multimedia. The area has a large research base, with leading institutions such as the California Institute of Technology (Cal Tech); the University of California, Los Angeles; and the University of Southern California. Combined, they provide the area with outstanding medical research expertise, especially in the biotech area.

Los Angeles is the top tech pole for navigational, measuring, electromedical, and control instruments manufacturing. It retains major operations of Northrop Grumman (despite losing its headquarters) and Boeing. The metro area is fifth in aerospace and products and parts manufacturing jobs. The inclusion of motion picture and video in our definition of high-tech industries boosts L.A.'s position in the tech pole rankings. This categorization is justified by the area's high-end special effects and postproduction talent. It is home to key players in the social media scene such as Snapchat. Its Silicon Beach area is thriving with highly regarded startups such as Tinder, TrueCar and JustFab.

San Diego-Carlsbad-San Marcos, ranking seventh on the tech pole index, is an important player in innovation, with the world's most geographically dense biotech cluster, an enviable position in telecom hardware and services, and strong representation in several other fields. San Diego was 80 percent more dependent on technology than the average for North America. The metro area placed in the top 10 in four of the individual high-tech sectors and had a concentration above the North American average in 14 categories.

San Diego's biotech network is closely knit and includes a wide range of members. The research milieu includes the Scripps Research Institute; the Salk Institute for Biological Studies; the Burnham institute; the T. Craig Venter Institute; and the University of California, San Diego.[52] Its research institutes and firms receive a disproportionate share of National Institutes of Health funding, National Science Foundation basic research funding, Small Business Innovation Research awards, and Small Business Technology Transfer awards in biotech research. The metro is home to large biotech firms such as Amylin Pharmaceuticals and many mid-sized and startup firms. More venture capital is findings its way to San Diego's biotech firms. Qualcomm is the key player in the communication chips arena, and AT&T has a major presence in telecommunications.

The Anaheim-Santa Ana-Irvine metro area is eighth on the tech pole index. The key drivers of its high-tech growth are medical devices; medical and diagnostic labs; and measuring, electromedical, and control instruments manufacturing. Anaheim ranks among the top 10 in six categories and exceeds the North American concentration in 16, tying San Jose for second in this measure. Additionally, area firm Broadcom is a key player in communication chips. The University of California, Irvine is turning out more top-notch technical talent, aiding the sector's performance. Aerospace remains an important industry for the region, with Boeing employing nearly 7,000. Architectural, engineering, and related services are important as well.

San Francisco-San Mateo-Redwood City is 10th overall. The bursting of the dot-com bubble hit San Francisco hard, but the creativity of its entrepreneurs and its highly skilled workforce allows the region to constantly reinvent itself. It is the "birthplace of biotech," and indeed, biotech heavyweight Genentech emerged out of locally based university research. San Francisco's tech importance is rising due to the city's remarkable recovery, powered by social media and mobile apps, computer systems design, cloud-based software and storage, Internet publishing, clean tech, biotechnology, and medical research.[53] This gives San Francisco a unique combination: strength in both the creative and scientific economies.

The metro ranks fifth among software publishers, with major operations of Electronic Arts and Oracle. Salesforce.com is among the leaders in web-based business applications software. San Francisco is a major hub of data processing, hosting, and related services, where it ranks seventh, and of computer systems design and related services. Within high-tech services, it ranks just behind the Washington, D.C. metro area. Between 2008 and 2013, the professional, scientific, and technical services sector recorded robust gains, creating 25,500 (or 45 percent) of the 56,100 added jobs in San Francisco. This was the key factor behind its being named the Milken Institute's Best-Performing City in 2014.

Oakland-Fremont-Hayward is 16th on the tech pole index. The metro area's strength lies in the diversity of its tech industries. Despite not recording a top 10 finish in any of the 19 high-tech categories, it earned a strong ranking overall by having a concentration exceeding the North American average in 16 of them. The area, centered near UC Berkeley, is home to a number of biotech firms, and its major tech employers include Oracle and Sybase. Berkeley has increased focus on spinouts and licensing of its intellectual property to local firms. Real estate costs are substantially below the rest of the Bay Area, providing an advantage for business and attracting talent.

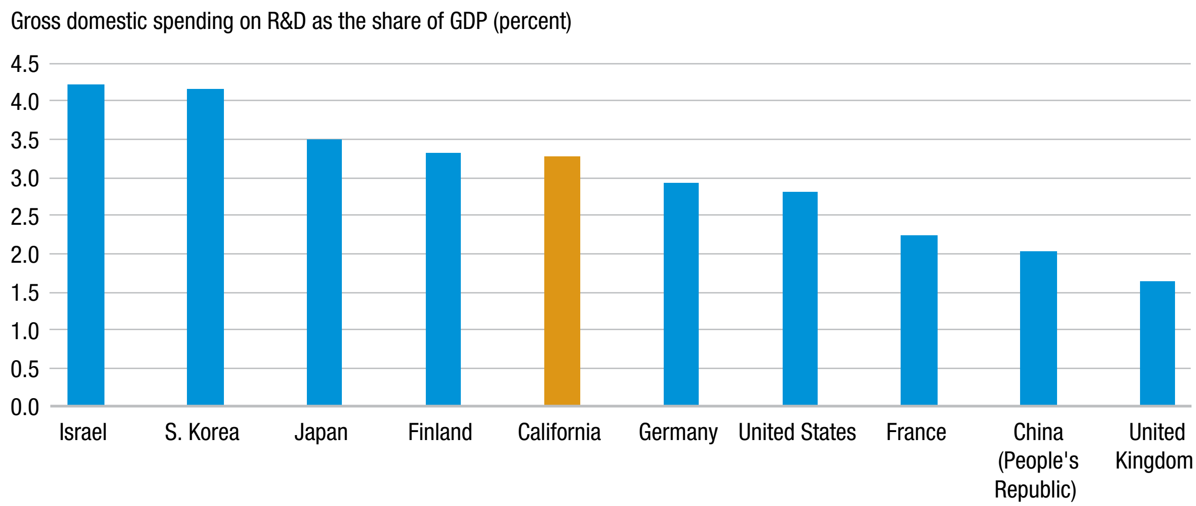
3.2.2 Challenges

California is endowed with great capacity for innovation. Yet it faces many challenges in maintaining its innovation advantage, stemming from recent deterioration in a few key research areas, human capital capacity, and ongoing cost and regulatory concerns. Further, because these business climate concerns have hurt areas other than technology, the performance of the innovation arena has become even more critical for California's broader economic growth potential.

As previously noted, California ranks 17th in per capita academic R&D spending. The state's vast size and the concentration of this funding at research universities along the coast allow this research to be commercialized/absorbed in an efficient manner. Nevertheless, other states are targeting academic funding as a way to boost their long-term economic performance. California's universities should be receiving more funding from industry sources. Of particular concern, California is ranked 11th in R&D spending on biomedical sciences at universities. Given the state's large industrial base in biotech and medical devices, its universities should be receiving more funding to conduct biomedical science research. Not only do smaller states such as Connecticut, New Hampshire, and Vermont have higher per capita rates than California, but so do larger states with strong biomedical clusters, such as New York, Pennsylvania, and North Carolina. California risks ceding its strong position in the biotech industry unless there is improvement in funding directed toward research in the biomedical sciences.

Another area of concern for California is its weakening position in academic R&D in engineering. Engineering prowess has long been a comparative advantage for the state's technology sector. California ranked 27th on R&D expenditures per capita in 2012, down from 12th as recently as 2000. This deterioration is cause for concern. Competitive National Science Foundation awards per dollar of state GDP measure the quality of scientific research at universities. These are mostly done on a competitive award basis. California was 20th on this basis in 2012 and its position has been slipping in recent years. Additionally, keep in mind that overall R&D expenditures have been rising more quickly outside of the U.S. over the past decade, indicating that California's research prowess is declining relative to several leading nations (see Figure 8). While California maintains a high ranking among states on per capita industry R&D, it is imperative that it capture a larger share in the future to sustain long-term economic growth.

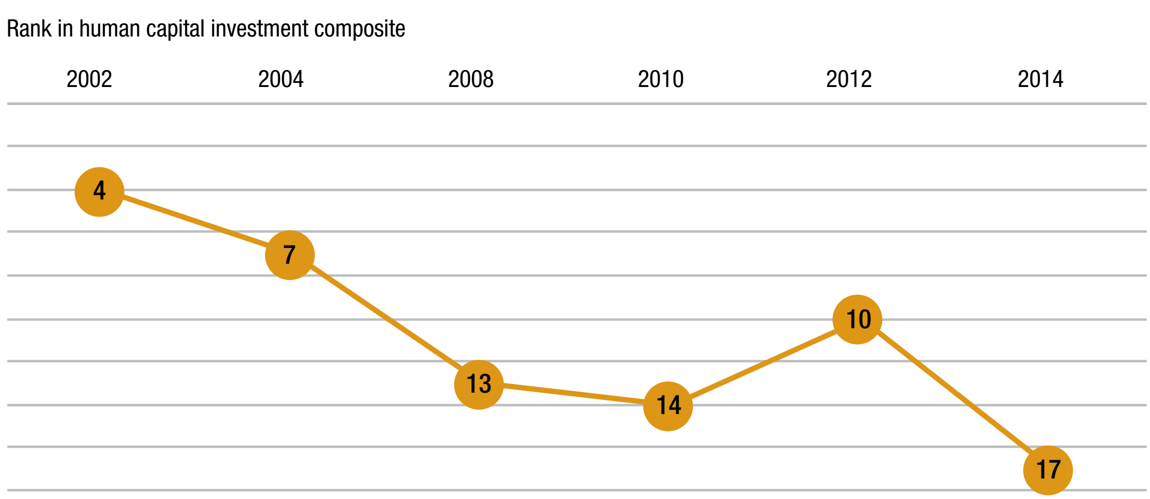
FIGURE 8 Gross domestic spending on R&D: California vs. leading nations



Source: OECD.

One of the biggest threats to California's long-term innovation capacity is its diminishing position in measures of human capital capacity. This is occurring in specific STEM categories and more broadly in areas such as bachelor's degrees granted. In the Milken Institute's 2014 State Technology and Science Index, California ranked 17th in the Human Capital composite, down from fourth in the inaugural reading in 2002—the largest decline of any state (Figure 9). This indicator attempts to measure stocks and flows of various science and engineering fields and broader degrees granted. California ranked 41st in recent degrees in Science and Engineering per 1,000 Civilian Workers in the 2014 index, a fall from 15th in the 2002 index. California is not creating enough of its own STEM talent.

FIGURE 9 California's diminishing human capital capacity



Source: Milken Institute's State Technology and Science Index (2014).

Even earlier in the STEM value chain, California students taking the SAT ranked a dismal 32nd on the math portion in the 2014 index. On the measure of science, engineering and health Ph.D.s awarded per 100,000 residents aged 25 to 34, California was an unenviable 20th. This is the future research human capital of the state's economy. California has fallen on a number of these flow measures in STEM areas.

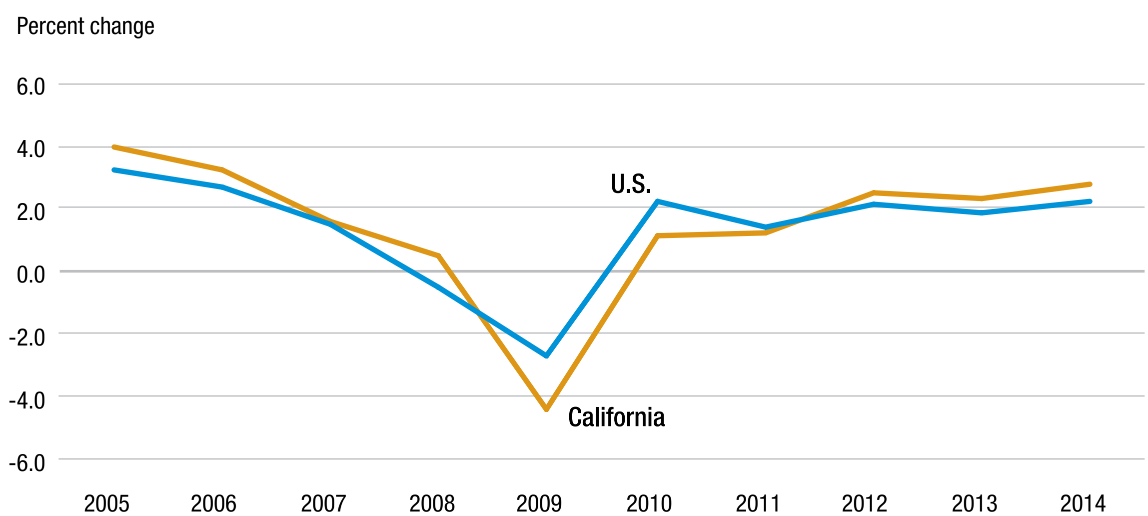
Some of the decline in STEM degree production in California has been offset by the immigration of knowledge workers from abroad. However, the evidence in recent years suggests that the quality of immigrants as measured by educational attainment has fallen in California relative to other states. Based on data for 2010, the average educational attainment of those immigrating to California was 13.0 years, versus a U.S. average of 13.1 years, ranking California 29th.[54]

3.2.3 Economic Competitiveness Measures

Innovation capacity is becoming more critical to California's economic growth as the state's poor position in tax policy, regulation, and overall cost of doing business weigh it down. A number of various indices have been created that compare states' competitiveness on the basis of a variety of tax rates, labor costs, energy and materials costs, and regulatory measures.

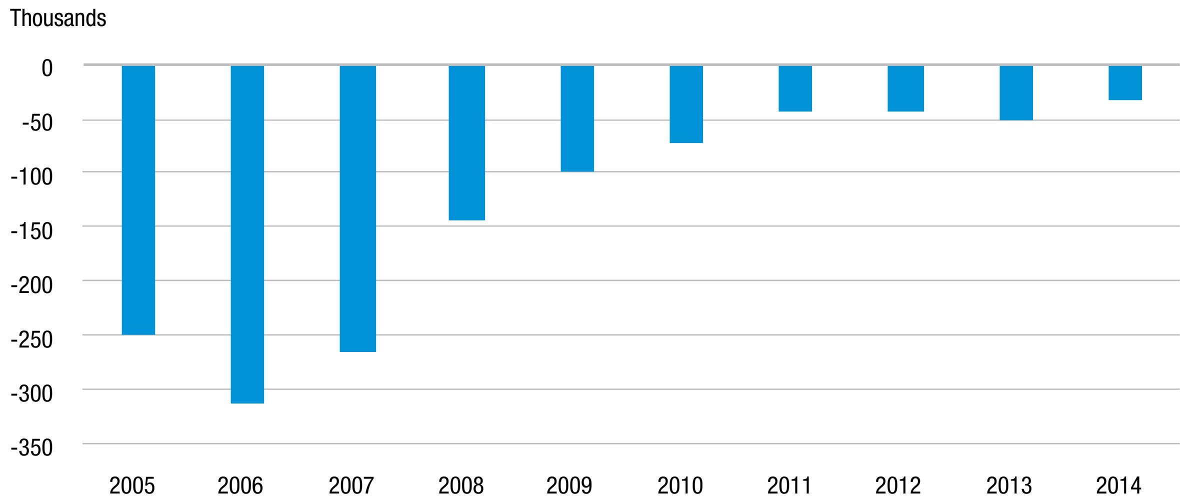
The ALEC-Laffer State Economic Competitiveness Index is one such measure. It looks at recent economic performance and variables affecting the economic outlook of states.[55] Economic performance is based on three variables measuring historical growth metrics over the latest 10 years: state gross domestic product, non-farm payroll employment, and absolute domestic migration (see Figures 10a, 10b, and 10c). By this measure, California ranked 37th. Another measure, Economic Outlook, includes 15 individual variables such as personal income tax rates, sales and property tax burdens, corporate income tax rates, minimum wages, workers' compensation costs, whether it is a right-to-work state, a liability system survey, and debt service burdens as a share of tax revenue. California ranks 44th in Economic Outlook, and placed last among the 50 states in four categories: top marginal personal income tax rate, personal income tax progressivity, average workers' compensation costs, and right-to-work state. California ranks 40th in top marginal corporate income tax rate.

FIGURE 10A Components of ALEC-Laffer State Economic Competitiveness Index: GDP



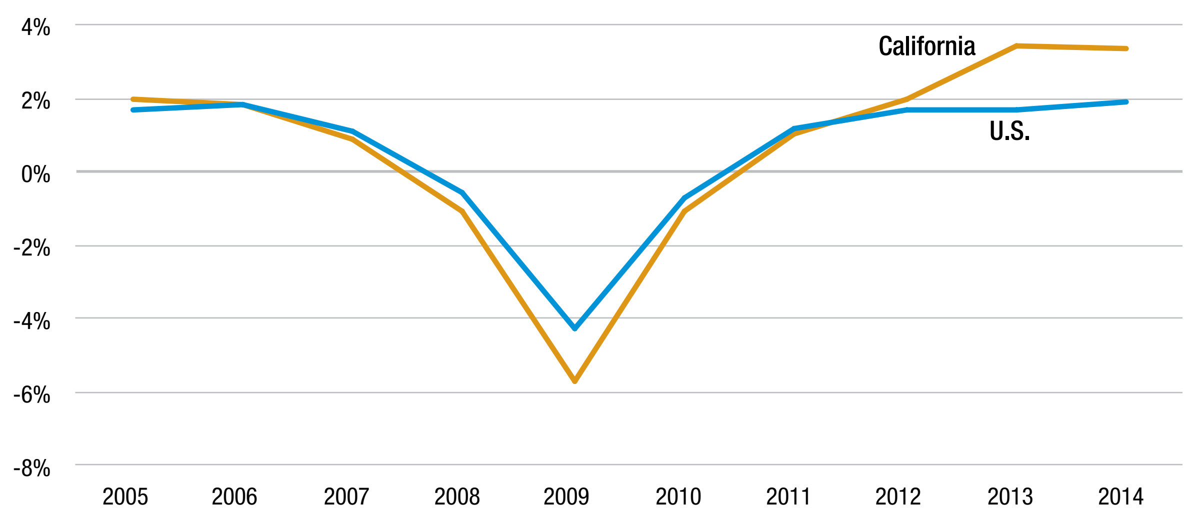
Source: Bureau of Economic Analysis.

FIGURE 10B Components of ALEC-Laffer State Economic Competitiveness Index: Domestic net migration



Sources: U.S. Census Bureau (BOC); Population Estimates & Projections; U.S. National Center for Health Statistics; Moody's Analytics (ECCA) Estimated.

FIGURE 10C Components of ALEC-Laffer State Economic Competitiveness Index: Non-farm employment



Source: Bloomberg.

California scores particularly poorly in indices comparing tax rates alone. One of these is the Tax Foundation's State Business Tax Climate Index.[56] The foundation states that the index "enables business leaders, government policymakers, and taxpayers to gauge how their state tax systems compare to others. While there are many ways to show how much is collected in taxes by state governments, the index is designed to show how well states structure their tax systems, and provides a road map to improving these structures." Its most recent version shows California ranking 48th. On the Council on State Taxation's "Best and Worst of State Tax Administration" scorecard, California receives a grade of D-, tying Louisiana for the lowest grade.[57]

Another frequently referenced comparison index is the State Competitiveness Report, published by the Beacon Hill Institute.[58] Beacon Hill includes traditional tax and cost-of-doing-business measures, but also incorporates measures of innovation output and potential. California's rank on the eight subcomponents displays a bimodal distribution, with the state scoring relatively well on innovation but poorly on other measures. For example, California ranks 49th on both government and fiscal policy and infrastructure. Overall it ranks 26th, reflecting the bimodal pattern. On Forbes' "Best States for Business," list, California is 37th.[59] Similarly, on CNBC's "America's Top States for Business," California ranks 27th.[60] On Moody's Analytics State Cost of Doing Business Index, it is 40th.[61]

The message is this: California's economy simply won't grow over the long term without maintaining or enhancing its capacity for innovation and converting it into commercial applications, thereby allowing firms to create high-quality jobs in the state and benefiting from the large multiplier effect associated with them. While it's true that California has long been a high-tax, high-cost place to do business, in a more competitive world the imperative to maintain the state's edge in innovation cannot be overstated.

4. California's Private-Sector R&D

4.1 Understanding the Distribution of R&D Activity Across the State

Companies in California invest heavily in research and development, accounting for more than a quarter of all in-house corporate R&D conducted in the U.S. But assessing the distribution of research work within the Golden State is challenging. While national surveys like the Business R&D and Innovation Survey (BRDIS) allow us to track company spending on R&D by broad industry category for each state, they do not report data at a local level, to avoid making specific company-level data public. Some companies do report R&D spending, but this provides only anecdotal data points and does not yield a comprehensive picture.

Given how important innovation is to economic growth in California, it would be useful for policymakers to have a credible estimate of the amount of R&D taking place in their communities as they assess tax or regulatory changes that may affect the innovation climate in the state. By combining company-level data with data from the National Science Foundation, National Center for Science and Engineering Statistics, and the U.S. Census, we were able to estimate R&D at each of the business locations across the state. This allows us to report estimated R&D in each of California's 58 counties and for major metropolitan areas, and would also enable the estimation for specific Assembly or congressional districts of interest.

This analysis provides insight into the geographic and industry concentrations of R&D within California, with the flagship Silicon Valley tech cluster complemented by activity across the state. Key high-level findings are outlined below, and more detailed analysis can be found in the Appendix.

4.2 Methodology for Mapping Research Activity in California

State-level data on R&D spending is readily available from the National Science Foundation (NSF).[62] Total spending by the private sector is broken down into a variety of categories, including company size, industry, and type of funding. To estimate research spending for smaller geographical areas, additional calculations were required. The National Establishment Time-Series (NETS)[63] database is a company location level source with details gathered about businesses, nonprofits, and sole proprietors, over time. NETS is created by Wall & Associates using data collected by Dun & Bradstreet.[64] The NETS database includes North American Industrial Classification System (NAICS) codes and address data for each company location in California, as well as employment data. Combining R&D spending at the state level by industry from the NSF with company address-level data in NETS using the NAICS codes present in both data sets creates a bridge that enables R&D spending to be assigned to each company location based on employment and industry code.

To assess and confirm the accuracy of the NETS database employment figures, total NETS employment by industry code for California was compared with government employment numbers from the Bureau of

Labor Statistics (BLS). NETS employment totals are typically higher than government estimates because the NETS data include private consultants and contractors. However, in our analysis none of the differences were so large as to cast doubt on the aggregate NETS numbers. Using the same industry groupings used to report R&D spending by the NSF,[65] the NETS data on California businesses was summed to establish employment by industry. California R&D spending per employee could then be calculated for each industry. This spending figure could then be assigned to each employee at each business location in the NETS database, to yield an estimate of the amount of R&D conducted at each business location in California. Based on address data for each business location, the total R&D spending could be aggregated by county.

In order to check the results of the NETS-based R&D spending allocation and analysis, comparisons were made to results generated using similar techniques but based on different government and privately sourced data. One review using research industry GDP intensity by county produced similar rankings to the original NETS-based analysis. Real GDP in R&D industries was calculated for every California county using data from the Moody's database.[66, 67] California R&D GDP was also computed, then used to calculate R&D intensity for each county using the equation below:

$$\text{R\&D intensity}_{\text{County}} = \text{R\&D GDP}_{\text{County}} / \text{R\&D GDP}_{\text{California}}$$

A similar check was conducted using occupation data. A list of R&D-related occupations was created to align with the NSF industry groupings. However, unlike the GDP-based calculation above, the occupation analysis attempted to focus on only highly R&D-intensive industries.[68] The NSF science and engineering professions looked only at the key occupations in Scientific Research and Development (NAICS 5417) and Pharmaceutical and Medicine Manufacturing (NAICS 3254). R&D intensity was then calculated using the same quantitative techniques as for GDP, this time using R&D employment for California and R&D employment by county. Unlike the NETS analysis and the GDP analysis, employment data were not available for every county. For the counties for which data were available, the calculation below was used:

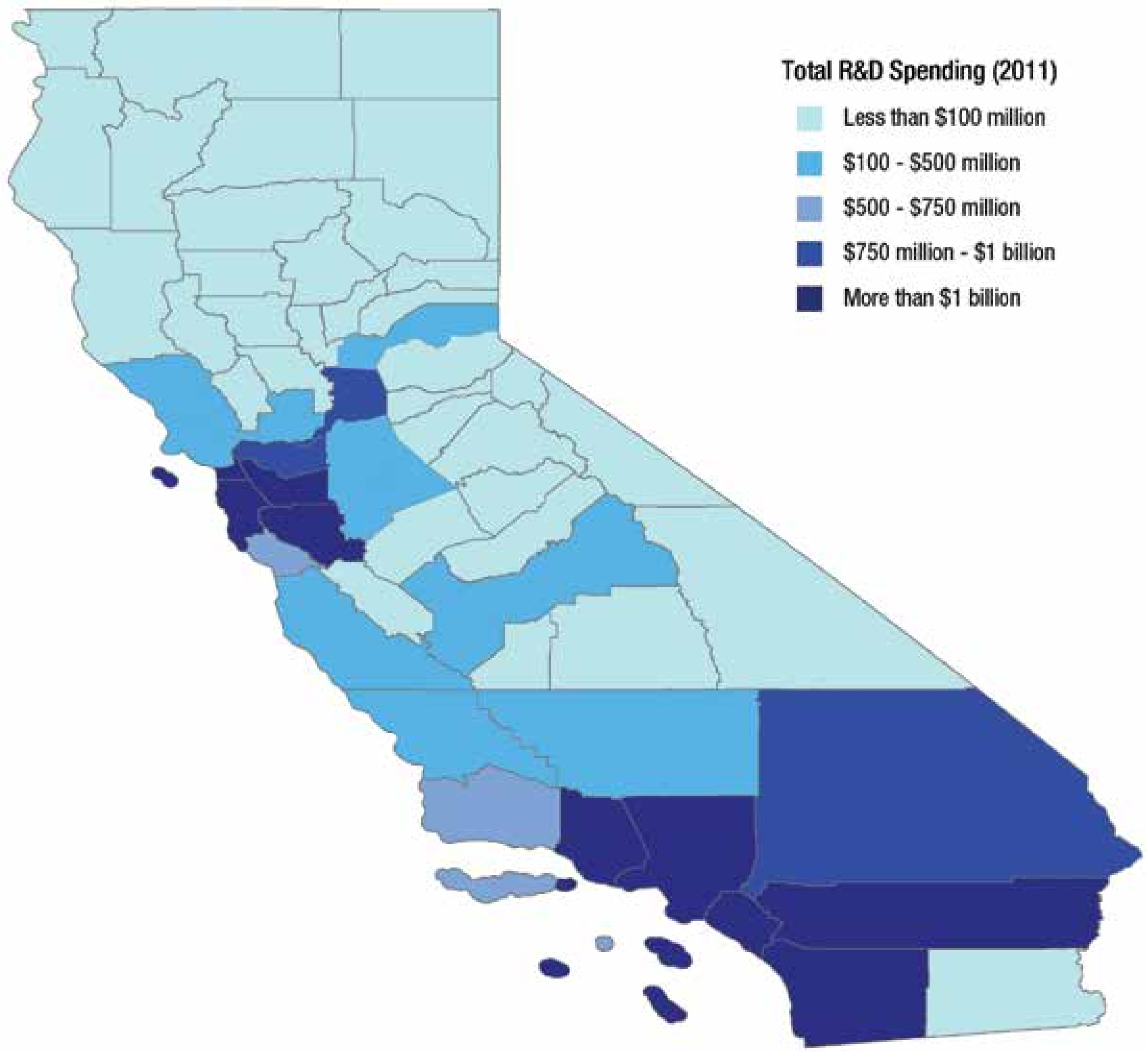
$$\text{R\&D intensity}_{\text{County}} = \text{R\&D employment}_{\text{County}} / \text{R\&D employment}_{\text{California}}$$

After performing the two checks on the NETS data without finding any significant differences in allocation by county, it was clear that making adjustments to the NETS-based analysis would be an unnecessary manipulation. Instead, the original R&D assignments from the NETS-based analysis were used without any additional weighting adjustments based on either the occupation or the GDP analysis.

The research and development spending at each business location was used to conduct the spatial analysis and mapping in Section 4.3.

4.3 California Research and Development Spending

FIGURE 11 California R&D spending by county



Source: Milken Institute.

The industry R&D spending per employee calculated using information from the NETS database shows that R&D activity occurs in every county of California. The amount spent on R&D in the private sector varies by location and is mostly clustered around large population centers, as would be expected. However, population is not the only factor driving R&D activity; the presence of research universities and the industry focus of the county are also key.

Santa Clara County has the highest level of private-sector R&D spending among California counties, despite its small size (see Figure 11). Santa Clara is a technology hub, and the high level of R&D in the county emphasizes its importance to businesses seeking to remain competitive in their fast-moving industry.

The analysis of R&D spending using maps shows the scale of clustering in California. As explored in detail in Section 2, economic clusters can create a positive cycle of activity, attracting talent and capital, developing supply chains, and enjoying the benefits of knowledge transfer that comes from geographic proximity. By looking at economic regions, urban areas, and counties, we are able to see the concentration of research-related industries, often bolstered by the presence of one or more major research institutions also creating knowledge and skilled workers to fuel innovation locally.

California is distinguished by having multiple areas with strong industry clusters and areas of specialization. The San Francisco Bay Area has a plethora of tech talent, the Los Angeles area has both entertainment and technology, and San Diego has an emphasis in biotechnology. These growing industries, in the right environment, could help drive California's economic future with sustainable growth.

4.4 California's High-Tech Economy: Key Industries

Most research and development spending in California is focused on the category Computer and Electronic Product Manufacturing (see Table 4). This includes the development of computer storage devices, semiconductors and other electronic components, audio and video equipment, and analytical laboratory instruments. Chemical Manufacturing ranks second and includes the production of a range of outputs, from plastics to fertilizer, with the largest R&D expenditures in pharmaceutical and medicine manufacturing. The Publishing Industries (except Internet) category includes software publishers, so despite the reduction in printed material production, the increase in software publishing has helped California maintain an innovative edge in this area. Professional, Scientific, and Technical Services is one of the most diverse industry groupings; it includes accountants, lawyers, engineers, architects, pre-clinical biotechnology research, and computer system designers. With Hollywood still maintaining its entertainment hub, bolstered by the state tax credit that helps keep productions local, the motion picture industry continues to draw talent and innovation to California.

TABLE 4 Top industries by R&D spending in California

3-digit NAICS code	Industry	Total (US$billions)	Share (percent)
334	Computer and Electronic Product Manufacturing	23.4	37
325	Chemical Manufacturing	10.5	16
511	Publishing Industries (except Internet)	7.8	12
541	Professional, Scientific, and Technical Services	6.1	10
512	Motion Picture and Sound Industries	3.5	6

Source: Milken Institute.

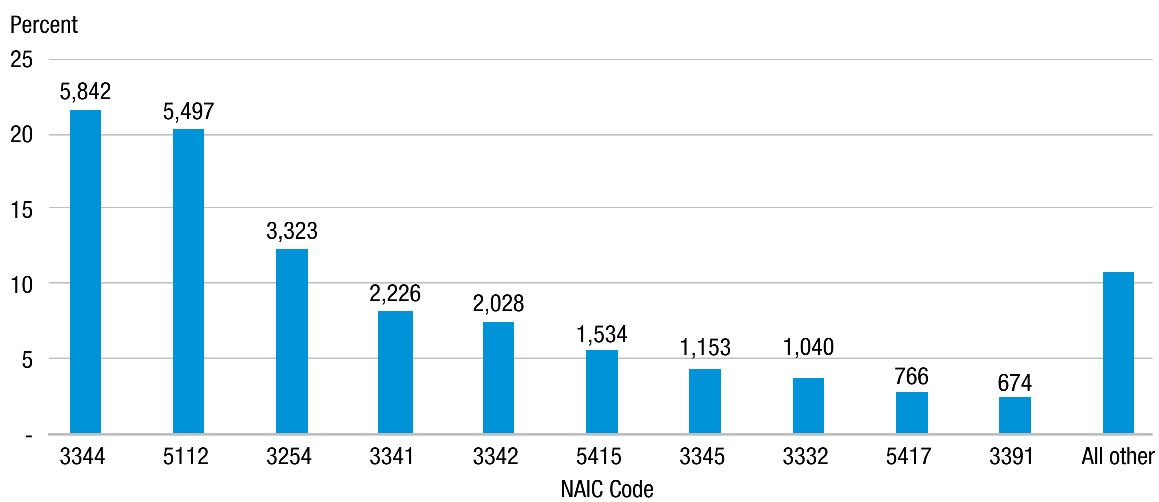
4.5 California's Economic Regions: Home to Diverse Research and Development Clusters

California's large and diverse economy can be grouped into distinct economic regions to analyze the factors that are driving development. These interconnected regions share business ties and workforce, and give a broader view of R&D spending patterns than the county or metropolitan analyses explored in subsequent sections. Three economic regions within California are home to innovation hubs, and they demonstrate the state's advantage of not being dependent on just one sector for research-related investment or employment.

4.5.1 San Francisco Bay Area Economic Region

In the greater San Francisco Bay Area, including Sonoma, Napa, Solano, Marin, Contra Costa, Alameda, San Francisco, San Mateo, Santa Cruz, and Santa Clara counties, the emphasis is strongly on Semiconductor and Other Electronic Component Manufacturing, and Software Publishing (see Figure 12). Combined, these two sectors completely overshadow other industries in the Bay Area economy, making up 22 percent and 20 percent of total private-sector R&D spending in the region, respectively. Each represents more than $5.5 billion in private-sector R&D spending. There is also a strong pharmaceutical and biotechnology presence in the Bay Area, with its more than $3.3 billion in R&D spending making up 12 percent of the economic region's total. The high concentration of research spending in these three industries accounts for more than half of all private-sector research spending in the region.

FIGURE 12 San Francisco Bay Area top 10 industries by R&D spending

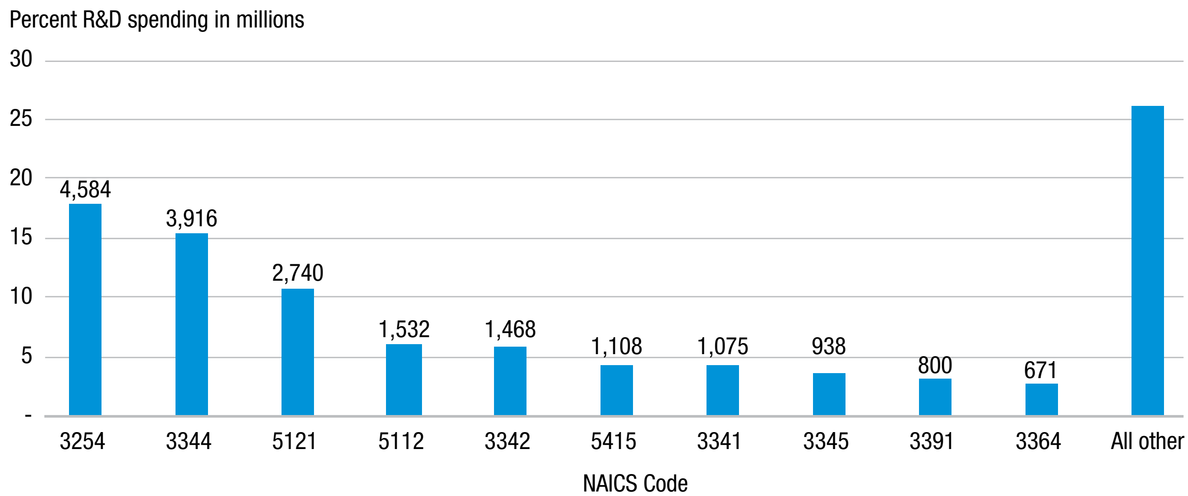


Source: Milken Institute.

4.5.2 Southern California Economic Region

The Southern California Economic Region includes Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties. As with the Bay Area economic area, research spending was concentrated in the Pharmaceutical and Medicine Manufacturing (18 percent, $4.6 billion) and Semiconductor and Other Electronic Component Manufacturing (15 percent, $3.9 billion) industrial sectors (see Figure 13). The Motion Picture and Video Industries sector, of key importance to the greater Los Angeles area, accounts for 11 percent of research and development spending, at more than $2.7 billion, and ranks third.

FIGURE 13 Southern California top 10 industries by R&D spending

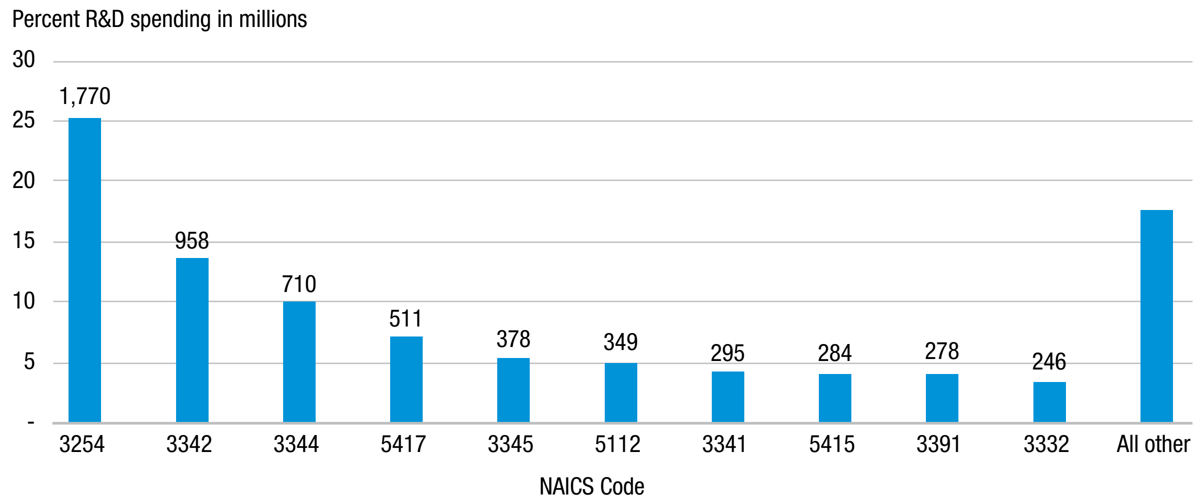


Source: Milken Institute.

4.5.3 Southern Border Economic Region

In San Diego and Imperial counties (see Figure 14), which together make up the Southern Border Economic Region, pharmaceutical and medicine manufacturing clearly dominates research activity. The industry spends $1.8 billion, which accounts for a quarter of all research spending—far more than the next-largest target for research spending, communications equipment manufacturing (14 percent, $1 billion). Demonstrating why it is the state's top-ranked industry for private-sector R&D spending overall, semiconductor and other electronic component manufacturing is key to this economic region as well, representing 10 percent of R&D spending.

FIGURE 14 Southern Border top 10 industries by R&D spending

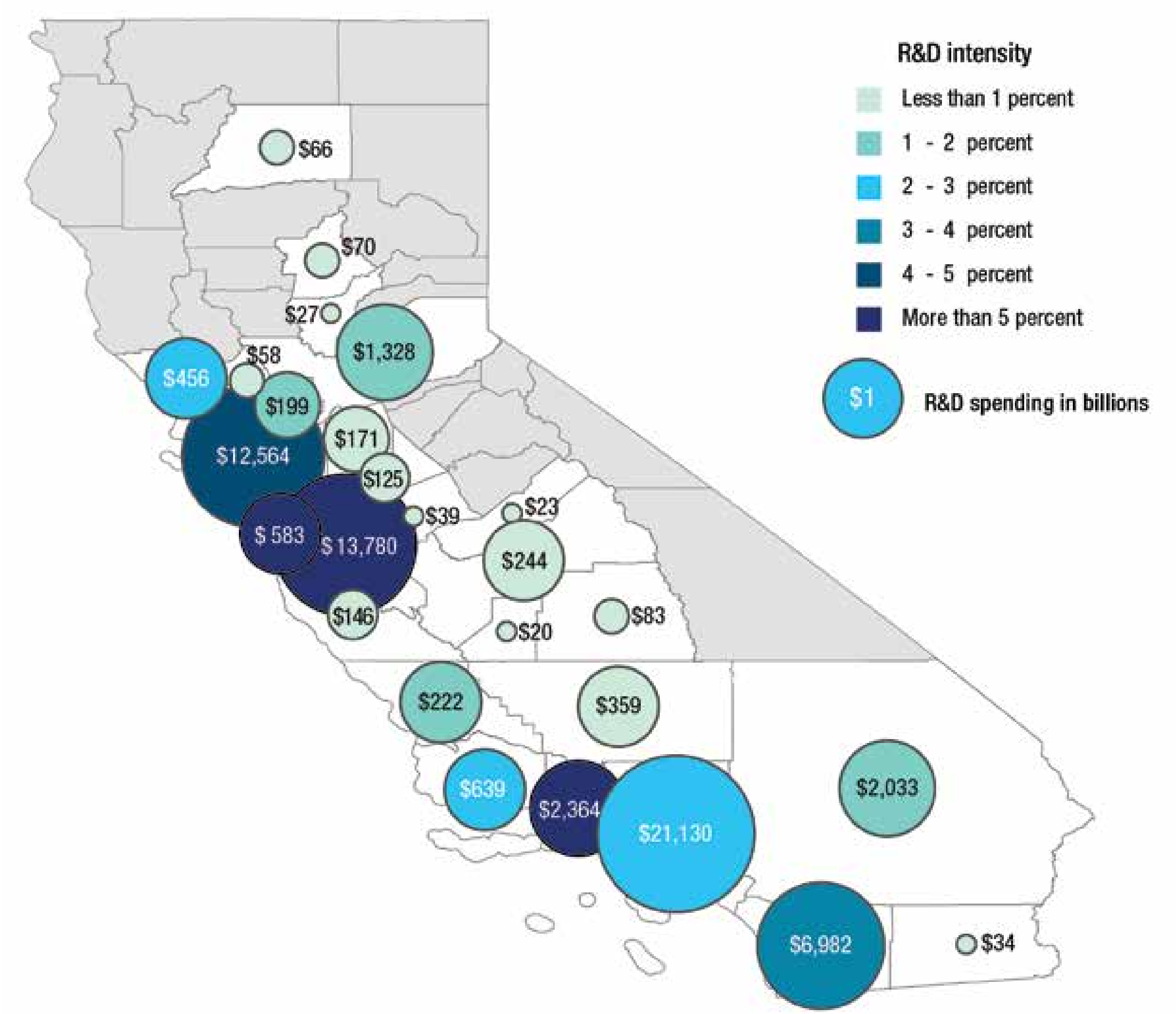


Source: Milken Institute.

4.6 Research Intensity in California's Metropolitan Statistical Areas

While total spending on R&D gives an indication of the scale of research activity in the economic regions cited above, it doesn't tell the complete story of the importance of R&D to local economies. By examining R&D intensity, which compares R&D spending to gross regional product, we see that the emphasis on research industries is typically higher in the metropolitan statistical areas (MSAs) where spending is higher. However, this isn't always the case. The Los Angeles MSA, with $21 billion in R&D spending, has a much lower R&D intensity than the smaller Oxnard-Thousand Oaks-Ventura MSA. Spending in the latter region totals about a tenth of the amount spent in Los Angeles. But because the population is smaller, it equals about 5 percent of the region's economy, which is anchored by large employers such as Amgen and Baxter. Unsurprisingly, in the three large MSAs in the Bay Area—San Jose-Sunnyvale-Santa Clara, San Francisco-Oakland-Hayward, and Santa Cruz-Watsonville—we see both high R&D spending and high R&D intensity. In Figure 15, larger circles on the map indicate MSAs with higher private-sector R&D spending, and darker colors indicate higher levels of R&D intensity. Table 5 shows the R&D intensity measure calculated for each California MSA.

FIGURE 15 R&D spending and intensity in California metropolitan statistical areas



Source: Milken Institute.

TABLE 5 R&D intensity in California metropolitan statistical areas

MSA	Intensity
San Jose-Sunnyvale-Santa Clara	9.89
Oxnard-Thousand Oaks-Ventura	5.48
Santa Cruz-Watsonville	5.18
San Francisco-Oakland-Hayward	4.29
San Diego-Carlsbad	3.81
Santa Maria-Santa Barbara	2.71
Los Angeles-Long Beach-Anaheim	2.70
Santa Rosa	2.00
San Luis Obispo-Paso Robles-Arroyo Grande	1.65
Riverside-San Bernardino-Ontario	1.47
Vallejo-Fairfield	1.23
Sacramento-Roseville-Arden-Arcade	1.20
Redding	0.96
Chico	0.87
Bakersfield	0.80
Napa	0.78
Salinas	0.77
Stockton-Lodi	0.70
Modesto	0.67
Fresno	0.59
Visalia-Porterville	0.54
El Centro	0.53
Yuba City	0.51
Merced	0.50
Madera	0.47
Hanford-Corcoran	0.36

Source: Milken Institute.

4.7 Research and Development in California's Counties

The top 10 counties in California for private-sector R&D, seen in Table 6 , encompass a diverse set of locations, including areas surrounding the urban centers of San Francisco, Los Angeles, and San Diego. The three largest cities in California have strong research and development focuses, though as outlined earlier, research activity is more important to some counties than others. These distinct innovation hubs demonstrate a depth and variety of private-sector R&D investment that few states can boast. However, while these 10 counties contain 70 percent of California's population,[69] they are home to 90 percent of the state's R&D spending by the private sector.

TABLE 6 Top 10 California counties by private-sector R&D spending (2011)

County	Total R&D spending 2011	Percent of California total private-sector R&D
Santa Clara	$13.70	21.38
Los Angeles	13.11	20.45
Orange	8.02	12.51
San Diego	6.98	10.89
San Mateo	5.17	8.06
Alameda	4.48	6.99
Ventura	2.36	3.69
San Francisco	1.47	2.29
Riverside	1.24	1.94
Contra Costa	1.00	1.55

Source: Milken Institute.

4.8 R&D Business Locations: An Example

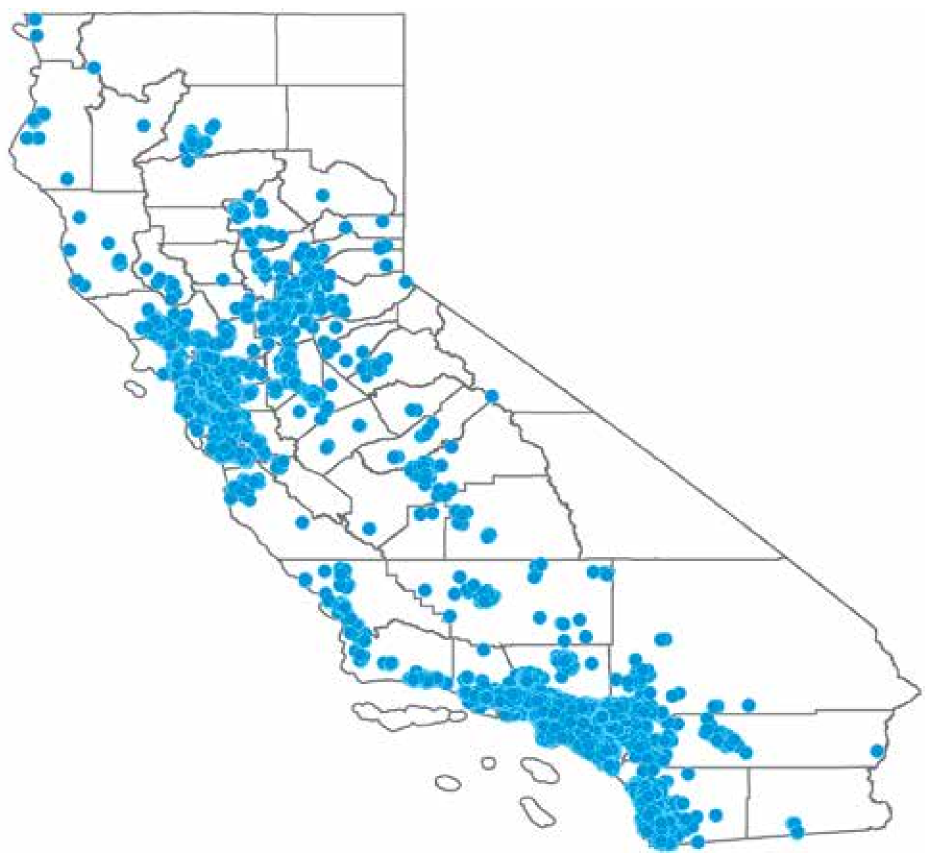
In addition to examining research spending by industry aggregated at the economic region, metropolitan statistcal area, or county level, our analysis also enables the mapping of spending at each California business location within a particular industry. While these maps can be cluttered, it is possible to get a general sense of density and dispersion of activity within the state. Table 7 offers a profile of the Computer and Electronic Product Manufacturing NAICS category, which sees the most private-sector research in Calfornia. Comparing total R&D spending and spending per company across the top 10 counties shows the varying profile of the industry across the state. For example, Los Angeles has more business locations in the sector than does Santa Clara County, despite seeing less than half as much R&D spending. Figure 16 shows the geographic spread of activity in this sector, with locations in corridors supplementing concentrations in major urban areas.

TABLE 7 Computer and electronic product manufacturing (NAICS Code 334)

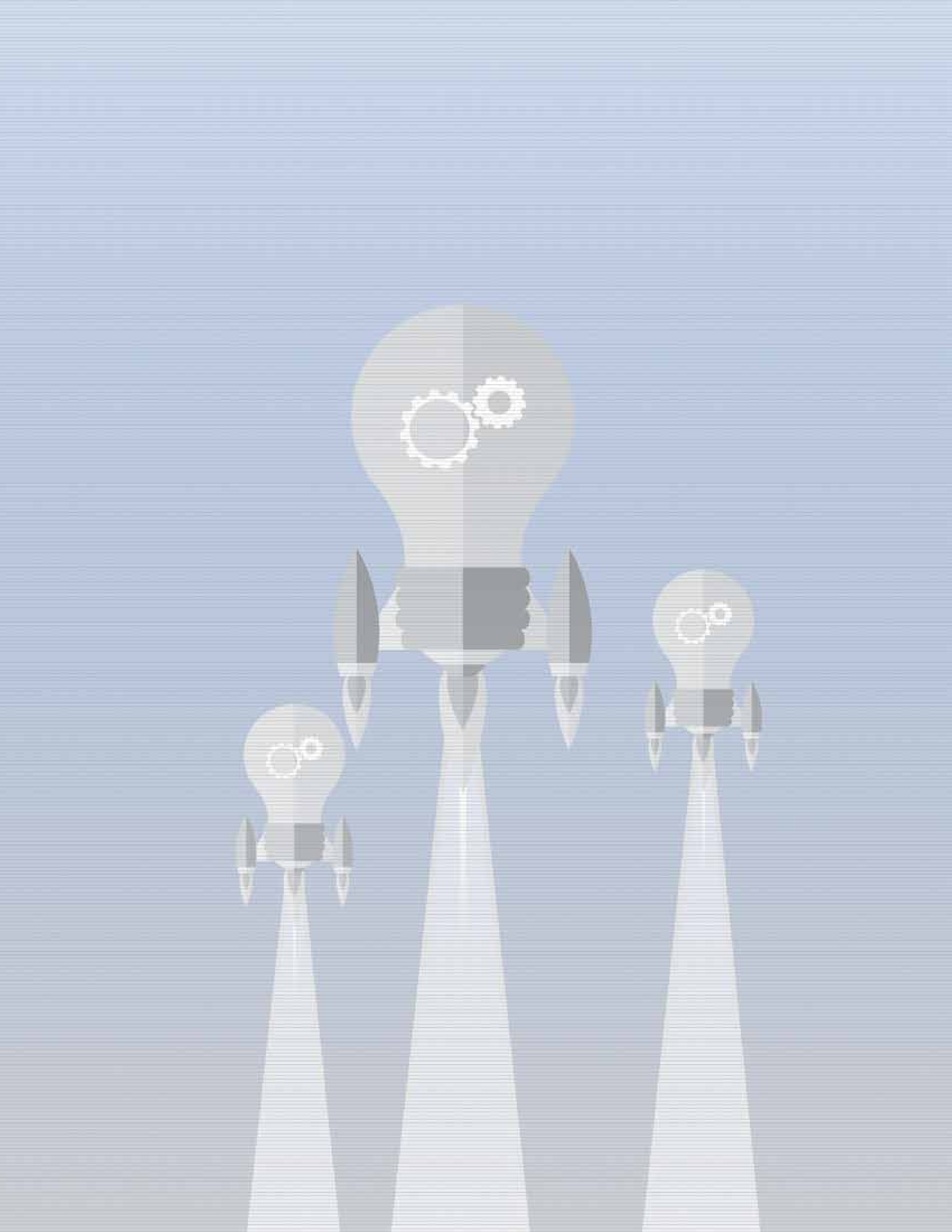
County	Companies in NAICS Code 334	R&D spending (millions)	Spending per company (millions)
Santa Clara	2,051	$8,910	$4.34
Ventura	361	1,057	2.93
San Diego	1,069	2,488	2.33
Orange	1,529	3,240	2.12
Alameda	718	1,507	2.10
San Mateo	293	479	1.64
Riverside	256	407	1.59
Los Angeles	2,363	3,278	1.39
Contra Costa	207	210	1.01
San Bernardino	255	195	0.76

Source: Milken Institute.

FIGURE 16 Computer and electronic product manufacturing locations (NAICS Code 334)



Source: Milken Institute.



5. Encouraging R&D Spending in California: Selected Policy Alternatives

National governments around the world have created incentives to attract research activity because they recognize the necessity of innovation in maintaining and enhancing the competitiveness of their economies.[70] These incentives include tax credits based on the amount of research spending within the country and direct funding for research activity awarded as grants. In the U.S., individual states have chosen to supplement the federal research and development tax credit with their own tax credits. California has a research tax credit, currently 15 percent of qualifying supplemental research activity conducted within the state.[71] This credit, in combination with the federal credit, forms a crucial part of the tax environment that businesses evaluate when deciding whether to locate new research activity in California or elsewhere. It provides one of the most direct policy levers the California Assembly has to try to affect the level of R&D conducted in the Golden State. In this section, we consider several ways in which the tax credit could be modified to increase research activity by private companies within California.

5.1 Overview of Tax Credit Literature

Tax credits for incremental research spending are offered in part because the benefits that accrue to the overall economy from research-related spending are estimated to be greater than the benefits to the particular company funding the research. These positive externalities may come in the form of a platform on which other companies can now develop products, knock-on employment in the supply chain, or benefits to society through improved access to information, for example. Investment in innovation also prevents the obsolescence of local industries, allowing economies to adapt and maintain their employment base even as technologies change. Since the investing companies do not reap the entire benefit and because research can be a riskier form of deploying capital, it is argued that private firms choosing how to allocate resources in an unaltered market will underinvest in research, stopping below the social optimum. Tax credits from the government aim to reduce the costs faced by firms by subsidizing this desired activity and thereby increase research activity to a level closer to the social optimum.

The federal research and development tax credit allows businesses to offset their corporate income taxes based on the amount of spending on "qualified expenditures." Up to 20 percent of these expenses can be credited against a company's income tax bill, and unused credits can be carried forward for up to 20 years. To qualify, research and development expenditures must meet a number of criteria, including evidence that they are supplemental to the baseline level of research-related spending and that they aim to create or improve products or processes. These conditions are intended to limit application of the credit to research that would not have occurred without the credit, rather than subsidizing research that companies would have conducted in the absence of any incentives.

Many states have implemented their own version of research and development tax credits in an effort to boost and attract more research activities and enhance their position in the innovation race. The structures of state tax credits vary, but they aim to stimulate the creation of high-value jobs and associated capital investment. Several studies have been performed demonstrating that these state R&D tax credits increase R&D spending at the margin by lowering the cost of capital relative to other nations and by attracting investments that might have been made in other U.S. states.

The existence of state R&D tax credits does shift the domestic location of research activities because mobility within a specific country is greater than across national borders. Nevertheless, the competition between states isn't "zero sum," as some observers suggest, because of the existence of the federal R&D tax credit program. Why? Because rational firms evaluate the joint effect of federal and state credits on their cost of capital.

A study by Wu found that "the statistical result shows that the establishment of state R&D credit programs is effective in stimulating more industrial R&D expenditure," and that "…this policy assessment sends a positive message to state policymakers because it shows the great potential in using R&D policy instruments to promote innovation-based economic development."[72] Another study examined the impact of the California R&D tax credit on R&D expenditures. It concluded that the California program boosted R&D spending more than was originally envisioned when the legislation was enacted. First, firms in California seem to have allocated more funds for R&D. Second, the credit appears to have prompted firms in other states to shift more R&D to California.[73]

Similarly, another study employed a user-cost-of-capital approach to analyze the influence of state R&D tax credits on R&D expenditures within states. This study estimated that over the long run, a 1 percent drop in the user cost of R&D within a state, on average, would induce a 2.5 percent gain in R&D expenditures.[74] A very recent study by Chang, from the Federal Reserve Board's divisions of Research and Statistics and Monetary Affairs, reviewed the latest data on R&D tax incentives and their impact on state-level R&D expenditures and found strong positive results. Chang found that after controlling for policy endogeneity bias, his preferred model estimates that each 1.0 percent increase in R&D tax incentives results in a 2.8 percent to 3.8 percent rise in R&D expenditures at the state level.[75] Many other state-specific studies on the effectiveness of R&D tax credits yield positive results.[76]

The combined value of state and federal credits is closely considered by firms choosing among international sites, and California's world-class regional innovation ecosystems place it squarely on the list. California's business research and development intensity is already twice as high as for the U.S. as a whole,[77] so it is well positioned to draw investment. Improving how the Golden State compares with other countries could help attract new economic activity to the U.S.

5.2 Tradable Credits: Creating Value Upfront for Businesses Conducting Research with Longer Development Cycles

Unused California research credits can be carried forward by firms for use in the future if they do not have sufficient tax liability in the year in which they earn the credit. This especially benefits companies in cyclical industries by allowing them to store credits for use in years when they have a sufficiently large tax burden to offset. In doing so, it levels the playing field between these firms and companies in industries with steadier profit margins, which use credits on a regular basis.

However, startup companies in highly research-intensive industries may not turn a profit for many years. For these firms, in technology manufacturing for example, use of the research tax credit may lie so far in the future that it becomes less valuable, diminishing its effectiveness as an incentive.

Most state research credits are not tradable, but in 2003 Pennsylvania established an assignment program for its R&D tax credit. The program permits a corporation that doesn't use its full allotted credit to apply to transfer the credit to a different corporate taxpayer in the state. The purchasing corporation can then use the credit to offset up to 75 percent of its Pennsylvania corporate tax bill. These transfers are usually conducted using a broker, who takes a commission (estimated by the Pennsylvania Department of Revenue at typically about 6 percent).[78] As a result, between 2003 and 2013, unused tax credits were sold for approximately 94 percent of their value. Just over 18 percent of R&D credits awarded by the state were resold over this period.[79]

California had $16.4 billion in unused research credits carried forward at the end of the 2013 tax year.[80] This dwarfs the $910 million in credits used in 2013. A change in policy to make all of these credits tradable would represent significant reductions in state corporate tax revenue as companies realized the assets they have been carrying on their books. These credits were accrued based on investment choices made under the existing research tax credit framework, so retroactively making the credits tradable may be seen as a windfall to the companies that will not necessarily increase the amount of research conducted in California in the future. Since the credits carried forward were more than double the corporation tax paid in 2013,[81] policies to limit the impact on the budget—such as making only newly generated credits tradable or permitting only businesses below a certain size to sell their credits—could be enacted while still creating an incentive for new research investment in California.

5.3 Refunding Credits for Small Businesses: Grass-Roots Growth

Small businesses[82] create 60 percent of net new U.S. jobs[83] and can be sources of innovation and entrepreneurship. Some states have created programs that specifically encourage research activity at small firms. Since 2013, small businesses in Maryland with assets of less than $5 million can receive a refund for any awarded research and development credits that exceed their income tax liabilities.[84] This benefits startup companies conducting research to develop new products and processes in industries with a long development cycle by providing an incentive that lowers their costs before they are generating profits.

California could introduce a program that refunds a fixed percentage of unused research credits to qualifying small businesses. To limit the direct fiscal impact in California, total credits refunded through this program could be capped each fiscal year. Unlike in California, total awards under the Maryland R&D credit are capped each year, placing a limit on the impact on the state budget of these refundable credits.[85] To assess the potential impact of a refundable credit for small businesses in California, and to set an appropriate cap, it would be necessary to know what share of total unused research credits are earned by small businesses each year. In 2012, 25 percent of total assessed corporate income taxes were paid by companies with state net income taxable in California below $5 million,[86] but this share doesn't necessarily align with the generation of research credits carried forward. A bill to make one time grants to small businesses of 15 percent of their unused research credits was estimated to cost $27 million by the FTB.[87]

5.4 Stimulating More Investment in University Research

Since 2000, firms that fund basic research conducted in California by qualifying institutions can receive a credit equal to 24 percent of this spending above a base amount. In addition to universities, qualifying institutions include scientific research organizations and grant organizations.[88] Basic research, which may take longer to bear fruit commercially than research conducted in-house by the private sector, is also vital to building California's knowledge base and innovative capacity. In the U.S., the National Science Foundation found that less than 5 percent of R&D conducted in-house by private companies was focused on basic research.[89] Encouraging companies to fund this research under contract by reducing the after-tax cost associated with it directs private-sector dollars into organizations with a long-term commitment to research.

Federal funding to universities for basic research has declined in recent years from a peak during the recession.[90] Given the importance of university R&D to the Golden State's innovation ecosystem, as outlined in Section 3.2.1, directing more funds to universities to expand their capacity is a laudable policy goal. Policymakers may choose to do this in a number of ways, including through direct expenditures or through tax expenditures.

Direct funding for university research, through increased transfers to institutions or through competitive grant programs, offers a transparent and state-managed method to increase basic research activity in California. The state ranked 17th both in per capita state appropriations for higher education and in per capita academic R&D dollars in the Milken Institute's 2014 State Technology and Science Index, so there is clearly room for improvement.

Increasing the percent of incremental basic research spending that private companies can claim as a credit would further decrease the marginal cost of funding this work at universities and other qualifying institutions. One proposal introduced in recent years called for raising the credit to 40 percent from 24 percent over five years. Basic research credits claimed by industry are not separated from the qualifying research credits claimed in California's Franchise Tax Board reports, so it is not possible to assess how much of a change this would represent to credits earned by California companies. However, while this approach would clearly have an impact on tax revenues for the state, by introducing the private sector into the process of choosing which research to fund, the state ensures that more projects viewed as having market value are pursued and that private funds are leveraged.

5.5 Increasing the Research Tax Credit: Sending a Strong Signal That California Values Innovative Activity

The California Assembly has considered several bills in recent years to expand the research tax credit, with the aim of cementing the state as a prime location for investment in research and development. California's reputation as a difficult place to do business acts against its ability to attract very mobile new corporate research spending, and a more generous research tax credit could send a very visible signal that the state values this type of activity and its contributions to the state's economy.

Although Silicon Valley is the benchmark for regions around the world trying to develop business clusters, California's regulatory and business climate often acts as a disincentive for new investment because of the higher costs of operating. Though research tax credits are only one of many factors a company considers when comparing potential locations for additional research and development investment, the combination of federal and state credits for incremental research spending can meaningfully reduce a company's expenses.

In-Depth Analysis: Benefits of Doubling the California Research Tax Credit

Rather than evaluate each of the proposals, we chose to focus on one, the doubling of the research tax credit over five years, to 30 percent from 15 percent, to give a sense of the economic effects such a change might yield.

Since the revenue impact had been estimated by the California Franchise Tax Board (FTB) for Assembly Bill 653 in the 2013-14 legislative session,[91] we could build on its assessment of the static impact of the change on state corporate income tax revenue in our analysis. Using a dynamic economic model and based on previous work, we looked at the potential impact of the lower cost of doing research at private companies and the additional research activity that would result from the credit.

5.5.1 Methodology

To model the impact of an increase in the California research credit to 30 percent from 15 percent over five years, we combined a structural model adapted from the Milken Institute's "Jobs for America"[92] report and the dynamic Regional Economic Models Inc. (REMI) model for California. Using historical trends in both private-sector research spending from the National Science Foundation and in utilization of the California research credit over time, we made adjustments from a baseline level of research spending in the state under different conditions, drawing on projections from the California FTB.

Three components were modeled to estimate the effect of a doubling of the California research credit over five years: the effect of reduced costs of R&D on company choices (shifting toward R&D); the effect of a more attractive R&D investment climate in the state (expansion of R&D, new location of investment); and the overlap between these two, which we excluded from the analysis to avoid double-counting.

Reduced marginal cost of research (Box A in Figure 17): The effect of reduced costs to California companies of performing incremental research and development activity was modeled as a reduction in the cost of capital for firms within industries that conduct research that qualifies for the credit. The size of the reduction in cost of capital was based on the California FTB report on the utilization of the research credit by industry category.[93] To refine the estimate, research credits assigned to broad industry categories by the FTB were apportioned to more detailed subsectors based on National Science Foundation data on research and development activity by private companies in the state. Using each sector's share of the total credits claimed in the most recent year, we then allocated the FTB's estimated revenue impact of the proposed tax change to the industries as a reduction in the cost of capital, ramping up as the credit increased and including a 4.4 percent annual baseline increase in credits claimed each year.[94] (See Table 8 for the phase-in of the additional research credit and the total credits allocated to industries in each year we modeled.) These changes were then modeled using the dynamic REMI model for California to capture the ripple effect on the economy of the shift in how companies in California deployed their resources because of the reduced cost of capital.

TABLE 8 Credit rate and total credits allocated in reduced marginal cost of research analysis using REMI model

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Additional research credit (percent)	3	6	9	12	15	15	15	15	15	15
Estimated research credit claimed (millions of dollars)	95	198	311	432	564	589	615	642	670	700

Source: Milken Institute.

More attractive research environment (Box B in Figure 17): To model the effect on the California economy of the change in the research investment climate, we drew on the estimates of changes to real research and development spending funded by industry that would be stimulated by a similar change at the federal level. These estimates were based on a Milken Institute structural model developed for the "Jobs for America" report in 2010.

Since the changes to the research and development tax credit modeled in "Jobs for America" were different in scale and scope, some adjustments were necessary before they could be applied to a California policy change. These included:

+ Scaling up the change in spending to reflect the larger proposed change to the total effective tax rate in California (including both federal and state taxes and credits)[95] compared with the federal change modeled.

- Reducing the effect by 25 percent quarter to reflect that the policy change in our federal model was permanent and this predictable ongoing reduction in costs increased the impact on investment more than the proposed temporary change in California.

- Reducing the effect of the policy change on investment to reflect that California's economy is smaller than the national economy. Since California's economy is a subset of the national economy, there is a more narrow set of investment opportunities (based on space, industry mix, etc.) and greater leakage of spillover effects into other parts of the country and the world. While the impact of these differences on research investment is difficult to quantify exactly, we modeled upper and lower bounds for their combined influence, reducing the investment effect for California by a further 25 percent or 50 percent, to indicate a range within which we expect the true results to lie.

After making these adjustments to the estimated additional research and development investment in California that would result from the change to the tax credit, we took a baseline estimate of 4.2 percent annual growth in research spending (based on NSF 10-year trend for California) and increased it by the percentage predicted by our adjusted model (see Table 9).

TABLE 9 Estimated incremental private-sector research spending projected with additional California research credit

		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
	Additional research credit (percent)	3	6	9	12	15	15	15	15	15	15
25 percent CA deflator	Adjusted modeled increase in CA research spending (percent)	0.92	2.77	4.42	5.16	4.79	5.16	5.72	6.08	6.64	7.01
	Estimated additional research spending in CA (fixed 2009 US$ millions)	616	1,924	3,208	3,899	3,772	4,233	4,883	5,415	6,155	6,769
50 percent CA deflator	Adjusted modeled increase in CA research spending (percent)	0.61	1.84	2.95	3.44	3.20	3.44	3.81	4.06	4.42	4.67
	Estimated additional research spending in CA (fixed 2009 US$ millions)	410	1,283	2,139	2,600	2,515	2,822	3,255	3,610	4,103	4,513

Source: Milken Institute.

Overlap in increased research investment (Box C in Figure 17): We modeled the results of both the reduced marginal cost of research (Box A in Figure 17) and the increased investment in research and development resulting from the more attractive research environment (Box B in Figure 17) simultaneously. Since the reduced marginal cost of research would result in higher investment in research and development, some adjustment to avoid double-counting this investment was necessary to avoid overlap. A reduction (Box C in Figure 17) equal to the increases in equipment and intellectual property investment stimulated by the reduced marginal cost of research when modeled alone was included in the final model to accomplish this.

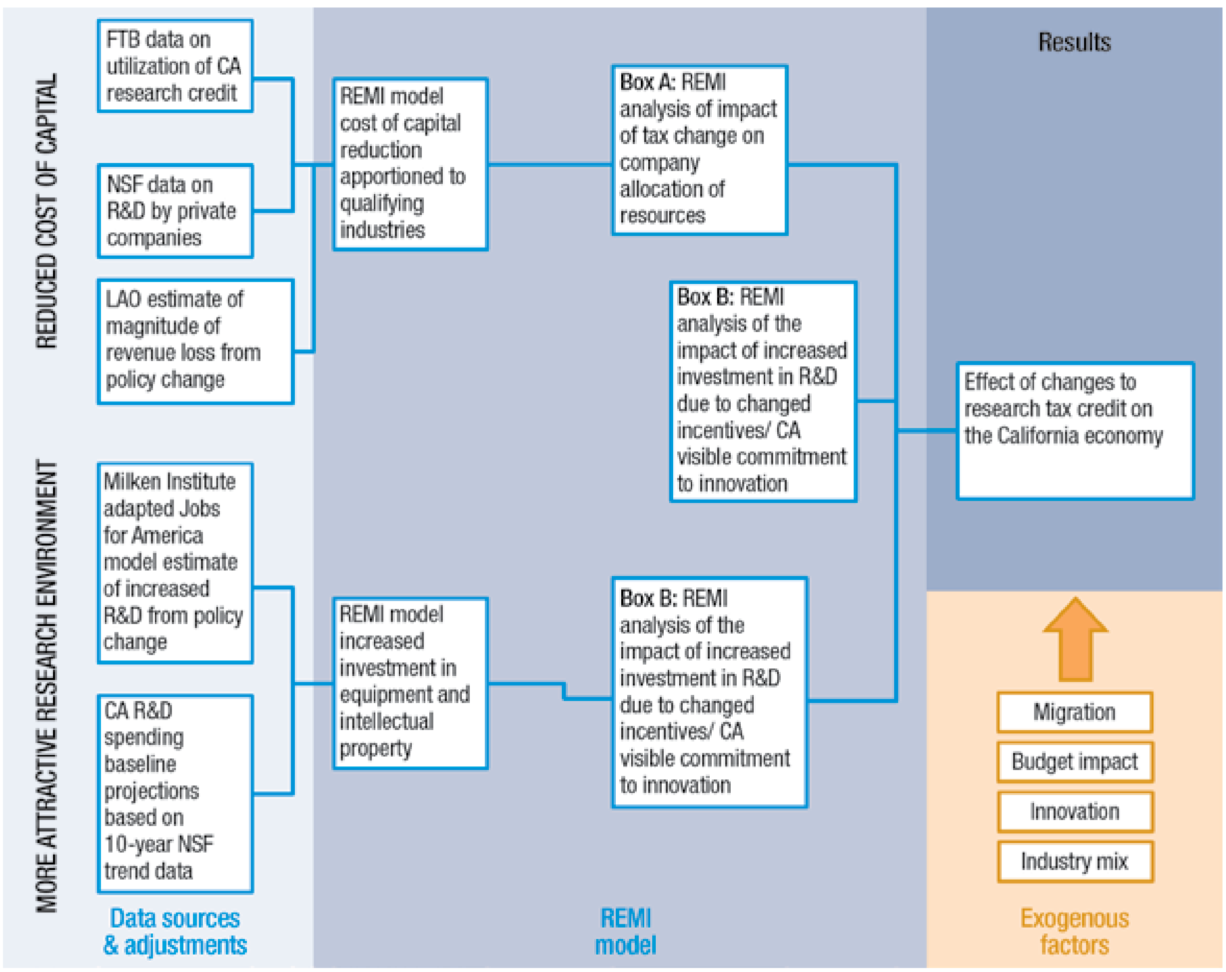
5.5.2 Exogenous Factors

California budget impact: While our model considers both the effect of the increased research tax credit on existing companies and on research investment in general, we did not include a number of other factors that would also affect the impact of this policy change on California's economy. One major factor we do not consider is how the forgone tax revenue would affect the California budget. While a straight reduction in state government spending equivalent to the increased credit can be modeled in REMI, this presumes indiscriminate cuts in state spending across the board. In reality, however, policymakers in California would make targeted reductions. The increased employment and output would close some of the gap by adding to revenue through other taxes. However, doubling the research tax credit would have a significant impact on tax revenue and represents a big commitment from the state to provide incentives for research activity and investment by the private sector.

Innovation and industry mix: Another factor we do not consider is how increased innovation would shift the industry mix and the sustainability of the state's employment. Since research and development enables businesses to develop new processes and products, it sows the seeds for industrial revitalization and transformation. While we recognize that increased innovation may result in the birth of new industries, we did not attempt to capture this in the model.

Migration: High-skill job opportunities attract candidates from around the country to California, and some in-migration would be expected to fill a share of the projected new jobs. The REMI model includes some migration effects, but due to the skills profile of the research jobs, we would expect a larger share to be from out of state than the model predicts.

FIGURE 17 Model schematic for changes to California's research credit



Source: Milken Institute.

5.5.3 Findings

Doubling the California research tax credit is a significant change in tax policy that would make doing research in the state more attractive for existing, new, and expanding businesses large and small. It also represents a large fiscal impact in forgone tax revenue for the California budget. Therefore, it is important to assess the effectiveness of this change in a way that can be compared with other potential uses of revenue or tax incentives. This allows legislators and policymakers to evaluate the opportunity cost of this change in the context of job creation, economic growth, and increasing incomes for California residents. Analysis using the REMI model yields estimates of a wide variety of economic and demographic variables. We have chosen to focus on a few key indicators.

As discussed in Section 2, creating a tax environment that stimulates more investment in research bolsters California's important regional innovation ecosystems, and this brings a range of additional benefits that are not as easily quantified.

TABLE 10 Impact of increased research credit on California employment, output, and personal income (high estimate)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10
Total employment (jobs)	10,303	30,568	49,967	60,590	59,816	83,979
Private non-farm employment (jobs)	9,357	27,740	45,295	54,861	54,031	75,631
Gross domestic product (millions of fixed 2009 dollars)	1,063	3,216	5,365	6,661	6,771	10,539
Gross domestic product as % of nation	0.006	0.018	0.029	0.035	0.035	0.049
Personal income (millions of fixed 2009 dollars)	769	2,426	4,220	5,463	5,799	10,212

Source: Milken Institute.

TABLE 11 Impact of increased research credit on California employment, output, and personal income (low estimate)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10
Total employment (jobs)	7,244	21,316	34,896	42,719	42,982	60,215
Private non-farm employment (jobs)	6,578	19,340	31,627	38,658	38,801	54,133
Gross domestic product (millions of fixed 2009 dollars)	750	2,252	3,770	4,736	4,924	7,720
Gross domestic product as % of nation	0.004	0.013	0.021	0.025	0.026	0.036
Personal Income (millions of fixed 2009 dollars)	538	1,687	2,941	3,841	4,150	7,330

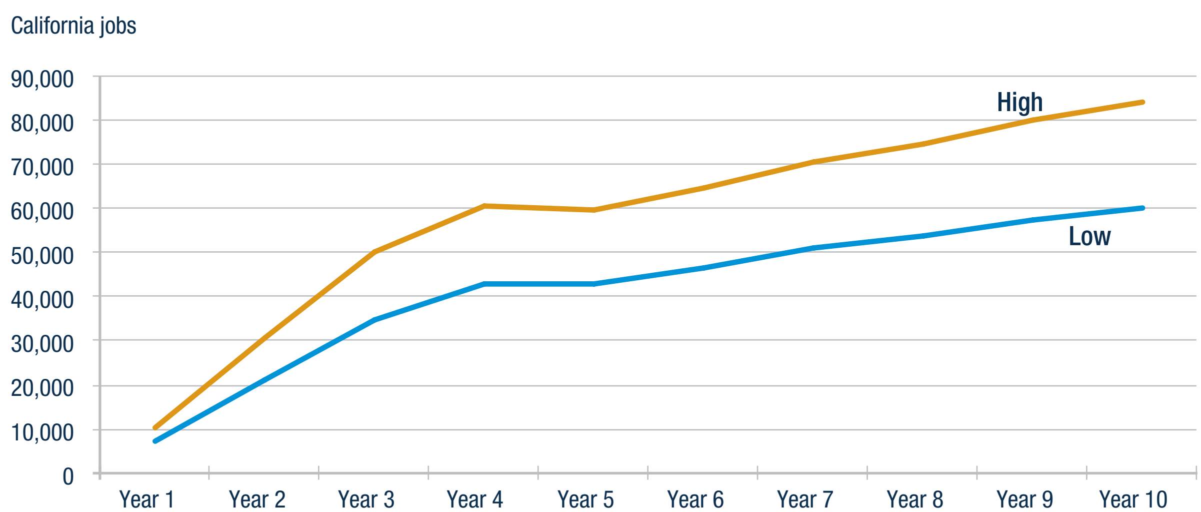
Source: Milken Institute.

Employment

Research involves high-skill and higher-wage jobs for employees with a range of qualifications. California companies are already conducting research across the state with regional industry concentrations, as outlined in Section 2. An increase in research activity would help create new employment opportunities. In our models, we estimate that by Year 10 there will be an additional 60,000 to 84,000 jobs (see Tables 10 and 11) in California over a baseline where no change is made to the research credit. This is equivalent to a "cost" in forgone corporate tax revenue of $8,300 to $11,600 per new job created. Ninety percent of the new jobs would be in the private sector.

These figures do not take into account any changes that need to be made in state government employment and spending because of net reduced tax revenue from lower corporate tax returns, which we expect would still exceed any net increases in revenue from raised personal income and other taxes.

FIGURE 18 Additional jobs in California over baseline (upper and lower bound estimates)

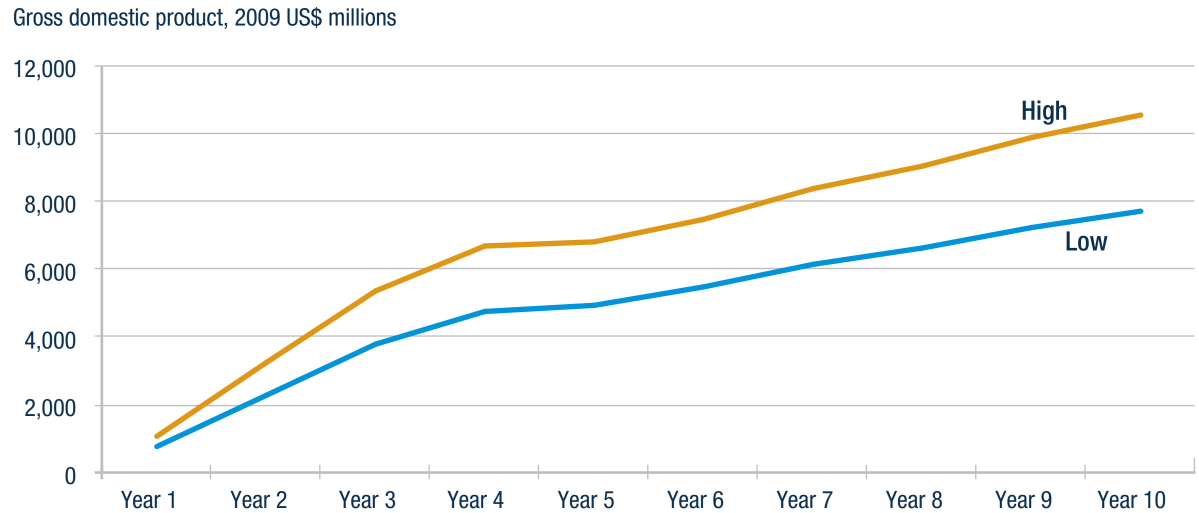


Source: Milken Institute.

GDP

Our model assumes that in Year 10, $700 million in additional research credits will stimulate approximately $4.5 billion to $6.8 billion in additional research and development activity in California, a multiplier of between 6.4 and 9.7. This extra research spending in turn stimulates additional economic activity and the generation of more output. Our model estimates between $7.7 billion and $10.5 billion in additional gross domestic product in California in Year 10 compared with the baseline where no change is made to the California research tax credit. This represents between $3.2 billion and $3.8 billion in knock-on economic impact from the additional research spending.

FIGURE 19 Additional GDP in California over baseline (upper and lower bound estimates)

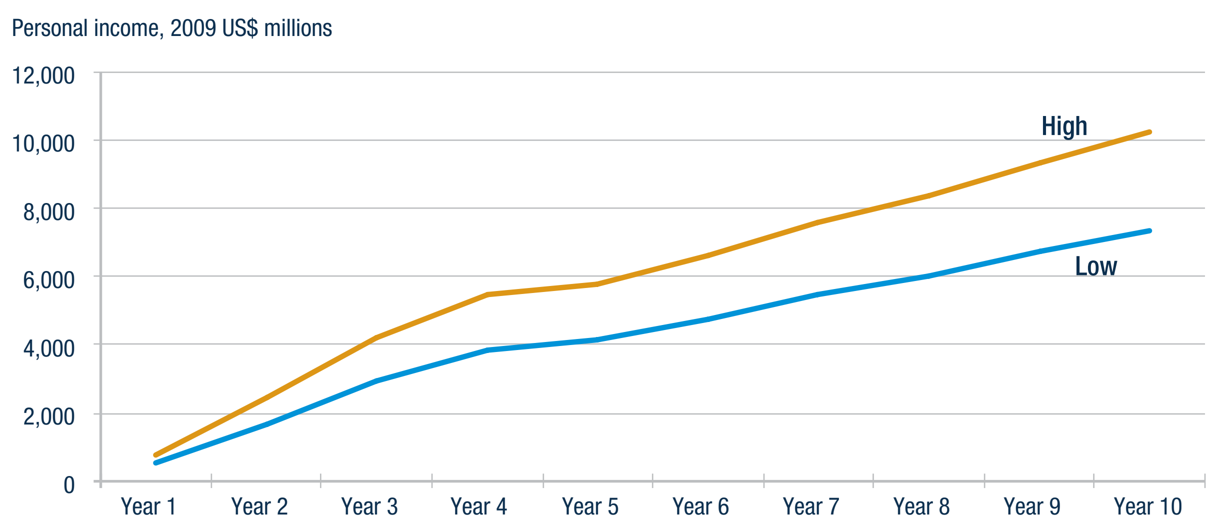


Source: Milken Institute.

Personal Income

In addition to increased employment and higher levels of economic activity, personal income earned by California residents would increase between $7.3 billion and $10.2 billion by Year 10 under our model. While this works out to approximately $121,000 per added job in Year 10, the new income will not necessarily accrue only to new employees. It could represent increases in wages for existing employees as well.

FIGURE 20 Additional personal income earned in California (upper and lower bound estimates)



Source: Milken Institute.

Industry Impacts

The industry distribution of impacts is concentrated in those sectors that invest heavily in research and development. Professional, scientific, and technical services receives the largest boost, rising between $4.2 billion and $6.2 billion in Year 10 (see Table 12). This is where biotechnology and much of the pre-market pharmaceutical research is captured. Computer and electronic product manufacturing experiences gains in output by capturing more R&D spending. Another industry benefiting from the expanded R&D credit is telecommunications. Through the indirect and induced impacts of greater R&D, sectors such as real estate, construction, retail trade, and wholesale trade are among the largest beneficiaries.

TABLE 12 Top 10 industries by increased output over baseline in Year 10 of increased California research tax credit

Top sectors by output	Year 10: Low (2009 US$ billions)	Year 10: High (2009 US$ billions)
Professional, scientific, and technical services	4.18	6.16
Manufacturing	1.62	1.74
Real estate and rental and leasing	0.97	1.33
Construction	0.76	1.03
Finance and insurance	0.52	0.72
Retail trade	0.52	0.70
Health care and social assistance	0.49	0.67
Information	0.44	0.58
Wholesale trade	0.35	0.46
Administrative and waste management services	0.34	0.47

Source: Milken Institute.

6. Conclusion

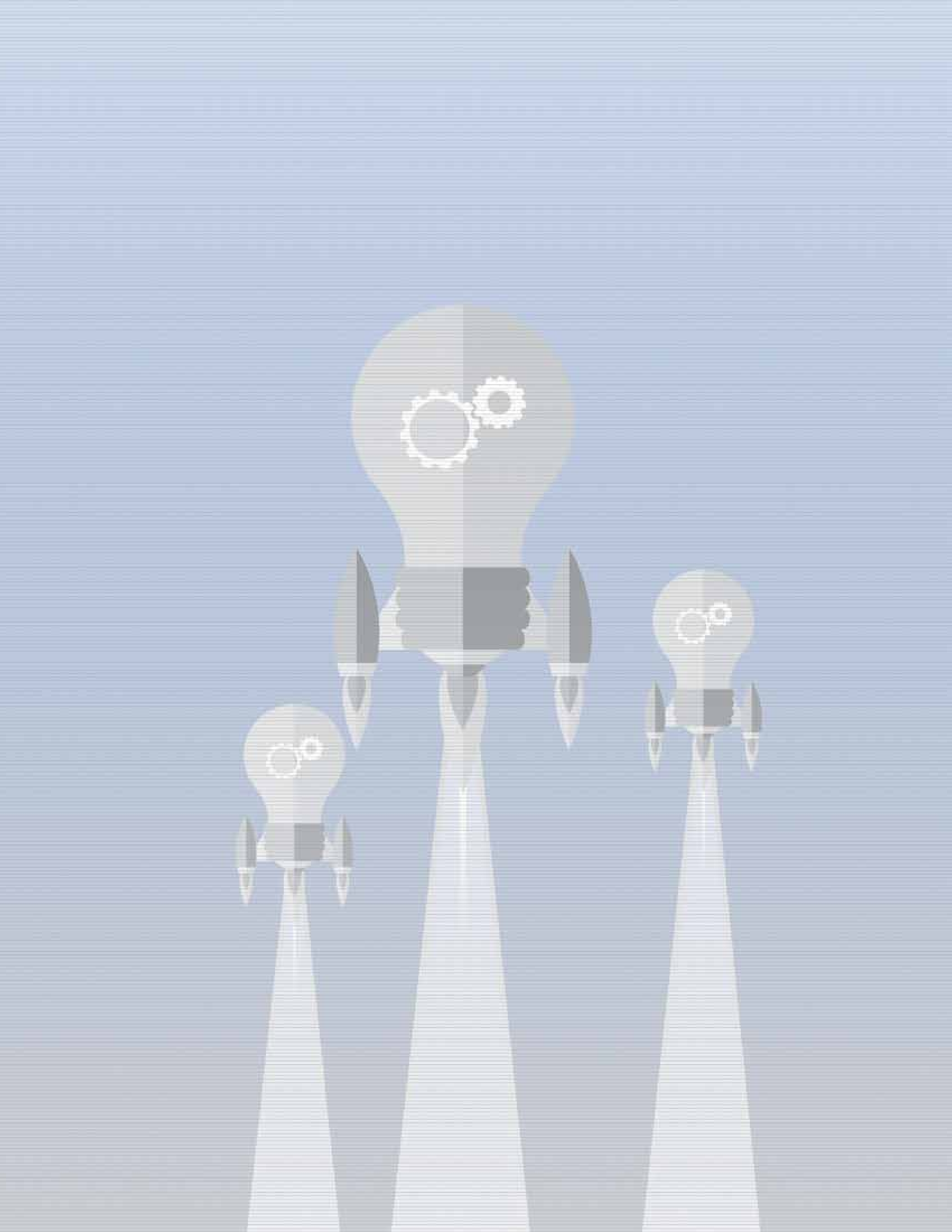
California's unique ecosystem of collaborating agents helping to bring innovations to the marketplace is its most important defense mechanism against being marginalized in a global innovation race. While California competes for innovative activities with other states, it must also evaluate its position versus other countries and their climates for innovation.

Both advanced and emerging nations see innovation as a fundamental determinant of their international competitiveness and national well-being. Whether it is the UK or China, these nations are formulating and reevaluating policies to improve their prospects in the competition for global innovation supremacy. National policies have been necessary, but local innovation-based actions also have been instrumental in determining success. California has been among the leaders in formulating innovation policies in the past. However, it must do more to remain competitive.

While officials can't alter California's high costs of doing business and onerous regulatory regime in the immediate future, other actions are possible. California has a history of incorrectly assuming that its innovation-economy architecture is solid during periods of technology-based expansion. For example, during the second half of the 1990s, as the dot-com boom was underway and tax receipts from capital gains and stock options were surging, California's policymakers didn't fully comprehend the boom's ephemeral underpinnings. Again, just before the Great Recession, when tax receipts boomed again, the technology sector seemed poised to continue its advance.

California should take bold steps to maintain and enhance its capacity for innovation and the conversion of it into commercial applications, thereby allowing firms to create high-quality jobs in the state and benefiting from the large multiplier effect associated with them. While it's true that California has long been a high-tax, high-cost place to do business, the imperative for innovation in the state can't be overstated.

The state Legislature must consider additional policies that will provide fertile ground for existing and prospective business and universities to conduct research. We believe that the policy prescriptions outlined in this report are an excellent place to start. Some might consider policies such as doubling the R&D tax credit as a tax giveaway. If so, we submit that such an inducement would be well worth the cost.

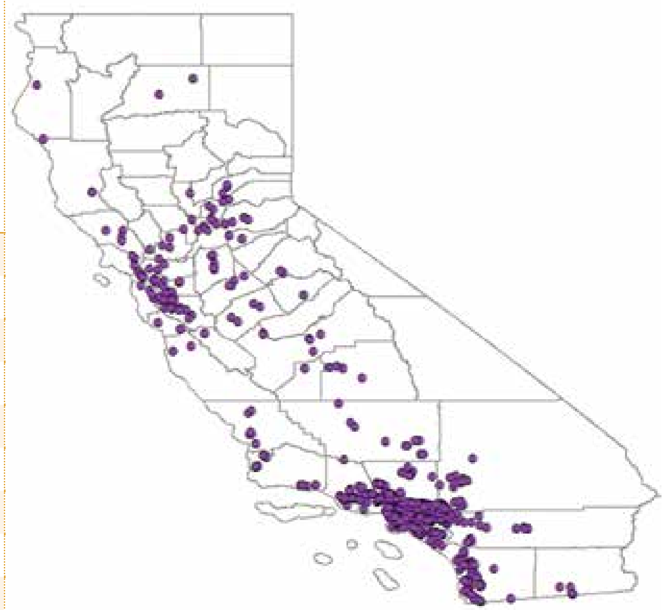


Appendixes

Appendix 1: R&D Data and Maps for Selected California Industries

A1.1 NAICS Code 3364: Aerospace product and parts manufacturing

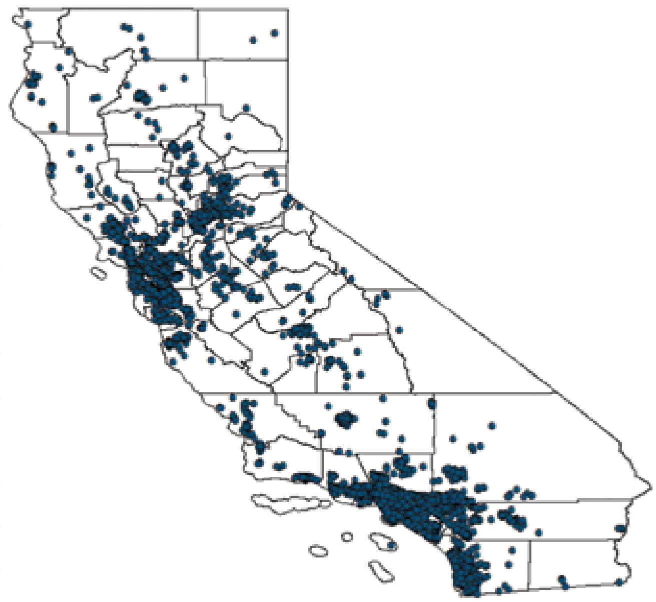
County	Companies in NAICS Code 3364	R&D spending (millions)	Spending per company (millions)
Santa Clara	27	80	2.95
Los Angeles	350	496	1.42
San Diego	68	72	1.06
Orange	158	123	0.78
Santa Barbara	13	8	0.65
Riverside	45	28	0.62
Alameda	14	8	0.59
Ventura	45	13	0.29
San Bernardino	45	10	0.23
Kern	17	2	0.13



Source: Milken Institute.

A1.2 NAICS Code 518: Data Processing, hosting, and related services

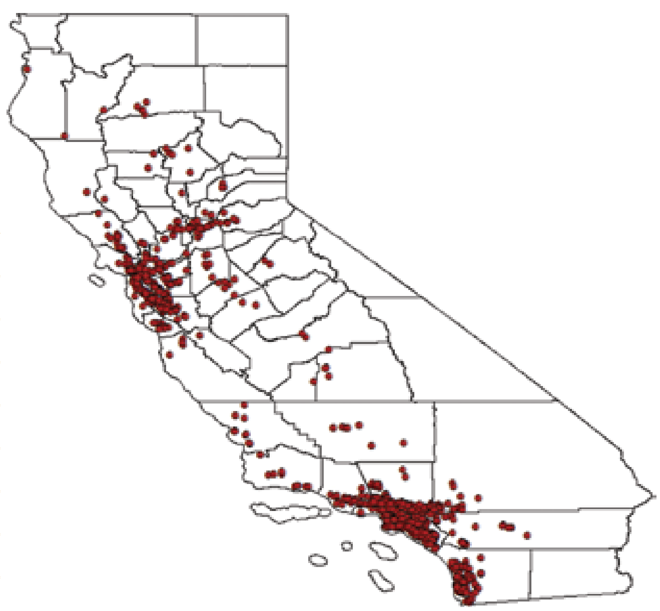
County	Companies in NAICS Code 518	R&D spending (millions)	Spending per company (millions)
Santa Clara	869	320	0.37
San Mateo	339	60	0.18
San Francisco	543	94	0.17
Sacramento	294	49	0.17
Los Angeles	2278	274	0.12
Orange	1061	115	0.11
San Diego	855	89	0.10
Alameda	415	39	0.09
San Bernardino	276	15	0.06
Riverside	262	13	0.05



Source: Milken Institute.

A1.3 NAICS Code 3254: Pharmaceutical and medicine manufacturing

County	Companies in NAICS Code 3254	R&D spending (millions)	Spending per company (millions)
Ventura	32	838	26.19
San Mateo	114	1,201	10.53
Orange	186	1,820	9.78
Contra Costa	42	324	7.72
Alameda	88	624	7.09
San Diego	259	1,770	6.83
Santa Clara	119	779	6.54
San Francisco	45	237	5.27
Los Angeles	295	1,540	5.22
San Bernardino	34	98	2.88



Source: Milken Institute.

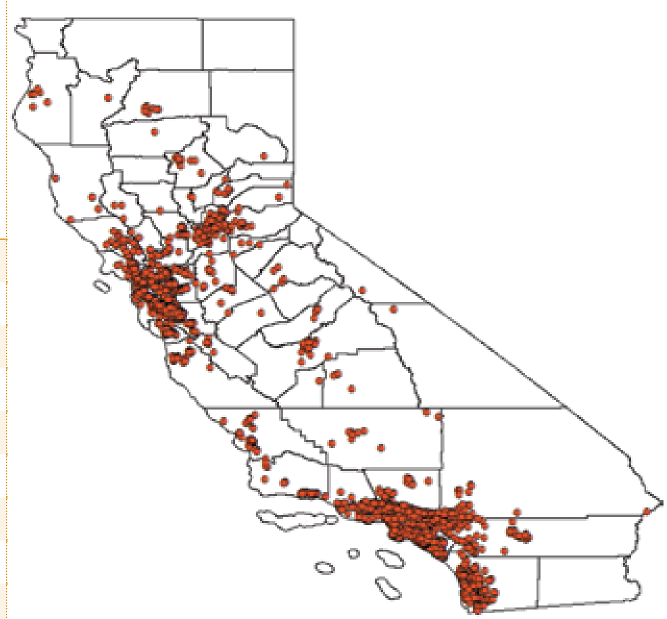
A1.4 NAICS Code 3391: Medical equipment and supplies manufacturing

County	Companies in NAICS Code 3391	R&D spending (millions)	Spending per company (millions)
San Mateo	169	224	1.33
Alameda	193	170	0.88
Orange	730	426	0.58
San Diego	486	276	0.57
Santa Clara	336	185	0.55
Los Angeles	1,268	285	0.22
Riverside	193	40	0.21
Contra Costa	146	25	0.17
San Bernardino	172	25	0.14
Sacramento	150	20	0.13

Source: Milken Institute.

A1.5 NAICS Code 5112: Software publishers

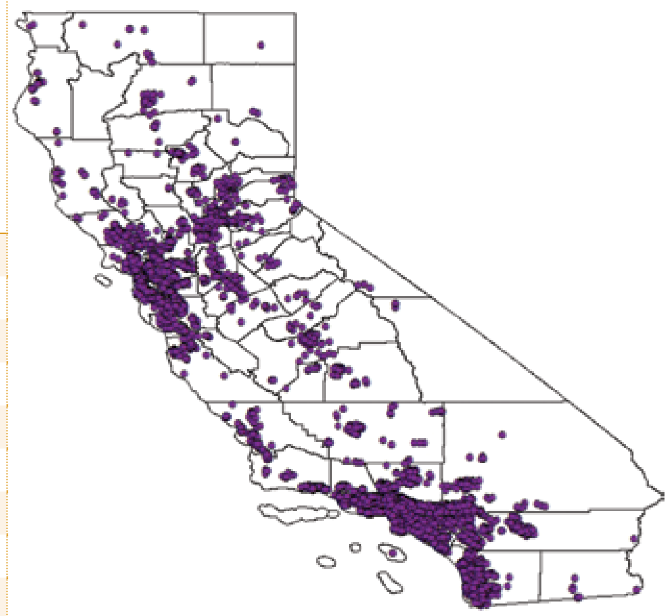
County	Companies in NAICS Code 5112	R&D spending (millions)	Spending per company (millions)
San Mateo	329	2,729	8.29
Alameda	348	715	2.05
Marin	124	224	1.81
Santa Clara	913	1,335	1.46
San Francisco	283	370	1.31
Orange	625	651	1.04
Sacramento	126	125	0.99
Los Angeles	935	759	0.81
San Diego	485	349	0.72
Contra Costa	159	101	0.63



Source: Milken Institute.

A1.6 NAICS Code 5121: Motion picture and video industries

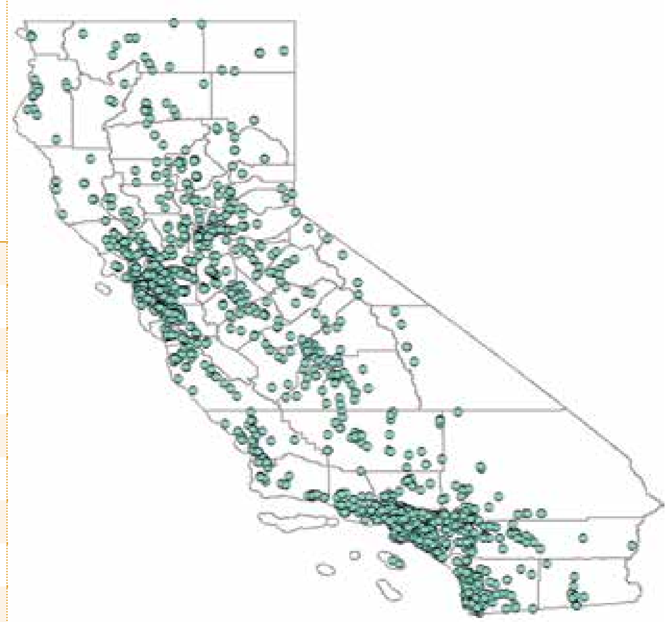
County	Companies in NAICS Code 5121	R&D spending (millions)	Spending per company (millions)
Los Angeles	16,354	2,525	0.15
San Francisco	832	84	0.10
Alameda	715	67	0.09
Sacramento	407	35	0.09
San Diego	1,319	101	0.08
Orange	1,498	115	0.08
Riverside	588	43	0.07
San Bernardino	397	25	0.06
Santa Clara	504	32	0.06
Ventura	534	32	0.06



Source: Milken Institute.

A1.7 NAICS Code 5191: Other information services

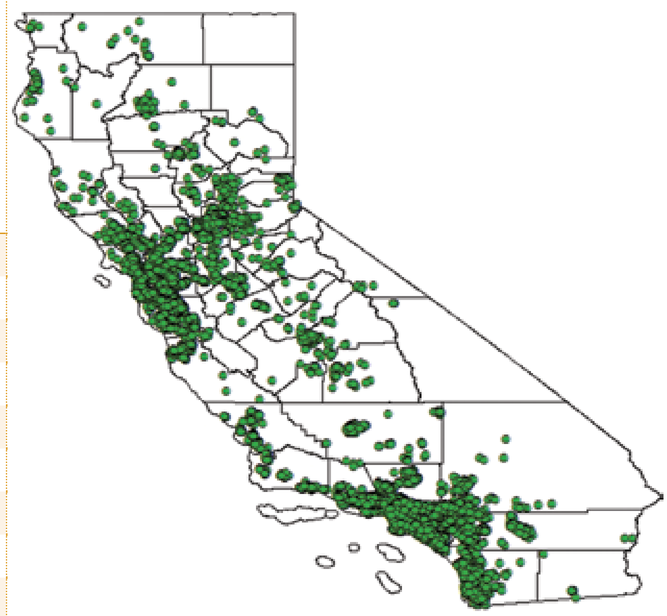
County	Companies in NAICS Code 5191	R&D spending (millions)	Spending per company (millions)
San Mateo	62	29	0.47
Sacramento	82	35	0.43
Orange	166	59	0.35
Los Angeles	659	218	0.33
Alameda	120	39	0.33
Santa Clara	133	36	0.27
San Bernardino	83	22	0.27
San Francisco	113	30	0.27
San Diego	197	47	0.24
Riverside	92	21	0.23



Source: Milken Institute.

A1.8 NAICS Code 5415: Computer systems design and related services

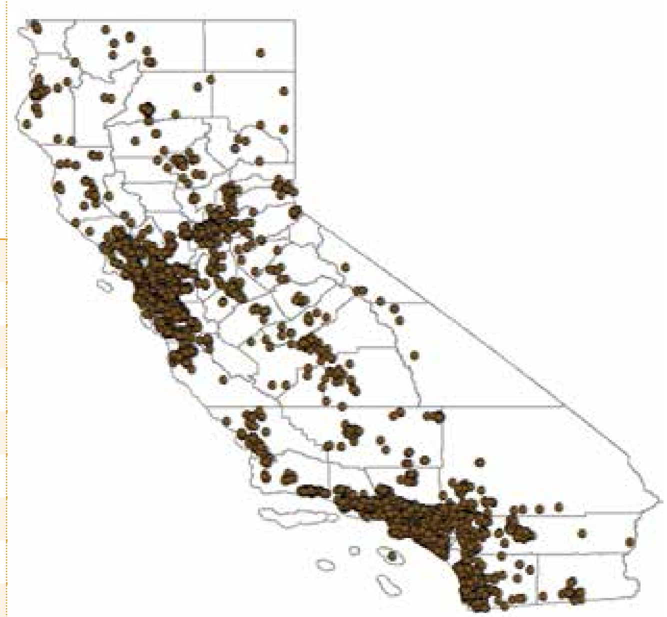
County	Companies in NAICS Code 5415	R&D spending (millions)	Spending per company (millions)
Santa Clara	3,406	796	0.23
San Mateo	1,024	184	0.18
Alameda	1,587	244	0.15
San Francisco	1,152	162	0.14
Orange	3,104	415	0.13
San Diego	2,424	284	0.12
Los Angeles	4,989	572	0.11
Sacramento	702	79	0.11
Contra Costa	819	84	0.10
Riverside	571	32	0.06



Source: Milken Institute.

A1.9 NAICS Code 5417: Scientific research and development services

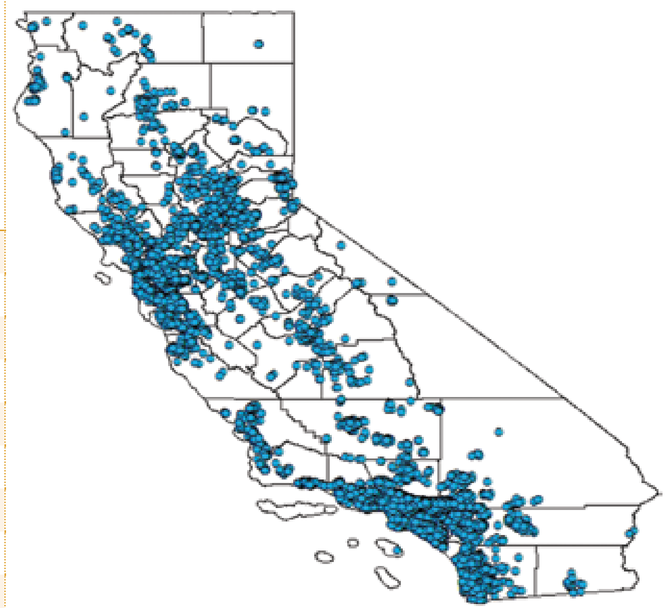
County	Companies in NAICS Code 5417	R&D spending (millions)	Spending per company (millions)
Alameda	667	291	0.44
San Diego	1,480	510	0.34
Santa Clara	938	271	0.29
San Mateo	404	90	0.22
Orange	858	116	0.14
Los Angeles	2,107	266	0.13
San Francisco	426	52	0.12
Contra Costa	250	25	0.10
Sacramento	244	21	0.08
Riverside	230	17	0.08



Source: Milken Institute.

A1.10 NAICS Code 54133: Engineering services

County	Companies in NAICS Code 54133	R&D spending (millions)	Spending per company (millions)
Sacramento	672	12	0.017
San Diego	2,182	15	0.007
Los Angeles	3,941	27	0.007
Orange	2,635	16	0.006
Contra Costa	735	4	0.006
Alameda	978	5	0.005
San Bernardino	683	3	0.005
Ventura	612	3	0.005
Santa Clara	1,430	6	0.004
Riverside	824	3	0.004



Source: Milken Institute.

Appendix 2: Private-Sector R&D Spending Estimates for California Counties

A2.1 Private-sector R&D spending estimates for California counties

FIPS11	County	Total spending 2011 (US$billions)	Percent of CA total private-sector R&D
6085	Santa Clara	13.71	21.38
6037	Los Angeles	13.11	20.45
6059	Orange	8.02	12.51
6073	San Diego	6.98	10.89
6081	San Mateo	5.17	8.06
6001	Alameda	4.83	6.99
6111	Ventura	2.36	3.69
6075	San Francisco,H6	1.47	2.29
6065	Riverside	1.24	1.94
6013	Contra Costa	1.00	1.55
6067	Sacramento	0.93	1.45
6071	San Bernardino	0.79	1.23
6083	Santa Barbara	0.64	1.00
6087	Santa Cruz	0.58	0.91
6097	Sonoma	0.46	0.71
6041	Marin	0.45	0.69
6029	Kern	0.36	0.56
6019	Fresno	0.24	0.38
6079	San Luis Obispo	0.22	0.35
6061	Placer	0.20	0.32
6095	Solano	0.20	0.31
6077	San Joaquin	0.17	0.27
6053	Monterey	0.15	0.23
6099	Stanislaus	0.13	0.20
6113	Yolo	0.10	0.15
6109	Tuolumne	0.10	0.15
6017	El Dorado	0.10	0.15
6057	Nevada	0.09	0.15
6107	Tulare	0.08	0.13
6007	Butte	0.08	0.12
6069	San Benito	0.07	0.11
6089	Shasta	0.07	0.10
6055	Napa	0.06	0.09
6047	Merced	0.04	0.06

A2.1 Private-sector R&D spending estimates for California counties

FIPS11	County	Total spending 2011 (US$billions)	Percent of CA total private-sector R&D
6023	Humboldt	35.6	0.06
6025	Imperial	33.8	0.05
6045	Mendocino	25.9	0.04
6039	Madera	23.2	0.04
6031	Kings	20.3	0.03
6101	Sutter	17.1	0.03
6033	Lake	14.3	0.02
6005	Amador	11.7	0.02
6115	Yuba	10.2	0.02
6093	Siskiyou	9.2	0.01
6009	Calaveras	8.9	0.01
6103	Tehama	8.2	0.01
6027	Inyo	5.7	0.01
6063	Plumas	5.2	0.01
6043	Mariposa	5.0	0.01
6015	Del Norte	4.5	0.01
6011	Colusa	4.4	0.01
6051	Mono	3.9	0.01
6035	Lassen	3.8	0.01
6021	Glenn	3.8	0.01
6105	Trinity	3.2	0.00
6049	Modoc	3.1	0.00
6091	Sierra	1.5	0.00
6003	Alpine	0.2	0.00

Source: Milken Institute.

Endnotes

1. Kevin Klowden, Kristen Keough, and Jason Barrett, “2014 State Tech and Science Index: Enduring Lessons for the Intangible economy,” Milken Institute, December 2014.
2. Ross DeVol and Perry Wong, “America’s High-Tech Economy: Growth, Development and Risks for Metropolitan Economies,” Milken Institute, July 1999, p. 17.
3. Barry Pearton, “Reshaping Shenzhen: Turning a New Page,” Asia Today International, August/September 2012, pp. 8-9.
4. http://www.revenue.pa.gov/GeneralTaxInformation/News%20and%20Statistics/Documents/RD%20 Reports/2015_rd_report.pdf
5. Joseph A. Schumpeter, *The Theory of Economic Development*, (Cambridge, MA: Harvard University Press, 1942).
6. Philippe Aghion and Peter Howitt, *The Economics of Growth*, (Cambridge, MA: MIT Press, 2009), pp. 85-99.
7. Robert Solow, “Technology Change and the Aggregate Production Function,” *Review of Economics and Statistics* 1957, 39: pp. 312–320.
8. Paul Romer, “Increasing Returns and Long-Run Growth,” *Journal of Political Econom*y 94, no. 5 (1986), pp. 1002-37; Romer, “Endogenous Technological Change,” *Journal of Political Economy* 98, no. 5 (1990), pp. 71-102; Manuel Castells, The Rise of the Network Society, 2nd ed. (Milden, MA: Blackwell Publishers, 2000)
9. Charles R. Hulten, “Total Factor Productivity: A Short Biography,” NBER working paper no. 7471, January 2000, and Hulten, E.R. Dean, and M. J. Harper, *New Directions in Productivity Analysis: Studies in Income and Wealth* (Chicago: University of Chicago Press for the National Bureau of Economic Research, 2001).
10. Romer, “Increasing Returns and Long-Run Growth” and “Endogenous Technological Change.”
11. Daniel Bell, *The Coming of the Post-Industrial Society: A Venture in Social Forecasting*, (New York: Basic Books, 1973)
12. Benjamin Russo, “A Cost-Benefit Analysis of R&D Tax Incentives,” Canadian Journal of Economics 37, no. 2 (2004), pp. 313-335.
13. Anwar Shah, “The Economics of Research and Development: How Research and Development Capital Affects Production and Markets and Is Affected by Tax Incentives,” World Bank, Policy Research Working Paper 1325, June 1994.
14. Benjamin Yeo, “Developing a Sustainable Knowledge Economy: An Investigation of Contextual Factors,” (Germany: VDM Publishing, 2009)
15. OECD “Economics: Innovation Central to Boosting Growth and Jobs,” news release, May 27, 2010 http://www.oecd.org/newsroom/economicsinnovationcentraltoboostinggrowthandjobs.htm
16. Luke A. Stewart, Jacek Warda, and Robert D. Atkinson, “We’re #27!: The United States Lags Far Behind in R&D Tax Incentive Generosity,” Information Technology & Innovation Foundation, July 2012, p. 2.
17. Lewis Branscomb and Richard Florida, *Investing in Innovation: Creating A Research and Innovation Policy That Works*, (Cambridge: MIT Press, 1998).
18. Jeffrey I. Bernstein and M. Ishaq Nadiri, “Interindustry R&D Spillovers, Rates of Return, and Production in High-Tech Industries,” *American Economic Association Papers and Proceedings*, May 1988, Vol. 78, no. 2.
19. Robert D. Atkinson and Stephen J. Ezell, *Innovation Economics: The Race for Global Advantage*, Yale University Press: New Haven and London, 2012, pp. 144-145.

20. Robert Atkinson, "Expanding the R&D Tax Credit to Drive Innovation, Competitiveness, and Prosperity," *Journal of Technology Transfer* 32 (2007), 617-628.

21. Charles Berube and Pierre Mohnen, "Are Firms That Receive R&D Subsidies More Innovative?" *Canadian Journal of Economics* 42, no. 1 (2009), pp. 206-225.

22. Benjamin Russo, "A Cost-Benefit Analysis of R&D Tax Incentives," *Canadian Journal of Economics* 37, no. 2 (2004), pp. 313-335.

23. Michael Porter, *On Competition*, (Boston: Harvard Business Review Book Series, 1998).

24. Michael Porter, "Competitive Advantage, Agglomeration Economies and Regional Policy," *International Regional Science Review* 19 (1-2).

25. Ross DeVol and Perry Wong, "America's High-Tech Economy: Growth, Development and Risks for Metropolitan Economies," Milken Institute, July 1999, pp. 39-42.

26. Richard Florida, "The Spiky World of Innovation: Metro Areas Generate 93 Percent of the World's Patented Inventions," *The Atlantic, City Lab*, April 3, 2012. http://www.citylab.com/work/2012/04/spiky-world-innovation/1592/

27. Paul Krugman, "Increasing Returns and Economic Geography," *Journal of Political Economy*, 99 (3) 1999.

28. A.B. Jaffe, "Real Effects of Academic Research," *American Economic Review*, 79(5), 1989, pp. 957-970.

29. David Audretsch and Maryann Feldman, "R&D Spillovers and the Geography of Innovation and Production," *American Economic Review*, Vol. 86, no. 3 (June 1996), pp. 630-640.

30. A.B. Jaffe, M. Trajtenberg and R. Henderson, "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," *Quarterly Journal of Economics*, 108, (1993), pp. 957-970.

31. David Audretsch and Maryann Feldman, "Innovation in Cities: Science-Based Diversity, Specialization, and Localized Competition," *European Economic Review*, 43, (1999) pp. 409-429.

32. Ross DeVol, I-Ling Shen, Armen Bedroussian, and Nan Zhang, "A Matter of Degrees: The Effect of Education Attainment and Regional Economic Prosperity," Milken Institute, February 2013, pp. 49-54.

33. See K. Meagher and M. Rodgers, "Network Density and R&D Spillovers," *Journal of Economic Behavior and Organization*, Vol. 53, 2004, pp. 237-260. Also C. Beaudry, S. Breschi, and G.M.P. Swann, "Clusters, Innovation and Growth: A Comparative Study of Two European Countries," in J.H. Dunning and J.L. Mucchielli (editors) Multinational Firms: The Global-Local Dilemma, (London: Routledge 2001) pp. 190-214, and R. Baptista and G.M.P. Swann, "The Dynamics of Firm Growth and Entry in Industrial Clusters: A Comparison of the U.S. and U.K. Computer Industries," Journal of Evolutionary Economics, 9(3), 1999, pp. 373-99. For a broader review of the literature, please see Thomas Döring and Jan Schnellebach, "What Do We Know About Geographic Knowledge Spillovers and Regional Growth? A Survey of the Literature," Deutsche Bank Research Notes, Working Paper Series, October 2004, No. 14, pp. 1-33.

34. Mark Muro, Jonathan Rothwell, Scott Andes, Kenan Fikri, and Siddharth Kulkarni, "America's Advanced Industries: What They Are, Where They Are, and Why They Matter," Brookings, February 2015, pp. 12-13.

35. Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference*, (Back Bay Books, 2000).

36. Michael Porter and Scott Stern, "The New Challenge to America's Prosperity: Findings from the Innovation Index" (Council on Competitiveness, 1999).

37. AnnaLee Saxenian, *Regional Competitive Advantage: Culture and Competition in Silicon Valley and Route 128*, (Cambridge, MA: Harvard University Press, 1994).

38. Richard Florida, "Startup City: The Urban Shift in Venture Capital and High Technology," Martin Prosperity Institute, University of Toronto, May 2014, pp. 12-16.

39. Paul D. Reynolds and Michael Hay, "Global Entrepreneurship Monitor: 1999 Executive Report," Kauffman Center for Entrepreneurial Leadership at the Ewing Marion Kauffman Foundation, 1999.

40. Ross DeVol et al., "Manufacturing Matters: California's Performance and Prospects", Milken Institute, 2002.

41. Paul Krugman, "What's New About the New Economic Geography?," *Oxford Review of Economic Policy* 14, no. 2, 1998.

42. Antonio Ciccone and Robert Hall, "Productivity and the Density of Economic Activity," *American Economic Review* 86 (1), 1996, pp. 54-70.

43. David P. Angel, "High-Technology Agglomeration and the Labor Market," *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region*, ed. Martin Kenney,(Redwood City: Stanford University Press, 2000).

44. J.S. Holiday, *The World Rushed In: The California Gold Rush Experience*, First Touchstone Edition, New York; Simon and Schuster, 1983.

45. Rob Koepp, *Clusters of Creativity: Enduring Lessons on Innovation and Entrepreneurship fromSilicon Valley and Europe's Silicon Fen*, Cambridge, England; Cambridge Press, 2002.

46. Joel Kotkin, "Why California's Salad Days Have Wilted," Orange County Register, April 13, 2015. http://www.joelkotkin.com/content/001068-why-californias-salad-days-have-wilted

47. R.N. Kostoff , "Successful Innovation: Lessons from the Literature," *Research-Technology Management* 60, no. 1, (1994)

48. Jane Jacobs, *The Economies of Citie*s, (New York: Vintage Books, 1968)

49. See http://statetechandscience.org/statetech.taf?page=overall-ranking&composite=tcci&sub2=htnaics

50. Ross DeVol and Armen Bedroussian, "Mind-to-Market: A Global Analysis of University Biotechnology Transfer and Commercialization," Milken Institute, 2006, p. 55

51. Ross DeVol, Minoli Ratnatunga, and Armen Bedroussian, "Best-Performing Cities: Where America's Jobs Are Created and Sustained," Milken Institute, January 2014, p. 14.

52. Ross DeVol, Perry Wong, Junghoon Ki, Armen Bedroussian, and Rob Koepp, "America's Biotech and Life Sciences Clusters: San Diego's Position and Economic Contributions," Milken Institute, 2004, p. 3.

53. Ross DeVol, Minoli Ratnatunga, and Armen Bedroussian, "Best-Performing Cities: Where America's Jobs Are Created and Sustained," Milken Institute, January 2015, p. 10. http://www.best-cities.org/2014/best-performing-cities-report-2014.pdf

54. Robert Atkinson and Adams Nager, "The 2014 State New Economy Index," Information Technology and Innovation Foundation, June 2014, p. 18.

55. Arthur Laffer, Stephen Moore, and Jonathan Williams, "Rich States, Poor States," 8th Edition, ALEC-Laffer State Economic Competitiveness Index, American Legislative Exchange Council (ALEC), 2015.

56. Scott Drenkard and Joseph Henchman, "2015 State Business Tax Climate Index," Tax Foundation, October 28, 2014.

57. Douglas Lindholm, Ferdinand Hogroian, and Fredrick Nicely, "The Best and Worst of State Tax Administration: Cost Scorecard on Tax Appeals & Procedural Requirements," Council on State Taxation, December 2013.

58. Frank Conte, "14th Annual State Competiveness Report," Beacon Hill Institute for Public Policy Research, 2014.

59. http://www.forbes.com/best-states-for-business/

60. http://www.cnbc.com/2015/06/24/americas-top-states-for-business.html

61. Tyler Case, "U.S. Cost of Doing Business: Costs Fall in 2010," Moody's Analytics, *Regional Financial Review*, September 2012.

62. National Science Foundation/National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey, 2011. http://www.nsf.gov/statistics/2015/nsf15307/pdf/tab19.pdf

63. Walls & Associates, National Establishment Time Series database 2012 edition, containing data up to 2011.

64. Walls & Associates creates NETS by using Dun & Bradstreet (D&B) establishment data records to build a time-series database of establishment information.

65. List of included NAICS codes based on the National Science Foundation R&D spending breakdown by state: 311, 312, 313–316, 321, 322, 323, 324, 3251, 3252, 3253, 3254, 3256, 3255, 3259, 326, 327, 331, 332, 33311, 333295, 3336, other 333, 342, 3344, 334510, 334517, 334511, other 3345, other 334, 335, 3361–3363, 3364, 336992, other 336, 337, 3391, 3399, 21, 22, 23, 42, 44, 45, 48, 49, 5111, 5112, 517, 518, other 51, 52, 53, 5413, 5415, 541711, 541712, 54171, 541720, other 54, 621–623, 55, 56, 624, 71, 72, 81.

66. The Moody's GDP data was only available for California counties at the four-digit NAICS code level so there were some differences to the NETS data, which was able to go into more detail using 6-digit NAICS codes. However, these were in areas where we could identify which sub-industries were likely to be causing the discrepancy.

67. List of included NAICS codes based on the National Science Foundation R&D spending breakdown by state with four-digit NAICS codes: 311, 312, 313-316, 321, 322, 323, 324, 3251, 3252, 3253, 3254, 3256, 3255, 3259, 326, 327, 331, 332, 3331, 3332, 3336, Other 333, 3342, 3344, 3345, Other 334, 335, 3361-3363, 3364, 3369, Other 336, 337, 3391, 3399, 21, 22, 23, 42, 44, 45, 48, 49, 5111, 5112, 517, 518, Other 51, 52, 53, 5413, 5415, 5417, Other 54, 621-623, 55, 56, 624, 71, 72, 81.

68. Only NAICS codes used in occupation analysis: 5417, 3245.

69. California Department of Finance, "California County Population Estimates and Components of Change by Year—July 1, 2010-2014" http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/view.php (accessed July 10, 2015).

70. See Deloitte, "2014 Global Survey of R&D Tax Incentives," March 2014 for an overview of credit programs in different countries, including the United States.

71. State of California Franchise Tax Board, "Research and Development Tax Credit: Frequently Asked Questions," 2008. https://www.ftb.ca.gov/forms/misc/1082.pdf (accessed August 31, 2015).

72. Yonghong Wu, "The Effects of State R&D Tax Credits in Stimulating Private R&D Expenditure: A Cross-State Empirical Analysis," *Journal of Policy Analysis and Management*, Vol. 24, No. 4, 2005, pp. 758-802.

73. Lolita Paff, "State-Level R&D Tax Credits: A Firm-Level Analysis," *Topics in Economic Analysis & Policy*, Volume 5, Issue 1, 2005, pp. 1-25.

74. Daniel Wilson, "Beggar thy Neighbor? The In-State, Out-of-State, and Aggregate Effects of R&D Tax Credits," *Federal Reserve Working Paper Series*, April 2006. It should be noted that Wilson's model specification suggests there was evidence of state tax credits being a "zero-sum game" in that increases in R&D spending in one state were offset to some extent by reductions in other states. However, his results are "on average" across all states. California can be considered to be different because it is a nation-state in term of R&D activity, ranking 5th (after the U.S., China, Japan and Germany) in the world on R&D expenditures. California can attract foreign-based firms' R&D activities with its breadth and depth.

75. Andrew Chang, "Tax Policy Endogeneity: Evidence from R&D Tax Credits," *Finance and Economics Discussion Series* (FEDS), Working Paper Series, Federal Reserve Board, November 21, 2014.

76. See Jennifer Weiner, "State Business Tax Incentives: Examining Evidence of their Effectiveness," New England Public Policy Center, Federal Reserve Bank of Boston, Discussion Paper 09-3, December 2009 for a review of state-specific studies on R&D tax credits.

77. California's ratio of R&D expenditures over GDP was 3.4; the ratio was 1.6 for the U.S. in 2011. See Wolfe, Raymond and Shackelford, Brandon, "2011 Data Show U.S. Business R&D Highly Concentrated by State and Metropolitan Location," *InfoBrief*, National Center for Science and Engineering Statistics, August 2014.

78. Pennsylvania Department of Revenue Bureau of Research, "Report to the Pennsylvania General Assembly on the Research and Development (R&D) Tax Credit," March 13, 2015.

79. Ibid.

80. California Franchise Tax Board, "Research and Development Credits Applied by Industrial Sector," Exhibit B-3, April 24, 2015.

81. Ibid.

82. Here we take the Small Business Administration definition of a small business as having fewer than 500 employees.

83. Kevin L. Kliesen and Julia S. Maués, "Are Small Businesses the Biggest Producers of Jobs?", *The Regional Economist*, Federal Reserve Bank of St. Louis, April 2011.

84. Maryland Department of Business and Economic Development, Research and Development Tax Credit. http://business.maryland.gov/fund/programs-for-businesses/research-and-development-tax-credit#sthash.KobLXgDS.dpuf (accessed August 28, 2015).

85. http://business.maryland.gov/Documents/FinanceDocument/RDTC-Statutes.pdf (accessed August 25, 2015).

86. California Franchise Tax Board, "Table C-8 Tax Liability by State Net Income Class, All Corporations", 2012 Annual Report—Statistical Appendix Tables. Available at https://www.ftb.ca.gov/aboutFTB/Tax_Statistics/2012.shtml (accessed August 31, 2015).

87. See analysis by Carlos Anguiano for the California Senate Appropriations Committee for Assembly Bill 437, available at https://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=201520160AB437# (accessed October 20, 2015).

88. State of California Franchise Tax Board, "Research and Development Tax Credit: Frequently Asked Questions," 2008. https://www.ftb.ca.gov/forms/misc/1082.pdf (accessed August 31, 2015).

89. National Science Foundation/National Center for Science and Engineering Statistics and U.S. Census Bureau, Business R&D and Innovation Survey, 2011.

90. Federal Basic Research Funding by Performer, http://www.aaas.org/page/historical-trends-federal-rd (accessed September 15, 2015).

91. See analysis by Roger Dunstan for the California Assembly Committee on Appropriations hearing on January 23, 2014, for Assembly Bill 653 available at http://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=201320140AB653 (accessed 8/31/2015).

92. Ross DeVol et al., "Jobs for America: Investments and Policies for Economic Growth and Competitiveness," Milken Institute, 2010.

93. Utilization in the most recent tax year for which data was available was used, rather than research.

94. This is lower than the 4.8 percent annual growth in credits claimed that the California Legislative Analyst Office estimated when discussing future utilization of the research tax credit in "The 2014-15 Budget: California's Fiscal Outlook" in November 2013.

95. Bronwyn H. Hall and Marta Woskinska, "Effectiveness of the California R&D Tax Credit," California Council on Science and Technology, 1999.

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