

Index of the Massachusetts Innovation Economy



MASSACHUSETTS
TECHNOLOGY
COLLABORATIVE

John Adams Innovation Institute



**The Index of the Massachusetts Innovation Economy,
published annually since 1997, is the premier fact-based
benchmark for measuring the performance of the
Massachusetts knowledge economy.**

Message from the Governor

Dear Friends:

It is my pleasure to introduce the **2009 Index of the Massachusetts Innovation Economy**. The **Index**, published annually by MTC's John Adams Innovation Institute, is the Commonwealth's instrument to benchmark our research and innovation enterprise against other leading technology states and nations and better understand its impact on the state's economy.



The **Index** highlights key trends and themes affecting the state's Innovation Economy and helps inform fact-based decision-making among Massachusetts' policymakers, industry practitioners, and academic leaders. This year, as the global recession continues to present challenges to people in communities throughout the state, we have become more aware than ever of how the state's research and innovation enterprise is a source of renewal and resiliency in times of crisis.

This year the **Index** offers further evidence of our pride in being a world leader in research and innovation. At the same time, it highlights areas of concern. The **Index** makes it clear, for example, that many high school students in the state lack an interest in pursuing science, technology, engineering and math (STEM) careers. In response to this challenge, last October we established the STEM Education Advisory Council to help coordinate initiatives, resources and goals among STEM advocates from the public and private sectors.

Like every year, the **Index** serves as a reminder of the need to engage in creative efforts to expand the opportunities of the Innovation Economy to more communities and citizens across the state. A promising initiative in this regard is the historic collaboration between leading research universities, corporations, and state government to establish a Green High Performance Computing Center in Holyoke. This initiative has the potential to catalyze a revival of that city's economy and transform the economic development trajectory of the Pioneer Valley.

I am encouraged by a renewed spirit of collaboration that is bringing together citizens and leaders from industry, academia, and government. As the Commonwealth continues on the road to sustainable prosperity, let us keep working together with confidence to strengthen Massachusetts' position as a global hub of research and innovation.

Sincerely,

A handwritten signature in black ink, appearing to read "Deval Patrick".

Governor Deval Patrick

The Massachusetts Technology Collaborative



The Massachusetts Technology Collaborative is a public economic development agency chartered by the Commonwealth to promote new economic opportunity and foster a more favorable environment for the formation, retention, and expansion of technology-related enterprises in Massachusetts.

MTC serves as a catalyst in growing the knowledge- and technology-based industries that comprise the state's Innovation Economy. It is working with major healthcare organizations to implement e-health solutions that save lives and reduce costs. The agency is aggressively pursuing federal funding to support economic development in Massachusetts through the American Recovery and Reinvestment Act of 2009. MTC's rich history of successfully managing complex projects that involve significant public and private investment have positioned the agency to serve as an important conduit for infusions of funding into the Commonwealth.

Working through its major divisions—the John Adams Innovation Institute, the Massachusetts e-Health Institute, and the Massachusetts Broadband Institute—the agency is strengthening the innovation economy by supporting and expanding economic clusters.

John Adams Innovation Institute



As the economic development division of the Massachusetts Technology Collaborative, the Innovation Institute is the Commonwealth's leading science, technology, and innovation policy agent which fosters the vitality and capacity for self-renewal of the Massachusetts Innovation Economy. We work to ensure the health and vibrancy of the Massachusetts innovation ecosystem.

Working closely with academics, industry practitioners and government officials, region by region and sector by sector, the Innovation Institute's mission is to enhance the capacity of the Massachusetts economy to sustain an ongoing flow of innovation which is crucial to create, attract, and grow companies in emerging and established industries.

To fulfill our purpose, the Innovation Institute partners and invests with academic, research, business, government, and civic organizations that share the vision of enhancing the Massachusetts Innovation Economy.

Our main target areas for partnership and investment include:

- Organizing for Innovation
- Innovation Capacity
- Statewide Innovation Initiatives
- Understanding the Massachusetts Innovation Economy

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Introduction and Highlights



Introduction

The **Index of the Massachusetts Innovation Economy** is an annual opportunity to assess the Commonwealth's economic progress and its changing competitive position. Through 25 indicators, the **Index** gives a comprehensive view of several dimensions of the innovation ecosystem. Using a rich set of US-based data sources, the **Index** benchmarks Massachusetts against nine Leading Technology States (LTS) to reveal relative strengths and weaknesses. The nine LTS chosen for comparison in the 2009 **Index** are California, Connecticut, Illinois, Maryland, Minnesota, New Jersey, New York, Pennsylvania, and Virginia.

To gain the nuanced perspective that only practitioners can provide, the **Index** also hosts guest commentaries from thought leaders working at the frontlines of innovation throughout the Commonwealth. Through the commentaries we also seek to highlight a subject matter of current relevance to decision makers across the Commonwealth. This year the theme is Massachusetts in the Global Economy, taking up once again a subject first discussed in the 2007 edition. To further complement this perspective, the 2009 edition includes international comparisons throughout the indicators where quality data are available.

When compared to countries around the world, Massachusetts comes out on top in terms of the amount of research and development performed as a percent of gross domestic product. However, many regions around the world are quickly catching up. This is most notable in South Korea, where the R&D intensity of the economy is growing at a rate higher than in Massachusetts. In 2004, South Korea surpassed the US average in R&D as a percent of GDP.

The key industry clusters of the Innovation Economy were less susceptible to the economic perturbations caused by the financial crisis than other sectors of the Massachusetts economy.

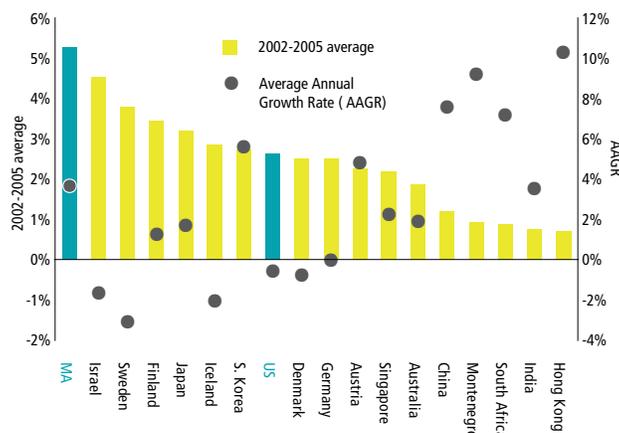
Jobs in the key innovation industry clusters were lost at about half the rate as in the economy as a whole. Consequently, Massachusetts' key clusters of the Innovation Economy continued to rise as a share of total employment. They also provide a large portion of the high-skill, high-wage jobs. In these ways, the core clusters of the Innovation Economy have contributed to Massachusetts comparative economic stability among the states. In Massachusetts, there was a 6% decline total wages and salaries paid in inflation-adjusted dollars from the last quarter of 2007 to the second quarter of 2009 – a smaller decline than the US or LTS average.

Highlights

The 2009 **Index** reveals a Massachusetts economy that is world-class by many measurements, leading in key indicators and cushioning the Massachusetts economy from some of the harshest effects of the current economic downturn. However, the **Index** also reveals several weaknesses that suggest avenues for improving performance.

Massachusetts is a world leader in research and development (R&D); however, some countries are making large gains in this arena.

R&D as a percent of GDP, international and Massachusetts, 2003–2007



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) and the National Science Foundation

Massachusetts shows no signs of a retreat from innovation.

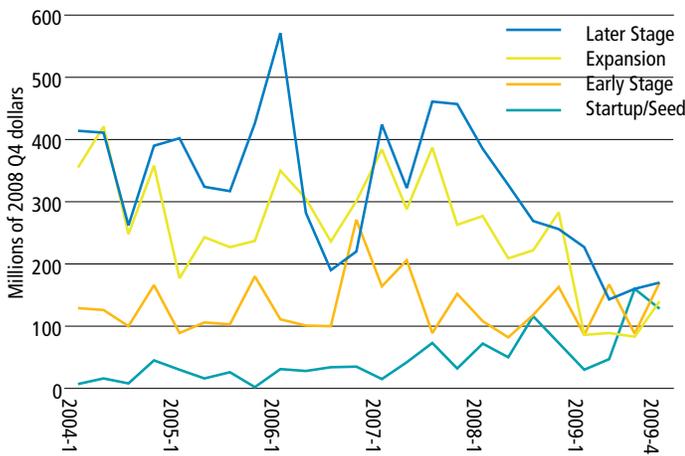
In this year's **Index**, there is evidence of confidence in the research and innovation enterprise. Last year, data raised concerns about declining performance across some measures of early-stage innovation activity, particularly patents and pre-market regulatory approvals of medical devices. However, this year's **Index** shows better performance on these measures. From 2007 to 2008, patenting held steady in Massachusetts while patenting declined nationally. Massachusetts companies also had more pre-market approvals of medical devices than any of the other LTS in 2008, more than making up for the absence of approvals in 2007. Other signs of confidence include a nearly 50% rise from 2002 to 2007 in industry-performed R&D as a percent of private industry output, a record high in 2008 in corporate R&D expenditures by publicly-traded companies based in Massachusetts, and the lead among the LTS in R&D performed by academic and nonprofit research institutes as a share of GDP. R&D at these institutions totals \$4.5 billion and rose 16% in inflation-adjusted dollars from 2002 to 2007.

New business formation is expected to be a critical element of economic recovery as Massachusetts emerges from recession.

Enhancing the environment for new business formation needs to be a key element of any strategy for economic recovery. Historically, new business formation accounts for 30-45% of all new jobs. The sharp increase in new business formation in 2007 was consistent with other indicators tracked in the Index which showed renewed strength in many of Massachusetts' key industry clusters beginning in 2007 and going into the most recent recession. The 2009 Index shows that Massachusetts lagged behind most of the LTS in creating new businesses and the resulting new jobs coming out of the 2001 recession. While the Greater Boston area has long been viewed as a hotbed for new business formation, this data suggests the need to enhance the entrepreneurial environment throughout the Commonwealth coming out of the recession.

Total Venture capital (VC) flows have receded but VC investment in startup and early-stage firms is the highest it has been in years.

Venture capital investment by stage of financing, Massachusetts, 2004–2009

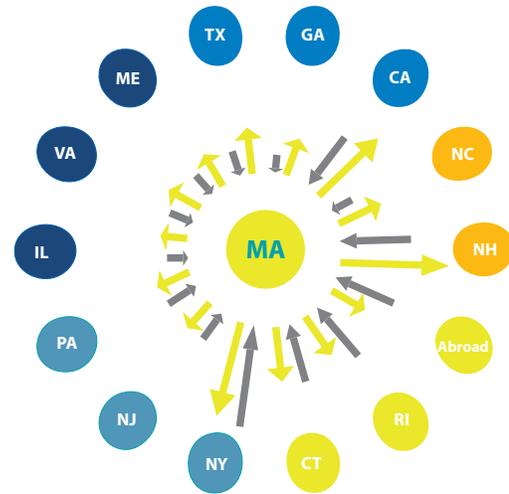


Source: PricewaterhouseCoopers MoneyTree Report

Nationally, the dollar amount raised by venture funds dropped 57% in the last quarter of 2008 and remains low. Not surprisingly, the amount of VC invested in Massachusetts-based firms was 35% lower in 2009 than in 2008. However, the amount of VC investment going to startup/seed and early stage firms in Massachusetts was higher in the last three quarters of 2009 than in any quarter in over ten years. The 3rd quarter of 2009 stands out as the highest quarter of startup/seed investments in recent history, at which time over \$161 million was invested in new businesses.

Massachusetts' score in attracting and retaining population is the best it has been in a decade.

Migration in and out of Massachusetts, top regions, 2006–2007



Source: The Internal Revenue Service, based on exemption numbers

In 2008, the number of people who relocated to Massachusetts outnumbered those moving out for the first time in six years, reaching levels comparable to those attained in the mid to late 1990s. For years, Massachusetts had been doing well at attracting highly-educated people, but losing population overall.

High school seniors in Massachusetts express below average interest in fields essential to the Innovation Economy.

Despite above average scores in math and science advanced placement tests, high school seniors in Massachusetts express below average interest in engineering, computer & information science and health & biological science degrees. This is especially significant since Health; Life, Physical, & Social Sciences; and Information Technology are among the fastest growing occupational groups in the state. Employment growth was positive in these occupational groups from 2003 to 2008 and employment is growing faster in these groups than in the US and LTS on average.

Massachusetts Performance at a Glance



The **Index** examines the Massachusetts Innovation Economy through 25 indicators. This chart provides an overview of the direction of year-over-year change for Massachusetts.

Direction of Year-Over-Year Change for Massachusetts

- ▲ up
- ▼ down

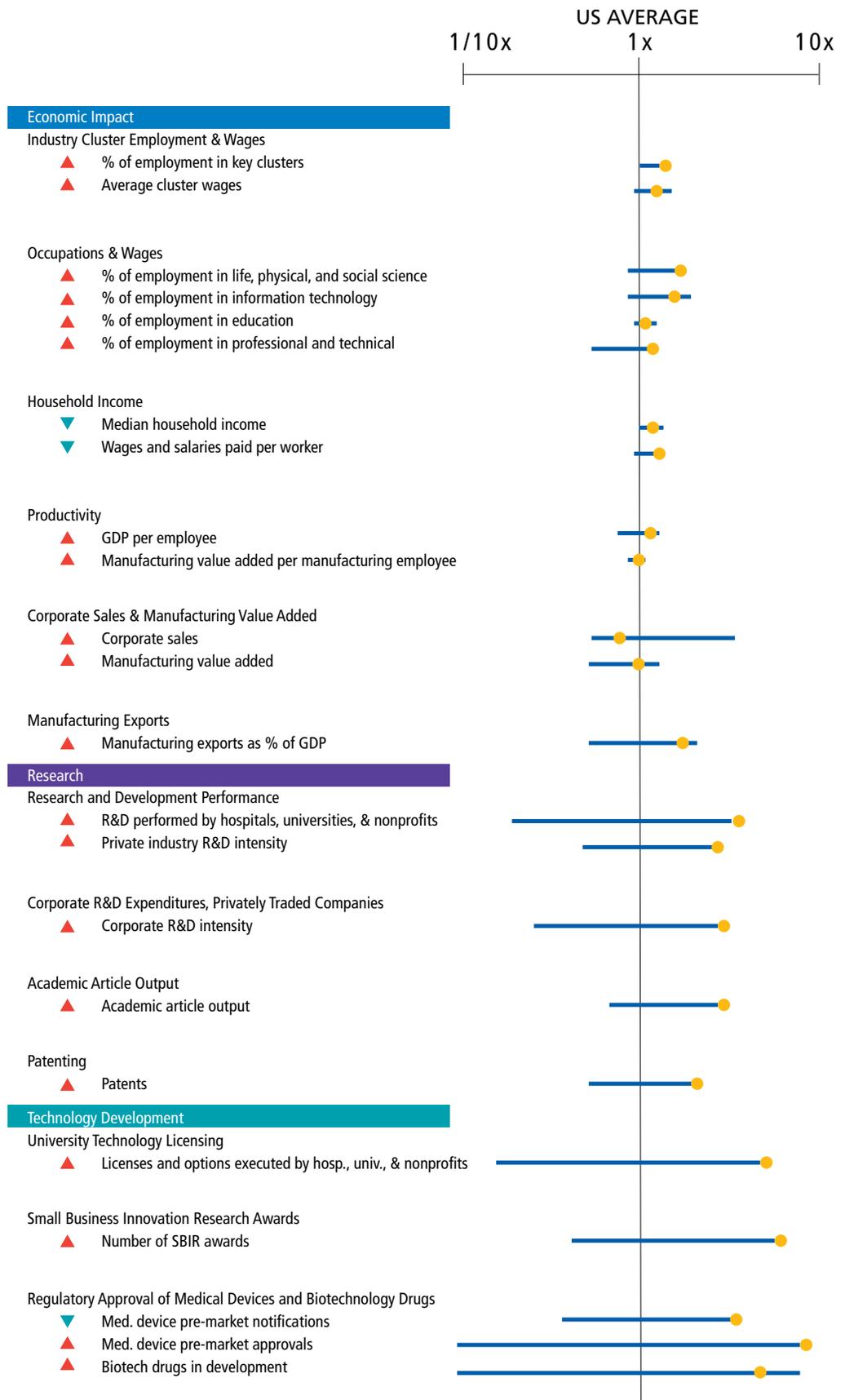
The chart also depicts Massachusetts' performance on each indicator relative to the performance of the Leading Technology States (LTS). The chart shows Massachusetts' performance as a fraction of the US average.

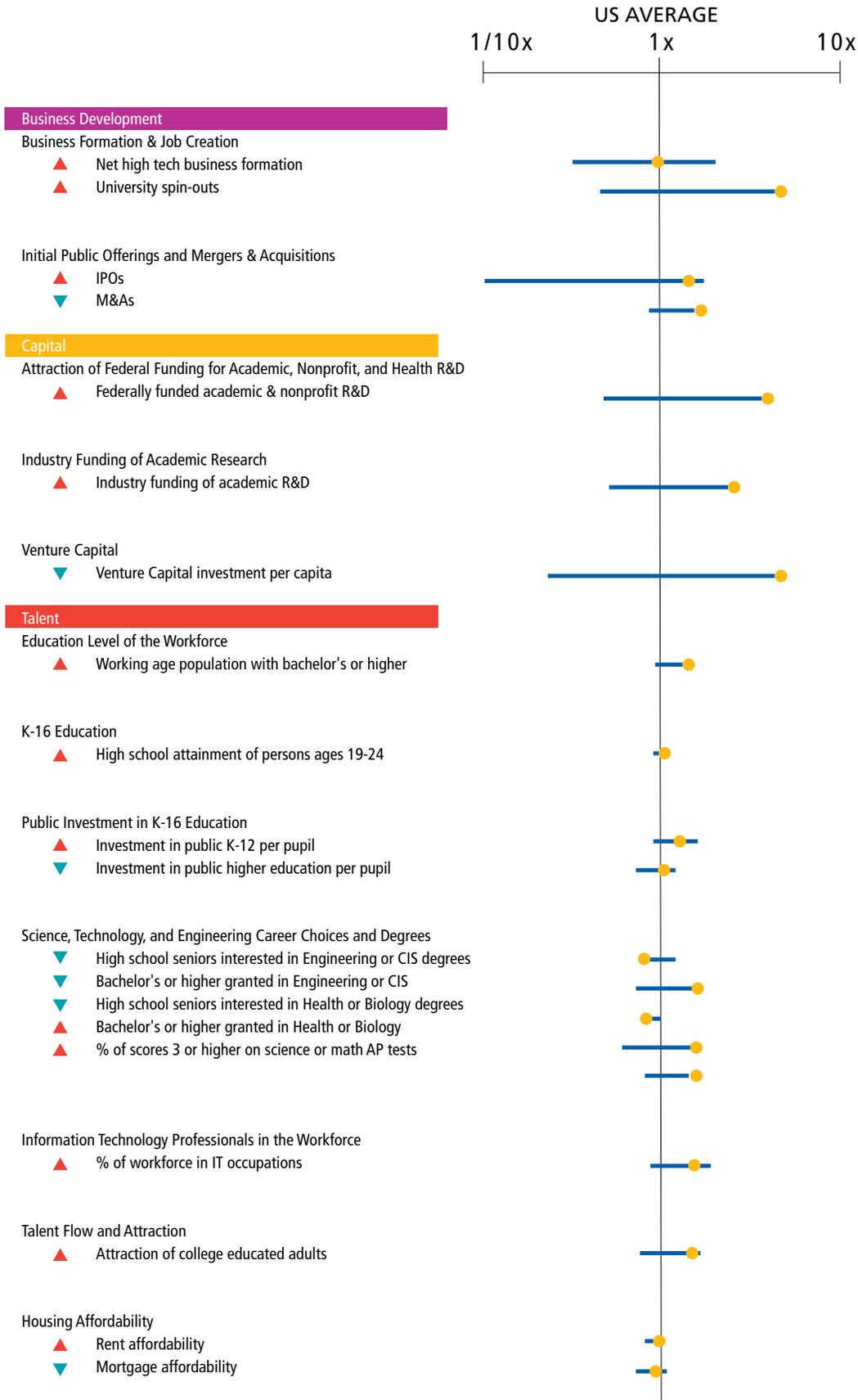
All comparisons are per capita except where otherwise indicated.

MA and the LTS compared to the US Average

- LTS Range
- MA

Together these chart elements reveal the complex picture of Massachusetts' performance. Massachusetts may rank at the top of the LTS on an indicator, but still have declined in the most recent year of data.





Massachusetts in the Global Economy

Introduction to the special analysis



ast year, the **Index** was released amidst the worst economic downturn since the Great Depression. In that context, we knew that the **Index's** indicators

did not yet capture the impact of the recession on the innovation ecosystem. So, we invited commentators to reflect on the question: "What can we do to preserve and strengthen the vitality of the Massachusetts innovation ecosystem even during tough economic times?" Our motivation was straightforward: this ecosystem sustains the self-renewal capacity of our economy and nurtures the innovation-intensive companies, universities, and hospitals that account for almost 40% of jobs in the Commonwealth.

In response, our commentators conveyed an important message. To sustain innovation and the long-term viability of our economy, they said we need to accomplish three things. First, we need to collaborate more. Second, we need to continue investing in innovation. Third, and most importantly, we need to maintain our optimism, confidence, and distinctive focus on the future.

This year, the context of the **Index** is a fragile and uncertain recovery with widespread and continued hardship for Massachusetts' citizens and businesses. No sector of our economy or society has been spared and the state's government is reckoning with a revenue crisis. And, as highlights in this publication's pages show, the performance of the Massachusetts Innovation Economy is mixed: it includes many measures with impressive results that place Massachusetts at the top nationally and internationally, but there are also clear signals that are cause for concern and careful review.

Looking back since the release of last year's **Index**, the research, innovation and entrepreneurship communities in Massachusetts have responded to the crisis as commentators suggested, with more collaboration, a sustained commitment to innovation, and most importantly, with optimism and confidence.

This unwavering commitment to innovation has made of Massachusetts a vivid example of what observers of economic development refer to as the greatest paradox of globalization: the emergence of sub-national regions as key economic units and engines of prosperity. One author has called successful regions the "locomotives" of national economies. Two key insights that build on this observation assert that success in the global economy hinges on vibrant regional economies and, in turn, this success is enhanced when regional economies successfully insert themselves into global flows of capital, ideas, and talented individuals.

With this in mind, this year's **Index** reopens a conversation started three years ago in its 2007 edition which advanced important understandings about Massachusetts in the global economy. This conversation echoes a current policy priority for the Commonwealth. During the last few months, the state's Executive Office of Housing and Economic Development has spearheaded an effort to better understand and leverage the state's resources to implement a strategic policy approach for the internationalization of the Massachusetts economy.

This year, the **Index** offers a global perspective in two ways. First, we take steps to incorporate international comparisons within individual indicators. In doing so, we have had the following question in mind: If Massachusetts were a country, how would it perform in key measures of the innovation ecosystem when compared against top international performers? We were able to answer this question with precision only where comprehensive and comparable data were available which occurs in six of the twenty-five indicators.

The second way in which this year's **Index** offers a global perspective is by inviting reflection from those who work on the frontlines of innovation. We are privileged

to host commentaries from individuals who bring a truly global perspective and are themselves living examples of a global spirit in Massachusetts. Michael Greeley was born in New York but grew up in Hong Kong. Pascal Marmier is a Swiss diplomat. David Meeker writes from the perspective of an actively globalizing company. After attending graduate school in the United States, both Harry West of Great Britain and Bernd Widdig of Germany chose to stay in Massachusetts.

We approached these individuals with the following questions to invite reflection: Through your eyes, what is the place of Massachusetts in the global economy? What are the strengths and weaknesses of the Massachusetts innovation ecosystem for enhancing our place in the world?

Each commentator views the world through a unique lens and addresses a different segment of the landscape of our innovation ecosystem: venture capital, diplomacy, medicine, design, and higher education. But, within the uniqueness of their perspectives, there is a common thread. Each of them speaks of the ways in which the global and the local aspects of innovation and competitiveness are deeply and synergistically intertwined.

First, we learn from all of them that the most forward-looking innovation remains a profoundly localized phenomenon even in the phase of globalization. For Massachusetts, this means that the strengths and weaknesses of our innovation ecosystem both enable and constrain the ability of individuals and organizations in the Commonwealth to operate in the global economy. Second, together they tell us that for individuals and organizations alike operating in the global economy requires an understanding of the societies and the cultures where individuals and organizations work and the ability to work across geographic, cultural and disciplinary boundaries. Finally, we hear once again that openness, connectedness, and collaboration enhance the ability of individuals, groups, and organizations to innovate.

All of them, without exception, highlight the concentration of some of the brightest men and women from all over the world as one of Massachusetts' greatest strengths. It is also here that some express concerns. Michael Greeley wonders whether non-compete agreements make some entrepreneurs chose California over Massachusetts, and expresses disappointment at the ability of Massachusetts start-ups to retain talented men and women due to limitations in federal visa policies. Bernd Widdig speaks for more awareness and more investment to expand the reach of the international education experience. Students need to be better prepared to work in an environment in which "the spirit of innovation knows no national boundaries". Harry West calls on Massachusetts to showcase its assets and compete forcefully to attract the world's best design-minded people. In his words: "Massachusetts can and must compete as a place where the most precious of natural resources—energetic, creative people—want to be."

The response to the recession has called on everyone in the United States and the Commonwealth to take a hard look within. But as the economy turns around, there will be new opportunities for prosperity, many of which will be realized through the full and strategic embrace of our global potential. This year's Index is an invitation to join a conversation and to work together to better understand Massachusetts' place in the global economy. How can we amplify, accelerate and leverage the self-organizing capacity in our innovation ecosystem to better pursue the economic opportunities that globalization affords? ■

Why "Massachusetts in the Global Economy"?

Carlos Martínez-Vela, Director of Innovation Policy, MTC's John Adams Innovation Institute



Throughout the Commonwealth's history, waves of immigrant entrepreneurs from a wide array of nations joined arrivals from the British Isles to enable Massachusetts' emergence as an industrial and economic powerhouse. In the 18th century, immigrants from mainland Portugal, the Azores, and Cape Verde were inextricably linked to New Bedford's dominance in whaling. In the 19th century, Lowell's destiny as a textile industry hub was built upon the work of French Canadians, Eastern Europeans, Greeks, Portuguese, and many others at the mills. Today, Lowell is home to one of the United States largest concentrations of Cambodian immigrants. Like many other towns and cities today, Lowell and New Bedford are called home by many of Latin American origin and descent. Both cities are among Massachusetts' twenty-four "Gateway Cities" because they continue to be entry points into the social and economic promise of Massachusetts for many immigrants.

In the two hundred years since Lowell's entrepreneurs helped launch the Industrial Revolution in the United States, Massachusetts reputation as a revolutionary and global epicenter of innovation has only been strengthened. Now, rather than whaling or maritime trade, it is the intensity and quality of our innovation ecosystem that makes Massachusetts a hub in the global networks of capital, knowledge, and people. The Massachusetts Innovation Economy attracts—and contributes—a disproportionate share of the global flows of investment, ideas, and talented individuals who fuel innovation.

Consider our research universities, now among the most global of enterprises. For decades they have increasingly become magnets that attract some of the brightest men and women from around the world. At MIT, for example, about

40% of graduate students and 10% of undergraduates were foreign nationals during the 2008-2009 academic year. Moreover, scientific research has never conformed to traditional boundaries be they organizational, regional, or national. This connectedness of the Commonwealth's research and innovation enterprise is magnified today by the global scope and impact of some of the world's most pressing challenges and promising opportunities. The imagination of students, scientists, and innovators everywhere is being captured by problems ranging from energy and climate to national security, from stubborn diseases to the alleviation of poverty.

The same is true of our business community. For Massachusetts-based corporations, expanding and competing globally and operating in foreign markets has long been a necessary focus for growth and, increasingly, for innovation. Perhaps less known are the many start-ups and young companies that are equally global in scope. Consider also the magnetic power of the Massachusetts Innovation Economy as a whole, evinced by the location decisions of some of the world's most prominent innovation-intensive businesses. Many continue to choose Massachusetts as a location for R&D facilities. Examples include the Novartis Institutes for Biomedical Research (biopharmaceutical, Swiss), the Schlumberger-Doll Research Center (oilfield services, Dutch), the Nokia Research Center (telecommunications, Finnish), and a branch of Vestas Technology R&D Americas (renewable energy, Danish).

It is no coincidence that many foreign governments maintain a formal presence in Massachusetts with specialized personnel devoted to building bridges with the state's research and innovation enterprise, including Canada, France, Germany, Japan, Norway, South Korea, Spain, Switzerland, and the United Kingdom. These countries are here partly because they want to join the innovation conversation, to be plugged

in to our Innovation Economy, and to build bridges of mutual understanding and collaboration. They want to learn what it means to build a research and innovation enterprise that is also a centerpiece of economic prosperity.

Businesses, universities, government, and communities across the state are now more deeply aware than ever of the place of innovation, regionalism, and industry clusters as cornerstones of economic growth. This inner strength also gives the Commonwealth its prominent place in the global economy. It enhances the ability of Massachusetts-based companies to compete globally by providing close and immediate access to the creativity of the best people and their best ideas. It drives the location decisions of foreign-owned corporations when they decide to establish R&D outposts in Massachusetts. It motivates the research, innovation, and entrepreneurship communities from all over the world to partner with and invest in Massachusetts. It inspires men and women to be here.

But we must not allow any of this to be taken for granted. Competition is intensifying as regions and countries around the world pursue innovation as an economic development strategy. Others are striving to create their own innovation ecosystems and competing for a share of the same capital, the same entrepreneurs, the same businesses, and the same talented individuals that today choose Massachusetts. Thus, it is vital to remain committed to strengthening the research and innovation enterprise while thinking strategically about how to leverage its connectedness to increase its magnetic power in the global economy.

This can be accomplished only with deep, empirical knowledge of how the Massachusetts Innovation Economy works, industry by industry. We need a better sector-by-sector understanding of value chains in order to identify gaps and

strategically attract to the Commonwealth, in a highly selective and targeted way, those functions (i.e. research, prototyping, manufacturing) and business segments that are likely to enhance innovation and competitiveness on an industry-specific basis. To ensure job creation as part of this strategy, we need to understand better the labor-intensity of each segment of an industry's value chain to set expectations right. We also need to be attentive to the natural tendency of some corporations and other institutions to bring their R&D operations to Massachusetts or to partner with Massachusetts institutions for research and innovation. There may be ways to accelerate and amplify these processes and extend them beyond R&D for greater job creation.

As vital as research and innovation are for our economy, we face an imperative to figure out how to improve the capturing of "downstream economic benefits"—including, but not ending, with jobs—from research and innovation and to do so more equitably across regions of the Commonwealth beyond Greater Boston.

To be sure, the effects of economic development are always local and manifest themselves one person, one business, one community at a time. But this reality can either tempt or mislead many to isolate and retreat from globalization. The history of innovation in the Massachusetts economy and the voices in the pages ahead show that today, perhaps more than ever before, the prosperity of the Commonwealth remains profoundly linked to the global economy while standing upon the strength of our Innovation Economy. ■

Investing in Innovation

Michael Greeley, General Partner, Flybridge Capital Partners



Massachusetts is one of the leading global centers of innovation. Twelve research universities with over 25,000 graduate students, a plethora of research institutes, leading multinational corporations and service providers (lawyers, accountants, consultants), an abundance of technical talent, and numerous start-ups are concentrated here. In 2006, the total expenditures on R&D performed in Massachusetts reached \$20.6 billion. In 2007, federal, state, industry, academic, and nonprofit organizations attracted \$6.7 billion in federal funds for R&D. Companies in Massachusetts invested another \$13.2 billion.

Importantly, Massachusetts has a long-established culture of entrepreneurship that has fueled the formation of clusters of new industries, including the well-known life sciences sector. Cloud computing, online video, marketing technologies, gaming and businesses at the intersection of IT and life sciences place us at the forefront of innovation in digital technology. It is also, arguably, the most active robotics region in the world.

A strong venture capital industry remains an essential part of the Massachusetts innovation ecosystem and one of our key assets in the global economy. According to the Organization for Economic Cooperation and Development, the US accounted for 49% of total venture capital investments in OECD countries (the UK was a distant second with 10%). Within the United States, Massachusetts companies alone attracted 11% of the US share.

The venture capital model as we know it was invented in Massachusetts. In 1946, a group of business and university leaders founded the American Research & Development Corporation (ARDC), a new mechanism to fund and nurture new businesses. With the economy struggling to recover from the Great Depression and the demise of traditional New England industries, these visionaries had a larger ambition: to revitalize the New England economy and its scientific and technological expertise to create new industries.

Sixty years after its founding, ARDC's legacy continues. Over 100 venture capital firms now call Massachusetts their home. From 1970 to 2008, venture capitalists worldwide invested \$50.4 billion in 2,764 Massachusetts companies. In 2008 alone, 346 companies in Massachusetts received \$3 billion in venture capital – at \$460 per capita, well ahead of all other states.

While Massachusetts retains a prominent place in the venture capital marketplace, its leadership is being challenged. Massachusetts' \$3 billion in venture investments in 2008 is a distant second to California's \$14.3 billion. Both states continue to attract venture capital investments at almost four times the rate of the nation as a whole, but the California share of all venture capital investments rose from 38% in 1998 to over 50% in 2008. The share of venture investing going to Massachusetts companies during the same period grew only from 9.6% to 10.5%. And according to the National Venture Capital Association (NVCA), there were 3,192 companies which attracted venture investments in 2008, but only 11% were in Massachusetts.

In the \$197 billion US venture capital industry, the top five states in the US represented nearly 82% of all venture capital managed in 2008. Local venture capital firms managed \$36 billion in 2008, or 18%. So, while local companies face tough competition to get investor attention, a meaningful portion of the venture capital industry is still managed in Massachusetts. However, only \$3.5 billion of the \$27.9 billion of new commitments to venture funds in 2008 (or 12.5%) were made to Massachusetts-based venture capitalists.

The composition of the venture investment portfolio in Massachusetts has changed significantly in recent years. Once heavily oriented toward digital technology, it is now concentrated in the biotech sector, accounting for 31% of all venture capital invested in Massachusetts companies. The software, medical devices, and IT services sectors followed with 20%, 9% and 7% respectively.

Future industry commentators will look back on 2009 as the year when the broader venture capital industry was fundamentally redefined by global economic crisis and unprecedented volatility in global capital markets. The US venture capital industry raised only \$13 billion for new investment, less than half of what it had raised in 2008.

Nationwide, the industry is confronting a number of significant issues, many of which stem from the lack of predictable and meaningful opportunities for liquidity events. The venture capital model is predicated on both the ability of portfolio companies to attract new investors as these companies mature, as well as to be sold in a vibrant M&A auction or taken public in an IPO. Years ago, there were a number of structural reforms which largely dismantled Wall Street's ability to take smaller, private venture-backed companies public. These reforms have impaired the ability of venture capital firms to generate liquidity for their limited partners, in turn dramatically reducing venture capital firms' investment returns. As a result, many limited partners have reduced their overall allocations to venture funds, which is further driving the rapid industry consolidation we are witnessing today. The era of billion dollar venture funds is effectively over. Average fund sizes will be more in line with the \$50 million per investment partner metric or \$150 to \$400 million of capital per fund.

These developments have now triggered debate as to what the successful venture capital model will be going forward. How these debates evolve will undoubtedly have consequences for Massachusetts. But looking to our history, we see a venture capital industry in Massachusetts with a remarkable ability to re-invent itself when confronted with headwinds.

Today, Massachusetts has a few unique factors which influence limited partners' perceptions of the local investment climate. Many analysts focus on the impact of "non-compete" agreements which are not recognized in California. It is time to examine objectively how non-competes

affect our own start-up environment. Many investors are also disappointed with federal visa policies: Massachusetts educates some of the most talented students from around the world, but struggles to retain them upon graduation, limiting the talent pool to staff local start-ups quickly and efficiently.

It is important that limited partners continue to recognize that Massachusetts has a vibrant, early-stage business community. This past year has seen a resurgence of start-up activity and the emergence of entrepreneurial and networking events like Mobile Mondays, Xconomy, Stay In Massachusetts, and TechStars to name a few. Importantly, we have seen the return of angel investors and the emergence of new investment and mentoring models such as Founders Collective, Launch Capital, Start@Spark, and CRV QuickStart.

Innovation does not conform to geographic borders and can occur anywhere. The last decade saw the exportation of the venture capital model to emerging international markets like India and China. Despite this, many firms continue to view venture investing as a local business, best practiced close to home. The next decade is likely to see further retrenchment of the venture capital industry in historic centers of excellence like Silicon Valley and Boston as the industry consolidates further. A future successful venture capital model will continue to work best when all of the required ingredients of the entrepreneurial ecosystem are in place. This certainly remains the case in Massachusetts. ■

Michael A. Greeley is the founder and general partner of Flybridge Capital Partners, a leading early stage venture capital firm based in Boston. He is the Chairman of the New England Venture Capital Association and a director on the board of the National Venture Capital Association.

Connecting the Dots

Pascal Marmier, Director/Consul, swissnex Boston, Consulate of Switzerland



For nearly a decade, swissnex Boston has been building bridges of knowledge exchange between Switzerland and New England—“connecting the dots” among individuals, organizations and universities in science, technology and innovation. Yet when we opened our doors in 2000, it was unclear what would emerge from our small, loft-style office at 420 Broadway in Cambridge.

Given our location, we imagined that local students and scholars would enjoy sharing in our panels, conferences, exhibits and discussions. What we did not anticipate was the process—and the many activities—that this first attempt to create a “science consulate” put in motion. Today, we’ve engaged in far larger circles than expected and have partnered with numerous organizations interested in providing support and ideas to build connections to other innovation centers.

As we plan our ten-year anniversary on October 10, 2010, we recognize that our location in Massachusetts and Greater Boston, the “brain hub” of New England, has redefined how the Swiss government and our stakeholders think, act and plan for innovation. We also recognize that we have become part of the fabric of the region’s innovation ecosystem, and that we contribute to its connectedness and global spirit.

Knowing the ‘software’

It is easy to discover the “hardware” of the Boston area’s innovation economy. Any website can list the unparalleled sources of new ideas and technology here (universities, hospitals, research institutions), the abundant financial resources available for entrepreneurs to transform ideas into products, and the companies that move these inventions to the marketplace. Yet such a list does not offer an understanding of the “software”: the people and organizations bringing this innovation economy to life.

Over the years, I’ve encountered a fascinating array of pacesetters with expertise on commercializing technologies and building organizations that maximize the potential of new products. These innovators evince the truly collaborative spirit of Boston. It is this spirit that makes our location viable and valuable. I can’t count the number of people who have come into our office, volunteered their time, and enlightened our guests—ranging from entrepreneurs and students, to corporate executives and government representatives.

Yet, given that the world has become so complex, finding new ways to collaborate is essential. Indeed, those who master the art of searching for, finding and combining complementary assets, regardless of location, are at an advantage. In the future, technology might become a combination of different fields and the research taking place at various universities worldwide, and its commercial success might depend on a joint effort from even more people.

Consequently, the first step to mastering this art is to help people meet each other to start connecting the dots. In this regard, swissnex Boston regularly hosts seminars and workshops in collaboration with our Swiss and American industrial and academic partners. Most recently, we’ve focused on the new trends of innovation partnerships in a troubled economy.

Offering world-class contacts and support to our Swiss partners is what Boston has allowed us to do. To this end, we’ve catalyzed successful partnerships among universities, companies and other organizations active in science and technology on both sides of the Atlantic. For example, a collaborative platform on nanotechnology started after discussions among Swiss and Boston-area scientists held at swissnex Boston. Additionally, executives from Swiss pharma companies traveling to Boston often contact us to arrange workshops where they can connect to the leaders in their field.

One of our key annual programs—a two-week “boot camp” that brings Swiss entrepreneurs to Massachusetts—has significantly benefited from the expertise of local technology and business experts who have shared their knowhow in marketing innovative products. In hosting this yearly boot camp, we’ve created a well-connected alumni community of venture leaders who can now share their expertise with each other and bring to Switzerland an added value from their stay in the USA. The boot camp even provides contacts and builds relationships for startups seeking to site their activities here.

Massachusetts also benefits from these connections. Dialogue and collaboration are at the heart of what we do at swissnex Boston and, as Massachusetts Housing and Economic Development Secretary Gregory Bialecki recently said, these are the kinds of discussions that ensure Massachusetts remains well-connected to places where other brilliant minds operate. Our efforts in promoting Swiss universities and universities of applied sciences, especially in Engineering and Business, have led to partnership agreements with local schools. And apart from supporting startups, we are delighted with our increasing connections to small and medium-sized enterprises thanks to the newly established Boston chapter of the Swiss American Chamber of Commerce.

Apart from these pursuits, the area’s collective knowledge and collaborative spirit have benefited our unique business model. A science and technology consulate such as ours found its natural home in the New England ecosystem. We are fortunate that visiting scientists and entrepreneurs take the time to stop at our office and “connect the dots” with others. Our network of “scientific diplomacy” has grown, and the model born in Boston nine years ago has been exported to other strategic hubs of science and technology such as San Francisco, Shanghai, Singapore and recently Bangalore.

Measuring success

Despite tangible achievements, however, we are often asked: “How do you really know that you’re successful?” This has been a recurrent challenge. At swissnex Boston, we track several metrics that measure our visibility and collaboration. For instance, our mailing list boasts more than 5,000 members, and we organize or co-host more than 70 events annually, ranging from delegation visits of Swiss universities to concerts on the Charles River.

It stands to reason, however, that innovation is so multifaceted that numbers are seldom sufficient to illustrate success. Indeed, the innovation economy is fueled by intangibles. So, for us, the value of the conversations we trigger—conversations that lead to enduring relationships and knowledge transfer, and ultimately to the building of a transatlantic community—is incalculable.

Learning from our experiences, we are ready to accompany the next generation of leaders in the challenges of the knowledge economy. Innovation is about change, and that is why swissnex Boston has made the strategic decision to be flexible and opportunistic. This allows us to explore new topics and pursue opportunities that are calling for collaboration and which demand our attention as they emerge.

As we celebrate our tenth anniversary, we are proud to have promoted Swiss innovation and higher education for nearly a decade, and we are pleased to contribute to the global spirit and connectedness of Greater Boston. ■

Pascal Marmier is the Director and Consul of Switzerland at swissnex Boston, a unique private-public partnership dedicated to facilitating collaboration between New England, Eastern Canada and Switzerland in all fields related to science, technology and innovation.

Bringing Massachusetts Innovation to Patients Worldwide

David Meeker, Executive Vice President and Chief Operating Officer, Genzyme Corporation



Genzyme is a health care company dedicated to developing and delivering innovative solutions for unmet medical needs.

From the beginning, we understood the responsibility of any company producing a unique, potentially life saving therapy to make that therapy accessible to patients in need around the globe. However, health is not simply a global issue, it is also a highly personal matter. In working to reach patients worldwide, we sought to do so in a way that allowed us to truly understand the health care needs of different local populations and serve them accordingly.

We have done this by establishing ourselves in countries around the world, not through satellite offices staffed by Americans, but by hiring local talent that understands the health care system and the regulatory and governmental environments that need to be navigated in order to ensure the best possible service to patients. We have structured ourselves in a way that gives each country organization the independence and flexibility to adapt to varying health care dynamics, to truly be “French in France,” and “Brazilian in Brazil.”

In establishing ourselves as an international corporation, as opposed to a US company with international offices, we facilitated drug development through our ability to more effectively run international clinical trials, establish scientific ties with researchers around the globe and build relationships with patient organizations in many countries. This has helped differentiate Genzyme from other biotechnology and pharmaceutical companies, and has been the foundation for our global success.

Our international expansion began with the acquisitions of two UK companies made within the first year of our founding in Boston in 1981. The purchase of Whatman Biochemicals Ltd. brought Genzyme manufacturing facilities and marketed products that served as the basis for the company’s business in diagnostic products. Through the acquisition of Koch Light Laboratories, Genzyme established a presence in Haverhill, UK, where we now manufacture Renvela and Renagel, Genzyme’s leading therapies for kidney disease patients. In 1987, prior to the approval of our first product, we became the first US-based biotech company to open an office in Japan. Over the last two decades, we have continued to expand our global presence, and now have more than 85 locations in over 40 countries. We have continued to pursue this strategy, establishing a strong commercial presence in Russia, India and China. Our Chinese investment includes the building of a \$100 million R&D center in Beijing, where we recently laid the corner stone for the new facility.

We established an early global presence because we understood that developing potentially life saving therapies carries with it the responsibility to ensure that the treatment is made available to everyone who can benefit from it, regardless of where they live or their economic circumstances. In creating access, we seek to partner with local health care authorities to optimize the health outcomes of their citizens. Local investments in the countries where we do business strengthen these partnerships. We have built and/or expanded manufacturing facilities in the UK, Ireland, France and Belgium in addition to establishing R&D facilities in the UK and the planned site in China. These locations also provide access

to favorable business environments, lower costs, strong government cooperation, and access to a highly trained workforce and potential partners.

Importantly, Genzyme's success in building a global health care company links directly to the advantages afforded by the Massachusetts life sciences community. This state is uniquely positioned to facilitate success in the life sciences, with its wealth of universities, hospitals and research institutions. These world-class organizations attract the best physicians and scientists from around the globe, which creates an environment capable of fostering innovation and development. The Massachusetts life sciences community is a leader in the global health care community and consequently it is no accident that so many biotech and pharmaceutical companies have placed research facilities here.

Although we appreciate the value of our global investments, we built our first and most important manufacturing facility here in Allston, Massachusetts, because we recognized, given the challenges of biologic manufacturing processes, the advantages of having a highly skilled work force and close proximity to the scientists who developed those processes. We have continued to expand our presence in Massachusetts over the years, most notably in Framingham. Of Genzyme's 12,000 employees, approximately 2,200 are in Framingham, where we have key R&D and manufacturing operations. Along with our headquarters in Cambridge's Kendall Square, and other Cambridge, Waltham, and Westborough locations,

Genzyme now has about 4,700 employees in Massachusetts.

In addition to the highly valued links to the life sciences community, we appreciate state and local recognition of our contributions to the area's economy and support for our expansion efforts. We encourage the state to continue to support education and training programs that will allow companies to recruit the right people for manufacturing and other functions associated with the life sciences. Genzyme is currently building another key manufacturing facility in Framingham. State support for infrastructure improvements there has enabled this and future projects by other companies to move forward.

Having a strong foundation in Massachusetts along with a well-developed global presence puts Genzyme in a unique position to connect this state with the rest of the world. Genzyme and others in the Massachusetts life sciences community are making new medical advances every day that hold the promise to transform patients' lives. As we continue to grow, we look forward to helping the state maintain its leadership in this area, and bringing more Massachusetts-grown innovations to patients around the world. ■

David Meeker, M.D., is Executive Vice President and Chief Operating Officer at Genzyme. Dr. Meeker is responsible for Genzyme's commercial organization, overseeing the company's business units, country management organization, and global market access functions. He works to maximize the potential of the company's broad portfolio of products, most of which are in their growth phases.

Designed in Massachusetts

Harry West, CEO, Continuum



One of Massachusetts best-kept secrets is its world-class cluster of excellence in design. Our company, Continuum, belongs to an ecosystem of 40,000 – 50,000 architects, graphic designers, product designers and other creative professionals.

How does a cluster of excellence get started? The essential qualities of a place, its geography, its legal environment, and its human capital matter a great deal. Often, the particular genius of an individual is a driving force. Sometimes government plays a catalyzing role. But the process is generally emergent and its evolution is difficult to predict. In retrospect, sometimes you can trace back the story of its creation and almost convince yourself that it was inevitable given the presence of the right ingredients. However, once this cluster of excellence has emerged like a rare orchid, what does it take for it to persist and grow, rather than fade away again? Continuum's story of growth towards global prominence is an example of the many factors that come into play.

An innovation design consulting company headquartered in West Newton, Continuum was founded in 1983 as a collaboration between Gianfranco Zaccai, whose primary training was in industrial design and architecture, and Jerry Zindler, a physicist and engineer. They built the company around the idea that by working together they could improve upon the old model of designers and engineers working separately and "throwing ideas over the wall" at each other. They were right. But the success of Continuum as a company is the result not just of this idea; it is also a result of the fact that the company was located in a state with a ready source of talent and customers.

From the vision of two men in a small, rented space in Boston's South End, which at the time was shoestring-budget-friendly

neighborhood, the company began to grow. At its foundation, Continuum was part of an ecosystem of companies in places like Lexington, Bedford, Boston, Maynard, Canton and Newton where other companies were forming and flourishing, or failing and thereby providing the resources for new companies to emerge.

When Gianfranco and Jerry needed talent, they were able to recruit from other companies in the area that had passed the peak of their business cycle or were reengineering to be more efficient. Those other companies, like mature trees falling in a forest, made space and provided resources for new growth to emerge. Similarly, Continuum hired talented designers and engineers from the computer industry, which was going through a period of decline in Massachusetts as it was being eclipsed by technologies and companies on the West Coast.

A critical moment in our history was Reebok's bold decision to hire Continuum to help them take on Nike. In a creative leap, Continuum invented the Reebok Pump, which went on to be one of the best selling athletic shoes of all time. When we look back we call this "innovation", but at the time it was simply the creative idea of a design company steeped in medical technology putting what was essentially a blood pressure cuff in a shoe. That is innovation: uncovering valuable ideas and capabilities that no one has thought of before, then developing those ideas so that they can be profitably realized and utilized.

The Pump spurred a pivotal moment in Reebok's history, making them bigger than Nike for a few years. It was also a turning point in the history of Continuum: it propelled the firm towards being a global consumer innovation design firm. The company developed the broad range of capabilities needed to be a creative leader working across the world in global consumer research, strategy, brand and service design.

Today, while most of Continuum's business is outside of Massachusetts, most of its employees are still based here. Whether we're bringing our expertise to transform telecommunications services in the Midwest, banking services in Europe, government innovation in Asia, helping US consumer packaged goods firms grow into China, India, Russia and Brazil, or helping Chinese companies grow into Europe and the US, the extraordinary human capital of designers and engineers in Massachusetts helps us to keep growing. To serve this broad array of clients the firm has established offices in LA, Milan, Seoul and Shanghai, yet West Newton remains the headquarters of Continuum, in an environment rich with people and ideas that first fertilized Continuum's growth.

So what keeps us rooted in Massachusetts even as our business has gone global? The answer is quite simple: there is a design community in the state and in Boston. Many other designers and creative thinkers exist here in numerous innovation and design firms: Altitude, Eleven, Essential, IDEO, Insight Product Development, Manta, Proteus, Product Insight, Radius, and the list goes on. A tremendous range of brands and manufacturers with their own internal design departments also are here, including: Adobe, Autodesk, Bose, Fidelity, Gillette, New Balance, Philips, Puma and, of course, Reebok. And there are even more impressive rosters of firms in architecture, landscape design, digital design, art directors, advertising, fashion design, graphic design and interior design. We all work with each other, engage with each other around design and even steal people from each other; it is this community that keeps us and the whole industry thriving in Massachusetts.

And being immersed in an ecosystem that is home to other science-and technology-based clusters of excellence, for example healthcare and medical devices, gives us and the whole design industry a particular innovation edge. Just as it happened with

Reebok, we continue to benefit from the opportunity to interact in close proximity with a demanding and highly-sophisticated local client base that is always pushing us to explore new ways to apply design thinking to create better products and services. They help us push the boundaries of design and innovation in revolutionary ways that make all of us more competitive.

But just as if we were speaking of a living thing, we must ask what it will take to keep the virtuous cycle of growth that is making design an ever more significant part of the Massachusetts economy. What must we do to make the industry impervious to increasing national and international competition from hubs such as San Francisco, New York, Portland, Chicago, Seattle and Austin, and across the globe in London, Amsterdam, Barcelona, Milan, Berlin, Shanghai and Seoul?

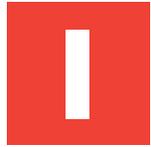
The answer is simple. If Massachusetts wants to keep a strong design industry here, it must continue to make Massachusetts a place where designers want to live and thrive. Massachusetts is blessed with remarkable natural resources, mountains and beaches, and wonderful cultural amenities that make it an undeniably attractive place to live. Home to world-class universities that continue to bring tremendous talent to the state and a supportive patron of the arts, public transportation and healthy lifestyles, Boston can and must compete as a place where the most precious of natural resources—energetic, creative people—want to be. ■

As CEO of Continuum, the global innovation design consultancy, Harry West guides its strategic direction and global growth. His experience as an innovation practitioner in engaging with executives, understanding global consumers, and helping organizations to design their future helps him to stay connected with real needs in our rapidly changing world.

Crossing Boundaries

International Education is Fundamental for Successful Innovation

Bernd Widdig, Director of the Office of International Programs, Boston College



Innovation is a social process that varies across industries and regions, serendipity is part of it, and often unexpected things happen when people come together

to innovate—this is how MTC’s John Adams Innovation Institute describes the fundamentals of any innovation process. Reading those characteristics, I realized that I could have easily substituted the term “innovation” with “international education.”

In fact, my argument is that international education is part of an invaluable preparation for all those young people who later in their life will engage in the process of innovation. Very briefly, I mean by “international education” the set of knowledge, skills, and attitudes that we need to understand, communicate, and work with people from cultures other than our own.

This exact same set of knowledge, skills, and attitudes is crucial for innovation. We know that some of the most exciting opportunities to innovate lie at the boundaries not of nations, but of industries and fields of knowledge which have their own cultural and language barriers. We know that to realize these opportunities takes collaboration and dialogue across these boundaries. And we know that it is not uncommon for the innovation process to draw from multiple geographic locations.

The best efforts and policies to promote innovation will fail if we don’t have people who embrace change, who can move out of their own professional and personal comfort zone, and who have learned to be engaged in new and often uncharted environments. We all know that such basic

attitudes cannot be simply learned from a textbook or a one-day seminar. To impart knowledge in the classroom is relatively simple and success can be easily measured. To teach skills is already more difficult. And to form basic attitudes requires a long and complex educational process. Most importantly, it involves experiential learning that moves beyond the classroom.

Going abroad as a student in high school or especially during college is such an experiential learning opportunity and one of the most effective and valuable ways to prepare people for a workplace that is rife with innovation and change.

Another reason, of course, emerges from the fact that our economies around the world are deeply interconnected. At the same time we have become aware that all major challenges that we face are truly global, both in their effect and solution. But make no mistake: the slogan “the world is flat” contains as much truth as astounding naïveté. Yes, it is true: humanity’s advances in production and information technology allow for an increasingly leveled playing field around the world. But when it comes to understanding cultures, local markets, and political forces, the world remains round, rugged, complex, and often opaque to the quick observer. And humanity’s ability to deal with the most pressing global challenges of our time, such as poverty and climate change, depends as much on global commitment as on devising and implementing local solutions. We need to expose our students to that complexity so that they can learn to thrive within it.

So what is our scorecard when it comes to international education? I am mostly involved with students at the college and university level, but let me point out that international education starts early, and that our scorecard is not great for K-12. We

have too few foreign language classes in the early grades in our schools and while it is laudable that so many students make some inroads in learning Spanish, I wish we had more students who would take the road less traveled—if their schools and colleges offered such languages. Our common knowledge of geography and international contexts is often the source for late night comedy shows. On the other hand we have made good progress in giving high school students the chance to go abroad in organized exchange programs. And most importantly, we see a surge in interest among young students in fields of study that include an international focus.

On the higher education level, especially in selective colleges and universities, going abroad has for many students become part of their undergraduate study experience. At Boston College, about 40% of our undergraduate students have gone abroad by the time they graduate. BC offers 60 of its own international programs in 30 countries. Studying abroad for a semester or a year is still the main pathway, but more and more students are also pursuing internships abroad, they do research around the world, or they work in service learning projects. Foreign language competency is important, but it often can be acquired or expanded in the host country. While most American students still go abroad to Europe, we see a welcomed trend towards greater interest in Asia, Latin America, and Africa. Australia also remains a popular destination.

Yet an international experience remains often not affordable for students who come from modest financial backgrounds.

At Boston College, a generous gift from the McGillicuddy-Logue family allows us to award travel grants that make a real difference for those students. I would argue that one of the most important avenues to improve our schools and universities is to find ways to expand the reach of international education to as many students as we can. Investment in international education by funding travel grants or by creating private-public partnerships to open international internship opportunities are, in my opinion, two opportunities well worth pursuing.

More than a millennium ago, Saint Augustine wrote: "The world is a book, and those who do not travel read only one page." Those who have been leaders in innovation have in all likelihood read more than one page and more than one language, they have observed what the world has to offer in its full diversity, and they understand that the spirit of innovation knows no national borders. ■

Bernd Widdig is Director of the Office of International Programs at Boston College which organizes study abroad and international education for 1100 BC students annually. He is also the Director of BC's McGillicuddy-Logue Center for Undergraduate Global Studies. Before joining Boston College, he served as Associate Director of the MIT International Science and Technology Initiative and was founder of the MIT-Germany Program.

Massachusetts Innovation Ecosystem



Each of the 25 indicators in the 2009 **Index** examines a dimension critical for the performance of the Commonwealth's innovation ecosystem. The **Index** classifies them in three categories: economic impact, innovation activities, innovation capacity. The sequencing and logic of indicators suggest how performance in one arena may affect performance in others, as well as overall results.

Economic Impact

A key goal of the **Index** is to convey how innovation impacts the state's economy. One way innovation contributes to economic prosperity in Massachusetts is through employment and wages in the key industry clusters [**Indicator #1**]. Jobs created in the innovation economy are often high paying [**Indicator #2**], which directly and indirectly sustains a high standard of living throughout the Commonwealth [**Indicator #3**]. This capacity hinges on the ability of individual firms to utilize innovative technologies and processes that improve the productivity of their employees [**Indicator #4**] as well as support the creation and commercialization of innovative products and services. Success in the national and global marketplaces brings in the revenue [**Indicators #5 and #6**] that enables businesses to survive, prosper, and to create and sustain high-paying jobs.

Innovation Activities

In the **Index**, innovation is defined as the capacity to continuously translate ideas into novel products, processes and services that create, improve, or expand business opportunities. The **Index** assesses innovation by examining three categories of activities that underlie this complex and interactive process.

Research

The massive and diversified research enterprise concentrated in Massachusetts universities, teaching hospitals, and government and industry laboratories [**Indicators #7 and #8**] is a major source of the new ideas that fuel the innovation process. Research activity occurs within a spectrum that ranges from curiosity-driven fundamental science whose application often becomes evident once the research has started, to application-inspired research which starts with better defined problems or commercial goals in mind. Academic publications [**Indicator #9**] and patenting activity [**Indicator #10**] reflect both the intensity of new knowledge creation and the capacity of the Massachusetts economy to make these ideas available for dissemination and commercialization.

Technology Development

In close interaction with research activities, but with a clearer application as a goal, technology development begins with research outcomes and translates them into models, prototypes, tests, and artifacts that help evaluate and refine the plausibility, feasibility, performance, and market potential of a research outcome. One way in which research universities, keystones of the Massachusetts innovation ecosystem, make new ideas available for technology and product development by business and entrepreneurs is through technology licensing [**Indicator #11**]. Small Business Innovation Research (SBIR) grants enable small companies to test, evaluate, and refine new technologies and products [**Indicator #12**]. In the medical device and biopharma industries, which are significant contributors to the Massachusetts Innovation Economy, regulatory approval of new products is an important milestone in the product development process [**Indicator #13**].

Business Development

Business development involves commercialization, new business formation [Indicator #14], and business expansion. For existing businesses, growing to scale and sustainability often involves an initial public offering (IPOs), a merger or an acquisition (M&A) [Indicator #15]. Technical, business, and financial expertise each plays a role in the process of analyzing and realizing business opportunities which result after research and development are translated into processes, products, or services. Business model innovation, in which new ways to create value are implemented, is also an important component of business development, but it is not measured by the **Index** since it is not amenable to quantification.

Innovation Capacity

The performance of the Massachusetts innovation ecosystem is greatly enhanced by a number of factors that increase the capacity for innovation by scientists, engineers, entrepreneurs, and firms in the Commonwealth.

Capital

Massachusetts attracts billions of dollars of funding every year for research, development, new business formation, and business expansion. The ability to attract public funds sustains the unparalleled capacity of individuals and organizations in Massachusetts to engage in the most cutting-edge and forward-looking research and development efforts [Indicator #16]. Universities in Massachusetts benefit from industry's desire to remain at the cutting edge of research and product development through university-industry interactions [Indicator #17]. For new business formation

and expansion, Massachusetts' concentration of venture capitalists and angel investors is critical [Indicator #18]. Investors in these areas, capable of assessing both the risk and opportunities associated of new technologies and entrepreneurial ventures, are partners in the innovation process and vital to its success.

Talent

Innovation may be about technology and business outcomes, but it is a social process. As such, innovation is driven by the individuals who are actively involved in science, technology, design, and business development. The concentration of men and women with a postsecondary and graduate education [Indicator #19], complemented by the strength of the education system [Indicator #20] provides the Commonwealth with competitive advantages in the global economy. Investment in public education helps sustain quality and create opportunities for individuals of diverse backgrounds to choose to pursue a high-school or college degree [Indicator #21]. Students and individuals with an interest or background in science, technology, engineering, and math [Indicators #22 and #23] are particularly important. Similarly, Massachusetts benefits from an ongoing movement of people across its boundaries, including some of the brightest men and women from the nation and the world that chose to live, study, and work in the Commonwealth [Indicator #24]. Housing affordability influences Massachusetts' ability to attract and retain talented individuals [Indicator #25].

Massachusetts Innovation Ecosystem *continued*



There are a number of aspects of a region's capacity for innovation that are equally as important, but are not directly measured in the **Index**:

Institutional Framework

The work of innovators in Massachusetts occurs within, and is supported by, an outstanding constellation of organizations that are critical for the innovation process. These include research universities, mission-oriented national laboratories, corporate laboratories, and research-based commercial ventures. Civic organizations, trade groups, and funding organizations operating across industries and regions are also an important part of the institutional framework for innovation. Finally, service providers such as patent lawyers, management consultants, and scientific and technical consultants make vital contributions throughout the innovation process.

Connections, Interactions, and Mobility

Ongoing interaction among the people involved in research, development, and entrepreneurship sustains the flow of new ideas and the discovery of opportunities that fuel the innovation process. These interactions include formal and informal conversations, joint projects, student internships, and many other relationships that span organizational—and often geographic—boundaries. The mobility and communication of people across such boundaries, affected by cultural factors and the density of relationships, are crucial for the creation and transfer of new ideas. In Massachusetts, connections and interactions between innovators and end users are extremely important for the inspiration of new R&D and the application of R&D outcomes.

Innovation Infrastructure

This category includes the physical spaces in which innovators work and interact, such as laboratories, incubators, and venues which allow innovators from across the economy to come together. Innovation infrastructure also refers to the technologies and instruments that support R&D activities, including: high-speed Internet access and bandwidth and computing capacity; as well as the analytical instruments that support R&D activities in universities, hospitals, industries, and mission-oriented laboratories.

Demand

Demand for new capabilities is an important driver of innovation. In this context, we distinguish demand for new capabilities from the traditional marketplace demand for existing products and services (captured as Impacts). In Massachusetts, demand for innovative products, processes, and services comes from two sources. Firstly, and most importantly, is the marketplace. Comprised of businesses and consumers around the state, nation, and world, buyers of products and services created and sold by Massachusetts companies are vital sources of demand. The “demanding customer” both stimulates and motivates entrepreneurs and businesses to keep creating new or improved products, processes, and services. Secondly, the Federal government, particularly through its mission-oriented agencies such as the Department of Defense and the Department of Energy, is a crucial source of challenges as well as funding that sustains viability and pushes the technological frontier of many Massachusetts businesses.

Construction of the Indicators



About the Indicators

Giving an objective view into many dimensions of the Innovation Economy, the indicators are quantitative measures which allow performance comparisons with other leading regional innovation economies. The indicators examine long-term changes and trends in regional economic fundamentals, such as the education level of the workforce and manufacturing productivity, in addition to aspects of the innovation environment that are subject to short-term fluctuations of economic activity, such as initial public offerings and venture capital funding.

The indicators were selected to be statistically measurable on an on-going basis and derived from objective and reliable data sources. When necessary, we have used three-year averages with sample-based data such as the American Community Survey and Current Population Survey. Familiar monthly data, leading indicators, and forecasts that are so important to grasping what is happening to the economy in real-time are subject to significant revision. In contrast, the Massachusetts Technology Collaborative and its advisors have worked hard to construct indicators that will not be subject to any significant revisions. Appendix A describes the construction of each indicator in detail.

Benchmark Comparisons

Benchmark comparisons provide the context for understanding how Massachusetts is performing. The 2009 **Index** benchmarks Massachusetts against the LTS and the national average. The nine LTS chosen for comparison in the 2009 **Index** are: California, Connecticut, Illinois, Maryland, Minnesota, New Jersey, New York, Pennsylvania, and Virginia. Appendix A

describes the methodology for selecting the LTS. To advance our understanding of Massachusetts' place in the global economy, this year the **Index** takes steps towards benchmarking Massachusetts against top performing nations/regions where high quality international data are available.

Eleven Key Industry Clusters

The 2009 **Index** monitors 11 industry clusters of the Commonwealth's Innovation Economy.

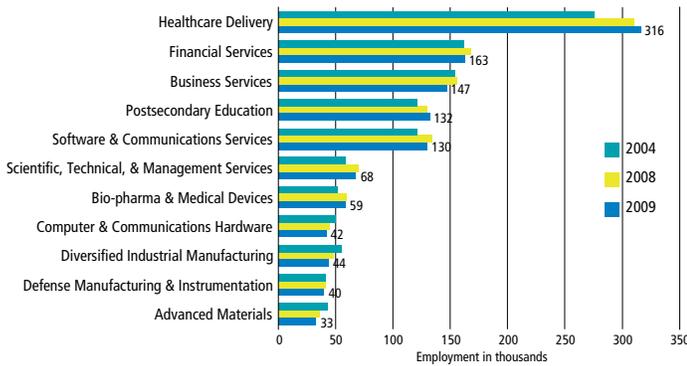
- Advanced Materials
- Bio-pharma & Medical Devices
- Business Services*
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Financial Services
- Healthcare Delivery
- Postsecondary Education
- Scientific, Technical, & Management Services
- Software & Communication Services

Together, these 11 core Innovation Economy clusters account for 37% of employment in Massachusetts, including most of the highest paying jobs in the Commonwealth. Counting direct and indirect jobs, these industry clusters support more than half of all state employment. For purposes of the **Index** analysis, however, indirect employment effects are not considered.

* Cluster definition has been modified in this year's **Index**. Appendix B outlines the changes.

Industry Cluster Employment and Wages

Total employment by industry cluster, Massachusetts, 2004, 2008, 2009*



Source: Moody's Economy.com (*2009 estimated in July 2009)

- ◆ Changes in employment in Massachusetts' key clusters tended to be more favorable than their LTS peers in the face of the recession.
- ◆ Employment in the key industry clusters declined at about half the rate as in Massachusetts' other industries.
- ◆ Healthcare Delivery and Postsecondary Education provided some stability amidst the recession.

Why Is It Significant?

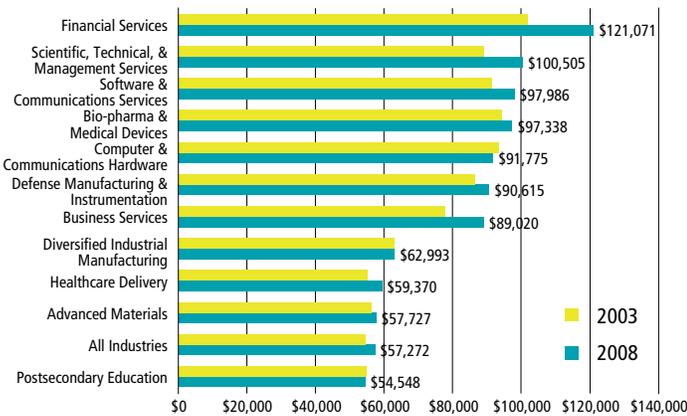
Increasing employment concentration in technology and knowledge-intensive industry clusters points to competitive advantages for the Massachusetts Innovation Economy and potential for future economic growth. Typically, these clusters provide some of the highest paying jobs in Massachusetts, which indirectly creates jobs in the communities these clusters are embedded in.

How Does Massachusetts Perform?

From 2008 to 2009, employment declined in Massachusetts by 3.3%. However, jobs in the key innovation clusters in Massachusetts were lost at about half the rate as in other industries. Consequently, jobs in the key industry clusters rose as a share of employment from 36.5% to 37.0%. Changes in employment in Massachusetts' key clusters tended to be more favorable than among their peers in the face of the recession. Seven of Massachusetts' eleven key industry clusters fared better than the LTS on average.

Even taking into account 2009 job losses in the eleven key clusters, employment in these clusters has grown over the last five years, adding 39,000 jobs from 2004 to 2009. Bio-pharma & Medical Devices, Software & Communication Services, and Healthcare are arguably the Commonwealth's strongest performing clusters in the 2004–2009 period, adding jobs faster than the elsewhere in the United States. Since 2004, the concentration of employment has risen faster in Massachusetts than in the United States in five clusters: Financial Services, Computer & Communications Hardware, Software & Communications Services, Bio-pharma & Medical Devices, and Healthcare Delivery.

Average annual wage by cluster, in 2008 dollars, Massachusetts, 2003 and 2008



Source: Bureau of Labor Statistics

Percent change in cluster employment, 2008-2009

	CA	CT	IL	MD	MA	MN	NJ	NY	PA	VA
Advanced Materials	-9.2%	-13.8%	-6.2%	-5.5%	-8.6%	-22.8%	-10.0%	-8.8%	-11.6%	-9.8%
Bio-Pharma & Medical	-3.3%	-5.3%	-2.9%	0.1%	-1.5%	-4.8%	-1.6%	-4.9%	-2.1%	-3.3%
Business Services	-4.9%	-6.3%	-4.4%	-2.2%	-5.4%	-6.5%	-2.9%	-2.1%	-3.7%	-3.7%
Computer & Comm Hrdwe	-9.3%	-9.7%	-8.0%	-1.9%	-4.9%	-12.6%	-9.6%	-8.3%	-12.7%	-9.9%
Def Mfg & Instrumentation	-4.0%	-2.8%	-11.7%	-2.3%	-3.2%	-7.5%	-3.4%	-1.8%	-10.8%	-8.0%
Diversified Ind Mfg	-10.2%	-7.5%	-12.1%	-3.6%	-8.7%	-10.8%	-11.0%	-11.9%	-11.5%	-9.3%
Financial Services	-5.1%	-2.8%	-3.0%	-4.7%	-3.1%	-0.7%	-1.2%	-6.0%	-1.5%	-1.7%
Healthcare Delivery	1.2%	1.8%	0.5%	1.7%	1.8%	2.7%	0.7%	1.8%	1.3%	1.3%
Postsecondary Education	1.8%	-0.9%	4.4%	2.8%	1.6%	6.5%	4.5%	3.8%	1.7%	-0.8%
Scientific, Tech, & Mgmt Svcs	-2.3%	-7.8%	-2.4%	2.1%	-2.8%	-11.2%	-0.5%	-0.4%	-1.5%	0.1%
Software & Comm Svcs	-4.4%	-5.2%	-3.8%	2.7%	-3.0%	-5.4%	-7.1%	-6.2%	-2.2%	-0.4%
Total State Employment	-4.6%	-3.9%	-4.3%	-2.1%	-3.3%	-3.8%	-3.3%	-2.5%	-3.0%	-2.8%
% of Total in Key Clusters, 2009	26.7%	33.4%	28.6%	26.7%	37.0%	29.0%	29.7%	29.9%	30.9%	27.1%

Source: Moody's Economy.com
Note: Blue shaded cells indicate job growth

Over the past ten years employment has declined in Advanced Materials, Computer & Communications Hardware, Defense Manufacturing & Instrumentation, and Diversified Industrial Manufacturing and increased in Bio-pharma & Medical Devices, Healthcare Delivery, and Postsecondary Education.

Occupations and Wages

- ◆ The employment percentages in the key knowledge economy occupations Life, Physical & Social Science and Information Technology (IT) are very high compared to the US averages. These occupations also pay significantly higher than average wages and salaries and exhibit strong growth relative to the LTS and the US as a whole.
- ◆ Employment and average wages in Production occupations are falling more rapidly in Massachusetts than LTS and US averages.

Why Is It Significant?

Massachusetts embraces the Innovation Economy in order to grow its base of middle- and high-wage jobs and provide a rising standard of living to people throughout the Commonwealth. Higher-than-average employment concentrations in specific occupational categories indicate competitive skill strengths. Changes in occupational employment and wages provide clues about shifts in job quality as well as the skill mix of the workforce across all industries.

How Does Massachusetts Perform?

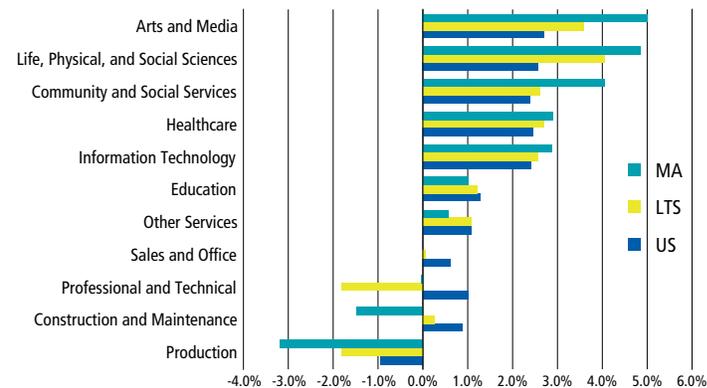
Massachusetts has the highest proportion of employment in Life, Physical & Social Science occupations among the LTS, and is second only to Virginia by this measure in the number of IT workers. Massachusetts also has a high proportion of employment in Healthcare occupations, a reflection of the extraordinary geographic concentration of academic health centers that support the Life Sciences Super Cluster. States, like Massachusetts with a high proportion of employment in these occupational groups had lower rates of mass layoffs in 2008.

Over the past five years, the rate of job loss in Production occupations in Massachusetts is the highest among the LTS and significantly higher than for the US as a whole. This is consistent with the cluster employment data indicating a decline in employment in most manufacturing clusters in Massachusetts during this period.

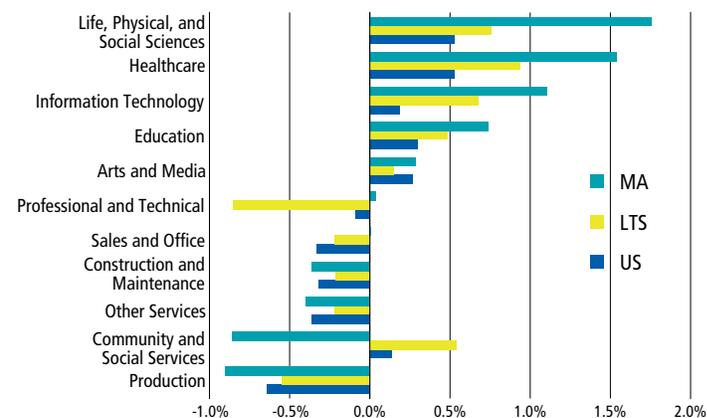
Real average annual pay rose the fastest from 2003 to 2008 in IT occupations, which expanded relatively quickly in Massachusetts and the LTS compared to the US.

The largest percent gain in employment in Massachusetts relative to the LTS and US was in Arts and Media occupations. Wages in this occupational group also grew in real terms, but not more so in Massachusetts than nationally. Massachusetts ranks third in the percent of employees in Arts and Media occupations relative to the US after California and New York.

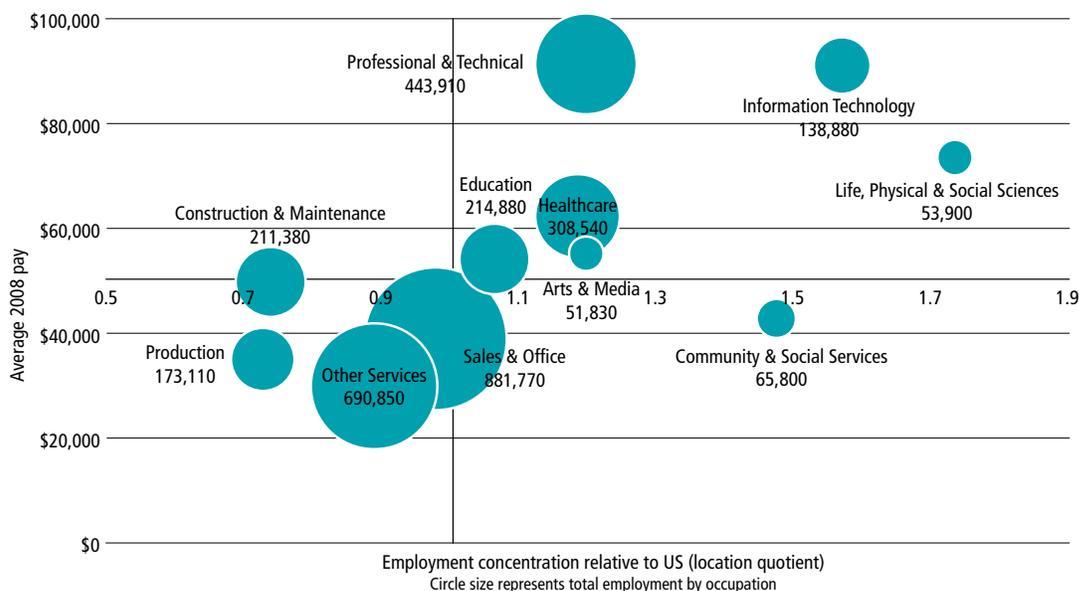
Average annual employment growth by occupation, Massachusetts, LTS, and US, 2003–2008



Average annual growth rate of real annual pay by occupation, Massachusetts, LTS, and US, 2003–2008



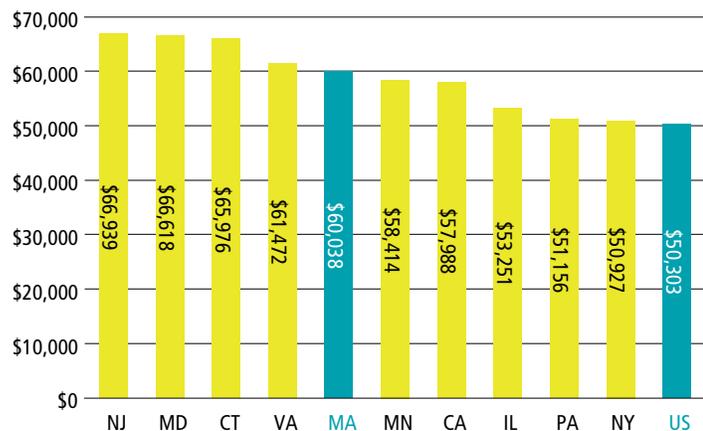
Occupations by employment concentration and annual pay, Massachusetts, 2008



Source of all data for this indicator: US Bureau of Labor Statistics, occupational employment estimates

Household Income

Three-year median household income, in 2008 dollars, LTS and US, 2008



Source: US Census Bureau

Total wages and salaries paid, Massachusetts, 2003 Q1–2009 Q2



Source: Bureau of Economic Analysis

- ◆ Real median income in Massachusetts declined in 2008 while this measure fell nationally more than twice as much.
- ◆ Median income in Massachusetts remains slightly above the LTS average.

Why Is It Significant?

Household incomes that rise in inflation adjusted dollars enable increases in standard of living. Median household income tracks changes in the general economic condition of middle income households in Massachusetts and other LTS. Data on the total dollar value of wages and salaries for Massachusetts-based jobs provide a more up-to-date measure of the impact of the recession on earnings.

How Does Massachusetts Perform?

The impact of the recession is noticeable in the median household income figures even though data is made available only as a three-year rolling average. Median household income fell short of keeping up with inflation in 2008, declining 0.8% in Massachusetts and 2.5% in the United States from 2007 levels. Median household income in Massachusetts remain 19% above the US average and 1% above the LTS average. Total wages and salaries paid, for which there is more recent data, also reveals the impact of the recession. In Massachusetts, there was a 6% decline in inflation-adjusted wages and salaries from the last quarter of 2007 to the second quarter of 2009 – a smaller decline than the US or LTS average.

Despite the impact of the recession, median income has risen over the decade. Since 1998, real median income in Massachusetts is up \$4,695 (8.5%). The strongest income growth among the LTS was achieved in Connecticut, in which the median income grew by \$6,731 (11.4%), followed by Virginia at \$5,397 (9.6%). Over the past seven years, the median household income of Massachusetts' households has remained above the LTS average.

Productivity

- ◆ Massachusetts' labor force ranks 3rd in productivity among the LTS and 5th in an international comparison.
- ◆ Manufacturing productivity grew steadily in Massachusetts from 2003 to 2006; however it grew slower in Massachusetts than in the US.

Why Is It Significant?

Increasing productivity enables wage growth. It is defined as the value of the outputs per employee (labor productivity) or per unit of capital goods (capital productivity) averaged over the economy as a whole. Firms that have high labor productivity produce comparatively high value goods, produce goods with relatively fewer employees, or a combination of the two. In order to achieve increases in the level of labor productivity, people and organizations must innovate in ways that increase the value of their product or service or make the production process more efficient. Some of the ways this can be achieved are increases in employee knowledge and skills or the adroit application of enabling technologies. Manufacturing value added per manufacturing employee is a measure of manufacturing labor productivity. Increases in manufacturing productivity are essential to avoiding the "race to the bottom" of manufacturing wages or the loss of manufacturing jobs to overseas production.

How Does Massachusetts Perform?

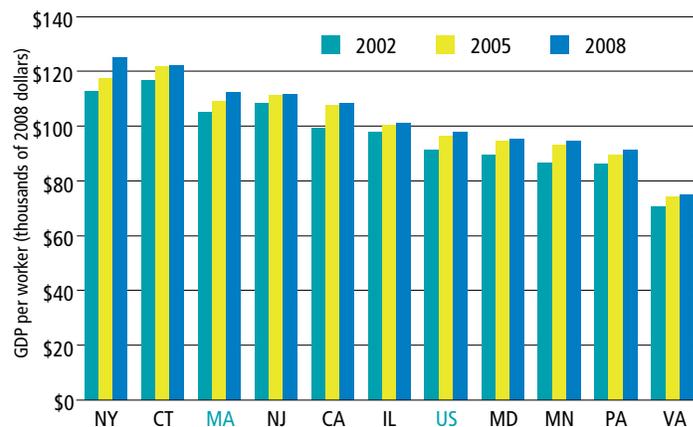
Massachusetts is highly competitive in terms of the labor productivity of the economy as a whole, both among the LTS and in an international comparison. The state ranked third among the LTS and fifth among countries in 2008.

All of the LTS have witnessed rising labor productivity over the past several years. New York has improved on this measure the fastest with an average annual growth rate of 1.8% from 2002 to 2008, followed by Minnesota at 1.6%. Massachusetts productivity growth has been above average among the LTS; however, it is only slightly above the US average. All of the top 15 countries in labor productivity have also had increases the level of productivity from 2002 to 2008. Labor productivity has improved the fastest in Norway, which also has the most productive labor force.

Labor productivity has been growing faster in manufacturing than in the overall economy in Massachusetts and the country as a whole. From 2003 to 2006, manufacturing productivity in Massachusetts grew at an average annual rate of 3.3% while the productivity in the Massachusetts economy overall grew by only 0.9%.

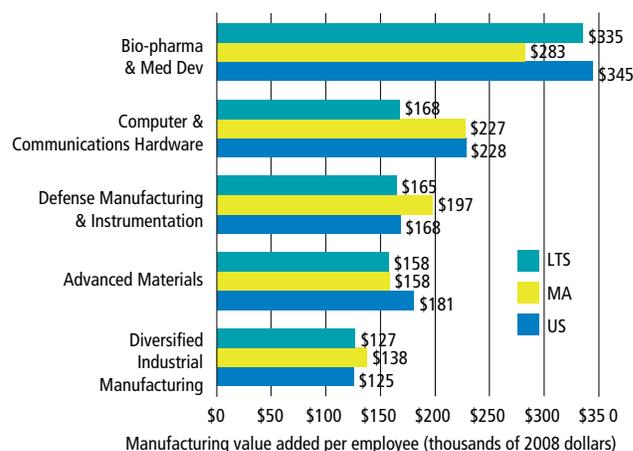
Computers & Communications Hardware, Defense, and Diversified Industrial Manufacturing are achieving above average productivity among the LTS. Manufacturing productivity grew steadily in Massachusetts from 2003 to 2006; however it grew slower in Massachusetts (10%) than in the US (17%). In addition, employment and average wages in Production occupations are falling more rapidly in Massachusetts than LTS and US averages.

Productivity, LTS, and US, 2002, 2005, 2008



Source: Bureau of Labor Statistics

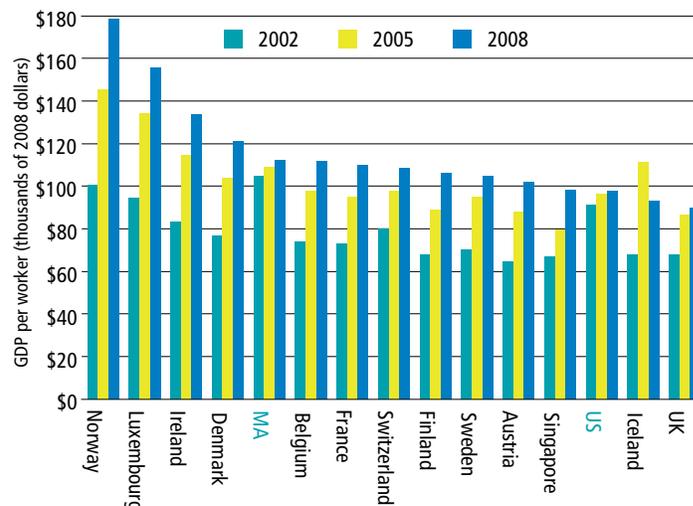
Manufacturing labor productivity by cluster, Massachusetts, LTS, and US, 2006



Source: US Census Bureau, Annual Survey of Manufacturers

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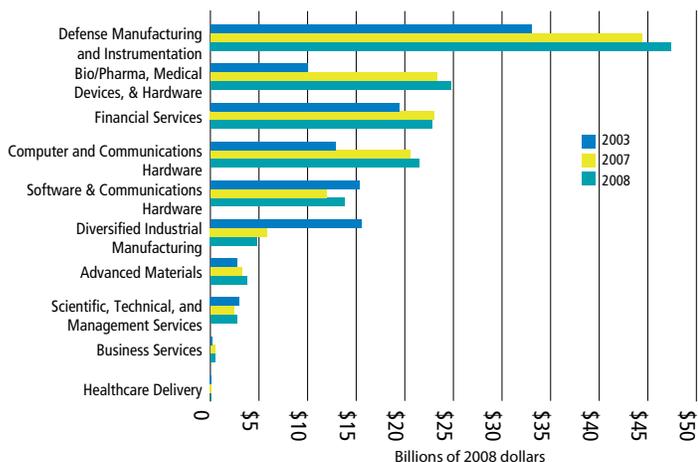
Productivity, International, 2002, 2005, 2008



Source: Bureau of Labor Statistics, the World Bank, and the International Labor Organization

Corporate Sales and Manufacturing Value Added

Corporate sales, Massachusetts, 2003, 2007, and 2008



- ◆ Average corporate sales at publicly traded Bio-pharma & Medical Devices companies headquartered in Massachusetts more than tripled from 2003 to 2008.
- ◆ Despite a waning number of headquarters of Diversified Industrial Manufacturing companies, in 2006 a large amount of manufacturing activity still took place within Massachusetts' borders.

Why Is It Significant?

Changes in market demand in each cluster as well as the competitiveness of Massachusetts' industry players within a cluster can be indirectly monitored through changes in corporate sales. Corporate sales data are organized by the location of the corporate headquarters regardless of where the economic activity takes place. In contrast, manufacturing value added data reflect value created by the location of manufacturing facilities rather than company headquarters. The most recent value added data are from 2006. Manufacturing value added is calculated by subtracting the costs of the manufacturing inputs from the value of the final product.

How Does Massachusetts Perform?

Despite the recession, corporate sales grew between 2007 and 2008 in the majority of Massachusetts' key industry clusters. Software & Communications Services, Advanced Materials, and Scientific, Technical, & Management Services corporations with headquarters in Massachusetts had a cluster average of greater than ten percent sales growth for the year.

Since 2003, there has been a substantial shift in the industries that are reporting the highest levels of corporate sales. Most notably, from 2003 to 2008, total corporate sales in Bio-pharma & Medical Devices increased 149% from \$10 billion to \$25 billion while sales in Diversified Industrial Manufacturing decreased 69% from \$16 billion to \$5 billion.

In Bio-pharma & Medical Devices, the average sales per company more than tripled to \$396 million. The cluster also created \$15 billion in manufacturing value added in the Commonwealth in 2006, suggesting that Bio-pharma & Medical Devices is increasingly important in the Massachusetts economy.

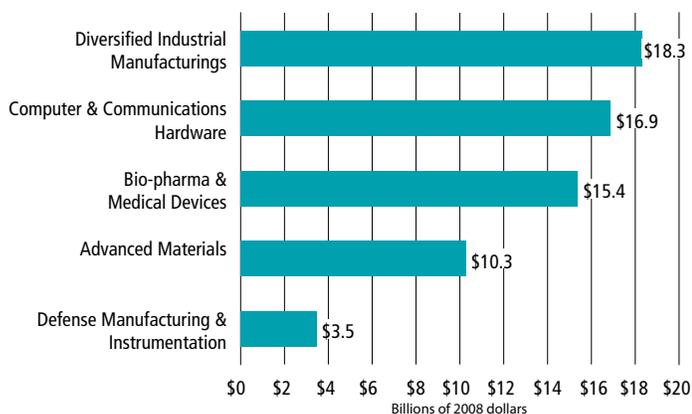
The decline in corporate sales in Diversified Industrial Manufacturing is in part due to the fact that the number of companies headquartered in Massachusetts decreased by five (22%). As of 2006, Diversified Industrial Manufacturing was still Massachusetts' top performing cluster in manufacturing value added. In addition, since 2006, the average corporate sales per company still headquartered in Massachusetts have improved in this cluster.

Corporate sales are still the highest in Defense Manufacturing & Instrumentation. However, in 2006 it was the lowest ranking industry in terms of the manufacturing value added created in the state.

The manufacturing value added across all sectors of the Commonwealth declined at an average annual rate of 1.5% from 2003 to 2006. Over this time both the US and LTS averages grew. Among the LTS, only in New Jersey did manufacturing value added decline faster than in Massachusetts.

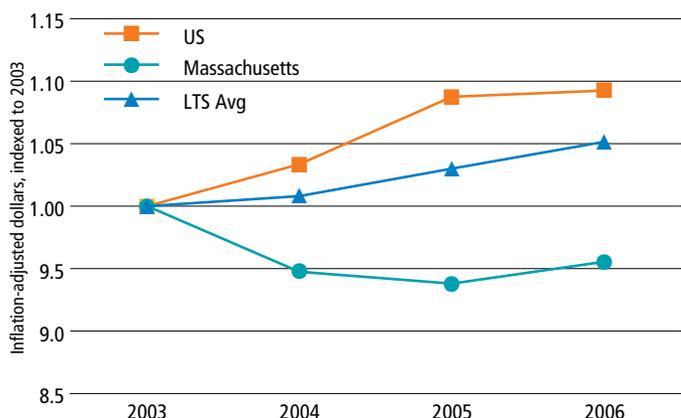
Source: Standard and Poor's COMPUSTAT

Manufacturing value added by cluster, Massachusetts, 2006



Source: US Census Bureau

Change in manufacturing value added, Massachusetts, LTS, and US, 2003-2006



Source: US Census Bureau

Manufacturing Exports

- ◆ Massachusetts ranks second among the LTS in manufacturing exports for the size of its economy.
- ◆ The majority of exports from Massachusetts come from the Bio-pharma & Medical Devices, Computer & Communications Hardware, and Advanced Materials clusters.
- ◆ Exports travelling from Massachusetts to China grew at an average annual growth rate of 21% since 2002.

Why Is It Significant?

Manufacturing exports are an indicator of the Commonwealth's global competitiveness. Supplying global markets can help bolster growth in employment and sales, and increase the market share for innovation-intensive companies in Massachusetts. In addition, diversity in terms of export markets and product categories may create a countercyclical hedge against an economic downturn in any particular region in the world.

How Does Massachusetts Perform?

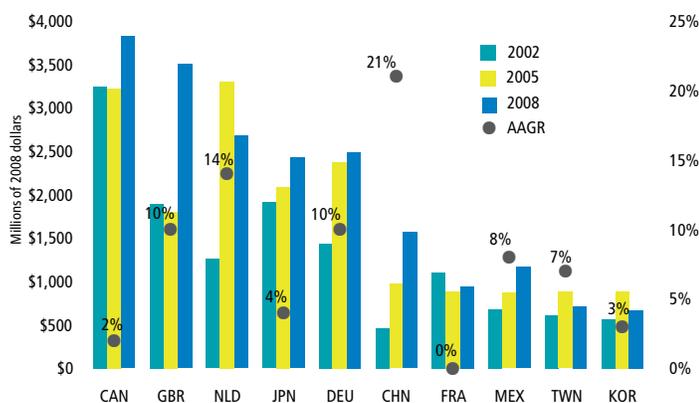
Exports from Massachusetts continue to grow at a slower pace than most of the LTS, but the state continues to rank second in manufacturing exports relative to GDP. All of the LTS are gaining a larger share of their GDP from manufacturing exports than they were in 2004. With 6% year-over-year export growth, Massachusetts companies had one of their best recent years for manufacturing exports, which grew at an average annual growth rate of 4% from 2004-2008.

The distribution of Massachusetts' top export categories have held steady over the last four years. The majority of manufacturing exports from Massachusetts were chemicals and computer & electronic products, which together make up over 51% of manufacturing exports for 2008. Products in these categories come from Massachusetts' Bio-pharma & Medical Devices, Computer & Communications Hardware, and Advanced Materials clusters.

Canada remains the top destination for exports from Massachusetts, although Great Britain is closing the gap. After four years of growth, manufacturing exports to Taiwan declined in 2008. Over the past six years, exports to China increased the fastest, at an average annual growth rate of 21%.

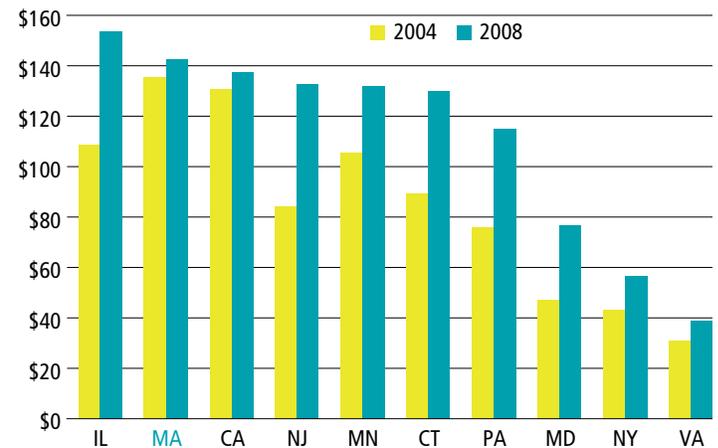
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Export value by top foreign trade destination, Massachusetts, 2002, 2005, 2008

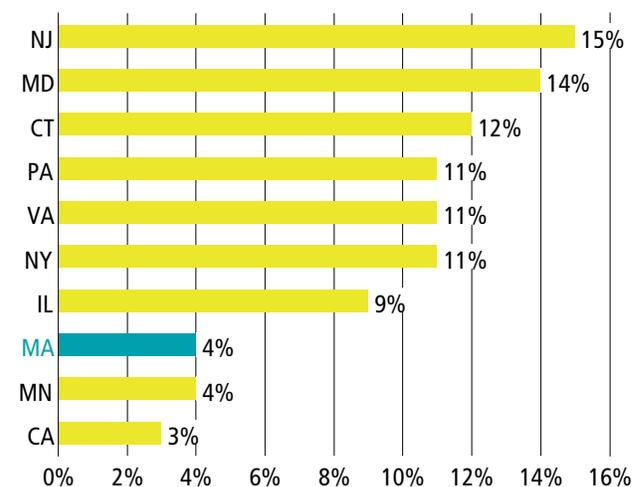


Source of all data for this indicator: WiserTrade

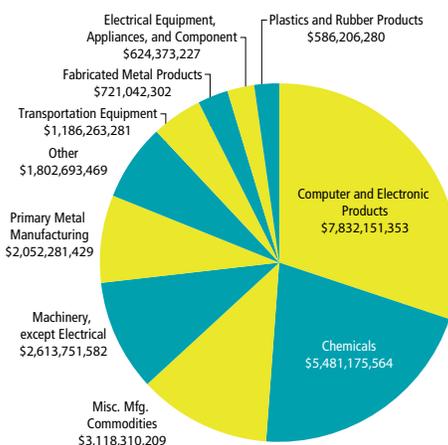
Manufacturing exports per \$1,000 state GDP, LTS, 2004 and 2008



Average annual growth rate (AAGR) of manufacturing exports, LTS, 2004-2008

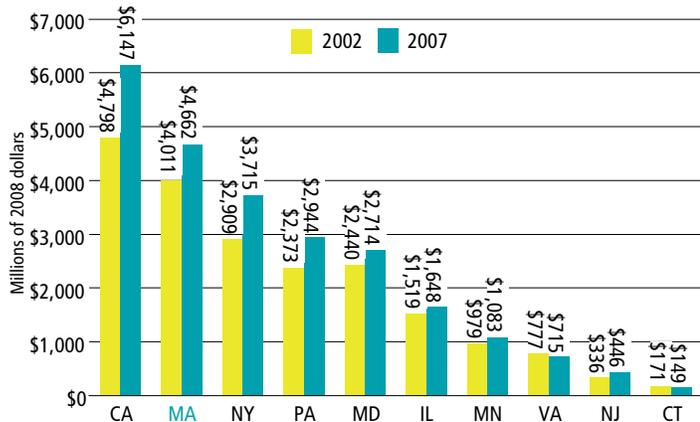


Distribution of manufacturing exports, Massachusetts, 2008



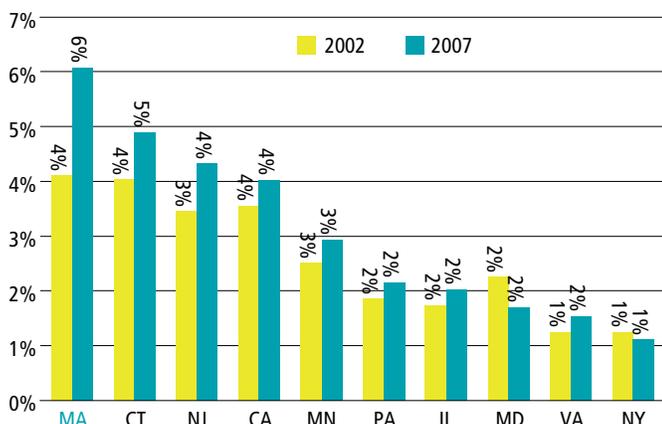
Research and Development Performed

R&D performed by universities, hospitals, and nonprofit research institutes, LTS, 2002 and 2007



Source: Association of University Technology Managers

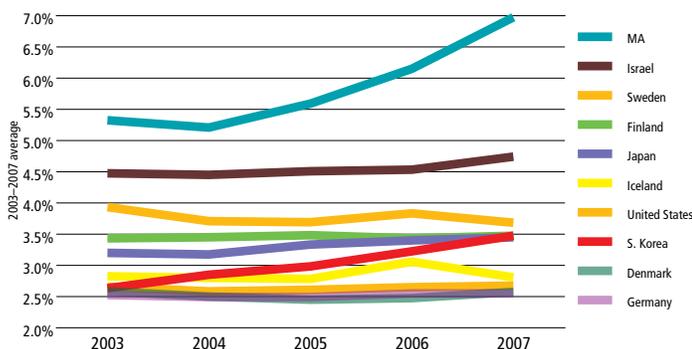
Industry-performed R&D as a percent of private-industry output, LTS, 2002 and 2007



Source: National Science Foundation and Bureau of Economic Analysis

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R&D as a percent of GDP, international and Massachusetts, 2003–2007



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) and the National Science Foundation

- ◆ As a share of GDP, Massachusetts' universities, hospitals, and nonprofit research institutes perform more research and development (R&D) than those in the other LTS.
- ◆ Massachusetts leads the LTS in industry-performed R&D as a share of private industry output.
- ◆ With an R&D enterprise equal to 7% of GDP in 2007, if Massachusetts were a country, it would have one of the most R&D intensive economies in the world.

Why Is It Significant?

Expenditures for R&D performed in Massachusetts is an indicator of the size of the science and technology enterprise. Even though not all new ideas or products emerge from defined R&D efforts, R&D can provide a sense of a region's capacity for knowledge creation.

How Does Massachusetts Perform?

Among the LTS, Massachusetts trails only California in the total amount of R&D performed by universities, hospitals, and nonprofit research institutes. However, for the size of its economy, Massachusetts' research institutions perform the most R&D among the LTS. R&D at these institutions totals \$4.5 billion and rose 16% in inflation adjusted dollars between 2002 and 2007. Over these five years all of the LTS improved on this measure except Maryland and New York.

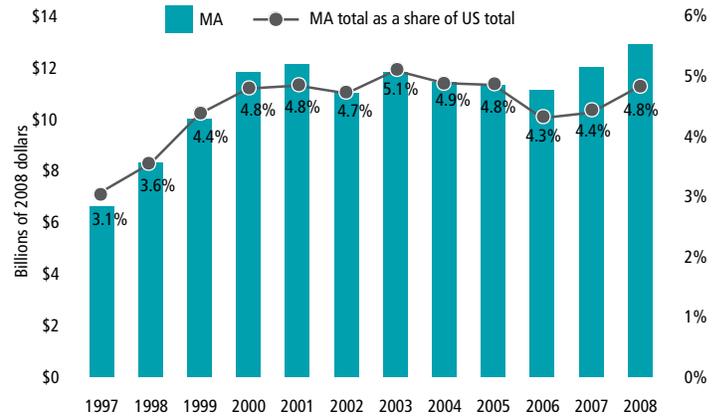
Massachusetts also leads in industry-performed R&D as a percent of private-industry output. Massachusetts' industry became increasingly R&D intensive from 2002 to 2007. Over this time R&D intensity rose 48% from 4.1% to 6.1% of gross output. The strong combination of R&D performed by industry, universities, hospitals, and other research institutes contribute to the dynamic innovation ecosystem which is enhanced by a productive balance of basic research and research that responds to the needs of the marketplace.

When compared internationally, the research enterprise in Massachusetts is very active. With an R&D enterprise equal to 7% of GDP in 2007, if Massachusetts were a country, it would have one of the most R&D intensive economies in the world. However, the R&D intensities of economies around the globe are increasing at a fast rate. This is most notable in S. Korea, the only leading country on this measure with a growth rate higher than Massachusetts. In 2004, Korea surpassed the US average for R&D as a percent of GDP.

Corporate R&D Expenditures, Publicly Traded Companies

- ◆ Corporate R&D expenditures by Massachusetts-based publicly traded companies hit a record high in 2008 at \$12.9 billion.
- ◆ Massachusetts' share of US corporate R&D spending by publicly traded companies grew for the second year in a row.
- ◆ Publicly traded companies headquartered in Massachusetts are among the most R&D intensive in the US, but from 2003 to 2008, New Jersey moved ahead to take the lead

Corporate R&D expenditures and as a percent of US total, publicly traded companies, Massachusetts, 1997–2008



Why Is It Significant?

Corporate research and development investment is essential to generate the new products and services that give Massachusetts' companies an innovation-based competitive edge in the global marketplace. Such investment indicates commitment to long-term competitiveness and the company's assessment of market potential for new products. The data for this indicator are organized by the location of the corporate headquarters.

How Does Massachusetts Perform?

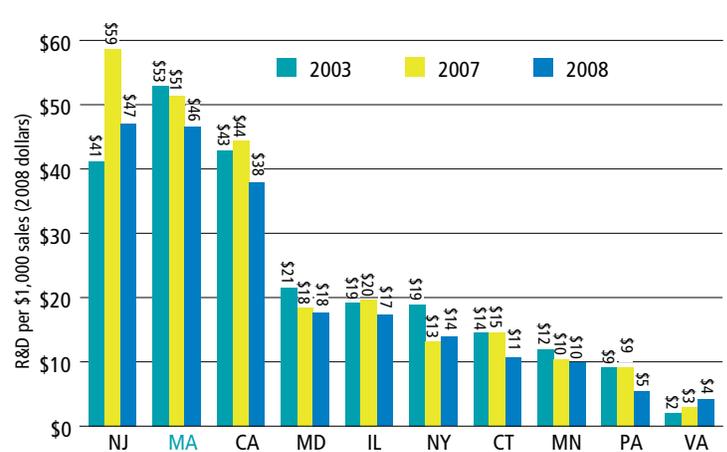
Publicly traded companies headquartered in Massachusetts invested \$12.9 billion in R&D in 2008, recording a new high for the state. This is nearly twice the level ten years earlier and over three times as much as in 1994 in inflation-adjusted dollars.

Corporate R&D expenditures by Massachusetts-based firms grew by 8% over the 2007 level; while sales grew at an even higher rate, resulting in lower overall R&D intensity. This pattern also occurred in many of the LTS. Massachusetts' share of total US corporate R&D expenditures rose in 2007 and 2008.

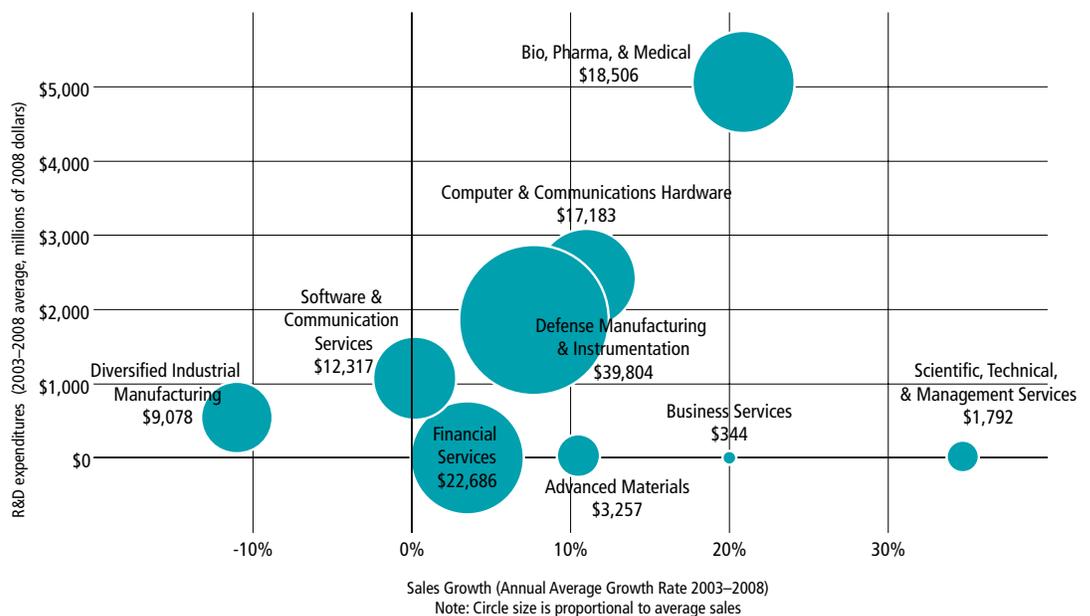
R&D expenditures by corporations headquartered in Massachusetts were higher in 2008 than in 2003 in all of the seven key industry clusters performing a substantial amount of R&D except Diversified Industrial Manufacturing. The general pattern of growth in R&D expenditures is particularly remarkable since over this timeframe, the number of headquarters in Massachusetts declined in every sector except Business Services and Advanced Materials.

Bio-pharma & Medical Devices is the most R&D intensive sector in the Commonwealth and the LTS. R&D by Massachusetts-based Bio-pharma & Medical Devices companies grew by 52% over the period, a rate exceeded only in Minnesota and Virginia. Computer & Communications Hardware comes in second for R&D intensity in Massachusetts.

R&D intensity, LTS and US, 2003, 2007, and 2008



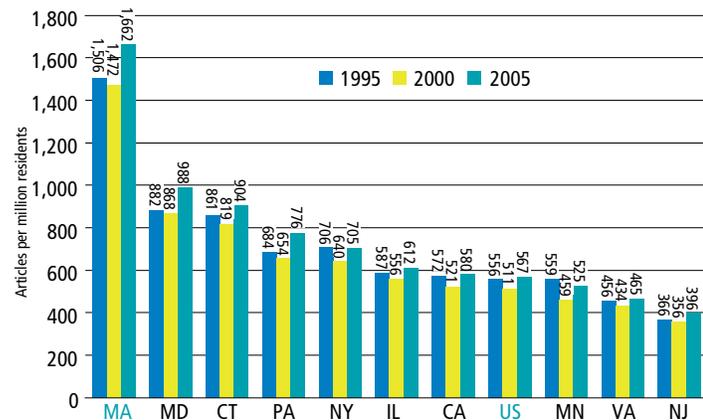
Corporate R&D expenditures, average sales, and sales growth by industry cluster, Massachusetts, 2003–2008



Source of all data for this indicator: Standard and Poor's COMPUSTAT

Academic Article Output

Academic article output per million residents, LTS and US, 1995, 2000, and 2005



- ◆ On a per capita basis, far more academic articles come from Massachusetts than any of the other LTS.
- ◆ Massachusetts researchers are among the most productive of the LTS, whether measured by academic articles per science and engineering (S&E) doctorate holder or per academic R&D dollar.

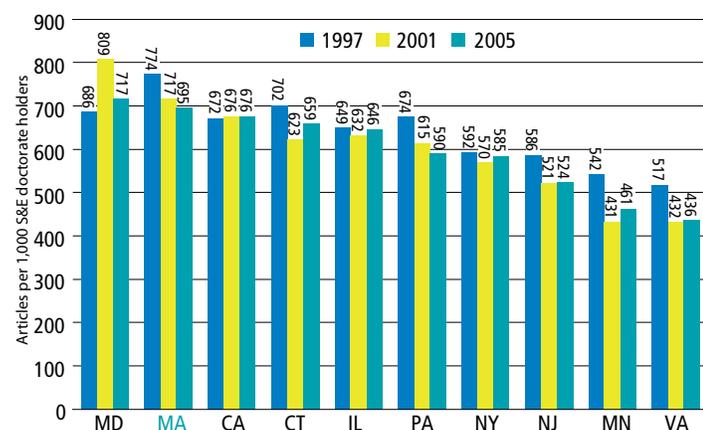
Why Is It Significant?

In contrast to R&D expenditures, which are an input to research, publication is a basic research output and the most common form of knowledge dissemination from academic research. The peer-review process in refereed journals provides a quality standard for the soundness and originality of the conclusions. This is a critical productivity measure as well as a measure of Massachusetts researchers' participation in the global scientific community.

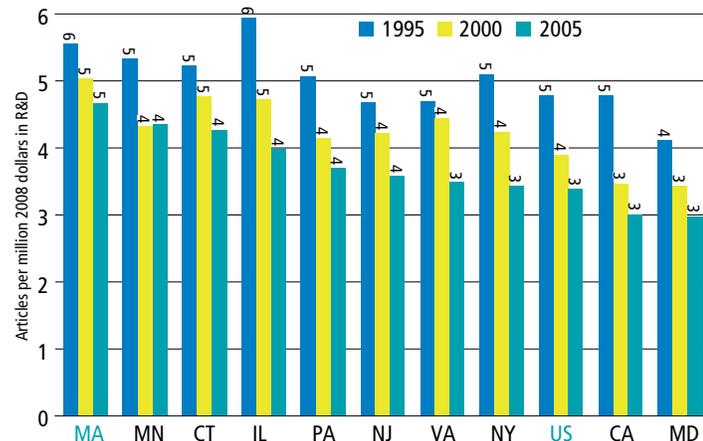
How Does Massachusetts Perform?

Massachusetts has the highest per capita output of academic articles published, a reflection of the research intensity of the Commonwealth and a measure with wide variation among the LTS. Measures of research productivity are less differentiated among the LTS. However, Massachusetts researchers are among the most productive of the LTS, whether measured by academic articles per science and engineering (S&E) doctorate holder or per academic R&D dollar.

Academic article output per 1,000 science and engineering doctorate holders, LTS, 1997, 2001, and 2005



Academic article output per million academic R&D dollars, LTS, 1995, 2000, and 2005



Source for all data for this indicator: The National Science Foundation

Patenting

- ◆ Massachusetts inventors were granted more US patents per capita than any of the other LTS or highest ranking nations in 2008.
- ◆ Massachusetts inventors rank highly among the LTS for the number of computer & communications and drugs & medical patents.

Why Is It Significant?

Patents reflect the legal codification and protection of innovative ideas and products. A patent award is particularly important for R&D-intensive industries in which the success of the company depends on its ability to develop and protect competitive advantage resulting from investments in R&D. As a result, strong patent activity typically suggests an effective R&D enterprise when coupled with the ability to translate research outcomes into ideas with commercial relevance.

To receive protection from imitators, a new patent must be filed with each country (or region) in which a company wishes to market an inventive product or service. US Patent and Trademark Office (USPTO) patents represent one-fifth of global patents and constitute a significant indicator of patent activity worldwide because of the size of the US market as well as the reach of US companies in international markets.

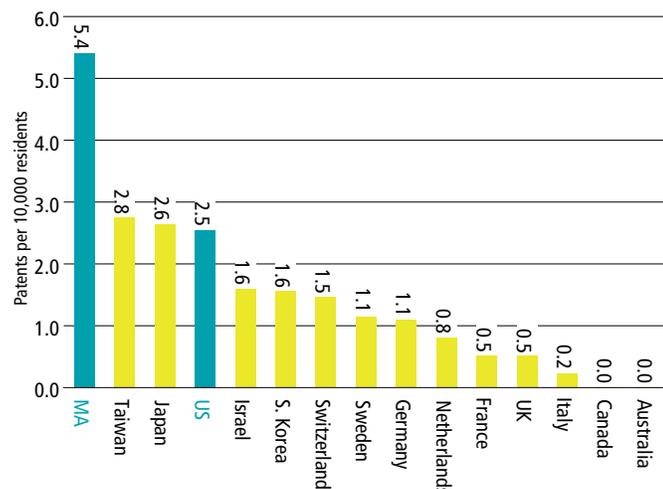
How Does Massachusetts Perform?

On a per capita basis, inventors in Massachusetts were granted more US patents in 2008 than in any of the LTS or leading nations. From 1995 to 2008, the number of patents granted to inventors in Massachusetts grew by an average annual rate of 4.7%. Among the LTS, this is second only to California where the growth rate was 6.5%. While having among the fewest USPTO patents per capita, China and India had very high growth rates in this measure, at 28.7% and 26.0% respectively, suggesting an increasing interest in competing with global US companies and selling in the US.

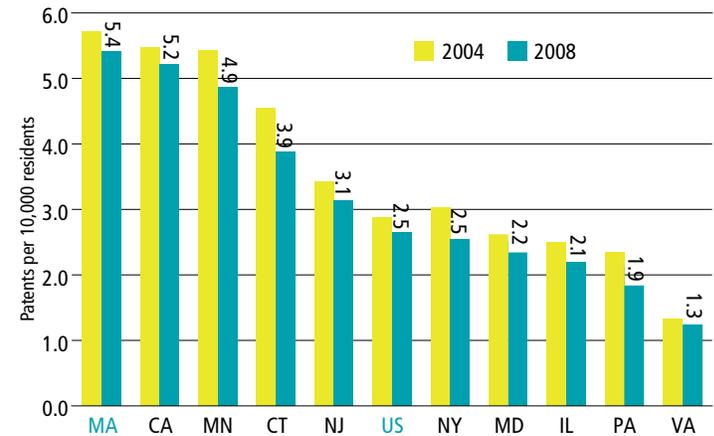
In 2008, Massachusetts led in drugs and medical patents per capita and trailed only California in computer and communications patents per capita. Even the absolute number of patents for inventions in these categories places Massachusetts in the top three in both categories.

INTERNATIONAL

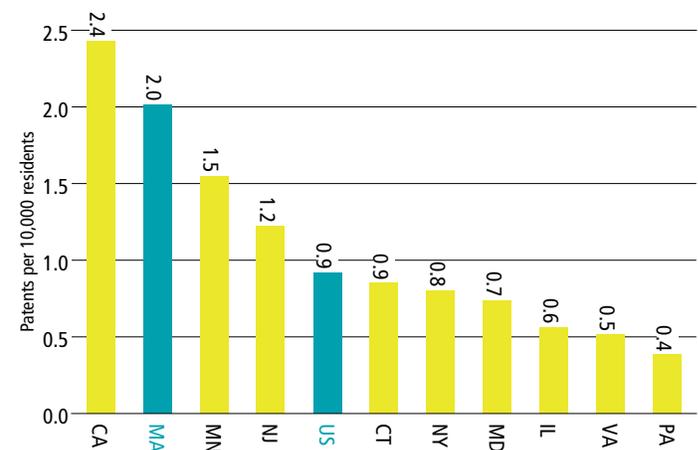
United States Patent and Trademark Office patents issued per 10,000 residents, international, 2008



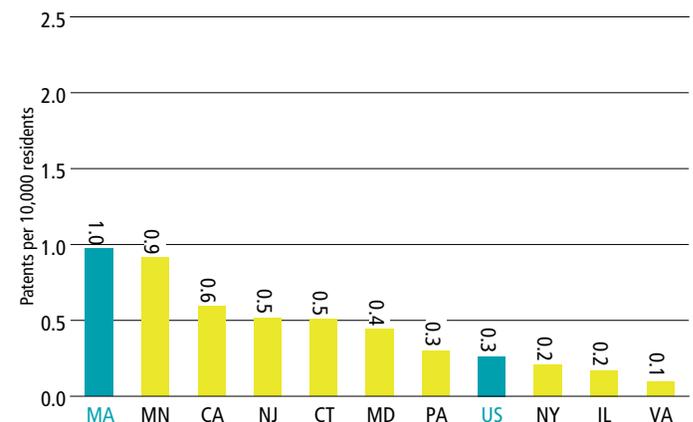
US Patent and Trademark Office patents issued per 10,000 residents, LTS, 2004 and 2008



US Patent and Trademark Office computer and communications patents issued per 10,000 residents, LTS and US, 2008



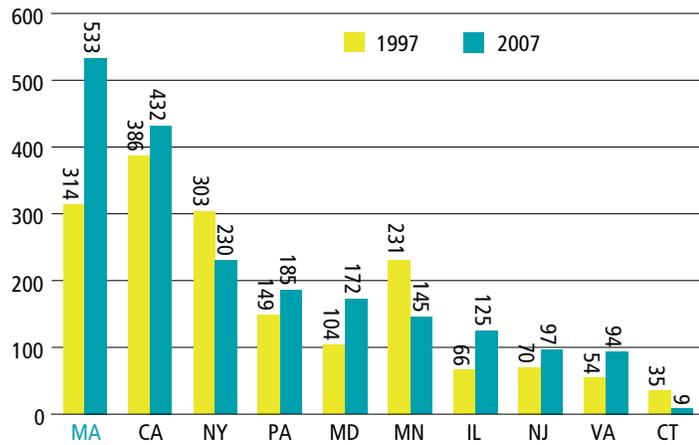
US Patent and Trademark Office drug and medical patents issued per 10,000 residents, LTS and US, 2008



Source of all data for this indicator: United States Patent and Trademark Office

University Technology Licensing

Technology licenses and options executed, LTS, 1997 and 2007



- ◆ Massachusetts' research institutions have a long-standing strength in intellectual property licensing and options, and have experienced long-term growth in both the number and dollar value of technology licenses.
- ◆ Massachusetts' research institutions led the LTS in 2007 in the number of licenses and options executed.

Why Is It Significant?

Technology licenses provide a vehicle for the transfer of codified knowledge in the form of intellectual property (IP) from universities, hospitals, and nonprofit research organizations to companies and entrepreneurs that seek to commercialize the technology. License royalties are evidence of both the perceived value of IP in the commercial marketplace and the actual revenues generated by the sales of products and services embodying the licensed IP. The increase in royalties collected is important, because a portion of this revenue is often reinvested in R&D feeding a cyclic process of innovation at universities, teaching hospitals, and nonprofit research institutes.

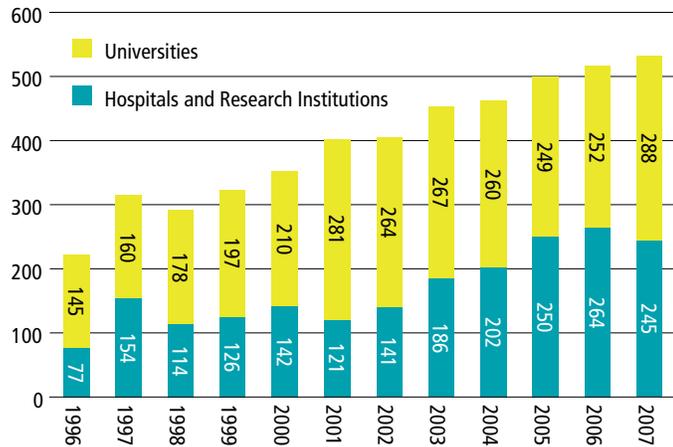
How Does Massachusetts Perform?

Massachusetts universities, hospitals, and other nonprofit research institutes have a long-standing strength in IP licensing and options and have experienced long-term growth in both the numbers and dollar value of technology licenses. Even without adjusting for the size of the LTS' respective economies, Massachusetts' universities, hospitals, and nonprofit research institutes led in the number of licenses and options executed in 2007.

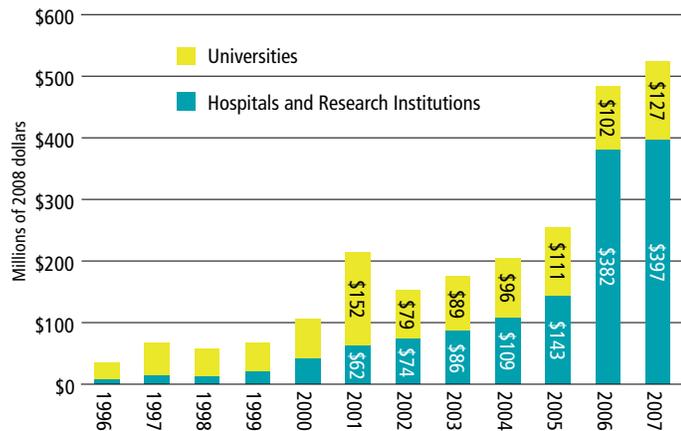
There is no aspect of the innovation ecosystem measured in the Index where Massachusetts' performance has increased as dramatically as licensing income to hospitals and nonprofit research institutes. In 2007, 66% of US licensing income to hospital and nonprofit research institutes flowed to institutions in Massachusetts.

Massachusetts General Hospital (MGH), a leader in technology licensing, tripled its licensing revenues in 2006 over the prior year. This \$346 million in revenues to MGH represents 60% of the revenues received by hospitals and nonprofit research institutes in the entire United States and 90% of such revenues in the Commonwealth. Massachusetts' large share of the US total since 2006 is due to the arthritis drug Enbrel—the largest money maker in MGH history. Excluding MGH, Massachusetts' other hospitals and nonprofit research institutions receive 6.3% of the US total down from 6.5% in 1997.

Technology licenses executed by major universities, hospitals, and other nonprofit research institutions, Massachusetts, 1996–2007



Technology licensing revenue received by major universities, hospitals, and nonprofit research institutes, Massachusetts, 1996–2007



Source of all data for this indicator: Association of University Technology Managers

Small Business Innovation Research Awards

- ◆ Massachusetts' small businesses were awarded 13% of the \$1.8 billion in federal Small Business Innovation Research (SBIR) dollars allocated in 2008, putting \$227 million to work to support proof-of-concept and prototype development activities in the Commonwealth.
- ◆ The number of SBIR awards going to teams led by Massachusetts' small businesses rose in 2008 after four years of decline.

Why Is It Significant?

The Small Business Innovation Research (SBIR) Program is a highly competitive federal grant program that enables small companies to conduct proof-of-concept (Phase I) research on technical merit and idea feasibility and prototype development (Phase II) building on Phase I findings.

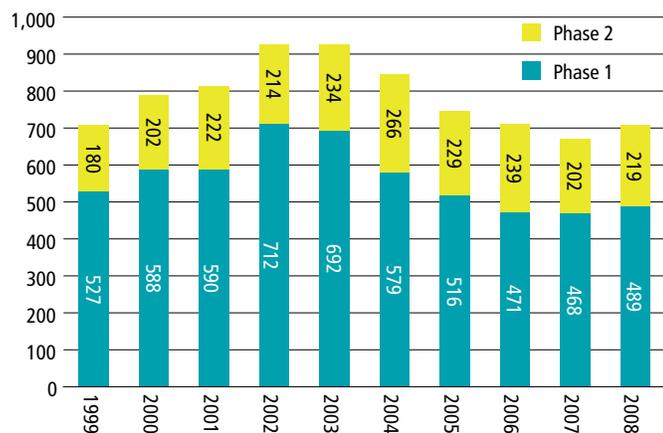
Unlike many other federal research grants and contracts, SBIR grants are reserved for applicant teams led by for-profit companies with fewer than 500 employees. The program is intended to address the technology needs of federal agencies while encouraging companies to profit from the commercialization of research. Participants in the SBIR program are often able to use the credibility and experimental data developed through their research to attract strategic partners and outside capital investment.

How Does Massachusetts Perform?

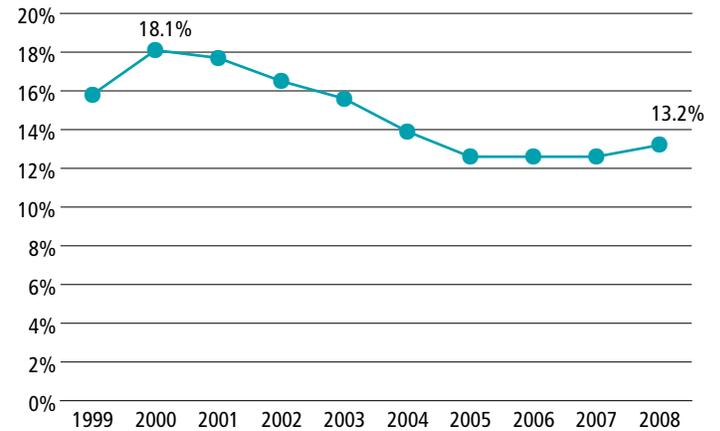
In 2008, Massachusetts' small businesses earned 13% of the SBIR funding awarded. While second to California in absolute terms (dollar value and number of awards), Massachusetts is by far the greatest recipient of SBIR funding per capita. The number of awards granted in Massachusetts rose slightly in 2008 after four years of decline. However, the share of awards made to Massachusetts companies is still lower than the peak in 2000. The majority of the fluctuation was in Phase I awards, with the number of Phase II awards staying close to 200 since at least 1999.

The Department of Defense (DOD) and Health and Human Services (HHS) are the largest sources of SBIR awards for the Commonwealth. Also, more than a quarter of the funds expended by the Department of Education (ED), the Department of Commerce (DOC), and the Environmental Protection Agency (EPA) through the SBIR program went to Massachusetts in 2008, while representing only a small fraction of the total dollar value of all SBIR awards for Massachusetts.

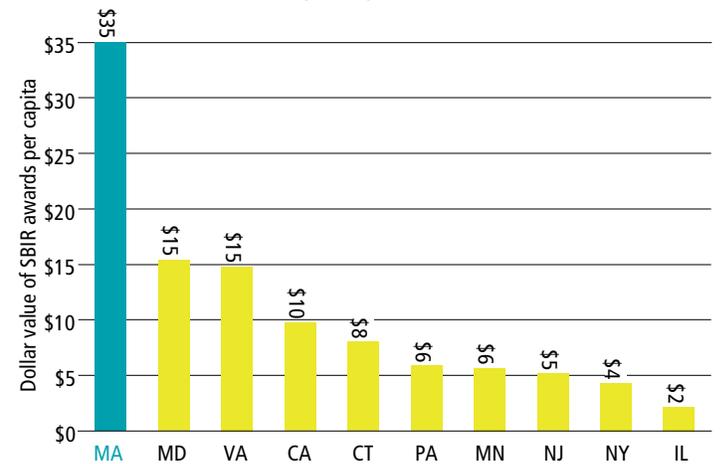
SBIR awards to companies by phase, Massachusetts, 1999–2008



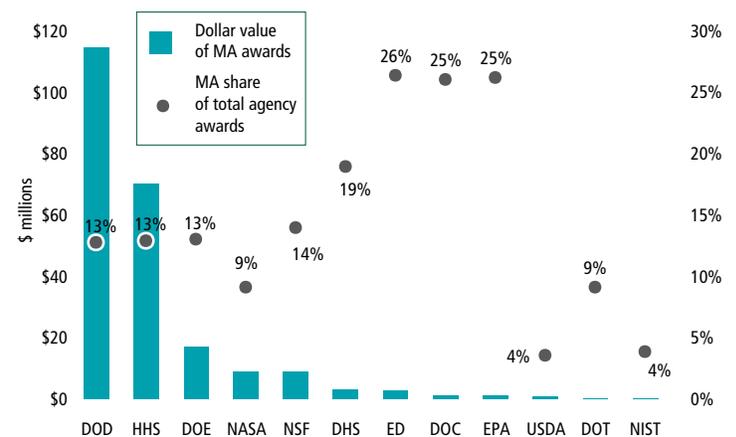
Massachusetts' share of SBIR awards, 1999–2008



Dollar value of SBIR awards, per capita, LTS, 2008



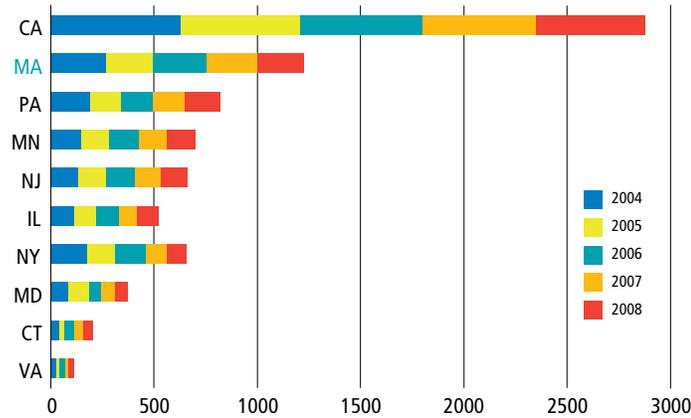
SBIR awards by agency, Massachusetts, 2008



Source for all data for this indicator: US Small Business Administration (SBA)

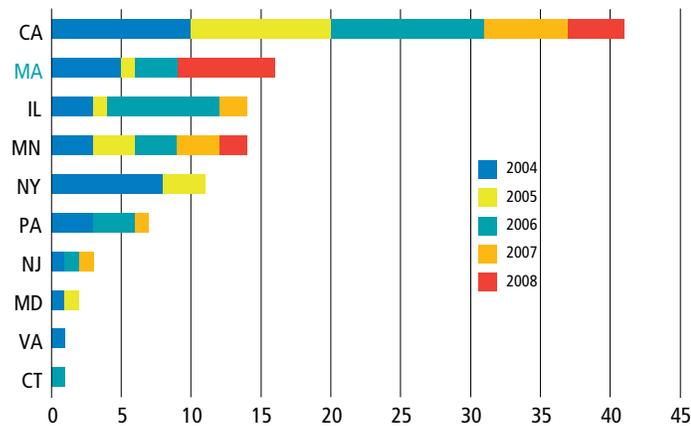
Regulatory Approval of Medical Devices and Biotechnology Drugs

Medical device pre-market notifications (releasable 510(k)s), LTS, 2004–2008



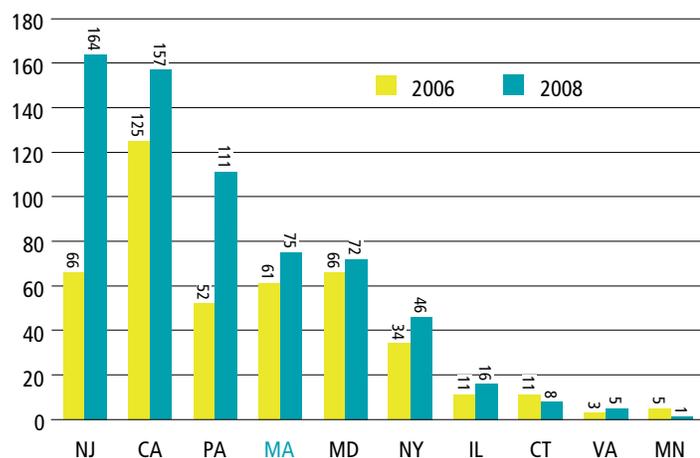
Source: US Food and Drug Administration

Medical device pre-market approvals (PMAs), LTS, 2004–2008



Source: US Food and Drug Administration

Biotechnology drugs in development, LTS, 2006 and 2008



Source: Pharmaceutical Research and Manufacturers of America (PhRMA)

- ◆ The number of pre-market notifications (510(k)s) held steady for all LTS.
- ◆ After receiving none in 2007, Massachusetts companies received more pre-market approvals (PMAs) than any other LTS in 2008.

Why Is It Significant?

The US Food and Drug Administration (FDA) classifies medical devices into two categories during the approval process: pre-market approvals (PMAs) and pre-market notifications, known as 510(k)s. PMA is the designation for the more sophisticated, developed devices, while 510(k)s is a classification for less sophisticated instruments or simple improvements to existing products or functional equivalents. Approval rates reflect innovation in medical device design and manufacturing as well as important relationships with those teaching and research hospitals where many of these instruments undergo clinical investigation and trial.

Biotechnology drugs in development track potential medicines in human clinical trials or under review by the FDA’s Center for Drug Evaluation and Research. This measure reflects innovation in health research and pharmaceutical manufacturing. Biotechnology drugs currently in development utilize state-of-the-art technologies to treat cancer, infectious diseases, autoimmune disorders, and other medical conditions.

How Does Massachusetts Perform?

Massachusetts regularly ranks high among the LTS, in both absolute and relative terms, in medical device approvals and notifications and biotechnology drugs in development. This reflects the Commonwealth’s strong life sciences and healthcare technology sectors.

After receiving none in 2007, Massachusetts companies received more pre-market approvals than any of the LTS in 2008. Massachusetts’ performance in biotechnology drugs in development ranks fourth among the LTS in 2008. Even though the number of biotechnology drugs in development in MA increased from 61 in 2006 to 75 in 2008, New Jersey and Pennsylvania doubled their respective numbers.

Business Formation

- ◆ New business incorporations fell by 7.2% in 2008 compared to 10.6% decline at start of the 2001 recession.
- ◆ Data shows Massachusetts lagged most of the LTS in new business formation and the resulting job creation coming out of 2001 recession.
- ◆ Massachusetts' universities, hospitals, and research institutions excel at creating ideas that make their way into the economy through new business formation.

Why Is It Significant?

New business formation is a key element of job creation and cluster growth—typically accounting for 30-45% of all new jobs in the US. In the Innovation Economy, new business formation plays a particularly important role in developing and commercializing emerging technologies.

The number of spinout companies from universities, teaching hospitals, and nonprofit research institutes is a proxy for the entrepreneurial culture at these institutions to translate research outcomes into commercial applications.

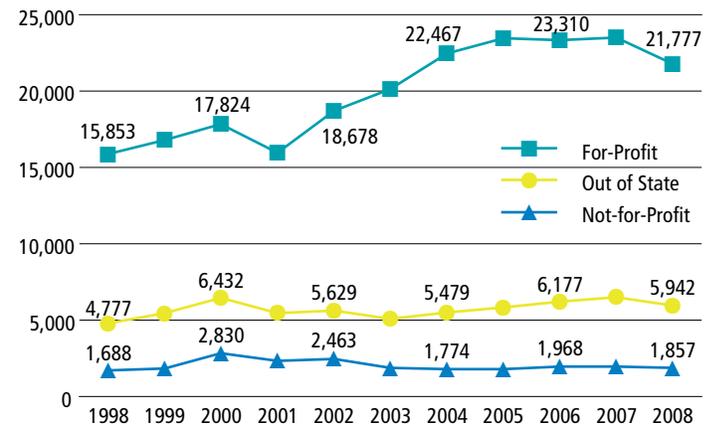
How Does Massachusetts Perform?

Following the pattern seen in other economic downturns, new business incorporations in Massachusetts declined by 7.2% between 2007 and 2008. This is significantly less than the decline at the start of the last recession in 2001.

Trends suggested by the data underscore the importance of supporting a strong entrepreneurial culture across the state as a strategy to accelerate economic recovery exiting the current recession. Consistent with employment data presented in other indicators, longitudinal analysis on new business formation and resulting job growth shows that Massachusetts struggled coming out of the last recession. Massachusetts consistently underperformed the LTS average in business formation and the resulting job creation during the period 2000-2006. Analysis of net high tech business formation shows that the economic recovery from the last recession did not really take hold until 2007, significantly later than many other Leading Technology States.

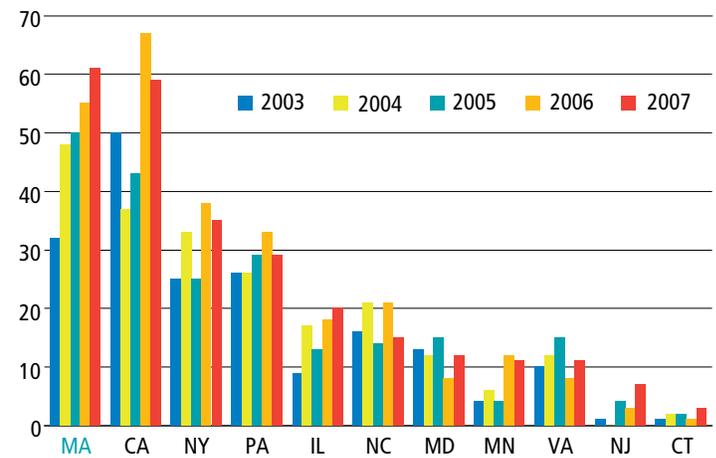
Massachusetts' universities, hospitals, and nonprofit research institutes excel as sources of ideas that lead to the formation of new businesses. Massachusetts ranked first among the LTS in the number of spinouts from these institutions in 2007. While spin-outs from these institutions represent a very small—but highly visible—fraction of the new business formation activity in the Commonwealth, the presence of a strong entrepreneurial community within these institutions can be leveraged to catalyze new business formation across the state.

New business incorporations by category, Massachusetts, 1997–2008



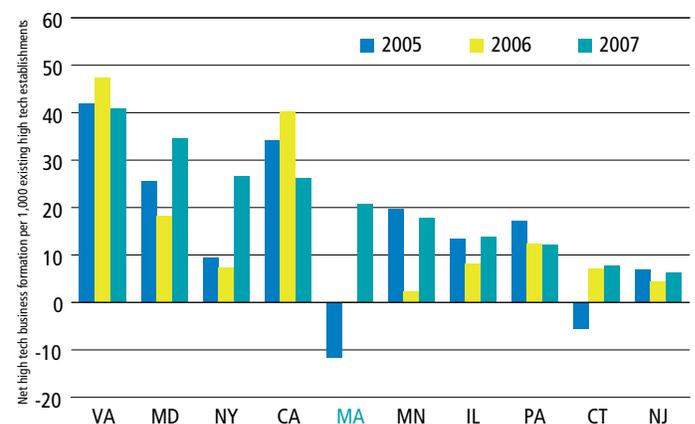
Source: Commonwealth of Massachusetts

Spin-out companies from universities, hospitals, and nonprofit research institutes, LTS, 2003–2007



Source: Association of University Technology Managers

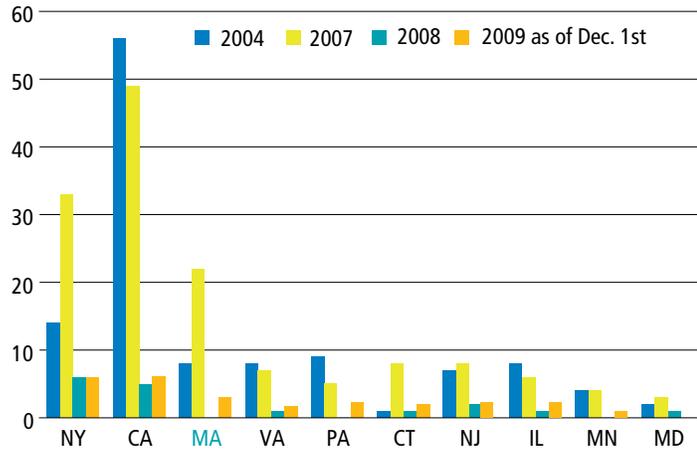
High tech business formation rate, LTS, 2005–2007



Source: US Census Bureau, County Business Patterns and MTC Analysis

Initial Public Offerings and Mergers & Acquisitions

Number of IPOs, LTS, 2004, 2007-2009



Source: Renaissance Capital, IPO Home

- ◆ Initial Public Offerings (IPOs) dropped by 84% in the US from 2007 to 2008. No IPOs were issued in MA in 2008, but 2009 started off strong relative to the LTS.
- ◆ Massachusetts-based companies are more often the acquiring company than the company being acquired.

Why Is It Significant?

IPOs and mergers and acquisitions (M&As) represent important avenues through which emerging companies can access capital to sustain operations and support growth. IPOs and M&As also are opportunities for early-stage investors to achieve liquidity for their financial investments. Some M&As enhance research outcomes by bringing together technological expertise and enhancing efficiency. However, other M&As can decrease the incentive to innovate within a business by softening the competition or by making innovation something that is essentially outsourced through the acquisition of startup companies with proven technologies.

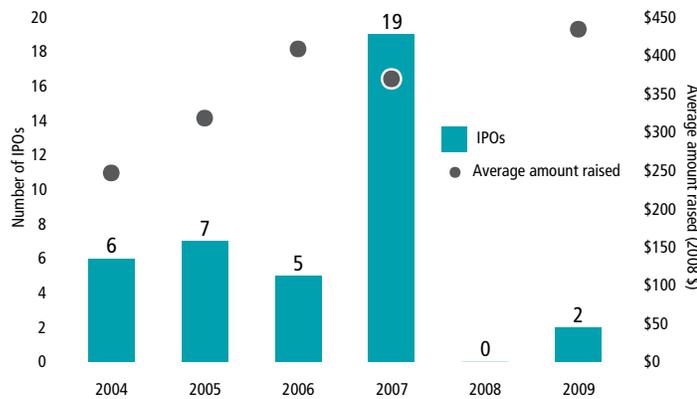
How Does Massachusetts Perform?

Volatility in the stock market made 2008 a very difficult year to issue an IPO. Few IPOs were issued in any of the LTS and in the US as a whole only 43 IPOs were issued compared to 272 the year before. After a year without a single IPO, three IPOs were issued by Massachusetts businesses in the first three quarters of 2009 placing Massachusetts third among the LTS. M&As also declined across the LTS from 2007 to 2008.

Of the three IPOs in Massachusetts in the first three quarters of 2009, two had received venture capital (VC) funding. The average amount raised by these firms exceeds the average amount raised by venture-backed Massachusetts firms in the past five years. In addition, the IPO of Boston-based A123 Systems raised more funds than any other venture-backed IPO in the nation since March of 2007.

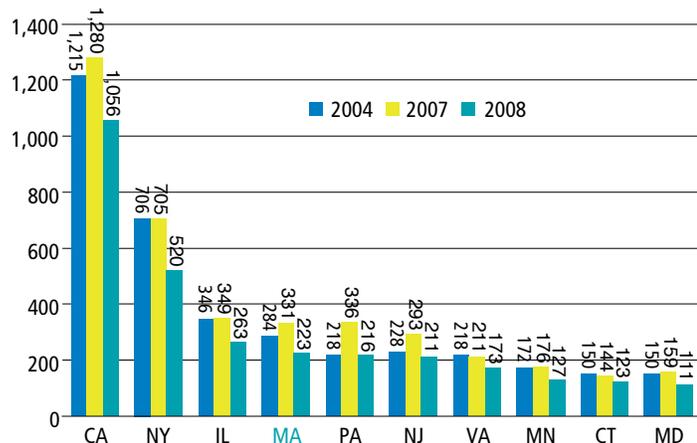
One consequence of unfavorable market conditions for the issuance of an IPO is that more venture funds choose to achieve liquidity by selling the venture-backed firms via an M&A. In the US, the number of venture-backed M&As as a percent of all VC liquidity events was 18% higher on average from 2008 Q1 to 2009 Q3 than during the previous seven quarters. The effect that this has on innovation depends on the nature of the acquisitions. The fact that since 2002 more Massachusetts companies were the acquiring company than the acquisition target suggests that the flow of ideas is positive for the Commonwealth.

Venture-backed IPOs, Massachusetts, 2004–2009 Q3



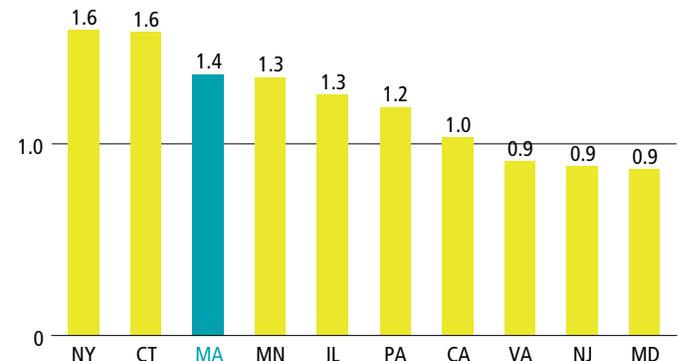
Source: The Boston Globe, PRNewswire.com, Thomson Reuters and the National Venture Capital Association

Mergers and acquisitions by location of acquired company, LTS, 2004, 2007, 2008



Source: Renaissance Capital, IPO Home

Number of companies bought per company sold, LTS, 2008



Source: FactSet MergerStat, LLC

Federal Funding for Academic, Nonprofit, and Health R&D

- ◆ Massachusetts' universities and nonprofit research institutes are among the top in the LTS for attracting federal R&D dollars, receiving \$2.9 billion in 2007.
- ◆ Massachusetts' research institutions continue to attract the largest share of National Institutes of Health (NIH) funding per capita.

Why Is It Significant?

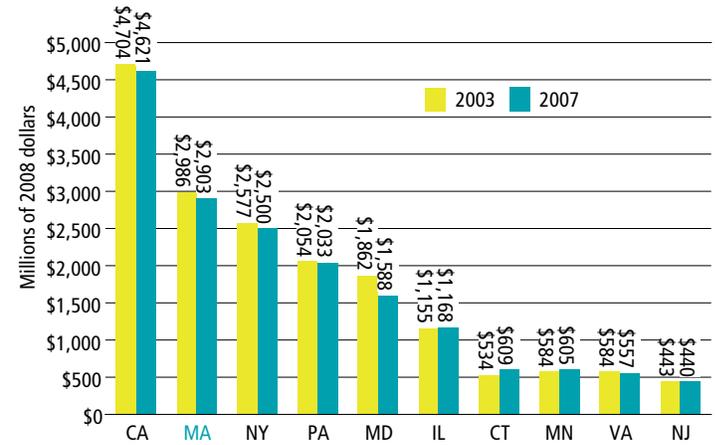
Research universities and other academic centers are pivotal in the Massachusetts Innovation Economy because they advance basic science, create technology that can be commercialized in the private sector, and contribute to educating the highly-skilled individuals that constitute one of Massachusetts' greatest strengths. Funding from the federal government is critical to sustain academic, nonprofit, and health-related research. Funding from the NIH, for example, is a driver of the Commonwealth's biotechnology, medical device, and health services industries, which together comprise the Life Sciences cluster.

How Does Massachusetts Perform?

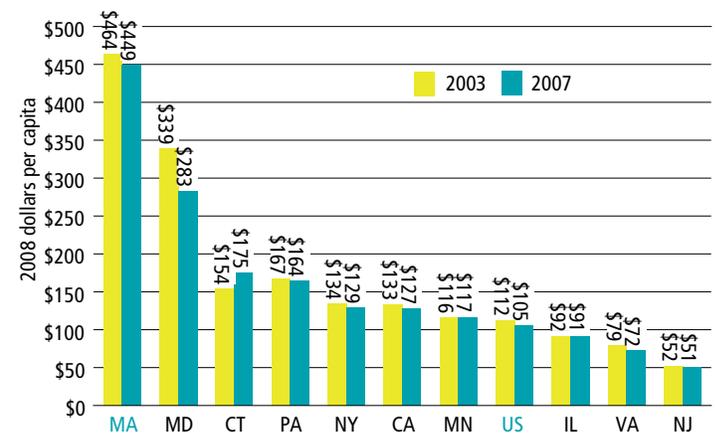
Whether in total dollars or on a per capita basis, universities and nonprofit research institutes in Massachusetts are among the top in the LTS for attracting federal R&D dollars. In 2003 and 2007, federal funding for Massachusetts' universities and nonprofit research institutes accounted for 9% of the US total. Academic and nonprofit institutes in Massachusetts received 2.9 billion federal R&D dollars in 2007.

The Commonwealth also maintains its leadership position among all LTS in health research funding. In 2008, Massachusetts research institutions were awarded 11% of NIH funds granted to US research institutions, a \$200 million increase for Massachusetts research institutions in 2008 over the prior year. Massachusetts was second to California in overall NIH American Recovery and Reinvestment Act (ARRA) grant awards through September 2009. California, which has six times the population of Massachusetts, received \$638 million compared to \$503 million awarded in Massachusetts.

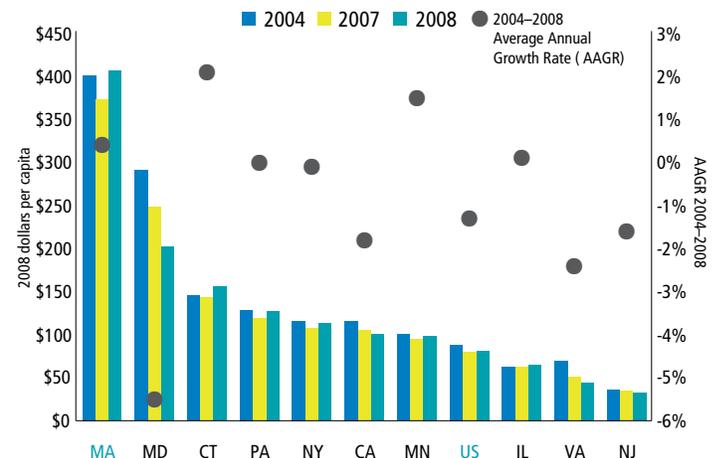
Federal expenditures for academic and nonprofit R&D, LTS, 2003 and 2007



Per capita federal expenditures for academic and nonprofit R&D, LTS and US, 2003 and 2007



NIH funding per capita and average annual growth rate (AAGR), LTS and US, 2004, 2007, and 2008



Source of all data for this indicator: The National Science Foundation

Industry Funding of Academic Research

Industry funded academic research, Massachusetts and Massachusetts' share of US total, 1998–2007



- ◆ Industry funding for academic R&D increased in real dollars and as a percent of total academic R&D funding from all sources.
- ◆ Among the LTS, Massachusetts' academic research institutes bring in the most industry funding for academic R&D per capita.

Why Is It Significant?

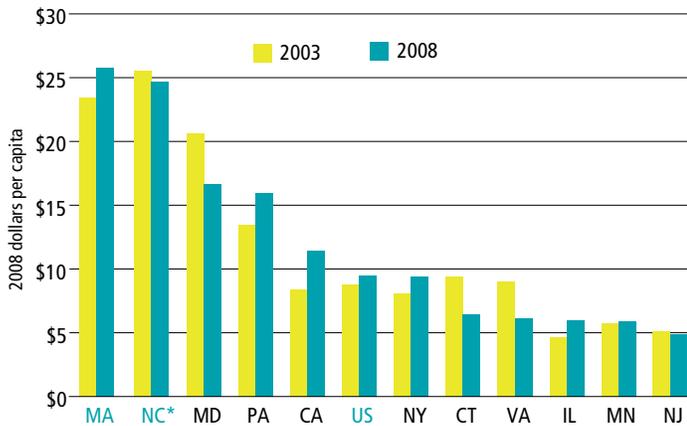
Industry funding of academic research is one measure of industry-university relationships and of the relevance that industry places on academic research. However, the impact of university research on industry is not limited to advances in knowledge at the forefront of technology. University-industry research partnerships also result in beneficial innovations across low, medium, and high technology industries. Moreover, university research in fields funded by industry helps educate experts in areas directly relevant to industry needs.

How Does Massachusetts Perform?

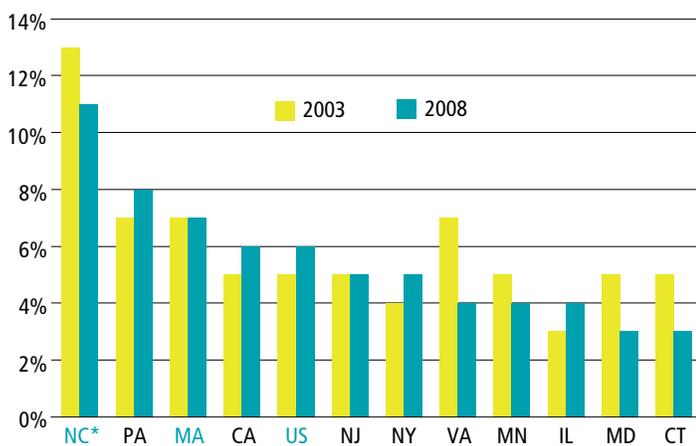
Industry's connection to academia remains strong in Massachusetts. From 2003-2008, industry funding for academic research Massachusetts' academic institutions increased \$17 million in inflation-adjusted dollars and 11% as a percent of all industry funding of academic research in the US. Among the LTS, from 2003-2008 industry funding for academic research grew the fastest at academic institutions in California. On a per capita basis, however, Massachusetts stands above the other LTS as a destination of industry funding for academic R&D.

Massachusetts ranks second, after Pennsylvania, among the LTS in the percent of academic R&D funded by industry. While no longer featured among the LTS in this Index, North Carolina stands out for its strong funding relationship between its universities and industry. With 11% of academic R&D funded by industry, North Carolina exceeds all of the LTS on this measure largely because of Duke University and its leadership as a center for clinical trials.

Industry funding of academic R&D per capita, NC, LTS, and US, 2003 and 2008



Percent of academic R&D funded by industry, NC, LTS, and US, 2003 and 2008



Source of all data for this indicator: The National Science Foundation
 *North Carolina is not part of the LTS but stands out on this indicator

Venture Capital

- ◆ Following national trends, thirty-five percent less venture capital (VC) flowed to Massachusetts-based firms in 2009 than in 2008.
- ◆ Despite the downturn, VC funding for startup/seed stage Massachusetts companies reached record levels.
- ◆ Biotechnology and software continue to attract the most VC funding in Massachusetts, but there have been large increases in VC investment since 2004 in industrial/energy and electronics/instrumentation.

Why Is It Significant?

Venture capital (VC) firms are an important source of funds for the creation and development of innovative new companies. Trends in VC investment can be predictive of emerging growth opportunities in the Innovation Economy. In addition, VC firms often provide valuable business strategy guidance. Private investment capital derived from sources such as angel investors are also important, but harder to measure and not included in this data.

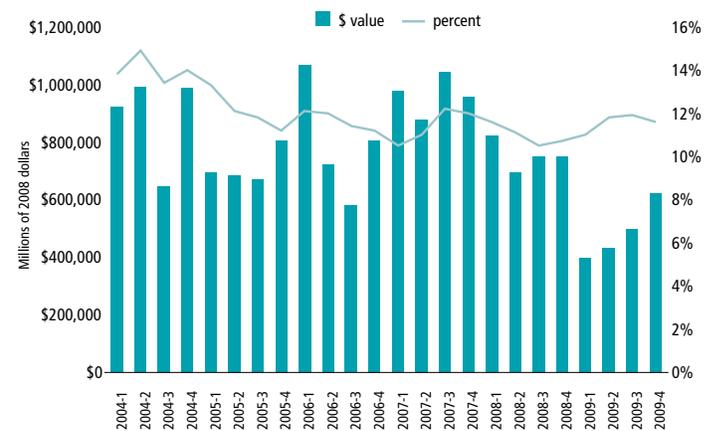
How Does Massachusetts Perform?

The recession has had a marked impact on the ability of venture capital firms to raise new capital to invest and on their willingness to make new investments, particularly in established companies. Nationally, the dollar amount raised by venture funds dropped 57% in the last quarter of 2008 and remained low during most of 2009. Not surprisingly, the amount invested in Massachusetts-based firms was 35% lower in 2009 than in 2008. However, in the nation as a whole VC declined by 40%. Among the LTS, Massachusetts companies continue to attract the greatest amount of venture capital per capita, while California continues to lead in total venture investment.

Although overall venture investments have declined since the start of the recession, this has been confined primarily to the expansion and later stages. Investments in early stage Massachusetts companies have remained stable, while those in start-up/seed stage companies have reached record levels. Equally as important, the average deal size for these investments is now comparable to or larger than those in other Leading Technology States. (Average deal size for expansion and later stage companies continue to be considerably smaller than for other LTS). These investments should place Massachusetts in a strong position to grow its innovation economy as the country emerges from recession.

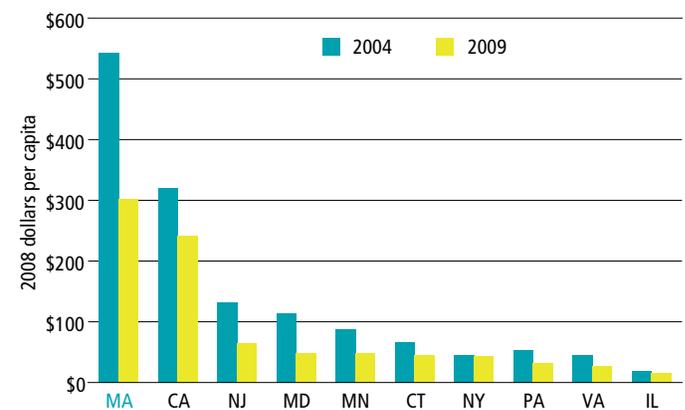
The only sectors in Massachusetts to receive more venture funding in 2009 than in 2004 are industrial/energy and electronics/instrumentation. However, the record investments in start-up/seed stage biotechnology and medical device companies suggest that Massachusetts continues to attract investments across a relatively broad range of sectors. Biotechnology, medical devices & equipment, electronics/instrumentation, and industrial/energy each had average annual growth rates exceeding 20% in startup/seed and early stage investment.

Venture capital (VC) investment in Massachusetts and as a share of total VC investment in the US, 2004 Q1–2009 Q4



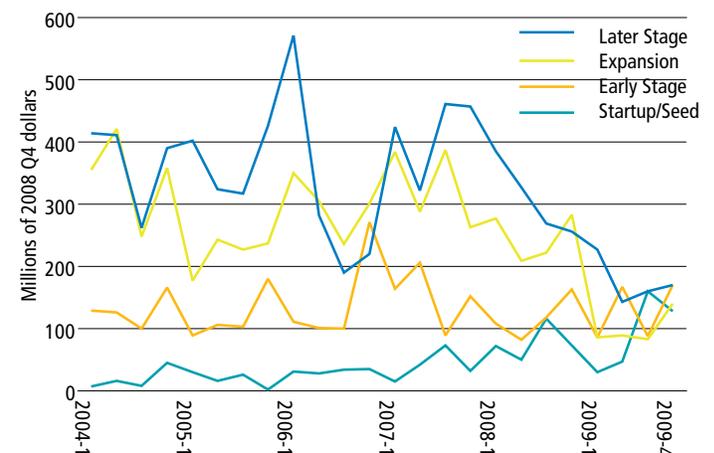
Source: PricewaterhouseCoopers MoneyTree Report

Venture capital investment per capita, LTS, 2004 and 2009



Source: Thomson Reuters and National Venture Capital Association

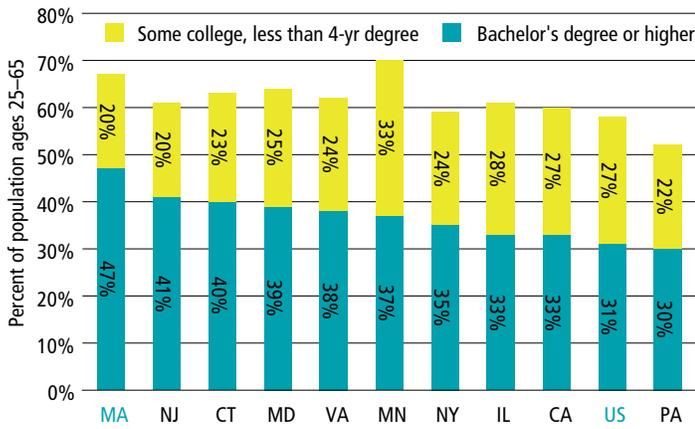
Venture capital investment by stage of financing, Massachusetts, 2004–2009



Source: PricewaterhouseCoopers MoneyTree Report

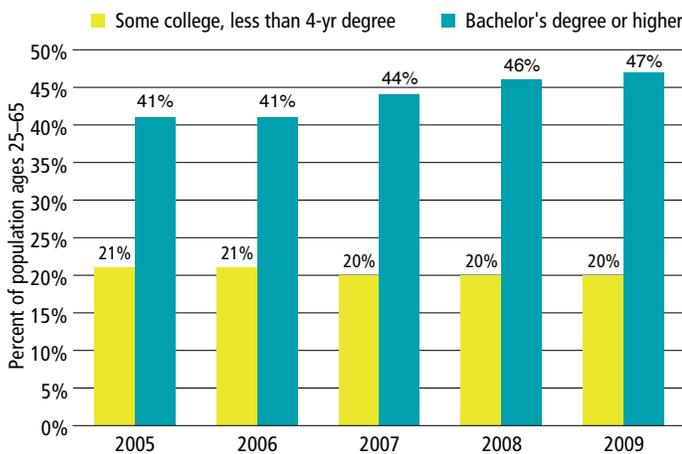
Education Level of the Workforce

Educational attainment of working age population, LTS and US, 2007-2009 average



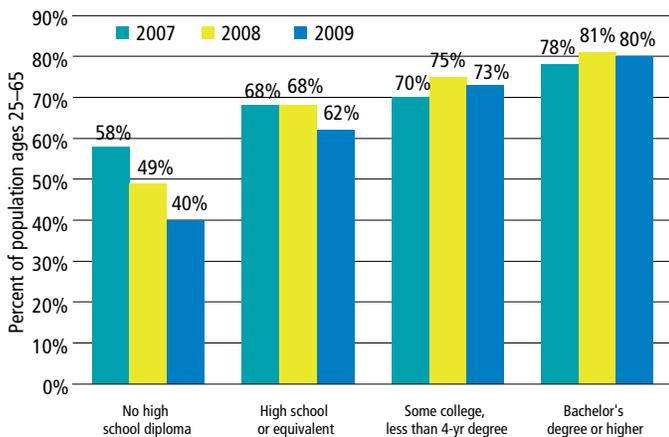
Source: Current Population Survey

College attainment of the working age population, Massachusetts, 2005–2009 three-year rolling average



Source: Current Population Survey

Employment rate by education, Massachusetts, 2007–2009



Source: Current Population Survey

- ◆ Massachusetts boasts the highest bachelor's degree attainment rate among the LTS and US.
- ◆ Massachusetts ranks second among the LTS in the size of the workforce with at least some education beyond high school.

Why Is It Significant?

The educational attainment of the workforce contributes directly to a region's ability to generate and support innovation-driven economic growth. Both the increasing technical skill demands of employment and the aging of the baby-boom generation contribute to concerns about the growth of the pool of educated working-age people.

How Does Massachusetts Perform?

Through a combination of education and talent flows, Massachusetts has a large stock of talent. Massachusetts continues to rank first among US states in the percent of residents with a four-year college degree or higher. The percent of the working-age population with at least a four-year college education has increased from 41% to 47% since 2005. During that same period, four-year college attainment in the other LTS increased more modestly from 33% to 35%.

The percent of the working-age population with some college, but less than a four-year degree declined slightly over this same period in Massachusetts. Having some education beyond high school is important for success in most jobs as is life-long skill acquisition to master new technologies in the workplace. Many science-based manufacturing, green building, laboratory technician, nursing, and computer support positions critical to the Innovation Economy are accessible with an associates degree or specialized certificate program. Community college coursework and associates degrees also continue to be an important pathway to bachelors' degrees.

With a slow growing population, increasing educational attainment is one way Massachusetts meets demand for labor. From 2005 through 2009 the college-educated working-age population grew by 186,000 while the total working-age population decreased by 77,000.

Employment rates in the recession demonstrate the importance of education in the current labor market. While the percent of working-age people with a job dropped for all education levels in 2009, declines in employment were most severe for the population with the least education. This pattern is also evident nationally. Massachusetts' high educational attainment has helped moderate unemployment in the current recession.

K-16 Education

- ◆ In the last four years, high school attainment among young adults in Massachusetts has risen significantly and is now the highest among the LTS.
- ◆ Massachusetts ranks seventh among the world's nations for college degrees conferred per capita.

Why Is It Significant?

Education plays a very important role in preparing Massachusetts residents to succeed in their evolving roles and career trajectories. A strong education system also helps attract and retain skilled workers who want excellent educational opportunities for themselves and their children. Economic growth in Massachusetts is heavily dependent upon improving the skill mix of the population, especially because of relatively slow population growth. Some of the key metrics of talent development are mathematics ability, high school attainment, and college degree attainment. High school attainment of persons ages 19-24 as measured by the American Community Survey replaces the drop-out rate as a metric because states often undercount drop-outs.

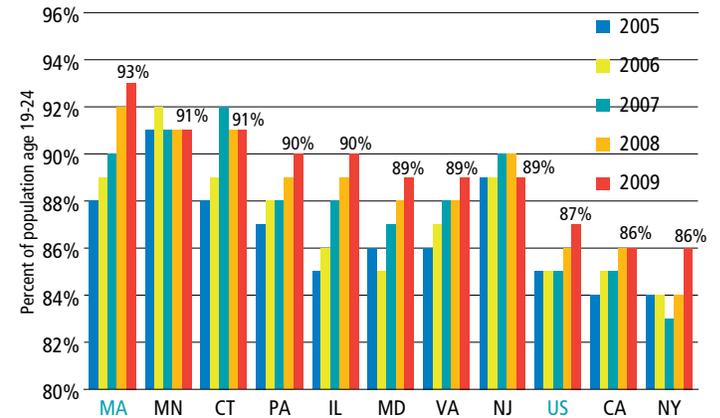
How Does Massachusetts Perform?

Massachusetts has the highest high school attainment rate among the LTS as measured by the percent of the population ages 19-24 with at least a high school diploma or GED. The progress achieved by the K-12 education system is evident in rising educational attainment among the youngest adults. The percent of the population ages 19 through 24 that has not yet completed high school dropped between 2005 and 2009 from 12 to 7 percent. Over the last four years, Massachusetts has improved more than twice as fast on this measure than the nation as a whole. This is evidence that Massachusetts' K-12 schools are providing at least a basic education to a growing percent of the youth population.

In mathematics, Massachusetts' students outperform their US peers and are highly competitive internationally. Massachusetts' eighth grade students taking the Trends in International Math and Science Study (TIMSS) math assessment ranked fourth among participating areas, behind Hong Kong, Singapore, and Taiwan.

Higher education has long been a strength of Massachusetts. Massachusetts ranks sixth globally in degrees conferred per capita. The US, in comparison, ranks 20th.

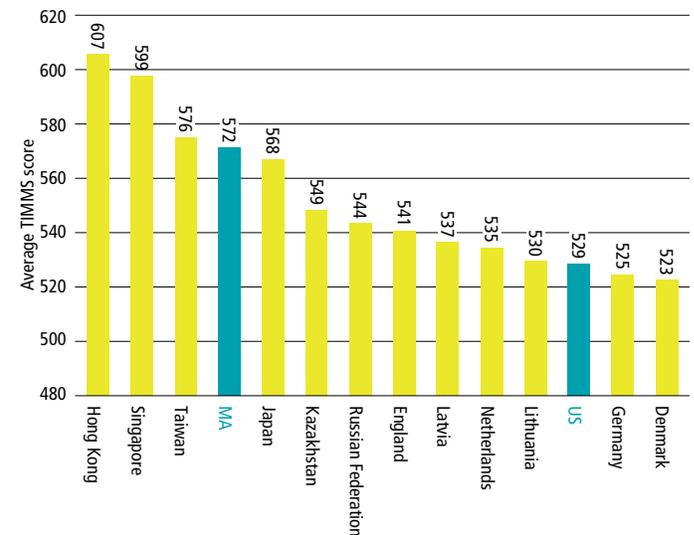
High school attainment of persons ages 19–24, three year rolling averages, LTS, 2005–2009



Source: American Community Survey

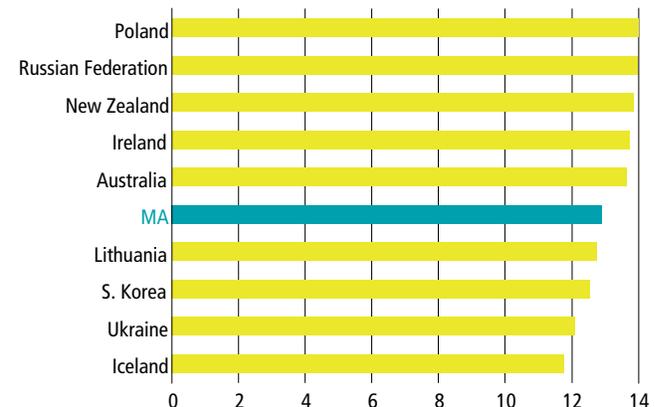
INTERNATIONAL

Top 15 nations participating in the 8th grade TIMSS mathematics evaluation with Massachusetts, 2007



Source: International Association for the Evaluation of Educational Achievement

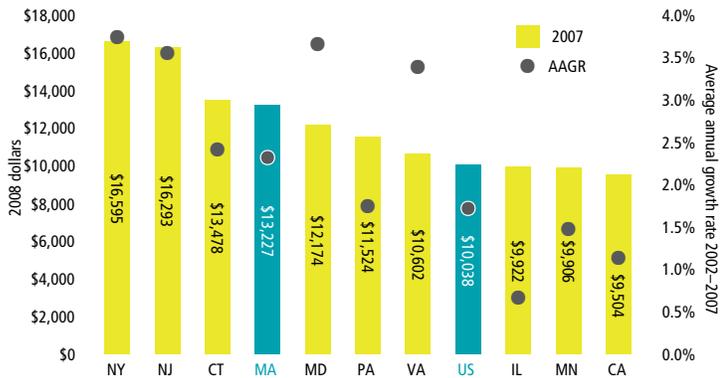
Degrees conferred per thousand inhabitants, all levels, international, 2007



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) and the National Center for Education Statistics

Public Investment in K-16 Education

Per pupil spending of public elementary/secondary school systems, LTS, 2007



Source: US Census Bureau

State higher education appropriations per full-time equivalent student, LTS, 2008



Source: State Higher Education Executive Officers

- ◆ During the last five years, Massachusetts increased real per pupil support for K-12, but decreased per student appropriations for higher education.
- ◆ Compared internationally, Massachusetts' per pupil investments in public education places it in the middle among high income nations*relative to per capita GDP.

Why Is It Significant?

Investments in elementary, middle, and high schools are important for preparing a broadly educated and innovation-capable future workforce. Investments in public, postsecondary education are critical to increase the ability of public academic institutions to prepare students for skilled and well-paying employment in Massachusetts. In addition, well-regarded public higher education programs enhance Massachusetts' distinctive ability to attract students from around the globe, some of whom choose to work in Massachusetts after graduation.

This indicator tracks public investments in education as this sector plays a large role in affordable access to education and is the sector most influenced by state government. Forty-eight percent of Massachusetts' high school graduates enroll in public higher education institutions, while 32% enroll in private ones. Massachusetts is unusual in that 43% of college students are in public institutions compared to 72% nationally.

How Does Massachusetts Perform?

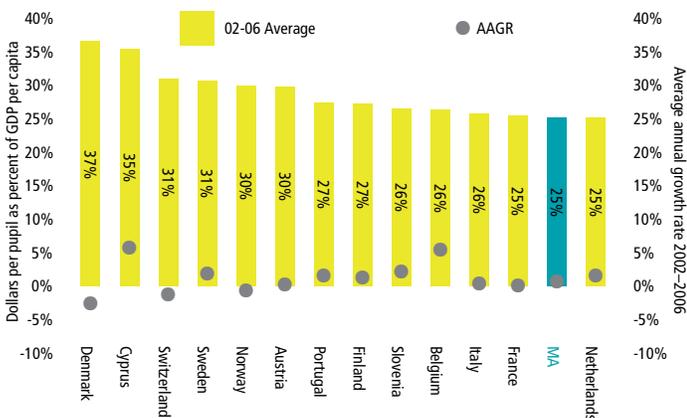
From 2002 to 2007, per pupil public support for K-12 education rose at an average annual rate of 2.3%. However, from 2003-2008, per pupil support for higher education declined. In 2008, Massachusetts public universities again saw total enrollment rise and real appropriations decline. Massachusetts' appropriations for higher education have declined significantly since the late 1980s, whether viewed per student, per capita, or relative to the size of the Massachusetts economy. In 2003, Massachusetts' appropriations per student were 23% percent above the US average, while in 2008 they are only 5% percent above the average.

Massachusetts ranks 13th among high income nations in per pupil public investment in education (inclusive of all levels) relative to per capita GDP. Massachusetts held steady on this measure from 2002 through 2006. The US on average ranks 18th on this measure, just after the United Kingdom

*In order to make comparisons based on GDP per capita, the nations selected were all high income as define by the World Bank. See appendix for more information.

INTERNATIONAL

Propensity to invest in public education, all levels, international, 2002-2006



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), Bureau of Economic Analysis, the National Center for Education Statistics, State Higher Education Executive Officers (SHEEO) and the Census Board

Science, Technology, and Engineering Career Choices and Degrees

- ◆ Massachusetts ranks first among the LTS in degrees granted in Engineering, Computer, & Information Science and Health & Life Sciences, but Massachusetts high school seniors express below average interest in these fields.
- ◆ Degrees granted in Engineering, Computer, & Information Science declined while employment in related professions continued to climb.

Why Is It Significant?

Science and technology offer promise in improving incomes and quality of life by driving productivity growth across sectors and creating whole new industries. Massachusetts' high earnings and quality of life have been achieved, in large part, through a strong ecosystem of science, technology, and engineering capabilities. This indicator focuses on the distinct trends in two broad fields: engineering, computer, & information science and health & biological science.

Massachusetts' business leaders are highlighting the "science, technology, engineering, and math (STEM) pipeline issue" because the number of students majoring in these critical fields is not sufficient to fill the vacancies expected as baby boomers retire over the coming decade. Massachusetts in particular has a high demand for STEM professionals.

How Does Massachusetts Perform?

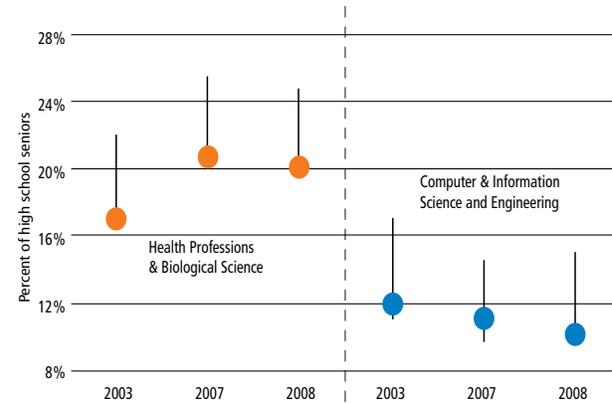
Massachusetts' high school seniors are less likely to indicate an intent to major in "Engineering, Computer, or Information Science" or in "Health Professions or Biological Science" than peers in many of the LTS. The lack of intent to major in STEM careers by Massachusetts' high school seniors stands in contrast to their relatively strong performance on math and science Advanced Placement exams.

Nevertheless, Massachusetts' colleges and universities educate many students from out of state. Massachusetts' colleges and universities rank first per capita among the LTS in terms of bachelor's and graduate degrees granted in these fields, a reflection of their ability to attract talent globally.

Over six percent of jobs today in Massachusetts are in engineering, computer, or information science professions – a percent equal to the height of the 2000 tech boom. The percent of jobs in health or biological science professions is above ten percent and climbing. Nearly all of these jobs require a postsecondary degree in the field.

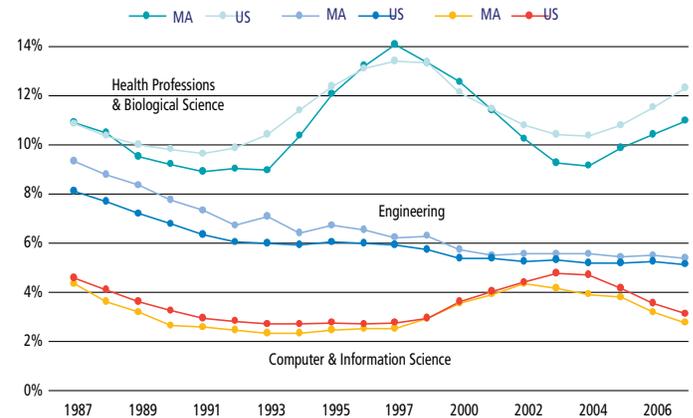
The trends in preparation for careers in health or life science fields are moving in a positive direction unlike trends in preparation for information technology careers. In addition, health and life science degree programs and professions have relatively high participation by women while the number of women in computer and information sciences is low and declining.

Intended major of high school seniors, Massachusetts, and LTS range, 2003, 2007, and 2008



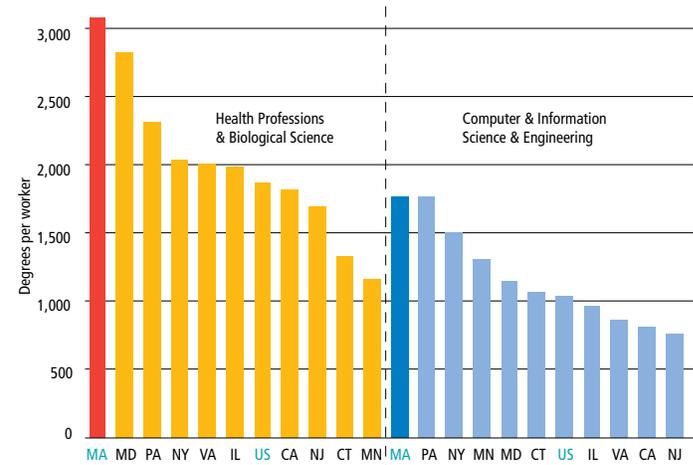
Source: The College Board

Engineering, health & biological sciences, and computer & information science bachelor degrees granted as a percent of all bachelor degrees granted



Source: Integrated Postsecondary Education Data System

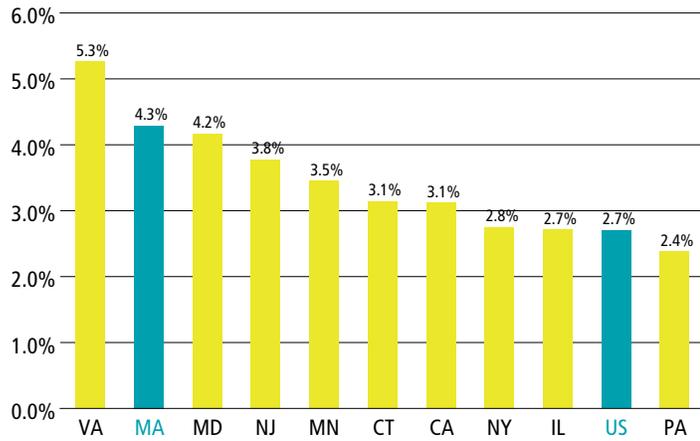
Bachelors' and graduate degrees granted in computer & information science & engineering and health & biological sciences, LTS, 2007



Source: Integrated Postsecondary Education Data System

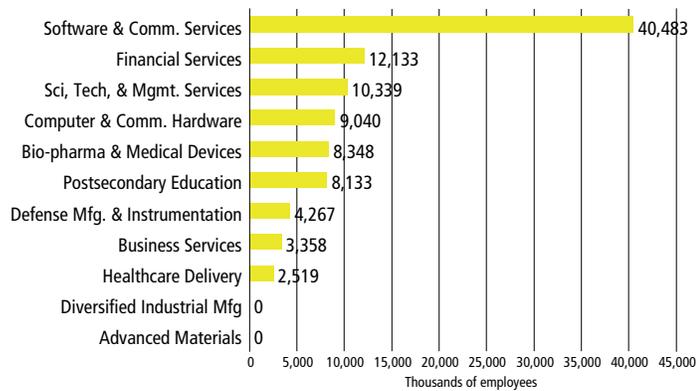
Information Technology Professionals in the Workforce

Percent of workforce in IT occupations, LTS, 2008



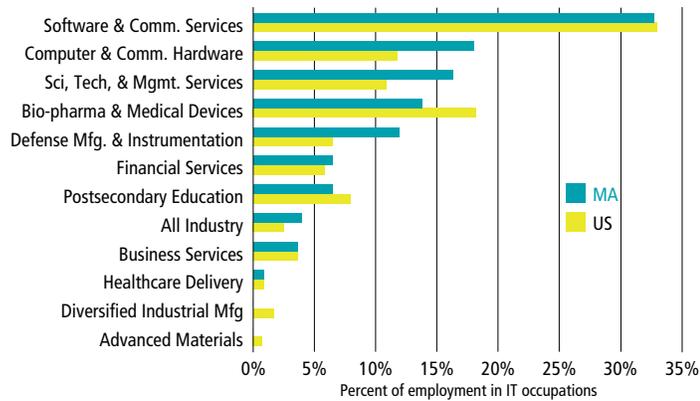
Source: US Bureau of Labor Statistics

Employees in IT occupations by industry cluster, Massachusetts, 2006



Source: Massachusetts Department of Labor and Workforce Development

IT intensity, Massachusetts and US, 2006



Source: Massachusetts Department of Labor and Workforce Development, Bureau of Labor Statistics, and Moody's Economy.com

- ◆ In 2008, Massachusetts had a higher percent of the workforce in information technology (IT) occupations compared to the LTS, second only to Virginia.
- ◆ Financial Services is the second largest employer of IT professionals in Massachusetts after Software & Communication Services.

Why Is It Significant?

The economy increasingly relies on a workforce that is skilled in IT because these technologies drive improvements in productivity across many industries. Therefore, the percent of the workforce in IT occupations is an indicator of the technological advancement of an economy across sectors and the extent to which companies are using IT to compete and create comparative advantages.

How Does Massachusetts Perform?

Over four percent of Massachusetts' workers are in IT occupations compared to 2.7% in the US economy. Among the LTS, Massachusetts is second to Virginia in the percent of workforce in IT occupations. Employment in IT occupations expanded relatively quickly in Massachusetts and the LTS compared to the US over the last five years. There are more people employed in IT occupations in Massachusetts in 2008 than at the height of the bubble, both in the raw number and as a percent of total state employment.

IT specialists are employed in a broad range of sectors. In Massachusetts, the Software & Communications cluster employs the greatest number of people in IT occupations, followed by Financial Services

An analysis of each of the key industry clusters in Massachusetts shows that Computer & Communications Services; Science, Technology, & Management Services; and Defense Manufacturing & Instrumentation have significantly greater IT intensity than the US average, suggesting that companies in these clusters are aggressively using IT to enhance their comparative advantage. Massachusetts employs relatively fewer IT professionals in five clusters including Postsecondary Education.

Talent Flow and Attraction

- ◆ Net migration to Massachusetts was positive in 2008 for the first time in six years.
- ◆ Massachusetts ranks third among the LTS in attracting college-educated people from other states.

Why Is It Significant?

Migration is both a driver of the Innovation Economy and a performance measure of the attractiveness of the region. Regions that are hubs of innovation have both high concentrations of educated, high-skilled workers and dynamic labor markets refreshed by flows of talent. In-migration fuels innovative industries by bringing in individuals with skill-sets and educational backgrounds that are in demand. While a positive net-talent flow is important, Massachusetts benefits from talent flows in both directions connecting Massachusetts' institutions and businesses to other regions.

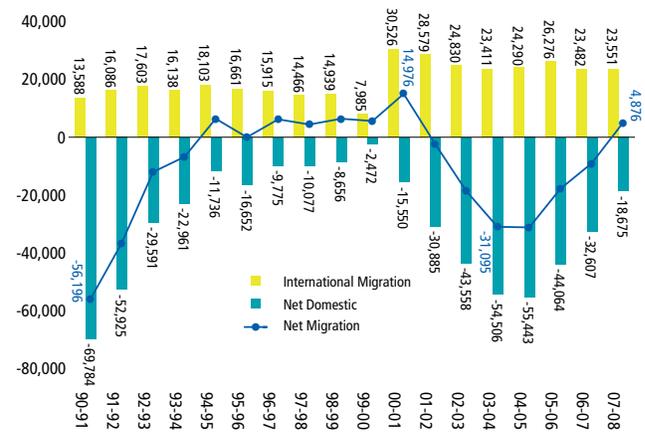
How Does Massachusetts Perform?

Tracking general employment trends in Massachusetts, net domestic migration continued to improve through 2008, while net international migration remained steady. Net migration turned positive for the first time in six years, reaching levels comparable to those attained in the mid and late 1990s.

Net migration has contributed to the rising educational attainment in the Commonwealth. Massachusetts continues to perform well in attracting and retaining college educated individuals. Over the last few years, the shrinking size of the ages 25-34 segment of the population gave rise to claims that Massachusetts faced a "brain drain." Research by the Federal Reserve Bank of Boston finds that when the in-migration of students into the region to attend college is taken into account, the region has a positive net flow of college graduates with in-migrants more than off-setting out-migrants. All regions of the US are competing to attract the smaller number of individuals who are today between the ages of 25 and 34.

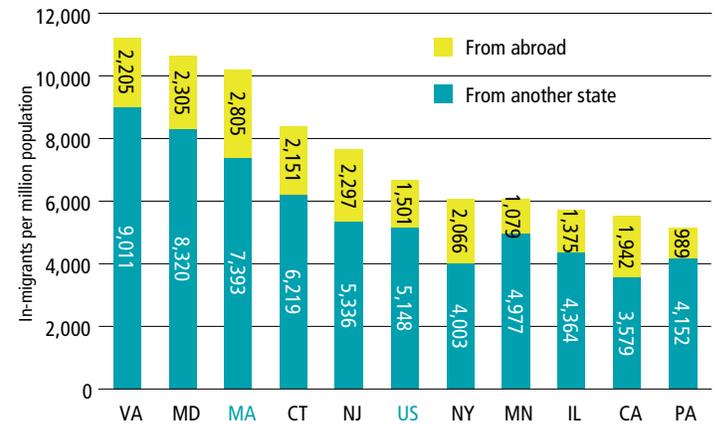
From 2006-2007, 231,767 people moved in and out of Massachusetts, 6% of which were from another country. In recent years, Massachusetts has contributed population to New Hampshire, North Carolina, and California, while net in-migration has occurred from New York, Connecticut, Rhode Island, and abroad.

International and net domestic migration, Massachusetts, 1992–2008



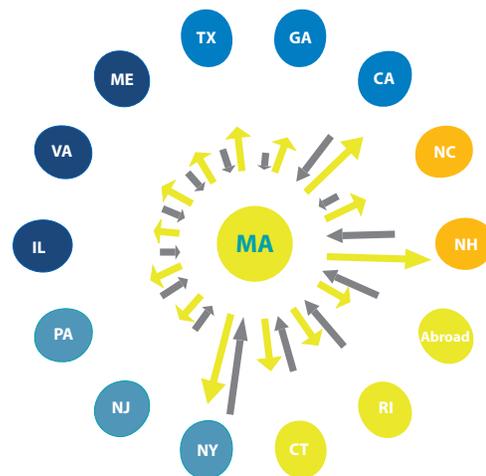
Source: US Census Bureau

Relocations to the LTS in 2008 by college educated adults



Source: US Census Bureau, American Community Survey

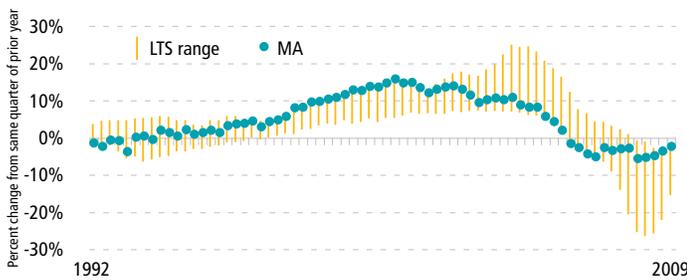
Migration in and out of Massachusetts, top regions, 2006–2007



Source: The Internal Revenue Service, based on exemption numbers

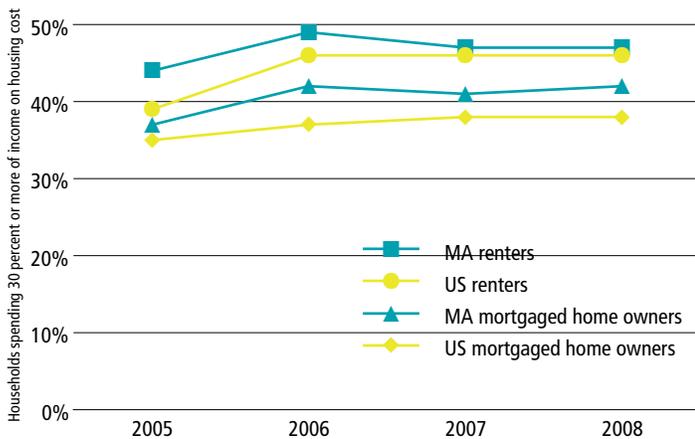
Housing Affordability

Housing price index, Massachusetts and LTS range, 1992–2009



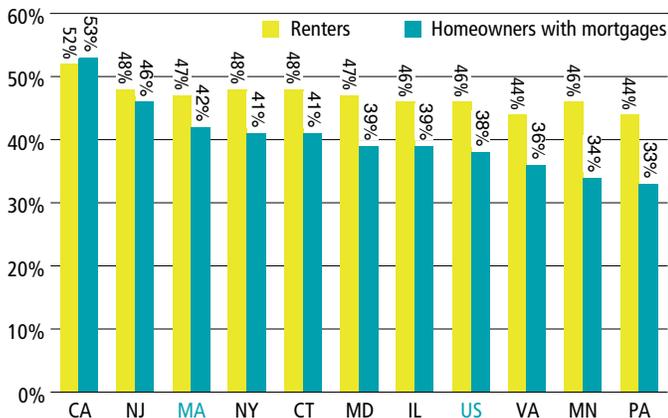
Source: Federal Housing Finance Agency

Housing affordability trends for renters and home owners with a mortgage, Massachusetts and US, 2005–2008



Source: American Community Survey

Households spending 30 percent or more of income on housing costs, LTS and US, 2008



Source: American Community Survey

- ◆ The rate of housing price declines slowed in 2008.
- ◆ The number of homeowners with mortgages spending more than 30% of income on housing costs in Massachusetts rose slightly in 2008, while conditions remained stable for renters.
- ◆ Massachusetts ranks in the top half of the LTS for housing affordability for renters and 3rd least affordable for homeowners with mortgages.

Why Is It Significant?

The combination of quality of life and housing affordability influences Massachusetts' ability to attract and retain talented people. A lack of affordable housing for essential service providers and entry-level workers can slow business expansion in the region. Spending 30 percent or more of income on housing costs is a common threshold to measure housing affordability.

How Does Massachusetts Perform?

Massachusetts, like the rest of the nation, experienced housing price deflation over the last four years reversing a long period in which housing cost increases drastically outpaced income growth. Housing prices in Massachusetts did not spike as high as in some of the other LTS in 2004 to 2006 and are not experiencing as sharp declines in 2008 and 2009.

Despite housing price declines, more homeowners with mortgages and renters are experiencing unaffordable monthly payments in 2008 than in 2005. Several US financial market factors have contributed to affordability problems. Loosened mortgage lending standards enabled people to take on mortgages with projected payments exceeding 30% of income and unprecedented numbers of adjustable rate mortgages exposed many homeowners to increases in required monthly payments. Focusing on the most recent year of American Community Survey data, the number of homeowners with mortgages spending more than 30% of income on housing in Massachusetts rose only slightly from 2007 to 2008, while conditions remained stable for renters.

Forty-seven percent of renting households in Massachusetts are spending 30% or more of income on housing costs, a rate similar to most of the other LTS and the US average. Massachusetts ranks third highest for the percent of households with mortgages at 30% or more of income. The two states with a higher percent of homeowners with mortgages that are experiencing affordability problems are California and New Jersey.

APPENDIX A: DATA SOURCES FOR INDICATORS AND SELECTION OF LTS

Data Availability

Indicators use proprietary and other existing secondary sources that, in most cases, required reconfiguration by MTC. Since these data groupings were derived from a wide range of sources, there are variations in the time frames and in the specific variables that define the indicators. This appendix provides notes on data sources for each indicator.

Price Adjustment

Because of rapid increases in the cost of living in 2007 and 2008, the 2009 Index uses inflation-adjusted figures for most indicators. Dollar figures represented in this report, when indicated, are in chained 2008 dollars.

Price adjustments are according to the Consumer Price Index for all Urban Consumers (CPI-U), US City Average, All Items.

Bureau of Labor Statistics, US Dept. of Labor.

<http://data.bls.gov/cgi-bin/surveymost>



I. Selection of Leading Technology States (LTS) for Benchmarking Massachusetts Performance

The Index benchmarks Massachusetts performance against other leading states and nations to provide context for interpretation. The Leading Technology States (LTS) list, which was updated in 2009, includes:

California, Connecticut, Illinois, Maryland, Minnesota, New Jersey, New York, Pennsylvania, and Virginia. The LTS are chosen by the number of key industry clusters with a high concentration of employment, the percent of employment in key clusters, and the size of the states' economy. The cluster employment concentration for each state compares cluster employment as a percent of total employment to the same measure for the US as a whole. This ratio, called the location quotient, is above average if it is greater than one. The LTS are the ten states with the greatest number of clusters with a location quotient greater than 1.1, ranked by the percent of jobs in the key clusters, excluding states with fewer than a half million jobs in the key clusters. The size threshold excludes states such as New Hampshire, Rhode Island, and Utah. North Carolina, which for many years was included among the ten LTS has 25% of jobs in the key clusters. This methodology yields a roster of LTS that is comparable to Massachusetts and has a similar composition of industry clusters.

2009 Cluster Employment Concentrations										
2009 Cluster Employment (LQ)	MA	PA	CT	NJ	MN	CA	IL	MD	NY	VA
Bio-pharma & Medical Devices	1.86	1.41	1.45	2.17	1.45	1.48	0.94	1.14	1.01	0.49
Computer & Com Hdw	2.07	1.04	1.098	0.65	1.48	2.09	0.87	0.64	0.87	0.47
Defense Mfg	1.37	0.66	3.09	0.55	0.79	1.35	0.81	0.84	0.53	0.24
Financial Services	1.38	1.14	1.82	1.27	1.26	0.86	1.22	0.84	1.37	0.71
Postsecondary Education	2.47	1.87	1.48	0.88	0.97	0.88	1.09	1.11	2.19	0.94
Scientific, Tech, & Mgt Serv	1.45	0.93	0.77	1.26	0.71	1.32	1.28	1.71	0.88	1.88
Software & Com Serv	1.47	0.86	1.07	1.24	0.98	1.16	0.94	1.48	0.95	2.03
Advanced Materials	0.89	1.32	0.81	1.01	0.76	0.64	1.37	0.49	0.61	0.83
Business Services*	1.11	1.12	0.90	1.13	1.13	1.02	1.05	0.90	1.21	1.27
Diversified Industrial Mfg	1.25	1.26	1.83	0.69	1.48	0.90	1.67	0.40	0.78	0.63
Healthcare Delivery	1.28	1.22	1.07	1.08	1.09	0.86	0.98	1.01	1.09	0.82
Count of Clusters with LQ>1.1	10	7	5	5	5	5	4	4	3	3
Percent of Jobs in Key Clusters	37%	31%	33%	30%	29%	27%	29%	27%	30%	27%

Cells are shaded to show industry cluster concentrations more than 10% above the US average.

Source: Moody's Economy.com and BLS CEW.

II. Notes on selection of comparison nations

For all indicators, the countries displayed on the graph are the top performers for that measure, including nations with the highest growth rate where growth rate is measured. Countries not reporting data were excluded and vary depending on the measure.

III. Notes on international data sources

For countries where the school year or the finance year is spread across two calendar years, the year is cited according to the later year. For example, 2004/05 is presented as 2005. All international population estimates were obtained from the World Bank. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship—except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The values shown are midyear estimates. The World Bank estimates population from various sources including census reports, the United Nations Population Division's World Population Prospects, national statistical offices, household surveys conducted by national agencies, and Macro International. Statistics on China obtained from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) do not include the two Special Administrative Regions Hong Kong and Macao. All economic data, such as GDP, GNI, and exchange rates, used by UNESCO and the Index staff are provided by the World Bank and are revised on a biannual basis.

IV. Notes on overview charts

The overview charts are created with the same sources used for the corresponding indicators. The definitions for each of the measures are also the same as defined in the indicators, except for mortgage and rent affordability, which are based on the number of renters and mortgage holders who do not have to spend 30% or more of income on housing as opposed to those who do. The measures are per capita comparisons unless otherwise indicated or unless based on an average or median. The up and down arrows represent the direction of change since the previous year measured of the performance on that measure in Massachusetts without indexing to the United States average or comparing to the LTS.

V. Notes on Data Sources for Individual Indicators

1. Industry Cluster Employment and Wages

Moody's Economy.com tracks state-level industry employment using a methodology based upon individual corporations filings with State Employment Securities Agencies and the US Bureau of Labor Statistics (BLS). Data do not cover self-employment, employment of military personnel, or government employment. Definitions for each industry cluster are in Appendix B.
<http://www.economy.com>

Data on cluster wages are from the BLS's Quarterly Census of Employment and Wages. This survey assembles employment and wage data derived from workers covered by state unemployment insurance laws and federal workers covered by the Unemployment Compensation for Federal Employees program. Wage data denote total compensation paid during the four calendar quarters, regardless of when the services were performed. Wage data include pay for vacation and other paid leave, bonuses, stock options, tips, the cash value of meals and lodging, and contributions to deferred compensation plans. Figures are presented in 2008 dollars.
<http://www.bls.gov/cew/>

2. Occupations and Wages

The US Bureau of Labor Statistics' Occupational Employment Statistics (OES) program estimates of the number of people employed in certain occupations and wages paid to them. The OES data include all full-time and part-time wage and salary workers in non-farm industries. Self-employed persons are

not included in the estimates. Wages data are presented in 2008 dollars. The OES uses the Standard Occupational Classification (SOC) system to classify workers. MTC aggregated the 22 major occupational categories of the OES into 10 occupational categories for analysis. For this indicator, MTC consulted with the Massachusetts Department of Unemployment Assistance; Collaborative Economics; and The Donahue Institute at the University of Massachusetts.
<http://www.bls.gov/oes/home.htm>

The occupational categories in the **Index** are:

- Arts & Media: Arts, design, entertainment, sports, and media occupations
- Construction & Maintenance: Construction and extraction occupations; Installation, maintenance, and repair occupations
- Education: Education, training, and library occupations (except post-secondary computer teachers because they are included in Information Technology).
- Healthcare: Healthcare practitioner and technical occupations; Healthcare support occupations
- Human Services: Community and social services occupations
- Information Technology: Information systems managers; Computer and mathematical occupations; Computer hardware engineers; Computer teachers, postsecondary.
- Life, Physical, & Social Sciences: Life, physical, and social science occupations
- Professional & Technical: Management occupations; Business and financial operations occupations; Architecture and engineering occupations; Legal occupations (except those included in Information Technology).
- Production: Production occupations
- Sales & Office: Sales and related occupations; Office and administrative support occupations
- Other Services: Protective service occupations; Food preparation and serving related occupations; Building and grounds cleaning and maintenance occupations; Personal care and service occupations; Transportation and material moving occupations; Farming, fishing, and forestry occupations

3. Median Household Income

Median household income

Median household income data are from the US Census Bureau, March Current Population Survey. As recommended by the Census Bureau, a 3-year average is used to compare the relative standing of states. Income is presented in 2008 dollars. Data for the US are from a single year rather than a three-year average.
<http://www.census.gov>

Wages and salaries paid

Data are from the Bureau of Economic Analysis series "State Personal Income, wage and salary disbursements by place of work for Massachusetts."
<http://www.bea.gov/regional/>

4. Productivity

Labor productivity

Labor productivity for the overall economy is defined by the Index as gross domestic product (GDP) per employee. For the LTS calculation, data on total employment are from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. For the international calculation, data on total employment are from the International Labour Organization (ILO).
<http://laborsta.ilo.org/>
<http://www.bls.gov>

Manufacturing productivity

Manufacturing productivity is defined in the **Index** as manufacturing value added per manufacturing employee. Data are from the Census Bureau's Annual Survey of Manufactures. Industry definitions used are the manufacturing components of the key industry clusters (all NAICS codes that begin with the number 3). For information on the calculation of value added, see Indicator 5 Manufacturing Value Added. <http://www.census.gov/manufacturing/asm/index.html>

5. Corporate Sales and Manufacturing Value Added

There are two major differences between corporate sales and manufacturing value added. Corporate sales data are organized by the state in which the headquarters are located whereas value added data are by the location of the manufacturing facility. The other major difference is that corporate sales include the value of the profit and intermediary goods and services in addition to value added by the firm.

Corporate sales, publicly traded companies

Corporate sales figures are from Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the US Securities & Exchange Commission. Sales data are aggregated to the location of the corporate headquarters. <http://www.compustat.com/www/>

Manufacturing value added

Data are from the Census Bureau's Annual Survey of Manufactures. Cluster definitions are based the **Index's** key industry clusters. The Census Bureau defines value added as follows: "This measure of manufacturing activity is derived by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of shipments (products manufactured plus receipts for services rendered). The result of this calculation is adjusted by the addition of value added by merchandising operations (i.e., the difference between the sales value and the cost of merchandise sold without further manufacture, processing, or assembly) plus the net change in finished goods and work-in-process between the beginning- and end-of-year inventories. For those industries where value of production is collected instead of value of shipments, value added is adjusted only for the change in work-in-process inventories between the beginning and end of year. For those industries where value of work done is collected, the value added does not include an adjustment for the change in finished goods or work-in-process inventories. 'Value added' avoids the duplication in the figure for value of shipments that results from the use of products of some establishments as materials by others." <http://www.census.gov/manufacturing/asm/index.html>

6. Manufacturing Exports

Manufacturing exports data are from the World Institute for Strategic Economic Research (WISER) at Holyoke Community College's Kittredge Business and Technology Center. <http://www.wisertrade.org/>

The export categories match up with the clusters as follows:

- Computer and Electronic Products: Bio/Pharmaceuticals, Medical Devices, & Hardware, Computer and Communications Hardware, and Defense Manufacturing and Instrumentation.
- Chemicals: Advanced Materials and Bio/Pharmaceuticals, Medical Devices, & Hardware.
- Electrical Equipment, Appliances, and Components: Computer and Communications Hardware and Diversified Industrial Manufacturing.
- Fabricated Metal Products: Defense Manufacturing and Instrumentation and Diversified Industrial Manufacturing.

- Machinery, except electrical: Defense Manufacturing and Instrumentation and Diversified Industrial Manufacturing.
- Miscellaneous Manufactured Commodities: Diversified Industrial Manufacturing
- Plastics and Rubber Products: Advanced Materials
- Primary Metal Manufacturing: Advanced Materials
- Transportation: Defense Manufacturing and Instrumentation.

7. Research and Development Performed

Research expenditures at universities, hospitals, and nonprofit research institutes

Data on research expenditures are from a survey conducted by the Association of University Technology Managers (AUTM). The Massachusetts institutions included in the AUTM survey are listed below. <http://www.autm.net>

Hospitals & nonprofit research institutes	Universities
Beth Israel Deaconess Medical Center	Tufts University
Brigham & Women's Hospital	Univ. of Massachusetts
CBR Institute for Biomedical Research	Northeastern University
Children's Hospital Boston	Harvard University
Dana-Farber Cancer Institute	MIT
New England Medical Center	Boston U./ Boston Medical Ctr.
St. Elizabeth's Medical Center of Boston	
Massachusetts General Hospital	
Schepens Eye Research Institute	
Tufts Medical Center	
Woods Hole Oceanographic Institution	

Industry performed research and development (R&D) as a percent of industry output

Data on industry performed R&D are from the National Science Foundation. Data on industry output, defined as the state gross domestic product of the industrial sector, are from the Bureau of Economic Analysis. <http://www.nsf.gov/statistics/http://www.bea.gov/regional/gsp/>

Research and development (R&D) as a percent of gross domestic product (GDP)

International data on R&D as a percent of GDP are from the United Nations Educational, Scientific and Cultural Organization (UNESCO). The statistic measures the gross expenditure on R&D (GERD). GERD is the total intramural expenditure on R&D performed on the national territory during a given period (Frascati Manual, 2002). Data for Massachusetts' R&D as a percent of GDP are from the National Science Foundation and the Bureau of Economic Analysis. <http://stats.uis.unesco.org>

8. Corporate R&D Expenditures, Publicly Traded Companies

Corporate research & development (R&D) expenditure and sales data are from Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the US Securities and Exchange Commission. Corporate R&D expenditure totals include only those companies that reported any R&D expenditures. All data are aggregated to the location of the corporate headquarters. <http://www.compustat.com/www/>

9. Academic Article Output

Data are from the National Science Foundation's (NSF) Science and Engineering Indicators. The NSF obtained its information on science and engineering articles from the Thomson Scientific ISI database.
<http://www.nsf.gov/statistics/seind08/>

10. Patenting

Patents per capita for the LTS and other nations are from the US Patent and Trademark Office (USPTO). Patents by "computer & communications" and "drugs and medical patents" are based on categories developed by in Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498. Hall et. al. maps each of the 800 patent classes to an industry category.
<http://www.uspto.gov>.

11. University Technology Licensing

Data on licensing agreements are from the Association of University Technology Managers (AUTM). Institutions participating in the survey are AUTM members.
<http://www.autm.net>

12. Small Business Innovation Research (SBIR) Awards

This indicator includes SBIR award data, not including Small Business Technology Transfer (STTR). Data are accessed through the US Small Business Administration's Tech-Net database.
<http://tech-net.sba.gov/>

13. Regulatory Approval of Medical Devices and Biotechnology Drugs

Medical devices approvals

Data regarding medical device approvals in the US are provided by the US Food and Drug Administration. Medical device companies are required to secure premarket approvals (PMAs) before intricate medical devices are allowed market entry. A 510(k) is an approval sought by a company for a device that is already on the market and is looking for approval on components that do not affect the type of device, such as new packaging or new name.
<http://www.fda.gov>

Biotechnology drugs in development

Data on the number of biotechnology drugs in development are from the Pharmaceutical Research and Manufacturers of America's biannual publication "Medicines in Development: Biotechnology Report". For the purpose of this report, product categories include antisense, cell therapy, gene therapy, growth factors, interferons, interleukins, monoclonal antibodies (mAb), recombinant hormones/proteins, vaccines, and others.
<http://www.phrma.org>

14. Business Formation

New business incorporations

New business incorporations data are from the Office of the Secretary of the Commonwealth of Massachusetts.
<http://www.state.ma.us/sec>

Business formation vs. resulting job creation

Data on new business formation and change in employment due to business births come from the US Census Bureau, Statistics of US Businesses data series "Establishment and Employment Changes from Births, Deaths, Expansions, and Contractions by Employment Size of the Enterprise for the

United States and All States."

<http://www.census.gov/econ/susb/index.html>

Net high-tech business formation

The net change in high-tech business establishments was calculated using the Bureau of Labor Statistics' (BLS) Country Business Patterns data for high-tech industry sectors. The definition of high-tech industries employed is the approach employed by the BLS as modified by the National Science Foundation in Science and Engineering Indicators.
<http://www.census.gov/econ/cbp/index.html>.

Spinout companies

Data on spinout companies are from the Association of University Technology Managers (AUTM). Institutions participating in the survey are all AUTM members.
<http://www.autm.net>

15. Initial Public Offerings and Mergers & Acquisitions

Initial Public Offerings

The number and distribution by industry sector of filed initial public offerings (IPOs) by state and for the US are from Renaissance Capital's IPOHome.com.
<http://www.ipohome.com>

Data on venture-backed IPOs for the first three quarters of 2009 are from Thomson Reuters and the National Venture Capital Association (NVCA) via PRNewswire.com in the article "Venture-Backed Exit Market Continues to Face Challenges Despite Largest IPO in 2.5 Years" published October 1, 2009.
<http://www.prnewswire.com/>. Data for 2004-2008 venture-backed IPOs are from Thomson Reuters and the NVCA via the Boston Globe in a graphic accompanying the article "Executives hope busy IPO week is precursor to rebound" by D.C. Denison published September 23, 2009.
<http://www.boston.com>

Mergers & Acquisitions (M&As)

Data on total number of M&As are from FactSet Mergerstat, LLC. M&A data represent all publicly announced mergers and acquisitions.
<http://www.mergerstat.com>

16. Federal Funding for Academic, Nonprofit, and Health R&D

Federal expenditures for academic and nonprofit research and development (R&D)

Data are from the National Science Foundation's table of all R&D funds by state, performing sector, and source of funds. Data used are the entries for federal funding for universities and nonprofits, excluding university and nonprofit federally funded research and development centers (FFRDCs).
<http://www.nsf.gov/statistics>

National Institutes of Health (NIH) funding per capita and average annual growth rate

Data on federal health R&D are from the NIH. The NIH annually computes data on funding provided by NIH grants, cooperative agreements and contracts to universities, hospitals, and other institutions. The figures do not reflect Institutional reorganizations, changes of institutions, or changes to award levels made after the data they are compiled. The figures also do not reflect health R&D spending by other federal agencies, such as DoD, DoE, EPA, and VA.
<http://www.nih.gov>

17. Industry Funding of Academic Research

Data are from the National Science Foundation's survey of R&D Expenditures at Universities and Colleges. Since FY 1998, respondents have included all eligible institutions.
<http://www.nsf.gov/statistics/srvyrdexpenditures/>

18. Venture Capital (VC)

Data for total VC investments, VC investments by industry activity, and distribution by stage of financing are provided by PricewaterhouseCoopers (PwC) and the National Venture Capital Association (NVCA) in the MoneyTree Report. <http://www.pwcmoneytree.com> Industry category designations are determined by PwC and NVCA. Definitions for the industry classifications and stages of development used in the MoneyTree Survey can be found at the PwC website. <http://www.pwcmoneytree.com/moneytree/nav.jsp?page=definitions>

Data on fundraising by venture funds are from the press release "Despite Fourth Quarter Increase Venture Capital Industry Experiences Slowest Annual Period for Dollars Committed Since 2003" by Thomson Reuters and the National Venture Capital Association on January 11, 2010. <http://www.nvca.org>

19. Education Level of the Workforce

For this indicator, the workforce is defined as the population ages 25-65. Data on educational attainment of this population are from the US Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2003 through 2009. Figures are three year rolling averages for the intervals ending 2005 to 2009. http://www.census.gov/hhes/www/cpstc/cps_table_creator.html

20. K-16 Education

TIMSS mathematics scores

Trends in International Math and Science Study (TIMSS) is the product of a comparative math assessment conducted every four years at the fourth and eighth grade levels. TIMSS is carried out by the International Association for the Evaluation of Educational Attainment and managed and directed by the International Study Center at Boston College. TIMSS involves 59 countries and 8 benchmarking regions including Massachusetts. <http://timss.bc.edu/>.

High school attainment by the population age 19-24

Data on high school attainment are from the US Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2003 through 2009. Figures are three year rolling averages for the intervals ending 2005 to 2009. http://www.census.gov/hhes/www/cpstc/cps_table_creator.html

College degrees conferred

International data are from the United Nations Educational, Scientific and Cultural Organization from the series "Total graduates in all programmes. Tertiary. Total." Tertiary corresponds to higher education, the definition of which can be found in the International Standard Classification of Education. Data for the US states comes from the National Center for Education Statistics using the sum of all degrees conferred at the bachelor's level or higher.

21. Public Investment in K-16 Public Education

Note: This indicator looks only at public investments in education. It should be noted that Massachusetts is unusual in the size of the private education sector. Forty-three percent (198,000 of 463,000) of higher education students attend public institutions in Massachusetts compared to 72% nationally with the remainder attending non-public institutions. These figures are from the National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS) Enrollment Survey using the NCES population of institutions available at webcaspar.nsf.gov. While private higher education is an export industry in Massachusetts, 48% of Massachusetts high school

graduates indicate that they will attend public higher education institutions compared to 32% indicating they will attend private institutions, with the remainder not attending college. This difference is even more dramatic for Hispanics (50% and 18% respectively), a growing component of the Massachusetts population. These figures are from the Massachusetts Department of Education, Plans of High School Graduates, Class of 2008. <http://www.doe.mass.edu/infoservices/reports/hsg/data.html?yr=08>

Per pupil spending in K-12

Public elementary-secondary school finance data are from the US Census Bureau. Figures are presented in 2008 dollars. Data excludes payments to other school systems and non K-12 programs. <http://www.census.gov/govs/www/school.html>

State higher education appropriations per FTE

Data on public higher education appropriations per full-time equivalent (FTE) student is provided by the State Higher Education Executive Officers' State Higher Education Finance (SHEF). The data consider only educational appropriations—state and local funds available for public higher education operating expenses, excluding spending for research, agriculture, and medical education and support to independent institutions and students. The SHEF Report employs three adjustments for purposes of analysis: Cost of Living Adjustment (COLA) to account for differences among the states, Enrollment Mix Index (EMI) to adjust for the different mix of enrollments and cost among types of institutions across the states, and the Higher Education Cost Adjustment (HECA) to adjust for inflation over time. More detailed information about each of these adjustments can be found on the SHEEO website. <http://www.sheeo.org/finance/shef-home.htm>.

Per pupil investments in public education, international comparison

This indicator compares per pupil investments in education relative to per capita GDP. International data are from the United Nations Educational, Scientific, and Cultural Organization. The countries selected are the highest ranking for this measure among high income nations as defined by the World Bank. According to the World Bank, "economies are divided among income groups according to 2008 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, \$975 or less; lower middle income, \$976—3,855; upper middle income, \$3,856—11,905; and high income, \$11,906 or more." For information on the World Bank Atlas method see: <http://go.worldbank.org/QEIMYOALJ0>.

State data was created by aggregating data on different educational levels

Per pupil spending on public K-12 was obtained from the US Census Bureau. The number of K-12 students enrolled in public school and spending on public higher education was obtained from the National Center for Education Statistics (NCES). The numbers of full-time equivalent postsecondary students in public schools are from the State Higher Education Executive Officers (SHEEO).

22. Science, Technology, and Engineering Career Choices and Degrees

Intended major of high school seniors

The intended majors of high school students is measured as the preference marked by students taking the Scholastic Aptitude Test (SAT) in Massachusetts and the LTS. Data are from The College Board, Profile of College Bound Seniors. Students are counted once no matter how often they tested, and only their latest scores and most recent Student Descriptive Questionnaire (SDQ) responses are summarized. The college-bound senior population is relatively stable from year to year; moreover, since studies have documented the accuracy of self-reported information, SDQ information for

these students can be considered an accurate description of the group.
<http://www.collegeboard.com>

Engineering, computer & information science, health, and biological science degrees

Data about degrees conferred by field of study are from the National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS) Completions Survey using the National Science Foundation (NSF) population of institutions. Data were accessed through the NSF webcaspar website. <http://caspar.nsf.gov>. Fields are defined by 2-digit Classification of Instructional Program (CIP). Engineering and computer and Information science includes CIP 11 Computer and Information Sciences and Support Services and CIP 14 Engineering. Health and Biological Science degrees include CIP 26 Biological and Biomedical Sciences and CIP 51 Health Professions and Related Clinical Sciences.

Advanced Placement (AP) testing

Data are from the College Board's AP Report to the Nation. The data show the percentage of a state's entire graduating class who scored 3 or higher on at least one AP exam in a given category. If a student was successful on more than one AP exam in a category, he or she was only counted once in that category.
<http://www.collegeboard.com/apreport>.

Jobs in science, technology, engineering, and math (STEM) fields

The statements in the narrative about jobs in STEM fields come from same US Bureau of Labor Statistics' Occupational Employment Statistics data as in Indicators 2 and 23. The number of jobs in engineering, computer, or information science professions is the sum of IT (from Indicator 23) and engineering professionals (17-0000 excluding 17-1011: "Architects, except landscape and naval," 17-1012: "Landscape architects," and 17-1022: "Surveyors"). Likewise, the number of jobs in health & biological science professions is the sum of healthcare and life science professionals (from Indicator 2).

23. Information Technology Professionals in the Workforce

IT professionals as a percent of the workforce

Data on IT professionals and the size of the labor force are from the Bureau of Labor Statistics, Occupational Employment Statistics. http://www.bls.gov/oes/oes_dl.htm. In the process of defining IT jobs, regardless of industry, the Index staff consulted the UMass Donahue Institute and the Information Technology and Innovation Foundation. The following Standard Occupational Classification (SOC) codes are used to define IT professionals:

- 11-3021 Computer Information Systems Managers
- 15-0000 Computer and Mathematical Occupations
- 17-2061 Computer Hardware Engineers
- 25-1021 Computer Teachers, Postsecondary

IT professionals by cluster

Data on the number of IT professionals by cluster were obtained from matrices that give the number of workers for each combination of occupational (SOC) and industry (NAICS) codes. The Massachusetts Department of Labor and Workforce Development provided The Massachusetts Industry-Occupation Employment Matrix. Because the matrix uses 4-digit NAICS data there may be a small amount of double counting and over-estimation in assigning IT professionals to the key industry clusters.
<http://lmi2.detma.org/Lmi/EmploymentProjections.asp>

IT intensity

IT intensity is calculated as the percent of all employment in a cluster in IT occupations. The same data obtained for IT professionals by cluster were used for Massachusetts along with the Bureau of Labor Statistics' National Employment Matrix for national data.
<http://www.bls.gov/emp/>

24. Talent Flow and Attraction Net population change

Data on population growth rate by state and the US as well as total foreign and domestic migration data are from the US Census Bureau's Population Estimates Program. This dataset is an annual release that reflects estimates of the total population as of July 1st for the respective calendar year.
<http://www.census.gov/popest/datasets.html>
http://www.census.gov/popest/archives/1980s/80s_st_totals.html

Sasser, Alicia. 2009. "Retention of Recent College Graduates in New England." New England Public Policy Center Series, Policy Brief No. 09-2 (2009).
<http://www.bos.frb.org/economic/neppc/briefs/2009/pb092.htm>

Migration in and out of Massachusetts

Data on migration flows are from the Internal Revenue Service (IRS), Statistics of Income, Migration Data. The unit of measurement is the number of exemptions claimed on IRS tax forms. The lengths of the arrows are relative to the number of people moving into and out of Massachusetts from each named state and abroad between 2006 and 2007. Areas chosen are those with the highest migration flows in and out of Massachusetts.
<http://www.irs.gov/taxstats/article/0,,id=212683,00.html>

Relocations to LTS by college educated adults

Data on population mobility come from the American Community Survey table B07009: "Residence one year ago by educational attainment, persons ages 25 and older." This is the number of people moving in and includes no information about the number moving out. It is a measure of churn and ability to attract talent.
<http://factfinder.census.gov>

25. Housing Affordability

Housing Price Index

Housing price data are from the Federal Housing Finance Agency's Housing Price Index (HPI). Figures are four-quarter percent changes in the seasonally adjusted index. The HPI is a broad measure of the movement of single-family house prices. The HPI is a weighted, repeat-sales index that is based on repeat mortgage transactions on single-family properties whose mortgages have been purchased or securitized by Fannie Mae or Freddie Mac since January 1975 [technical description paper available here: http://www.fhfa.gov/webfiles/896/hpi_tech.pdf].

Housing affordability

Housing affordability figures are from the US Census Bureau, American Community Survey. The Index includes data from table R2515: "Percent of Renter-Occupied Units Spending 30 Percent or More of Household Income on Rent and Utilities," and R2513: "Percent of Mortgaged Owners Spending 30 Percent or More of Household Income on Selected Monthly Owner Costs."
<http://factfinder.census.gov>

APPENDIX B: INDUSTRY CLUSTER DEFINITIONS

INDUSTRY CLUSTER DEFINITIONS

The Index makes use of three-, four-, and five-digit North American Industry Classification System (NAICS) codes to define key industry clusters of the Massachusetts Innovation Economy. The Index key industry cluster definitions capture traded-clusters that are known to be individually significant in the Massachusetts economy. Consistent with the innovation ecosystem framework, these cluster definitions are broader than high-tech. While strictly speaking, clusters are overlapping networks of firms and institutions which would include portions of many sectors, such as Postsecondary Education and Business Services, for data analysis purposes the Index has developed NAICS-based cluster definitions that are mutually exclusive.

Modification to Cluster Definitions

The eleven key industry clusters as defined by the Index reflect the changes in employment concentration in the Massachusetts Innovation Economy over time. For the purposes of accuracy, several cluster definitions were modified for the 2007 edition. The former "Healthcare Technology" cluster was reorganized into two new clusters: "Bio-pharmaceuticals, Medical Devices and Hardware" and "Healthcare Delivery." The former "Textiles & Apparel" cluster was removed and replaced with an experimental "Advanced Materials" cluster. While "Advanced Materials" does not meet the most strict baseline criteria for analysis, it is included to in an attempt to quantify and assess innovative and high-growing business activities from the former "Textiles & Apparel" cluster.

With the exception of Advanced Materials, clusters are assembled from those interrelated NAICS code industries that have shown to be individually significant according to the above measures. In the instance of the Business Services cluster, it is included as it represents activity that supplies critical support to other key clusters. In the 2009 Index, The definition of Business Services was expanded to include 5511 Management of companies and enterprises. According to analysis by the BLS, Management of companies and enterprises have at least twice the all-industry average intensity of technology-oriented workers. All time-series comparisons use the current cluster definition for all years, and as such may differ from figures printed in prior editions of the Index. The slight name change in 2009 of the Bio-pharma and Medical Devices cluster does not reflect any changes to the components that define the cluster.

Advanced Materials

3133	Textile and Fabric Finishing and Fabric Coating Mills
3222	Converted Paper Product Manufacturing
3251	Basic Chemical Manufacturing
3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
3255	Paint, Coating, and Adhesive Manufacturing
3259	Other Chemical Product and Preparation Manufacturing
3261	Plastics Product Manufacturing
3262	Rubber Product Manufacturing
3312	Steel Product Manufacturing from Purchased steel
3313	Alumina and Aluminum Production and Processing
3314	Nonferrous Metal (except Aluminum) Production and Processing

Bio-pharma and Medical Devices

3254	Pharmaceutical and Medicine Manufacturing
3391	Medical Equipment and Supplies Manufacturing
6215	Medical and Diagnostic Laboratories
4234 ¹	Professional and Commercial Equipment and Supplies Merchant Wholesalers (apportioned based on 42345 Medical Equip. & Merchant Wholesalers and 42346 Ophthalmic Goods Merchant Wholesale in County Business Patterns)
5417 ¹	Scientific Research and Development Services (apportioned based on 5417102 Biological R&D in the Economic Census)
3345 ¹	Navigational, Measuring, Medical, and Control Instruments Manufacturing (apportioned based on 334510 Electro Medical Apparatus Mfg. and 334517 Irradiation Apparatus Mfg. in County Business Patterns)

1. Four digit data from economy.com are apportioned to this cluster based on more detailed industry data from one of two U.S. Census Bureau sources: County Business Patterns or the Economic Census.

Business Services

5411	Legal Services
5413	Architectural, Engineering, and Related Services
5418	Advertising & Related Services
5511	Management of Companies and Enterprises
5614	Business Support Services

Computer & Communications Hardware

3341	Computer and Peripheral Equipment Manufacturing
3342	Communications Equipment Manufacturing
3343	Audio and Video Equipment Manufacturing
3344	Semiconductor and Other Electronic Component Manufacturing
3346	Manufacturing and Reproducing Magnetic and Optical Media
3359	Other Electrical Equipment and Component Manufacturing

Defense Manufacturing & Instrumentation

3329	Other Fabricated Metal Product Manufacturing
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing
3345	Navigational, Measuring, Electro-medical, and Control Instruments

Manufacturing

3364	Aerospace Product and Parts Manufacturing
Diversified Industrial Manufacturing	
3279	Other Nonmetallic Mineral Product Manufacturing
3321	Forging and Stamping
3322	Cutlery and Handtool Manufacturing
3326	Spring and Wire Product Manufacturing
3328	Coating, Engraving, Heat Treating, and Allied Activities
3332	Industrial Machinery Manufacturing
3333	Commercial and Service Industry Machinery Manufacturing
3335	Metalworking Machinery Manufacturing
3339	Other General Purpose Machinery Manufacturing
3351	Electric Lighting Equipment Manufacturing
3353	Electrical Equipment Manufacturing
3399	Other Miscellaneous Manufacturing

Financial Services

5211	Monetary Authorities - Central Bank
5221	Depository Credit Intermediation
5231	Securities and Commodity Contracts Intermediation and Brokerage
5239	Other Financial Investment Activities
5241	Insurance Carriers
5242	Agencies, Brokerages, and Other Insurance Related Activities
5251	Insurance and Employee Benefit Funds
5259	Other Investment Pools and Funds

Healthcare Delivery

621 ¹	Ambulatory health care services
622	Hospitals

Postsecondary Education

6112	Junior Colleges
6113	Colleges, Universities, and Professional Schools
6114	Business Schools and Computer and Management Training
6115	Technical and Trade Schools
6116	Other Schools and Instruction
6117	Educational Support Services

Scientific, Technical, & Management Services

5416	Management, Scientific, and Technical Consulting Services
5417 ²	Scientific Research and Development Services
5419	Other Professional, Scientific, and Technical Services

Software & Communications Services

5111	Newspaper, Periodical, Book, and Directory Publishers
5112	Software Publishers
5171	Wired Telecommunications Carriers
5172	Wireless Telecommunications Carriers (except Satellite)
5174	Satellite Telecommunications
5179	Other Telecommunications
5182	Data Processing, Hosting, and Related Services
51913	Internet publishing and broadcasting and web search portals
5415	Computer Systems Design and Related Services
8112	Electronic and Precision Equipment Repair and Maintenance

2. Minus the portion apportioned to the Bio-pharma and Medical Devices cluster.

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